PROSPECTS OF AGROFORESTRY PROMOTION IN THE HILLS OF NEPAL

by

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Abstract

The overall objective of this study is to analyze the prospects of agroforestry promotion in the hills of Nepal. The study was conducted in Kumpur, Nalang, and Salang VDC areas of Dhading district, located in the central hills and inhabited by multi ethnic communities, with special reference to an agroforestry project initiated by Nepal Agroforestry Foundation. The study was undertaken to find out the nature, extent, determinants and constraints, problems and possibilities of agroforestry promotion. Household survey of a total of 223 farm households (82 "with" and 141 "without" project) combined with RRA techniques in rural settlements at altitude ranging from 500 to 1200 meter above mean sea level were carried out. Analytical tools employed include statistical test; costs, returns, cost-benefit ratio, soil sample analysis, index construction and regression analysis. Factors determining agroforestry adoption were analyzed and soil sample analysis was done to estimate agroforestry's impact on soil fertility.

Farming, practiced both in khet and bari, is the main source of livelihood of all sampled households. Bari comprised significant portion of the total land holdings. Uses of different agroforestry species under different systems to supply basic household needs and to maintain productivity have been the major concerns in subsistence production system. The average number of agroforestry species planted by project households in bari parcels is significantly higher ($p<0.01$) than non-project households. The significant variations were mainly associated with livestock herd size, availability of extension services and management practices. The results revealed a general tendency of species concentration, applying more manure and efficient management in parcels close to the farmhouse. Similarly, households in areas easy to access have planted significantly higher number of fodder, fuelwood ($p<0.01$) and fruit trees ($p<0.05$) in their bari parcels than households in areas difficult to access. Although project activities were concentrated in easily accessible areas, the results indicated the spill over effect of NAF project to non-project households mainly through demonstration effects.

The analysis on agroforestry's impact on soil fertility and farm income revealed that agroforestry had made a positive contribution to soil fertility and was more profitable than the conventional system. Soils with project have higher amounts of OM, N, P and K than without project but the differences are not significant at 0.05 level. Agroforestry provided opportunity and potential to diversify farm earnings through multipurpose species, such as mulberry, which further enhanced the profitability. Although agroforestry has great potential to enhance food production and farmers' economic conditions, low level of knowledge on improved species, practices and management, inefficient technical support, small and fragmented land holdings, ineffective extension services, and unreliable markets were the main constraints for promotion. However, findings revealed fodder scarcity, high yielding animal breeds and closure of community forests as major motivating factors for adoption. Decline in vegetative cover due to widespread deforestation and increased households' subsistence requirements and resultant effect on accelerating soil erosion, lowered soil fertility, land degradation and productivity decline have been the important factors for adoption. The findings show that livestock population ($p<0.01$), male membership in local NGO ($p<0.05$), female education level and perception ($p<0.10$) about agroforestry significantly influenced the adoption. Building positive perceptions on agroforestry by increased awareness through better access to technical know-how, extension services and facilities and education for women would increase adoption of agroforestry in both bari and khet.

Results indicate that adoption of agroforestry to harness hill development potential needs to be sensitive to the characteristics of technology, biophysical environment and socio-economic conditions. Management and enrichment of private farmlands, a finite and fragile resource which is vulnerable to degradation, is indispensable for sustained productivity. In this vein, detailed strategy and policy recommendations are presented, supplemented by research requirements to further advance the promotion of agroforestry. The approach that combines socio-economic, institutional and environmental issues by strengthening linkages, coordination and cooperation among organizations and people at large is recommended to enhance agroforestry promotion in the study area and the regions with similar environments. The suggested management strategy to promote agroforestry includes formulation of policies congenial to agroforestry development, the creation of mass awareness, provision of training, adoption of high yielding multipurpose species, promotion of agro-enterprises, improvement and strengthening of support services and facilities.

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Definitions

Agricultural Land	this includes areas on which farmers or any organization have right to use for agricultural activities
Agricultural year	The period 1 Baisakh (mid-April) to 31 Chaitra (mid-April next) which is also the Nepalese calendar year
Community land	this includes areas, which as a whole belong to the community, but the ownership remains with the government
Community forests	forests areas that is used by the particular community or communities from the ancient times and now under the full ownership and management by the Forest User Group (FUG) if the hand over process are completed.
Farm	when the land labor and capital are organized into a productive unit, which in agriculture called farm
Farm size	land area own by a farm household
Farmer	one who resides in a village, who cultivates the farmland and/or raise livestock on it that he/she owned or leased
Farm household	a basic unit of the farming system hierarchy in which a group of family members, who live in a common house, share a common kitchen and have common financial transactions
Labor	efforts of human beings including that of farmers, their families and the hired workers
Land	in economics, it's a free gift of nature including land, water and local climate, however, in this study, land is referred in the ordinary sense that is what we generally perceive
Lowland	the lowland include the khet land irrigated either partially or year round
Upland	the upland in this study indicates the rain-fed terraced and sloping bari land
Ward	The lowest administrative unit in the village development committee structure of the local government

Glossary

abbal	the first grade cultivated land based on the traditional land classification system.
bagaicha	home garden, fruit orchards, or specialized plantation unit
bagarkhet	khet lands of valley bottom and flood plains prone to flooding.
banda	a caste clans group similar to that of *Newars* in the hills
bari	the dry land also called pakho.
bhakari	grain storage structure normally constructed from bamboo and other wooden materials
bhari	a back load of things: commonly use for the measurement of fodder, fuelwood, crop residues, harvested maize cobs.
brahmin	members of the highest Hindu priestly caste of Aryan origin, the sacred caste, most dominating caste with agriculture as the main occupation and distributed throughout the country.
chahar	cultivated land of the lowest quality based on the traditional land classification system.
chhetri	caste ranked second in the caste hierarchy of Aryan origin, in ancient time, this caste was a warrior caste, distributed throughout the country.
dal	grain legumes used as pulse soup: important component of daily diet in Nepal
dalo	a small bamboo basket used to store things.
damai	tailor : lower caste group in Hindu caste hierarchy
dashain	the greatest festival of Nepal celebrated in the month of Aswin/Kartik (September/October), in honor of Goddess Durga-the deity of power
deepawali	also called Tihar (the festival of lights): a second biggest festival after Durgapuja or Dashain

dhan-ban-misrit	growing rice and perennial trees on the field
dhan ropne	rice transplanting
dhungebari	hillside gravelly terraced bari lands with gentle to moderate concave slope and high infiltration capacity
doko	a big bamboo made back-basket used to carry things.
doyam	cultivated land of second grade based on traditional land classification system.
durgapuja	The biggest Hindu festival of Nepal celebrated countrywide, synonym to *Dashain*.
gharbari	the *bari* land nearer to the farm households.
gharkhet	the *khet* land near by the farm households areas.
gharti	a minor hill ethnic group similar to *magar*
goth	temporarily or permanently constructed makeshift animal pens
gurung	members of community of Tibeto-Burman origin, ethnic group living in the hills: recruits normally from this group for British and Indian Gorkha army and renowned for bravery.
hal	pair of bullocks and an area of land which can be ploughed by them in one person-day's time or an animal day time.
kami	black smith - the untouchable lower caste group of Hindu caste system
kanla	terrace risers of both khet and bari lands
kanle bari	hillside bari lands with moderate to steep sloping narrow terraces and higher terrace risers
kanlekhet	hillside narrow terraced khet lands with higher terrace risers
khadyanna-ban-misrit	growing cereal crops with trees
khet	a well terraced cultivated land which is used for rice crop in rainy season.

kholakhet	the *khet* land of the midland and mountain valley floors, along a *khola*
khola	a water stream (for both perennial and seasonal stream)
kharbari	the areas used for raising thatch grass and agroforestry species and land not suitable for cultivation of crops.
krishiban	a nepali term for agroforestry
livestock standard unit	it is an unit used to standardized the different types and age groups of animals based upon their body weight for their food requirements.
magar	mongoloid origin ethnic community living in the hills and dominant group in the far western development region, also recruited for British and Indian Gorkha army regiments.
majhi	a minor ethnic community living in the river side: the boatsmen by tradition. Falls under 3rd rank in caste system.
makei-ban-misrit	maize cultivation under perennial trees in the farmland
makai godne	maize weeding operation, normally done twice per crop
mandro	mattress made out of bamboo and related species
muri	a measurement unit in Nepali expressed in volume by weight (eg. 1 muri of maize = 64 kg, equivalent given)
nanglo	a shallow flat tray used extensively by housewives for winnowing and normally made from bamboo and related species of bamboo
newar	a hill community with a mixture of Aryan and Tibeto-Burman ethnicity; most skillful in trade and traditional inhabitants of Kathmandu valley and concentrated in market area and spread throughout the country
patabari	wider and moderately sloping hillside bari land
pangomato	soil in the flood water that are washed down with run off water from the upper fields
perma	labor sharing system within the farmers living in close to each other
phagatekhet	khet lands of steeply sloping hillside with narrow terraces

sarki	shoe maker: a lower caste cobbler and his family name in the Hindu castes hierarchy
seem	a third grade cultivated land based on traditional land classification system.
seemkhet	khet lands of footslopes, colluvial slopes spring or marshy areas.
tar	river terraces, the inner plains (flat lands by the side of hills)
tarbari	bari land in river terraces, fans and ridge tops with wide and gently sloping terraces and short terrace risers
tarikhet	dry flat khet lands in river terraces and rice is cultivated in monsoon season
tamang	an ethnic hill community of Tibeto-Burman origin, majority of them live in the several hill districts located around Kathmandu valley

Abbreviations

AEA	Areas Easy to Access
ADA	Areas Difficult to Access
ADB	Asian Development Bank
ADB/N	Agricultural Development Bank of Nepal
ADO	Agricultural Development Office
APROSC	Agricultural Projects Service Center
BCR	Benefit Cost Ratio
DADO	District Agriculture Development Office (Officer)
DOA	Department of Agriculture
DFO	District Forest Office
DSCO	District Soil Conservation Office
EW	Extension Worker
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FORESC	Forest Research and Survey Center
FUG	Forestry User Group
GM	Gross Margin
GR	Gross Return
HMG/N	His Majesty's Government of Nepal
ICIMOD	International Center for Integrated Mountain Development
ICRAF	International Center for Research in Agroforestry
IDRC	International Development Research Center
IOF	Institute of Forestry
LSU	Livestock Standard Unit
NAF	Nepal Agroforestry Foundation
NAFSCOL	Nepal Agroforestry Seed Cooperatives Limited
NR	Net Return
PRA	Participatory Rapid Rural Appraisal
RRA	Rapid Rural Appraisal
SAARC	South Asian Association for Regional Cooperation
SAGUN	Social Action for Grassroots Organization
SD	Standard Deviation
SDO	Sericulture Development Office
SWC	Social Welfare Council
TDN	Total Digestible Nutrient
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat

Equivalents

1. Area

Measuring Unit	Ropani	Acre	Hectare
1 Matomuri	0.2500	0.0314	0.01270
1 Khetmuri (Bhari)	25.000	3.1428	1.27180
1 Hal (Khetland)	1.4100	0.0644	0.07050
1 Hal (Bariland)	2.3500	0.1053	0.11750
1000 Sq. Meter	0.6656	0.0837	0.03390
1 Ana	0.0620	0.0010	0.00004
1 Ropani	1.0000	0.1257	0.05090
1 Hectare	19.6564	2.4711	1.00000

2. Weight

Measuring Unit	Pau	Dharni	Kilogram	Quintal	Metric Ton
1 Pau	1.0000	0.0833	0.1994	0.0020	0.0002
1 Dharni	12.0000	1.0000	2.3934	0.0239	0.0024
1 Kilogram	5.0138	0.4718	1.0000	0.0045	0.0004
1 Quintal	501.3768	41.7814	100.0000	1.0000	0.1000
1 Metric Ton	5013.7680	417.8140	1000.0000	10.0000	1.0000

3. Volume

Measuring Unit	Mana	Pathi	Muri	Liter	Gallon
1 Mana	1.0000	0.1250	0.0062	0.5682	0.1250
1 Pathi*	8.0000	1.0000	0.0500	5.5460	1.0000
1 Muri	160.0000	20.0000	1.0000	90.9192	20.0000
1 Liter	1.7598	0.2200	0.0110	1.0000	0.2200
1 Gallon	8.0000	1.0000	0.0500	4.5460	1.0000

4. Volume by Weight

Crop Grain	I Muri equivalent to kilogram
Rice (husked)	72
Rice (unhusked)	48
Maize	64
Wheat	64
Barley	37
Millet	72
Potato	62
Mustard	59
Lentil	66
Soybean	65
Bean	65
Pigeon Pea	71
Black Gram	72

5. Nepali Calendar Equivalent to Gregorian Calendar

Nepali Month	Gregorian Month	
	From	To
Baisakh	Mid-April	Mid-May
Jestha	Mid-May	Mid-June
Ashad	Mid-June	Mid-July
Shrawn	Mid-July	Mid-August
Bhadra (Bhadau)	Mid-August	Mid-September
Aswin (Ashoj)	Mid-September	Mid-October
Kartik	Mid-October	Mid-November
Mangsir (Marg)	Mid-November	Mid-December
Poush	Mid-December	Mid-Mid January
Magh	Mid-January	Mid-February
Falgun	Mid-February	Mid-March
Chaitra	Mid-March	Mid-April

6. US Dolor Equivalent to Nepali Rupees (NRs.)

US $ 1 = Nepali Rupees 68, as of September 1998.

Chapter I

Introduction

Agriculture is the mainstay of Nepal's economy as it generates about 56% of the country's GDP and provides employment to 93% of the labor force. People, land and water are the major resources of Nepal. Varied topography and geographical locations with three distinct agroecological regions, namely, the Tarai, the Middle Hills and the Mountains, reflect opportunities and constraints, illustrating the diversity and complexity of the farming systems. Dominant farming systems vary with physiographic regions. Farming system in the middle hills hereafter referred to as Hills, is mixed subsistence and heavily dependent on forest resources (Mahat, 1987; Thapa and Weber, 1995; Kadariya, 1992). Farming Systems of the Hills are multidisciplinary since forestry, livestock and crops subsystems are inter-related. Livestock is an inseparable part of the farming system generating 37% of the total income to Hill people (NASA, 1991) and providing 55% of the on-farm income to small farmers (FAO, 1991). The term farmer in this study indicates both the men and women farmers unless otherwise stated. But whenever possible farmers will also be identified by sex and analysis made by gender. The crop and livestock subsystems are inter-linked and the output of the one sector acts as the input of the other sector by efficiently utilizing the limited farm resources. Under such interdependence the declining availability of forest resource and low livestock productivity means the overall decline in land productivity.

Hill economy has remained self-sustaining for a long time owing to low population density, good forest cover and grazing areas, low number of livestock, relatively better soil fertility, higher per capita cultivated land and terraced cultivation. Hill agriculture is heavily dependent on trees and forests and could not be sustained without them, which in turn are subjected to heavy human and livestock pressure. Forest resources are important for leaf litter, green manure, poles, fuelwood, fodder, and non-timber forest products. Fuelwood represents the only one major source of household energy, which comes both from on-farm and off-farm sources. Varying figures of per capita fuelwood consumption are reported by different researchers (Bajracharya, 1983; Metz, 1994) which differs with season, household livestock size, and the elevation. Farmers in the Hills are increasingly faced with fuelwood scarcity due to resource depletion and are forced to think of managing more tree on-farm. Fodder too is supplied from both the farm and off-farm sources. More than 50% of the total fodder supply comes from the forest (Kadaria, 1994) whereas compost application is variable with the range of 3-21 metric tons per hectare. Crop production depends on both livestock and forest. Imbalances in any component can bring changes in whole farming systems.

1.1 Statement of the Problem

In recent decades, Hills have undergone rapid changes due to higher human and animal population, stagnant agricultural production, deforestation, and small fragmented land holdings. People face serious constraints imposed by a meager resource base, poor technological capabilities, fragile mountain ecologies, and severely limited accessibility (Pudasaini, 1997). Cultivation of marginal land to meet the growing food demand created by the increased human and animal population resulted in serious implications for soil stability and Hill environment. Hill farmers possess both the uplands (*Bari*) and the valley or gently sloping lands (*Khet*) for paddy cultivation. Due to repeated ploughing and hoeing operations, widely spaced outward facing terraces and intensive utilization, *bari* are vulnerable to soil erosion, on the other hand khet, whose intensive utilization would not deteriorate the soil if adequately manured (Thapa and Weber, 1995) are not normally used for tree planting. This underutilization of khet increases farmers' dependency on forests, particularly the fodder, by reducing the amount of on-farm crop residues and straw production and accelerating erosion in *bari* indirectly. It is generally believed that bari lands without proper ground cover undergo severe soil erosion. Removal of forests accelerated soil erosion, lowered soil fertility and declined crop yields. Concluding that both the intensive field crop cultivation and fallowing are environmentally unsustainable practices, Thapa and Weber (1995) suggest shifting from arable to non-arable agriculture, which further highlights the importance of agroforestry in Hill farming systems. Agroforestry is therefore an inseparable part of the hill farming system.

Farmers' response to decreasing crop yield was to increase cropping intensity (Mahat, 1987) which led to nutrient mining. Increase in crop intensification from 1.23 in 1981/82 to 1.77 in 1991/92 (CBS, 1996), and decrease in grazing lands and forest resources and closure of the community forests have constrained livestock production and resulted in more dependence on cultivated crops. Depletion of vegetative cover weakened soil resistance to erosion, lessened organic matter supply, reduced the productive capacity, declined productivity and severely impaired fodder supply contributing to a sharp decline in livestock productivity and increased dependency on crop residues (Mahat, 1987; Thapa and Weber, 1990). In this respect, MPFS (1988) has indicated that all the hill districts except the eastern hills are in fodder deficit situation. Crop intensification reduced the crop aftermath grazing in the farmland. Due to decrease in thatch grasses, crop residues are also used as roofing materials and fuel purpose thereby reducing livestock feed as well as organic matter incorporation into the cropland. Land fragmentation is on the rise, crop yields have stagnated or declined, livestock productivity has declined and the traditional farming systems of the hills have experienced heavy pressure to sustain the population.

Traditional farming systems are characterized by flow of the forest biomass into cropland in the form of organic manure via livestock (Yadav, 1992; Gilmour, 1989; Griffin et al., 1988). Crop biomass is recycled into cultivated land in the form of organic residues, mulch, animal feed and bedding materials through livestock and human beings. Livestock population pressure is considerably high in Nepal, which has resulted in overgrazing (Banskota and Jodha, 1992) and environmental imbalance (Pandey, 1992) due to excessive drain on natural resources. Declining agricultural productivity, increasing pressure on land, water and forests, which are exacerbated by an increasing human and livestock populations are the complex issues of Nepal's economic development and environmental improvements. Relying completely on renewable sources of energy such as sunlight, forest biomass, crop residues, human and animal power, and microbial process the farming system is mostly controlled by ecological principles. Performance of mountain farming system is influenced enormously by measure of diversity which are in turn created by altitude, slope, direction, temperature, humidity, rainfall, availability of irrigation and accessibility to market centers. Due to various cereal crop based agricultural interventions initiated to increase productivity, biodiversity has been fast declining and farmers are exposed to more risk factors.

Agriculture intervention techniques and processes through cereal-based production system, such as introduction of high yielding hybrid varieties, application of chemical fertilizers, pesticides, provision of credit program with extension and intensive tillage practices, are directed towards maximizing the production. Such measures directed to short term benefits have resulted in increased soil erosion, plant nutrients mining, land degradation, reduced biodiversity and water availability. The land degradation is more serious, not only because of the amount of soil erosion, but because there are no other obvious options for gaining a livelihood (Blaikie, 1989). The traditional farming is constrained to meet the present food demands and sustain the livelihood owing to the greater population pressure and land degradation. This is well explained by the magnitude of the poverty. Although different criteria and values are used to define the poverty line the figure of 40% (NPC, 1992), 66% (Lipton, 1983) and 71% (SAARC, 1992) of the total population below poverty line has been reported. Whether the improvements in the field crop cultivation in the Hills will fulfill the subsistence requirements of the population in general and the population below the poverty line in particular has become an important question. If the low energy and high yielding tree and livestock based agriculture system in contrast to energy intensive mechanistic and soil destructive modern agriculture can be a viable option for self-sufficiency in food production in the Hills is also the other question connected to this. More research is required before making any conclusions on these issues.

In a study for Nepal Agricultural Sector Strategy, Asian Development Bank noted that Nepal's agricultural sector is characterized by (ADB, 1982);

- a high population-land ratio;
- large number of poorly fed livestock, low productivity and high incident of diseases;
- declining forage base;
- deteriorating environment;
- declining soil fertility and reduced yield.; and
- reduced availability of the full range of forest products.

This sectoral study clearly indicates that agroforestry could serve as one of the appropriate remedial measures to improve the agricultural sector. Because of deterioration in land person ratio, very high rate of deforestation, and diverse needs of farmers, agroforestry has special significance to Nepal, allowing farmers to diversify their production system through reduced risk of total crop failure. But information on the animal feeding practices, changes in animal breeds and their numbers, household labor availability and demand and changes in other socio-economic factors "with" and "without" agroforestry interventions are not available. Under such situation intensive and properly managed agroforestry has been considered a viable land use alternative for the Hills as a number of studies have mentioned the intimate role of forests and agroforestry system in enhancing the Hill farming system *vis a vis* the Hill economy (Wyatt-Smith, 1982; Mahat, et al., 1987; Thapa, 1989; Amatya, 1994; Shrestha, 1994). Together with the conservation objective agroforestry interventions should also aim at poverty alleviation. This requires the proper understanding of existing agroforestry systems, project interventions and status of present agricultural systems in the region.

Trees are considered multi-faceted resources of poor people (Chambers et al., 1989) and best protectors of the fragile mountain environment (Thapa and Weber, 1993). According to Denholm (1991) 3.5 to 6 hectares of forestland are required to support each hectare of cropland. In many areas the land ratio has dropped to 0.5: 1 ha. from traditional 4:1. Depleting forest resources, high demand for fuelwood and fodder and increased soil erosion has put enormous pressure on subsistence farming system and environment. Thus requiring suitable alternatives for improvement and increased level of awareness on degradation among farmers. There are opinions that these are not true or supported by the facts, and problems of Himalayan environmental degradation (Eckholm, 1975; Wallace, 1981; Myers, 1986) are seriously distorted as well as unnecessarily generalized (Fox, 1993; Ives and Messerli, 1989; Bajracharya, 1983; Mahat, 1986).

Due to over population, forested land is converted to cropland, and Nepal lost half of its forest cover within 30 years (1950-1980) period (World Bank, 1979) and nearly one-quarter disappeared between 1964-1975 (Ruddle and Rondinelli, 1983). ADB (1982) indicated that between 1975 and 1980, the cultivated area of Nepal expanded by 34%, accompanied by decline in total area under forest. But Ives and Messerli (1989) claimed that conversion of forestland to arable land occurred most before 1950 with only a little loss in recent decades. Comparing tree cover changes using aerial photographs in two Hill districts east of Kathmandu, Carter and Gilmour (1989) showed a three-fold increase in the number of trees on private land over a period of 24 years. Gilmour and Nurse (1991) recorded similar trend and an increase on most of the landscape of tree cover in a 17 year period. Although these are conflicting to each other, absence of gainful non-farm employment opportunities and limited potential of cropping intensification, farmer had to resort to the expansion of agricultural land into forests, scrubs and grazing lands (Thapa and Weber, 1996).

Although sporadic incidences of better management of forest are reported, their sustainability is very much questionable (Fox, 1993). But the increasing concern about environmental degradation and crisis helped to promote the forestry program and raise public awareness. Despite the efforts, Nepal's forest area has dwindled to less than 37% and even if all the forests are managed scientifically, the demand for forest products for construction, energy, food, and fodder will not be met as some of the remaining forests are located in inaccessible high mountain areas (Shakya, 1995). It is seen that the Hill region is faced with enormous problems, which are clouded in uncertainty and complexity (Ives and Misserli, 1989).

Agroforestry is a new term for an old practice of growing assorted varieties of trees and shrub species in association with field crops in Nepal. Most Hill farmers have grown assorted varieties of trees to supplement inadequate supply of fodder and fuelwood from forests. Studies revealed people's dependency on forests and grazing land for considerable proportion of fodder, fuelwood, and timber (Fox, 1983; Mahat, 1986; Metz, 1994). But the studies almost remain silent on the question of why they could not fulfill all the requirements from the farm sources? Most of such studies are sectoral and have not dwelt on the issue of whether improvements in agriculture alone are sufficient for food self-sufficiency and economic development in the Hills. It is often in doubt that the production increase is sufficient to supply the people's needs, especially as those needs expand with the demand for consumer goods (Metz, 1994). But the National Planning Commission in its 20 years Agriculture Perspective Plan envisages to reach 5% increase in the total growth of agriculture output per capita by reverting degraded land to forestry, planting soil conserving trees, fruits and fodder crops including fodder trees and legumes with salutary environmental effects in the Hills (APP, 1995). Agroforestry becomes vital to achieve this target.

Both the government (GO) and non-governmental organizations (NGO) have designed and implemented projects and programs related to agroforestry in Nepal. Besides, different bi-lateral and multi-lateral project activities in community forestry, agriculture, and soil conservation are also supporting the work on agroforestry to some extent in different specific locations. Many of such programs are confined to a sectoral approach and focused only on meeting the subsistence requirements of fodder and fuelwood. The programs have not been successful to accomplish the objectives of providing economic incentives of agroforestry. But sometime are just confined to fulfill the interest of the implementing agency. In many instances, various agroforestry programs initiated by both Governmental and Non-governmental organizations are focused on meeting subsistence needs of fodder and fuelwood which do not offer much incentive to farmers for additional investments in agroforestry. In view of farmers' poor economic conditions and increased access to market centers, GOs and donors have to shift agroforestry promotion strategies from purely subsistence to commercial oriented. Agroforestry research and development is further complicated by institutional fragmentation, such as Nepal Agriculture Research Council (NARC), under the Ministry of Agriculture, which is responsible for agriculture and livestock related research, and Forest Research and Survey Center (FORESC) and Department of Medicinal Plants at the Ministry of Forest and Soil Conservation responsible for forestry related research. Institute of Agriculture and Animal Science (IAAS) and Institute of Forestry (IOF) are also engaged in agroforestry research independently. But agroforestry remains nobody's responsibility.

Some NGOs have made agroforestry as an entry point to their community-developing programs. Farmers have not been able to visualize agroforestry as a viable program to increase their household income but just as a supporting activity to supplement some portion of fodder and fuelwood requirements. The important role of productivity increase and economic improvement has not yet been realized by farmers owing to the technology being directed towards meeting the subsistence requirements of fodder, and fuelwood only. Although, fodder and fuelwood are more important to women and already a significant contribution to improve women's condition, the interest of men is more towards increasing household income. Personal experience in working with the farmers shows that such programs have not even been able to meet the household subsistence requirement and thus trailing far behind from economic improvements. Although some success has been observed in some specific locations, they are only confined to the adoption of tree planting program by some farmers.

NGOs often fail to realize the importance of community approach in utilizing the available land resources as potential for agroforestry development, which can be economically attractive. The extension program, which is considered crucial in the adoption process, is very weak. It is seen that majority of NGO or government initiated programs to a larger extent have either been forgotten or remained very limited after the external intervention is withdrawn showing unwillingness of farmers to continue adoption of the introduced practice or resource management interventions due to lack of income incentives. This is also related to the technology itself, which does not generate tangible outputs or cash for the family. It is usually seen that the farmers are adopting technologies which are cash earning in nature even after the withdrawal of the external support. The proposition is more appropriate for male farmers than female farmers. Although there are problems, NGOs have been able to reach to the grassroots people due to high flexibility and fewer bureaucratic hurdles than GOs and contribute to improve the rural economy.

Despite debate on the extent of its severity, empirical studies conducted in the Hills revealed that the environment is deteriorating gradually due primarily to land degradation arising from increase in total livestock population, excessive soil nutrients mining, and monocropping practices leading to soil erosion. This has threatened to undermine the food supply. Under such situation, agroforestry could play an important role in enhancing farm household economies. Besides, it can contribute to control land degradation and deforestation by means of increased availability of fodder, food, fuelwood, improved vegetative cover and reducing pressure on the forest.

As forest or tree cover is lost gradually, the soil erosion increases rapidly. During rainy season discharges from hilly terrain upstream due to over exploited watershed areas have posed serious threats to land productivity and stability. Forests with relatively sparse tree density and grazing lands in the vicinity of settlements have been undergoing degradation due to fuelwood and fodder collection and livestock grazing (Thapa and Weber, 1995). On the other hand traditional agricultural systems are no longer able to sustain and support the pressure on the land. In many areas in the Hills, the balance between forest and arable land has now been irrevocably disturbed (Seddon, 1990). In the context of significant biophysical and socio-economic variations in the mountains, it is futile to make any general statement based on the few case studies and occasional field observations in certain areas (Thompson and Warburton, 1985; Ives & Messerli, 1989). Therefore it is necessary to look further into the type of agroforestry systems and suitable agroforestry interventions with respect to their sustainability in the immensely varied environmental and socio-economic conditions.

Realizing the importance of sustaining mountain farming system and accelerating the development, the government of Nepal in its eighth five year development plan state (NPC, 1992);

" The biggest challenge today is to achieve stability and sustainability in agricultural and forestry development by fostering mutual complementarities among agriculture, forestry and natural resources". Therefore, agroforestry has emerged as a primary focus of rural development efforts due to its characteristics of meeting subsistence needs.

The proper assessment of the problems and the nature of prevailing development interventions to support the sustainable agriculture systems are much felt today. Although external interventions are necessary to ensure higher productivity per unit land area, they not only influence positively but also negatively. Likewise negative effects of the conventional approaches to development have generated a need to search for ways and means for achieving the goal of sustainability. Only realizing the importance of conserving natural resources, commitment to their better and wiser use do not mean that the interventions are likely to be sustained. Research should be aimed at documenting the various agroforestry systems that are practiced by farmers to meet their subsistence needs, as well as to supplement household earnings and finding out appropriate technological processes to ensure both productivity and sustainability. Despite the fact that agroforestry involves crops, trees and livestock, there have been hardly any research activities or studies that effectively considers all these elements together.

1.2 Rationale of the study

Identifying existing agroforestry systems under different socio-economic and agroecological conditions and the suitable indicators of sustainability, with respect to intervention techniques to improve the economy without creating ecological problems is the need of today's development in Nepal. This has become important in order to improve the productivity of the system that farmers have been adopting since generations. As there are serious doubts that the focus on food production alone will improve the economy of the hills but they have better comparative advantages for other sectors of the economy. Ample scientific evidence has been reported from studies carried out in different countries that considerable benefits, both environmental and economical, can be derived from agroforestry and have the potential to solve many land use problems by appropriate interventions (Current et al., 1995). But these studies do not necessarily mirror the conditions faced by the hill farmers. Farmers themselves have not been able to observe the benefits outside their subsistence requirements. In-country studies are limited to such conclusions due to lack of sufficient integrated package of information. In comparison to other disciplines, scientific studies in agroforestry have been very limited and therefore the potential of agroforestry remains under-exploited.

Use pattern of the resources is an expression of deep political, economic and cultural structure (Eckholm, 1976) and can not be changed easily. Natural diversity has been and is being utilized by local farmers for their sustenance and/or developing diverse food production and livelihood systems. But increased level of production, under traditional farming system with environmentally sustainable land use practices is no longer feasible on large-scale production intensification. In these regards, the management efforts of the farmers of the Hills are under stress of such an order as to threaten the basis of their livelihood. To facilitate resource use intensification for higher productivity resources need to be well managed, upgraded and value added by measures such as soil moisture conservation, less animal grazing and increased greenery through the promotion of agroforestry. The vital elements for sustainability such as regeneration and inter-linked uses of forest resources need to be addressed properly through understanding the local dynamic of resource use in the community, which ensures the intimate relationship with the nature. Biophysical, social, economic and national policies are the factors that need to be studied in meeting this end.

The existing biodiversity that offers both wide ranges of opportunities and constraints at all levels in the mountain is a wealth for the future. Tapping such potentials can influence performance of mountain economic system. Due to special ecological and environmental situations, mountains offer several unique opportunities of comparative advantages. Harnessing such opportunities from what Banskota and Jodha (1992) refer to, as 'niches' is important for sustainable development. Such diversity is created due to variations in microclimatic conditions, altitude, and slope. Such varied conditions in the mountain provide opportunities for multiple products having high demand in the market. The demand for such forest products is increasing and will remain high even in the future. Under the competitive marketing mechanism of the world, locational potentiality provide good comparative advantages in future and opportunities exist for creating off-farm activities in the Hills of Nepal (Pandey, 1992). The biodiversity in the mountains needs to be protected, preserved and enriched for sustainable development and saved from negative development intervention. It is self-explanatory that erosion of biodiversity or promotion of monoculture leads to ecological and economic problems.

Selection of appropriate intervention approaches and processes being adopted by farmers, institutions and organizations with sustainable results, is not an easy task. Seeking appropriate technological process for sustainability, entails an in depth analysis. In recent years, sustainability has been the focal point of discussion among foresters and agriculturists.

Gender discrimination in agroforestry research and extension is considered critical as fuelwood, fodder collection and livestock feeding are considered the main responsibility of the women. Inserra (1989) describes the vital role played by women in forest management- collecting fuelwood, fodder, leaf for compost and bedding, tree planting and controlling grazing. The linkages between gender and agroforestry development are not very clearly understood. Agroforestry interventions may cause or exacerbate gender imbalances, for example reduce female time of collecting fuelwood and fodder but may need more on-farm labor whereas most planners simply fail to consider the impact of agroforestry projects on women and their role in implementation (Fortmann, 1983). Higher on-farm fodder production may not mean that it automatically relieves women's workload. In an impact study of a village livestock project in the Hills, Bhatt, et al., (1994) argued that business of livestock production poses particular constraints such as more work, less mobility, no access and control over returns on rural women living under dwindling fodder and fuelwood availability. It has been reported that men are also taking over activities which are traditionally reserved for women, when such activities become attractive with the introduction of new techniques (Rao, 1994). They may be different in different cultural, socio-economic, institutional and environmental contexts. Despite the women's role in agriculture and forest resource management activities, they are not sufficiently represented in research (Grantham, 1996).

Although women represent themselves as producers, child-bearers and household managers, they are also the majority of the food producers. Major activities performed by women are essential for the basic survival of the household members. There is still insufficient gender dis-aggregated data on involvement of women in farming. It is generally perceived that both sexes are equally involved in agricultural production but in practice there are some specific activities, which are exclusively carried out by particular sex. Gender division of labor by separating men in certain types of work and women in other types, is a source of perpetuation of female subordination. In fact, the subordination of women is an embedded feature of the wider social and economic structure. Both men and women take the field production activities ranging from land preparation, weeding, to harvesting, while women have traditionally managed the home production activities. Having similarity on working in the farm with men, women have the biggest difference for lone taking the burden of managing household chores and reproductive work. In an gender division of labor study, Joshi (1998) revealed that within the household some work is exclusively done by women and men separately and showed that women's work is for longer hours, tedious, full of drudgery and more fragmented than men. Therefore, gender dis-aggregated data will be useful for the promotion of agroforestry.

Almost all agroforestry practices demand labor at various times of the year for different tasks. It is therefore vital to understand household labor situations. Labor requirement is always a factor which rural people take into consideration in decision making to adopt any new practice (Hoskins, 1987). They are often confronted with complex tradeoffs among alternative uses of time and limited capital (Bentley, 1993). Confronted with a choice of land use options of differing labor intensive methods of meeting their production needs, people will be reluctant to adopt more labor intensive practices until population pressure compels them to do so (Raintree, 1990). Generally most land use intensive innovations tend to be the most labor intensive which should have some impact on women. Although impact of reduced water, fuelwood, fodder supply and agroforestry intervention on women is not addressed properly, women in the Hills of Nepal are found to be very positive about the new irrigation facility since these considerably reduces the time they needed for fetching water for domestic use (Backer, 1992). It is not known whether it alleviates their household workload. In the same study, women reported that the increased availability of irrigation water had considerably reduced the time needed for weeding. Though gender relation is considered a crucial factor in promotion of agroforestry, no critical study has been done to examine linkages between gender and agroforestry interventions. Thus, gender analysis is required to explore important problems, areas of concerns, constraints and areas of interventions under specific conditions.

In the situation of environmental degradation and shrinking natural resources in the Hills women's condition is getting worse and it is of great importance to know how women spend their time, take part in decision making and how the agroforestry interventions has changed the situation if any. It will be also interesting to know how the increased income is spent and its impact on gender relations in the households. Although in the general context of deepening poverty, situation of women looks worsened; the improvement in some areas with outside interventions can not be ruled out or is even expected. Therefore gender analysis should be included as a multiple approach to solution identification.

Although there is considerable knowledge base on state-of-the-art agroforestry technique and practices, Raintree (1990) suggests that most of those agroforestry prescriptions should be treated as hypotheses for testing. Micro-regional studies with watershed focused approach to environmental management are required in understanding and unfolding the actual nature and extent of the problem to formulate pragmatic conservation and management strategies (Thapa and Weber, 1995). Because existing improved technology, which are promising to some farmers and in some location, are not necessarily so for everybody and everywhere. What the farmers can do and is feasible in different areas depends on resource endowments, and socio-economic systems.

Research on agroforestry in Nepal has been focused on fodder trees. The other perennial and non-perennial vegetation including herbs, issues of crops and livestock integration, role of gender within agroforestry systems and their concern in rural ecology in terms of ecodevelopment have not been given due consideration. Also research activities have remained overwhelmingly focused on private farm land despite the increased recognition of the important role of public forest and grazing lands in the hill farming system, which are vital for poor households with small land holdings (Malla, 1992; Malla and Fisher, 1987; Denholm, 1991). Similarly the project activities are also confined mostly on fodder trees and grasses promotions. Other species of agroforestry are not given adequate attention both on research and project implementation. Interrelationships between various components of livestock, crops and forests, its role in poverty alleviation and the impact on the environment has not received adequate attention. Most studies are confined to propagation techniques, growth rates, biomass yields, and the value of tree normally as fodder (Sherpa, et al., 1996; Karki and Gold, 1992; Robinson and Thompson, 1989).

Most research on tree crop has been the concern of foresters whereas agronomists tackle crop production issue without considering tree components, which are in fact inseparable components of the Nepalese farming system. There is often mutual distrust, competitive environment for scarce resources, between academic disciplines, particularly between natural and social sciences (Blaikie, 1989: 34). Agriculture and forestry sciences are highly interrelated and no single sector can be studied separately under the present farming system of the Hills. But due to highly variable biophysical conditions, farmers in favorable niches may shift from arable to non-arable farming and depend upon agroforestry based enterprise in the future. Under present condition and without proper conservation of scarce resources, cultivation of crops and livestock raising in isolation to trees/shrubs/grasses will cause adverse ecological and economic consequences in the Hills. Therefore, eco-degradation is seen essentially as the consequence of failure to cope with the rising demand for food, fodder, fuelwood and other forest products through adequate investment, technological advancement and organizational set up to manage the resources.

Farmers have been continuously experimenting the suitable techniques and do possess indigenous knowledge to cope with the problems. Such indigenous technical knowledge (ITK) built over many centuries has supported the livelihoods in the past and will continue to support in future. There are also differences in knowledge between men and women. But pressure has been accelerated too rapidly that suitable ITK has not evolved. Most research on indigenous knowledge looks at farmers' attitude towards and preferences for fodder trees (Upadhaya, 1991; Kapali, 1992; Tiwari, 1994). Tiwari (1994) found that indigenous propagation techniques for fodder trees were practised by farmers across range of agro-ecological zones in western Hills of Nepal. Similarly, Robinson (1993) citing number of studies conducted to evaluate traditional tree protection and propagation techniques noted that some of the techniques such as multiple air layering and complex bark cuttings for propagation were not known to forestry specialist. Therefore the tradition of generalizing and viewing farmer as ignorant and unaware of certain agroforestry practices such as mixed, intercropping and alley cropping is not valid. But analysis, synthesis, and interpretation of the qualitative knowledge held by farmers and professionals across a range of disciplines are conceptually and practically challenging (Sinclair and Walker, 1998).

"Farmers know everything, and recognize problems" vs "farmers are ignorant and do not know anything" views should be examined critically. It is clearly known that farmers know something and can analyze problems, but may not be aware or able to provide answers for many of the problems. This entails a comprehensive research to explore and know more in partnership with the local people, who are struggling to face challenges.

The Hill farmers have not practiced alley cropping although widespread in some countries. People have not started planting trees on terraces, which are utilized solely for crop cultivation. Very limited studies have been done on economic aspects of agroforestry. Long-term economic benefits have been mentioned without empirical research to show the profitability under farmer's condition, with little information on short-term benefits from agroforestry systems. But clear economic analysis to demonstrate the actual benefits from agroforestry systems, which will convince farmers to adopt the technology, is not available. Studies have not been carried out to recommend some specific agroforestry models and studies carried out in some places can not be generalized for larger area. Therefore site-specific agroforestry research has become the need of present day development in identifying suitable technological intervention for the transformation of the hill farming system into the economically profitable, ecologically suitable and just system.

Success in agroforestry promotion depends on scientific validation of promising agroforestry practices and development of area specific technologies based on the people's needs and aspirations. The practices used traditionally also have great potential, which needs to be explored, and further developed to obtain economic and environmental benefits. This study will contribute substantially to promote agroforestry for optimal productivity and economic development through intensification of land use in the Hills. Several factors are involved in farmers' decision to adopt a new or continue the existing practice. The land use problems, labor requirement, yield levels, household needs, farmers biophysical and economic resources and practices are but some of the important factors. Detailed analysis of these factors will contribute significantly in agroforestry promotion. The community and household decision making processes in terms of land tenure, access to market, resource use and institutional arrangements deserve attention. Under such circumstances social factors must be understood for socially beneficial solutions. Therefore, a holistic perspective in research is required to understand the complexity of agroforestry interventions. This research aims to fulfill this gap in the current Hill agroforestry research and development. The focus on the socio-economic, biophysical and agroecological aspects, including gender of agroforestry interventions and adaptations for hill developments are considered the innovative features of this study.

Understanding the system by exploring social, economic, technical or organizational factors related to adoption is important for planning purpose. Proper planning facilitates program implementation and better adoption. Better adoption of the agroforestry interventions by farmers is the sign of productive systems, which justify the used inputs through the level of output produced and positive net returns. Research findings become meaningful for the planning process only if they can be put into practice. The farmers will slowly reject interventions that do not suit the socio-economic and biophysical conditions of the area once they start practicing. Similarly, subsistence farmers' sophisticated ecological knowledge can be a key resource for planning and implementing research and development program.

Therefore research to improve agroforestry should explore social, economic, technical or organizational factors and recommend appropriate strategies related to adoption in integration. As these are the innovative features of this study, the research results will be highly applicable in real situation. The findings will be useful for planners, policy makers, project implementers (both GOs and NGOs), and donors who are interested in the agroforestry research and development in the Hills of Nepal. The outcome of the study will provide guideline for better planning and facilitates in deciding the type of technological interventions which are location specific, gender balance, and viable for given set of biophysical and economical conditions.

1.3 Objectives

The main objective of the study is to analyze the prospects of agroforestry promotion in the study area. The followings are the specific objectives;

- Examine the existing agroforestry systems and influencing factors in the study area.
- Access the impact of agroforestry on soil fertility and its role in soil fertility management.
- Analyze the financial cost and benefits of agroforestry from the "with" and "without" project.
- Investigate the determinants of agroforestry adoption.
- Recommend appropriate strategies and approaches for agroforestry promotion.

1.4 Thrust of the study

1. Existing Agroforestry systems under given socio-economic and agroecological conditions.
2. Use of agroforestry species under the different land types and categories in the hills.
3. How to intervene or the suitable extension (agroforestry planning process)
4. whom to involve (households, community, grass roots organizations/NGOs)
5. point of intervention (private land - khet, bari, marginal lands, kharbari)
6. whom to involve (men & women, disadvantaged groups, ethnic group, community)

1.5 Conceptual Framework

The conceptual framework was developed to examine the problems and prospects of agroforestry promotion under the given socio economic, technology and resource management patterns. The existing systems of agroforestry, available farm level resources and their capabilities to sustain crop-livestock-tree-integrated system were assessed. Real problems limiting the adoption of agroforestry were assessed by identifying the explanatory variables. Adoption of agroforestry practices to fulfill the household subsistence requirement and to increase the farm production through conservation based practices have been constrained due to high population pressure on the arable lands, increasing livestock number, fragmented institutional support, weak policies, social constraints and dwindling resource base. Technological, institutional and policy intervention are required to achieve substantial improvements in the existing situation leading to greater adoption of the agroforestry. Improvement in family gender relations, awareness and motivational programs on agroforestry needs to be addressed. These empirical findings through both statistical and economical analysis lead to formulate the strategies for agroforestry development in the study area. Based on the constraints, the present state of the farming community in the hills, levels of interventions required and potential benefits envisaged, the broader conceptual framework of the study is presented in Figure 1.1.

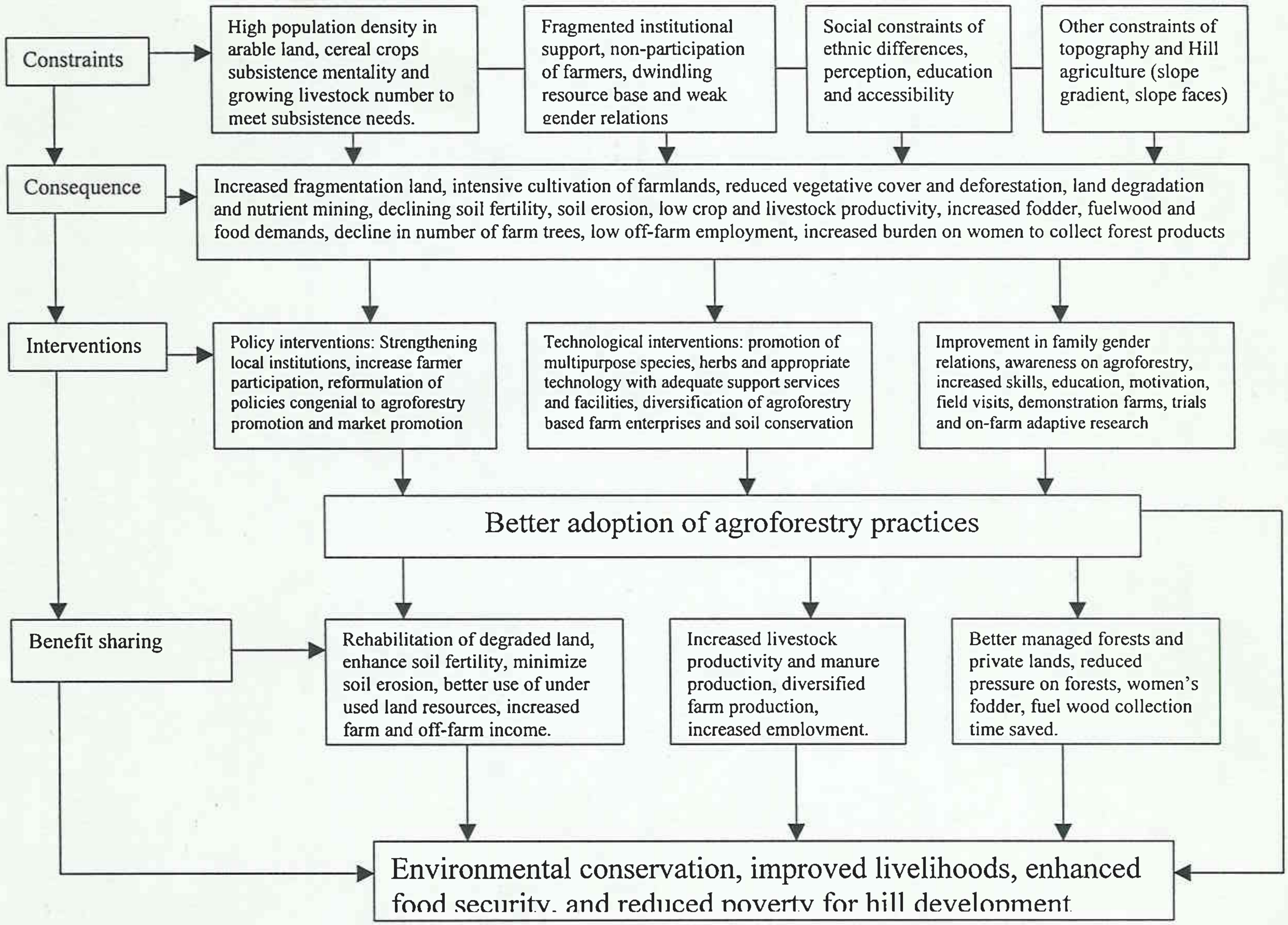


Figure: 1.1 Agroforestry Promotion in the Hills of Nepal: A Conceptual Framework

1.6 Scope and limitation of the study

The scope and the limitation of the study are presented based on the objectives of this study. The objectives are further elaborated as farmers' problems, research problems and bound by the scope of the study (Table 1.1). Based on the detail conceptual framework presented in Figure 1.1 specific factors related to social, institutional, environmental, economic and personal characteristics of the technology adopters influencing the promotion of agroforestry are identified and presented in concise form (Figure 1.2). Participation, migration, ethnicity, occupation, family size, land tenure are identified as important social variables. Environmental and location factors included types of land, soil quality and accessibility whereas land and livestock holdings, crop yields and costs and benefits were recognized as economic factors. Institutional factors ranging from policies to support services and farmers' personal characteristics, such as perceptions towards agroforestry, education, attitude and age were pertinent factors influencing the agroforestry promotion in the study area.

Table 1.1 Scope of the study: a schematic view

Objective	Farmers' Problem (s)	Research Problem (s)	Scope of the Study
1.	Necessary to bring changes in existing farm practices to improve productivity and household economy.	How farmers have been managing their farm resources to adjust with the internal and external influencing forces under the existing hill farming conditions.	Analyze existing agroforestry systems, species, land use practices and influencing factors.
2	Soil fertility decline, decreasing crop yields and farm productivity	What kinds of impact does agroforestry have on soil fertility and how farmers maintain fertility under the given farming systems in the hills.	Analyze soil samples to compare soil fertility levels and examines farmers' strategies to maintain soil fertility.
3	Traditional Agroforestry practices causing decrease in field crop production	What is the economic rationale of adopting agroforestry systems from farmers' perspective under the given farming conditions.	Compare the profitability between the traditionally managed and improved agroforestry systems
4	Not able to demonstrate transformation for higher adoption of agroforestry	What are the factors that influence farmers' decision making, bring transformations and adoption of agroforestry technology.	Analyze factors influencing decision making and agroforestry adoption.
5	Farmers' participation in agroforestry promotion is low and adoption is slow and very difficult.	Is there any prospect to improve farmers' situation by participation of user groups, farmers, NGOs, and government institutions in agroforestry programs implementation.	Assess existing systems and explore strategies for promoting agroforestry to improve farmers' economic status.

Conceptual framework for explanatory variables

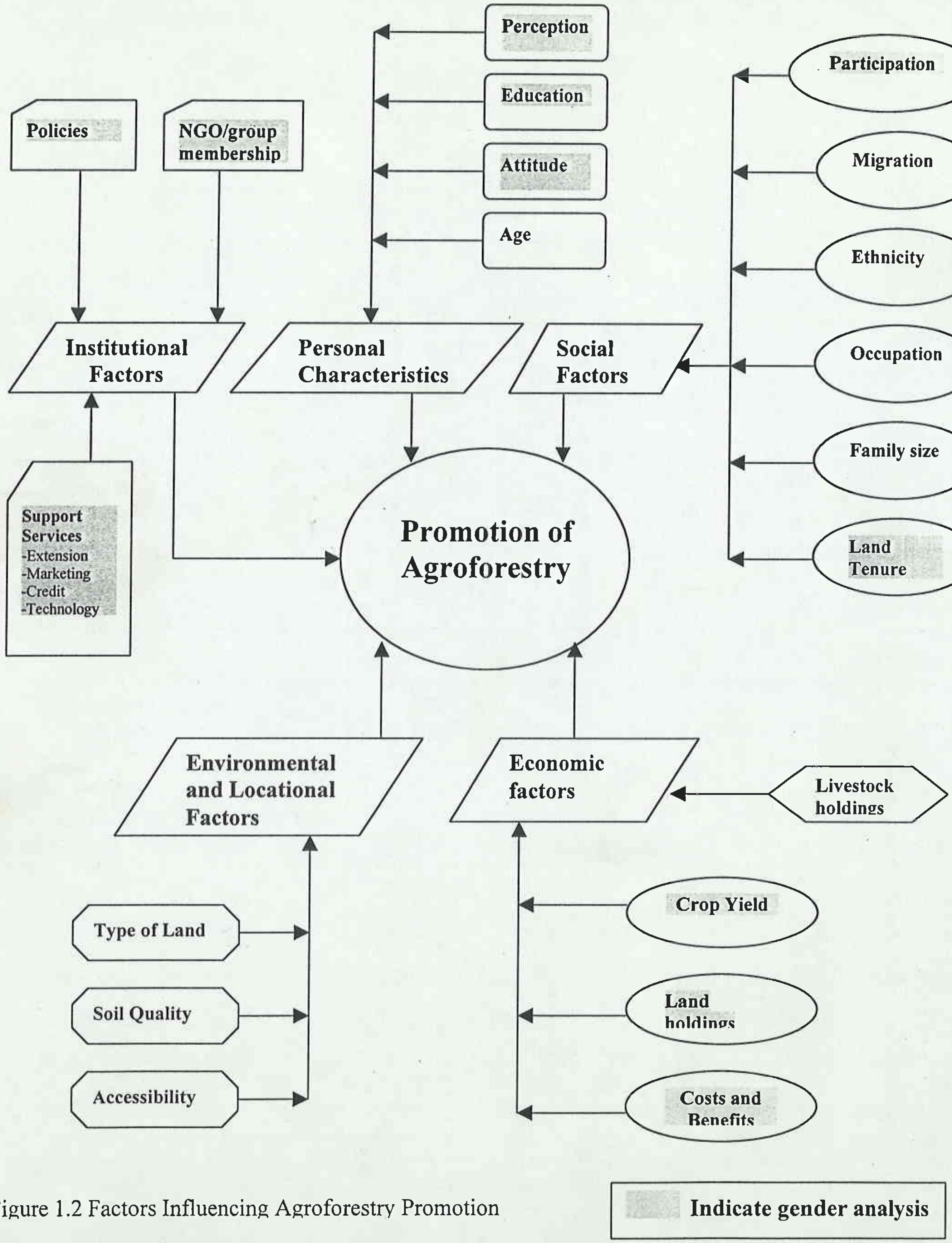


Figure 1.2 Factors Influencing Agroforestry Promotion

Chapter II

Literature Review

People have lived over generations based upon the available resources around them and underwent a transition from hunting/gathering to the use of domesticated plants and livestock. Agroforestry practices were existed since the human being learnt to do farming after domesticating plants and animals (Arnold, 1987). With the rise in population, gradually people started cutting down trees, burnt them and sowed crops in the ash-enriched soil. By this way the slash-and-burn agriculture, which is considered the forerunner of present day agroforestry, evolved (MacDicken and Vergara, 1990). Together with the gradual evolution of various process of domestication, the problems such as soil erosion, accelerated nutrient extraction by crops emerged which forced farmers to move to new sites to repeat the process known as shifting cultivation. The practice is still continuing in many developing countries in various forms.

King (1987) stated that the Hanunoo of the Philippines practiced a complex and somewhat sophisticated type of shifting cultivation where trees were inseparable part of their farming systems providing both the productive and protective functions. Complex and diverse agroforestry systems in Asia-Pacific regions evolved over centuries with continued innovation, change, experiment and improvement by farmers through driving forces of population growth, poverty and transition to market economy (FAO, 1996). Traditionally people have developed the agroforestry systems through their informal experimentation based on their knowledge of coping with any new situation. The trees were kept on established farmland to support the agriculture. Ultimate objective in those days was not the tree products *per se* but food production. In 1806, during the British Empire, "taungya" method was established in Burma (King, 1987) by government or private companies to grow crops on plots to be replanted with valuable timber species. Later the practice spread in many countries of the world and still continues in several countries. As population pressure intensified during the second half of the twentieth century, people from the flood plains migrated to nearby uplands establishing spontaneous and unplanned settlements. These migrants lacked knowledge and experience of sustainable upland farming and resulted on forest destruction and accelerated loss of soil (Rao, 1994).

FAO redirected its thrust and assistance in the forestry sector and utilized the Eighth World Forestry Congress (1978) to focus the attention of the worlds leading foresters on the important topic of agroforestry (King, 1987). In July 1975 the International Development Research Centre (IDRC) commissioned Mr. John Bene (1910-1986) to undertake a study to identify gaps in forestry research and training, to formulate research program and to make recommendation for institutional arrangement to carry out forestry research. Which ultimately led to the establishment of International Council for Research in Agroforestry (ICRAF) in 1977 (King, 1987). Within the decade (1975-1985), agroforestry has moved from a virtually unknown concept, to respected scientific discipline (Lundgren, 1993) and subsequently reemerged as a potential land management option in many countries.

2.1 Environmental Role of Agroforestry

The growing demand for food, fuel and forage needs are to be fulfilled through making adjustments in the total production systems keeping in view of the available land resources. This increase in food should either come from increase in the area under cultivation, increase the frequency of cropping, reclamation of the degraded land or increase the productivity of areas currently under cultivation. Agroecological conditions constraint agricultural intensification such as the case of mountain agriculture or agriculture in rain-fed areas. In Asia, where some 79% of the arable land is already under cultivation, most of the production increase will have to come from the technological intensification resulting in the higher yields per unit of land (Raintree, 1990). The most of the yield increment (76%) in Asian region came from the increased land productivity whereas in Latin American region the higher contribution is from the expansion of the land (FAO, 1981 cited by Raintree, 1990). Any further improvements in the current level of production require new environmentally friendly technological interventions.

Conventionally agroforestry has emerged as an alternative strategy to meet the subsistence requirements of food, fuelwood and fodder. But with the increased population, subsequent land degradation, soil fertility decline and environmental degradation, agroforestry has reemerged as an important land use system, which combines economic and environmental concerns together. The system is environmentally friendly because in terms of tradition it does not depend on external inputs. Conservation farming practices have indicated that soil loss can be reduced but the appropriate mixture of practices and their impact vary considerably from location to location. Use of grass strips, hillside ditches, improving agronomic practices, contour hedgerows in soil fertility management will be of considerable importance for the substantial reduction in soil erosion. In addition they also supply plant nutrients as well as the fodder for animals. They could also be more efficient local method of conserving moisture in area with critical water constraints. Experiment on 20-50 percent sloping land in Chiang Rai, of Thailand showed very substantial soil loss reduction when using grass strip and hillside ditches (Syers, 1994). Management of vegetative cover, production of organic mulch, green manure or wind protection, reduction of pressure on forest through increased on farm tree cover are considered environmentally beneficial aspect of agroforestry.

The issue of land degradation, which extent varies from one region to another, needs to be addressed properly. Singh (1994) reported that as much as 2 billion ha of lands worldwide that were once biologically productive are now degraded. Quoting Lal and Stewart (1990) he further stated that current rate of land degradation (5-7 million ha/year) may climb to 10 million ha/year by the turn of the century. Such degraded land can often be rehabilitated by agroforestry while this also provides some income to poor farmers. Chundwat and Gautam (1993) estimated that if soil erosion continued at its 1983 rate, loss in rain-fed crop land in the developing world would range from 9.7 percent to 35.6 percent, leading to an overall 28.9 percent decrease in crop production by the year 2000. The excessive erosion rates observed in some countries are attributed to intensive land use, replacement of traditional fallow periods by continuous cropping and extensive hoeing plowing operations. According to a study conducted at the Central Tuber Crops Research Institute, Kerala, India, on tree crops (Eucalyptus and Leucaena) and cassava intercropping, the soil erosion loss was 70-80% less than mono crop of cassava (Ghosh, et al., 1989: internet).

"Agroforestry is considered of potential to address and alleviate the problems through proper use of trees and shrubs. There are four major factors which play an important role in working out the potential of an agroforestry systems i.e., biological productivity, soil quality related, economic and social factors (Nair, 1993). Apart from these factors, the locational factor plays very vital role as some areas are more potential than the others. However in a study Punam and Khosla (1994) reported that the accumulation of biomass in horticultural trees emerged as a fifth most important component. Many agroforestry species can provide considerably higher amount of organic manure *vis a vis* important plant nutrients to improve the soil fertility. The *leucaena* has particularly rapid decomposition releasing 50% of the nutrients in first 25 days. The principal species under evaluation for hedgerow intercropping are *Leucaena leucocephala, Calliandra calothyrsus, Gliricidia sepium, Cassia siamea, Flemingia congesta, Sesbania sesban,* and *Cajanus cajan* (ICRAF, 1992). The available results show that it is possible to design systems of hedgerow intercropping which maintain soil fertility (Young, 1989). Agroforestry can contribute to improve soil fertility through increasing the quality and quantity of fodder and hence livestock manure, providing biomass for composting and reducing nutrient loss through run off (Garforth et al., 1999). A study on adoption of live hedges in the central plateau of Burkion Faso show that water availability is an important condition for the adoption of live hedges and probability of adoption increased by 20% when water was readily available. Probability of adopting live hedges increases by 37% if the farmers produces mainly cash and annual/perennial crops and derives additional income directly from the live hedge species (Ayuk, 1997).

Soils have been affected by various toxicities, deficiencies and waterlogging conditions. Such degraded land can be reclaimed by appropriate agroforestry interventions. Many species of trees can grow well in the problem areas where most agricultural crops cannot. For example various species of Sesbania have been grown successfully in saline, alkaline, and even waterlogged soils (Swaminathan, 1987). Sepcies of *Salix babylonica, Salix xuchonensis, Alnus trabaculosa, Alnus cremostogyne, Morus alba, Taxodium distichum, Taxodium scandens, Paulownia torentosa* are commenly used for wetland agroforestry (Chundawat and Gautam, 1993). Eroded wastelands in the Loess Plateau of China have been reclaimed by planting trees and legumes as ground cover (Swaminathan, 1987). Because the trees are more drought resistant than the field crops, they are able to provide food, fodder, fruit and other products when the rains fall in arid regions (Harsh et al., 1993). Although potential of hedgerow intercropping has been demonstrated in the humid and sub- humid tropics, it is unlikely to be widely successful in arid and semi arid environment (ICRAF, 1992).

2.2 Definition and Classification of Agroforestry

Agroforestry is increasingly recognized as an approach to tree planting that also falls within the scope of the community forester's work, although this is a territory that must be shared with the agriculturist, horticulturist, livestock specialist, social scientist, gender specialist and others (Raintree, 1991). Associated socio-environmental benefits and multiple output of agroforestry such as providing food for family, fuelwood for household use, medicinal products and timber are considered vital for household survival. There are problems on the adoption of practices that are proved to be beneficial through scientific experiment. The process of the adoption of improved technology in agroforestry does not happen suddenly rather on an incremental basis. Spontaneous transitions from annual cropping systems to tree based cropping system have been observed at numerous locations throughout the tropics and scattered case studies support the economic rationality of such changes (Raintree, 1990).

Various definitions of agroforestry have been proposed. It is usually seen in these definitions that there are frequent mixing up of the definitions. According to Lundgren (1982), a strictly scientific definition of agroforestry should stress two characteristics common to all agroforestry practices,

1) The deliberate growth of woody perennials on the same unit of land along with agricultural crops and /or animals either in some form of spatial mixture and in some temporal sequence; and
2) There must be significant interactions- ecological and /or economic (positive or negative) between the woody and other components of the practice.

ICRAF defines agroforestry as follows;

"Agroforestry is a collective name for all land –use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops and/or animals. This can be either in some form of spatial arrangement or in a time sequence. To qualify as agroforestry, a given land-use system or practice must permit significant economic and ecological interactions between the woody and non-woody components".

The ICRAF's definition clearly underlines the integrated nature of the approach. Obviously, there could be various definitions of agroforestry depending upon how people see the system. FAO (1996) defines agroforestry as "the deliberate growth and management of trees, along with agricultural crops and /or livestock, in system that aims to be ecologically, socially, and economically sustainable. Or more simply, agroforestry is the integration of trees with the farming system.

There are numerous types of agroforestry systems being practiced in various countries. Most are traditional systems developed over time in response to changing conditions and some are recent systems developed or improved through research and extension. Agroforestry systems are generally categorized on the basis of its structure, function, agroecological and environmental adaptability, socio-economic and cultural characteristics, and management practices. Tejwani (1993) has reported 48 classes of agroforestry systems (Tejwani, 1987) in partial modification of Combe's (1982) classification who identified 24 types of agroforestry. Nair (1985) suggested the inclusion of agro-ecological zones and socio-economic aspects, for example, silvopastoral system for cattle production or agrosilvicultural system for soil conservation in tropical Savannah whereas Vergara (1982) considered the relative allocation of land to trees, crops, pastures in various agroforestry systems. Wiersum (1986) made a distinction between practices dominated by natural forests, by planted (timber) trees, by fruits or cash crop trees, and by scattered trees or trees in row in agrosilviculture or silvopastoral systems.

Looking at the relative dominance of trees or crops/pastures in a practice, and non-wood forest products, Tejwani (1987) suggested the following classification system. Where trees are major component of the land use system, and a agricultural crop is combined with them, the system is referred to as 'Silvoagriculture" but where the agricultural crops are the major component and trees are combined then it is referred to as "Agrosilviculture". Whereas the combination of trees and grasses is referred to as "Silvopastoral".

2.2.1 Silvoagriculture

Under silvoagriculture practice, farmers grow agricultural crops with commercial trees. Forest dwellers and farmers use plantations and woodlots to grow crops and to extract non-timber forest products. The practice is called Taungya system. The commercial trees refer to species, which are grown for marketable products such as timber, rubber, oil, fruits and coconut. Taungya and shifting cultivation are the important practices under Silvoagriculture systems.

Taungya system is what was first developed in Myanmar during 19^{th} century (FAO, 1996) in teak plantations. Different modifications have been reported. Inheritable land-use right are given to landless encroachers in Thailand. In Bangladesh, encroachers who plant tree and crops in the encroached land are entitled to have a portion of revenue when trees are harvested. Whereas in Indonesia, full rotation agroforestry is practiced in forest plantations where farmers may also harvest branches for fuelwood and low interest credit for seeds, fertilizers and pesticides, is given as an incentive. Similarly in Lao, PDR, farmers have long-term land-use rights to intercrop food crops with teak trees. After the canopy closes, the standing trees are sold to investors and farming household retain the land use rights (FAO, 1996). The intercropping varies according to the agro-ecological situations. The major tree species grown in the system are *Shorea robusta* and *Tectona grandis* (Singh, 1987). Outstanding practices are seen in intercropping with coconut, arecanut and other horticultural trees. Commercial tree crops such as *Poplar* and *Eucalyptus* have become increasingly popular in the systems. Depending upon the agroecological conditions and the requirements of the farmers, a wide variety of crops could be incorporated in the system.

Shifting cultivation over the time has gone into different transformations. Population pressure is unquestionably one of the driving variables behind the historical perspective of land use intensification but this is not the only factor. In response to mounting population pressure, technological changes resulting in higher outputs per units of permanently cultivated land have tended to be accompanied by lower yields per unit of labor (Raintree, 1991). Farmers practicing shifting cultivation have been undergoing substantial changes. In India, shifting cultivation cycle has decreased to 5-7 years from 30-40 years (FAO, 1996). They have also started increasingly growing the arable crops such as paddy, maize and other cash crops in contrary to traditionally non-arable type of cultivation. In Bangladesh, shifting cultivators have been encouraged to grow in combination- short rotation crops like Pineapple, Banana and Bamboos; medium rotation crops like Guava and Jack fruit; and long rotation crops like Teak plantation. Whereas intercropping of Erythrina with taro and yam in Samoua, Leucaena with sweet potato in Papua New Guinea, and leucauna and Gliricidia with cocoa in the Solomon Islands transforms shifting cultivation practices into a permanent and continuous agroforestry systems (Rao, 1994).

2.2.2 Agrosilviculture, Silvopastoral and Agrosilvopastoral

Under agrosilviculture systems the woody perennials may either be grown in agricultural fields, or farm boundaries, or as separate woodlots but the extent and type of trees grown vary distinctly with different socio-economic and biophysical factors. Trees are grown for uses such as shade, fodder, fuelwood, fruits, timber, shelterbelts, windbreaks and soil conservation. Some of the practices are highly developed and extensive. In China intercropping food crops with *Pauwlonia sp.,* poplar (*Poplus sp.*) and willow (*salix sp.)* have become important practices (FAO, 1996). Throughout the Senegal, Upper Volta, Niger, Chad and other areas of West Africa, farmers selectively preserve *Acacia albida* trees in their fields because of its beneficial effects on surrounding crops as well as the protein-rich pods for livestock fodder (Hoskins,1984: p.47).

Silvopastoral is the system of growing of woody plants with the pastures. A three-stratum forage system consisting of grass layer, a shrub story and an upper stratum of trees was developed by farmers in Indonesia to provide fodder throughout the year (FAO, 1996). Raising livestock under coconut plantation is widely practiced in the Pacific Islands such as Vanuatu, Tonga, Fiji, and Papua New Guinea (Rao, 1994). In natural stands, grasses and legumes are most important for grazing and cover crops, such as kudzu (*Pueraria phaseoloides*), centro (*Centrosema pubescens*) and calopo (*Calopogonium mucunoides*) in particular (Nair, 1993). These includes the intensively managed cut and carry system (Protein bank), live fence post and extensively managed browsing, grazing systems.

Agrosilvopastoral is the practice of growing trees, shrubs and grasses in agricultural fields and on farm boundaries together with raising animals. This system is, in effect, combination of agrisilviculture and the silvopastoral systems (Huxley, 1984). It is estimated that 20-40 trees per hectare of *Acacia albida*, an outstanding tree species for dry area, can provide nutrients equivalent to the normally required quantity of fertilizer. This is considered a low cost, sustainable technology and an attractive alternative to prevailing shifting cultivation and bush-fallow system (Swaminathan, 1987; p. 25-40).

2.2.3 Traditional agroforestry

Traditional agroforestry practices play an important role in developing countries where fruit trees are planted in home gardens, pastures, and crops are cultivated under trees. These systems are also classified on the basis of temporal association- shifting cultivation as temporary or more permanent like home gardens. Among the traditional systems, the home garden systems of SriLanka have been considered to be highly intensified and well developed.

Home gardening is a very old tradition which may have evolved over a long time from the practices of hunters/gatherers and continued in the ancient civilizations up to modern times (Soemarwoto, 1987). In Srilanka these are called " Kandyan Gardens". Although the home gardens type of agroforestry has been practiced in many countries the well-known examples of home gardens are normally referred from the island of Java in Indonesia, Thailand, Malaysia, Srilanka and India. Home gardens exhibit the layer of vertical structures of tree, shrubs and ground cover plants. The prominent structural characteristics of the home gardens is the great diversity of species ranging from the creeping on the ground such as sweet potato, shrubby species such as different herbs, turmeric, ginger, different vegetables and beans, to tall trees such as coconut, jack fruit and mango trees. The diversity of the species and the plant density varies with the ecological and socio-economic factors. Soemarwoto (1987) argued that more subsistence type of crops is grown in the home gardens of more remote areas whereas the number of cash crops increases with accessibility to transportation systems. This is largely attributed to the accessibility of markets; and high demand of such products. Women are generally responsible for the management of homegardens (FAO, 1996) as they are traditionally more occupied with providing food for the family.

In a comparative study of the productivity of home gardens and wet rice in Java, Penny and Gitting (1984) found that an average holding of 0.23 hectare of wet rice contributed 35 percent of household income, whereas an average holding of 0.10 hectare of home garden contributed 49 percent. Although the contribution of home garden varied with household type, the smallest landowners in the village obtained 92% of their household income from home gardens in comparison to just 8% from their rice fields while for the large landowners the figures were 42% and 58%, respectively. Nuberg et al. (1994) referring home gardens of Uvan Uplands of Sri Lanka as forest Gardens, argues that forest gardens are traditional agroecosystems in the humid tropics that have evolved a forest like structure and are commonly thought to be a good example of sustainable agriculture. Fruit trees are important woody perennials to provide higher net income for most profitable systems. Fruit growing could obviously be commercial enterprise. Asian home gardens are dominated by fruit trees such as guava, rambutan, mango, and mangosteen whereas indigenous fruit tree for cooking (*Dacroydes edulis*) and condiment (*Pentaclethra macrophylla*) dominates the West African compound farm (Nair, 1993). The present need is to identify and document such species, their mode of propagation and bring about further improvements.

2.3 Determinants of Agroforestry

Promotion and development of agroforestry will depend on various factors. Analysis of the different factors that determine the success and failure of agroforestry under various conditions will be highly useful to formulate future strategies. Certain determinants are specific to certain socio-economic contexts and ecological potential of an area is the prime factor that determines the distribution and extent of adoption of specific agroforestry systems (Nair, 1993).

Success of the effort to promote agroforestry depends on how many farmers adopt the system and continue adopting. Profitability critically influences farmers' decision making. Income diversification is a strong positive benefit reducing risk in the case of crop and livestock failure. But how to create more and better employment at rural areas is largely an unsolved and important issue in the promotion of agroforestry. The sustainability of the farming system not only depends on diversification of cropping by the farmers themselves but on a whole range of developments in the economic environment, such as increased availability of non-farm employment and improvements in rural infrastructure (Cramb, 1993). Policies supportive to market infrastructures and skill training on traditional and introduced agroforestry system would appear to offer opportunities for development (Hoskins, 1987). High economic rates of return are also being demonstrated for agroforestry projects where trees are being inter-planted with crops or included as an integral component of livestock-farming systems (Spears, 1987). The economic potential of agroforestry is the basis of its adoption in different countries. Land could be an incentive for agroforestry adoption when per household land holding is higher but could act as deterrent when land holding is very small. It is dangerous to generalize the situation, hence home gardens are excellent examples of agroforestry when land holding is very small.

Marketing is one of the important pull factors in the adoption of agroforestry. The market and interest of farmers will exist only if the product satisfy family needs and there are proven markets (Linteau, 1996, Internet). Proximity to markets is also an important determinant for the promotion of agroforestry. But in some regions farmers do encounter with limited market, such as the case of Costa Rica, as well as problem of saturation in certain market have been also arisen in Asia (Current, et al., 1995). Although marketing is a strong pull factor, it has not yet been able to drive the development of agroforestry in many developing countries. One of the reasons could be that still large portions of the forest products have been harvested as open access resources and sold in cheaper prices mostly through middlemen or traders. The local and regional markets for agricultural products have been reported important in inducing farmers to adopt agroforestry in Africa, Asia, Central America and Caribbean; but in a lesser degree in Central America and Caribbean countries because of highly commercialized farming system (Current, et al., 1995).

2.3.1 Farm Size and Land Tenure

Farm size obviously has influence over the pace and scale of adoption with greater adoption rate on larger farms (Current et al., 1995). In case of small to medium scale farmers, they are the main clients for widest range of technology adoption and require agroforestry for fulfilling both the subsistence and commercial requirements. In areas of scarce land availability, agroforestry ensures the land use intensification. Empirical research has shown that even operating small landholdings and being aware of the severe environmental and economic consequences of any mismanagement, most farmers properly utilize and manage their agricultural land (Thapa and Weber, 1995). Therefore the widespread feeling that tree growing is predominantly an activity of larger farmers does not have convincing evidences.

In some countries, farmers with inadequate land or landless often lease land from large farmers. Crop-sharing arrangements vary from country to country or even region to region within the country. In Bangladesh, the general trend is one third of the harvest to land owner where the lessee is supposed to invest both in inputs and labor but in China farmers are obliged to provide the state with a quota of certain crops for land-use rights (FAO, 1996). In case of sharecropping arrangements and lack of land rights, lessee are not interested in adopting agroforestry system by planting useful tree species unless their rights over harvest and use of tree product is ensured. The general belief that poor people are not able to grow trees on their land is very much questionable. Gupta (1994) in a study to look at tree density on cultivated land found that the marginal and small farmers had higher tree density than the bigger farmers in dry villages owing to the greater reliance on livestock for the livelihood. Although the farmers with more land planted more trees in total, farmers with less land tended to plant more trees per hectare (Current, et al., 1995). Obviously the adoption pattern differ between the small and large farms.

The fragmentation of land holdings is also considered a constraint in agroforestry due to negative impact by above and underground tree-crop interactions. Fragmented land holdings may therefore restrict adoption of the agroforestry. But the long gestation period commonly referred for tree based system does not seem to be a problem for most of the agroforestry practices (Current et al., 1995) in some developing countries. Land tenure or the rights over the property is one of the sources of the uncertainty and barrier to the adoption of agroforestry. In many developing countries there are problems in land tenure, gender rights and relationships, right over use of trees, relationship between planting trees and land ownership claims, which are varied and locally very complex. Experience in the implementation of agroforestry projects has clearly demonstrated that the security of land tenure is a major incentive to investment in agroforestry and to the protection of the trees (Spears, 1987). Apart from a technical issue, land tenure has also become a political issue in many developing countries, which is reflected in various 'land to the tiller' peasant movements. Right to harvest tree species by the person who planted them encourage tree planting. Secured tenure system is positive factor for agroforestry adoption whereas any insecure situation acts as deterrent. For example, Indian farmers fear of ownership claim by tenants if they lease the land for more than one season (Kerr and Sanghi, 1992). Similar phenomenon prevails in Nepal.

2.3.2 Research

Poor resource allocation in general and in research in particular is the another constraint in agroforestry development. The proven potential of agroforestry so far has not been fully realized outside the research stations. Because of many other constraints, such as negligible interactions among researchers, land users, poor coordination among institutions and general lack of information, research in agroforestry is seriously lagged behind.

It is also well recognized that farmers need to involve in research activities and research results from the participatory research will ultimately help to ensure the greater adaptability of the improved technologies. Most of the research on agroforestry still lacks the system approach and is discipline oriented or a sub-sector in the forestry or agriculture sector. The neglect of cultural factors is most evident in the research design of ICRAF which has in turn influenced the design of agroforestry research programs in various developing countries (Raintree, 1984). Most of the scientific research on agroforestry is focused on identifying optimal crop tree combinations rather than understanding how those combinations have evolved in the communities and maintained viable agroforestry systems. Therefore, Bently (1993) recommended that the agroforestry research should consider why systems have not been adapted. Similarly the appropriate methodologies to understand the systems for its replicability are also very limited as most statistical techniques and experimental designs have been developed for monoculture (Steppler, 1987). Generation of location specific technology is the need and challenge for the agroforestry development. A new technology can readily succeed when it offers a better all-round return to the rural family than the technologies they are already using (Hoskins, 1984).

Agroforestry association with cultural traditions and values has been reported in several studies. Gupta (1994) reported that in India certain uses of trees in private land might be governed by rules that are collectively designed, managed and regulated through social cultural and economic sanctions. The role of cultural symbols and institutions in communicating scientific and technical information about agroforestry is not studied sufficiently. About the adaptation of the agroforestry interventions, Bentley (1993) argued that when local farmers do little or no experimentation and adaptation, one or more of three general factors are likely to be the cause. First, the site and possibly the system are not productive enough to deserve serious attention from the farmers. Second, the economic or subsistence values are not high enough to justify the investment and waiting required. Farmers of marginal land, however may find comparative advantage in growing trees for cash then buying food. As the return from the tree products are rising and the returns from the food commodities are declining, a shift towards trees may be expected over time. Third, uncertainty may lead farmers to expect low net returns.

Interesting results were obtained from on-farm agroforestry demonstrations in Ecuadorian Amazon where corn, plantains, cassava, pasture, cacao and coffee plants were planted in the forested land with an average of 20 commercial timber trees per hectare. Development and adoption by farmers of slash-and-mulch management of *Desmodium ovalifolium*, a ground cover for reducing weeding costs, improved soil fertility with robust coffee production have been reported. In these regards, the slash-and-mulch helped to improve soil fertility from the slow release of nutrients from decaying organic materials and initial delayed weed competition (Peck and Salinas, 1988: internet). Although there are limitations, technologies have been promoted and have high potential to be introduced as well as improved in many countries. There have been innovations through research in agroforestry and different technologies have been emerged. *Leucaena leucocephala*, *Gliricidia sepium*, *Calliandra calothyrsus*, *Sesbania spp*. are some of the rapidly developed and researched species in many countries because of their high yield potential, multiple use and vigorous coppicing ability (MacDicken, 1990).

Diversity in agroforestry systems is very important for their ecological sustainability. Shading effect is one of the major problems in tree crop interactions. The issue of under ground root competition and its management in agroforestry is extremely complicated. This issue is very poorly understood even among the scientific community. In this respect, information on both the above and under ground interactions provide basis to develop systems which maximize the positive interactions by minimizing the negative ones. Thapa (1994) noted that in Nepal, farmers' knowledge on above ground interactions was more pronounced and comprehensive than below ground and suggested below ground interactions as key areas of further research on agroforestry. But ICRAF (1992) in a *Leucaena leucocephala* hedgerow and maize intercropping trial in Machakos, Kenya reported that despite evidences of importance of below ground interactions, the root barriers had a negligible effect. In contrast, in intercropping with tree research suggested that high rooting densities of nitrogen fixing trees might actually improve the growth of the associated crops (Raintree, 1991).

2.3.3 Management and Social Constraints

There is also a need to resolve silviculture problems. It is important to solve the problem of establishing the tree species, getting the fast growing tree species, and raising the ecological adaptation of the tree species. Selection and management of agroforestry components requires a basic understanding of how a system functions as a whole. Management factors include timing and method of establishing trees and grass, spacing, and the timing and heights of cuttings. Often agroforestry is referred to as labor-intensive system, which compete with other agricultural activities especially staple food crop cultivation. Labor requirements for some system such as hedgerow intercropping are clearly higher per acre than simpler agricultural cropping system (Raintree, 1991). An advantage of agroforestry is that management operations can often be scheduled for slack periods of labor demands. Farm families have traditionally developed labor shortage strategies to use inputs of various family members at various times of the year for different tasks (Hoskins, 1987). When trees and crops are planted together there is competition for the growth resources. The productivity of each component depends on its ability to utilize resources in response to the climate of higher competition. Management could be a powerful means of manipulating densities and arrangements to capitalize on beneficial effect of the tree-crop interactions (Nair, 1993). Growth of components in agroforestry systems could be managed according to the management option attaining either increased growth or decreased growth.

Promotion of the agroforestry should also be viewed from the social perspectives. In South and South East Asia, different intensities of land management largely appears to be related to the population density (Ashton and Ashton, 1993). Experience show that farmers adopt the species, which show fast growth, multipurpose and the performance visibly surpasses that of the locally available trees. The species should also be grown widely, easy to propagate and can tolerate certain levels of damages during the establishment period. The productivity is an important attribute in social acceptability of agroforestry. This means any technology which is not sufficiently productive is also unlikely to be socially acceptable (Nair, 1993). Direct involvement of local people in species selection, location of the project activity will greatly enhance the process of learning from farmers and leading to the success (Hoskins, 1984). The question of agroforestry promotion is not only biophysical and technological constraints, but also equally the social. The awareness to conserve forests by promoting agroforestry in their farmland is strongly linked to the dependence of local people on the forest for various products. In a community forests management study at Northern Thailand Jintana (1997) reported that people feel more negative impacts of public forests laws imposed on community when dependency of local people on forest is higher. Because people living close to the forest felt that public forest laws affected their access to and the use of forest resources than those living far from the forest.

2.4 Significance of Agroforestry in the Hills of Nepal

Nepal, a mountainous country with an area of 147,181 square kilometers, is broadly divided into five physiographic regions; Tarai, Siwaliks, Middle Mountains (Hills), High Mountains and High Himal and three agroecological regions namely Tarai, Middle Hills and Mountains. Hills is variously described as covering some 42% of the land area of Nepal (Sharma and Subedi, 1994), or 49% of the land area (Carson, 1992) depending on where the boundary with Siwaliks and high Himal is drawn. According to Sharma and Subedi (1994), 30% of the Hills comprises as agricultural lands (20% cultivated, 10% uncultivated)), 54% as forest, 11% as grazing and 5% listed as 'others'. Agriculture is the main occupation of majority of the people living largely in the rural areas. Majorities of them live in uplands, under resource poor condition, facing serious problems of poverty due to rapidly growing population and dwindling natural resources. Current agriculture development strategies are aimed at reducing poverty through utilizing productive resources of fragile mountain ecosystems, and securing food security and self-sufficiency. Subsistence agriculture is being intensified to feed the growing population at the expense of greater human efforts (Shroeder, 1985). Trees play very vital role in the process of intensification and to arrest soil erosion and provide higher amount of fuelwood and fodder on a sustained basis.

The intensification of existing production through agroforestry interventions and biologically maintaining the soil fertility has become crucial in recent years. Promotion of market-oriented cash crops and forest products through research is urgently required. The main thrusts have therefore been to evolve simple and easily adaptable technologies. The technological developments have been confined mainly to the irrigated flat lands. The small and marginal farmers, possessing rain-fed and steep land could not make use of the technology. As most agroforestry research in the hills is limited to a narrow range of biophysical issues and problems (Garforth et al., 1997). Although technology has increased crop yield and rose the economic level of large farmers, it could not give benefits to poor farmers. Rather the intensive use of resources and its depletion contributed to the aggravating poverty and exacerbated rural inequality (Roy and Clark, 1994). Development planners, policy makers and professionals, have been advocating and adapting different technological interventions for sustainable resource management. But the satisfactory success has not yet been achieved. This shows the large gaps in information and requires more empirical research. When the available knowledge base cannot guide to success then we need to search and rely more on the farmers who have been able to eke out the living by maintaining the stability of fragile mountain ecosystem by their accumulated experiences.

2.4.1 Deforestation

Deforestation is essentially a human process. In the world wide case, major cause of forestry degradation are slash-and-burn cultivation (45%), overgrazing (30%) and other (25%) including fuelwood harvesting (Kunio, 1993). In the late 1970s, there was a strong international perception of ecological crisis in the Himalayas, which influenced early forestry development program in Nepal. Eckholm (1975) and Myers (1986) linked rapid population growth, farming in the steep slopes and villagers dependence on forest, and subsistence agricultural economy of Nepal to ecological degradation associated with deforestation, flooding and landslides. The World Bank (1978) forwarded a serious prediction that on the basis of then estimated deforestation trends there would be no trees left in the hills of Nepal by 1993, which proved to be wrong. But these predictions provided the very basic push factors for the government as well as all concerned organizations to think it seriously and act accordingly.

Both pessimistic and optimistic views have been found in the literature regarding the deforestation in the Hills of Nepal. The claims for catastrophic deforestation are proved to be inaccurate and the loss of forest area in the middle mountain in recent decades and linkages of population growth, deforestation leading to increased soil erosion and land slide activity is open to challenge (Ives and Messerli, 1989). Which is also consistent to studies carried out by some others (Bajracharya, 1983; Mahat et.al. 1986) but Bajracharya concluded that deforestation has continued up to the present. Mahat (1986) also expressed similar view. Mahat et al. (1986) presents evidence that land use boundaries in the hills have remained largely unchanged, with population pressure leading to additional exploitation and degradation of remaining forest areas, but not a conversion of forest land to agriculture. Zurick (1990) presents somewhat conflicting evidence in a micro-level study of land use changes in Phalabang, a mid-hill village in Rapti zone, over a thirty-two year period (1953-1985). The study shows a small increase in area of *khet* land (11%), a slightly larger expansion of *bari* land onto former open lands (17%) and a large expansion in the area of grassland (63%). Grassland expansion has been the end result of a "roll-back" process by which mature forest (-24%) has been converted to shrubland (-30%) which in turn has been converted to grassland. Conversion in this case has not been explicitly to expand agricultural cultivation, rather it has been the result of more intensive land use, particularly increased grazing and fodder collection pressures.

In certain areas the improvements have also been reported. Referring the improvement in the extent and quality of tree and forest cover in certain locations, Ives and Messerli (1989) argues that it is the result of response of local people to growing awareness and government decentralization policy rather than outside aid or development. With the vast degree of variations and biophysical specificity, the consequences of increased demand of fodder, fuelwood, timber and non-timber forest products are complex and unknown. Most pioneering micro studies are narrowly focused on deforestation without equal importance on socio-economic and spatial factor (Thapa and Weber, 1995). Ives and Messerli (1989) argue that progress is to be made through a continuation of the process of systematic questioning of unquestioned assumptions.

2.4.2 Dependence of Hill Farming Systems on the Forest

Farming communities are heavily dependent on forest for their daily necessities, such as fuelwood, fodder, grasses and leaf litter. Forest area in Nepal is estimated as 5.5 million hectare (37.4% of total land area). The steady swelling of the population coupled with dwindling household economies led to an ever greater dependency on forests for fuelwood and fodder (Thapa and Weber, 1995). Researchers (Bajracharya, 1983; Fox, 1983; Mahat, 1986; Yadav, 1992; Metz, 1994; Neupane, 1995) have given different figures for the dependency on forest in terms of fuelwood and fodder collection from forest and farm sources. Complete supply of required amount from the farm sources alone even in the areas where different institutions have promoted agroforestry and forestry in private land is a distance reality. The case of the very poor farmers and landless settlers is even worse due to the protection of forest through community forestry program. Studies are not done to analyze their situation after the introduction of community forestry thus there is the gap in the knowledge.

Fuelwood and fodder are the most important products extracted from forest. Fuelwood gathering is one of the several factors involved in contributing significantly to the loss of forest. But there are conflicting views of different researchers. Shrestha (1985) reported that 59% of the people interviewed in four villages of Surkhet district in Mid-Western development region identified livestock grazing and fodder collection as responsible for deforestation in their locations. Metz (1994) puts livestock as the main cause of forest degradation owing to greater household needs of fodder and fuelwood. Similarly, Fox (1983) indicated grazing and fodder required by the livestock population in the hills as the major causes of poor condition of forest and its degradation. Whereas Mahat et al., (1986) and Griffin et al. (1988) viewed fodder as secondary cause of deforestation. Wallace (1981) does not consider fodder demand as direct cause of deforestation but an important factor inhibiting the natural regeneration of the forest. Similarly, Pandey (1992) perceives livestock as a wrong assumption to become a causative factor in deforestation process. But Karki (1996), views deforestation due to livestock as serious environmental degradation. Whereas Joshi (1988) argue that increasing human and animal population led to uncontrolled lopping of forest trees for fuelwood and fodder.

Bajracharya (1983), from a village study in Eastern Nepal, believes that reduction in the forest cover is the result of the need of the increasing subsistence population to develop more agricultural terrace or grazing areas to ensure the production of more food than demand for fuelwood. Widespread deforestation is also associated largely with the variety of deliberate government policies (Griffin et al., 1988). However it can't be denied that fuelwood collection is part of forest destruction process. But shortage of livestock fodder especially during the dry seasons and removing the accessibility to forest due to community forestry program becomes a push factor for planting fodder species in the private land.

The role of forest in the process of nutrient transfer is vital in the hill farming system. In the Middle Mountain, 52% of the livestock feed has been estimated to come from the forest, representing a considerable transfer of nutrients from forest to agricultural land. Nutrient transfer is mostly facilitated by cattle, buffalo, goats and sheep (Carson, 1992). In a study of three villages representing low sub-tropical, mid-hill (1,150-2.200m) and higher hill (2,000-2,400m) locations smaller transfers of nutrients at the two higher sites of 128 and 164 kg of TDN per LSU is estimated. However forest contribution to annual TDN consumption was estimated to be of a similar magnitude, 18 and 63% respectively (Yadav, 1992). Collection of the leaf litter from forest for bedding and composting materials is an another facet of hill community's dependency on forest. Amount collected varies considerably between locations, seasons and the accessibility to the forest. Yadav (1992) found from 439 kg to 1,957 kg being collected per hectare of cultivated land at three sites, representing from 7% to 12% of the total material for composting. Other researchers have estimated that approximately 50% of annual litter production are removed from some forests in the mid-hills (Khadka et al., 1984). This represents a considerable dependence on forest for nutrients.

The survival of Hill people depends on their capacity to manage the sustainability of agricultural production, which in turn depends on survival of forests and preservation of natural resources, and their capacity to control the damage to the environment. The environment, agriculture and rural societies are mutually interdependent. The forest area per unit of cultivated land is an important factor to sustain the Hill farming systems. There are conflicting estimates of amount of forested land needed to support one hectare of arable land. Although the requirement varies with altitude and agricultural cycle, 1-4 hectare of forest is required for the sustainable use of 1 hectare of arable land. The desired ratio of agricultural and forest land in the context of mixed farming system of the Hills has been estimated to be 1:2.8; 1:0.24 to 0.48, and 1:0.32, respectively for fodder, fuelwood and timber (APP, 1994). These findings are based on a study carried out in Pokhara and Tansen. This indicates that about 3 ha. of forest area accessible to farmers is needed to sustain a hectare of agricultural land in present mixed hill farming systems. Mahat et.al. (1987), reported from their study at Kavre, and Sindhupalanchowk districts that 1.33 hectares of forest lands are required for 1 hectare of agricultural land. Pointing out that the decreased forest to land ratio is not the recent phenomenon, Ives and Messerli (1989) argued that the growing subsistence population was faced with reduced ratio of forest to arable land during 18^{th} and 19^{th} centuries. Such inferences made from some micro level studies can not be applied to whole country or the particular region. It could be true for specific cases, this ratio is certainly not available and can not be maintained in many part of the country (Table 2.1). Although APP does not provide information on the amount of accessible forest, a micro level study carried out in Shyangja, a mid-hill district not far from the study area, revealed that only 60% of the available forests, shrubs and range lands are accessible (Thapa and Paudel, 1999). These figures obviously show the importance of forest to sustain the Hill farming systems.

Table 2.1 The per capita forest areas in different physiographic zones

Physiographic zones	Per capita forest area
Terai (T)	0.067 ha
Siwaliks (S)	1.040 ha
Middle Mountain (MM)	0.219 ha
High Mountain (HM)	1.270 ha
High Himal (HH)	5.000 h

Source: APP, 1994

Forest in the Middle Mountain area is in a state of very low productivity due to over utilization or exploitation. The Forestry Sector Master Plan (1993) stresses the need of promoting community forestry to sustain farming system. Introduction of community forestry restricts the access to the forest, making agroforestry an essential element of the system. As support to the farming system, the farm land need to have more tree cover to fulfill daily needs of fuelwood, fodder as well as generate income. This helps to reduce dependence on forests and maintain the ecological balance.

2.4.3 **Fuelwood Use**

Nepal's indigenous energy sources include biomass and electricity only. The biomass energy, which is the concern of agroforesters, constitute about 92% of total energy consumption of which fuelwood share about 69%, agricultural residue 15%, and dung 8% (WEC, 1994). The residential sector accounts for about 96% of the total fuelwood consumption (see Table 1.2). The sources of fuelwood are natural forest, non-cultivated inclusions and on-farm supply. An average person in Nepal uses 640 kg /yr. of fuelwood whereas estimated yield per capita from forest is only 479 kg/yr). Fuelwood consumption in dry weight basis of 940 kg per person per year at mid elevation of eastern hills (Bajracharya, 1983), 646 kg at mid elevation (1200-1400) of central hills (Neupane, 1995), 570 kg at lower elevation of western hills (Fox, 1983), and 527 kg at upper elevation (1800 meter msl) of western hills (Metz, 1994) have been reported.

Table 2.2 Contribution of Fuelwood in Sectoral Energy Consumption (in '000 tone)

Sector	Amount of fuelwood consumption	Percentage
Domestic	4316.18	95.8
Industrial	164.83	3.7
Commercial	22.66	0.5
Total	4530.67	100

Source: WECS, 1994

Donovan (1981) has noted that the great variability exits in the data as fuelwood consumption; from 0.1 to 2.57 (or even 6.67) m^3 $person^{-1}$ $annum^{-1}$. High possibility of error exists on such estimations due to conversion factor on weight of a head load (*bhari*). A *bhari* of fuelwood does widely vary with place, season, and calculations based on dry weight basis (Air dry weight, oven-dry weight, dry weight). *Daura*, a Nepali word commonly used to refer fuelwood, in all places can not represent the total combustible materials used by the households making room for more variation. Some people thus do not report all the fuelwood materials they use in their homes.

Different words such as *Daura* (fuelwood), *Jhikra, Sittha* (small piece of burning materials) and left over branches from fodder, weeds and crop residues are used by villagers to refer to the fuelwood which also makes the estimation more complicated. Therefore the differences in fuelwood estimates is generally unavoidable unless more standard and accurate methods are developed. Mahat et al., (1986, 1987), Bajracharya (1983), and Fox (1983) have examined such implication and wide seasonal and altitudinal variations. With lot of uncertainties, Donovan concluded that 1.4 m^3 $person^{-1}$ $annum^{-1}$ was a likely average consumption of fuelwood (assuming 5.5 persons $family^{-1}$ and a weight of 600 kg fuelwood m^{-3}). In many fuelwood shortage areas, people are more relying on agricultural residue and animal waste, which in turn have led to declining soil fertility. Increasing use of forest has pushed the forest to further distance taking longer hours for fuelwood and fodder collection. This has put tremendous pressure and burden on women. Although many researchers have challenged the assumption that Middle Mountain faces fuelwood crisis, farmers in the Hills do face fuelwood problem but in varying degree depending on location specific situation. The women are particularly affected by the fuelwood crisis, as they are mainly responsible for fuelwood collection. The crises have pushed farmers to plant more trees on their land and have made farmers aware of managing their forest.

Fuelwood is gathered not only from the forest but also from non-cultivated inclusions and on-farm areas. The estimate on fuelwood use shows that forest, shrubs and grassland constitutes about 67% of the total supply, whereas farmland and non-cultivated inclusions supply about 25% and 5% respectively (WECS, 1995). Agricultural residues are also important source of fuel in Nepal but its use is location specific. Supply of such residues depends on crop production. There is also growing concern that the use of animal manure (dung) as fuel purpose has caused serious problem in the supply of plant nutrients in the field. The increased use of dung for fuel is the another assumption of reduction in crop yield due to decrease in the plant nutrient replenishment. Unlike *Tarai* communities, people in the Hills do not use dung for fuel thus the case of reducing animal manure to fertilize the fields does not occur.

2.4.4 Community forestry and agroforestry

Nationalization of forest in 1957 led to upsurge of forest encroachment, as no one took the responsibility of their management. People who were the sole responsible for those forests before this act acted negatively and led to destroy the efficient traditional systems of forest management. Bhatt and Shrestha (1996) pointed out that the nationalized policy brought negative impact resulting the immediate and indiscriminate felling of trees in private lands. Realizing the past mistakes, in 1977, a new forestry regulation sought to transfer some of the rights over some of the nationalized forests to communities. Community Forestry in Nepal formally commenced in 1978, with the enactment of progressive legislation (Panchayat Forest Rules, 1978 and Panchayat Protected Forest Rules, 1978) enabling government forest to be handed over to then village Panchayat (presently the VDC) for protection and management.

Although the objective was to return the ownership of forest resources to the people, the Panchayat being a political body did not represent the real users of the forest. After the restoration of democracy, the regulation was revised in 1990 to involve the real forest users of the community the Forest Users Groups (FUG) who are legally entitled to harvest the forest products. In 1993, Forest Act. (And forestry regulation- 1995), the latest legal arrangements to transfer community forest by handing over the management of government owned forest to FUGs for collective benefits, came into action. Since the inception of community forestry program many donors have provided financial and technical assistance to help in the handing over the community forest. To date, the community forestry program is considered successful and people are highly motivated to have the right over their own forests although the handing over process is slower than expected.

There are important interactions between community forestry initiative and agroforestry. Initially FUGs operational plan lead to reduction in off take in early years putting pressure on remaining national forest and also put pressure on women and children who collect fodder and fuelwood (Garforth et al., 1999). When access to the forest is denied then there is great need to work towards meeting these necessities from private land. Despite the general belief that commercial plantations is not suitable for hills, there appears great potential to explore the prospects of exploiting location specific land suitability in the hills to go for commercial fuelwood plantation. A feasibility study conducted on the ridge of the Yamdi watershed area in Western Nepal to explore possibility of private commercial fuelwood plantation, it was found that farmers had a positive attitude towards gradual adoption, provided their cereal crop production was not impaired significantly (Thapa and Weber, 1993). Community forestry projects have contributed significantly in the protection and management of forest compared to any previous efforts to control forest use. Considering the benefits from community forest, Wallace (1987) argues that local elite, village leaders, and landlords control these programs. Therefore predicts that if future benefits in terms of fuelwood, fodder from community forest are obtained by these elite then villagers would be deprived of their traditional rights to the common property forest resulting in overall economic deterioration. Participation of women in major decision making is very rare not only because they have limited time and less mobility outside the home affairs, but also the provision of household heads to be represented in Forest User Group. This provision deprives women to participate in FUG meeting, making low involvement in decision making (Subba, 1998). Therefore, in addition to the adequate supply of household requirement, the gender balanced participation in decision making and benefit sharing through agroforestry becomes a viable alternative to sustain the community forestry programs.

2.4.5 **Gender Issues**

Gender has been the most widely discussed subject in the present development interventions. Is gender issue a real need for agroforestry promotion in Nepal and does this have some thing to do with the adoption and extension process? These are some of the questions that people rise time to time. Both men and women are heavily involved in farming activities. In some cases and activities, their role is clearly identified but in many cases, both are involved with various shares of their daily time allocation. Women's work consists mainly of time-consuming, repetitive and labor intensive tasks that centers around the fulfillment of households needs ranging from collection of fuelwood and fodder, fetching water, reproduction to livestock rearing as well as work on farm. The depletion of natural resources demands additional time and efforts to meet the growing household requirements and thus making the women's daily life more difficult and excruciating. Both men and women farmers are responsible for maintaining and altering the components of agroforestry systems but their role in different activities have not been adequately addressed.

In the context of deepening environmental degradation and poverty, life of women in the Hills is becoming worse (Ives and Messerli, 1989) as women are the main food producers who stay in the villages while men move to town centers in search of off-farm jobs. Women bear the brunt of environmental degradation in the village. They need to walk further and higher up the hills to collect fuelwood, fodder and water which is also associated with higher school dropouts in case of girl child. They work relatively longer hours and normally do not participate in decision making. But this can not be generalized for all areas, all ethnic groups and all the situations. Even though, the gender role is crucial, for agroforestry professionals gender is relatively new and simply fail to consider (Fortmann, 1983). It is essential to understand household labor patterns as availability of labor critically determines the level of output (Sharma and Banskota, 1992). Therefore the gender analysis will play a vital role in revealing important problems, areas of concerns, constraints and interventions points under the specific conditions.

Traditionally, fuelwood and fodder collection, and water fetching have been the main responsibilities of women in addition to the farm work. Therefore the relation of women with nature (soil, forest, and water resources) is considered stronger than that of men in many instances. Livestock productivity is directly linked with the capability of women in the household to manage them properly compared to men. Livestock, which provide milk, draft-power, meat and manure to fertilize the agricultural fields, is an inseparable component of farming systems. Every components of the system are inter-linked with each other. Carson (1992) explains that Nepali farming communities and individuals farms possess highly integrated and inter-linked production system. Agroforestry may increase livestock holding and increase burden on them. In a case study of livestock and milk production program in the Middle hills of Nepal, with a specific focus on women and the impact on gender roles and relationships, Bhatt et al., (1994) argued that market oriented livestock production in the Hill community poses particular constraints on rural women of livestock maintaining households. Animal production directly depends on the availability of fodder. Dwindling fodder and fuelwood availability and degradation of the environment have significant effect on women's life in the village, with increased daily tasks. Although it can be stated evidently that this is particularly genuine for women in the hills, further studies are required to validate the proposition.

Access to and control over fodder determines the degree to which households can effectively enter into livestock production. With the more profit coming into the family from selling the milk through buffalo raising, the male members of the family started to undertake the more responsibility for buffalo care (Bhatt et al., 1994). This was not the case previously, and the male involvement centered mostly on monetary transactions and crisis situations, such as illness of the animal. Men also slowly started helping women in fodder collection from forest since inadequate fodder adversely affected quantity of milk produced and fat content. The study reported that women attributed men's newfound motivation less to concern about the excessive workload on women than the fear of investment not yielding returns. Buffalo raising delivered a greater economic security for families through increased milk and livestock sale and employment, while it has circumscribed the lives of women in ways previously inexperienced. The women have more work, less mobility and virtually no financial access or control over returns from livestock production and milk sale (Bhatt, et al. 1994). They also reported that women have not had their share of social and economic benefits derived from buffalo enterprise. More girls than boys were dropping out of school to assume livestock responsibilities and assist mothers in other household work. The overall effect of agroforestry must be taken into account, as increase demand for female household labor leads directly to the withdrawal of girls from school (Garforth et al., 1999).

It is not clear what is actually meant by the benefit sharing between men and women, particularly between the husband and wife. Whether the unequal distribution of benefits influences the productivity/efficiency of economic activities is not understood. After all, as the study was undertaken in Hills, the increased household income will be used for the livelihoods of the family under existing Hill condition, unless their husbands do not behave rationally. The argument presented is that even though they behave rationally, they use the money according to their priorities. Therefore the use of money by the men in their own sake and nothing going for the women within the family needs to be checked properly. These propositions need to be verified, as the gender relation in subsistence economy may be different than what is said. The situation can not be generalized and more studies are required for verification and fact finding.

Although many organizations have put emphasis on gender equity and even advocate for women empowerment, in practice men dominate the agroforestry process, policy and plans whereas women are often considered more knowledgeable and regularly use the forest resources (ecofeminism). Women in subsistence economies are also active managers of forest resources and traditionally play a leading role in the conservation. In case of community forestry, there appears to be a risk factor associated with the capturing of benefits by the village 'elite' and male members within the village communities. Therefore the matter of equity should be addressed properly and care should be taken to understand and integrate the gender issue in such programs for benefit sharing. Inequitable participation of women in the implementation process may jeopardize the equity and gender issue in case of benefit sharing. It is generally seen that males or "well-off" people of the concerned communities dominate the groups or FUGs.

We must be careful of generalization and danger of extrapolating conclusions drawn from one place to another. There could be exceptions and variations with respect to ecological and cultural diversity, across different sub cultural groups and in different situations. As Ives and Messerli (1989) wrote that Sherpa women in the mountains seem to experience a relatively egalitarian existence with their men folk. Though gender relations are considered important aspects in promotion and development of agroforesstry, no critical assessment has been done on gender effect of agroforestry/community forestry. For women, increased farm fodder production means more girl child attending the school, more milk available for consumption, better nutrition in family and alleviation of household pressure on women. But studies are very limited to cite examples or emperical evidences, which shows the research gap and requires scientific studies in gender analysis.

In the situation of environmental degradation and shrinking natural resources in the Hills, women's condition is getting worse and it is of great importance to know how women spend their time, take part in decision making and how the agroforestry interventions has changed the situation if any. It will be also interesting to know how the increased income is spent and its impact. Although in the general context of deepening poverty, situation of women looks worsened; the improvement in some areas with outside interventions can not be ruled out or is even expected. Therefore gender analysis should be included as a multiple approach to solution identification.

2.4.6 **Livestock and Agroforestry**

Over population of livestock combined with decreasing feed availability is the main reason for decline in livestock productivity. Thus increase in fodder supply is the foremost priority to maximize animal productivity. There is general consensus among researchers that number of animals in the Hills should not increase in order to minimize forest damage by increased fodder demand. According to an estimate (Rajbhandary and Shah, 1981), Hills and mountains can maintain only 2.78 million livestock units out of the total 5.2 million heads, which will reached to 5.8 million heads by 2000. A large part of the overgrazing and deforestation problems can be attributed to the rapid growth of livestock population (Banskota and Jodha, 1992). Existing livestock population in the absence of proper provision of on-farm feed resources will put enormous pressure on available natural resources leading to severe productivity decline. The fodder scarcity has alarming effect on ecosystem and survival of both human and animal population. Therefore, agroforestry program linked with community resource conservation becomes pertinent and research can contribute significantly.

The major source of nutrients for crops comes from animals through farmyard manure. This is part of the complementary relationship that exists between the crop and livestock components of the farming systems in the Hills where crops supply feeds and bedding materials to livestock and in turn receive draft power and manure. As agroforestry is an integral component of the farming system, any intervention to farming systems must consider livestock, which is particularly important for the promotion of Hill agroforestry. Farming system is a complicated, interwoven mesh of soils, plants, animals, implements, labor, other inputs and environmental influences (CGIAR, 1978). It is widely recognized that system approach covering different components of the farming system is required for Agroforestry research. Although planting tree is a traditional practice, fodder from private and public land has declined considerably owing to population growth, overgrazing, uncontrolled lopping and poor management. Decrease in livestock production in the hills is the major constraints to livestock production as they provide almost all the draught power needs, manure to field crops and source of family income. Up to 50% decline in milk yield has been reported by farmers due to fodder shortage (Uprety, 1986). Whether appropriate answer could be obtained to the problems encountered by the farmers and will research on Agroforestry help farmers to alleviate those problems. Presently, little information is available on these aspects.

The major sources of animal feeds are crop by-products, forest resources and grazing lands. Greater availability of feed from farmland (fodder, grasses, agric. by-products) can reduce pressure on cultivated/communal grazing land for grazing by animals. Rising income, shortage of animal feed from open access areas, technological change and market incentive may increase the demand for high producing milch/meat animals. Since these animals will be stall-fed they may not exert undue pressure on the environment. In case of environment two important variables to be considered in animals in agroforestry systems are the number of animals and the extent of their dependence on areas other than cultivated areas. Further, the number of animals is influenced by area under cultivation, the intensity of cultivation, farm size, amount of fodder and availability of open access grazing areas. The Land Resource Mapping Project's (1986) estimate of proportion of fodder nutrients obtained from farm and forest, clearly shows a greater dependence on off-farm sources at higher altitude (Table1.3).

Table 2.3 Total Digestible Nutrient supply by ecological regions

Ecological regions	Livestock Units ha^{-1}	Total TDN* t ha^{-1}	TDN* from farm t ha^{-1}	TDN from forest t ha^{-1}	Dry matter from forest t ha^{-1}
High Mountain	6.1	6.7	1.7	5.0	20.0
Middle Mountain	4.5	5.9	2.4	2.6	12.9
Tarai	3.4	3.8	3.2	0.6	1.5

Source: LRMP, 1986
*TDN- Total Digestible Nutrients

Higher livestock density per household is an important factor for agroforestry development in the Hills. Why farmers maintain large herd size? Even their animals are unproductive and feed resources are dwindling, farmers keep considerably larger herd size. This is a question that few people have looked into seriously although many have recommended to reduce the number of animals in the Hills. Related research in livestock management with households increasing and reducing their number of livestock in response to market, fodder availability and alternative uses of household labor have also been reported (Garforth et al., 1999). Therefore, blanket recommendation on the reduction in livestock herd size without carefully studying the significance of animal in the subsistence farming system and a viable alternative, is not going to do any better. The question here should be to address the problems and suggest appropriate strategies to have sustainable resource management and utilization and gradual transformation through appropriate research. Researches carried out so far have not looked into this matter in depth.

Farmers give priority to human food crops rather than animal feed. However, their animals are suffering from short supply of fodder. There is a great scope to increase animal production through supply of proper fodder. The total fodder production in Dry Matter has been estimated by Pandey (1982) as 4.12 million tones from private land, 4.49 million tones from forest lands and 2.1 million tones from grass land and pasture out of annual fodder requirement of 16 million tones. However, the deficit in fodder supply may not be as that of Pande's estimates as many agencies and individuals have been promoting fodder program in the country. Pande (1990) viewed that the fodder is of very short supply in Nepal, where animal production can be improved substantially by increasing feed supply. Denholm (1991) indicated that however, most farmers have their own fodder trees, some farmers also possess private forest land, the feed for livestock is rarely sufficient to meet year round requirement of the increasing numbers of livestock. Malla and Fisher (1989) quoted from Robinson (1986) show that the planting of trees on private land is due to the recognition of the importance of multipurpose trees in small farming agroforestry systems. Which was also due to the potential for the planting of trees on the private land in bridging the gaps between demand for and production of forest products.

Pande (1997) confirmed that the shortage of fodder is the major constraint for livestock production in Nepal. Supply of quality feed on year round basis and particularly, during the lean period from October to March, is severe. Feed balance situation in Nepal shows that severe deficit has been observed in concentrated feed and green fodder, which are 67 and 54 % respectively. Pande (1997) further noted that the feeding of straw with abundant use of concentrated rations has not only increased the cost of milk production but also has affected animal health. The severe deficit of green fodder also adversely affected available natural feed sources mainly forest and pasturelands. There are gaps in information regarding the shortage of fodder, whether the shortage is in terms of quantity fed, types of fodder available, deficit to dietary requirements or shortage to meet certain production objectives is not clear. Research is required to fulfill these gaps and identify the farmers' feeding strategies to cope with the fodder shortage under different situations and the environments.

2.4.7 **Indigenous Knowledge Base**

Warren and Cashman (1988) defines indigenous knowledge as the sum of experiences and other forms of knowledge of a given ethnic group that forms the basis for their decision making. This knowledge has accrued over many centuries, which is not static but is continuously adapted to meet the changing needs and circumstances of the people. Carter (1992) concluded that many villages possess detailed, specialist knowledge about trees and their cultivation and often cultivate trees on their own land in response to local decline in trees/forest product availability. Ives and Messerli (1989) quoting Whiteman, (1985) present subsistence farmer as a highly knowledgeable and intelligent land manager with a wealth of accumulated, traditional wisdom of great potential value to the 'educated' elite, if only they would listen. There is need to stress the importance and unique value of indigenous knowledge but should be careful to romanticize its potential. The type, extent and distribution of such knowledge varies with societies, the capacity to innovate, apply and transfer existing knowledge are also diverse.

In some parts of the middle hills local people do care on having enough trees on their private land to balance their forest product needs between private and common property resources. This knowledge is also seen with respect to the demand and supply of their fodder situation i.e. farmers do keep certain trees maintained in their farm land which provide fodder in the winter and dry months of the year when collecting fodder from the forest is not possible. Huge tree canopy of different fodder trees is maintained to meet the household fodder requirement during dry months. Regarding the methodology, Sinclair and Walker (1998) have developed intuitive method for representing qualitative knowledge held by farmers and researchers about complex agroecosystems on the basis of research work carried out in Nepal, Tanzania, Sri Lanka and Thailand. For example, *Tapkan, Obhano-Chiso*, and *Posilo- Kamposilo* have been referred to as the some important farmers knowledge related to the fodder trees in Nepal. Some of such terms and their significance may not be generally applied consistently by farmers across ethnic groups, locations and gender. But such terms reflect the farmers understanding of village ecology, practical and contextual knowledge of how farmers differentiate fodder quality, yields, preferences and behaviors. Research is required to test its consistency, use and how it is transformed.

Both view of putting all the blame on people for degradation as being ignorant, profit oriented, short term gainers or over citing or emphasizing the indigenous knowledge, skills and long experiences as everything is not doing good to cure the problems in the hills. It is indeed true that working with the human beings is not easy and land degradation with human cause is a very complex phenomenon. Referring to indigenous knowledge Walker and Sinclair, (1998) argued that farmers' knowledge may be involved through their participation in activities and decision-making but remains implicit and hence can not be evaluated or used by research and development workers outside the immediate activity of interacting with the farmer.

A large number of traditional agroforestry systems are prevalent in the country and only a few have been studied and hence there is inadequate scientific understanding of such systems existed in the country. The little research is done to explore the merits of these time-tested systems. Knowledge can be of great resource for planning and implementing the technological interventions. This indicates the possibility of finding out useful knowledge that farmers have accumulated since ancient time to bring improvements in agroforestry. In case of adoption, whether farmers adopt agroforestry systems or not depends heavily on how they perceive the costs and benefits of growing trees on their farms. For example Alley Cropping have not been successful because farmers do not know its costs and benefits but do plant trees on terrace risers since generations and posses considerable knowledge on its costs and benefits. Harnessing, analysis, and interpretation of the qualitative knowledge held by farmers for complex agroecosystem development and management poses interesting challenges for researchers and decision-makers (Sinclair and Walker, 1998).

2.4.8 **Non-Governmental Organizations (NGO) in agroforestry**

Many efforts have been made by NGOs to meet fodder deficit and to improve the quality while some have also been engaged in fodder research. Nepal Agroforestry Foundation (NAF), Social Action for Grassroots Organization (SAGUN), Institute of Sustainable Agriculture Nepal (INSAN), SEARCH Nepal, Center for Environmental and Agricultural Policy Research Extension and Development, Nepal (CEAPRED), Integrated Agricultural and Cooperative System (COSIS), are some of the NGOs involved in promoting agroforestry. Some of the species promoted are NB 21, Dinanath, Stylo, Napier, Molasses, *Desmodium* and Broom grasses and fodder trees like Tanki, Kutmiro. Ipil, , Kimbu, *Gliricidia, Sesbania* (personal experience). The field survey conducted by BTRT project under CARE Nepal in 1996 investigated that most *Ficus species* (*F. lacor, F. glaberrima, F. roxburgii)* including *Dendrocalamus and Castanopsis indica* casted more shade to farm crops as compared to other tall and less branchy trees like *Leucaena spp* and *Melia azedarach (*Rimal, 1997). After 5 years of Agroforesry intervention by NAF in Ramechhap district, it was found that nearly three quarters of households' fodder (70%) requirement was obtained from farm land which included tree fodder, cut grass and crop residues in contrast to 30 % in near by control village (Pandit, 1994).

The results of the New ERA (1996) study on " Community forest management with relation to population" conducted in Lele VDC of Lalitpur District pointed out that some tree species like Lapsi, Painyu *(Prunus)*, Utis, Bakaino, Chilaune have been promoted by very few people. It was reported that 84% of the population obtained fodder and grass from community forest, 12 % from private lands and 2 % from government forest. Most of the respondent (90%) said that there has been no encroachment into forest areas since the implementation of community forestry program. Very few people (less than 9%) sell forest products but not the fodder. The stall feeding practice is being practiced by 84 % of the respondents. NAF conducted a lopping trial in farmers' fields for four fodder tree species namely (1) *Morus alba* (Mulberry), (2*) Gauzuma ulmifolia*, (3) *Flemingia congesta* (Bhatamase) and (4) *Sesbania sesban* in Hinguwapati of Kabhre district and Majhigaon of Sindhu Palchok district during whole year cropping cycle (1990-1991). It is concluded that coppicing give better results than lopping. The lopping trial conducted on *Gauzuma ulmifolia* determined that the fodder yield increased with the increase in tree height. The optimum height seems to lie near 160 cm. The results on *Sesbania sesban* showed higher fodder yield per tree in 2 and 2.5 months harvesting but poorer regeneration with more frequent removal of newer leaves and shoots (Adhikary and Pandit, 1992).

A collaborative research done by NAF with FORESC during June 1995 to Nov 1996 on identification of appropriate fodder technologies for marginal farmers investigated that simple technologies are adopted more easily by farmers than sophisticated ones and also have more success (Elliott, 1996). Gilmour and Nurse (1991) of Nepal Australia Community Forestry Project described that edible tree leaves are used for animal fodder, and large quantities of dead herbs are collected from the forest floor and used for animal bedding, which ultimately a good source of manure when mixed with cow dung. This has become a good substitute to chemical fertilizer. ICIMOD (1994) has initiated SALT demonstration sites in Godawari of Kathmandu, Paireni village of Chitwan and Tistung village of Makanwanpur districts. Fodder tree species such as *Leuaena spp, Flemingia congesta, Desmodium teliaefolium, Ethythrina variegata, Calliandra spp* and grasses such as *Cynodon dactylon, Crysmopogon spp, Seteria anceps, Pennisetum purpureum,* and *Thysanoloena maxima* have been included in the hedge rows. Most of these species including *Morus alba* were being tested for hedge row suitability and bio-mass production.

2.4.9 **Sustainability**

The sustainability can also be defined as the ability of the system to sustain livelihoods. In the context of Hills, sustainability is mainly related to sustaining farming systems, which broadly includes managing watersheds properly and prevent the depletion of natural resources mainly soil, plant, water and the forest. Sustainability is viewed as the right balance in meeting the needs of present and the future generation. There has been increased awareness of the importance of forestry related activities as a viable alternative for employment, income and food for the people. Due to the improper and ineffective government mechanisms and extension program farmers are poorly informed about market and prices for their forest products. Studies are not conducted on comparing different agroforestry extension approaches and of their influence on farmer adoption (Vergara and MacDicken, 1990). Process of interventions, dissemination of information, constraints and incentives for adoption of agroforestry needs elaboration.

Although agroforestry activities have attracted the support and are potential for further investment from public agencies, NGOs and donors, they have been poorly documented (Current, et al., 1995). Conditions under which farmers will be willing to adopt interventions and type of external assistance required becomes important to find out strategies of agroforestry promotion. In depth analysis is required in searching for appropriate technological process for sustainability, which means differently to different people, context, system and environment. Agroforestry as a means for creating biodiversity is considered to be the most potential option for sustainability. Extreme biophysical and socio-economic variability in the Hills requires well identified, local tested technologies evolved through research to solve the specific local problems.

2.4.10 **Summary**

Agroforestry is described as a traditional practice in the subsistence farming systems of the hills, and developed through farmers' informal experimentation and coping strategies to emerging situations (such as, population pressure, increased livestock, resource degradation, and declining productivity). Research in agroforestry has been focused on fodder trees and confined to propagation techniques, growth rates, lopping trials, biomass yields and nutritive value. The other perennial and non-perennial vegetation including herbs, crops and livestock integration, role of gender has not been considered. Despite evidence of farmer's willingness to plant trees on khet land, the general focus has been only on bari land terrace risers and edges. Traditionally protection of trees is common in bari but much less to nonexistence in khet.. Agroforestry is mostly referred to as improvement in fodder and fuelwood but utilization of agroforestry species for agro-based enterprises, diversification and shift to commercial production in the context of changing farmers' preferences, new economic opportunities and marketing facilities have not been given due consideration.

There seems to be general consensus among the researchers on interactions between cropland, livestock, trees on private farmlands, intimate role of forests and trees in hill farming system with greater dependency and decreased availability of forest products but with different estimations on amount collected. The role of forests in the process of nutrient transfer via livestock in the hills is greatly recognized. They agree that farmers rely heavily on livestock and forest resources and grazing land to sustain farming system. Researchers have diverse view on the growth of livestock population causing overgrazing and deforestation. Some also reported farmers' decision to reduce livestock number and agree that number of animals in the hills should not increase. There is no consensus on causes, process and extent of deforestation, extent to which soil erosion is exacerbated by human agency, conversion of forested land to cropland, benefit sharing between husband and wife within household and resource degradation in the hills. Conflicting estimates of amount of forestland required to sustain per hectare of arable land are given and no studies are done to estimate the amount of accessible forests. Higher extraction has pushed the forest to further distance taking longer hours for collection, which resulted in high pressure on women.

Women's role in livestock and natural resource management, fodder and fuelwood collection and heavy workload due to resource degradation is recognized and documented. Though gender relations are considered important aspects in agroforestry development, family labor distribution, impact of project interventions, factors influencing adoption, participation in decision-making and benefit sharing within a household are poorly understood. A large number of traditional agroforestry systems are prevalent but only a few have been studies hence there is inadequate scientific understanding on such systems. Though many researchers mentioned economic benefits of agroforestry, limited studies have been done on economic aspects of agroforestry. Large numbers of studies have been confined to soil erosion but limited information is available on specific agroforestry systems. The clear economic analysis to demonstrate the actual benefits under farmers' conditions is not available. Understanding about different factors related to the adoption of agroforestry, under the diverse socio-economical, institutional and biophysical conditions of the hills, is limited. What makes farmers particularly women and which circumstances encourage farm households to involve in agroforestry are not known. Research studies on the impact of agroforestry on soil fertility management and farm income are severely limited.

Chapter III

Research Design and Study Area

3.1 Methodological Approach

For the scientific community agroforestry is still new and efforts are underway to find appropriate methodologies to gain insights of the most promising land management systems. Agroforestry research in Nepal has not received adequate attention and thus methodologies for carrying out research in the complex ecosystems of the Hills have not been developed adequately. Still large gaps on suitable methodologies to understand the Hill agroforestry systems exist. Location specific nature of the technology has limited the use of useful technology generated through research elsewhere and requires further research on validity, re-testing and bringing improvement based on the particular socio-economic, and biophysical conditions. The International Council for Research in Agroforestry (ICRAF), presently an CGIAR member, approach of the Diagnosis and Design methodology of agroforestry research incorporates many elements of the farming systems research approach (Raintree, 1990). Understanding farmers choices and behaviors requires using the research methodology of farming system and household economics (Bentley, 1993). Improvements can be made by building on an existing body of facts and theories and not in isolation, as agroforestry cuts across different land use disciplines.

Since the main objective of any agroforestry research is to develop technologies and generate knowledge to help farmers, their participation is recognized beneficial. The farmers' participation in this research was ensured through participatory research methods, like Focus Group Discussion (FGD) and Participatory/Rapid Rural Appraisal (P/RRA). Emphasizing the important role of stakeholders in the research, Avila (1990) considers farmers as partners who can complement the expertise of researchers and make a valuable contribution to research. Participation has become the popular term in the social science research for researchers to work together with the farmers in fact findings. The method of RRA/PRA is widely used in participatory research (Chambers, 1992). Time is the biggest constraints in such methods, as R/PRA sessions should be carried out by skilled and experiences researchers after a good rapport with the villagers.

In this respect the selected areas were visited prior to the field survey and focus group discussions for rapport building. In fact, researcher had previously visited the areas in number of occasions and was known to many of the potential respondents because of his involvement in the Nepal Agroforestry Foundation (NAF) initiated agroforestry project. In areas where project was not implemented, researcher had to give some efforts in convincing farmers that the information collection was undertaken solely for the purpose of academic research and not for the program extension. As and when they came to know about the researcher's involvement in agroforestry project, the community people were interested to know more about the future activities of NAF and its program expansion. During the field survey period, many of the community people especially women came up with requests to expand the agroforestry program in their village.

A number of institutions are involved from local level to national level for agroforestry development in Nepal. The outcome of the intervention is the result of a complex interaction of those institutions and the target population involved in agroforestry development. To understand complexity of adopting the practice steaming from interventions, multiple research methods, such as household survey, case study, R/PRA were adopted. Informal discussions were carried out to understand the view of local people on their interpretations on adoption. Project sites of Nepal Agroforestry Foundation (NAF) was used for this purpose. NAF is a non-profit making non-governmental organization (NGO) committed for the promotion of agroforestry and community forestry in hills through supporting local NGOs and FUGs. Registered with the Government in 1990 and affiliated with Social Welfare Council (SWC), under the Association Act-2034, its programs are focused on some Hill districts, namely Sindhupalchowk, Kavrepalanchowk, Ramechhap and Dhading. NAF mission is "to provide agroforestry support to grassroots NGOs committed to strengthen the capacity of poor and marginalized communities and groups to meet their basic needs". Some of the institutions involved in the agroforestry and community forestry program, such as Nepal UK community forestry project, Nepal Australia Resource Management Project, Watershed Management Project, and Department of forests were visited for necessary information.

The problem situation was analyzed through systems perspective (agroforestry as the system of crop, livestock, trees and community). Information from the institution selected for the studies were obtained to supplement information on the agroforestry project intervention at the local level. Project level case studies from NAF command areas were obtained to understand the economics of agroforestry interventions in the existing farming systems. For inductive and qualitative research, case studies have become popular in recent years. In case of seeking answers to "why" and "how" types of questions, Yin (1984) argued that case study approach is the most appropriate method. A case study from selected agroforestry project was used to analyze the detail technical interventions and adoption. The economic performances at the farm level were carried out to analyze the agroforestry's economic contribution under prevailing socio-economic conditions.

Agroforestry is an age-old practice of farmers' in Nepal. There is a huge pool of information available with immense variability with respect to altitude, ethnicity, and socio-economic conditions. Farmers have practiced different systems since long to fulfill their necessities. The immense diversity as reflected in mountain areas is the product of farmers' innovations evolved through their informal experimentation. It is recognized that the farmers' role in the management of subsistence based farming system must be appreciated rather than overlooked. For this, individual household surveys were conducted to gather information from farmers involved in agroforestry through standard questionnaire survey. Household survey, which has become a very popular method of collecting information, was enhanced by combining other methods of information collection, such as focus group interviews, informal conservation, observations, rapid rural appraisal and cross checking through check lists. Laboratory analysis of soil samples for various soil fertility parameters were performed to supplement the information collected through household survey on various issues of fertility management and maintenance in the study area.

Focus Group Discussion (FGD) has become important method for collection of information on community needs, issues, priorities and particular group perceptions on the impact of some external interactions. Small groups of 7-10 participants with members from a community or beneficiaries having certain common characteristics (e.g. Agroforestry Group and User Groups) were selected to conduct FGD. One of the advantages is that FGD can stimulate dialogue among the participants enabling researcher to gain insight of the problem under discussion. Researcher's past experience in conducting FGD was highly helpful in information collection through this method.

3.2 **Research Design**

In order to produce the empirical evidence to fulfill the set objectives, data collection is necessary in a particular location. The process of discovery required primary as well as secondary data which had to be collected using appropriate methods and techniques, including household survey and rapid appraisal methods and application of analytical tools. The study included both "exploratory" and "evaluation" analyses. Analysis were done primarily considering "with" and "without" project interventions and occasionally by "Areas Easy to Access (AEA)" and "Areas Difficult to Access (ADA)" locations and gender aspects. Accessibility is defined in terms of access to the motorable road within 30 minutes of walking distance from the community. In case of the study area, the motorable road passes along the riverside in the lower elevation and the walking distance to and forth the road from the areas difficult to access is taken as about 2 hours. Whereas with and without project refers to the areas with and without the project intervention by NAF within the defined study area comprising the parts of 3 VDC areas.

Household survey, participatory appraisals and discussions with the farmers, case studies on economies of integrating agroforestry in the existing farming systems and laboratory chemical analysis of soil samples drawn from both project and non-project situation were employed as methods of information collection. Household survey, designed to assess farmers' existing farming systems, agroforestry intervention, adoption of agroforestry and role of gender in agroforestry, was one of the major sources of information. Each individual household, defined as a unit of family members living together and jointly sharing the costs and benefits, in the study area was considered as a sampling unit. Specifically, household in the Hills is considered as a unit in which numbers of family members lives together and share a same kitchen. Information about the household composition and size, land holdings, agroforestry practices costs and benefits, livestock, agriculture, knowledge and attitude on agroforestry related activities were collected using the standardized questionnaire.

Additional primary data were gathered from farmers, key informants, community leaders, NAF project staffs and professionals through household survey, formal & informal meetings, discussions and direct measurements, and observations. To get general information on agroforestry interventions, indigenous knowledge, local potentials and problems with regards to the management of available resources, members of Forest Users Groups, local NGOs members and village elders were consulted. Efforts were made to avoid some data collecting errors, such as coverage error (not allowing every household to have an equal chance of being sampled), sampling error (only some members are asked to provide information) and measurement error (obtaining inaccurate answers to survey question due to unclear instructions, and tendency to provide socially acceptable answers). Having up-to-date household population list, random sampling, indirect questioning and trust building with the respondents were some of the measures taken to minimize these errors. However, higher representation of women respondents from with project has been associated with the higher involvement of women farmers in the NAF project activities.

Before the field data collection, a considerable time period was given to the literature review for building up the strong theoretical background of the study at the institute's library and in Kathmandu. Reviewing policy papers and research reports were of vital importance. The literature review was useful to understand the issues of agroforestry systems, economies and role of gender in depth and as mentioned by Cooper (1984) to identify the position of other scholars in the field. This helped the researcher in defining and correctly focusing on the issues that need further explanations and answers to questions, which are not addressed previously. Experience of researcher's, farmers, planners, and extension workers were integrated to fill the identified knowledge gàps.

3.2.1 **Pre-Survey Field Visit**

A visit to the study area was made during the month of December1997- prior to the advancement to the researchers' Ph.D. candidacy exam. Discussions were held with the community members, staff and volunteers of the NGO and key informants of the community, such as ward chairman, teacher, women agroforestry group members, NAF demonstrator farmers and members of the users' groups. The study locations were selected roughly for the survey. Pre-survey field visit was found to be useful for rapport building and research area identification.

3.2.2 **Field Reconnaissance Survey**

Prior to the data collection, using households survey questionnaire, focus group discussion, rapid rural appraisal and through direct observations in the field, a reconnaissance visit of the study area was made to facilitate the information collection. The questionnaire prepared were pre-tested in the field together with the training to field enumerators during this period. Some changes were made in the questionnaire after the pre-testing and final sets of questionnaire were prepared in Kathmandu. Discussions were held with the community members, key individuals (ward chairman, NGO members, members of FUG or other informal groups) of the community, schoolteachers to inform them about the purpose of the information collection and type of the data sought in the field survey.

The enumerators were introduced to the community people in general and some key individuals in particular to facilitate the ease of moving from one household to other and acquiring vital information related to their farming and property, the land holding is particular. This was particularly important due to deteriorating security situation in the country in recent years where the government security personnel are closely watching the movement and activity of any new persons in the community. An underground Nepal Communist Party (Maoist), which has started the peoples' war in some hill districts of Nepal, is also active in the district. Despite fears walking in the night and rumors of people being killed both by the police and the guerillas, there were no problems in data collection as the community people were fully aware of our activity and purpose of our data collection team. It was indeed a great pleasure to be with the people and know how they have managed their livelihoods under extreme conditions.

The field reconnaissance visit was very important and most useful to facilitate the subsequent field data collection for this study. During the reconnaissance visit, the lodging and food arrangement for data collection team were done. General information about the study area was obtained during this period. Although, researcher was previously known to the some members of these communities, particularly agroforestry group members, village leaders and schoolteachers, reconnaissance visit provided another opportunity to meet larger section of the village households, good rapport building with the locals and better knowledge on the general situation of the area.

3.2.3 Methods of Information Collection

The sources of information and the corresponding survey tools employed to gather them are presented in Table 3.1. Multiple tools and methods were used to check and verify the information collected from different sources as per the need and field level conditions.

Table 3.1 Survey Sources and Tools for Data and Information Collection

Survey tools	Sources						
	Households		Others				
	Project	Non-project	NAF	FUG	NARC	FORSC	Other
Survey questionnaire	*	*					
Structured conversation			*	*	*	*	
P/Rapid rural appraisal	*	*		*			
Focus group/Group discussion			*				
Professional consultation			*		*	*	
Observation	*	*					
Publications/Statistics			*		*	*	*

AEA = Areas Easy to Access; ADA = Areas Difficult to Access

To collect primary data from the households, a coordination schema was prepared (Appendix A), based on which sets of standardized questionnaire was developed (Annexes B). The questionnaire was later translated into Nepali language from English. Household survey questionnaire alone was not enough in collecting information about plans, policies, programs, rules and regulations of the government, FUGs and local NGOs regarding various aspects of agroforestry and community forestry activities. Therefore, in order to close this information gap structured conversation approach was also employed.

Many of the qualitative information collected in this research were based on RRA, formal (FGD) and informal group discussion. These methods were used in all the areas and every aspect of data collection and the need. This was the main basis of collecting necessary qualitative information. For the reconnaissance of linkages between the spatial parameters and location specific activity researcher's observation was important to provide opportunity to understand the situation and supplement the information collected through other sources. Topics such as the condition of the forest, local development activities, availability of grazing lands, location and biophysical conditions of the area and presence of the local institutions were covered. In short, these techniques were employed in the other aspects not covered by the various methods.

3.2.4 Determination of the Sample Size

Characteristics of the population (size, type, and location) affects sample size. Smaller samples are adequate for homogenous population, whereas heterogeneity requires larger samples. The confidence level and the margin of error of findings are important factors in determining level and sample size. The Village Development Committee area in the study site covers large area where settlements lie from lower elevation (500 meter) to high elevation (1100 meter). The selections of wards were done according to the accessibility and inaccessibility factors. The selections of the wards were also based on the motives to cover the areas of project intervention by NAF. As every wards of a VDC area is not covered by the agroforestry project. Standard statistical procedures were used to determine the sample size. Standard sampling procedure for selection of the households was followed.

The sample size was determined on the basis of the total households in the study area (Table 3.2). The study area consists of Majhitar, Gajurichhap and Chekbang villages of Kumpur VDC area, Baireni, Nayabasti, Chhapgaon areas of Nalang VDC area and Gauthale, Adamara, Arubas, Arubastar as well as all the other households of ward no. 9 of Salang VDC area. Households for the study were selected at two stages. First, wards were selected from each of the above three VDCs through purposive sampling. Accordingly, wards 3 and 8 of Kumpur, wards 6, 7 and 9 of Nalang and ward 9 of Salang VDC were selected. The ward selection was based on the motives to cover both households from the NAF project and non-project areas and to compare the situations "with" and "without" the project. Second, at least 40% of households were randomly selected from each ward for questionnaire surveys. Accordingly, a total of 223 households, including 82 project households and 141 non-project ones, were selected. The sample accounted for about 44% of all households in the selected wards and 5% of households in all three VDCs. Considering the probability that some of the respondents might not be available for interview for various reasons, reserves of 10% were taken. Out of these total respondents, approximately 50% were taken from those in accessible areas and remaining from inaccessible locations. This was further divided into the project and non-project areas after the samples were drawn randomly.

Table 3.2 Number of sampling household by VDC area and Wards

VDC area	Total VDC area population	Total HHs in the VDC	Selected ward (s)	Total HHs in selected site	Sampled households	Percentage HH sampled
Kumpur**	7,916	1,466	3 & 8	186	81	43.5
Nalang**	7,054	1,306	6, 7&9	158	67	42.4
Salang*	4,751	8,79	9	165	75	45.4
Total	19,721	4,238	-	509	223	43.8

Source: Field Survey, 1998

* Only some parts of the VDC area are accessible by road within 30 minutes of walk

** The VDC area touches to the road-linking district head quarters at Dhading Besi.

HH = Households

Since only small portion of the total households are involved in project activities, their representation in sampling was expected to be less than number of sampled households from non-project areas. Similarly, it was expected that very few households with agroforestry project category would be sampled within the areas difficult to access. Because project intervention by NAF is concentrated in the easily accessible areas. In case of gender balance for administrating the questionnaire, it was expected that the participation of the women would be fairly high because of women focused agroforestry program of NAF. For costs and benefits analysis, 15 households from with agroforestry project situation (at least 10% of the households) were sampled out of the total household involved in NAF promoted agroforestry activity and similar number of households were sampled from the same area for the control group. When determining the households' population for sampling in accessible locations (closer to the road head points) small adjustments were made by the researcher to include locations covered by NAF project.

The sample size representing with and without project situation as well as accessibility is presented (Table3.3). Due to random sampling within the selected wards of the VDC areas, higher proportions of households belonged to the with project category have been sampled from AEA. Because the wards were selected in such a way that they represent areas easy to access (AEA) and areas difficult to access (ADA) as well as with and without project situation. This was the reason behind very small proportion of households (7.2%) being obtained in with agroforestry project category within ADA. But in the case of AEA, higher number (66%) of sampled samples belonged to AEA. This is reflected from the fact that number of farmers involved in agroforestry program is much higher in AEA. As a whole, majority (63%) of the samples drawn from the intended population belonged to the without agroforestry project category.

Table 3.3 Sample size from "with" and "without" agroforestry project and accessibility

Accessibility*	With Project		Without Project		Row total	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
AEA	74 (33.2)	90.2	038 (17.0)	27.0	112	50.2
ADA	08 (03.6)	09.8	103 (46.2)	73.0	111	49.8
Column total	82 (36.8)	100.0	141(63.2)	100.0	223	100

Source: Field Survey, 1998

Figures in the parenthesis indicate the percentage of the total sample size.

* AEA: Areas Easy to Access; ADA: Areas Difficult to Access

3.2.5 Sampling Method

The Sampling was done in two levels. Firstly, the selections of the settlements were done through judgmental or purposive sampling approach. Since the purpose of the study was to explore, analyze, find interrelationships and compare the various aspects of agroforestry systems between the "with" and "without" project situation and "areas easy to access " and "areas difficult to access" locations, the wards or settlements and the VDCs were purposely chosen to accommodate these factors. Secondly, the samples were drawn randomly from the selected settlements using simple random sampling procedure.

As the second level of sampling number of households were sampled from the total number of households in the selected wards/settlements randomly. The households from both the "areas easy to access" and "areas difficult to access" were sampled and households belonged to "with project" and "without project" situations were thus included in the sampling procedure. In order to identify the total sample households population, the names of the households were taken from the respective settlements by the help of teachers, ward Chairman, members of the FUG, and local people who are familiar with the community. After the identification of the households, their numbering was done and using the "Simple Random Sampling" the sample households were determined. Therefore, selection of the communities/ settlements within each VDC area was done purposively while the households were sampled on the basis of simple random sampling (Table 3.4).

Table 3.4 Sampling Methods

Study Unit	Purposive Selection	Simple Random Sampling	Sampling Household
VDC area	*		
Settlements (Wards)	*		
Accessible		*	50%
With Project and Without Project		*	
Inaccessible		*	50%
With Project and Without Project		*	

To assess the fertility status of soil and possible contribution from agroforestry interventions, soils samples were taken from the cultivated private lands. The soil samples were taken from different types of lands, mainly gharbari, bari and khet land. The sampling included both the with agroforestry and without agroforestry project situation. All together, 18 soil samples were taken for analysis representing 8 from without project and 10 from with project situation. Soil samples were drawn from terraces where farmers have implemented NAF introduced agroforestry program by planting number of tree fodder and grass species in addition to what they had maintained already in their farmlands as traditional agroforestry practice. Whereas without agroforestry project refers to the existing Hill farming system where tradition agroforestry exists with scattered tree and grass species on the private land.

3.2.6 Data Processing and Analysis

The bulk of the data analysis was done using the SPSS computer software package. The excel program was used wherever necessary. The data were of two types, a set of secondary data drawn from available statistics at the local and national level, and a set of primary data collected in the field. The primary data were analyzed by categorizing the respondents into different groups.

Most of the analyses were based on with and without project as well as accessibility factors. A pragmatic approach was followed in using specific tools - descriptive statistics, cross-tabulation, ranking, scaling and diagnostic and inferential statistics using particular tests for description, diagnosis and analysis. Descriptive statistics particularly maximum and minimum distribution, mean, standard deviation, frequencies, indices were computed as per the requirements. Appropriate statistical tests (t-test, F-test, X^2-test) were used to test the relationships between the variables. Linear relationships between variables were determined by using correlation coefficients whereas cross tabulations were used to determine associations. Analysis of variance (ANOVA) was used to determine differences in mean scores as necessary.

For economic contribution of agroforestry intervention, farm level costs and benefits analyses were employed. Cost-benefit analysis was used to determine the profitability of the system under study using the inputs and outputs levels under farmers' existing conditions. Analysis on economic viability of cultivating different vegetables, integrating sericulture due to increased mulberry plantation and promotion of bee keeping project with agroforestry were undertaken to demonstrate the possibility of increasing household income. Quality data obtained from open-ended questions, case study, observation, informal discussion and focus group interviews were categorized, classified or tabulated for in-depth interpretation.

In order to make the comparison among different groups and between genders and types of agroforestry systems indexing was done. Construction of indexes was an important technique for the analysis of field data. By the nature of this study, some data sets were qualitative in nature. This necessitates transformation of attributes through aggregation and quantification by weighing, scoring and computing index values. In order to make the comparison easier and clearer, index value can also be calculated in some cases for quantitative data. Among the techniques of multivariate analysis, multiple regression analysis was used when and as needed.

3.3 Profile of the Study area

Under the Nepalese condition the selection of study area is normally based on the settlement or political division, i.e., Village Development Committee (VDC) area. A VDC area has a total of 9 wards. A ward consists of one or more villages depending upon the number of households and geographical location of the villages. Due to rugged topography and presence of too small settlements a ward may consists of large areas with number of settlements of few households. The village size in the Hills varies from 10-15 households to couple of hundreds. Although variation may exists between the settlements and the wards due to elevation, and slope, complementary concern with formal local level political and development units is necessary for studies of local resource management and rural development planning as VDCs are the lowest local level government bodies for planning. Under the current decentralized planning procedure, wards are the lowest level formal planning units. Ward level plans are incorporated into the VDC area planning, which ultimately goes to the District Development Plan where final decisions are taken.

In view of the recently promulgated decentralization Act, where the District Development Committes (DDC) & VDCs are being given more development roles and planning responsibilities, it has become more important and necessary to consider a ward as the basic planning unit within a VDC area. But elevation, slope aspects and other variations, which may cause larger variation within a short distance in the Hills, were taken care during the sampling procedure. Areas of reasonable households from some wards of three VDC areas of Dhading district, which are, close enough for homogeneity representing "with" and "without" agroforestry project and areas "easy to access" and "difficult to access" were selected. The selection was also based upon the proportionate of the household as only the few households are engaged in NAF promoted agroforestry program.

3.3.1 Dhading District

Dhading district, one of the least developed districts, is located in the central Hills of Nepal (See Map 3.1). It boarders Kathmandu and Nuwakot districts in the east, Rasuwa district and Tibet autonomous region of China in the north, Makwanpur and Chitwan districts in the south and Gorkha district in the west. Prithvi Highway, which links Kathmandu with the rest of the country, passes through the district in the south along the foothills of Mahabharat range and Trishuli river. Some areas close to the road particularly towards Kathmandu, have become famous for vegetable production and thereby increased household income. This has become very important in the economic well being of the people living along the highway. Dhading Besi, the district headquarters, is located 90 kilometer west of Kathmandu. Although located centrally and close to Kathmandu, many parts of the district are still inaccessible by road. The total population of the district is approximately 314,040 people living in 50 different VDC areas with almost equal proportions of male (49.6 %) and female (50.4) population. The annual population growth rate is 1.36 with average household size of 5.4 persons. Almost all (98 %) of the total population depends on agriculture.

The district is administratively divided into 3 parliamentary constituencies and 13 Illakas (regions) consisting of 4 VDC areas in each Illaka with the exception of 2 Illakas (#10 & 11) having only 3 VDC areas. The northern part of the district is the most remote, isolated in terms of accessibility and thinly populated. The central and southern parts are densely populated especially along the roads. The entire district is extremely mountainous and presents a rugged topography. The district has sub-tropical, temperate and humid zones with 3 distinct physiographic regions (See Table 3.5). The altitude ranges from 488 meter to 7500 m above mean sea level with most of the areas in the 700 to 2000 meter region (DDP, 1990). The mean annual rainfall is 1819 mm. Climate varies from sub-tropical in areas below 1000 meter to the alpine (3000-4000 meters) and arctic climatic above 4000 meters.

Table 3.5 Physiographic regions of Dhading district

Regions	Elevation range	Area (% of the district)
Middle Mountains	< 2000 m	72
High Mountains	2000-4000 m	20
High Himalayan	>4000 m	08

Source: LRMP, 1986

The total area of the district is 192,500 hectares. Nearly three fourth (72%) belongs to the middle mountain region extending from the southern Mahabharat range towards north till an elevation of about 2000 meter and is inhabited by majority of the district population. The land use type by physiographic regions shows that about 46% of the land have been used for agricultural purpose (See Table 3.6).

Table 3.6 Land use type by physiographic regions (in '000 ha.)

Land use	Total	MM	HM	HH
Agriculture	89.3 (46)	73.6 (38.2)	10.8 (5.6)	4.9 (2.5)
Forestry	92.8 (48)	63.7 (33.1)	26.2 (13.6)	2.9 (1.5)
Others	10.3 (06)	1.45 (0.8)	1.1 (0.6)	7.8 (4.1)
Total	192.5 (100)	138.8 (72)	38.0 (20)	15.7 (08)

Source: LRMP, 1986
Figures in parenthesis indicate percentages.
MM = Middle Mountains; HM= High Mountains; HH = High Himal

Agriculture is the main occupation for more than 90% of the population. Most of the people practice subsistence agriculture possessing small sized and fragmented land holdings. The per capita and per household cultivated land is 0.12 hectare and 0.63 hectare respectively (CBS, 1996). Although there are few landless households (2%), majority of the households (68%) owns less than a hectare of land. Almost half of the populations (45%) do not produce enough food for twelve months. For little less than one fifth (17%) of the district population, food produced by them is sufficient only for only 6 months of the year. Just over one third (38%) of the district population have attained food self-sufficiency. The per caput and per household food production figures for Dhading district are given as 0.34 and 1.8 metric tons respectively (DADO, 1997). This is reflected from the fact that cultivation is mostly based on upland (*bari*) rainfed condition as per caput irrigated land (0.04 hectare) and per household irrigated land (0.25 hectare) is very limited.

Map 3.1 Map of the Nepal showing Dhading District

Maize, millet, barley, mustard, and potato are crops grown in the uplands (*bari*), where as paddy, maize, wheat, potato and vegetables are the crops of the lowlands (*khet*). Regarding horticulture, assorted variety of tropical fruits like mango, jackfruit, litchi, guava, pineapple, banana and citrus are grown on small scale whereas temperate fruits like apples, peach are grown in high mountains. Farmers have to depend on the small plots of sloping agricultural lands, which are losing fertility and valuable topsoil (Banskota, 1994). The moisture regimes are often the decisive factor for the intensity of agricultural land use. Monsoon rains during summer months allow cultivation of rainfed crops especially upland rice. Children labor forms a major labor force with 33% of the 10-14 age group being involved in the farm production. In case of gender, female children (45%) labors are more than double the corresponding male (22%) child labor used (CBS, 1991). This reflects that female children's contributions in household activities are more than male children's contribution. Child labor are generally used in sowing, weeding, harvesting of crops as well as caring farm animals, collecting fodder, fuelwood, and helping parents (particularly mothers) in different other activities, such as carrying water, and food to the field and taking care of the younger siblings. The engagement of economically active population (10 years and above) in various profession and trades is presented in Table 3.7.

Table 3.7 Economically Active Population in Various Occupations (10 years and above)

Occupation	Percentage
Farm Workers	91.65
Productive Labor Workers	2.15
Service Workers	1.89
Sales Workers	1.39
Professional/ Technicians	0.97
Clerical Workers	0.32
Administrative Workers	0.06
Others	1.58
Total	100.00

Source: CBS, 1991

The figures presented in Table 3.7 shows that overwhelming majority of the total economically active population is in agriculture (92%) sector, which clearly indicate that the economy is based on agriculture. The statistics presented for the different sources of the household's income shows that agriculture alone contributes three fourth of the total income (Table 3.8). This shows that agriculture sector is still predominant in the country's economy and accommodating the ever increasing workforce in the rural areas. The average annual income per capita is estimated to be Rs. 1,071.00. The figure shows that the development of agriculture is crucial for the economic well being of people in the rural areas.

Table 3.8 Contribution to household economy by sources of income

Sources of income	Percentage contribution
Agriculture	75
Service/ Business	15
Construction and others	10

Source: DADO, 1997

Livestock is an inseparable component of the Hill farming system. The productivity of the system has been maintained and sustained by the recycling of crop residues, and organic biomass via the use of farm animals. They are also the major source of draft power. Farmers in Dhading keep considerably higher number of livestock amounting to 297405 livestock units altogether and 5.1 livestock standard unit (LSU) per household (Table 3.9). In terms of livestock unit goats outnumbers all the other species (2.06 LSU per household).

Table 3.9 Amount of livestock in livestock unit.

Type of animal	Total livestock units	LSU per household
Oxen	46,890	0.81
Cows	59,250	1.02
He-buffalo	8,260	0.14
She-buffalo	56,050	0.96
Goats	119,900	2.06
Sheeps	7,055	0.12
Total	297405	5.11

Source: DDP, 1990

Carrying capacity of the land is an important indicator to indicate the pressure on land resource. Hills are facing the problem of decreasing carrying capacity and increasing stocking density due mainly to the degradation of natural resources caused by population pressure and excessive use of natural resources. For example in Middle Hills of Nepal, the carrying capacity of open grassland and forest are 0.54 and 0.31 units of large livestock per hectare respectively, whereas the stocking rates are 7.0 and 2.8 respectively (Thapa and Weber, 1990).

3.3.2 The Research Sites (Kumpur, Salang and Nalang VDC areas)

The study area lies on either sides of the 19 kilometer graveled link road from Prithvi Highway at Malekhu to Dhading Besi, the district headquarters. Which will be black topped in the current (1999/2000) fiscal year with the financial assistance from the Government of Germany. The research sites fall within the middle mountain region of the district (see Map 2). Some parts of all these VDC areas are accessible by road but certain parts extend far away (2-3

Map 3.2 Map of the Study Villages within the Districk

hrs walking distance) from the road head. The administrative boundaries of these VDCs extend from the lower elevations (450-500 m) at Trishuli and Thopal river basins to higher elevations (up to 1200 m) of the Middle Mountains. Salang consists of more steeply Hills and less gradual sloppy lands than Kumpur and Nalang. Whereas Nalang and Kumpur have relatively more flat terraces and tar (flat) lands than Salang, thus they have higher population (Table 3.10). Suspension bridges across the *Trishuli* river connects Kumpur and Salang VDC areas with the Prithvi highway in the south. Whereas *Thopal Khola* runs to the south from the north in between the Kumpur in the east and the Salang and Nalang VDC areas in the west. Thopal Khola ultimately drains out into the Trishuli river at the end boarder of Kumpur and Salang VDC areas. Population is relatively dense below 1000-m. elevation and sparse towards higher elevation. Mixed ethnic communities, but predominantly the Brahmin, Chhetries, and Magars, are found in these areas.

Table 3.10 Average elevation range of the study area and population by VDC area

Name of VDC area	Elevation (in meter) above mean sea level		Population
	Lowest	Highest	
Kumpur	500	1100	7,916
Nalang	550	1000	7,054
Salang	450-500	1030	4,751

Source: Field Survey, 1998 and District Soil Conservation Office, 1998

The major portion of the land in the middle mountain region consists of terrace cultivation (83%), out of which more than 60% is leveled terraces (see Table 3.11). About 34% of the total land area in the middle mountain region of the district have slope gradient more than 30 degree (Table 3.12). This has contributed to accelerated soil erosion. The cultivation is practiced in the valleys (valley floors, alluvial fans, tars, and lower foothills), hill ridges, hill tops and the Hill slopes.

Table 3.11 Agriculture land use in Middle Mountain region (in '000 ha & %)

Land Type	Area (hectare)	Percentage
Sloping Terraces	25.1	34
Leveled Terraces	35.8	49
Tars	06.8	09
Valley Floors	00.7	01
Grazing Land	05.2	07
Total	73.6	100

Source: LRMP, 1986

Along the smaller rivers and rivulets, areas of alluvial plains and depositional fans having the highest land capability are found. These lands are nearly flat or gently sloping and intensively cultivated with very often irrigated. Monocropping is possible with double rice crops in a year. Along the bigger rivers (Trishuli, Ankhu Khola and Budhi Gandaki), some important 'Tars' (flat lands at the banks of the river) are found. These lands have a potential high land capability and are normally flat or gently sloping. 'Tars' are located high above the riverbeds and thus difficult to irrigate. They are cultivated under rainfed conditions. In recent years, some tars have received irrigation through the irrigation canals constructed by the government under local participation and managed by the local user groups. In the study sites, Majhitar of Kumpur VDC area has received irrigation water in limited amount from a stream. But most of the agriculture areas are situated on moderately to steeply sloping mountain terrain with 5-30 degree slope where rainfed cultivation is practiced. Considerable proportion (33.6%) of this region falls under steeply to very steeply (>30 degree) sloping terrain (see Table 3.12).

Table 3.12 Land forms with slope in middle mountains regions

Land Form	Land Capability Class	% of dist. area	% of the region
1. Alluvial plains &Fans	Lands flat (slope <1 degree)	0.9	1.2
2. Tars	Gently sloping (slope 1-5 degree)	3.6	5.0
3. Moderately to steeply sloping terrain	Moderately to strongly sloping (Slopes 5-30 degree)	35.8	49.7
4. Steeply to very steeply sloping terrain	Lands too steep to be terraced and cultivated (slopes>30 degree)	31.8	44.1
Total		72	100.0

Source: DDP, 1990

Forest plays an important role as suppliers of fuelwood, fodder, timber, food, and forest litter for animal bedding and compost. The ratio of forest to agriculture land ranges from 0.6 to 1.5 in the middle mountain area (DDP, 1990). The forest land use consists of all types of forests in different stages of maturity and crown density as well as shrublands (Table 3.13). It is estimated that most of the forest cover has crown density of 10-40% only.

Table 3.13 Forest land use in Middle Mountain region (in '000 ha and %)

Type of forest	Area ('000 ha)	Percentage
Conifers	02.6	04
Mixed	12.7	20
Hardwood	29.5	46
Shrublands	18.9	30
Total	63.7	100

Source: LRMP, 1986

Almost one third of the forest (30%) land use in Middle Mountain regions consists of shrublands, which are heavily degraded due to overgrazing. Due to higher number of animal in the region only 0.03 hectare of grazing lands are available per livestock units.

The three VDC areas selected for the study consists of both upland slopping terraces (bari) and lowland flat terraces (khet lands). The cultivation is based on the rainfed conditions as majority of the cultivated land belongs to the uplands. The *khet* land receiving permanent source of irrigation is very limited (Table 3.14). The lowlands of Nalang VDC area mostly consists of partially irrigated lands, where they receive irrigation water during monsoon months or until few months after the monsoon ceases. Such monsoon fed mountain streams get dried up during drier months of the year. Therefore availability of sufficient soil moisture for the crops is one of the major limiting factors in enhancing agricultural productivity.

Table: 3.14 Average land in the VDC area by major land type.

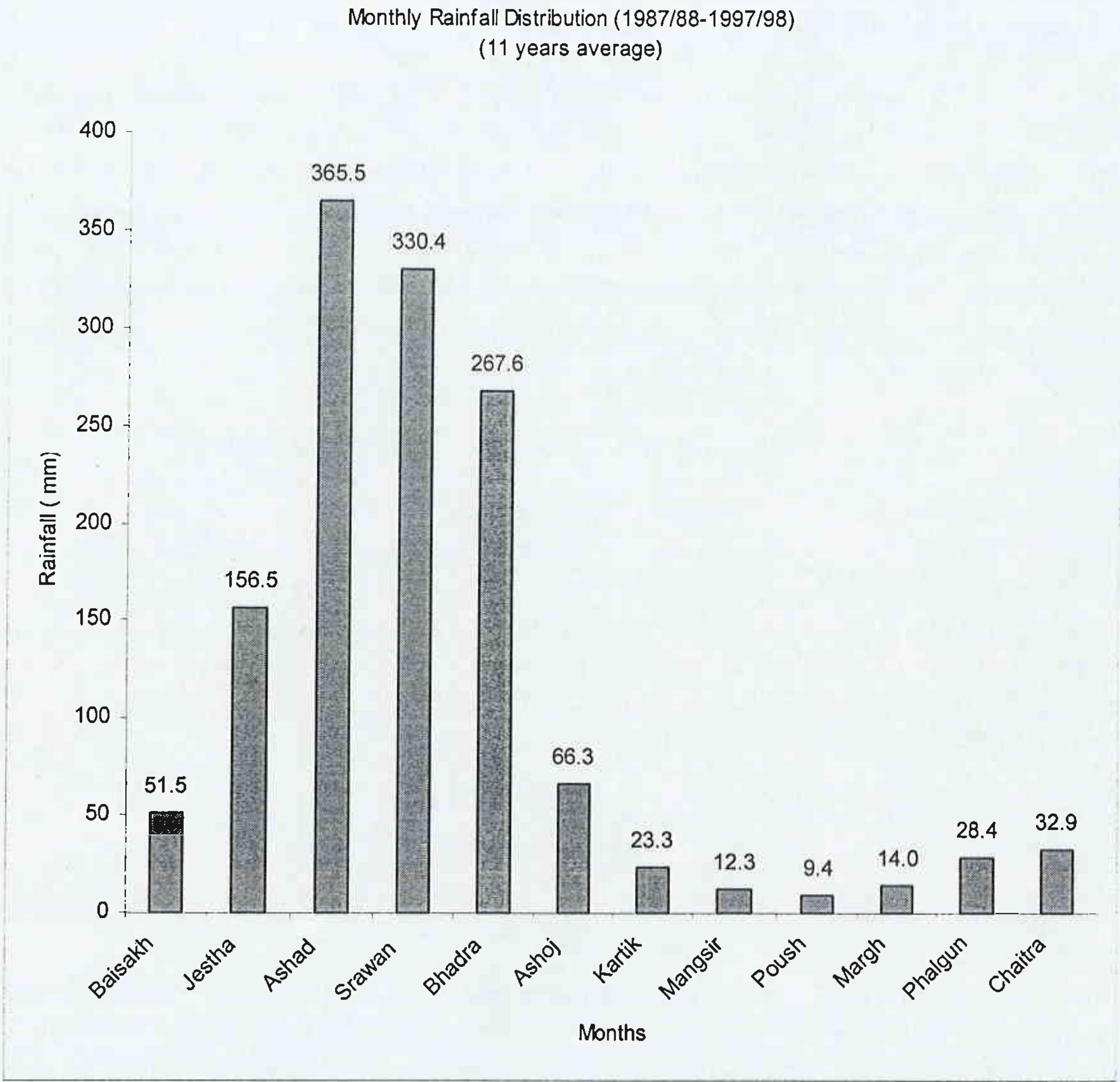
VDC area	Type of land (in Hectares)				
	Khet land			Bariland	Total land (khet & bari)
	Irrigated	Partially irrigated	Total		
Salang	137.0 (16.16)	-	137.0	711.0	848.0
Kumpur	150.0 (12.0)	-	150.0	1295.0	1445.0
Nalang	005.0 (0.4)	222 (17.3)	227.0	1007.0	1234.0

Source: DADO, 1997

Figures in parenthesis are percentages

3.3.3 Rainfall in the area

The eleven years (2044-2054 BS) monthly average rainfall data were obtained from the nearest meteorological station (Dhunibesi, Dhading) to analyze the average monthly rainfall for the study area. The analysis showed that the area receives more than 80 percent of the annual rain within the short period of 4 monsoon months of Jestha, Ashad, Shrawan and Bhadra (May/June to August/September). The pre-monsoon rains during the month of Baisakh (April/May) and post-monsoon rains in the month of Ashoj (September/October) provide some precipitation for agricultural crops during these months while rest of the months remains dry (Figure 3.1). Lack of adequate soil moisture all most for half of the year limits the growth of intensive agriculture in the study area. This also has the effect on the promotion of agroforestry. Farmers face difficulties to raise seedlings during the dry months and need to have the provision of water for the nurseries either by irrigation water or transporting from the drinking water sources through manual labor.



Source: Field Data from Meteorological Station, Dhunibesi, Dhading, 1998

Figure: 3.1 Average Monthly Rainfall of Study Area

3.3.4 The rationale for the selection of this area

These areas represent the typical mid-hill condition of the district in particular and the country in general. The site consists of river basins, ridges, hill slopes, and hilltops with concentration of the population. The combination of both *bari* and *khet* land cultivation is found and the condition of community forest plus the grazing land is degraded. Some communities have already initiated the community forestry program. Similarly some parts of these areas are linked by the Prithvi Highway and link road to the district headquarters. Further more, Nepal Agroforestry Foundation is working in these VDC areas of Dhading District since 1993/94 by promoting on-farm agroforestry and community forestry activities. Being a volunteer member of this organization and having associated since its establishment in 1991, researcher already has linkages with the local people, good rapport with the community people and familiar with these areas.

Therefore, there are possibilities to experiment the outcome and recommendations of promoting agroforestry research and development in these areas. Some of the sites are also easily accessible by a motorable road. The policy recommendations made can be easily implemented and it will be possible to assess their impact in future. If the approaches and the activities recommended be implemented with success then it can really be a model of agroforestry intervention for the economic development in areas where the conditions and constraints specified by the study exist.

Chapter IV

Socio-Economic Status

Farmers live under heterogeneous socio-economic conditions in terms of household size, land holding size, labor force, land tenure, livestock composition and herd size, and ethnicity. All these factors have some kind of relationships with management of farm level resources and maintaining the livelihoods of the community. Types of crop grown, fragmentation of land parcels and their distribution are important factors in agroforestry based farming systems. This section highlights the brief discussion on these socio-economic factors.

4.1 Farm household gender structure

The analysis on respondents' sex indicates that men respondents interviewed represented just over 60 percent of the sampled households while women represented the rest (Table 4.1). Comparatively, representation of women was much higher in project group (52%) than non-project (31%). Interestingly, women representations in project group outnumbered men respondents whereas their participation is slightly less than one third in non-project condition. This reveals to the fact that women's involvement in intervened agroforestry project implementation is high in project group.

Table 4.1 Respondents by gender and type of land use

Sex	With AF Project		Without agroforestry		Both	
	f	f'	f	f'	f	f'
Men	39	47.6	97	68.8	136	61.0
Women	43	52.4	44	31.2	87	39.0
Total	82	100.0	141	100.0	223	100.0

Source: Field Survey, 1998

f = Frequencies: f'= Proportions

Respondents by sex, type of land use and accessibility is explored to understand their participation. Accessibility in this study is considered the access facility to nearest road head point within one hour of walking distance as areas easy to access (AEA) and beyond it as areas difficult to access (ADA). Although in an overall situation the involvement of men in interviews is much higher than that of women, their representation from AEA is almost in equal proportions. But participation of gender in household survey by accessibility shows that women's representation in ADA is less than one-third (Table 4.2). Within AEA the gender representation with agroforestry land use category is exactly equal between men and women. Even within non-agroforestry project group, the participation of women is considerably higher (42%). This shows that the agroforestry project activities are concentrated in the areas easy to access, which has resulted in women members of the household being able to come forward for interviews as equally as their men household members. Situation within ADA is different, as only a few households have been involved in agroforestry project which shows the significantly less representation in the household survey. In terms of the total respondents, the equal representation is seen between the AEA and ADA.

Table 4.2 Respondents by sex, type of land use and accessibility

Accessibility	Land use type	Gender					
		Men		Women		Total	
		f	f'	f	f'	f	f'
AEA	With AF	37	50.0	37	50.0	74	66.0
	Without AF	22	58.0	16	42.0	38	34.0
	Total	59	52.7	53	47.3	112	100.0
ADA	With AF	02	25.0	06	75.0	08	07.0
	Without AF	75	33.6	28	12.6	103	93.0
	Total	77	69.4	34	30.6	111	100

f = Frequencies: f'= Proportions

4.2 Household Size

In the hills where the existing farming system is labor intensive, the performance of field cropping, agroforestry and livestock rearing depends largely on the labor force of the individual farm household. Households belonged to non-project group had higher household size (6.7) in comparison to project group (6.2). This suggests that non-project households were having higher family labor than project households were. In terms of the respondents' age groups, except for respondents in less than 25 years category, all the others have household size consisting of more than six members. However, the highest household size of 6.9 members was found with 40-60 years age category (Table 4.3). Comparably, within the project group, size of women members was found less than that of men, while the average household size for either gender in without project situation is more or less equal. Farm households in the study area mostly depend on the family labor force for the entire household production system, which invariably will have greater impact on system productivity in case of any shortage in family labor. Ethnicity, a strong social caste system in the hills, is also an important determinant of the household size.

Table 4.3 Average household size by sex, land use type and respondents' age groups

Land use type and age group	Men		Women		Total	
	Size	SD	Size	SD	Size	SD
Project group	3.21	1.54	2.97	1.52	6.2	2.3
Non-Project group	3.38	1.70	3.34	1.77	6.7	2.8
Age groups						
< 25 Years	2.9	1.7	2.8	1.8	5.7	3.0
25 –40 Years	3.3	1.6	3.2	1.6	6.5	2.5
40-60 Years	3.5	1.7	3.4	1.6	6.9	2.5
> 60 Years	3.1	1.2	3.0	1.9	6.1	2.5

Source: Field Survey, 1998
SD = Standard Deviation

Among the different caste groups, average household size was highest in magar/gharti (MG) while Sarki/Kami/Damai (SKD) had the lowest. Households of four in five categories of ethnic/caste groups consisted of more than 6 household members, except for those SKD groups, which on average, had almost equal to six members (Table 4.4). Except for average numbers of women per household in Sarki/Kami/Damai group, households of all the other caste groups are almost equally represented by members of either gender. In terms of the project and non-project groups, distribution within non-project group is more even than project group. Within the project group, mean household size between Brahmin/Chhetry (BC) and Magar.Gharti caste is significantly different (p<0.05). Except for Magar/Gharti ethnic group, which had highest household size within project group, the average household size for all the ethnic groups was found relatively less than non-project situation. Average household size for Majhi/Tamang/Gurung (MTG) and Newar/Banda (NB) was found higher for non-project households.

Table 4.4 Average household size by sex, land use type and ethnicity

Ethnicity	Gender		Total	Land use type	
	Men	Women		Project	Non-Project
BC	3.2 (1.5)	3.0 (1.8)	6.2 (2.4)	5.8 a	6.7
MG	3.4 (1.8)	3.4 (1.7)	6.8 (2.9)	7.0 a	6.7
MTG	3.3 (1.6)	3.3 (1.7)	6.6 (2.8)	6.0	7.0
NB	3.3 (1.6)	3.2 (1.7)	6.5 (2.6)	5.0	6.7
SKD	3.3 (1.4)	2.6 (1.3)	5.9 (1.7)	5.0	6.2

Figures in parenthesis are standard deviations
Means followed by same letters are significantly different (ANOVA, LSD, p<0.05).

4.3 Respondents' Occupation

In an overall situation, agriculture is the major occupation of the overwhelming majority of the respondents (92%) in the study area. Comparatively, dependency on agriculture was found relatively higher in non-project (94%) than project group (89%). When respondents' occupation is further disintegrated into project and non-project group within AEA and ADA, the occupation pattern still remained more or less similar as overwhelming majorities were involved in agriculture irrespective of the agroforestry project interventions (Table 4.5). This may be associated with the nature of the agroforestry project where the activities of the project are integral part of the farming system and they have not been able to bring some changes in the existing occupational patterns. Interestingly, besides their involvement in farming, few farmers were also found involved in some kind of business activities, such as teashops, restaurants and groceries in project areas within AEA. This may not be directly related to the project activities but rather associated more to the availability of a link road to district headquarters from Prithvi highway. These small income-earning activities are particularly concentrated along the road that passes from communities within AEA. The transportation facility has also provided the important opportunity for community to get access to higher education and better information to get involved in other activities, such as getting employment opportunity.

Table 4.5 Respondents' occupation by land use and accessibility

Occupation	Accessibility				Project	Non-Project	Both
	AEA		ADA				
	Project	NP	Project	NP			
Agriculture	66 (90)	35 (92)	07 (87.5)	97 (94)	73 (89)	132 (93.6)	205 (91.9)
Agriculture + Job	03 (4)	03 (8)	01 (12.5)	06 (6.0)	4 (4.9)	9 (6.4)	13 (5.8)
Agric. + Business	04 (5)	0	0	0	4 (4.9)	0	04 (1.8)
Job + Education	01 (1)	0	0	0	1 (1.2)	0	01 (0.5)
Total Land Use	74 (100)	38 (100)	08 (100)	103 (100)	82 (100)	141 (100)	223 (100.0)
Tot. Accessibility	112 (50.2)		111 (49.8)				

Figures in parentheses are percentages.
AEA= Areas Easy to access; ADA= Areas Difficult to Access
NP = Non-Project

4.4 Caste/Ethnic affiliation

Study area is inhabited by multiethnic communities. Brahmin and chhetri enjoy better position in the prevailing caste hierarchy and also known for better performers at farming. Among the caste groups, magar/gharti were found to be in higher proportions (34%) followed by brahmin/chhetri (26%) in an overall situation. Comparatively, brahmin/chhetries and magars/gharti are represented highly in project group while magar/gharti and newar/banda formed the majority in the non-project group (Table 4.6). The distribution patterns of different ethnic groups is more even in non-project category while it is skewed towards BC, and MG groups in project category. The analysis shows that brahmin/chhetri, magar/gharti and majhi/tamang/gurung are the major ethnic communities involved in the agroforestry adoption. Surprisingly, representation of brahmin/chhetri in project group is almost double to non-project group, while representation of newar/banda was more than fourfold higher in non-project group in comparison to project group.

Table 4.6 Respondents' Caste/Ethnicity by land use type (N=223)

Caste/ Ethnicity	Land Use Type				Total ethnicity/caste	
	With Agroforestry		Without Agroforestry			
	f	f'	f	f'	f	f'
BC	31	37.8	27	19.0	58	26.0
MG	30	36.6	46	33.0	76	34.1
MTG	13	15.8	21	15.0	34	15.2
NB	04	4.9	33	23.0	37	16.6
SKD	04	4.9	14	10.0	18	08.1
Total	82	100.0	141	100.0	223	100.0

Source: Field Survey, 1998
BC = Brahmin/Chhetries; MG = Magar/Gharti; MTG = Majhi/Tamang/Gurung
NB = Newar/Banda; SKD = Sarki/Kami/Damai

4.5 Respondents' Age Structure

Overall age structure of the sample respondents show that respondents from project group are relatively younger (39 years) than non-project group (42 years). In terms of gender, women respondents were relatively younger (39.5) than men (41). Within the project group, average age of women respondent was also relatively low than men. Interestingly, no difference is observed in the average age between men and women in without project situation (Table 4.7).

Table 4.7 Average age of respondents by sex (N=223)

Type of land use	Average age (in years) by sex		Average age for Land use
	Men (n=136)	Women (n=87)	
With Project	39.4 (39)	37.7 (43)	38.5 (82)
Without Project	41.7 (97)	41.3 (44)	41.6 (141)
Average for Gender	41.07	39.5	40.5 (223)

Source: Field Survey, 1998
Figures in Parenthesis indicate number of respondents

Looking at the age group perspective, the distribution patterns show that about half of the respondents' fall under the age group of 40-60 years, while about one thirds consists of 25-40 years' age group. Although farmers of younger age group (<25) represented relatively strongly in both project and non-project category in comparison to old age group (>60), their combined representation is around one fifth only (Table 4.8).

Table 4.8 Respondents' age group by gender.

Land Use Type	Respondents sex	Age groups (Years)			
		< 25	25- 40	40-60	> 60
With Project	Men (n= 39)	5 (12.8)	16 (41.0)	15 (38.5)	3 (7.7)
	Women (n= 43)	11 (25.6)	13 (30.2)	17 (39.5)	2 (4.7)
Without Project	Men (n= 97)	11 (11.3)	29 (29.9)	48 (49.5)	9 (9.3)
	Women (n= 44)	6 (13.6)	14 (31.8)	20 (45.5)	4 (9.1)
Total	Men (n=136)	16 (11.8)	45 (33.1)	63 (46.3)	12 (8.8)
	Women (n= 87)	17 (19.5)	27 (31.0)	37 (42.5)	6 (7.0)
	Both (N= 223)	33 (14.8)	72 (32.3)	100 (44.8)	18 (8.1)

Source: Field Survey, 1998
Figures in parenthesis indicate row percentages.

4.6 Respondents' and Family Members' Educational Attainment

In general, illiteracy is very high among the hill population in Nepal. The level of literacy was higher among the project respondents than non-project ones. The female illiteracy was found higher than male in both the project and non-project respondents. Among the non-project female respondents, more than two-thirds were found to be illiterates in comparison to just over one-third among the female project respondents (Table 4.9).

Table 4.9 Respondents' education level by sex

Land use	Gender	Just Literate	Primary Education	Secondary School	Higher Education	Illiterates
With Project	Men (n=39)	13 (33.3)	8 (20.5)	7 (18.0)	2 (5.1)	9 (23.1)
	Women (n=43)	25 (58.1)	1 (2.3)	2 (4.7)	0 (0.0)	15 (34.9)
Without Project	Men (n=97)	36 (37.1)	3 (3.1)	14 (14.4)	1 (1.0)	43 (44.4)
	Women (n=44)	13 (29.5)	1 (2.3)	0 (0.0)	0 (0.0)	30 (68.2)
Total (N= 223)	Men (n=136)	49 (36.1)	11 (8.1)	21 (15.4)	3 (2.2)	52 (38.2)
	Women (n=87)	38 (43.7)	2 (2.3)	2 (2.3)	0 (0.0)	45 (51.7)
	Both sexes	87 (39.1)	13 (5.8)	23 (10.3)	3 (1.3)	97 (43.5)

Figures in parentheses are row percentage

In total, 40% of the family members were found to be illiterates. Illiteracy is rampant among the women members, as more than half (51%) of the women members are illiterate. Comparatively higher percent of women in non-project group (57%) are illiterate than project group (41%). Women illiteracy level between the project and non-project is significantly different (p<0.05). Among the just literate category, number of women in project group (26%) are significantly higher (p<0.05) than non-project group (16%).

Surprisingly, there are relatively higher percentages of farmers who had received some formal education of secondary school or higher level. The results show that about one third and one forth of the men respondents in project and non-project group respectively have attained secondary or higher level of education (Table 4.10). Irrespective of the project, the results indicate that only 10 percent of the women had attained such educational level. The literacy rates are higher than national and district averages. The higher literacy rate and relatively higher proportion of respondents with formal education is associated with NAF project intervention and their proximity to educational in the district as well as the capital city of Kathmandu.

Table 4.10 Family members' education level by sex and type of land use

Land Use	Gender	Family members' educational attainments				
		Just Literate	Primary Education	Secondary School	Higher Education	Illiterates
With Project	Men (n=251)	47 (19)	63 (25.1)	66* (26.3)	12 (5.0)	63 (25.1)
	Women (n=217)	56# (26)	49 (22.6)	23 (10.6)	1 (0.05)	88** (40.5)
Without Project	Men (n=423)	82 (19.4)	109 (25.8)	81* (19)	17 (4.0)	134 (31.7)
	Women (n=394)	61# (15.5)	66 (16.8)	39 (10)	4 (1.0)	224** (56.8)
Total (N= 1285)	Men (n=674)	129 (19)	172 (25.5)	147 (21.8)	29 (4.3)	197 (29.2)
	Women (n=611)	117 (19)	115 (18.8)	62 (10.1)	5 (0.8)	312 (51.0)
	Both sexes	246 (19)	287 (22.3)	209 (16.3)	34 (2.6)	509 (39.6)

Source: Field Survey, 1998
Figures in parenthesis indicate row percentage
* F-test significant at 0.030 level (p<0.05)
# F-test significant at 0.046 level (p<0.05)
** F-test significant at 0.10 level (p<0.10)

4.7 Livestock Rearing

Livestock rearing is an integral part of the local subsistence farming system and the second most important enterprise after crop cultivation. Multiple species of farm animals are kept for draft power, requirements of manure, dairy products and cash income through the sale of animals and animal products. Farm households prefer to have a pair of oxen to meet their requirements of draught animals. But it is not the situation always, and all the farm households are not able to keep a pair of oxen. In such condition, farm households had devised the strategy of sharing the oxen and sometimes even four households share a pair of oxen. In such condition, households in the rotation basis rear the animals. In agroforestry system, livestock is an important component to recycle nutrients within the system. In this regard, animal dung is mostly used as organic manure in field cropping. Cattle, buffaloes, goats and pigs are the important livestock species reared by farm households.

Irrespective of the project intervention, virtually all households reared some species of livestock (Table 4.11). Regarding livestock herd sizes, no difference is observed between the project and non-project groups. However, the large livestock had substantially outnumbered the small livestock, as the average number of cattle per household was found to be higher than goats, in both project and non-project groups. Numbers of farms keeping pigs were lower in both groups. This is explained by the fact that brahmin/chhetri ethnic group do not raise pigs, as it is by religion prohibited. Comparably, it becomes evident that buffaloes are reared at higher concentration by farmers of project group than those of non-project. Buffaloes are kept for fresh milk and dairy production, which forms a vital part of the family's diet in the study area. This is probably related to the higher availability of fodder in project groups. Type of livestock kept by the households is also determined to some extent by the farm household's ethnicity.

Table 4.11 Average number of livestock raised per households (in Livestock Standard Unit)

Type of animals	With Project				Without Project			
	f	f'	Mean *	SD	f	f'	Mean *	SD
Any species named	-	100.0	-	-	-	97.2	-	-
Cattle	71	86.6	2.25	1.25	122	86.5	2.44	1.30
Buffaloes	75	91.5	1.6	1.02	115	81.6	1.5	0.80
Goats	69	84.1	1.1	0.97	110	78.0	0.92	0.62
Pigs	21	25.6	0.31	0.06	29	20.6	0.40	0.26
Total	82	100.0	4.4	2.42	141	100.0	4.3	2.3

Source: Field Survey, 1998

f = Frequency; f' = Proportions

* F-test non-significant even at 10% level ($p<0.10$).

Apart from pigs, which are prohibited by religion to BC group, entire ethnic groups raise different kinds of livestock with variable herd size. Comparably, there is no significant difference between the average numbers of different species of livestock reared by farms between project and non-project group, with respect to livestock standard unit (LSU) (Table A4.1). But variations are observed within a group with respect to the different ethnic communities. Within project group only SKD ethnicity reared significantly ($p<0.05$) lower number of livestock than BC and MG groups. Greater differences, which are significantly ($p<0.01$) different, are observed between different ethnic/caste groups within non-project farms.

Differences of means between different ethnic/caste groups, using least significant difference (LSD) test, show that BC group reared significantly ($p<0.05$) higher numbers of livestock than all other ethnic groups, while MG group differed significantly with NB and SKD in terms of keeping larger number of livestock. No significant differences were observed between MG and MTG, and NB and SKD (Table 4.12).

Table 4.12 Average numbers of livestock by caste (in Livestock Standard Unit)

Ethnicity/ caste	With Project *	Without Project **	Total
Brahmin/Chhetries	4.82 a	5.84 abcd	5.30
Magar/Gharti	4.85 b	4.51 aef	4.64
Majhi/Tamang/Gurungs	3.77	4.08 bg	3.95
Newar/Bada	2.50	3.46 ce	3.35
SKD	2.06 ab	2.41 dfg	2.33
Total	4.4	4.27	4.32

* F-test significant at 0.056 ($p<0.10$); ** F-test significant at 0.000 ($p<0.01$)
Means followed by same letters within a column are significantly different (ANOVA, LSD, $p<0.05$)

4.8 Land holdings

Farmlands are the most important source of employment of nearly all of the households in the study area. In terms of the land under cultivation, the farmlands fall into two broad categories, the bari (upland dry terraces) and khet (low land paddy fields). Another type of land, which has special significance to agroforestry, is called Kharbari, which is not used for crop cultivation but used to grow thatching grass called khar (*Typha angustata*) and other agroforestry species of fodder, fuelwood, timber and grasses.

An average farm household was found holding 15.5 ropani (0.78 hectare) of land. The breakdown of the average holdings into khet, bari, and kharbari is presented in Table 4.13. The average size of the total landholding per farm in non-project group (16.3 ropani) is slightly higher than project group (14.2 ropani). Irrespective of the project and non-project group, bari lands comprised the significant portion of the total land holdings. But the results indicate that non-project households have significantly higher ($p<0.01$) amount of bari land (12.7 ropani) than project (9.52 ropani). Khet lands are relatively scarce in the study area. In terms of the households having different kinds of lands, the results show that lesser percentage of non-project households' (65%) had khet land compared to project group (78%). Although the average size of kharbari (1.76 ropani) per farm household was found very small, almost equal proportions of the households in both project and non-project group possessed kharbari.

Table 4.13 Average landholding size by type of land

Type of land	Project group		Non-Project group		Both Average	
	f	Size	f	Size	f	Size
Bari	77 (93)	9.52 #	137 (97)	12.68 #	214 (96)	11.55
Khet	64 (78)	6.02	92 (65)	5.33	156 (70)	5.61
Kharbari	17 (21)	1.85	32 (23)	1.72	49 (22)	1.76
Total	82 (100)	14.2	141 (100)	16.3	223 (100)	15.52

F-test significant at 0.002 ($p<0.01$)
Figures in parentheses are percentages.

Ethnicity is an important determinant of average land holding size in the hills. In comparison to non-project groups, the average land holding size belonged to every caste within project is lower. Average landholding size by ethnicity showed that farms belonged to the Magar/Gharti ethnic group under the project category had the higher land holding size than all the other group, but significantly (p<0.05) differed with Magar/Tamang/Gurung, Newar/Banda and SKD groups. Similarly, in non-project category, Brahmin/Chhetries had higher land holding size than others but differed significantly (p<0.05) with MTG, NB and SKD groups (Table 4.14).

Table 4.14 Average landholdings per household by ethnicity (in ropani)

Ethnic/ Caste group	Project *	Non-project *	Both
Brahmin/Chhetry	14.02a	20.69 abc	17.12abc
Magar/Gharti	17.53bcd	18.00 def	17.81def
Majhi/Tamang/Gurung	11.85b	13.24 ad	12.70ad
Newar/Banda	6.88c	13.93 be	13.17be
Sarki/Kami/Damai	5.62ad	12.25 cf	10.78cf
Total	14.20	16.28	15.51

* F-test significant at 0.002
Means followed by same letters within a column are significantly different (p<0.05)

To look into the average land holding size of different strata of households in the study area, the farm households are arbitrarily divided into four farmland categories of less than 5, 5-10, 10-20 and more than 20 ropani. In terms of the further disintegration into the khet and bari lands belonged to four different farm land categories, it was found that almost one third of the both khet and bari in project and bari in non-project farms fall under the average land holdings size of less than half a hectare (10 ropani). Out of four farm size categories, considerably higher numbers of (around 40 %) farms in both project and non-project group belonged to farmland category of 0.5 to 1 hectare (10-20 ropani) of land (Table 4.15). Although majority of the households possessed bari lands, relatively higher percentage of non-project households (97%) had bari land than project households (94%). Contrary to bari lands, higher percentage of project households (78%) has khet land in comparison to non-project households (65%).

Table: 4.15 Frequencies of households by farm size category and land type

Farm land category	Project		Non-project		Average land type		Both
	Bari	Khet	Bari	Khet	Bari	Khet	
0-5 ropani	8 (10.2)	6 (9.4)	11 (8)	2 (2)	19 (9)	8 (5)	23 (10)
5.1-10 ropani	20 (26)	13 (20.3)	33 (24)	13 (14)	53 (25)	26 (17)	54 (24)
10.1-20 ropani	31 (40.4)	29 (45.3)	53 (39)	41 (45)	84 (39)	70 (45)	88 (40)
>20 ropani	18 (23.4)	16 (25)	40 (29)	36 (39)	58 (27)	52 (33)	58 (26)
Total	77 (100)	64 (100)	137 (100)	92 (100)	214 (100)	156 (100)	223 (100)

Figures in parenthesis are column percentages.

The average landholding size by farm category is presented in Table 4.16. The farms belonged to the 0-5 ropani category had an average size of about 4 ropani, whereas large farm holdings (>20 ropani category) consisted of an average of 28 ropani of land. Irrespective of land use type and type of land, the average land holdings of different farm land categories is significantly different (p<0.01). Within project group, bari lands belonged to 10-20 ropani category is significantly (p<0.05) different to less than 5 ropani, 5-10 ropani and >20 ropani categories, while khet lands of more than 20 ropani category is significantly (p<0.05) different to all the other groups. In comparison to project group, bari lands belonged to non-project group had greater variations within different farm land categories as every group is significantly (p<0.05) different to each other.

Table: 4.16 Average land holding size by farmland category (in ropani)

Farm land category	Project		Non-project		Average land type		Both
	Bari*	Khet#	Bari*	Khet**	Bari *	Khet*	average *
0-5 ropani	3.50ab	2.50a	3.25abc	2.5	3.36 abc	2.5a	3.64 abc
5.1-10 ropani	5.03cd	4.58b	7.24ade	2.3ab	6.4 ade	3.4bc	8.14 ade
10.1-20 ropani	8.76ace	5.60c	11.5bdf	5.0a	10.5 bdf	5.3bd	14.92 bdf
>20 ropani	18.5bde	9.25abc	21.4cef	6.9b	20.5 cef	7.6acd	28.00 cef
Total	9.52	6.0	12.7	5.3	11.5	5.6	15.52

* F-test significant at 0.000
# F-test significant at 0.001
** F-test significant at 0.005
Means followed by same letters within a column are significantly different (p<0.05)

4.9 Land Ownership

Overwhelming majority of the farmers in both project (93%) and non-project group (97%) owned bari lands. In principal, the male household head normally hold the land title and female ownership is uncommon. In contrast to the ownership situation of bari lands, only three fourth of the farmers in project group and less than two thirds in non-project group owned khet land. Although the owner-operator dominates in the land tenure system, few farmers have rented in and rented out their lands. In an overall situation, only about 5% of the farmers have rented in lands in both bari and khet lands. Interestingly, none of the farmers had rented out their khet lands in the study area (Table 4.17). This is because khet lands are scarce in the study area and having higher portion of khet lands symbolizes the wealthiness of the farm household. Farmers normally avoid renting out khet lands because these lands are intensively used for cereal crop cultivation and normally with the application of chemical fertilizers. The landholding by ownership pattern shows that practice of renting in and renting out land is relatively very small, owing mainly to the small sized land holdings per farm household.

Table 4.17 Average landholding size by land ownership

Type of land	Project group		Non-Project group		Average	
	f	Size	f	Size	f	Size
Own bari	76 (93)	9.20	137 (97)	12.56	213 (96)	11.36
Own khet	61 (74)	5.93	91 (65)	5.07	152 (68)	5.41
Rented in bari	05 (06)	4.20	05 (3.5)	3.5	10 (4.5)	3.85
Rented in khet	07 (8.5)	3.36	04 (3.0)	7.25	11 (4.9)	4.77
Rented out bari	03 (3.7)	4.33	0	0	03 (1.3)	4.33

f = frequencies of households
Figures in parentheses are percentages.

The figures presented in Table 4.18 shows that there are few farmers who were renting their land. This is elucidated by very small size of land that farmers own in the study area. This also explains why more farmers are renting in some of their land in comparison to renting out in both project and non-project groups. Interestingly, none of the farms belonged to non-project group rented-out their land under any types of land. It is worth mentioning that farmers of the both project and non-project group were found to rented-in land in all land categories.

Table 4.18 Land leasing by land use type

Type of land	Percentage of households by land use type			
	Project		Non-Project	
	Rented-in	Rented-out	Rented-in	Rented-out
Irrigated Khet	7.3	0	2.8	0
Non-irrigated Khet	1.2	0	0.7	0
Gharbari	4.9	1.2	2.8	0
Bari	3.7	2.4	0.7	0

Source: Field Survey, 1998

4.10 Fragmentation of land holdings

Average number of plots, their distance from the household area and average plot size by farmland type is presented in Table 4.19. Irrespective of the type of land, the average plot size was relatively higher in project group than without project situation. In with project situation, farms have relatively higher number of khet parcels (1.0) per household than without project. In contrary, average number of bari plots in without project (3.3 parcels) are more fragmented than with project (2.4 parcels). This indicates that khet and bari lands belonged to with and without project households group respectively are more fragmented. The analysis indicates a comparatively higher degree of fragmentation. This type of land fragmentation is caused by the tradition of equal sub-division of land among sons, which they inherited, from their parents as parental property. With respect to the temporal distribution of the different land parcels, the khet lands are distantly located than bari lands. Comparably, khet lands belonged to the non-project group were located relatively at longer distance (34 minutes) than those of project group (26 minutes).

Table: 4.19 Total number of plots, distance and plot size by type of land and land use type

Type of land use	Type of land	Average distance (minute)	Total number of plots	Average plot size (ropani)	Average plots per household
With Project	Bari	7.1	193	3.9	2.4
	Khet	26.0	82	4.2	1.0
Without Project	Bari	7.8	459	3.7	3.3
	Khet	34.2	114	4.12	0.8

Source: Field Survey, 1998

4.11 Crop cultivation by fragmentation

The analysis on the major cereal crops cultivation on different parcels shows that majority of bari parcels in both project (88%) and non-project group (84%) have been utilized for maize cultivation whereas only one third of the parcels are used for wheat and millet cultivation in project group. Interestingly, more than half of the total bari parcels have been used to cultivate millet in non-project group. In case of khet lands, all most all of the parcels are used to cultivate paddy in both project and non-project groups, while use of parcels to cultivate wheat in project group are two folds higher than non-project (Table 4.20). Although, millet is an important crop in the hill-cropping pattern, practice of growing millet in khet land belonged to both groups is almost negligible.

Table: 4.20 Major cereal crops cultivated by proportions of parcels under land use type

Major Cereal Crops	Project Group				Non - Project Group			
	Bari (n =193)		Khet (n = 82)		Bari (n = 459)		Khet (n =114)	
	f	f'	f	f'	f	f'	f	f'
Paddy	93	48	79	96	176	38	112	98
Maize	170	88	58	71	384	84	62	54
Wheat	61	32	35	43	52	11	24	21
Millet	62	32	04	05	245	53	03	03

Source: Field Survey, 1998

Paddy based pattern are found in the khet land. Paddy followed by wheat is a pattern followed in irrigated low lands. These patterns are common in valleys, river basins and on stable slopes where the possibility of level terraces exists. Beautiful narrow level terraces with small parcels of paddy fields are seen in the study area. Upland paddy based patterns are common in the Tars, areas usually located just above the riverbanks. They have gentle slopes, deep and heavy textured, soils types and is usually rainfed. These soils possess the characteristics of upland soils. In tars, upland paddy is followed by black gram or mustard. The cultivation of peanuts on small scale during the summer season has also been introduced. Practice of relay cropping is common in the study area, where the second crop is shown before the harvest of the first crop. Seeds of the second crop germinate and start to develop while moisture is still available in the fields. Usually relay cropping is practiced with the first monsoon crop which is relayed with the second winter crop. Wheat, as winter crop, is shown before paddy field dry up, using residual moisture. In terms of crop yield in both khet and bari lands, the yields of rice, wheat, and maize were found to be slightly higher in project condition than that of non-project fields (Table 4.21). But the millet yields were substantial higher in bari lands of project group than non-project whereas it was vice versa in case of khet lands.

Table 4.21 Average area and cereal production in different parcels (Yield in Muri).

Land Use Type	Type of cereal and area	Bari land		Khet land	
		Mean	No. of parcels	Mean	No. of parcels
With Agroforestry Project (n=82)	Area (ropani)	3.9	185	4.2	81
	Rice yield	5.5	93	11.16	79
	Maize yield	6.7	170	7.51	58
	Wheat yield	3.4	61	6.33	35
	Millet yield	5.4	62	8.05	04
Without Agroforestry Project (n=141)	Area	3.7	458	4.12	114
	Rice	5.1	176	9.7	112
	Maize	5.3	384	7.2	62
	Wheat	3.2	52	5.6	24
	Millet	2.7	245	11.5	03

Source: Field Survey, 1998

4.12 Agroforestry Land Use

Analyses were carried out to find out the use of different parcels for growing assorted types of agroforestry species. Among the species, fodder trees were found to be grown in the higher proportions of the total parcels belonged to both bari and khet lands of with and without project situation. The results indicate that substantially higher percentages of khet land parcels are used to grow different agroforestry species in with project than in without project farmlands (Table 4.22). This clearly reflects the impact of NAF introduced agroforestry interventions, as more khet parcels belonged to project groups are used to plant agroforestry species. The figures on proportions of parcels used for maintaining agroforestry species clearly reveals that proportions of khet parcels used for tree fodder, shrub, fuelwood trees and grasses in project group is double than non-project group farmlands. But in case of bari land parcels, fodder shrubs in project group is found to be double than non-project group.

Table: 4.22 Major Agroforestry Species by Proportions of Parcels

Agroforestry Species	With Project (n=275)				Without Project (n= 573)			
	Bari (n=193)		Khet (n= 82)		Bari (n=459)		Khet (n=114)	
	f	f'	f	f'	f	f'	f	f'
Fodder trees	155	80	36	44	354	77	20	18
Fodder shrubs	104	54	22	27	156	26	09	08
Fuelwood trees	90	47	28	34	182	40	18	16
Fruit trees	85	44	20	24	136	30	17	15
Grasses	57	30	18	22	107	23	12	11
Medicinal herbs	17	09	02	02	22	05	02	02
Bamboo	40	21	08	10	56	12	04	04

Source: Field Survey, 1998
f = absolute number of plots

4.13 Land Quality and Soil Fertility

In the study area, soil fertility is maintained by the application of manure. Farmers belonged to project group have applied more manure in their farmland than non-project group (Table 4.23). This is related to the higher amount of bio-mass production in the project group due to promotion of improved agroforestry practices. Irrespective of the project intervention, brahmin and chhetri farmers were found to be applying higher amount of manure than other ethnic/caste group. The LSD test employed to find out the differences in average amount of manure used between different ethnic/caste group within the project category shows that brahmin/chhetry used significantly ($p<0.05$) higher amount of manure than SKD group, while differences observed between other groups were not significant. Similarly in the case of non-project group, use of manure by brahmin/chhetry was significantly ($p<0.05$) higher than magar/gharti, newar/banda and SKD groups.

Formal classification of land consists of four categories namely awal, doyam, sim, chahar, which is vital in terms of soil fertility. The land quality index prepared from these soil fertility status indicated that farm soils belonged to brahmin/chhetri ethnic community is significantly different with magar/gharti, and SKD in with project condition (Table 4.24). Interestingly, magar/gharti had significantly better quality soil fertility in comparison to all other groups within the project group. In non-project category, significant variations ($p<0.01$) in land quality between the different ethnic/caste group were found. Comparably, significantly ($p<0.05$) higher land quality indexes were found with MG group than BC, MTG and SKD groups.

Table 4. 23 Amount of compost application in the farmland and land quality index by caste.

Ethnic/Caste group	Manure application (in bhari)		Land quality index[1]	
	WP *	WOP **	WP #	WOP ##
Brahmin/Chhetry	342.1 a	278.9 abc	0.21 ab	0.23 ab
Magar/Gharti	256.0	177.4 a	0.31 acde	0.30 acd
Majhi/Tamang/Gurung	253.5	186.0	0.16 c	0.21 ce
Newar/Banda	195.5	188.2 b	0.11 d	0.31 bef
Sarki/Kami/Damai	63.8 a	149.8 c	0.08 be	0.17 df
Total	273.3	198.0	0.23	0.26

* F-test significant at 0.085 ($p<0.10$)
** F-test significant at 0.093 ($p<0.10$)
# F-test significant at 0.000 ($p<0.01$)
F-test significant at 0.001 ($p<0.01$)
1 = Larger the index value, higher is the soil fertility (1.00 = Aul; 0.75 = Doem; 0.50 = Sim; 0.25 = Char)
Means followed by same letters in a column are significantly different (ANOVA, LSD; $p<0.05$)

4.14 **Summary**

The total population of the sampled household was found to be 1508 comprising 810 men and 698 women. The overwhelming majorities of sample households were involved in subsistence agriculture. The average household size was higher in non-project (6.7) than project groups (6.2) highlighting the higher family labor available with the non-project households. With respect to the age group, highest family size of 6.9 members was found with 40-60 years age group irrespective of the gender. Study area is inhabited by multiethnic communities with Magar/Gharti in higher proportion followed by Brahmin/Chhetry, Newar/Banda, Maji/Tamang/Gurung and lower caste groups the Sarki/Kami/Damai.

With regard to the education attainment, illiteracy particularly among women is rampant where more than half of the female population is illiterate in contrast to less than one third of male population. Percentage of women illiteracy is higher among non-project households owing to the adult literacy program conducted for project households as part of the providing agroforestry education to the adult household members. Virtually all households reared some species of livestock with variations between the ethnic groups. The average number of livestock in terms of livestock standard unit (LSU) per household was 4.3 with project households rearing slightly higher number (4.4 LSU) than non-project households (4.2 LSU). The large ruminants had substantially outnumbered the small livestock, as the average LSU of cattle per household was found higher than goats in both the project and non-project households.

Farmland, comprising bari, khet and kharbari represented the important resource of the farmers in the hills. The average farm family was found to be holding relatively less land (0.78 hectare) where *bari* land comprised the significant portion of the total land holding. Ethnicity is an important determinant of average land holdings in the hills. Variations in land holding were found between the ethnic groups with higher degree of fragmentation. Magar/Gharti ethnic/caste group among project households had higher land holding size than all the other groups. Overwhelming majority of farmers in both project and non-project households have own land. The practice of renting in and renting out land was found relatively very small owing mainly to the small sized land holding per household. The temporal distribution of different land parcels shows that khet lands are distantly located than bari from the farm households. Among the agroforestry species, fodder trees were grown in higher proportions of total land parcels followed by fuelwood and fruit trees irrespective of the agroforestry project intervention. Soil fertility was primarily maintained by manure application with project households applying higher amount of manure than non-project. This variation was due to higher biomass produced by the project households. Differences are observed between ethnic/caste groups on amount of manure applied. In terms of land quality perspective, Magar/Gharti caste group posed better quality land than other caste groups.

Chapter V

Agroforestry Systems Practiced

5.1 Introduction

Agroforestry is an integral part of the local farming systems, which are very complex, highly interactive, and subsistence type. Traditionally, people have been integrating perennial trees, shrubs and grasses with crops in farm, as per their manifold needs and generation old experiences. Larger elevation differences within a short distance and diversity in climate are the specific biophysical characteristics of the study area, which have influenced the occurrence of agroforestry species. Even within a micro watershed of about 1-2 kilometer in length, the climatic variation is prominent. Sometimes, even within a given physiographic zone, the system varies from one location to another. The altitude, a modifier of temperature regimes and consequently a determinant of cropping systems and slope aspect are the main determinants of variations. Under such diversity, farmers have been traditionally practicing several types of agroforestry systems according to their needs and strategies to manage private and community lands to maintain livelihood systems. The agroforestry systems of the study area indicate that the use of land is directed towards satisfying basic needs. Another important feature of this type of subsistence system is that the household members primarily manage these systems. Households, which produce cash crops in limited amount including surplus production of basic commodities, are also considered the part of subsistence agroforestry systems.

Planting and protecting of different kinds of trees and shrubs in their private land is one of the *agrisilvicultural* strategies adopted by people among project households. Trees and shrubs are thus found scattered on private lands of both groups in the study area. Field observation shows that tree species are planted and protected more on rain-fed *bari* lands and less common in the *khet* lands. Trees are particularly planted on edges of agricultural lands, fallow and wastelands due to the fear of loosing crop yields by negative tree-crop interactions. It is the effect of the NAF project which promoted the plantation of additional trees to existing practices of protecting self-grown trees and this explained the higher number of trees found in project farms. Apart from perennials, livestock and crops are other important components of the farming systems. A proper understanding on different components is vital for analyzing different agroforestry systems.

5.2 Components of agroforestry systems

Krishiban (agroforestry) is a new word for a long practiced system for farmers in the study area. The main components of agroforestry based land use system are crops, including agricultural crops, vegetables and grasses, woody perennials (trees and shrubs) and animals. The terms, agroforestry practice, subsystem and systems will be widely used in this section to describe various forms of prevailing agroforestry systems. In agroforestry literature, subsystem indicates a lower level in the system hierarchy. A system can be conceived to be composed of various subsystems, components or compartments, each having a definite boundary. An agroforestry practice denotes a specific land management operation. Commonly the practices include the arrangements of components in space and time *vis–a-vis* the major function of the tree component. It is difficult to classify various systems, as their boundaries are difficult to define. But criteria, such as spatial and temporal arrangements of components, relative importance and role of components, outputs from the system are commonly used to classify. Alley cropping, boundary planting, trees and shrubs as shelter belts, tree gardens, wood lots on agricultural lands are commonly found practices in most agroforestry systems of the study area. In fact they all form different levels of organization of the components, that is, a system consists of several subsystems and each subsystem consists of several practices. All the farming households of the study area have tree, livestock and crop components in their farming systems. Although independent to each other, changes in one subsystem will have subsequent effects on other subsystems. These subsystems have been inseparably inter-linked within the entire system, which is maintained by the efficient recycling of nutrients.

5.2.1 Crop production subsystem

Out of the three broad categories of land, such as bari, khet and kharbari that farmers own, khet and bari are used for field crop cultivation. Bari lands that include gently sloping terraces are used for upland crop cultivation mainly maize (*Zea mays*), upland rice (*Oryza sativa*), finger millet (*Elusine corocana*) and kidney bean (*Phaseolus spp.*). *Khet* lands include flat and bunded terraces, which are primarily used for paddy cultivation besides producing maize, wheat (*Triticum aestivum*) and other grain legumes. Very few farmers grew exclusively pulses in separate plots, as the normal practice is intercropping pulses with maize, millet and other crops in *bari* lands. Besides, pulses are grown in bunds of *khet* lands with rice crop. Vegetables are grown both in *bari* and *khet* lands either separately as a mono crop or with agroforestry, with increasing commercialization of agriculture.

Rice growing lowlands are generally referred to as khet in Nepali language. They are bench-terrace oh hill slopes and bunded in valley floors. These lands have either perennial sources of irrigation water or receive water during certain months of the year, normally after the onset of monsoon rains in June, and continue receiving for some months depending upon the source and location. Such lands are normally found in foothills, river terraces and river/stream banks. Farmers have developed different nomenclatures to classify khet lands on the basis of their production potential, soil type, terrace type and management limitations. Some of such nomenclatures given to different khet land parcels are *bagar* khet, *sim* khet, *tari* khet, *pakho* khet, *kanle* khet, and *phagata* khet. *Bagar* khet refers to khet lands of valley bottom and food plains, which are prone to frequent flooding. Khet lands of footslopes or colluvial slopes, spring or marshy areas with poor drainage and high water table during monsoon are called *sim* khet. Originally dry flat lands in river terraces receiving irrigation water in recent years are called tari khet whereas pakho khet refers to khet at ridge top or alluvial fan with narrow terraces. Kanle khet refers to khet land with high terrace risers of steeply sloping hillside but phagata khet means khet lands of steeply sloping hillside with narrow terraces where ploughing using bullocks is very difficult. Amount of khet owned in the Hills is normally taken as a yardstick of economic status of a farmer. Therefore, a farmer with relatively higher amount of irrigated khet land is considered a rich farmer in the community. The poorest farmers have either very less or no irrigated khet. Only two thirds of the households own khet, with average size of 4.16 ropani (0.25 hectare) per household.

Besides maize, wheat and other leguminous crops, rice is the major crop cultivated in khet. These lands are puddled prior to transplantation of rice seedling. To overcome the negative effect of puddling in lowland rice cultivation practices, higher amount of compost is required, as puddling of soils disturbs their structure and forms a dense impervious layer called plough pan. The formation of plough pan is necessary to regulate standing water supply during the rice growing period. But this condition is not suitable for upland crops. In some cases, farmers apply small amount of compost to khet for winter crops cultivation, making compost less available for bari. In general, khet in the study area are fertilized for maize cultivation. Manure is incorporated in soil just before the maize seeds are planted. Residual plant nutrients available from manure become available for the successive rice crop. Chemical fertilizers are increasingly applied to khet land. Weeds grown naturally after rice transplantation, are some of the important sources of organic matter. Weeding is usually done manually. No households in the study area were found using herbicides to control weeds. Rice fields are normally weeded twice, where all weeds are uprooted and then imbedded inside the mud under the standing water. They subsequently get decomposed and contribute to the soil organic matter.

Bari, as higher proportion of the land lands, have been further categorized into gharbari and other bari lands in the present study to examine variations between the different parcels of bari lands owned and managed by farmers. Gharbari are homesteads comprising small land parcels around farmers' houses, which are managed more efficiently. In case of other bari lands, farmers refer them separately, such as tar bari, pata bari, kanle bari and dhunge bari, depending upon their production capabilities, size of the terrace risers and management limitations. *Tar bari* refers to bari lands in river terraces, fans and ridge tops with wide and gently sloping terraces and short terrace risers. They are normally with low fertility status, prone to gully erosion and deficient in moisture. The wider and moderately sloping hillside bari are termed as Pata bari. Hillside *bari* lands with moderate to steep sloping narrow terraces and higher terrace risers and lower fertility status are called kanle bari. Such lands are prone to high surface erosion and mass wastage. The word kanle in Nepali refers to the taller terrace risers. Dhunge bari refers to those hillside gravelly terraced bari lands with gentle to moderate concave slope and high infiltration capacities. Dhunge in Nepali language refers to the presence of pebbles in the bari and terrace risers. An individual farmer may have all these different types of bari lands.

Bari are the primary sources of food grains for majority of the people. Findings from this study show that households in the study area own relatively small and fragmented land holdings. On average, a farm household had about 11 ropani of bari land fragmented into three parcels of which gharbari comprised about 4 and bari 7 ropani. In comparison to the medium and richer farmers, the poor farmers own proportionally more bari than khet. Farmers have to make living out of these small and fragmented land holdings. The other bari land consists of different parcels of varying sizes (see Table 6.2). Bari lands are managed in low input and low output systems compared to khet lands, while they comprise major proportion of land holdings. This combined with very limited availability of required resources, unavailability of location specific technology and unfavorable national policies have compelled farmers to adopt subsistence type of farming systems.

Bari lands in the Hills are prone to environmental hazards, such as drought, accelerated soil erosion caused by monsoon run off and steep slopes, and land slide which impinge severely on land fertility. During rainy season as much as 30 tons/ha of fine topsoil is lost each year. Along with topsoil, valuable nutrients such as nitrogen, phosphorus and potassium are also lost, resulting in decreased maize and millet yields. Loss of topsoil not only degrades soil quality, but also aggravates moisture-holding capacity and organic matter content of the land, leading to soil becoming infertile, hard and sterile. This is further aggravated by unavailability of appropriate technology, such as suitable crop varieties and cultivars, water management techniques, high producing animal breeds and easily cultivable fast growing multipurpose perennial trees, shrubs and grass species suitable for marginal uplands. The basic research has not yet been able to find the appropriate solution to the problems faced by hill farmers. Enough evidences and facts are still not known regarding the complexity of the hill farming systems. The analysis of a specific component of the system is not sufficient for making inferences and formulations of strategies. Uplands, which have supported the livelihood, have not been given priority in any agriculture development planning.

Traditionally farmers were managing bari lands by allowing longer fallow period to restore soil fertility and by applying larger quantity of compost/manure. But increased livestock grazing and cropping intensification pushed by population growth compelled them to shorten the fallow periods. This led to further decline in yield, as nutrient uptake is continuous and heavier, while addition to the soil becoming less and less. Weeds grown naturally in the bari lands are normally removed completely, although the number of weeding depends on the type of crop. Cereal crops, such as upland rice, maize and millet are weeded twice during their early growth period. Unlike khet lands where weeds are imbedded in the soil, weeds in bari lands are removed first and not kept in-situ. If the weeds are of fodder quality and species, then they may be selectively used as fodder. Otherwise they are sun dried to ensure their non-reemergence in the field and later returned to the soil as fertilizer. Although being a major source of plant nutrients, amounts of manure applied by the farmers in their farmlands vary considerably. Traditionally, farmers were using compost/manure at the rate of 10-20 tons per hectare (Carson, 1992) to ensure the fertility status of bari lands. Due to increased cropping intensity in khet, compost is being increasingly diverted from bari to khet.

From the group discussion with farmers, it revealed that lands located relatively far from the household generally received less inputs and inadequate attention in terms of management. More inputs and better management practices are given to land parcels with higher production capabilities. In general, wide and gently sloped terraces are located near farmhouses that receive better management. However, a considerable amount of biomass is regularly harvested from the bari lands located further away from homesteads. Those parcels of land located relatively distant from the homesteads received the least or no compost, which has resulted in degradation of such uplands gradually. This tendency is corroborated by results of the analysis based on household survey (see Chapter 8 Table 8.4).

Baris are generally outward (or downward) sloping wider terraces. Prior to the monsoon rains (normally during *Chaitra/April* and *Baisakh/May*), the bari are ploughed thoroughly and bigger soil clods are broken into finer particles. With the onset of rain, compost is applied into the soil and, then maize seeds are sown. The monsoon rains wash away the fine topsoils and compost. The extent of topsoil removal is usually higher in the parcels located relatively distant from homestead. Once fertility declines severely, due to soil erosion, farmers tend to abandon such parcels of land temporarily. Some farmers even abandon such lands for a few years so as to allow replenishment of fertility. The abandonment of lands once were productive and supporting to farmers may have contributed to the village economy at large. Although estimation on amount of land abandoned due to severe fertility reduction in the study area is beyond the scope of this study, conservative estimate puts that between 10-20% of the rainfed cultivated lands of Nepal are temporarily fallowed or abandoned, due to lack of fertilizing materials (Carson, 1992). From the focus group discussion, it revealed that farmer compensate the declining production in their distant parcels of bari lands by intensifying cultivation in parcels located near to their homesteads. Though, moisture deficiency is a limiting factor to establish suitable species, the adoption of appropriate agroforestry practices in distant parcels of land will provide additional benefits to farm families. Furthermore, agroforestry will control the large amounts of soils from being washed way annually and help to restore soil fertility to some extent. Attention towards this important land management practice has not been seriously paid yet. As a result, the production potential of bari lands remains largely untapped.

5.2.2 Animal production subsystem

Farm animals combined with annual crops and multipurpose perennial trees are typical constituents of agroforestry systems in the study area. The synergistic association between trees, land and animals has been established through the use of woody perennial as fodder for livestock, fertilizers and erosion control measures. The two major types of agroforestry systems found in the study area are agrosilvopastoral system and silvopastoral system. The production capacity of the livestock subsystem is influenced largely by the tree subsystem in agroforestry system. Nearly all the households in the project and non-project have raised several types of livestock namely, cow, buffalo, sheep, goat, pig and poultry in a mixed herd system. As pig raising is limited to a few ethnic groups, only about one fourth of the households in project and one fifth in non-project areas have kept pigs. Traditionally, Brahmin and Chhetri caste raise buffaloes, cows and goats but prohibited from keeping the pig and poultry. In the process to changing socio-economic condition they have started raising chickens but not pigs yet.

There is no significant difference between project and non-project groups in terms of Livestock Standard Unit (LSU) (see Table 4.1). The project group kept relatively smaller number of cattle (2.25) and pigs (0.3), compared with the non-project group and vice versa in the case of buffalo and sheep/goats. Cattle, buffalo, and goats are the most prevalent and economically important livestock, which have close relationship with the prevailing resource and agricultural systems in the study area. For most small holder farming systems, they are a valuable component. Still farmers accord livestock subsystem secondary priority over the crop production. Apparently most livestock in non-project households remain underfed due to inadequate availability of fodder. Feeding concentrates was generally found to be limited to cows and buffaloes during later part of their pregnancy, parturition and lactating periods, and during peak working season for draught animals. Production from livestock subsystem is directly related to crop and tree subsystems, as they are sources of fodder.

Experience with the farming system of the study area and the direct observations in the farm households during field survey show that both men and women farmers participate in animal husbandry. Irrespective of the gender and project situation, involvement of both genders in equal proportions in livestock feeding is around 40% percent. But higher percentage of women in without (48%) and with project (37%) said that livestock feeding activity is entirely managed by women members of the household. Similarly, the analysis shows that livestock grazing is also the primary responsibility of women. This is indicated by women responses in both with and without project situation. This is also agreed by one third of the men who reported that livestock grazing is exclusively the women's responsibility (Table 5.1).

Table 5.1 Involvement of Gender in livestock feeding by gender and type of land use

Involvement of gender	With Project (n =82)		Without Project (n=141)	
	Women (n=43)	Men (n=39)	Women (n=44)	Men (n=97)
A. Feeding				
Done by women only	16 (37.2)	13 (33.3)	21 (47.7)	35 (36.1)
Done by men only	5 (11.6)	3 (7.7)	2 (4.5)	5 (5.1)
Equal (50%) by both	15 (34.9)	19 (48.7)	16 (36.4)	42 (43.3)
75% by women, 25% men	5 (11.6)	3 (7.7)	5 (11.4)	15 (15.5)
75% by men, 25% women	2 (4.7)	1 (2.6)	0	0
Total	43 (100.0)	39 (100.0)	44 (100.0)	97 (100.0)
B. Grazing				
Done by women only	16 (38.1)	13 (33.3)	21 (47.7)	32 (33.0)
Done by men only	3 (7.1)	2 (5.1)	1 (2.3)	7 (7.2)
Equal (50%) by both	17 (40.5)	21 (53.8)	17 (38.6)	42 (43.3)
75% by women, 25% men	5 (11.9)	2 (5.1)	5 (11.4)	16 (16.5)
75% by men, 25% women	1 (2.4)	1 (2.6)	0	0
Total	42 (100.0)	39 (100.0)	44 (100.0)	97 (100.0)

Source: Field Survey, 1998

Discussions with farmer and farmer groups revealed that involvement of men is higher in other livestock production activities, such as disease management, selling and buying of farm animals and animal products.

5.2.3 Tree production subsystem

Traditionally farmers have been maintaining multiple tree species by protecting naturally grown trees as well as by planting exotic varieties of trees in association with field crops. The type, extent, and location of perennial species within the farming system, however, vary according to the existing biophysical environment and socio-economic condition of farmers. The trees are grown both by integrating with the field crops and grown separately on those lands usually not suitable for arable agriculture, such as kharbari and other marginal lands. Farmers have been using all available spaces, such as the edges of the terraces, fallow lands, wide terrace risers, non-cultivated inclusions, and gullies or stream edges to protect and plant perennial trees, shrub and grass species. Such uncultivated areas have been very useful as 'fodder banks' for farmers with very small land holdings. Foliage from trees usually harvested and is a principal source of quality fodder. Grasses are cut and fed to livestock and used for grazing depending upon the slope. Normally livestock graze on gentle slopes during dry season.

Some of the predominant farm trees grown for fodder, timber, and fruit are gayo (*Bridelia retusa*), dabdabe (*Geruga pinnata*), badahar (*Artocarpus lakoocha*), bakaino (*Melia azerdiarch*), kutmiro (*Litsea monopetala*), tanki (*Bauhinia purpurea*), khanyu (*Ficus semicordata*), painyu (*Prunus cerasoides*), mango (*Mangifera indica*), litchi (*Litchi chinesis*), banana (*Musa paradisica*), orange (*Citrus spp.*), guava (*Psidium guava*), chilaune (*Schima wallichii*), sal (*Shorea robusta*), sisoo (*Dalbergia sissoo*) and utis (*Alnus nepalensis*). The average number of fodder, fruit, fuel wood and timber trees grown per household in with and without project situation is presented separately elsewhere in this chapter. Multiple agroforestry tree species found in the study area is presented in the appendix (Table A5.1, A5.2 and A5.3).

The analysis on an average number of fodder trees, fodder shrubs, and fruit trees available in bari lands showed that with project households have significantly higher ($p<0.05$) number of agroforestry species than non-project households. Likewise, even the amount of grass available in bari terraces of with project household is significantly higher ($p<0.05$) than that of without project households (Table 5.2). While, no significant difference is seen in number of species between the khet land of project and non-project households. Within the project households, higher number of agroforestry species was found in bari than in khet lands, which is in contrary to without project households. This is because khet land in non-project areas are located near to the forests and streams having increased number of agroforestry species maintained in stream edges and khet boundaries. This is not the general situation in all types of khet land in the hills. Irrespective of the agroforestry intervention, the proportion of households maintaining the different agroforestry species in their khet lands is substantially lower than those maintained in bari lands. In terms of the households, nearly all of them have maintained fodder trees in their farmland in both with and without agroforestry project. In case of tree and shrubs having medicinal value, substantially higher percentage of households in with (22%) project have planted and protected than without (13%) agroforestry intervention.

Table 5.2 Agroforestry species in *bari* and *khet* lands

Type of species	Bari			Khet		
	Project	Non-project	F-value	Project	Non-project	F-value
Fodder trees (no.)	71.3 (70)	42.1 (135)	6.121*	32.5 (31)	171.2 (18)	1.735
Fodder shrubs (no.)	147.5 (53)	53.4 (68)	5.594*	82.3 (18)	92.6 (07)	0.031
Fruit trees(no.)	87.4 (69)	14.2 (112)	4.618*	35.9 (16)	18.0 (15)	0.477
Fuelwood/timber trees (no)	57.5 (56)	31.6 (105)	2.418	14.1 (27)	28.7 (15)	2.409
Medicinal plants (no.)	39.0 (16)	35.2 (17)	0.033	17.0 (02)	1.5 (02)	1.419
Grass (bhari)	84.7 (35)	15.8 (51)	5.170*	85.0 (17)	30.5 (08)	0.593

Source: Field Survey, 1998
* F-test significant at 0.05 level ($p<0.05$)
Figures in parenthesis indicate frequency of households

Fuel wood and other trees in *kharbari* land: an average of 21 (25) trees per household consisting 22.0 (9) in project and 21.0 (16) in Non-project households.

Analysis on total farm trees and shrubs comprising of fodder, fruit, fuel wood, timber, and medicinal species show that average density of fodder shrubs per hectare (235) in project is significantly higher ($p<0.01$) than without project households (74). Similarly, farm households involved in agroforestry project had maintained significantly ($p<0.05$) larger number of fruit trees and shrubs per hectare (128) in their farmlands than without project (20) households (Table 5.3). With respect to per hectare trees and shrubs, households involved in agroforestry project have higher number of different agroforestry species (fodder, fuelwood/timber, grasses medicinal,) than household of without agroforestry intervention. These estimations are obtained by converting the average number of trees found per household into per hectare species density (1 hectare = 20 ropani). Average total land per household in the study area was 15.5 ropani (consisting 14.2 in project, 16.3 in non-project households). The analysis shows that per hectare fodder, shrubs dominated all the other species found in both with (235 trees/ha) and without (139 trees/ha) agroforestry project households (Table 5.3).

Table 5.3 Summary of different agroforestry species by agroforestry project

Type of species	Project	Non-Project	F-value	Average
Fodder trees (Trees/ha)	114	78	0.378	90
Fodder shrubs ** (Trees/ha)	235	74	7.083**	139
Fruit trees/shrubs # (Trees/ha)	128	20	5.304*	58
Fuel wood, timber & other trees (Trees/ha)	83	45	1.970	58
Medicinal tree/shrubs (Trees/ha)	51	41	0.027	45
Grasses (Bhari/ha) ##	169	25	5.141*	78

Source: Field Survey, 1998
* F-test significant at 0.05 (p<0.05)
** F-test significant at 0.01 (p<0.01)

These differences between with and without project households are attributed to the plantation of fodder tree/shrubs in the project households that are promoted by NAF. As a general rule of thumb, to become a demonstrator farmer in NAF introduced agroforestry program, one needs to plant and protect about 300 saplings of mixed species. Similarly, a trainer farmer, who is selected among the demonstrator farmers, will have maintained similar or even higher number of mixed tree/shrub species in their farmland.

5.3 Gender role in agroforestry activities

Within a household, "who does what and why" is normally taken as an entry point to understand gender relationship. These aspects of how the work is divided between the gender are complex processes of gender stratification. Gender division of labor is social- culturally constructed, where society has different roles, responsibilities and activities according to what considered best for each gender which to be larger extent was influenced by the position and power held by each. Because of the cultural ideology, women's engagement in family survival activities is rigid, and this ideology of women's domesticity is an obstacle to their involvement in outside work, which is being slowly changed. In subsistence food production economy, women's role has always been a central one, and for them farm work includes preparing fields (except ploughing), raising nurseries, planting and nurturing of trees, harvesting, gathering fodder, fuelwood, crop residues, care and management of livestock and growing crops. Restricted employment opportunities and greater responsibilities in crop production have made women concentrate heavily on activities in and around the homesteads.

Women's work particularly the reproduction related work and kitchen works are generally taken as reserved work for women. When asked with both men and women, they agreed that reproduction and kitchen related activities are the works of women, not men. This socially perceived gender division of labor is deeply rooted in the minds of both sexes. Even women do not want to share certain household activities (considered low prestige work) with their husband. Some disputes between the genders have been reported by local people during various discussion sessions. In one of the focus group discussion sessions, a woman farmer leader involved in agroforestry project cited an incidence of her village where a dispute between a husband and wife was settled by a village meeting when the gender sensitive husband had carried out the cleaning of floor using cow dung during one morning. His wife, with college education, was bitterly unhappy for man carrying out a low prestige work. The men under consideration happened to an elected Chairman of the village. The dispute was solved by agreement that husband will only share other works and leave such low prestige work to his wife. Such incidences are clear evidences of unchanging patterns in gender relationships due to social values and also changing attitudes of gender sensitive males within a household. Since men hold the power in the society, women were found involved in low-prestige, hazardous, arduous, monotonous, repetitive and time consuming activities, such as weeding, digging, transplanting and harvesting. Involvement of men in sharing of low prestige work with the women members in the family is traditionally taken as prestige issue. But radical decisions from both genders are required to bring substantial improvements in the gender relations within a family and the society at large.

Household is incorrectly assumed as a homogenous unit where each member is supposed to shares a common interest, position, economic condition, responsibility and benefits. Traditionally, women's involvement has been limited within household whereas men are involved outside of the household. Farmers revealed that this type of traditional gender division of labor is considered an efficient means of maximizing the household income and is even compared with the principle of comparative advantage. In some families, men share some household work (carrying water, feeding animals and sometimes helping in cooking) but few of them try to avoid being noticed publicly while performing such activities. For the field crop cultivation women and men usually share different tasks. There is a gradual shift from exclusive responsibility to shared task responsibilities due to growing gender awareness on both men and women.

It was observed during the fieldwork that all members of the farm family (men, women and children) participate actively in tree and field crop production activities. There are certain activities, which are performed exclusively by men and others exclusively by women. For example, in land preparation, men exclusively do fields ploughing. In case of female head household where men are absent for some reasons, the labor is hired for this operation. Irrespective of the gender more than 50% of the respondents in both with and without project households stated that land preparation is an equally shared activity between gender in the household. In both with and without project situation one third and nearly a quarter of the women respondents respectively, said that women exclusively do land preparation (Table 5.4). This is confirmed by the response from their respective males in with project (21%) and without project (10%) households. Land preparation by women indicates all the other operations exclusive of ploughing, as women do not do ploughing in Nepal. Ploughing the field is exclusively assigned to male responsibility although Brahmin men, a higher caste in Hindu society, are not supposed to plough fields. The overall responses indicate that land preparation is an activity shared by both the sexes. Land stability is critical to the people. The distribution of parcels of *bari* and *khet* land in different directions and various distances severely taxes women's time carrying compost as well as having anything to do with its preparation.

Table 5.4 Gender involvement in seedling, seedbed land preparation

Involvement of gender	With Project (n=82)		Without Project (n=141)	
	Women (n=43)	Men (n=39)	Women (n=44)	Men (n=97)
A. Land Preparation				
100 % by women	13 (31.7)	8 (20.5)	10 (22.7)	10 (10.4)
100 % by men	6 (14.6)	7 (18.0)	8 (18.2)	26 (27.1)
Equal (50%) by both	22 (53.7)	21 (53.8)	25 (56.8)	58 (60.4)
75% by women, 25% men	0	2 (5.1)	1 (2.3)	1 (1.0)
75% by men, 25% women	0	1 (2.6)	0	1 (1.0)
Total	41 (100.0)	39 (100.0)	44 (100.0)	96 (100.0)
B. Seedling & Seedbed Preparation	Women (n=43)	Men (n=39)*	Women (n=44)	Men (n=97)*
100 % by women	21 (50.0)	14 (35.9)	16 (37.2)	16 (17.4)
100 % by men	8(19.0)	6 (15.4)	6 (14.0)	28 (30.4)
Equal (50%) by both	12 (28.6)	16 (41.0)	20 (46.5)	46 (50.0)
75% by women, 25% men	1 (2.4)	2 (5.1)	1 (2.3)	2 (2.2)
75% by men, 25% women	0	1 (2.6)	0	0
Total	42 (100.0)	39 (100.0)	43 (100.0)	92 (100.0)

Source: Field Survey, 1998
* Chi-Square test significant at 0.039 ($p<0.05$; Pearson value = 10.094; degrees of freedom = 4)
Figures in parenthesis are percentages

Seedbed preparation and seedling production are important activity of agroforestry in the farm household. Analyzing the situation with respect to the gender reveals that irrespective of the gender response, involvement of women in seedling and seedbed preparation is higher in with project situation than without project situation. Fifty percent of the women respondents of project and 37% from non-project situation indicated that seedling and seedbed preparation is entirely done by women, which is confirmed by the males (36 and 17 %) response respectively. Significantly higher percentage ($p<0.05$) of the men (36%) from project in comparison to non-project (17%) revealed that seedling and seedbed preparation is the sole responsibility of women. Results indicate that involvement of women in seedling and seedbed preparation is higher than males. This has planning significance to agroforestry interventions.

Tree and field crop management, planting, weeding and fertilization are some of the major farm operations where involvement of household labor is crucial. Results indicate that women are exclusively involved in planting and weeding activities (Table 5.5). This is confirmed by the results that almost two-thirds of the women respondents in project and more than half in non-project stated that these are exclusively carried out by women in the family. This is highly rectified by nearly half of the male respondents (46%) from project and substantially higher percentage (41%) from non-project situation. Although, there are conflicting responses among the gender for other farm activities, both the gender agreed that planting and weeding activities are the primarily responsibility of women in the household.

Planting and weeding are the most time consuming farm activities normally performed by women. Comparison between project and non-project situation shows that involvement of women is higher in project situation owing to increased work due to agroforestry activities. As like planting and weeding, involvement of women is also higher in crop management and fertilization than men. But results show that men's involvement in crop management and fertilizer is much better compared to planting and weeding activities. The chi-square test shows that the men's response between project and non-project is significantly different ($p<0.05$).

Table 5.5 Gender role in crop management, fertilization, planting and weeding.

Involvement of gender	With Project (n = 82)		Without Project (n = 141)	
	Women (n=43)	Men (n=39)	Women (n=44)	Men (n=97)
A. Management		#		#
100 % by women	20 (48.8)	15 (38.5)	15 (34.1)	27 (29.3)
100 % by men	6 (14.6)	3 (7.7)	6 (13.6)	24 (26.1)
Equal (50%) by both	14 (34.1)	17 (43.6)	21 (47.7)	39 (42.4)
75% by women, 25% men	1 (2.4)	3 (7.7)	0	1 (1.1)
75% by men, 25% women	0	1 (2.5)	2 (4.5)	1 (1.1)
Total	41 (100.0)	39 (100.0)	44 (100.0)	92 (100.0)
B. Planting and weeding				
100 % by women	25 (61.0)	18 (46.2)	22 (51.2)	37 (40.7)
100 % by men	1 (2.4)	2 (5.1)	0	8 (8.8)
Equal (50%) by both	14 (34.2)	16 (41.0)	18 (41.9)	44 (48.3)
75% by women, 25% men	1 (2.4)	2 (5.1)	2 (4.6)	2 (2.2)
75% by men, 25% women	0	1 (2.6)	1(2.3)	0
Total	41 (100.0)	39 (100.0)	43 (100.0)	91 (100.0)

Source: Field Survey, 1998
Chi-Square test significant at 0.049 (p=0.05; Pearson value = 9.520; degrees of freedom = 4)

In with agroforestry project intervention households, women's involvement in agroforestry products harvesting is considerably higher than that of men in the family. This is evident from the results that more than half (54%) of the women and more than two fifths (44 %) of men respondents said that this is exclusively the women's job in the household (Table 5.6). Similar response was obtained from both genders in without agroforestry project situation. Interestingly, none of the respondents from either genders in with project and remarkably low numbers in without project situation said that agroforestry product harvesting is the sole responsibility of men. The analysis reveals that agroforestry product harvesting is exclusively the women's domain, irrespective of the project intervention.

In contrast to agroforestry harvesting the women's involvement in marketing of agroforestry products is considerably less. In case of overall marketing activities performed in the household, the men's involvement is higher than women. Although around one fifth of the women respondents in both with and without project situation referred the activity as an exclusively carried out by women, substantially lower percentage of men in with project (5%) and without project (9%) agreed. This is a clear sign of gradual shift in the responsibility sharing between two genders after the agroforestry project interventions. In contrast, irrespective of the agroforestry intervention, around one third of the women respondents stated that men in the family exclusively carry out overall marketing activity.

Despite greater involvement of women in other agroforestry activities their involvement in marketing is low. Despite the fact that women dominate in other activities including product harvesting, the agroforestry product marketing comes under men's domain in the family's division of labor.

Table 5.6 Gender involvement in agroforestry product harvesting and marketing activities

Involvement of gender	With Project(n=82)		Without Project (n=141)	
	Women (n=43)	Men (n=39)	Women(n=44)	Men (n=97)
A. Product Harvesting				
100 % by women	23 (53.5)	17 (43.6)	17 (39.5)	46 (47.9)
100 % by men	0	0	1 (2.3)	6 (6.3)
Equal (50%) by both	18 (41.9)	19 (48.7)	19 (44.2)	37 (38.5)
75% by women, 25% men	2 (4.6)	2 (5.1)	4 (9.3)	4 (4.2)
75% by men, 25% women	0	1 (2.5)	2 (4.7)	3 (3.1)
Total	43 (100.0)	39 (100.0)	43 (100.0)	96 (100.0)
B. Marketing				
Always done by men	14 (32.5)	16 (41.0)	12 (27.3)	47 (49.0)
Always done by women	8 (18.6)	2 (5.1)	10 (22.7)	9 (9.4)
Both do in equal proportions	14 (32.5)	16 (41.0)	18 (41.0)	34 (35.4)
Women do by 75% of times	3 (7.0)	1 (2.6)	2 (4.5)	1 (1.0)
Men do by 75 % of the cases	3 (7.0)	4 (10.3)	2 (4.5)	3 (3.1)
Rarely done by women	1 (2.3)	0	0	2 (2.1)
Total	43 (100.0)	39 (100.0)	44 (100.0)	96 (100.0)

Source: Field Survey, 1998

Women members of the farm households are the most important forest users in the study area. They have suffered by the impact of deforestation and dwindling natural resources leading to inadequate sources of fodder and fuel wood in and around their community. Analysis shows that women primarily carry out fodder and fuel wood collection in the study area. This is confirmed by the by the responses from both genders (Table 5.7).

According to women response, fodder and fuel wood collection, which is a most time consuming job, is undertaken solely by women in nearly two thirds of the cases in with project and 40% cases in without project situation. This is highly agreed by equal proportions of men's response (44%) in both with and without project situation. Despite the fact that women dominate in fodder and fuel wood collection and overall contribution to tree activities, field observation shows that men also put in more time in other activities, such as chopping the larger fuel wood piece into manageable size, cutting farm trees for timber and chopping logs.

Table 5.7 Involvement of gender in fodder and fuelwood collection

Involvement of gender	With Project (n =82)		Without Project (n=141)	
	Women (n=43)	Men (n=39)	Women(n=44)	Men (n=97)
A. Fodder collection				
Done by women only	27 (62.8)	17 (43.6)	18 (41.0)	42 (43.3)
Done by men only	2 (4.7)	0	1 (2.3)	3 (3.1)
Equal (50%) by both	9 (20.9)	18 (46.1)	16 (36.4)	33 (34.0)
75% by women, 25% men	4 (9.3)	3 (7.7)	9 (20.9)	16 (16.5)
75% by men, 25% women	1 (2.3)	1 (2.6)	0	3 (3.1)
Total	43 (100.0)	39 (100.0)	44 (100.0)	97 (100.0)
B. Fuelwood collection				
Done by women only	18 (41.9)	11 (28.2)	16 (36.4)	25 (25.8)
Done by men only	7 (16.3)	4 (10.2)	2 (4.5)	15 (15.5)
Equal (50%) by both	13 (30.2)	19 (48.7)	16 (36.9)	36 (37.1)
75% by women, 25% men	3 (7.0)	2 (5.1)	9 (20.9)	17 (17.5)
75% by men, 25% women	2 (4.7)	3 (7.7)	1 (2.3)	4 (4.1)
Total	43 (100.0)	39 (100.0)	44 (100.0)	97 (100.0)

Source: Field Survey, 1998

5.4 Inter-relationships among agroforestry components

Competitive use of green biomass for livestock fodder and green manure, grasses for thatching and livestock fodder, and crop residues for mulching and livestock feed, are important interactions that need to be seriously considered by farmers in their decision making on allocation of scarce household resources. The interaction between trees and field crops is considered most important in farmers' decision making regarding the agroforestry adoption. Cultivation of hill slopes, which are normally considered beyond the limits of arable agriculture, has been made possible owing to positive effect of the presence of trees. Despite causing shading on field crops, trees play vital role in protecting soil from erosion, and providing fodder, fuel-wood and other household requirements. Farmers are well aware of benefits of combining woody perennials with field crops. As a strategy to get a compromise between tree planting and grain yield, farmers avoid maintaining trees on some of the terrace risers, especially with higher cereal crop production capability. But farmers maintain tree/shrubs on relatively marginal terraces. They are found to be reconciling the negative interaction effects, such as shading, low yield around trees in the farmland, in appreciation of multiple positive effects of perennial tree species in their farmland.

Crop-livestock interactions some times cause labor shortage in the family, particularly during planting and harvesting seasons. But the livestock subsystem provides employment to household members during the off-season. Crops provide feed, forage and bedding materials to livestock, which in turn receive draft power and manure from livestock. Livestock feed and forage supplied by crops mostly consists of roughage, such as straw, stalk and stover and some cereal grain concentrates. Farmers revealed that animals are important to turn roughage into edible human food in the form of milk, meat and dairy products as supplimentary sources of livelihood. In this respect livestock-crop-tree integration plays an important role in efficient utilization of farm resources by converting biomass and non-edible agroforestry products into human food. In this process, livestock recycle nutrients back to the soil, from where they are extracted by plants. The competition between livestock and crop subsystems under the present agroforestry system has been minimized by farmers by adopting methods, like stall feeding of livestock, use of crop residues as forage and feed and allocating labor according to the priority with the most important task being accomplished first.

Farmers have always been experimenting to find out the best alternative, which can maximize the positive interactions between the different components of the agroforestry system. Arrangements, priority, relative dominance of either components or order of preferences in combining crop, livestock and tree subsystems under the existing biophysical conditions are important factors differentiating various agroforestry systems from each other. These combinations and arrangements, both temporal and spatial, have special significance to the context of Nepalese agroforestry systems, practiced in small fragmented land holdings. Types of land available, particularly *bari* lands with terraces, livestock composition and herd size, and the nature of cropping system in the study area make agroforestry an integral part of the household production system. In the pursuit of maintaining livelihood system under the prevailing conditions, different agroforestry systems have evolved through the natural growth and deliberate plantation of woody perennials in farmlands along with cultivation of field crops and or rearing of livestock.

5.5 Agroforestry Systems

The widespread presence and maintenance of trees on the farmlands indicate that farmers from generations have recognized the importance of trees as an essential component of the farming system. Although farmers clearly express that growing particularly taller tree species, in farmlands causes some losses in crop production, thy cannot forgo benefits that accrue from trees. To minimize the losses caused by integrating tree with field crops, farmers have developed different types of method to make the agroforestry system more compatible with their farming system. The farmers have developed their own ways of managing trees and agricultural crops in different agroforestry systems.

Several systems practiced in the study area can also be grouped broadly into two categories of being traditional and improved. Having similarities with the traditional systems, the improved systems are characterized by the introduction of exotic fodder, grass species and better management practices. Management practices in terms of controlling height, time and frequencies of cuttings, and arrangement of species are helpful in identifying the improved systems with the existing traditional systems, where farmers have established fodder, fuelwood, and fruit trees in and around their farmland. Farmers assisted by NAF have been trained to adopt improved nursery and management practices, and persuaded to adopt specific tree-crop combinations to maximize the benefis accruit from the positive interaction benefits. Complexity and diversity of the prevailing agroforestry system observed in the study area give rise to a difficult situation to classify them in accordance with the standard agroforestry classification systems. In a more wider perspective and as a single large system, the agroforestry system of the study area can be classified as an agro-silvo-pastoral (Crop-tree-animal) system. However, based on the researcher's knowledge of agroforestry and the working experience in the study area before and during the field survey, different agroforestry systems have been identified.

5.5.1 Home garden (*Bagaicha*) systems:

Few households have managed a small garden or intensively used patch of land near or around the house, which is termed as home garden. In Nepali, the system is sometimes called *ghar-bagaincha* system where farmers grow perennial trees with vegetables for their subsistence needs and to sell whatever surplus they have. In recent years particularly after the agroforestry interventions, farmers are emphasizing the use of market value crops in their garden. During the field work, discussions with farmers revealed that although home gardens are traditional practices, their role in subsistence farming system have become even more prominent as a result of villagers exhausting their accessible forest resources around their communities. Discussions with marginally poor farmers who do not have home gardens revealed that they are now in difficult position because the large amount of products that are harvested from home gardens have been collected from the forest in the past. Now the collection of such products from the forest has been curtailed severely both due to introduction of community forestry program where the access is controlled by the user group and decreased availability in the natural forests owing to increased human and livestock population and widespread deforestation.

Home gardens in scientific classification system are type of traditional farm-based *agrosilviculture* system found in the study area. Practice of growing a mixture of fruit trees, fodder species, and vegetables in and around farm households can be seen in nearly majority of the farm households. But only a small number of households (12%) in the study area have managed a particular home garden, which is called *Bageincha* in local language. Comparatively higher percentages of the households in "with" project (20%) situation have maintained home garden than in "without" project (8%) situation (Table 5.8). The increased number of home gardens in the project household may not be fully explained by the project intervention. But interventions have some effect due to the fact that farming household who had maintained few fruit trees near to their home have converted to small home garden by incorporating other agroforestry species after the project intervention and they term it as *bageincha*.

The average size of home garden in both the condition was found to be very small (1.16 ropani/HH). It was observed in the field that farmers have used the land as effectively as possible to produce a wide variety of products and becomes nutritionally important for the subsistence. In majority of cases, they are normally located in and around the households. Some household who moved from upper hill slopes to the lower foothill near the roadsides and did not sold their homestead, have still maintained their previous home gardens now located far way from their present household area. But during the discussion, farmers reported that such gardens are difficult to maintain due to their distance location from the household. Farmers are slowly converting them into cereal crop cultivation area by clearing the smaller trees and shrubs because it is increasingly difficult to protect the fruits, vegetables and other products being lost before they are ripen or ready for harvest. Arguably, intensive care is not possible owing to travel time taken to reach the place. According to farmers, the location of home gardens from the household area is one of the very important factors for its maintenance and sustainability.

Home gardens found in the study area are often bordered by live fences of different plant species. Integration of trees and shrubs (fruit, fodder, fuelwood, and timber) with vegetables and grass species is the characteristics phenomenon of the existing home gardens. Apart from the home gardens, farmers have also grown perennial or biannual vegetable shrubs, green vegetables and garlic under the tree/shrub species and as separate crops near the homestead. This is particularly done in the favorable locations, such as near the compost pit or the area where dishes are cleaned, household members wash their hands, face and wastewater is thrown. These areas are of particular importance for the household kitchen needs of those farm households without a proper home garden during dry seasons. Since moisture is always a limiting factor in the study area due to long dry period (more than 6 months per year), the reuse of household wastewater to grow some plants is very vital for the family. This is the example of optimum use of scarce water resource and recycling of resources within the household. Although the size of individual home garden is very small, their cumulative effects in terms of supporting livelihood systems and natural resource management are very crucial.

Table 5.8 Average size of Home garden maintained by household by land use type

Type of land use	Households (HH)		Size of the Home garden (ropani/HH)	
	Frequency	Percentage	Mean	Standard Deviation
With Project (n=82)	16	19.5	1.14	0.89
Without Project (n=141)	11	7.8	1.20	0.90
Total (N=223)	27	12.1	1.16	0.88

Source: Field Survey, 1998

It is observed that productive and protective multipurpose tree species are integrated in the home garden. The tree species often comprise the upper layer of the home garden, where canopies are arranged in different vertical layers. The medium layer is composed of the shrubby and medium height species, such as papaya, banana, and litchi. Vegetables, medicinal plants and grass species, such as tomato, eggplant, potato, napier, stylo, and NB 21 are at the lowest level. Home gardens generally have some fruit trees of different types depending upon the agro-climatic condition and size of the garden. Perennial fruit crops found in the home gardens include, banana, mango, citrus, *katahar* or jackfruit (*Artocarpus hirsuta*), litchi, pineapple, guava, papaya, and others. The analysis reveals that irrespective of the land use type, citrus, *katahar,* banana, mango and litchi are the dominant fruit tree species found in the home gardens (Table 5.9). Among the household having home gardens, overwhelming majority (94 %) in "project" and almost three fourth (73%) in non-project have planted and protected mango/litchi tree species in their home gardens. Results show that mango, and litchis are included by most households followed by citrus, jackfruit and banana in both cases. In terms of average number of individual species, banana in with project and jackfruit or *katahar* in without project household dominates the other species found in the home gardens. The numbers of multiple species are being maintained in the homegardens.

Table 5.9 Average number of main fruit trees in the home gardens.

Fruit tree species	With Project (n=16)		Without Project (n=11)	
	% of HH	No. of trees	% of HH	No. of trees
Citrus	62.5 (10)	9.8	63.6 (7)	8.7
Mango/Litchi	93.7 (15)	9.1	72.7 (8)	3.3
Jackfruit	50.0 (8)	3.4	36.4 (4)	13.2
Banana	31.2 (5)	31.0	54.5 (6)	8.0
Others	93.7 (15)	33.7	91.0 (10)	64.1

Source: Field Survey, 1998
Figures in parenthesis are frequencies of households.

Apart from fruit trees, farmers have planted and protected fodder, fuel wood and other plant species in their home gardens. Some of the fodder tree species are *Kutmiro, Badahar, Tanki*, and *Leucaena*. *Chap, Chilaune* and *Sissoo* are found among the important fuel wood and timber species (Table 5.10). Among the timber species in the home garden, *Chanp* and *Sissoo* are high valued. Out of the total households having home gardens, only 12% belonged to "with project" situation have planted *Sissoo* in their home garden whereas no households in "without project" situation have included *sissoo* in home gardens. This is due to the project intervention and availability of *sissoo* sapling in project areas as well as other technical and extension support extended by NAF for its promotion and production.

Table: 5.10 Important fodder, fuelwood and other species in the home garden

Species type	With Project (n=16)		Without Project (n=11)	
	% of HH	No. of trees	% of HH	No. of trees
Kutmiro/Badahar	12.5 (2)	29	18.2 (2)	9
Tanki	6.2 (1)	2	36.4 (4)	31
Other fodder trees	50.0 (8)	116	54.5 (6)	71
Chap	18.8 (3)	3.7	45.5 (5)	8
Sissoo	12.5 (2)	163	-	-
Chilaune	18.8 (3)	26	36.4 (4)	31
Other timber trees	12.5 (2)	48	36.4 (4)	57
Medicinal plants	12.5 (2)	4	-	-
Other plant species	31.2 (5)	13	36.4 (4)	17

Source: Field Survey, 1998
Figures in parenthesis are frequency of households.

Farmers revealed that the home garden practice has developed to serve the household with daily basic needs and to utilize the available resources around the households. They also reported that system is a good example of maximizing per unit land productivity from small holders' perspective in the hills. In the study area, home gardens normally supplies the households' kitchen needs. A number of pulses like pigeon pea, black gram and horse gram and oil seeds, such as groundnut, are commonly integrated into the home gardens as a understorey ground layer species. Local green leafy vegetables, beans, spices and medicinal plants are also grown under trees. Apiculture is also practiced by some farmers in their home gardens located adjacent to households. These gardens satisfy the local demand for fruits, beans, fuel wood, medicinal plants and raw materials for the rural handicrafts or cottage industries.

Moisture is the limiting factor in the Hill crop production system. Even drinking water becomes the problem during several months of the year. Establishment of a small portion of their land as a garden with multiple species of plant is vital. Wastewater from the kitchen is used to raise the seedlings or even provide moisture to the crops grown in home gardens. This is particularly important during the long dry spells in the Hills. Whenever farmers introduce any new species, either fruit, fodder, grass or vegetables, he/she generally plant them either in the home gardens or in the homestead areas to see its adaptability and performances. In that sense, home garden serve as the nursery for many plant species. Because homestead area is highly fertile, moist and farmer can provide intensive care. It is found that farmers involved in agroforestry interventions have managed their home nurseries mostly in their home gardens.

5.5.2 Agroforestry system of maintaining perennial tree/shrub and grasses in terrace risers combined with field crop cultivation in the terraces

This is an *agrosilviculture* system where woody perennials have been grown in agricultural fields, in farm boundaries or in terrace risers. This is a well-adopted practice by farmers in the study area and commonly referred to as *Khadyanna-ban misrit* (tree-crop mix) system in Nepali. Increasing number of farmers, under this system of agroforestry, do not prefer to plant trees with higher shading effects in their croplands. Usually they prefer to plant with light crowned trees, such as *Siris* (*Albizia spp.*), ipil-ipil (*Leucaena spp.*) on their terrace bunds. Despite farmers' concerns of negative effects, they have maintained number of tree species in the terrace risers particularly in bari lands. The agricultural crops grown by farmers in this system are maize, wheat, buckwheat, and millet. As every farmland found have been terraced, there is tremendous potential to increase tree densities by utilizing the unused terrace risers.

Fodder trees and grasses have been planted or protected from naturally grown stocks since generations in such risers. The plantation of agroforestry species in the terrace risers makes maximum possible use of the available land space within smallholdings contexts. It ensures the availability of fodder and grasses near the home and efficient use of areas that would otherwise be left unused. It is observed during the survey that large areas of terrace risers are still vacant and there is enormous scope for plantation work. As lots of terrace risers that farmer have are not being used to their capacity. It helps to strengthening of the risers, reduce soil erosion and provide fuel-wood from the pruning of tree fodder. Due to NAF promoted agroforestry interventions, some changes are seen in the existing systems in terms of management and utilizing the terrace risers. Therefore two types of patterns are seen under this system namely the existing traditional system and NAF introduced improved alley cropping system.

5.5.3 Existing Traditional System

Under the traditional system, scattered trees of different uses have been maintained in the farm along with the cultivation of agricultural crops. Depending upon the grass species, planting is done in the terrace risers. There are various grass species, some of them are naturally grown and some others are planted in the terrace risers (Table 5.11). Farmers involved in agroforestry project have planted Napier and NB 21 grass species in the *khet* and *bari* terrace risers, and bunds. After the introduction of some grass species, farmers from other areas, who were not interested to start agroforestry program in the beginning, have also planted these grass species in their terrace risers after visualizing the potential benefits obtained. NB 21 is particularly liked by all the households, because of its multiple benefits, such as a good fodder for dry season, easy to propagate, have no adverse effect on crop yields, and preferred by animals. Adoption of NB 21 is extremely high. During the most dry months of the year, where no other green grasses will be available in the farmlands, NB 21 was observed as green fodder growing in all most all the bunds and terraces of the farmlands in the study area. Farmers unveiled that they are able to sell grass slips to District Soil Conservation Office for Danida funded watershed management project, which encouraged other farmers to adopt the practice. Farmer to farmer extension of NB 21 grass species has become a reality.

The results show that NB-21 is very popular in the with project situation as majority of households (71%) have planted this species in their farmland in comparison to without project case where only less than one third of the household have planted. Among many other local grass species, *Musekharki* have been maintained in majority of households of both with project (63%) and without project (75%) situation. In case of households involved in agroforestry interventions, terrace risers, where musekherki and other local grass species are grown, have been replaced by NB 21 grass species. In terms of number of terrace risers (*Kanla*) occupied by different species, *Siru/Kans* (13.9) in with project and *Musekharki* (16.3) in without project situation have higher number of terrace risers per household (Table 5.11).

Table: 5.11 Average number of terrace risers per household covered with major grasses.

Type of grass species	Mean number of terrace risers (*kanla*) per households							
	With project (n=82)				Without project (n=141)			
	F	F'	CF	Mean	F	F'	CF	Mean
NB-21*	58	70.7	19*	9.8	37	26.2	10*	6.8
Napier	20	24.4	10	5.4	11	7.8	10	7.7
Musekharki**	52	63.4	2	11.1**	106	75.2	2	16.3**
Banso	17	20.7	2	6.3	26	18.4	2	4.9
Siru/Kans	38	46.3	2	13.9	55	67.1	2	12.9
Other grasses	2	2.4	-	3.5	4	2.8	-	6.7

Source: Field Survey, 1998
Figures in parenthesis are number of households' response
F = Frequency of households; F' = Percentage of households
CF = Cuttings frequency per year
* F-test significant at 0.004 ($p<0.01$)
** F-test significant at 0.004 ($p<0.01$)

Grasses are grown either separately or as understorey below the fodder, timber trees/shrubs, which occupies the upper layer of the agroforestry system. Fodder tree species, such as lower to medium height leguminous trees and evergreen, as well as winter deciduous species, are planted at a close spacing in a single row on the upper part of the terrace risers just below the bunds. Depending upon the height of the terrace risers and the type of species, farmers have also planted another row of trees species below the first row. Several fodder tree species (trees and shrubs) have been either protected or planted in the terrace risers. Majorities of the households in with project have maintained Khashreto (90%), Gayo (82%), Tanki (79%), *Kutmiro* (78%) *and Khanyo* (72%) in their farmland. Similarly, *Tanki* (87%), *Kutmiro* (86%), *Khastero* (85%) and *Khanayo* (82%) were found in majority of the farm households in without project situation (Table 5.12). This shows that these are the most preferred local fodder trees found in the study area. In terms of average number of fodder tree species found per household, *Tanki* stood the upper most species preferred by farmers in both with (9.5 trees per household) and without (9.2) project situation followed by Khanyo (6.5), *Kutmiro* (6.1) and *Bakhre* (5.9) in with project. For without project situation, the higher mean values of 9.2 for *Tanki*, 7.7 of *Khanyo*, 6.8 for each of *Gayo* and *Kutmiro* have been found. But in terms of average number of tree species found per household, only *Phurse* in without project (5.2 trees) is significantly higher ($p<0.05$) than in with project (2.2 trees). Similarly numbers of Ginderi found in with project (4.3 trees) is significantly more than without project (2.5 trees) household.

Table: 5.12 Average number of some fodder trees per household by land use type

Name of fodder tree species	With AF project (n=82)			Without AF project (n=141)		
	Households		Mean # of trees	Households		Mean # of trees
	F	F'		F	F'	
Gayo	68	83	5.2	88	62	6.8
Khanyo	59	72	6.5	116	82	7.7
Kutmiro	64	78	6.1	121	86	6.8
Phurse #	28	34	2.2	40	28	5.2
Badahar	25	30	2.1	20	14	1.4
Dabdabe	56	68	4.4	68	48	5.8
Bans	08	08	2.9	08	06	1.9
Tanki	65	79	9.5	122	87	9.2
Khashreto	74	90	6.0	120	85	5.5
Dumri	39	48	1.9	29	21	2.3
Gindari ##	56	68	4.3	78	55	2.5
Jalma	27	32	1.7	20	14	2.1
Kapro	55	67	2.9	74	52	3.1
Newaro	14	17	4.4	10	07	1.3
Tartalo	16	20	2.2	31	21	1.5
Bakhre	38	46	5.9	79	56	6.1
Gede	06	07	1.2	36	26	2.9

Source: Field survey, 1998
Significant at 0.032 level ($p<0.05$)
Significant at 0.006 level ($p<0.01$)
F = Frequencies of households; F' = Percentage of households.

In the existing agroforestry system these perennial tree/shrub/grass species are scattered throughout the farmland. In some plots, such as *kanle bari, dhunge bari, pakho khet* and *kanle khet*, the density of tree species is normally higher than *pata bari, tar bari, tari khet* and *geiri khet*. Majority of the households practice *khadyanna-ban misrit* system, where crop rotation is an important management practice. As farmers in the study area grow crops in sequence in the same part of the field, this system is further categorized into *Makai-ban misrit* (maize-based) system and *Dhan-ban misrit* (rice-based) system. In *Makai-ban misrit* system, maize is the major crop grown in the field while trees are grown along the terrace risers of the *bari* land. Maize-vegetable-wheat is being the most common pattern of cropping system under this system. Maize is shown in April/May and is harvested during July/August followed by vegetables or sometimes with upland rice. Wheat as a third crop is sown in

November/December after vegetables are harvested in October/November. Under this system, two types of perennial combinations are seen in the farmers' field. One involves the naturally grown trees along terrace risers whereas the other deals with exotic and /or indigenous mixed tree species planted in terrace risers, which are frequently loped to maintain low height. This second pattern, promoted by NAF, is the modification of the first pattern.

In *Dhan-ban misrit* system, rice is the major crop grown while tree/shrub and grasses are maintained along the terrace riser/bunds of *khet* land. The common cropping pattern practiced is rice/soybean-wheat-maize or vegetables. Soybean seeds are sown in bunds when rice seedlings are transplanted in July. After rice harvest in October/November, wheat is sown and is harvested in March/April. In general case, *khet* lands are normally kept free from naturally growing tree species as well as farmers are reluctant to plant trees on *khet* lands. In contrary to general belief and practice of not growing trees in khet, farmers of the study area have planted and protected number of tree species in their *khet* land. But trees planted in *khet* land differed from those in *bari* land. Mostly less shading, deep-rooted leguminous trees, such as *Leucaena* and *Flemingia sp.* are planted in the bunds of *khet* land. Introduction of these species is the improvements on existing agroforestry system. Obviously the system was adopted after NAF staff and local NGO volunteers encouraged and promoted the agroforestry system.

5.5.4 NAF introduced improved agroforestry system (Alley cropping)

Apart from the traditional practices of agroforestry, farmers in the study have adopted several improved practices promoted by NAF. Most of the improved practices are the improvements in the traditional systems with some modifications, such as height of the trees, introduction of exotic tree/shrub/grass species and arrangements of different species within the existing system being practiced by farmers. Alley cropping is one of the improved methods adopted. Viewing the shortage of fuelwood and fodder, NAF introduced certain species to be planted in the terrace bunds and risers, which are mostly underused. Some of the important fodder tree species introduced are, different species of *ipil-ipil* (*Leucaena leucocephala; L. diversifolia, L. pallida), bhatmase (Flemingia congesta), guajuma (Guazuma ulmifolia),* and *kimbu* (*Morus alba*). Under the NAF promoted agroforestry project intervention, the underutilized terrace risers, terrace edges, fallow lands and lands not suitable for cultivation have been used for planting. The terrace risers between the terraces have been the focus of the NAF agroforestry program where farmers have planted rows of grass and tree species.

Alley cropping is an *agrosilvopastoral* agroforestry system where fast growing, nitrogen fixing shrubs and trees are planted in hedgerows together with naturally grown and traditionally maintained local tree species, and food crops are interplanted between the rows. The pruned foliage is used to feed livestock. Farmers involved in agroforestry project have started to plant rows of leguminous species trees, such as *Leucaena sp.* on the terrace bunds as like of alley cropping but it is not done inside the terraces as such. In the design part, the system is bit different from that of typical alley cropping where crops are planted in between the rows of perennial trees. It is to be noted here that terrace risers still have number of indigenous tree species, which are taller and have large canopy cover. But the density of such species is very low to no trees in some terraces.

Depending upon the height of the terrace, the tree species are also planted in one or more than one rows in the risers just between the bunds and terrace flats. *Khet* terraces have been planted with single row of fodder species. Two or more rows are found in *bari* terraces, where the top most row at the bunds and near to the crop comprised of leguminous species, such as *Leucaena* or *Flemingia.* Non-leguminous fodder species, such as *Morus alba, gaujuma* are planted below the bunds or in second row. The terrace space, which are normally narrow (2-4 meter wide) in the study area, between the two terrace bunds and risers resembles the "alleys" where food crops are grown. This system provides green foliage for livestock fodder, the fuel wood for household cooking and green manure for food crops.

One of the important tree component management aspects of alley cropping is the maintenance of tree heights. This is done to minimize the adverse effect of shade on crop yield and competition for getting sunlight between incercropped species. Aerial manipulation of light interception by maintaining the cutting heights through regular pruning is the characteristic phenomenon carried out by farmers in the study area. Cutting at the breast height (about 1.5 meter) was found appropriate under farmers' condition through NAF on-farm research and farmers' experimentation carried out on *kimbu* and *ipil-ipil* species. The beauty of the system adopted by the farmer is that small tree and shrubs planted are pruned regularly for fodder, which prevent them from producing too much shade to field crops. Similarly, women find it easy to cut fodder when maintained at breast height by standing on the terrace bunds or risers. Unlike most of the local fodder tree species, where they are harvested only once a year except *ginderi* and *dabdabe* (*Geruga pinnata*) which are loped twice, the introduced tree species are pruned even 4- 5 times a year. In contrast to the typical practice of alley cropping, where the pruned foliage are incorporated into the soils as green matter, farmers in the study area use them as livestock fodder and no foliage except fallen leaves is incorporated into the soil.

5.5.5 System of crop cultivation intercropped with fruit trees (Agrosilviculture).

Farmers cultivate fruit trees for home consumption and cash earning to invest in farm production as well as for the family welfare. Farmers cultivate field crops, such as maize (*Zea mays*), finger millet (*Eleusine coracona*) and grain legumes under the fruit tree plantation, such as mango (*Mangifera indica*) and litchi (*Litchi chinensis*) orchards. Apart from mango and litchi, some other fruits cultivated in the study area are, papaya (*Carica papaya*), jack fruit (*Artocarpus integrifolia*), banana (*Musa paradiceae*), guava (*Psidium guajava*), *citrus* species, peach (*Prunus persica*), pomogranate (*Punica granatum*) and pineapple (*Ananus sativus*). Growing field crops under fruit trees is also an another type of practice under *agrosilviculture* systems. Although not done in larger scale, farmers having large acreage of land practice this system. Once the fruit trees get older and do not yield to a considerable level, then they are cut and used as fuel wood or timber. This type of agroforestry is found more prevalent in the foothills and valley bottoms than hillsides, hilltops and the ridges. Farmer practice wider spacing varying from 5 to 6 meters between fruit trees to enhance crop cultivation. The agricultural crops are mainly the cereal crops like maize and wheat and different kinds of vegetables. Although the extent of fruit plantation varies, farmers' practice of crop cultivation integrating with fruit trees is an important *agrosilviculture* system.

Among the fruit trees grown by the households, banana plants dominate both with project (71%) and without project (61%) situation followed by citrus trees in with project (59%) and without project (48%). The results show that significantly higher ($p<0.01$) numbers (32) of local banana trees are found in with project than without project (11) situation (Table 5.13). In comparison to non-project households, peach trees were found significantly higher ($p<0.01$) in project household's farmland. Among the improved varieties of fruit trees planted and protected, mango is the most preferred as nearly sixty percent of the household in project and one third in non-project have improved mango trees in their farmlands. This result indicates that in comparison to local varieties, household planting improved variety is more than four folds in project situation. Notably, farmers belonged to project had higher number of improved mango trees (3.9 trees per household) than non-project households (2.6). Results indicate that households in project situation had significantly higher ($p<0.05$) number of other different fruit trees than in non-project situation.

Table 5.13 Average number of selected fruit species per household by type of land use

Name of the species	With Project (n=82)				Without project (n=141)			
	Local varieties		Improved varieties		Local varieties		Improved varieties	
	F	Mean	F	Mean	F	Mean	F	Mean
Mango	11(13)	1.9	48 (59)	3.9	27 (19)	1.7	39 (28)	2.6
Citrus*	48 (59)	2.5	5 (6)	3.8*	67 (48)	2.3	6 (4)	11.0*
Pear (Naspati)	15 (18)	1.9	3 (4)	7.7	19 (13)	3.1	7 (5)	2.0
Aru (Peach)	39 (48)	2.2 **	5 (6)	1.2	45 (32)	1.3 **	7 (5)	2.3
Guava	18 (22)	4.2	3 (4)	2.7	20 (14)	2.3	4 (3)	2.7
Pineapple	35 (43)	137.0	4 (5)	33.4	28 (20)	69.7	2 (1)	100.5
Jackfruit	32 (39)	4.4	-	-	22 (16)	1.3	-	-
Papaya	22 (27)	8.5	2 (3)	152.5	15 (11)	6.7	1 (0.7)	2.0
Banana	58 (71)	31.8**	4 (5)	10.2	86 (61)	11.1**	4 (3)	4.0
Others ***	7 (9)	26.6	5 (6)	73.4	11 (8)	2.0	6 (4)	3.4

Source: Field Survey, 1998
F = Frequency of households
Figures in parenthesis are percentages
* Significant at 0.029 level ($p<0.05$)
** Significant at 0.001 level ($p<0.01$)
*** Significant at 0.025 level ($p<0.05$)

Cultivation of mango, pineapple and banana by most of the households in with project situation show that farmers are more aware of growing fruit tree species which fledge more price in the market. In case of citrus, local variety is grown by more than half of the households in project and about half in non-project situation. Interestingly, the average number of improved citrus trees/shrubs in non-project is found significantly higher ($p<0.05$) than project. But only a few households from both situations have planted improved citrus varieties. During the field survey, it was revealed that NAF has been providing training in fruit tree nursery management, propagation, and integrated pest management. Some respondents have already received such training from NAF and have started planting number of improved variety of fruit trees.

5.5.6 Trees/shrub combined with animal production system (Silvopastoral)

This type of agroforestry system is very common in the study area, as livestock is the integral part of the farming system. Majority of the farmers practice cut and carry system, where tree fodder, such as *Khanyu* (*Ficus semicordata*), *Gogan* (*Saurauria nepalensis*), and *Kimbu* (*Morus alba*), Tanki (*Bauhinia purpurea*), Kutmiro (*Litsea monopetala*) and grasses, such as Napier (*Pennisetum purpureum*), Stylo (*Stylosanthes sp.*), and NB 21 (*Pennisetum sp.*) are cut and carried from their own farmland to the animal shed and fed to livestock. These cut and carry systems have become more important due to the increasing stall feeding practices after the intervention of agroforstry program. In another system, *kharbari* is an important piece of land that an individual farmer holds, where grasses and fodder trees are maintained along with the *khar* (*Typha angustata*). Some of the tree species like bakaino (*Melia azerdarach*), boddhairo (*Lagerstroemia parviflora*), tuni (*Toona ciliata*), and sals (Shorea robusta) are found in the *kharbari*. Farmers have also established different fodder, fuelwood, and timber tree species in their marginal lands, dry farmlands, and non-cultivated inclusions. Certain portion of the Kharbari is sometime used for grazing animals, as grazing in the forest is already limited.

Apart from community forests, farmers take their animals to other available grazing places either community or privately owned. The community grazing lands are virtually under severe degraded condition with no substantial regrowth of grass species taking place due to increased pressure by grazing animals. The declines in community grazing areas have forced farmers towards additional tree plantation. Areas available around the farm boundaries, not used for crop cultivation, have become important grazing places for animals. More farmers have been involved in plantation of different plant species in their farmlands thereby limiting the free grazing practices. In the past, animals were allowed to graze in both *khet* and *bari* lands during fallow periods. Even during the winter months when farmlands are fallow, farmers are not able to allow their animals graze in the farmlands due to newly growing plant species in their own lands and of neighbors' farmlands. The land with fodder trees also serve as a fodder bank for the winter and dry season. *Silvopastoral* system increase income by producing meat and other animal products, contribute to organic manure for the agricultural field and reduce weeds in community, government and private forests plantations and shrub lands.

In recent years, farmers are trying to use all the available spaces within their farmlands to meet the growing fodder needs. During the discussion with farmers it was explored that there are hardly any households, which does not have some kind of uncultivated, marginal or rocky lands not suitable for crop cultivation. But extent of such land varies household to household. These lands are therefore the main places where trees, particularly fodder trees, are planted for livestock fodder. Plantation of useful tree, shrubs and grasses on those lands as well as on other cultivated lands have increased in recent years owing to the effective implementation of community forestry program where community forests have been managed by user groups with certain restrictions imposed on free access. Farmers clearly admitted that they are looking for tree species that can yields to multiple lopping a year in contrast to single harvest of majority of the indigenous species in the study area. They also revealed that grasses like NB 21 have become popular due to this important parameter.

5.5.7 Crop, Livestock and Tree integration System (Agrosilvopastoral System)

Field crops integrated with livestock and forestry is one of the most common agroforestry systems found in the study area. These systems as the name imply combines trees, and herbaceous crops with animal and /or pasture. The traditional subsistence agroforestry systems are in fact *agrosilvopastoral* systems. Different kinds of tree/shrubs and grasses can be seen on farmlands, particularly along the edges or risers of the terraces and /or around the field boundaries. Trees, shrubs inside the field are scattered whereas they are densely planted/protected in the field boundaries. The type of fodder, fruit and grass species planted in the farmlands are presented separately in this chapter (Table, 5.13, 5.14 and 5.18). The other species, which are important for fuel wood and timber, found in the farmland are chilaune, phandir, sal, chanp, karam ankhatare and boddhayero (Table 5.14). These species are mainly found in the forest but farmers have also maintained them in their marginal lands usually not used for cultivation and occasionally in cultivated lands. Mainly cut and carry system of fodder is used because there is restricted scope to take the farm animals to these forest areas owing to the closure of community forests.

Table: 5.14 Some important fuel wood, timber species found in the study area

Species Name	With agroforestry project (n=82)			Without agroforestry project (n=141)		
	Households		Mean # of trees	Households		Mean # of trees
	Frequency	Percentage		Frequency	Percentage	
Chilaune	55	67	23.0	117	83	17.2
Phandir	39	48	10.0	33	23	4.7
Sal	37	45	21.4	43	30	35.2
Tidu	11	13	2.2	16	11	2.7
Champ	7	09	2.0	5	04	2.0
Karam	19	23	4.6	16	11	4.8
Botdhayero	43	52	9.7	46	33	9.1
Saj	34	41	1.9	36	26	2.9
Bar/pipal	41	50	2.6	57	40	2.2
Ankhatare	18	22	6.1	13	09	4.3

Source: Field Survey, 1998

Among the fuelwood and timber trees, the overwhelming majority of households (83%) in without project and majority of households (67%) in with project have maintained an average number of 17 and 23 *chilaune* trees per households respectively. *Chilaune* is an important fuelwood and timber tree species found in the study area. Sal (*Shorea robusta*), which is considered one of the best timber trees, have been maintained by almost half of the households in with project and one third in without project, with an average of 21 and 35 trees per household respectively. Interestingly, *bar/pipal* (*Ficus religiosa*) trees, which have high religious sentiments and not widely used for fuelwood, timber and fodder in certain parts of the country, have been protected by more than half of the project households and two fifth in without project (Table 5.14). Community people use pipal tree leaves to feed goats. Pipal tree leaves are in fact highly preferred by goats.

Along with the livestock production, fodder, fruit, fuelwood and timber trees are commonly found scattered throughout their fields. Fodder trees are regularly lopped once in every year or more depending upon the growth parameters and agronomic characteristics of the species concerned. Lopping of such trees, which is normally done during the winter months when there is shortage of fodder is favorable for winter crops as the practice reduces shade against them. When crops are sown or planted and they are very young, the tree will not have developed its canopy and cause less shade. By the time tree attains its maximum canopy and have larger shading effect, crop grown in the farmland reaches the maximum vegetative growth or attains reproductive phase. This mechanism of avoiding shading effect is very crucial to minimize crop loss due to shading. Other strategies are that tree species are planted along the borders of agricultural lands, maintain in the gardens, on fallow lands and on wastelands.

Farmers have also maintained some tree species that are economically valuable. Some of such valuable tree species found are Chiuri (*Bassia butyracea*), Amala (*Emblica officinalis*) and Odalo. Chiuri and amala fruits can be sold in the market. Chiuri is good for apiculture. Bark of some species such as, Dabdabe and Amala are important for their medicinal value. Odalo is found in the forest, however around one fifth of the household in both with and without project situation have maintained these trees in their farmland (Table 5.15). The tree is very important for farmers to make ropes (Damla, and namla) that are used to tie farm animals, carry fodder and other materials.

Table: 5.15 Selected economically valuable tree species found in the study area

Species Name	With project (n=82)			Without project (n=141)		
	Households		Mean # of trees	Households		Mean # of trees
	Frequency	Percentage		Frequency	Percentage	
Chiuri	13	16.0	1.5	13	9.0	1.4
Amala	11	13.0	2.8	14	10.0	1.6
Odalo	16	20.0	3.3	31	22.0	3.7

Source: Field Survey, 1998

Farmers in the study area practice bamboo cultivation in integration with field crops in their farmlands. Different types of crops, such as maize wheat, and paddy, are planted. Bamboos have multiple uses ranging from fence posts, matting, ceiling and eating as vegetables to construction of walls in the houses. Varieties of products from handicraft making, and furniture for household use makes up to the market. Bamboo leaves are nutritious and palatable fodder for animal, whereas branches and waste clumps are used as firewood. Bamboo planting in the study area is mostly limited to the edge of terrace slopes, and gullies, acting as a very important and useful species for soil conservation.

Farm households gather multiple products from farmlands, non-cultivated inclusions, community lands, community forests and natural forests for their subsistence requirements. Particularly for resource poor farmers, these products harvested from various sources serve as emergency food, important vegetables and medicinal purposes. During the field visit, information on some of the important food crop species, which are not utilized to their maximum capability to support the livelihood system, were gathered through discussions with farmers involved in collecting those products from various sources occasionally (Table 5.16). Different kinds of products are harvested for home consumption but no serious efforts are given to improve their availability either in the natural habitat or in the private lands. Some of the species could become very useful in integrating into the agroforestry system to increase per unit land productivity and effective utilization of farmers' available land resources.

Table: 5.16 Some important underutilized food crop species in the study area

Name of the species	Plant Characteristics	Uses	Remarks
Githa Tarul (Dioscorea bulbifera)	Wild growing, rhizomatous root and aerial tuber.	Emergency food and medicinal uses	Available from August to December
Bhakyur (D. deltoidea)	A perennial herbaceous wild climber propagated by tuber.	Medicinal and emergency food	Available from Dec. to March/ April
Paniamala (Nephrolepis cordifolia)	Perennial herbaceous tuber bearing roots grown wild.	Grown as foliage ornamental	Mostly growing as wild in terrace, edges
Chariamili (Oxalis corymborsa)	Low growing herb, propagates by itself	Tender foliage and bulbous tuber	Foliage is pickled.
Van Kurilo (Asparagus racemosus)	Herbaceous perennial, mostly gown in wild habitat.	Tender leafy shoots are consumed.	Available during July to September
Tamabans (Dendrocalamus hamiltonii)	Tall growing grass propagated by rootstock	Tender spring shoot consumed.	A grass of multipurpose uses.
Lunde (Amaranthus blitum)	A summer annual herb of gregarious habit,	Tender shoot eaten as vegetables	Rich is minerals and propagated by seed.
Sisnu (Urtica parviflora)	Herbaceous perennial with stinging bristles	Tender foliage is consumed.	Propagated by rootstock
Niuro (Dryopteris cochleata)	Perennial herbaceous fern propagated by rootstock.	Tender stem and leaves consumed	A regularly marketed wild vegetables.

Source: Field Survey, 1998

Regarding the question as to why "under-utilized wild food crop species" are not used by more household or cultivated on farms, one of the reasons mentioned by farmers was that some of them, such as *Dioscorea* species, are normally eaten by very poor villagers who had extreme food shortages (known as fallback crops). People have not made attempts to domesticate other species, such as *Asparagus racemosus,* as they are not aware of market potential and techniques of domestication. Some farmers were also found to be selling the roots of this species collected as medicinal herbs from forests. Yet, they did not cultivate it on farms. In view of the demand for *Asparagus* in Kathmandu, NAF has recently taken initiative to promote its cultivation on a trial basis. For some communities like Chepang (a minority hill tribe living in high hills of Dhading, Makwanpur and Chitwan districts), collection of wild fruits, nuts, berries and yams was the traditional source of food. Later on this practice scaled down as they starting practicing shifting cultivation of cereal crops. Some of these species, such as *Dryopteris cochleata* and *Asparagus racemosus* are sold in Kathmandu market. Even in other hilly areas, people collect some wild vegetable species, such as *Amaranthus blitum*, *Urtica parviflora*, and *Dryopteris cochleata* especially in the dry season when there is insufficient supply of farm vegetables, but so far they have not considered domesticating wild vegetable species.

5.5.8 Live fences around farmlands (Agrosilviculture system)

Farm lands are surrounded by lines of trees or shrubs planted on the farm boundaries. These living fences are found on the borders of home compounds, home gardens, pastures, crop fields, kharbari and also used as animal enclosures. In this section, living and live fences are used interchangeably as they refer to the same thing. During the discussion with the farmer regarding the purpose of live fences, they reported that practice of live fence primarily evolved due to the need of protecting field crops, vegetables or plants in the home gardens from animals. Not only the control of animals was important but also farmers need to control the movement of people in their farmland to protect crop damage due to movement as well as theft of some cash crop, fruits or even farm implements. Besides their main function of controlling human and animal movement inside the farmlands, live fences have been providing fuel-wood, fodder and food for the household needs. Farmers revealed that they also act as wind breaks, and provide shade during hot sunny days in field. Although live fences have been contributing to enrich the soil fertility, acting as bee forage, controlling dust and noise pollution, minimizing the soil erosion and bringing overall improvement of the environment, farmers do not give proper credit and economical value for such beneficial effects of live fences. Live fences are equally good to arrest soil erosion. In sloping terraces, live fences turn into the vegetatively constructed terraces. Such important roles of live fences in the hills have received less importance in farmers' recipe and have not been estimated as well by researchers.

Initial establishment of live fences, which requires investments and efforts, is very crucial for farmers. For the initial establishment period, live fences are protected by the farmers either with temporary man-made structures or by restricting the movement of animals and human for few years until the species planted are tall enough to withstand browsing livestock. Once they are established the temporary structure, such as fence made out of sticks or woods are removed to another farm plots for similar purpose. Stones are used whenever they are available. Since farmer find it very difficult to protect the live fence species being browsed by the grazing animals, they select those species, which are least or not preferred by animals. Farmers usually prefer thorny species, such as *Sihundi, Bhainsi Kanda*, *Ghiu kumari,* and *Nil Kanda* for the outside layer of live fence. Normally fodder, fuelwood, timber and green manure species are included in the inner layer of the living fence. Depending on the tree and shrub species planted on the lives fences, farmers regularly practice pruning to control excessive shade to adjacent field crops. Farmers are concerned with the optimization of spatial and temporal combinations of tree-shrubs and herbaceous species in the live fences.

Green manure species are grown as live fences but not necessarily grown together with field crops. Only few species like *khirro, siris* are protected in the bari terraces and some are grown in farm boundaries. Majorities of them are found naturally grown as wild plants and protected by the farmers in and around the farmlands, either sides of the village walkways, in and around natural water resources, non-cultivated inclusions, community lands and in any other fallow lands. Out of several species that have potential green manuring value, some commonly used species are *asuro, titepati, khirro, ankhitare, siris*, and rice bean. Apart from these species, there are other species found in the study area, which have green manuring values.

Those species are *Bakaino* (*Melia azaderach*), *bakula simi (Vicia faba)*, *Banmara* (*Eupatorium adenophorum*), *Simali* (*Vitex negunda*), *Chilaune (Schima wallichii)*, *Jhuse Til (Guizotia abbysinica)*, Pumpkin (*cucurbita moschata*), *Rato siris* (*Albizia procera*), and *sajiwan* (*Jatropa curcas*). Farmers have not made use of such species for green manuring purpose as such but they are in use by the farmers for different uses, such as fodder, food grain production, and live fences. Although green manure species have greater role in increasing productivity and improving the quality of agricultural land, their use is primarily limited to rice crops. Rice fields are ploughed and irrigated before incorporating the green manuring species. Succulent twigs and leaves of the green manuring plants are collected and spread over the field. The field is then ploughed to incorporate the bio-mass into the soil. Water depth is maintained for few days to decompose the added green manure. Then rice seedlings are transplanted into the puddled soil.

Species selection for live fences is very important because species with competitive rooting systems, which are aggressive, sprouting or self- seeding, producing growth-inhibiting substances or toxins, high competitive for plant nutrients may reduce the crop yields severely. Farmers, through their experiences gained over the years, are knowledgeable to select appropriate species for their live fences. Experience sharing discussion meetings held with the farmers during the field survey revealed some important facts on species selection. Farmers revealed that they value certain characteristics, such as quality fodder, easiness in propagation, initially fast growing, able to withstand frequent lopping and strong winds, and withstand the frequent browsing by animals, as more important to others while selecting the species. Many different species are found to be having potential role in live fences but only some of them are being used for live fence. Their use depends upon the ease of establishment, specific needs of a farmer and the type of farmland to be living fenced. The most common species are *Nil Kanda* (*Duranta repens*), Sajiwan (*Jatropa curcas*), *Tanki* (*Bauhinia purpuria*) and *Asuro*. In recent years, farmers involved in the project have planted *Sisoo* (*Dalbergia sisoo*) and *Ipil-Ipil* (*Leuceana leucocephala*) at the boundary of their farmlands as live fence species (Table 5.17).

5.5.9 Shade loving plants under trees/shrubs (Silvoagriculture):

Farmers grow shade-loving crops with tree species, which is termed as *Silvoagriculture* system. This system of agroforestry is generally practiced by majority of farmers but their extents vary enormously. Under this system, farmer practice growing of shade loving plants, such as ginger and turmeric under tree canopies. The commonly found tree species are *eucalyptus*, *utis (Alnus nepalensis)*, sissoo (*Delbergia sisoo*), and *casia*. This system is very much limited to planting of few shrubs or clumps or slips under the tree usually for home consumption. Adoptions of this practice have largely been dependent on whether households have some moist areas where they have maintained old plantation.

5.5.10 Hedgerow Plantation of Multiple use shrub:

After the NAF promoted agroforestry program, few farmers are being trained and motivated to start hedgerow plantations. Some farmers have already started the establishment of few hedgerows on their farmlands in trial basis. The species used in the hedgerows are ipil-ipil (*Leucaena leucocephala*), *bhatmase* (*Flemingia congesta*), *cassia sp*., *calliandra spp*., *sesbania sp*. and pigeon pea (*Cajanus cajan*). This system is promoted for the purpose of constructing terraces vegetatively on the sloping *bari* terraces similar to that of SALT (Sloping Agriculture Land Technology) practices. Farmers practice hedgerows plantation by using multiple trees and shrubs in the terraces near homestead area for the protection of crops from domestic animals. In addition to serving as natural fence, they also help in controlling the soil erosion by acting as physical barrier to overland water flow, protection from raindrops by reducing the detachment of soil particles and reducing the volume of run off. It is demonstrated that species used for live fence in the study area serve multiple purpose, such as providing fodder, food, green manure, work as insecticide, medicinal value, soil conservation, wind breaks and ornamental value.

Table 5.17 Some species commonly used as live fencing and hedgerows

Nepali Name	Botanical name	Other uses
Acacia	*Acacia auriculiformis*	Fuelwood, green manure and bee forage
Ainselu	*Rubus ellipticus*	Fruiting shrub
Arari Kanda	*Caesalpinia decapetala*	Fuelwood
Ashare	*Lagerstroemia pariflora*	Ornamental and timber
Ashuro	*Adhatoda vasica*	Green manure and medicine
Bainsh	*Salix sp.*	Fodder, wood products
Bakaino	*Melia azadirach*	Fuelwood, fodder, and insecticide
Bans	*Dendrocalamus spp.*	Fodder, construction, windbreak, food.
Baramase phul	*Bougainvillea spp.*	Thorny ornamental vines
Bhainsi Kanda	*Rosa brunonii*	Fodder
Boksi ghans	*Mimosa rubicaulis*	Throny shrub, medicine
Cassia	*Cassia siamea*	Fuel, livestock bedding, firebreak
Dabdabe	*Garuga pinnata*	Fodder and fence post
Dhaincha	*Sesbania sesban*	Green manure, fuelwood, and fiber
Ghiu kumari	*Aloe variegata*	Medicine
Ipil-Ipil	*Leucaena leucocephala*	Fuel, fodder and green manure
Kimbu	*Morus alba*	Fodder, edible fruits
Masino Kanda	*Lantana camara*	Fence construction
Nigalo	*Arundinaria spp.*	Weaving doko, dalo and handicrafts
Nil Kanda	*Duranta repens*	Throny shrub
Rahar	*Cajanus cajans*	Fodder, food, fuel, green manure
Sajiwon	*Jatropa curcas*	Fuelwood and medicine
Sihundi	*Euphorbia royleana*	Thorny shrub and medicine
Simali	*Murraya paniculata*	Ornamental shrub, soil conservation
Siris	*Albizia spp.*	Fuel, fodder, bee forage, green manure
Sisnu	*Urtica dicioa*	Edible leaves, and medicine
Sisau	*Dalbergia sisoo*	Timber, fuelwood
Tanki	*Bauhinia purpuria*	Fodder, fuel, green manure
Koiralo	*Bauhinia veriagata*	Fodder, fuel, green manure and edible flowers
Khayer	*Acacia catechu*	Timber, fuelwood, medicine

Source: Field survey, 1998

The analysis on the amount of introduced fodder species reveals that farmers of the without project households have also planted number of introduced species, such as *ipil-ipil, bhatmase, guajuma* and *kimbu*. Among the fodder tree species, majorities of the households in both with project (85%) and more than one third in without project (35%) have planted *kimbu* in their farmlands. The average number of trees per household was found to be highest for *kimbu* (229 trees) in with project while household in without project situation planted more *ipil-ipil* (85 trees) compared to other introduced tree species. Among the introduced species, households in with project (48 trees) had significantly higher ($p<0.05$) number of *gaujuma* trees per household than without (11 trees) project (Table 5.18). The study clearly shows that there exist the spills over effect of agroforestry project because non-project farm households have also planted improved fodder tree species. This is particularly true for mulberry (*Morus alba*) trees and NB21 grass species.

Table 5.18 Average number of introduced fodder tree species in the study area

Name of the species	With Project (n=82)		Without project (n=141)	
	% of households	Mean number	% of households	Mean number
Ipil-Ipil	(68) 82.9	124.1	(55) 39.0	84.7
Bhatmase	(36) 43.9	28.2	(14) 9.9	24.3
Gaujuma *	(42) 51.2	48.0	(22) 15.6	10.6
Kimbu	(70) 85.4	229.1	(49) 35.0	53.1

Source: Field Survey, 1998
* Significant at 0.022 ($p<0.05$)
Figures in parentheses are the frequencies.

5.5.11 Small scale mulberry plantation for fodder and silkworm production:

Mulberry (*Morus alba*) plants, commonly known as *kimbu*, have become popular fodder tree species in the study area. During the field survey, it was observed that in Majhitar community out of 53 households 90% had planted *kimbu* cuttings in their home nurseries. Similarly, in other villages of NAF command area, most of the farmers involved in plantation of the fodder trees had raised *kimbu* seedlings from cuttings. Some times NAF is blamed to be being biased towards *kimbu* because farmers preferred the species to others. During one of the discussion sessions held at NAF office, some field staff revealed that they are sometimes blamed for promoting *kimbu* in home nurseries. Because *kimbu* dominates all the other species in all most all of the home nurseries established by NAF agroforestry group members. It was clearly expressed that majority of home nursery grower preferred to keep *kimbu* cuttings. Initially, *kimbu* seedlings were planted in terrace risers, terrace edges and uncultivated fallow lands for livestock fodder.

During field survey, farmers revealed that *kimbu* is preferred to other species because it is easily propagated through cuttings, needs no special care and management during the nursery stage, and have high rate of survival in the field plantation. Most importantly, it provides green fodder during the dry season when there will be severe scarcity of green fodder for livestock. This is of particular significance to dairy farmers during dry season to supplement green fodder to their milking animals. Farmers reported that integration of *kimbu* with field crops is also a good example of negative tree crop interaction due to its rooting system. Roots cause harmful effects to crops as well as make tillage operations, such as ploughing, difficult. Due to this, farmers have changed the location of planting from the top of the terrace risers to somewhat below the bunds. Initially, NAF provided training on how to plant different fodder trees in the terrace risers where *kimbu* was placed for top layer of the terrace risers. Farmers quickly found out that *kimbu* roots are causing decrease in crop yields so they changed the place of planting. Planting in the terrace risers just below the bunds or as second layer cause no such adverse effect on the growing crops, either in the lower terrace or in the upper terrace.

During the field survey, it was observed that some farmers from Naya Basti community have found the new avenue of growing *kimbu* trees for silkworm rearing. Initially they started silk worm rearing from the existing *kimbu* trees planted for fodder. Now farmers have established separate small plots of *kimbu* plantation in their farmland for sericulture. This is a new type of agroforestry system developed by the farmers themselves after the project intervention. During the focus group discussion with agroforestry group members and the direct observation visit to plantation site, it was revealed that farmers have allotted a small parcel of land, mostly rocky areas having poor soil quality for cereal crop cultivation, for *kimbu* plantation. Farmers also revealed that the income they are getting from silk worm rearing or just by selling the *kimbu* leaves to other silk worm rearing farmer is much higher than what they used to obtain by crop cultivation. Although practiced by only a limited number of farmers in some communities within the study area, this systems of mulberry plantation for fodder and sericulture have emerged as a viable agroforestry system. Farmers involved in mulberry plantation reported that systems have better prospect in the area to increase household income, provide employment to household members and maximize the per unit productivity of the available land resources, which are prone to soil erosion, and marginal in terms of field crop cultivation.

5.6 Summary

Agroforestry has been the integral part of subsistence, very complex and highly interactive farming system comprising crops including grasses, woody perennials and livestock as inseparably inter-linked components within the system. Crops including vegetables, grasses and legumes are grown in association with perennial tree species under different systems and productions are maintained by efficient recycling of nutrients. Synergistic association exists between tree, crop, land and animals. Livestock contribute significantly to soil fertility management via manure production, while tree and crop component provide fodder and feed. Cultivation that are in practice beyond normal slope limit has been possible due mainly to positive effects of perennial tree, shrub and grasses.

Though, there are negative interaction effects between agroforestry components, arrangements and priorities to select for best alternative and maximize production levels. Farmers have developed different systems compatible to farming system. Various agroforestry systems, such as Bagaincha, perennial trees in terrace risers combined with crops in terraces, scattered trees in farmland, alley cropping, crop intercropping with fruits, tree/shrub combined with animals, and crop-livestock-tree integration are in practice. The other form of agroforestry system such as live fences, shade loving plants under trees, hedgerows and small scale mulberry plantation, are also found in the study area. Tree and field crop management, land preparation, planting, weeding and fertilizer applications are some of the major form of household labor involvement. Women's involvement is higher in crop management, planting and weeding, fertilizer application, seed bed preparation, agroforestry product harvesting, and seedling production, whereas agroforestry product marketing comes under male domain.

Chapter VI

Spatial distribution of farmland parcels and agroforestry species

6.1. Introduction

Farmers in the study area practice subsistence agriculture in miniature-sized, fragmented land holdings. Uses of different agroforestry species to provide for basic household needs and to maintain agricultural productivity have been the main concerns. Farmers have used different strategies in utilizing and managing their fragmented land parcels located at different distances from their homes. Hill farmers tend to prioritize their needs and resources, based on the production potential of different land units. Farm-level decision making on resource allocation and need prioritization depends upon numerous location-specific characteristics of land parcels. The range of soil characteristics (such as texture, depth, and moisture retention capacity) of different parcels determines management practices employed by the farmers and the level of agricultural production. Likewise, multitude of other factors, such as slope, slope faces (particularly north- or south-faced), type of terraces and height of terrace risers, and type and amount of vegetation are also important. Knowledge of spatial distribution of land parcels is vital for promotion of agroforestry and sustainable resource management in the Hills.

Government and non-government agencies involved in agroforestry activities tend to present agroforestry purely as a new concept and usually ignore the traditional practice of utilizing land parcels according to their production potential. Agroforestry state-of-the-art indicates that these generation-old practices have improved through improved designs and experimentation. Agroforestry in most instances has been misunderstood by implementing organizations as improvement in fodder and fuelwood production. NAF introduced more fast growing, less shady and leguminous species, such as *Calliandra calothyrsus*, *Leucaena diversifolia*, *Leucaena leucocephala*, *Flemingia congesta*, *Leucaena pallida,* into the existing agroforestry system with emphasis on the use of underutilized terrace risers. The objective was to fulfill fodder requirements rather than to improve household income, provide employment, and enhance soil fertility. Private farmlands are the focal point of NAF-introduced agroforestry program in the study area.

Steady population growth and the tradition of dividing parental lands among sons in each successive generation has led to fragmentation of agricultural holdings. This has resulted in land units that are small, less economical and increasingly difficult to integrate tree species and sustain food production. Land use and productivity studies at the farm level have often neglected the variations in nature and number of land parcels that farmers operate and the related constraints they face. The efforts so far have been limited to find out management strategies to improve resource use at the farm level as a whole. The recommendations are made and technologies are generated by treating households as homogenous production units. Past studies have analyzed information at the household level, and there is no single study dealing with management of individual parcels and integration of agroforestry.

6.2. Spatial distribution of farmland parcels

The number of farm parcels per household ranged from 1 to 9. The results showed that on an average, a farm family owned about four parcels of land having considerable distance between them (Table 6.1). The analysis indicated that, on average, the household owned higher numbers of bari parcels (2.9/household) than khet parcels (1.0/household). The results further showed that, on average, bari parcels were located closer (7.6 minutes) to the home than khet parcels (30.7 minutes).

Table 6.1. Characteristics of land holdings and land parcels

Characteristics	With project (n=82)	Without project (n=141)	Total (n =223)
1. Average total land holding per household (in ropani)	14.2	16.30	15.50
Gharbari	3.73	4.20	4.10
Bari	5.20	8.10	7.00
Khet	4.70	3.50	3.90
Homegarden	0.17	0.10	0.13
Kharbari	0.38	0.39	0.39
2. Average total cultivated land per household (ropani)	12.97	15.42	14.48
Gharbari	3.63	4.14	3.94
Bari	5.14	7.94	6.91
Khet	4.20	3.34	3.63
3. Average number of parcels per households (in number)	3.30	4.10	3.80
Gharbari	0.88	0.98	0.94
Bari	1.38	2.27	1.94
Khet	1.00	0.81	0.88
4. Average area per parcel (in ropani)			
Gharbari	4.10	4.20	4.20
Bari	3.73	3.50	3.56
Khet	4.20	4.10	4.10
5. Average distance of parcels from the house (in minutes)			
Gharbari	00	00	00
Bari	7.13	7.90	7.60
Khet	26.00	34.20	30.70
6. Average household size (in number)	6.20	6.70	6.50

Source: Field Survey, 1998
n = number of samples

The analysis of the spatial distribution of land parcels without disaggregating the sample into project and non-project households indicated that the overwhelming majority of the bari parcels (90%) and about three-fourths of khet parcels were located within 10 minutes of walking distance from the home (Table 6.2). About one-third of the bari parcels (32%) were attached with the home as homestead (gharbari). Contrarily, only a few khet parcels (6%) were located adjacent to farmhouses, locally termed as gharkhet.

Farmers manage each parcel of land differently depending on their size, distance from the home and production potentials. However, no formal studies have yet been conducted on factors determining farmers' decision making in the utilization and management of different land parcels. Farmers reported that available farmyard manure, green manure and compost is usually applied to parcels located closer to the home and that it has been increasingly difficult for them to practice better management and apply enough input to relatively distant parcels as a considerable amount of time is spent on travelling. As a result, distant parcels have been gradually marginalized and their yields are decreasing over the years.

Table 6.2. Spatial distribution of farm land parcels

Parcel No.	Bari (f = 652)				Khet (f =196)			
	Parcels by distance (minutes)	Mean distance (minutes)	No. of parcels	Percent age	Parcels by distance (minutes)	Mean distance (minutes)	No. of parcels	Perce ntage
Parcel 1	0 – 0	0.00[1]	210	32.2	0 - 0	0.00[1]	12	6.1
Parcel 2	0 – 7	3.6	243	37.3	0 - 20	8.9	103	52.5
Parcel 3	7 – 15	10.6	135	20.7	20 - 40	30.2	28	14.3
Parcel 4	15 – 30	26.9	46	7.1	40 - 60	59.6	36	18.4
Parcel 5	30 – 60	59.6	14	2.1	> 60	125.0	17	8.7
Parcel 6 & > 6	> 60	150.0	4	0.6	-	-	-	-
	Total	7.6	652	100.0		30.7	196	100.0

Source: Field Survey, 1998

f = frequency of parcels
[1]Parcels adjacent to the home. In case of bari it is called *Gharbari* (upland homestead), whereas in case of khet it is called *Gharkhet* (lowland homestead).

It was observed during the field visit that compared to relatively well-off families or ethnic groups, poor families in the community, particularly those from lower caste ethnic groups (such as *Damai, Kami,* and *Sarki*), normally resided on more sloped, marginalized and degraded land parcels and away from the community. In terms of maintaining agroforestry species, the lower caste households had maintained considerably fewer species. They had less fodder available, kept fewer livestock and hence produced less manure for soil fertility. At the same time, unlike other caste groups, they could not afford to use chemical fertilizers. The production of crop residues was nominal, as they did not have sizable land to produce food grains. The majority of those families depended on agricultural wage labor and off-farm employment based on their traditional skills, such as iron works, shoe making, tailoring and carpentry.

Despite marginalized and degraded farming conditions, the lower-caste farm households are continuously harvesting outputs from such land parcels while replenishment of plant nutrients that are withdrawn from the soil is very nominal. This has led to the progressive degradation of limited land resources they own. Although exact estimation for such differences among the ethnic and economic groups is beyond the scope of this study, the direct observation indicated that there is tremendous potential and urgency to improve agroforestry for these households in order to restore soil fertility, rehabilitate degraded lands, reduce land degradation and supply adequate fodder for livestock. It was observed that this has been the challenge for NAF to involve such families in agroforestry program and bring improvements.

A similar trend of parcel distribution also prevailed when land distribution pattern was analyzed separately for project and non-project situations (Table 6.3). Around 90% of the bari parcels belonging to both project and non-project households were located within the distance of 10 minutes from the home. The analysis revealed that in comparison to bari parcels (7.1 minutes for project households and 7.8 minutes for non-project ones), khet parcels were located relatively more far away from the home (26 minutes for project households and 34.2 minutes for non-project ones). No significant differences were found when average walking distance of the both bari and khet parcels between project and non-project households were compared (Table 6.3). Majority of khet parcels belonging to both project (80%) and non-project (68%) households were located within the walking distance of half an hour.

Table 6. 3. Distribution of farm parcels by average distance and land use systems

Parameters by type of land		Parcels according to the average distance from the farm household *.						Total
		1	2	3	4	5	6	
Project households								
Bari	Distance (min.)	0.0	3.7	11.0	28.2	59.3	-	7.1
	Total parcels (no)	72	66	37	11	7	-	193
	Percentage	37	34	19	6	4	-	100
Khet	Distance (min.)	0.0	8.3	29.0	58.6	135	-	26
	Total parcels (no.)	9	46	10	11	6	-	82
	Percentage	11	56.1	12.2	13.4	7.3		100
Non-project households								
Bari	Distance (min.)	0.00	3.6	10.4	26.5	60.0	150	7.8
	Total parcels (no)	138	177	98	35	7	4	459
	Percentage	30	39	21	7.6	1.5	0.9	100
Khet	Distance (min.)	0.00	9.3	30.8	60.0	119	-	34.2
	Total parcels (no)	3	57	18	25	11	-	114
	Percentage	2.6	50	15.8	22	9.6		100

Source: Field Survey, 1998

* The time intervals for every parcels for both khet and bari land in terms of the distance from the house is presented on the Table 6.2. The parcel number used in the subsequent tables represents the particular frequency.

The spatial distribution of farm parcels and time taken to reach them may be an important factor determining the farm productivity. Fragmentation and frequent sub-division of farmlands causes wastage of human resources, draught animal's working hours and agricultural equipment, as there is an enormous loss of labor and time in moving from one plot to another. In most cases, the distances to be covered in transporting inputs, carrying out cultural operations (such as land preparation, weeding, fertilizing, etc.) and transporting outputs to the home are considerable and absorb a good portion of the household labor. During planting and harvesting seasons, the farm household needs to carry water and food to the fields requiring more labor to manage the faraway parcels than parcels close to the home. Sometimes, the same activity, such as seedbed preparation, needs to be replicated at several parcels. Different tillage operations, such as ploughing, hoeing, and digging of land parcels become difficult and time consuming. Therefore, production capabilities of distant parcels gradually decline as farmers employ fewer soil conservation and management measures.

Given the constraints imposed by spatial distribution of land parcels, farmers prioritize the allocation of inputs and management practices depending upon the production potentials of their land parcels. Farmers harvest what ever they can obtain from distant parcels by using minimum inputs and efforts possible. Likewise, they can not make investment in irrigation facilities due to the small, fragmented parcels scattered at different places. They concentrate their efforts on parcels adjacent to homestead and on those with good soil fertility. The fragmentation also creates the problem of taking care and management of cultivated land. Discussion with farmers and key respondents revealed that decreasing family labor size, owing to increased schooling of the children and temporary migration of adult household members for education and employment aggravated the situation.

6.3. Land fragmentation and cropping patterns

Land fragmentation has become a constraint to promote the adoption of on-farm agroforestry practices. Farmers practice various cropping patterns on their lands depending upon elevation and types of land. In khet with perennial irrigation, rice is grown twice a year during summer and rainy seasons, while in khet irrigable only in the monsoon season, farmers practice a sequential cropping pattern, such as summer paddy followed by wheat or mustard followed by maize. In khet, farmers generally do not have traditionally maintained tree species due to fear of decreased crop yields from shading effect. However, with the implementation of NAF's agroforestry program they have now planted improved fodder species in the bunds and terrace edges. Trees are maintained at breast height through regular pruning. Maize, millet and grain legumes are the major crops grown in uplands and unirrigated lowlands. During April farmers plant corn in uplands and after mid-April in the lowlands. In contrast to khet lands, scattered trees are maintained traditionally and improved agroforestry tree species are deliberately planted in the bari lands.

Normally, farmers broadcast variety of beans, and cowpea in the cornfield after a month of maize planting. Millet is transplanted when maize is about ready to be harvested (relay cropping). Black gram and soybeans are broadcasted after millet transplantation, either separately or together with corn, millet and beans. Corn is harvested around the beginning of September and millet and legumes are harvested about one to two months later. After harvesting the monsoon crops, most bari lands remain fallow until the onset of next monsoon except for those with higher moisture retention capacity, in which wheat is cultivated if the rains fall soon after the harvest.

The cropping pattern of the study area is presented as follows:

Khet (lowland):

Rice – Wheat – Maize
Rice – Fallow – Rice
Rice – Wheat – Fallow
Rice – Wheat – Rice
Rice – Potato – Maize
Rice – Fallow – Maize
Rice – Vegetable – Maize
Rice – Rice + Green Gram – Vegetables
Vegetables – Vegetables
Tomato - Wheat

Bari (upland):

Upland Rice – Green Gram – Fallow
Upland Rice – Maize/Millet
Maize – Pigeon Pea, Soybean – Fallow
Maize – Sesame (Til), other Oil crops – Fallow
Maize – Maize – Fallow
Sugarcane –
Maize – Green Gram – Fallow
Maize/upland rice – Fallow
Maize/ Millet
Maize – Millet – Fallow
Maize + Upland Rice
Maize/Bodi, masyang, Groundnuts
Sesame – Fallow (limited to marginal lands only)
Soybean – Mustard – Fallow

Sign used:
" – " (Rice – wheat) = one after the other
" + " (Maize + Soybean) = Mixed ,
" / " (Maize/Millet) = Relayed,
", " (Rice – Mung, bodi) = and , or

The decision to choose a particular cropping combination depends on the availability of labor, chemical/compost fertilizers, seeds and water, elevation, soil type and fertility status, climate, land tenure, drainage condition, type of agroforestry practices employed and market opportunities (Fig. 6.1). External interventions, access to the modern technology and inputs, farmers' needs and preferences, and adoption of different crop varieties are the other important factors in determining the choice of cropping patterns. Type of agroforestry species and system practiced would also have an effect on the selection of crops and cropping combinations. The project households have started growing NB 21 grass species permanently in khet terrace bunds and risers replacing the traditional practice of cultivating of legumes, such as green gram or soybean, with paddy. Although some of the non-project households due to project's spillover effect have planted NB 21, most of them still practice traditional crop combination. Therefore, among project households the type of agroforestry species, system and crop combinations have brought about changes in the traditionally practiced cropping systems.

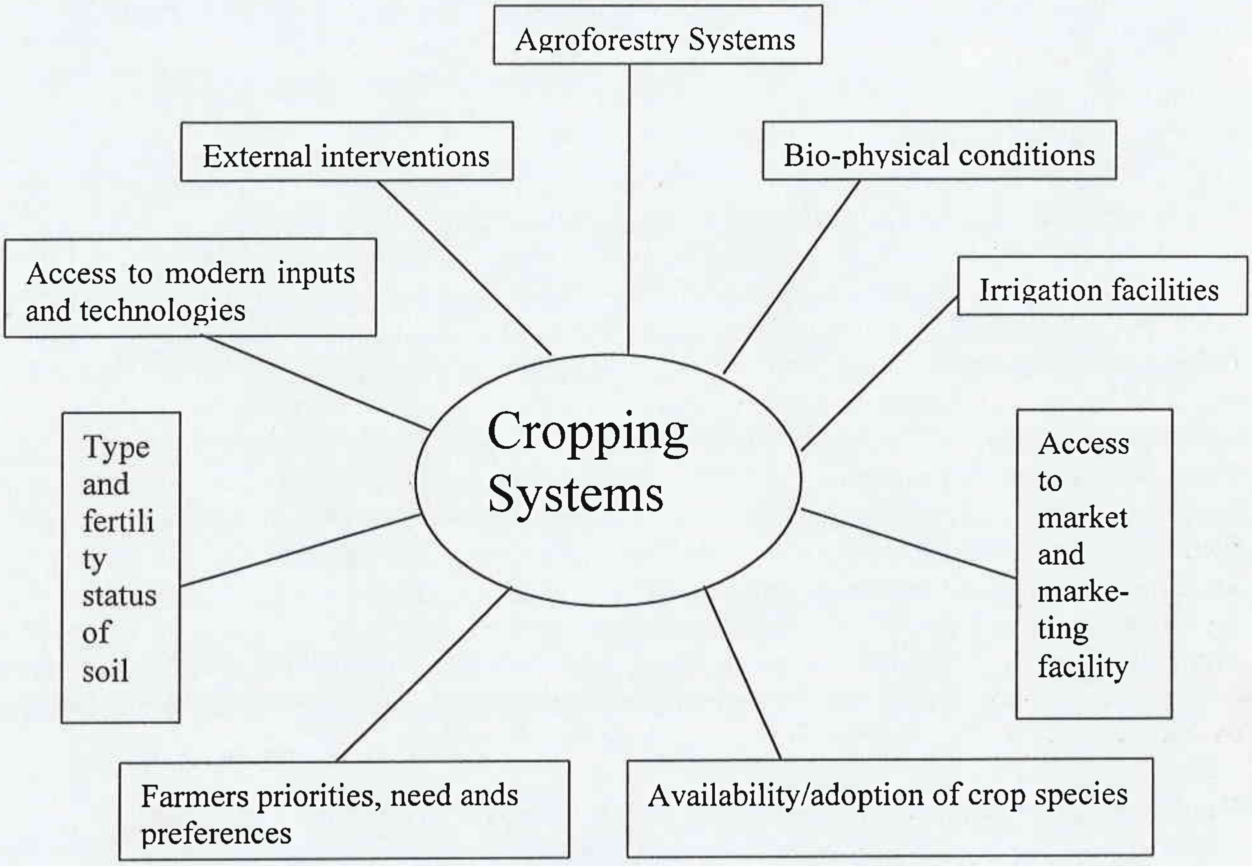


Figure 6.1. Factors determining the cropping patterns in the study area

The type of crops grown also determines the type of agroforestry system. The main field crops grown on the bari lands are cereals, such as maize, upland rice, millet and other minor crops like soybean, wheat, and potato. Maize-based cropping patterns are most popular. Maize followed by or relayed with millet is a widely practiced cropping pattern. Other important cropping patterns are maize followed by mustard and wheat. At small-scale, buckwheat and barley are also grown during winter. Aside from these crops, farmers also grow pumpkin, cowpea, soybean and other legumes in the maize fields, and spinach, radish, kidney beans, cucumber, chili and other vegetables in their homestead lands. Makai-ban-misrit (maize-based agroforestry) system is followed in the bari land, while Dhan-ban-misrit (rice-based agroforestry) is practiced in the khet land. The major difference between the two systems is the type of tree species introduced. Mostly less shading and deep rooted leguminous species, such as *Leucaena* and *Flemingia,* are planted in khet land under Dhan-ban-misrit system, while wide varieties of species (such as *gauzuma, leucaena, artocarpus lacocha, flemingia*) are planted in bari land. Depending upon the production potentials of various land parcels owned by the household and household needs, different cropping patterns are used in different land parcels. Higher diversity of crops grown in their different land parcels reduces the risk of crop failure. The rationale is that even if one crop in one parcel of land does badly, the others would still provide some harvests. Agroforestry-based system is associated with higher diversity, risk minimization and optimum utilization of land parcels.

6.4. Cropping intensity

Increasing cropping intensity is believed to be an alternative in response to declining crop yields and food deficit (Mahat, 1987c: 14). Accordingly, hill farmers have changed their cropping pattern through the introduction of winter wheat and early maturing paddy varieties to allow an extra crop of maize, double cropping of paddy in irrigated fields and inter-cropping of millet with maize (Blaikie, 1985:24). Abundant labor availability allows for this practice, but it is practiced only in irrigated fields. Moreover, cropping intensification demands for higher amounts of inputs, including farmyard manure and chemical fertilizers (Schreier et al., 1995:247). So far studies have analyzed the increased cropping intensity at the total farm and have ignored the differences among individual parcels. The analysis showed that cropping intensity differed with distance of parcels from the home, with a general trend of decreasing cropping intensity with distance from the home in both bari (Table 6.4*)* and khet lands (Table 6.5) belonging to both project and non-project households. However, the differences in cropping intensity in bari lands were not statistically significant at the 0.05 level when analysis was done separately for project and non-project households. These differences were significant at the 0.01 level for the aggregated sample (Table 6.4).

Table 6.4. Average cropping intensity by parcel of bari lands and land use type

Parcels by distance (minutes)	With project *			Without project *			Both **		
	n	Mean	Distance (minutes)	n	Mean	Distance (minutes)	n	Mean	Distance (minutes)
0 – 0	71	2.18	0.0	132	1.98	0.0	203	2.05abc	0.0
0 – 7	64	1.73	3.7	174	1.86	3.6	238	1.82a	3.6
7 – 15	35	1.77	11.0	95	1.85	10.4	130	1.83b	10.6
15 – 30	11	1.86	28.2	33	1.73	26.5	44	1.76c	26.9
30 – 60	07	2.14	59.3	06	1.83	60.0	13	2.00	59.6
> 60	-	-	-	03	2.00	150.0	03	2.00	150.0
Total	188	1.93	7.1	443	1.88	7.5	631	1.9	7.6

Source: Field Survey, 1998

n = number of parcel observation.
* F-test not significant even at the 0.1 level ($p < 0.1$).
** F-test significant at the 0.000 level ($p < 0.001$).
The means followed by same letters in a column are significantly different (LSD, $p < 0.05$).

Cropping intensity differed between bari and khet parcels. Owing to the availability of water for irrigation either partially or year round, the cropping intensity in khet land was found higher (2.1) than in bari land (1.9). The analysis revealed that irrespective of the land use type (project vs. Non-project), the cropping intensity between different bari parcels was significantly different (P<0.10). The analysis showed that the parcels located nearer to the home were used more intensively while obtaining higher number of crops. To find out the significance of mean differences in cropping intensities, means were tested using the least significance difference (LSD) test at the 0.05 level. The LSD test showed that cropping intensity of parcels located near to the home (*Gharbari*) was significantly ($p < 0.05$) higher than that of other bari parcels located in an average distance of 3.6, 10.6 and 29.6 minutes. Although cropping intensity for bari parcels in the project area was higher than that in the non-project area, the difference was not significant even at the 0.10 level. The introduction of agroforestry program may have contributed to increased cropping intensity due mainly to the reduction in fallow period as farmers have adopted stall feeding practices for their animals, as opposed to free grazing in the farmland to protect tree species planted.

Within the khet parcels, significantly ($p < 0.01$) higher cropping intensity was found in the project area (2.28) compared to the non-project area (1.97). Cropping intensity decreased with distance under both project and non-project conditions. The parcels located near to homesteads were more intensely cultivated than those located farther away from the home. In an overall condition, the differences between the different parcels were more pronounced and significantly different ($p<0.01$). The LSD test for mean differences between different plots showed that mean values of cropping intensity for nearest parcel (parcel with 0 distance) was significantly different ($p < 0.01$) from all other parcels. Whereas the parcel located within 0-20 minute distance was significantly different to other parcels located at 0.0, 40-60 and more than 60 minutes walking distance from the farm house (Table 6.5).

Table 6.5. Average cropping intensity by parcel of *khet* lands and land use type

Parcels by distance (minutes)	With project*			Without project*			Both **		
	n	Mean	Distance (minutes)	n	Mean	Distance (minutes)	n	Mean	Distance (minutes)
0 - 0	09	2.89	0.0	03	3.0	0.0	12	2.91	0.0
0 - 20	46	2.41	8.3	57	2.02	9.3	103	2.19 a	8.86
20 - 40	10	2.10	29.0	18	2.0	30.8	28	2.03 ac	30.2
40 - 60	11	1.64	58.6	25	1.76	60.0	36	1.72 b	59.6
> 60	06	1.83	135.0	11	1.9	119.5	17	1.88 bc	125.0
Total	82	2.28	25.9	114	1.97	34.2	196	2.10	30.75

Source: Field Survey, 1998

* F-test significant at the 0.001 level ($p < 0.01$).
** F-test significant at the 0.000 level ($p < 0.01$).
The means followed by same letters are not significantly different (LSD, 0.05).

6.5. Crop yields

Increased demand for food in the past was primarily met by expanding cultivation to fragile and steep forest and grazing lands. In the hills, this opportunity does not exist any more. In view of limited opportunity for non-farm employment, seasonal migration has been adopted an alternative strategy by hill farmers in order to fulfill their basic needs. Working outside the village in the urban areas of Nepal and India during agriculturally slack months enables households to buy food grains and other consumer goods. However, the chance of getting such employment has decreased in recent years due to an increase in labor force and low labor absorbing capacity of economic activities in the cities. Thus, hill farmers are more and more exposed to the threat of food deficit and malnutrition, as there are only scarce alternative employment opportunities to offset the diminishing agricultural production (Thapa and Weber, 1994b: 477). However, some changes, though not examined here formally, have occurred in agricultural land management practices due to the influence of both internal and external factors. Agroforestry interventions and transformation of farming system towards commercial production are required to bring improvements in the existing situation.

With the exception of some lowland valleys and narrow stretches of riverbanks, most of the farming is predominantly rain-fed and dependent on monsoon rain. Agricultural produce is hardly enough to meet the subsistence requirements owing to low productivity. The chief objective of farming is to provide for subsistence. The commercial crops are grown in a very limited scale. Thus, ensuring food security by enhancing crop yield has been a major challenge to farmers, scientists, planners and policy makers. Use of modern agricultural technology has not been possible to have substantial increase in productivity due to fragmented land holdings located at different distances. The further sub-division of land is expected. Therefore, very complex strategies, such as focus on fertile land parcels and parcels located near to the homestead for cereal grain productions and use of land for growing tree species, are developed. These parcels act as "safety nets" for the rural households as intensive agriculture is very much limited.

Size of the bari parcel (~ 4 ropani/parcel) owned by households and the average distance (7-8 minutes) to the parcels from the farm household were found to be almost similar in both the project and non-project groups. The results indicated that the majority of bari parcels are located closer to the home. The analysis of the cereal crop production showed that crop yields are relatively higher in project than in non-project parcels. However, yield differences between the project and non-project areas were significant only for maize ($p < 0.10$) and millet ($p < 0.05$) (Table 6.6). In contradiction to the general belief that introduction of tree species in the farmlands reduces crop yields, the study showed positive effects on yields. Positive effects on crop yields of agroforestry project parcels are associated with better soil fertility. In overall, the analysis showed that planting trees/shrubs in terrace risers and terrace edges and maintaining them at lower heights would enhance cereal crop production.

Table 6.6. Average area, parcel distance and major cereal crop yields in bari land

Parameters	With project	Without project	Both	F-value
Average distance (minute)	7.1 (193)	7.8 (459)	7.6 (652)	0.261
Area (ropani)	3.9 (185)	3.7 (458)	3.8 (643)	0.245
Upland rice yield (muri)	5.5 (93)	5.1 (176)	5.2 (269)	0.349
Maize yield (muri)	6.7 (170)	5.3 (384)	5.8 (554)	2.996*
Wheat yield (muri)	3.4 (61)	3.2 (52)	3.3 (113)	0.069
Millet yield (muri)	5.4 (62)	2.7 (245)	3.2 (307)	6.166**

* Significance at the 0.10 level.
** Significance at the 0.05 level.
Figures in parentheses are numbers of parcels.

The parcel-level analysis showed that yields of maize ($p < 0.01$) and wheat ($p < 0.05$) were significantly different ($p < 0.05$) between the different bari parcels. The results indicated that parcels located near to the homes had higher yields than those located farther away (Table 6.7). The LSD results showed that differences in maize yields between parcels located at distance of 0.0 and 3.6 minutes and distance of 3.6 and 10.6 minutes were significantly different ($p < 0.01$). The yields of different cereal crops are the good indicators of farmers' management practices applied to different parcels.

Table 6.7. Average area and cereal crop yields in bari land parcels by distance

Area and Yield	Land use type	By mean distance from farmhouse (in minutes)						F-value
		0.0	3.6	10.6	26.9	59.6	150.0	
Area (ropani)	WAF	4.1	2.9	4.8	3.9	4.7	-	1.757*
	WOAF	4.2	3.4	3.9	3.0	2.1	4.2	
Yield (in muri)								
Upland rice	WAF	6.3	3.4	5.5	10.6	3.7	-	2.491
	WOAF	6.5	4.1	5.3	3.6	2.3	4.5	
Maize	WAF	7.5	5.2	7.4	6.5	9.7	-	4.175**
	WOAF	8.1	3.9	4.0	4.7	7.7	1.7	
Wheat	WAF	3.4	1.7	3.3	9.5	-	-	2.944*
	WOAF	4.3	1.9	0.9	5.0	-	-	
Millet	WAF	9.3	4.1	4.2	2.1	1.4	-	1.270
	WOAF	3.7	2.0	2.7	2.1	1.7	1.0	

Source: Field Survey, 1998
WAF = With agroforestry project; WOAF = Without agroforestry project
* Significance at 0.05 level.
** Significant at 0.01 level.

Unlike bari parcels, khet parcels were located farther away from the homes. The average walking distance to khet land was found slightly higher for non-project (34 minutes) than project households (26 minutes), while average size of the khet owned was found to be almost similar in both groups. Although, except for millet, yields of cereal crops in khet land parcels belonging to the project households were slightly higher than those for non-project farm households, the difference was not significant at the 0.05 level (Table 6.8).

Table 6.8. Average area, distance and crop yields in khet lands

Parameters	With project	Without project	Both	F-value*
Average distance (minute)	26.0	34.2	30.7	1.822
Area (ropani)	4.2 (81)	4.12 (114)	4.16 (195)	0.028
Lowland rice yield (muri)	11.16 (79)	9.7 (112)	10.3 (191)	0.682
Maize yield	7.51 (58)	7.2 (62)	7.4 (120)	0.026
Wheat yield	6.33 (35)	5.6 (24)	6.05 (59)	0.189
Millet yield	8.05 (04)	11.5 (03)	9.5 (07)	0.144

* Not significant at 0.05 level ($p < 0.05$).
Figures in the parentheses are number of parcels.

The parcel-level analysis indicated that area and rice yields between different khet parcels were significantly different ($p < 0.01$), but for maize, wheat and millet, yield differences between khet parcels were not significant at the 0.05 level (Table 6.9).

Table 6.9. Average area and crop yields in khet land parcels by distance

Parameters	Land use type	Parcels by mean walking distance from farm house (in minutes)					F-value
		0.0	8.9	30.2	59.6	125.0	
Area (ropani)	WAF	5.7	4.2	2.7	3.2	6.3	4.016**
	WOAF	7.0	3.4	4.1	3.7	6.4	
Upland Rice yield	WAF	14.5	12.0	4.45	9.1	15.0	4.041**
	WOAF	10.0	8.4	9.2	7.5	22.5	
Maize yield	WAF	9.5	6.96	2.7	11.4	6.00	1.349
	WOAF	6.0	8.0	2.6	8.8	4.7	
Wheat yield	WAF	5.9	6.1	15.5	1.0	2.0	0.651
	WOAF	5.7	6.1	5.2	4.3	5.0	
Millet yield	WAF	0.0	10.1	2.00	0.0	0.0	5.241*
	WOAF	0.0	1.5	3.0	3.0	0.0	

Source: Field Survey, 1998.
* Significant at the 0.10 level.
** Significant at the 0.01 level.
WAF = With agroforestry project; WOAF = Without agroforestry project

Average yields comparisons of major cereals between the district and study area showed that yields of rice, wheat, maize and millet in khet lands were slightly higher in study area than the district averages. However, in the case of bari lands, rice and wheat yields in the study area were lower whereas maize and millet yields were higher than their corresponding values for the district (Table 6.10). Similarly, rice and maize yields in the study area were lower than average yields reported for Lalitpur district, a hill district with similar conditions. Compared to national averages, the yields of rice and wheat were lower in the study area. There was still a wide gap between the existing and potential yield (Research station) of the cereals. The results indicated that almost 3-4 folds of yield increment in cereal crops are still possible with the adoption of available technology and management practices in the study area (Table 6.10).

Table 6.10. Average yields comparisons of selected cereal crops

Major cereal crops	Productivity in Metric tons/hectare					
	Study area average[3]		District average[1]	Lalitpur district[1]	National average[1]	Research station yield[2]
	Bari	Khet				
Rice	1.9	3.5	2.1	4.0	2.4	7.5
Wheat	1.1	1.8	1.7	1.6	1.6	5.0
Maize	1.9	2.2	1.6	2.5	1.7	4.8
Millet	1.2	3.2	1.1	1.3	1.1	3.5

Source: 1= CBS, 1997; 2 = DOA, 1998; 3 = Field Survey, 1998

6.6. Agroforestry species distribution on farmland parcels

Different economic and environmental factors, such as farm size, distance to parcels, slope, soil depth and water holding capacity, presence of rocks and irrigation water, are important in farmers' decision making on planting different tree species on their farmlands. The results indicated that the average number of fodder trees, shrubs, fruit trees and grasses planted and protected in bari land parcels were significantly higher ($p < 0.01$) for the project group than non-project group. Similarly, number of fuelwood and bamboo species maintained by project groups were significantly larger ($p < 0.05$) than non-project group (Table 6.11). This is largely attributed to the motivation, extension and training programs undertaken by local NGOs and farmer groups through NAF-initiated agroforestry.

Table 6.11. Average number of agroforestry trees species in bari land parcels

Type of species	With project	Without project	Both	F-value
Fruit trees (numbers)	70.92 (85)	11.68 (136)	34.5 (221)	7.895**
Fodder trees (numbers)	32.4 (155)	15.96 (354)	21.0 (509)	10.74**
Shrubs (numbers)	75.5 (104)	23.1 (156)	44.0 (260)	7.533**
Fuelwood trees (numbers)	34.5 (90)	18.07 (182)	23.5 (272)	4.225*
Grasses (bhari)	52.03 (57)	7.5 (107)	23.0 (164)	10.36**
Medicinal herbs (numbers)	36.7 (17)	27.2 (22)	31.3 (39)	0.309
Bamboos (no. of bushes)	3.45 (40)	1.25 (56)	2.17 (96)	5.443*

* Significant at the 0.05 level.
** Significant at the 0.01 level.
Figures in parentheses are number of parcels.

The analysis on the types of agroforestry species found in different bari parcels of project and non-project groups showed a general tendency of species concentration in parcels located near to the households. However, only the fodder trees between the different parcels were significantly different ($p < 0.05$). Farmers reported that they prefer to plant agroforestry species closer to their homes because of management considerations. Farmers feared of loosing tree products, if they are located at distance where close supervision is not possible. This is particularly true in case of fruit and fodder trees. Fodder trees having lower heights could easily be harvested and stolen if located in areas away from the home. In the context of limited labor availability, they need to utilize available labor very wisely and efficiently. Availability of species nearby their houses will also give farmers enough time for management.

The results indicated that parcels belonging to project households had higher number of species planted and protected than non-project households (Table 6.12). This is clearly related to the NAF efforts of promoting new and improved agroforestry species in the project area. Some of the promoted species that are preferred by farmers include *leucaena, flemingia, morus* and *gazuma*. Although NAF initially promoted fodder tree species in its agroforestry program, the leader and demonstrator farmers were also trained in fruit tree plantation, management of existing fruit trees, propagation techniques and integrated pest management technology.

Table 6.12. Agroforestry species in different bari parcels by distance

Types of species	Area	Average number of species by mean walking distance from farm household (in minutes)						F-value
		0.0	3.6	10.6	26.9	59.6	150.0	
Fruit trees (number)	WAF	72.8	22.8	209.3	8.0	5.33	0.0	0.343
	WOAF	11.7	13.5	9.9	1.0	0.0	0.0	
Fodder trees (number)	WAF	49.6	11.7	37.5	12.8	31.2	0.0	2.264*
	WOAF	21.3	15.5	12.1	5.7	2.7	5.0	
Shrubs (number)	WAF	136.3	20.5	77.0	6.4	41.8	0.0	1.789
	WOAF	35.7	19.5	11.0	5.4	4.0	10.5	
Fuelwood trees (number)	WAF	55.7	11.4	29.2	5.8	28.7	0.0	1.565
	WOAF	25.0	17.6	14.1	11.2	15.0	19.7	
Grasses (bhari)	WAF	64.1	3.5	94.6	15.0	10.0	0.0	0.642
	WOAF	8.76	4.72	9.3	5.7	5.0	0.0	
Medicinal herbs (number)	WAF	33.1	3.2	113.7	2.0	0.0	0.0	1.758
	WOAF	29.8	14.1	49.7	2.0	0.0	0.0	
Bamboo (number of bushes)	WAF	5.9	1.8	2.2	1.5	1.33	0.0	0.874
	WOAF	1.3	1.28	1.1	1.0	0.0	0.0	

WAF = With agroforestry project; WOAF = Without agroforestry project

* Significant at the 0.05 level.

Unlike bari parcels, non-project households had maintained higher number of fuel wood trees and shrubs in khet land while project households had more fodder, grasses, bamboo and fruit trees (Table 6.13). It was observed during the field survey that only the project households had planted improved tree/shrubs species in their khet land terrace risers and bunds in addition to the species grown at the edges, and sides of the farmland. Non-project households had maintained tree species only on edges of khet lands. The higher number of fodder species found in the khet parcels belonging to project households is due to efforts of NAF extension program and local NGOs efforts to promote agroforestry. One of the other reasons that encouraged farmers to adopt the species is the income generated by selling planting materials. Farmers reported that they were able to earn considerable amount of money by selling the mulberry cuttings and NB 21 grass slips to Nepal Denmark Watershed Management Project and other interested organizations. The researcher also observed bundles of mulberry cuttings being sold by farmers in Majhitar to the project and other organizations. Farmers in the study area are highly motivated in agroforestry due to income they obtained by selling such products.

Table 6.13. Average agroforestry species per household in khet parcels

Type of species	With project	Without project	F-value
Fodder trees (in numbers)	27.30 (36)	15.2 (20)	1.916
Shrubs(in numbers)	67.00 (22)	72.8 (9)	0.016
Fuelwood trees (in numbers)	14.50 (28)	21.94 (18)	0.804
Grasses (in bhari)	80.38 (18)	20.25 (12)	1.151
Medicinal herbs (in numbers)	01.70 (02)	1.5 (2)	1.419
Bamboos (in no. of bushes)	11.40 (08)	1.0 (4)	1.310
Fruit trees (in numbers)	28.80 (20)	15.8 (17)	0.567

Figures in parentheses are number of parcels.

It was observed that considerably fewer households had planted and protected tree/shrub species in their khet parcels. It is obvious that farmers are reluctant to plant tree species in their khet land. Project households have planted trees in their khet lands but by maintaining them at lower heights to minimize negative effects due to shading. The results indicated that the concentration of different agroforestry species was found mostly in parcels located within 10 minutes of walking distance from the household (Table 6.14). This is also in conformity with the similar patterns observed in bari parcels.

Table 6.14. Agroforestry species in different *khet* parcels by type of land use

Types of species	Land Area	Number of species by mean walking distance from farm household (in minutes)					F-value
		0.0	8.9	30.2	59.6	125.0	
Fodder trees	WAF	39.3	25.7	5.7	7.0	55.0	0.194
(in number)	WOAF	38.3	247.8	4.3	1.0	0.0	
Shrubs	WAF	33.7	97.0	0.5	1.0	10.0	0.871
(in number)	WOAF	37.0	108.4	0.0	2.0	0.0	
Fuelwood trees	WAF	31.3	14.6	2.33	7.0	12.0	0.793
(in number)	WOAF	0.0	29.2	0.0	4.0	10.67	
Grasses	WAF	6.5	111.6	0.0	25.0	20.0	0.256
(in bhari)	WOAF	6.0	25.0	0.0	16.5	4.0	
Medicinal herbs	WAF	0.0	17.0	0.0	0.0	0.0	NA
(in number)	WOAF	0.0	1.0	2.0	0.0	0.0	
Bamboo	WAF	2.0	20.7	0.0	2.0	0.0	0.162
(number of bushes)	WOAF	0.0	1.0	0.0	0.0	0.0	
Fruit trees	WAF	75.8	12.7	30.0	1.0	0.0	1.231
(in numbers)	WOAF	26.3	21.0	8.0	1.5	0.0	

Source: Field Survey, 1998.

WAF = With agroforestry project; WOAF = Without agroforestry project

6.7. Impact of accessibility on agroforestry

Accessibility was also found to be an important factor in the agroforestry promotion. The results on overall agroforestry species in bari land showed that the households in areas easy to access (AEA) had planted significantly higher number of fodder, fuelwood ($p < 0.01$) and fruit trees ($p < 0.05$) than those in areas difficult to access (ADA) (Table 6.15). This is also related to the fact that NAF-promoted agroforestry project is mainly concentrated in AEAs.

Table 6.15. Agroforestry species per household in bari parcels by accessibility

Species	AEA	ADA	Both	F-value
Fruit trees (in numbers)	57.3	9.64	34.5	5.340**
Fodder trees (in numbers)	30.9	13.9	21.0	13.134***
Shrubs(in numbers)	50.9	36.9	44.0	0.539
Fuelwood trees (in numbers)	35.9	14.9	23.5	7.650***
Grasses (in bhari)	40.6	7.0	23.0	6.334**
Medicinal herbs (in numbers)	39.8	22.4	31.3	1.067
Bamboo (in no. of bushes)	3.02	1.23	2.2	3.594*

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.
AEA = Areas easy to access; ADA = Areas difficult to access

Unlike bari lands, trees are generally not planted in khet. Although locational variations exist, agroforestry has evolved mostly as the traditional practice adopted in bari land. To intensify crop cultivation, farmers avoid planting trees in their khet land. However, the situation differed with the type of khet land found in the area. For example, khet parcels that are located adjacent to the community/national forest, stream, rivers, and rivulets and that have wide terrace risers (Kanle khet) and narrow terraces (Phagate khet), had a higher number of tree, shrub species. Traditionally, farmers having khet lands in valley areas with low terrace risers do not maintain tree and shrubs in khet. The analysis indicated that relatively higher numbers of different agroforestry species are planted in khet plots of AEA than ADA. As relatively few khet parcels have been used for growing agroforestry species in ADA, the use of higher number of khet parcels by project households is related to the motivation of NAF agroforestry project (Table 6.16).

Table 6.16. Average agroforestry species per household in khet parcels

Species	AEA	ADA	Both
Fruit trees (in numbers)	79.8 (29)	3.37 (8)	22.8 (37)
Fodder trees (in numbers)	89.7 (45)	4.64 (11)	73.0 (56)
Shrubs(in numbers)	79.8 (26)	10.8 (5)	68.7 (31)
Fuelwood trees (in numbers)	21.75 (32)	7.57 (14)	17.4 (46)
Grasses (in bhari)	63.0 (25)	23.0 (5)	56.3 (30)
Medicinal herbs (in numbers)	11.7 (3)	2.0 (1)	9.2 (4)

Figures in parentheses indicate number of parcels

6.8. Summary

Steady population growth and tradition of land distribution among male members of the family has led to the fragmentation of land, resulting in miniature-sized land holdings. The practice of continuous fragmentation is causing difficulty to integrate tree species with crop production as family's increasing food grain needs are often more critical. An average farm household owned four parcels of land located at different distance from the farmhouses. The spatial distribution of land parcels causes wastage of human resource and animals' working hours, inequalities in input use and gradual decline in cropping intensity and production capabilities of distant parcels. This has also led to poor management and conservation practices in those parcels that are located far away from the household.

The land parcels located closer to farmhouses received higher inputs and better management, leading to relatively higher yields than distant parcels. Similarly, a general trend of growing higher number of agroforestry species in the parcels closer to households was observed. Generally, farmers were found reluctant to grow tree species in their khet land. However, due to the NAF motivational efforts, training and availability of planting materials, project households had planted a higher number of agroforestry species in khet land in comparison to non-project households. Similarly, agroforestry adoption was higher in areas easy to access than areas difficult to access. The results explained the fact that NAF project activities are concentrated in areas easy to access. Besides the accessibility factors *per se*, the higher adoption of agroforestry by farmers in accessible areas is mainly attributed to the agroforestry project implemented by NAF.

Chapter VII

Impact of Agroforestry on Soil Fertility

7.1 Introduction

Agriculture is still the main source of livelihood for the majority of Hill population living under subsistence farming. Hill farming systems are very diverse and depend primarily based on compost manure for maintaining the soil fertility. Livestock, forest, and crops are the three major components of the systems. Crop productions is mainly based on the recycling of organic residues available from forests and crop cultivation, used as livestock fodder and bedding materials to produce manure and compost. Livestock, which is an integral component of the farming system, relies heavily on the on-farm fodder production, crop residues and forests. Despite the fact that the system's productivity is sustained by the continued fertility maintenance from compost manure, soil fertility has not been a priority issue in the National Agriculture and Forestry Departments (Shah, 1996). Soil erosion and crop intensification are well-recognized causes of declining soil fertility. Therefore in recent years, there has been growing concern over steady deterioration of soil fertility and possible ways of supplying required amount of plant nutrient to sustain the agriculture production in the Hills.

In the Hills, agricultural lands are vulnerable to soil erosion. Several studies carried out in the Hills found declining soil fertility due to soil erosion and plant nutrient depletion. Most of such studies have been confined to estimating soil loss using universal soil loss equation, and paid attention towards farmer's land use and soil conservation practices, and socio-economic causes of soil erosion. Pahari (1993:62) estimated average soil loss of about 60 tons ha^{-1} yr^{-1} in the upper Andhikhola watershed of the western hills, whereas an average of 33 tons ha^{-1} yr^{-1} was estimated for Tinahu watershed of western hills (Shrestha, 1996). Similarly, the average soil loss of 44 tons ha^{-1} yr^{-1} in Nakkhu khola watershed, located south of Kathmandu (Tiwari, 1990:59), and 18 tons ha^{-1} yr^{-1} in Trijuwa watershed in the eastern Churia hill (Sah, 1996) have been reported. These estimations indicate that soil erosion particularly in cultivated land is a serious problem in the hills of Nepal. The process that leads to land degradation and subsequently soil fertility decline needs to be explained both in biophysical and socio economic terms before effective management options are developed (Schreier et al., 1995:51). Soil erosion and land degradation processes are still insufficiently understood due to lack of reliable data and records. Above mentioned studies reveal that soil erosion rates in agricultural land vary significantly from one area to another depending on slope gradient, land use and soil management practices employed by farmers. However, they provide little information on farmer's adaptive strategies employed to manage fertility of different types of land.

Soil fertility, which is determined by the physical and chemical properties of the soil, indicates the ability of the soil to supply the nutrients needed by plants. Productivity is the capacity of soil to produce crops that is commonly measured in terms of quantity produced per unit of area. To a considerable extent the crop productivity is influenced by the plant growth that depend on human management. The relative amount of nutrient in soils affects their uptake by plants. Too high level of either element suppresses the uptake of other elements (antagonisms). Fertility decline is a progressive reduction in the productivity of soil, and it is a complex process of deterioration in organic matter content, nutrient availability and biological activity in the soil (ESCAP, 1997:33). The uplands or bari are more prone to accelerated degradation (Table 7.1). The declining soil fertility has challenged sustaining food security in the hills and mountains. Significant reduction in nitrogen and magnesium losses from the soil through hedgerow integration has been reported (Scroth et al., 1995) and agroforestry's role in reducing the losses from soil erosion has also been widely recognized in the literature (Bremen and Kessler, 1997, Roose and Ndayizigiye, 1997).

Table 7.1 Estimated soil and nutrient losses by rainfall erosion under different land uses of Nepal

Descriptions	Level Terraces	Sloping terraces	Shifting Cultivation
Soil Loss (tons $ha^{-1}yr^{-1}$)	5.0	20.0	100.00
Organic Matter Loss ($kgha^{-1}yr^{-1}$)	150.0	600.0	3000.0
Nitrogen loss ($kgha^{-1}yr^{-1}$)	7.5	30.0	150.0
Phosphorus loss ($kgha^{-1}yr^{-1}$)	5.0	20.0	100.0
Potassium lot ($kgha^{-1}yr^{-1}$)	10.0	40.0	200.0

Source: Land Resources Mapping Project, 1986

Constant loss of soil fertility due to multiple reasons has been a challenging issue of land management in the Hills (CBS, 1998:359) where most agricultural lands are terraced from valley bottom to the ridge. The terraced lands are likely to be exhausted of mineral nutrients (Jodha, 1995:142) and the farmers find increasingly difficult to grow crops without chemical fertilizers. Cultivation in the steep slopes is considered a important factor in accelerated soil erosion from the farmlands. Although expansion of cultivated land into marginal hill slopes is disputable, hill slopes up to 45% are reported under cultivation (Bansyat, 1995, quoted Lal, 1988). Farmers explicitly mention that soils are not as fertile as they once were (Carson, 1992:1; Vaidya et al., 1995: 69). However, there is wider variation in soil fertility depending on soil constituents, land type and soil management practices. Some of the soil lost from one plot will end up on other plots further down the slope and so are not lost to the system (personal communication with C.J.Garforth, 2000).In the Hills, the nutrient loss through water erosion is much higher than the removal by crops. As a result soils are characterized by nitrogen, phosphorus, potassium and calcium deficiencies, implying of low soil fertility (ESCAP, 1993: 41). However, the extent and severity of declining soil fertility has not been well studied.

Of the several factors, the excess removal of surface litter, crop residues and the erosion of topsoil have been the major causes of soil fertility decline. Dwindling traditional practice of maintaining vegetative cover through agroforestry has aggravated soil erosion and land fertility. Some farmers seeking more food grain production from their already fragmented and miniature land holdings have cut down number of tree species from their farmlands. This is attributed to some bigger trees causing shade in the field crops. This was done not only to increase food grains production but also to fulfill other household needs, such as timber for construction, fuel wood for cooking and cash earning by selling the tree species. While agroforestry can potentially play an important role in improving soil fertility, much attention has not been paid towards related research and technology promotion. This has lead to unavailability of appropriate management systems to improve or maintain the soil fertility for resource-poor farmers (Tamang, 1991; Carson, 1992; Shrestha and Katuwal, 1992).

Soils are heavily leached during the short period of intense monsoon rains, more than 80% of which is concentrated during July-September. This problem of excess moisture moving down the soil profile is more severe in bari than in khet soils. Decreasing vegetative cover, including mulching, intensive tillage and land preparation carried out prior to the onset of monsoon rains have further accelerated the pace of soil erosion. Compared to a same amount of rains over a longer period, heavy rainfall concentrated in a short duration facilitates higher suspension of nutrients, which are lost through infiltration and surface runoff. Nitrogen in particular is more prone to leaching. Although such analysis is beyond the scope of this study, an analysis of river or stream water during rainy season may indicate what is being removed from the soil. Improvements in vegetative cover through increased plantation of tree and grasses in the farmlands have been recognized as an appropriate means of improving soil fertility in the hills. Improvements in vegetative cover through better agronomic practices and contour hedgerows are found to be beneficial (Angus et al., 1998; Okoji and Moses, 1998; Nelson et al., 1997; Nuberg and Evans, 1993).

The perennial tree crops grown in bari, which are rainfed and vulnerable to accelerated soil erosion, helps to keep soil moisture for a longer duration and control soil erosion. In warm dry months, when crop cultivation in bari becomes difficult due to increased soil temperature, plant cover and shade help to control soil temperature fluctuations. It is estimated that the rate of chemical reaction in the soil doubles with every rise of about 10 ^{0} c in temperature (Ahn, 1993). Even the practice of mulching is a useful practice to control soil temperature fluctuations. In winter months, plant residues covering soils prevent the temperature from dropping down and protect the soils from cold spells.

Agroforestry systems influence the formation and properties of soils by supplying humus and removing nutrient ions from the root zone. Perennial trees tap nutrient from the lower layers of soil, control soil erosion, provide shade to field crops, lower soil temperature and modify the microclimate beneath the canopy. One advantage of the tree-crop based cropping systems is that trees extract nutrients from the lower horizon beyond the reach of the annual crops. Thus the agroforestry system is important to tap water and nutrients that have leached from the surface into the subsurface (Carson, 1992). Apart from the increased availability of nutrients to feeder roots in the topsoil, the ground surface is shaded not only by the bush itself but by the usually dense layer of dead leaves, twigs and pruning forming a thick mulch on the soil surface. The amount of the surface mulch that replenishes nutrients, conserve soil moisture and supplies organic matters to the soil (Young, 1990) varies with the type and density of tree cover, type of trees and the practice of biomass harvesting. Apart from controlling soil erosion, especially hedgerows consisting nitrogen fixing trees and shrubs help to maintain or enhance soil fertility. The systems not only fix nitrogen but also add organic matter to the soil.

Mixed species of both leguminous and non-leguminous trees and grasses are planted in the study area. Unlike typical agroforestry designs, such as alley cropping, strip cropping and others, trees are planted in terrace risers, fallow lands, terrace edges and uncultivated inclusions.

They are not planted in terraces in association with field crops. The above ground biomass is harvested and fed to livestock, whereas the root systems enrich terrace risers and not the soils of terraces as such. Therefore agroforestry's direct contribution to soil fertility is very much limited under the current system being adopted in by many farmers. But through the chain of nutrients recycling agroforestry systems have been contributing to maintain soil fertility to some extent. Slicing of terrace risers, normally practiced in khet, helps to transfer nutrients to terraces. But *bari* terrace risers, which are utilized for agroforestry are not sliced. Therefore, there may not be any significant difference in organic matter and nitrogen contents in particular between the soils of agroforestry and non-agroforestry project areas.

Indirect contribution of agroforestry to soil fertility becomes visible overtime and in terms of overall improvement of farm household economies. The net benefits from the system depend upon how the system capitalizes the useful benefits that could be derived from the tree-crop interactions. Selection of suitable species and their combinations, spatial and temporal arrangement, within the agroforestry system, to a larger extent determines the amount of benefits. Specifically the incorporation of higher number of fast growing and high biomass producing leguminous species in the system contributes to improve soil fertility substantially. Some studies indicate that increase in soil organic matter due to agroforestry occurs slowly and can take several years to detect (Clark et al., 1998).

In this study, an attempt has been made to evaluate the soil fertility status of farmlands so as to facilitate formulating appropriate agroforestry intervention policy. The primary objective of the soil analysis is to assess the general fertility situation and impact of the agroforestry interventions on soil fertility. These analysis complements the other analyses based on information collected through a household survey. Analyzing the soil fertility the geomorphic dynamics and pedogenetic processes are not included. As the focus of the study is management aspect of agroforestry, only soil's ability to supply nutrients to crops has been addressed. Apart from the scientific analysis, farmers' experiments and experiences related to soil fertility management are also taken into consideration. In this chapter soil fertility status, which is determined through the fertility index, has been analyzed with respect to "with" and "without" agroforestry intervention, type of land and relative accessibility to the motorable road.

7.2 Soil sample design, collection and analysis

Research on agroforestry's contribution to soil fertility based only on information collected through the household survey alone will be inadequate, as the type and amount of nutrient to be applied to any crop depend on the nutrient status of the soils. Therefore, soil test is deemed necessary for fertility evaluation that includes the assessment of the amount of plant nutrients available in soils and thereby the ability of soils to supply nutrients to crops. Soil sampling, laboratory analysis, and interpretation of the results are the essential procedure of fertility evaluation. Soil sampling is an important aspect of the entire evaluation process. Due to larger possibilities of expected variations within small area caused by several factors, such as parent materials, soil type, types of crop grown, soil types, micro climatic condition, amounts of inputs used and management practices employed by individual farmers, extreme care should be taken in soil sampling.

Sampling should therefore represent plots "with" and "without" agroforestry project intervention where biophysical and socio-economic conditions are similar. Since trees are integral component of the farming system, maintaining assorted species of trees on farmlands has been a traditional practice of all households in the study area. In this study "with" agroforestry refers to households involved in planting additional tree/shrub and grass species as part of the NAF promoted agroforestry program. Fodder trees and grasses dominate the species planted by farmers in their farmland. Fodder trees are of mixed type, comprising both leguminous such as, ipil ipil (*Leucaena leucocephala* and *Leucaena diversifolia)*, calliandra (*Calliandra calothyrsus*) bhatmase (*Flemingia congesta)*, and non-leguminous, such as kimbu (*Morus alba*), gauzuma (*Gauzuma ulmiformis*) and kutmiro (*Litsea monopetala*). Grass species of NB 21 (*Pennisetum sp*.), napier (*Pennisetum purpureum*) and stylo (*Stylosanthes guianensis*) have been promoted. These species are promoted in the project area. However, the project participants may not have practiced agroforestry in all of their land parcels. The traditional practice has been to maintain trees and hedges on risers of bari terraces, gharbari and other non-cultivated inclusions. Only a few species or no species are kept in khet land. The case "without" agroforestry project refers to a situation where no deliberate attempt has been made to promote agroforestry.

7.2.1 Soil Sampling

A two stage sampling procedure was followed during the soil sample collection. Identification of the appropriate farming community and the households was the first step employed. Out of several villages included in the household survey, only farm households of two adjoining villages of Nalang and Majhitar were considered for soil sampling in view of similarity in their biophysical and agricultural conditions. Both villages have households in "with" and "without" project situation. In the second stage of sampling, the farm plots belonging to households "with" and "without" agroforestry project were sampled randomly. Due to expected variations in amount of inputs used and management practices applied, soil samples were drawn from individual farm households representing both with and without agroforstry plots. Careful attention was paid to select plots to which relatively same amount of fertilizer was applied by farmers. Out of the several plots "with" and "without" agroforestry project, 10 samples were collected for "with" project situation and 8 "without" project condition. Being a study focused on socio-economic and management aspects of agroforestry this sample size was deemed adequate to analyze general soil fertility situation in the areas "with" and "without" project.

After clearing all the weeds, leaf litters, twigs and stones covering the surface, soil samples were drawn from the 0–20 cm deep plough layer with the help of a spade. To make the sample true representative, soils were randomly collected from 8-12 different spots of a plot. Then all individual soil cores taken from different spots were thoroughly mixed to form a composite sample. This method was applied to all 18 soil samples. In case of the project area, the samples were taken from the distance of one meter on the either side of the terrace risers with trees.

Leaf litters, plant roots, twigs, stones and other alien objects were sorted out from the composite samples placed in containers. Soil clods of each composite sample were thoroughly broken to make a proper mix, and then divided into four equal parts from where two parts placed diagonally were removed. This process was repeated until the successive quartering reduced the weight of a composite sample to about half a Kg. A representative sub sample of about half a kg from each of the 18 composite samples were taken for laboratory analysis following this method. Samples were air dried and then put in plastic bags clearly labeled with i) the name of the farmer, ii) address, iii) date of soil sample collection, iv) type of the land (*gharbari/bari/khet),* and v) the mode of current land use, for example, "with" /"without" agroforestry project. To ensure that the information will not be lost, another information label was put inside the sample bag. Soil samples were then taken to the Kirtipur Horticulture Farm, for necessary laboratory analysis.

7.2.2 Laboratory Analysis

Soil samples were analyzed at the Soil Testing Laboratory of the Fruit Development Project implemented by the Department of Agriculture at its Horticulture Development Farm in Kirtipur, Kathmandu. Different methods were used to analyze various soil parameters (Table 7.2). The percentage of nitrogen available in soils was estimated following the *Kjeldahl Method* whereas the organic matter percentage was estimated as a measure of carbon through *Walkley-Black Rapid Titration Method.* To estimate the proportion of sand, silt and clay *Hydrometric Method* was used and the pH meter was used to determine pH (Table 7.2).

Table 7.2 Laboratory methods used for chemical analysis of the soil samples

S.No.	Soil Parameters	Method used	Instrument used for analysis
1	pH	1:2.5 dried soil: distilled water	pH meter
2	OM	Walkley & Balck method	-
3	Total Nitrogen	Kjeldahl method	Kjeldahl apparatus
4	Available P_2O_5	Bray 2 method	Spectrophotometer
5	Available K_2O	1 N ammonium acetate	Flemephotometer
6	Soil texture	Hydrometer method	Hydrometer

Source: Soil Analysis Report, 1998

7.2.3 Analysis of soil samples:

A total of 8 soil properties- *soil reaction* (pH), *organic matter* (OM), *total nitrogen* (N), *available phosphorus* (P_2O_5), *available potassium* (K_2O), and *textural classes* (*sand, silt and clay*) were analyzed through chemical tests. For subjective interpretation of availability of nitrogen, phosphorus, potassium and organic matter, a five point rating scale was adopted

(Table 7.3). The diagnostic techniques, such as identification of deficiency symptoms, and soil and plant tests are normally employed to determine fertility status. Chemical soil tests, which are extensively used, have the added advantage over deficiency symptoms and plant analysis because needs of the soil can be determined before the crop is planted (Tisdale et al., 1990). Although extensively used, the laboratory test does not adequately reflect the productivity of soils for which fertility management is dominated by compost additions because soils shown to be severely deficient in one or more nutrients often produce satisfactory crop (Carson, 1992).

Table 7.3 Soil Analysis Rating Chart

Rating	N	P_2O_5	K_2O	OM
Very Low	< 0.05	< 10	<55	< 1.0
Low	0.05-0.10	10-30	55-110	1.0-2.5
Medium	0.10-0.20	30-55	110-280	2.5-5.0
High	0.20-0.40	55-110	280-500	5.0-10.0
Very High	> 0.40	> 110	> 500	> 10.0

Source: MOA/HMG- Nepal (1998); Dahal (1996); Maskey (1998)

N = Nitrogen; OM = Organic Matter; P_2O_5 = Phosphorus; K_2O= Potassium
N and OM are in % of soil by weight
P_2O_5, and K_2O are in Kg ha^{-1}

7.3 Soil Fertility Evaluation

Soil fertility evaluation is based on the analysis of major soil variables such as soil reaction, soil organic matter, soil nitrogen, soil phosphorus and soil potassium. Soil physical properties are analyzed by looking into the presence of different sized soil mineral particles, namely clay, silt and sand. The analysis report of the laboratory test revealed variation in nutrients content in soils "with" and "without" agroforestry project (Table 7.4). The results of soil analysis revealed that soils 'with' agroforestry project contained relatively higher amounts of organic matter, nitrogen, phosphorus and potassium than soils 'without' the project. However, these differences were not statistically significant at the 0.05 level (Table A7.1). Bari soils had relatively lower amounts of organic matter, nitrogen and silt, and higher amounts of phosphorus than khet soils both 'with' and 'without' the project. Comparing between the project and 'without' project conditions, the analysis indicated that, except for phosphorus, bari soils from project areas had higher amount of organic matter, nitrogen, silt and clay than 'without' project, while for khet soils organic matter, nitrogen, phosphorus, and potassium were higher under project conditions. This indicates the positive contributions of agroforestry to soil fertility.

The lack of significant differences in soil nutrients between 'with' and 'without' project conditions may partly be attributed to the fact that the agroforestry program was introduced in the year 1993/94 and the agroforestry's contribution to improvements in soil fertility may not have been fully realized yet. Studies indicate that increase in soil organic matter due to agroforestry occurs only slowly and can take several years to detect (Clark et al., 1998).

Moreover, the improvement in soil fertility could be masked by the removal of large amounts of nutrients through intensive fodder, fuel-wood and poles extraction. This is consistent with the findings of a study in the Philippines where the direct contribution to soil fertility from contour hedgerows of nitrogen fixing legume species trimmed four times a year was reported to be very much limited (Garcia and Gerrits, 1995, p. 59).

Table 7.4 Summary of soil test results by land use and type of land

Soil variables	Bari			Khet		
	With project (n=6)	Without project (n=4)	F-value**	With project (n=4)	Without project (n=4)	F-value**
PH	6.47	6.66	1.394	6.44	6.47	0.052
OM (%)	1.53	1.02	1.006	2.35	2.04	0.200
N (%)	0.073	0.048	0.985	0.115	0.10	0.172
P_2O_5 (kg ha^{-1})	69.43	87.39	0.480	46.77	30.88	0.219
K_2O (kg ha^{-1})	154.06	158.72	0.023	150.2	94.08	2.269
Sand (%)	37.33	50.90	1.945	26.95	28.25	0.009
Silt (%)	39.33	28.00	2.341	50.00	49.50	0.002
Clay (%)	23.33	21.10	0.277	23.05	22.25	0.052

n is the number of composite samples.
OM = Organic matter; N = Nitrogen; P_2O_5 = Phosphorus; K_2O = Potassium.

** *Non-significant even at 0.10 level*

Normally the hill soils have been noted for severe acidity problems (Schreier, et al., 1994). However, soils in the study area with an average pH value of 6.5 did not exhibit such problems. Despite high leaching of nutrients from bari soils, particularly under the steep condition, the use of manure and agroforestry practices might have contributed to maintain the soil pH within the optimum range recommended by the Department of Agriculture (Maskey, 1998). Soil tests revealed higher amounts of OM in project plots (1.9%) compared to without project plots (1.5%). On average, soil contained 60 kg of P_2O_5 ha^{-1}, which is substantially higher than 50 kg of P_2O_5 ha^{-1} considered to be good enough to maintain maximum yield in Ivory Coast (Ahn, 1993). Slightly higher amounts of clay and silt particles found in project plots than in non-project plots showed that agroforestry has contributed to minimizing the removal of clay particles by topsoil erosion, thus leading to improvements in soil fertility.

Other explanatory factors are farmers' fodder collection practices and type of agroforestry species promoted by NAF. It has been a traditional practice of farmers to "cut and carry" all available fodder and grasses required for livestock, which are an integral component of farm household economies. Other plant species that are not eaten by the animals are lopped for animal bedding materials whereas twigs and branches are used for fuel wood. The practices contribute very little to the soil organic matter content directly. Therefore, the direct contribution to soil fertility could be low due to large amounts of nutrient removal through intensive tree fodder, grasses, fuel-wood and poles extraction. But the contribution will be reflected in the form of total amount of organic manure produced, and the overall household income level. Because in the system, the direct effect of one component upon other will not be always visible from a single component analysis but may reflect in the system output.

In the Philippines, contour hedgerows of nitrogen fixing leguminous species established at the base of the rock walls were trimmed an average of four times per year. On an average, 70% of the trimming was used as fodder for livestock, 23% was incorporated into the soil as green manure and remaining 7% was used for other purpose. Under this system of agroforestry, the direct contribution of hedgerows trimming to soil fertility was reported to be very much limited (Garcia, 1995:59).

7.3.1 Soil Structure and Texture

Soil consists of solid materials (organic materials in various stages of decomposition) and mineral particles (clay, silt and sand). Soil texture refers to the relative proportions of sand, silt and clay in the soil. Soil consists of a mixture of particles of all these three size classes. Different types of soil particles present in the soil have significant contribution to soil fertility status. Soil texture is a fundamental property of soil, because farmer/cultivator can do very little to change or modify the existing soil texture. Soil fertility management is not only determined by bio-chemical properties but also by physical properties of the soil. Soil characteristics depend greatly on the relative proportion of different class sizes. Soil particles effect soil structure, which in turn determines nutrient content, water holding capacity, aeration through soil porosity, temperature and other processes of the soil ecosystem vital for plant growth. High clay content soils are referred to as heavy soils whereas sandy soils are called light soils. Heavy soils require greater efforts to cultivate than light soils.

Soil structure refers to the arrangements of individual soil particles within a soil. Good soil structure facilitates good root growth, better water management and soil erosion control. With continuous tillage operation and lesser amount of FYM addition, the topsoil structure deteriorates with a reduction in porosity and crop productivity. The developed structure in topsoil increases porosity, which improves aeration and water infiltration. It makes cultivation easier, favors seedlings emergence and root penetration. This is again related to organic matter level. Low level of OM during cultivation declines in the grade and size of structural units and consequently reduction in topsoil porosity, lowering water infiltration rates. This action will lead to increase in runoff water, which lowers the effective rainfall available to plants and may lead to sheet erosion. Careless handling of soil specially when wet and misuse of soil results in loss of stable structure (Ahn, 1993).

Irrespective of the land use type, the soil texture is loam type in the study area (Table 7.5). A loamy soil is formed with a combination of 10-25 percent clay, approximately equal amount of silt and sand combined with several percentage of organic matter (Thompson and Troeh, 1973). Loamy soil will have all the soil constituents more or less in the same proportions. Loamy soils have good water holding capacity and optimum aeration. The textural analysis revealed that soil texture is fine and quality of soil is fairly good.

Table 7.5 Soil textures

Soil particles	Average Soil Particles (in percentage)	
	With Project	Without Project
Sand	33.2	39.57
Silt	43.6	38.75
Clay	23.2	21.67
Soil textural class interpretations[1]	Loam	Loam

Source: Field soil test report, 1998

[1]Classification is based on USDA soil textural triangle classification system.

Soils in the project plots have slightly higher amounts of clay and silt particles, whereas non-project plot soils contained slightly higher level of sand. Higher clay content in project plots indicates the agroforestry's contribution in protecting soil by minimizing soil erosion and thus to soil fertility improvements. Topsoil erosion, which washes away the clay particles from the farmlands, is the main problem of soils in the study area. Higher percentage of sand in without project plots may be related to higher soil erosion and leaching losses. Sandy soils are extremely permeable and require more water. Low levels of clay fraction in the soil suggest that the texture is moderately coarse. Under such soils, tillage operations, soil aeration and drainage are not problems.

7.3.2 Relationship among soil variables

Relationship among the soil variables is analyzed through generating correlation matrix. The matrix reveals significant correlation among most of the soil variables in both with and without project plots (Table 7.6). The N and P_2O_5 levels are highly correlated ($p< 0.01$) with OM content of the soil. The strong positive relationship between OM and nitrogen is an established fact as OM supply bulk of the nitrogen in the soil. OM and P_2O_5 are negatively correlated. Organic matter affect P_2O_5 availability, either by lowering pH or displacement of phosphate from iron and aluminum phosphate. Which may have been associated with the inverse relationship with phosphorus.

High degree of inverse correlation between sand and silt, OM and sand was observed in both with and without project plots. A strong negative correlation was also found between P_2O_5 & nitrogen, P_2O_5 & silt, and nitrogen and sand in both types of soil. Nitrogen losses are higher in sandy soils, which are leached heavily due to higher infiltration rates leading to negative relationship. Because of their excellent physical condition, the fine textured soils are known for phosphate fixation showing the weaker negative relationship. Whereas phosphorus and sand in both with and without project plots showed highly significant ($p<0.01$) positive correlation.

Table: 7.6 Correlation matrix among soil variables in with and without project.

	pH	OM	N	P_2O_5	K_2O	Sand	Silt	Clay
pH	1.00	-0.564	-0.564	0.636	0.990**	-0.527	-0.579	0.244
OM	-0.545	1.00	0.999**	-0.973**	-0.530	-0.993**	0.969**	0.084
N	-0.560	0.999**	1.00	-0.965**	-0.527	-0.995**	0.969**	0.094
P	0.528	-0.644*	-0.634*	1.00	0.612	0.954**	-0.961**	0.052
K	0.156	0.279	0.292	-0.114	1.00	0.490	-0.551	0.284
Sand	0.838**	-0.654*	-0.659*	0.866**	-0.070	1.00	-0.975**	-0.091
Silt	-0.728*	0.632*	0.633*	-0.860**	0.042	-0.951**	1.00	-0.133
Clay	-0.793**	0.494	0.504	-0.604	0.108	-0.782**	0.550	1.00

Source: Soil test report, 1998

The correlation coefficients in left and right hand side of the diagonal are for with and without project plots respectively.

* = Correlation is significant at 0.05 level ($p< 0.05$)

**= Correlation is significant at 0.01 level ($p <0.01$)

The significant relationship among soil variables confirmed that the deficiency of one nutrient leads to deficiency of the other positively correlated soil nutrient. This will also effect the uptake of other nutrient available in relatively sufficient amount. Coarse textured soils (sandy soils) are more susceptible to leaching than fine textured (clay) soils. Similarly bare soils are more prone to leaching losses in comparison to those covered by plants. Analysis shows that plots with project have more potassium than without project plots because of more clay particles found in with project plots owing to agroforestry's contribution in minimizing soil erosion. The reason of potassium being converted into non-available forms is because it is attracted by clay particles. Because potassium is attracted to clay particles, loss by leaching is a problem only on sandy soils.

7.3.3 Overall soil fertility analysis

This sub section summarizes the overall fertility status of the soils in the study area. An estimate of overall fertility, derived through indexes out of the variables tested, is made for the comparison of the soils. Although the overall fertility status of the soils is high, soils in the agroforestry project area have relatively higher fertility status compared with soils in non-project areas (Table 7.7). Thus the agroforestry intervention has contributed to improve the fertility status of soils, through the process of nutrient recycling within the system. Since crops and vegetation, which covers the ground surface well and have extensive root systems, reduce soil erosion, the fertility decline will be relatively low compared to the plots without such practices. Higher amount of organic matter in agroforestry project plots is related to the adoption of planting greater number of tree/shrub and grass species, which resulted in improved fertility status.

Table 7.7 Overall soil fertility evaluation

Soil fertility parameters	Mean soil fertility index	
	With Project	Without Project
Organic Matter	2.1	1.8
Nitrogen	1.9	1.8
Phosphorus	3.3	3.1
Potassium	2.8	2.5
Mean index	2.5	2.3
Fertility Level Interpretation	High	Medium
Soil pH	6.43	6.55
Soil Texture	Loam	Loam

Source: Field soil test report, 1998

The Hill economy very much depends on the quality and fertility of the agricultural land. The physical and chemical analysis of the soil parameters confirmed the vulnerability of soils to declining fertility, as with the exception of potassium and phosphorus, other nutrients are relatively low in soils (Table 7.7). Higher clay and organic matter content promotes good soil structure whereas high sand and silt content results in poor soil structure. Excessive and/or prolonged drought, which is often the case in the hills, can reduce organic matter contents causing loose topsoil in silty or sandy textured soils. Although, the scientific analysis on soil nutrient status indicates that the soils in the study area have little problem but farmer perceive that soil fertility problem exists. It may be true that the problem have been appearing in the study area due to the increasing trend of chemical fertilizer use and farmers' tendency of replacing farm yard manure application with that of chemical fertilizers. In comparison to the use of chemical fertilizer by a normal hill farmer and Dhading district average, the use of chemical fertilizer in the study area is found higher in this study. This could be problematic in future to maintain the soil fertility and crop production level under the conditions of land fragmentation, deforestation, less organic matter availability, higher livestock number and labor shortages.

There is a widespread tendency of generalizing the situation for household level in the Hill situation. But this study shows that generalization even at the household level will result in the misinterpretation of the actual situation in the Hills. Analysis shows that variations exist within household level and between the different parcels of land a particular household owns. Within a household and between land types, the problem is more serious in bari than khet lands. In terms of bari lands, the problem is more acute in parcels located far away from the households than those located near to the homestead areas which receives more organic manure and effective management practices.

7.4 Comparison of soil fertility between gharbari, bari and khet Soils

Bari soils have higher ($p<0.05$) levels of phosphorus and potassium than khet soil. Statistically the phosphorus content between the bari and khet lands are significantly different ($p<0.05$). Similarly, levels of organic matter content, and nitrogen are significantly ($p<0.05$) higher in khet land (Table 7.8) than bari soils (Table A7.2). The soils of gharbari and bari are tested to be more or less similar because the soil samples from bari lands are taken within 10 minutes walking distance from the households. Results from this study indicate that there are chances for bari soils to be different from gharbari, if sample are taken from different parcels located at various distances from the household. Bari lands near to homestead areas, received more chicken manure, vegetable roots and leaves, oil seed cakes and other materials from the homestead area. This is reflected by the test results that soils from gharbari showed more organic matter content in contrast to bari soils. Although mean values for organic matter and nitrogen content of gharbari are found higher in comparison to bari lands, the differences are not statistically significant at 0.05 level.

Table 7.8 Contents of soil properties by type of land (N= 18)

Properties	Gharbari (n=6)		Bari (n=4)		Khet (n= 8)		F- value	Sig.
	Mean	SD	Mean	SD	Mean	SD		
pH	6.4650	0.2997	6.67	0.089	6.4550	0.1733	1.521	0.250
OM	1.5567	0.9649	0.9825 a	0.1690	2.1988 a	0.9310	2.893	0.087
N	0.075	0.0500	0.045 b	0.0580	0.1075 b	0.048	2.874	0.088
P_2O_5	64.728	40.9862	94.45 c	32.4175	38.8275 c	45.2976	2.450	0.120
K_2O	150.34	48.2147	164.298	45.3804	122.1663	57.3216	1.017	0.385
Sand	37.0	18.6509	51.4 d	2.6683	27.60 d	17.698	2.882	0.087
Silt	37.67	14.3898	30.5 e	8.2260	49.70 e	15.872	2.790	0.093
Clay	25.33 f	5.0162	18.1 f	5.9431	22.7	5.009	2.316	0.133

Source: Soil Test Results, 1998

Means accompanied by the same letters within a row are significantly different at 0.05 level (ANOVA, LSD, and $p < 0.05$).

Soil textural analysis shows higher percentage of sand, silt and clay particles in gharbari than other bari but only the clay content is significantly different ($P<0.05$). This indicates that the loss of clay particles by water erosion is higher in bari lands compared to gharbari land parcels. Furthermore, this is reflected to the better conservation management applied in the bari land parcels, such as gharbari, located in and around the farm household area. Low clay content of bari soils indicates that the soil texture is coarse and water holding capacity of such soils are lower. Low levels of soil moisture retention in bari soils is caused due to low water holding capacity which proves to be a problem. Leaching will be more rapid in coarse textured soils. Silt content of khet land is found to be significantly higher ($p<0.05$) than bari land.

Due to low water holding capacity, high leaching losses, and nutrient loss through erosion bari lands need to be manure heavily than khet lands. This is proved by the present research results that application rate of FYM in bari land is more than khet land (see Table 8.3). This is partly due to the need of balancing the nutrient loss from bari soils caused by surface run off in comparison to khet soils. The higher phosphorus content of bari lands in comparison to khet lands could be related to more manure application.

7.5 Summary

All together, 8 soil parameters, namely *soil organic matter, pH, nitrogen, phosphorus, potassium,* and *textural analysis* for *clay, silt* and *sand* were analyzed. The results show that soil with agroforestry project has higher amount of organic matter and nitrogen in contrast to soil from without agroforestry project but the difference is not tested significant statistically. Levels of organic matter and nitrogen are significantly higher in khet than bari land. In overall fertility analysis, soils show no major problems. Agroforestry has contributed positively to improve the soil fertility. But there are problems or problems may be appearing due to the increasing use of chemical fertilizers mostly nitrogen fertilizers, such as urea, diammonium phosphate, and ammonium sulphate. Farmers have been practicing multiple soil fertility management strategies to keep the soil fertility intact and sustain the production levels. But with increasing human and livestock population, decreasing amount of organic matter collection from the forest, land fragmentation and increasing travel time to various parcels, the farmers are increasingly facing the soil fertility problems.

Chapter VIII

Agroforestry and Soil Fertility Management

8.1 Introduction

Agricultural land degradation is an emerging environmental and economic problem in the hills. It is manifested through soil erosion, nutrient mining, soil compaction and increased soil acidity. Farmers need to consider different influencing factors before taking decisions on management of their farmlands. The preceding section shows different fertility situation of bari and khet lands. Although soils from project plots contain slightly higher amounts of nutrients than soils in non-project plots, organic matter and nitrogen content of the soil samples are low in both situations. Farmers have been applying multiple approaches and methods to maintain the farmlands' productivity from the available resources. Apart from the agroecological diversity, variations in types and numbers of crops grown and specific management practices required for specific crops in bari and khet lands, the management considerations are also influenced by the socioeconomic factors, production enterprises and the need of conservation practices. The farm resource management systems are made up of social, biophysical and economic systems, which are complex and interrelated.

Socioeconomic factors, such as markets, transport, credit, support services, land tenure, labor, cultural attitudes and government policies are important in decision making. In case of production enterprises, the management decisions will differ according to the types of enterprise to be promoted, such as introduction of agroforestry (fodder/fuel/timber trees, grasses), annual crops (cereals, legume, vegetables) and livestock. Similarly, the management practices were found to be different according to the need of conservation practices for specific parcel of land within each households. Decision on resource management on conservation practices are influenced by the type of structural practices, such as terracing of the farmlands, and agroforestry based vegetative practices, such as mulching, crop rotation, grasses on terrace risers and sloping lands, cover crops and composting. As farmers have practiced intensive land use without adequate inputs, plant nutrients are gradually depleting in soils. However, the impact of land use intensification on the long-term productive capacity of the soil is yet to be understood clearly. In the hills, the soil fertility decline and resultant impact on production has been a major concern for sustaining agricultural production (Schreier et al., 1995:249).

The developments of infrastructure, such as roads, and growth of market activities due to rapid growth of urban centers, have facilitated new economic opportunities. In response, farmers have been seeking and experimenting with new technologies, such as commercial fruit and wood trees plantation, mulberry plantation for silk production. Due to the shortage of fodder caused on restricted access to community forests, fodder became the immediate need for farmers. Though livestock number was found to be positively associated with agroforestry adoption (Chapter 11), the pattern of use of agroforestry has been gradually changing (chapter 9 discussion on plantation of mulberry for silk production, though NAF originally promoted it as fodder species). Therefore farmers are envisaged to grow more trees for other commercial purpose and not necessarily for livestock fodder. Their decision to plant trees on their private land is generally the reflection of their response to a number of environmental and socio-economic changes taking place around them, including new economic opportunities (Garforth et al., 1997)".

Based on the in-built indigenous knowledge, hill farmers have traditionally followed integrated soil management practices. However, over the time, these technologies alone could not be able to meet the required food production demands to sustain the ever-increasing population (Pandey et al., 1995:43). In several areas, farmers are increasingly applying small amount of chemical fertilizers to restore soil fertility. The declining forest fodder required to produce farmyard manure and farmers' inability to purchase chemical fertilizers have been serious constrains for increasing farm productivity. At the same time, intensive use of chemical fertilizers without adequate organic matters in some areas of the hills has warned of serious acidity problem (Carson, 1995:1). To avert possible soil fertility problem, farmers need to search a balanced way of sustaining soil fertility and ensuring food security.

This chapter describes the farmers perception regarding the fertility status and fertility management practices employed by farmers in different types of cultivated lands mainly bari (gharbari and bari) and khet. The chapter also explores the farmers' response on fertility status of their farmlands and describes different fertility management strategies employed by them to maintain the farmland productivity. Although soil test analysis showed that soils of the study area are in good conditions, farmers have experienced decreased soil fertility status. This is more pronounced in the bari lands than in khet lands. Due to the differences in the nature of cultivation practices, production capabilities, types of crop grown and availability of production resources, farmers over the years have developed different management practices specific to bari and khet lands. Only the management practices that farmers apply to their farming system have been considered. The farmers' strategies in the management and maintenance of soil fertility and role of agroforestry in fertility maintenance are presented with discussions.

8.2 Farmers' Views on soil fertility

Farmers of the study area strongly believe that soil fertility in both the bari and khet lands have been decreased over the years (Table 8.2). Similar views have been expressed by the farmers and researchers, and have reported that agricultural soils of the country are being degraded (Carson, 1992). The analysis shows that about half of the farmers involved in the discussion perceived that soil fertility has decreased over the years (Table 8.1). In comparison to fertility situation of khet (46%) higher percentage (55%) of farmers perceived that soil fertility has been decreased in bari lands. Almost one-third remain in the neither decrease or nor increase category. In an overall situation, less than one-fifth for bari and less than one-fourths for khet land believed that soil fertility in bari and khet lands respectively have increased. But when the comparison is made between the farmer of project and without agroforestry situation, comparatively higher percentage of farmers in project category perceived that fertility in the bari (22%) and khet (24%) lands have been improved. These findings prove that agroforestry contributes positively in soil fertility improvements in the Hills. Previous study on farmer's opinion towards soil fertility status conducted in Sangkos and Nilkantha areas of Dhading district (elevation 660-760 meters above mean sea level) had shown that 63% of the respondent were in the view that fertility status have been decreased. Interestingly, the use of chemical fertilizer was mentioned as one of the reasons by 39% of the respondents (Pandey, 1995).

Farmers said that the levels of organic matter application to their farmland in general and uplands (bari) in particular has declined over the last years. Farmers know the value of organic matter or compost as a physical amendment to enhance soil structure. During the focus group discussion sessions they realized that the plots where chemical fertilizers are applied receives smaller amounts of manure in comparison to other plots where chemical fertilizer is either not applied or applied in smaller quantity. Although it is true that the plots receiving more chemical fertilizer receive less manure, khet comparatively receive higher amount of chemical fertilizers than bari. But due to scarcity of compost and priority for increased cereal crop production farmers are increasingly applying more manure to irrigated khet, thereby reducing the amount of compost applied to bari. In view of scarcity of manure/compost farmers' strategy was to apply it selectively. The top priority is given to seedbeds followed by bari cultivated with cash crops and lands with potentially high yields of cereals. The chemical fertilizer application to the bari is very limited. In some cases, farmers have been substituting the application of manure/compost by applying chemical fertilizers.

Table 8.1 Farmers' Perception of soil fertility (N=78)

Soil fertility Status	With agroforestry		Without agroforestry	
	Bari	Khet	Bari	Khet
Increased	09 (22.0)	10 (24.4)	06 (16.2)	08 (21.6)
Same	12 (29.0)	14 (34.1)	08 (21.6)	10 (27.0)
Decreased	20 (49.0)	17 (41.5)	23 (62.2)	19 (51.4)
Total	41 (100)	41 (100)	37 (100)	37 (100)

Source: PRA, field study, 1998
Figures in the parentheses are percentages.

Note: 3 PRA sessions were conducted in both with and without agroforestry project locations with the total of 12, 13, 16 in project and 11, 12 & 14 in non-project location participants in each session respectively.

During the discussions, farmers explained different reasons for increased or decreased soil fertility (Table 8.2). Out of several reasons, farmers relate the decline in yield to the introduction of chemical fertilizers. They feel that chemical fertilizers contributed to increase crop yield in the initial years, but became a cause of declined yield in subsequent years. Increasing soil acidity might be the possible cause as lesser organic matter is applied, but pH analysis does not indicate soils to be in acidic range. Farmers felt that steady use of mineral fertilizers made soil compact and hard, eventually constraining air and water circulation and tillage practice. Substitution of manure requirements by chemical fertilizers is seen as the real cause. Some farmers reported that they have started using lesser amount of chemical fertilizer and making efforts to increase the application of organic fertilizers, such as green manure, legumes species and farm yard manure. The organic matter content is high in topsoil, but the repeated ploughing and harrowing operations, have loosened the soil, increased oxidation of organic matter and broken down the soil structure.

Tables 8.2 Reason for increase and decrease in soil fertility

Increased soil fertility	Declined soil fertility
1. Improved irrigation facility 2. Use of chemical fertilizers 3. Adoption of improved agroforestry practices with introduction of legumes 4. Increased Farm Yard Manure production due to increased on-farm fodder 5. Adoption of land improvement practices such as hedgerows, cover crops 6. Increased stall feeding practiced increased manure production.	1. Low labor availability and less care given to the soil 2. Declining livestock number and decreasing manure production 3. Siltation from irrigation water in lowlands (*khet*) due to upstream landslide and cultivation practices 4. Increased cropping intensity and use of mineral fertilizers 5. Lesser amount of grass, fodder and leaf litter collected from the forest 6. Entire crop residues are harvested to feed livestock and no stubble are left in the farmlands 7. Decline in fallow period and in-situ manuring 8. Use of high yielding varieties extracting more nutrients from the farmlands.

Source: PRA, 1998

8.3 Role of Agroforestry in soil fertility management adopted by farmers

Hill farmers have adopted number of approaches to sustain or improve the fertility status of their farmlands. The methods applied depend upon various factors ranging from socio-economic to ecological. It is the nutrient recycling in agroforestry system, which has enabled farmers to maintain soil fertility. Animal manure/compost is mostly used in maintaining soil fertility. Fodder species planted on farms are cut and fed to livestock, which fulfils fodder demand partially. National and community forests are other sources of fodder. The bulk of the nutrients removed in the form of fodder and crops residues from the farmlands is returned to the cultivated land as manure or compost. Animals through grazing and feeding fodder collected from forest contribute to benefit the cropped land. In the process of nutrient transfer from forest and grazing land to agricultural land and recycled within the farming system via livestock, considerable amounts of nutrients is lost. The extent of such loss depends on the management factor. The management and sustainability of farmlands fertility is therefore ensured through multiple sources of nutrients supply. The total nutrient needs of crop production in the study area are met from the soil reserves, organic manures/compost, crop residues, green manures, mineral fertilizers, waste recycling, biological nitrogen fixation and atmospheric depositions.

In this study, analysis on two major components of soil fertility maintenance, such as use of chemical fertilizer and manure/compost, by farming household in different type of land units was carried out to understand the farmers' practice of fertility maintenance. Some of the other important agroforestry based practices, such as use of green manure, adoption of mulching, inclusion of grain legumes with cereal crop cultivation, in-situ manuring and other miscellaneous practices adopted by the farmers in the study area, are also discussed in this section. Information on varieties of such strategies adopted by farmers were documented with the help of PRA sessions, direct field observations, and discussions with farmers and key informants.

8.3.1 Farm Yard Manure/Compost

FarmYard Manure (FYM) and compost are the major sources of plant nutrients. FYM, a most common form of organic manure, is livestock excreta including dung and urine mixed with variable amounts of farm and non-farm litter, crop residues, and household wastes, including ash from cooking fire. The use of genuine compost in its true form is less common. Livestock bedding materials, which include leaf litter, crop residues, and left over fodder and forage are spread on the surface of animal shed. These materials are incorporated with manure and urine. Bedding materials are changed at the interval of a week to keep pens dry. The type of bedding materials used has effect on the quality of manure. Bedding materials used varies with type of vegetative species found in the area, situation of the forest resources, and availability of household labor. Commonly used bedding materials from the farmlands in the study area are, crop residues (maize stover, rice straw, millet and wheat straw, and residues from leguminous crops), left over tree fodder and grasses. Broad leaf forest species, such as Katus (*Castonopsis spp.*), Uttis (*Alnus nepalensis*), Dhurselo, Chilaune (*Schima wallichii*), Asuro (*Adhatoda vasica*), and other species found locally, are commonly used as bedding materials. Farmers reported that some households bring partially decomposed leaf litters from the forest to use as bedding materials. After certain time, these partially decomposed bedding materials are either put into a pit dug or heaped adjacent to livestock pens.

Variable sized pits are dug near the shed to store FYM. The bedding materials removed from pens are disposed into these pits. Normally, lower layers of the bedding materials are taken out and placed on those pits. The animal dung slurry and urine is sometime drained into compost pits. So the compost remains stored in pits until it is transported to the field. The duration of storage varies depending upon the labor availability to relatively distant field. To make it easy to transport compost to farmlands, it is removed from the pits and heaped for 1-2 days prior to transporting to farm plots. This also helps to reduce the weight of compost that enables farmers to make efficient use of scarce labor, as relatively moisture dried compost requires less labor for its transfer. In normal practice, FYM/compost is transported to the field during December – February when fields remain fallow and farmers are not engaged in other activities. The time gap between FYM/compost transfer to the field and subsequent incorporation into the soil varies from a few days to a month, depending upon the distance of plots from the homestead and household labor availability. The practices of drying manure before transporting it to the field to reduce weight and long exposure to sunlight and air before incorporated into the soil results in denitrification of the nitrogen. Farmers are aware of the loss of nutrients caused by this method of FYM/compost application, but still practice it due to unavailability of adequate labor for compost/FYM transportation during the period of field preparation.

The quantity of FYM applied varied with the land use practice and type of land. In the both with and without agroforestry project situation, the two thirds of the manure available was used in bari lands (gharbari + bari). It was also found that highest amount of the manure (11,012 Kg ha^{-1}) was used on bari lands near to the homestead area (gharbari). These shows that bari parcels located near to the household are intensively manured (Table 8.3). This is an important revelation, which shows that farmers prioritize the use of their scarce farm resources within the different types of land and their respective parcels with production potential they own. The cereal crops (maize, finger millet, vegetables) grown in bari gets priority for manuring as they assure family's food supply. The analysis shows that FYM is still the major source of plant nutrients in the study area. Farmers in agroforestry project area use comparatively more farmyard manure to fertilize the farmland than farmers in without agroforestry (Table 8.3). This difference in manure/compost used between type of land use practice is statistically significant ($p<0.05$). This shows the significant contribution of agroforestry adoption in the supply of plant nutrients to maintain and sustain the soil fertility.

The FYM application to khet land is found lower than bari land in both with and without project cases. Farmers, during the discussion, reported that in comparison to the past, in recent years increasingly higher amount of FYM/compost is being applied to khet due to cropping intensification. This amount otherwise would have been gone to the bari lands. Results show that almost two thirds of the total farm yard manure/compost is applied to bari (Table 8.3). This is corroborated by research conducted elsewhere (Pokhrel, 1997). As these lands are more vulnerable to soil erosion, nutrient leaching and losses, agroforestry intervention will have significant contribution to maintain their soil fertility, besides increasing food supply and enhancing farm household economies.

Table 8.3 Amount of FYM/Compost (Bhari) used per household by type of land

Land type	With Agroforestry (n=82) #			Without agroforestry (n=141) #		
	F	Mean	Kg ha^{-1}	F	Mean	Kg ha^{-1}
GB	77 (94)	108.1	12649.0	131 (93)	85.9	10050.0
Bari #	58 (71)	145.0	10699.0	107 (76)	112.8	8321.0
Khet	49 (60)	99.2	11714.0	51 (36)	86.2	10187.0

Source: Field Survey, 1998

GB = Gharbari; F: Frequency of households
Figures in parenthesis indicates percentages
F- test significant at 0.041 level ($p<0.05$)
Mean values are in Bhari (backload) for average land holding size of 4.20, 6.66, and 4.16 ropanis for Gharbari, Bari and Khet land respectively. (1 ha = 19.6579 ropanis and 1 Bhari = 25 Kg).

Amount of nutrient content in FYM varies considerably depending on type of animal, quality and composition of fodder and feed supply, and management practices. Addition of FYM helps to increase moisture retention capacity of soils, that facilitates cropping intensification particularly in bari. Relay cropping particularly millet relayed to maize, as well as pulses, oil seeds, potato and vegetables are sown before or immediately after harvesting the first crop. The initial establishment of second crop is possible due to the residual moisture available. The number of cropping per year is found higher in bari plots located relatively near to the household. This may be related to the amount of compost applied as the nearest parcel (gharbari) received higher amount (see Table 8.3).

8.3.2 Use of Chemical Fertilizers

Fertilizers, as carriers of essential plant nutrients, are used by farmers to improve the fertility of their soils. In countries where crop yields have been to their maximum biological capacity, the high level of production is attributable to fertilizer use. Balanced and efficient uses of fertilizers have proved to be highly advantageous to the farmers as well as to the economies of the different countries. Scientific fertilizer used means more than simple adding to the soil but the contents of a fertilizer. What a farmer can accomplish from fertilizer application depends on how correctly they are used, what and how much plant nutrient they contain and how they react in soil. Fertilizer is a key component in the adoption of modern crop production technology enabling several countries to become self-sufficient in their food grain production. Sustained level of production is the key issue in fertilizer application rather than to attain higher level of production in the pursuit of high productivity. Therefore use of fertilizers in a balanced and efficient way becomes highly remunerative, energy conserving and environment-friendly in the pursuit of meeting growing food and fiber needs of ever-increasing populations.

The chemical fertilizers are the second most important externally applied essential source of plant nutrients in the Hill farming systems. Increasingly more number of farmers applies chemical fertilizers for all crops including rice, maize, upland rice and finger millet. Declining soil fertility due to decrease in compost/FYM production, decrease livestock population and dung output, decrease in organic matter supply caused by depletion of forest resources and labor shortage have prompted farmers to use the mineral fertilizers whose availability is very much limited. The availability of mineral fertilizers in the Hills is generally confined to the easily accessible areas. Farmers' use of mineral fertilizers is confined to certain crops, such as vegetables, cereal crops on khet lands and maize, wheat, millet and oil seed crops in bari. This strategy is adopted to have the rational use of such expensive fertilizers. The analysis of the use of chemical fertilizers show that higher amount of chemical fertilizer is used in khet than in bari land in "with agroforestry", where as farmers belonging to "without agroforestry" project category have used higher amount in their gharbari (Table 8.4). Overall, the use of mineral fertilizer is higher in *khet* land (195 Kg ha^{-1}).

The results show that farmers in the study area use higher amounts of chemical fertilizer than under normal hill conditions of Nepal. During the discussion with the farmers it was revealed that they do not know the amount of fertilizer recommended by the department of agriculture for their area. They are also not aware of the importance of appropriate doses of fertilizer recommended for particular locations. There are large variations in the rate of fertilizers used, which is mainly based on the economic status of the farmers. But farmers reported that the average amount of fertilizer use (Farmers' own recommended dose) in the village is at the rate of about 10 kg per ropani of land.

Table 8.4 Average amount of chemical fertilizers used (In Kg)

Land type	With Agroforestry (n=82)*			Without agroforestry (n=141)*		
	F	Mean #	Kg ha^{-1}	F	Mean #	Kg ha^{-1}
GB	57 (69)	36.8	172	94 (67)	41.8	196
Bari	32 (32)	32.5	96	66 (47)	43.6	128
Khet	50 (61)	48.9	231	70 (50)	35.9	170

Source: Field Survey, 1998

GB = Gharbari; F: Frequency of households
Figures in parenthesis indicates percentages
* F-test non significant at 0.05 level ($p<0.05$)
# Mean values are in Kg for average land holding size of 4.20, 6.66, and 4.16 ropani for *gharbari, bari* and *khet* respectively. (1 ha = 19.6579 ropani).

During the discussions with farmers, they expressed that unavailability of fertilizer in right time, right form and quantity is the major concern of the farmer. High price, longer distance to transport from market center to the farmlands constrains its use. Unavailability of irrigation is another constraint in the effective use of mineral fertilizers in the study area. The higher amount of mineral fertilizers (187 Kg ha^{-1}) was used in gharbari land in comparison to other bari parcels (118 Kg ha^{-1}). This is associated with growing cash crops, such as vegetables, in the land near to household as well as increased level of moisture for longer duration. Therefore, irrigation becomes one of the limiting factors in the use of chemical fertilizers. Because moisture sufficiency enhances the fertilizer use efficiency. In total only 54% of the households have used chemical fertilizer in their khet. Higher numbers of households (68%) have used chemical fertilizers in their gharbari than bari lands (44%). This finding shows that farmer accord higher priority to land parcels located relatively adjacent to their homestead. The use of chemical fertilizer for the farmers in the study area is a necessity rather than a casual value in traditional means of crop production. Farmers are compelled to use mineral fertilizers due to need of increasing food grains to feed the growing family members as well as the demand created due to the use of modern high yielding varies, which are yield responsive towards the chemical fertilizers. Looking at their present trend of fertilizer application, decreasing availability of other sources of plant nutrients and family food demand, increased use of chemical fertilizer in the study area is almost unavoidable in the future. But there is also a question of affordability. However, this will call for nutrient management strategies in which nutrient recycling through diverse sources will have to play increasingly important role. In such a condition, the role of agroforestry in nutrient management becomes indispensable.

In contrast to "soil building" through the long-term process of improving soil fertility through biological means (such as adoption of agroforestry), chemical and biological fertilizers are applied for optimizing short-term results. The short-term yield increments are achieved by the use of high yielding crop varieties through the combined efforts of mineral fertilizer and the expense of inherent soil fertility. The high yielding crop species generally require more nutrients with increase in crop growth and the use of mineral fertilizers remained always well below the recommended amount in the hills. Although, analysis carried out in this study does not deal with this issue, the progressive uptake of nutrients by the crops at the expense of soil nutrient reserves in the study area may be detrimental to the long-term soil fertility maintenance. As every harvest takes away large amounts of nutrients from the field, nutrient removal by crop is considered the single largest factor of nutrient depletion from the soils.

8.3.3 Green Manuring

The use of green manure plays a vital role in the farmer's overall fertility management strategies in the study area. Because of scarcity of green manure species, the practice is very much limited. Under the existing practices, green leaves, twigs or entire plant species are incorporated into the soil to enrich soil fertility. Some farmers also bring partially decomposed leaves, mostly comprising of broad-leafed species, from the forest to put into the farmlands. Practice of using green manure is mostly limited to rice and millet nurseries. Green leaves and twigs of Asuro (*Adhatoda vasica),* Titepati (*Artemisia vulgaris*), Khirro (*Satrium insigne*), *Albizzia species* and other plant species are incorporated in the puddled soil during the rice seedbed preparation. These species are also applied to millet nurseries to provide nutrients to young seedlings. But in general practice, the green manure is applied in the form of mulch to facilitate easy establishment and provide plant nutrients.

The practice is also used in vegetable cultivation but limited to only some particular vegetable crops, such as radish, ginger, and taro. In practical terms, farmers do not plant and manage the green manure species, but they are grown wild and found in smaller quantities. Usually the plant species used for green manure are not palatable for livestock. The species, which are used as animal fodder, are normally not used for green manure due to the scarcity of fodder and probably they are not as easily decomposable as green manure species.

8.3.4 Mulching, grain legume cultivation and in-situ manuring

Mulching, in-situ manuring and use of grain legumes in crop rotation are other soil fertility improvement strategies adopted by the farmers. Mulching with crop residues and other vegetative matter has been a successfully practiced traditional method of soil fertility improvement. Mulching with weeds, fallen leaves, crop residues, fodder leftovers, and twigs is a widely used practice adopted by farmers. Over the years, this practice has been decreasing and is practiced in limited scale in recent years. Farmers reported that due to overall decrease in vegetative cover, decreasing on-farm and off-farm animal fodder considerably lesser amount of green materials are being use as mulch in the soil. Presence of organic cover as mulch reduces evapotranspiration, increases infiltration rates and suppresses weed growth. The practice can be practiced by small to large farmers. Biologically, mulching materials increase activities of soil organisms, including earthworms. Mulching minimizes soil erosion by reducing the raindrop impact on the soil. These principles of mulching are highly related to agroforestry systems and inclusion of compatible and desirable agroforestry species on farmlands have higher potential of bringing substantial improvement in soil fertility. Fast growing and quickly regenerating woody perennials established together with the agricultural crops could become potential source of mulch materials when they are regularly lopped. The choice of mulch depends upon the locally available materials. But farmers in the study area prefer to plant multipurpose tree species in their farmlands and utilize the tree lopping for animal fodder.

In situ manuring is practiced where animals are kept in bari or khet for some time, especially during winter months when lands are fallow. The practice is more common in the bari terraces than khet. This is related to the cropping intensity; which is relatively low in bari than khet. The animals are moved from one terrace to another to fertilize the terraces. Farmers either construct makeshift pens, locally called *Goth* in the fallow lands to keep animals or the animals are kept in the fields during the day and moved to their permanent sheds during nights. This is commonly done after the harvest of finger millet (October-November) and before planting winter crops. The practice may be repeated again before maize planting (March-April). But this practice has sharply declined due to increased cropping intensity, adoption of agroforestry by farmer and increased stall feeding practices. Farmer reveal that even when the bari lands are fallowed for sometimes, animals are not being taken to the fields due to growing tree saplings. Farmers from with project mentioned that they need to keep their animals in pens to protect their own as well as neighbors' sapling.

Grain legumes are important plant species in the Hill farming system. They are being included either as mixed crop, inter-crop, relay crops or planted on rice bunds, terrace risers and under orchards. These species are also grown on uncultivated inclusions where cereal crop cultivation is not possible. The commonly cultivated legumes are soybean (*Glycine max*), blackgram (*Phaseolus mungo*), beans (*Dolichus lablab),* lentil (*Lens esculentus*), mungbean (*Vigna radiata*), garden peas (*Pisum sativum*), pigeon pea (*Cajanus cajan*) and cowpeas (*Vigna sinensis and V. unguiculata*). Grain legumes are mostly cultivated in bari particularly during maize growing season (April to August). They are mainly grown for home consumption as a source of vegetable protein, consumed either as fresh green vegetable or in the form of dried pulses as *dal* (pulse soup). Soybean and lentils are often planted in association with cereals. Soybean is planted in well-drained rice bunds terrace risers, which contributes to enhance soil fertility by fixing atmospheric nitrogen. Fallen leaves of these species also enrich soil fertility. They are not normally incorporated into the soil in the form of green manuring but they contribute to the soil fertility through animal feed. Residues of grain legumes are fed to livestock and are important sources of livestock fodder particularly during the dry months when availability of green tree fodder and grasses is very limited. This is how they enter the nutrient recycling system within the Hill farming system.

8.3.5 Miscellaneous

Burning of trash, trapping floodwater, slicing terraces, use of kitchen ash, use of crop rotation and fallowing are some of the other practices adopted by farmers to maintain soil fertility. Burning of dried weeds, maize and millet stubble, left over wheat straw, or other plants is a common practice in bari and khet. This practice is more common in bari because of the availability of such plant materials. Besides enhancing the soil fertility, the burning of trash has other advantage of improving the general cleanliness of the farmland, which in turn helps to reduce the insect/pest infestations. This is normally done during the winter and dry hot seasons. The practice is limited because there is normally very little stubble or plant materials left on the fields. Farmer collect entire crop residues from the field to meet the livestock fodder requirements. Only the materials not preferred by livestock are left in the field. Some farmlands, to a very limited extent, receive nutrients from night soils either directly or through monsoon run off water. Because farmers in the study area use open lands (both private and public) for the excretion purpose. Some household construct makeshift type of toilets using locally available materials, such as twigs, wooden poles, leaves, and crop residues, which are incorporated into the soil once toilets are abandoned. Normally villagers plant fruit trees at such locations.

Floodwaters or runoff water flowing from streams, creeks and agricultural lands during initial rains are considered rich in essential soil nutrients. Farmers to a very limited extent, divert floodwater to khet to tap nutrients. Mostly practiced in the khet lands located near by temporary streams, which receives floodwater from community land, public areas used as toilets by the community, bari lands and forests areas. Farmers give priority to tap the runoff coming from forest, village roads and rangelands. Farmers divert such floodwaters into their farmlands to trap leaf litters, organic matters, humus, nutrients and fertile topsoil, locally called "Pango Mato", washed down with runoff water. This is practiced by some farmers with khet in favorable locations.

Farmers have practiced crop rotation and fallowing to maintain soil fertility. Farmers are knowledgeable that practice of growing same crops over and over again in the same parcel of land will decrease the crop yield. Therefore, they rotate the crops grown among different parcel of land as far as their different parcels allow doing so. This applies mostly to vegetables and grain legumes. In case of cereal crops, the adoption of this practice is limited owing to small land holding size and greater need of food grain production. Rotation is also followed between vegetables, grain legumes and other field crops to better utilize moisture regimes and soil fertility. The crop rotation practice ensures the rational use of plant nutrients and soil moisture, fertility improvement, crop diversification and pests and diseases control. Giving soils some break from crop growing to renew their fertility status was one of the methods of soil fertility management in the study area. But the practice of such fallowing almost stopped due to the need for intensive cultivation to meet the family food needs.

Slicing of terrace risers during field preparation for rice cultivation and subsequent incorporation of organic residues and sliced soils on the field below is a characteristic phenomenon in the khet land cultivation. However, slicing of terrace risers is seldom performed in bari. Farmers reported that the practice is important to control weeds on terraces that would otherwise compete with young growing crops. The crops would grow without competition prior to the emergence of grasses on the sliced terrace risers again. This practice also controls rodents, rats and insects. Farmers expressed that some times they bring forest topsoil when they plant some tree species in their farmland. They reported that the forest soil facilitates the easy establishment of transplanted seedlings. Although farmers rarely apply the practice, they are aware of the importance of nutrient rich forest soil. Application of ash and cow dung slurry to control insect and pests are other methods, which facilitate healthy plant growth. The ash is supplied from wood, rice husk, straw, maize stubble, and cobs and other farm products. Cow dung slurry, which is applied on to the ground floor and walls of a house almost daily by farm household for house cleaning, is applied to standing crops and vegetables to protect them from insects. But the use of ash and cow dung slurry is very limited and thus their contribution to soil fertility. Similarly cattle urine is used on plants as pesticide to keep crops clean and free from many diseases as well as insect pests. The important practices of fertility improvements in the study area are summarized in tabular form (Table 8.5).

Table. 8.5 Important soil fertility improvement practices

Practices	Type of land in priority order	Significance to soil fertility
Application of Farm Yard Manure/ Compost	Gharbari, Bari, and Khet	Major component of the soil fertility maintenance.
Application of mineral fertilizers	Khet, Gharbari and Bari	Becoming increasingly an important source of pant nutrients.
In-situ manuring by animals	Gharbari, Bari, and Khet	Practice is slowly disappearing due to reduced fallow period, and agroforestry adoption.
Application of green manure	Khet, Bari	Limited to paddy and millet nursery beds.
Use of grain legumes in crop rotations	Gharbari, Bari, and Khet	Traditional practice in *bari* but important component to sustain the crop production.
Forest leaf litter and animal bedding materials converted to FYM	Gharbari, Bari, and Khet	Important traditional practice but now limited.
Mulching with forest litter and crop residues.	Gharbari, Bari, and khet	Confined to some crops which need mulching during the initial establishment period.
Slicing of grasses and weeds from terrace risers	Khet, Gharbari, and Bari	Spreading onto soils of lower terrace prior to rice cultivation limited extent in bari lands.
Application of ash, cow dung slurry and cattle urine	Gharbari, bari and Khet	Used mainly to control insects, pests and diseases attack but in very limited quantity.

Source: Field Survey (Focus Group Discussion), 1998

8.4 Agroforestry in structural measures of soil fertility maintenance

Farmers have tried to keep soil losses at minimum through structural measures thereby maintain soil fertility. The terracing and construction of retaining walls are two of the most important structural measures observed in the study area. Besides these, most farmers have maintained live fences in and around their farmlands as an important measure to protect crops from grazing animals. They also have important role in soil erosion control and fertility improvement through diversion of run-off. Some farmers implementing agroforestry program have started to plant in close density to develop them into vegetative terrace hedge in the long run. Densely planted tree/hedge in the sloping bari land act as a barrier for run off water and eroded soil gets settled in the hedge which ultimately turn into a terrace. Use of live fences as the means of vegetative measures helps to improve soil conservation and yields other direct benefits in the form of food, fodder, fuel wood and timber. Out of the structural measures, terracing has been the most important form of structural measures in the study area.

From time immemorial, hill farmers have practiced terracing as an approach to make agriculture cultivation possible on steep slopes. Hill slopes have been modified to suit the different agricultural practices both in bari and khet. Almost all the lands in the study area have been terraced by using family labor in the past. Some new terraces (which are mostly old collapsed terrace) constructed by farmers in recent years have also been seen during the field survey. Farmers were in the view that construction of new terraces to the larger extent is almost not possible now due to decline in family labor availability and construction materials. In some farms, farmers have not even been able to repair the collapsed terraces, instead they have planted some tree or grass species and used the space to grow some grain legumes, such as cowpea and beans. Some project farmers have started planting hedgerow, in their bari on relatively steep slopes to prevent soil erosion and to develop those hedgerows into vegetative terraces in the long run. The khet lands are terraced, levelled, and bunded for paddy cultivation. Bunds made at the edge of the terraces are planted with grasses for fodder. The erosion is thus kept to a very minimum level in khet land. The bari lands, where upland crops are grown, are mostly terraced but not necessarily levelled and bunded. They are sometimes semilevelled but usually maintained at some slopes. The terracing of bari land also helps to reduce soil erosion. Some bari lands are almost flat with wide terraces. Tree and grass species are maintained in bari terrace risers which provide food, fodder and serves as conservation purpose.

Farmers to prevent terrace failure have constructed retaining walls. The failure of terrace is a common feature in the study area especially during the monsoon season when soil becomes saturated to its maximum. Stones were widely used to construct retaining walls due to their availability in abundance during early years of settlement in these areas. Retaining wall made of dry, packed stone protects houses from landslides and erosion. Some other material, such as bamboo, is also used. Retaining walls were constructed to prevent further slips at the site of terrace failure and to minimize soil erosion. Some farmers still practice construction of retaining walls using locally available materials. Some important species, such as bamboo and utis (*Alnus nepalensis*), as well as grass species are also grown in gullies, walkways, and collapsed terraces to prevent soil erosion. Trees and grasses help to retain the soil and stones.

8.5 Use of FYM and Chemical Fertilizer by accessibility

The analysis of the use of manure and chemical fertilizer by accessibility is presented in Table 6.7. Accessibility was found to be a major factor in the use of chemical fertilizer. This is associated with the availability and transportation of the fertilizers. The figure presented in Table 8.6 shows that the farmers' from easily accessible areas have used more chemical fertilizer than from areas difficult to access. Farmers have to carry back loads of chemical fertilizers from the nearest market center/fertilizer depot to their village. In some season farmers from areas difficult to access do not get required amount of fertilizer when they visit possible fertilizer distribution centers. It is the farmers in areas easy to access who have easy access to fertilizers, where fertilizer supply is in limited quantity. During discussions, farmers reported that irrigation is necessary to get effective return from the crop because crop response to added mineral fertilizer is high under irrigated condition.

Farmers were in the view that use of fertilizer in bari lands farther away from homestead area may not be profitable due to high price of the fertilizer. Regarding the use of chemical fertilizer in bari, it is mostly confined to gharbari and other bari parcels located near to homestead and with relatively more moisture in soil. Bari plots located relatively distant from the homestead rarely receives chemical fertilizer, as they are mostly dry, low yielding and marginalized. These propositions are satisfied from the results to chemical fertilizer use in different land parcels, which are presented in Table 8.6. Irrespective of the accessibility bari lands in and around household area (gharbari) had received more chemical fertilizers than other *bari* lands located farther away.

Table 8.6 Amount of fertilizer (kg) and manure (bhari) applied by accessibility

Type of Fertilizer	Land type	AETA (n=112)			ADTA (n=111)		
		F	Mean	Kg ha^{-1}	F	Mean	Kg ha^{-1}
Chemical (Kg)	GB	78 (70)	47.0**	220.0	73 (66)	32.4**	151.0
	Bari	39 (35)	46.8	138.0	59 (53)	35.4	105.0
	Khet	65 (58)	47.9	226.0	55 (50)	33.6	160.0
Manure (Bhari)	GB	106 (95)	105.9	12396.0	102 (92)	81.8	9574.0
	Bari	80 (71)	137.3**	10134.0	85 (77)	111.6 **	8239.0
	Khet	66 (59)	117.4 *	13870.0	34 (31)	44.3 *	5239.0

Source: Field Survey, 1998

GB = Gharbari; F = Frequency of households
1 Bhari (Backload) = 25 Kg
Figures within parenthesis are percentages of observation (households)
* significance at 0.01 level ($p<0.01$)
** significance at 0.08 level ($p<0.1$)

AETA= Areas Easy to Access: ADTA= Areas difficult to access.

Overall, 68, 44 and 54 % of farmers are using chemical fertilizer in gharbari, bari and khet land respectively. But in case of manure, 93, 74 and 45% of the household have used in gharbari, bari and khet land respectively. The use of chemical fertilizer was found significantly associated with accessibility factor. Higher amount of fertilizer is used in gharbari located in easily accessible areas (AETA) in comparison to gharbari in ADTA. This was found to be significantly different at 0.078 level of significance ($p<0.1$). Even the use of manure is found higher in easily accessible areas compared to areas that are difficult to access. Results on use of manure on farmland presented in Table 6.7 shows that the use of manues in both khet ($p<0.01$) and bari lands ($p< 0.1$) between the AETA and ADTA is significantly different. This is reflected by the level of agroforestry adoption because farmers of AETA have higher adoption rate than from ADTA.

8.6 FYM use comparison between now and 10 years before

Information on annual farm yard manure use comparison between the present time and 10 years before was collected through Rapid Rural Appraisal (RRA). During the RRA sessions, participating farmers were asked to recall the amount of manure used in their field 10 years before and compare with the amount they used last year. Their answers in terms of whether the use has been increased, decreased or remained same over the 10 years period was recorded. Farmers revealed that fields that were used to graze livestock during winter fallow and in situ manuring have been gradually diminished due to crop intensification and protection need of newly planted tree species. Traditionally used grazing areas belonging to the community are either brought under community forest area or have been degraded to an extent that they are no more than the resting site for animals, where livestock are taken to pass time or to stretch their body and legs. Seemingly farmers are interested to plant additional tree species in their farmlands due to restriction on the use of community forests and longer travelling distance required to collect from national forests.

Almost every piece of land that is cultivable has been used for arable agriculture. Forest have shrank thereby putting pressure on livestock raising and which has further worsened by lower feed availability. About one third of both project and non-project farmers were in a view that manure application to their farmland has increased over the years. Whereas slightly less than half of the farmers involved in RRA discussion groups agreed that in comparison to 10 years before the annual production of manure/compost per household during the current years have declined (Table 8.7).

Table 8.7 FYM production status between now and 10 years before

FYM production status between 2 time periods	With Project (n= 41)		Without Project (n=37)	
	Frequency	Percentage	Frequency	Percentage
Increased	12	29.3	10	27.0
Remained Same	10	24.4	09	24.3
Decreased	19	46.3	18	48.7
Total	41	100.0	37	100.0

Source: Field Survey (RRA), 1998

Availability of chemical fertilizers, deforestation, loss of vegetative cover, closure of community forestry, decrease in per household animal herd size and unavailability of family labor owing to increased school enrollments and temporary out migration of family members were some of the important causes of decreased FYM production mentioned during the discussion. Therefore, results of the present study indicated that the decline in soil fertility and subsequent reductions in yields are partly related to the lesser amount of compost added to the field in comparison to the previous years.

8.7 Crop residues management for soil fertility

Out of the total bio-mass produced in crop cultivation, substantial amount is in the form of crop residues. Crop residues are important for soil fertility maintenance. Crop residues conserve moisture, improve soil fertility and structure, prevent erosion and surface crusting. Standing residues conserve water by trapping the rainwater and by increasing water infiltration. Residues act as mulching material, provide ground cover, and replenish some of the soil nutrients extracted by crops. Crop residues have a great role in protecting bare soils and thus minimize their erosion. Internally generated residues are better alternatives of increasing organic matter levels in the soil.

Farmers in the study area leave only a small fraction of crop residues in the field after crop harvest. In the study area, crop residues of both the cereals and leguminous grains occupies greater value in terms of animal feed. They are important source of animal fodder throughout the year and particularly during dry season when availability of green fodder is scarce and during rainy, crop planting and harvesting season when farmers have no time for fodder collection. The shortage of fodder during the dry winter season overrides the potential benefits of these residues for soil fertility. Return of soil nutrients removed by crop plant is indirect and only through the animal manure. Continuous removals of crop residues from the field have caused decline in fertility levels and subsequently decline in yields. Apart from fodder, crop residues, such as maize stalk, empty cobs, are used for fuel-wood. Analysis on use of crop residues as fuelwood shows that irrespective of the land use type and accessibility factor more than 95% of the households use crop residues as fuelwood. It was found that use of crop residues ranged from 1 *bhari* to 50 *bharis* per household per annum. Although average amount of crop residue use for fuel wood was found relatively smaller, farmers in "with" project situation used significantly lower (7.1 bhari/household/annum) amount than farmers (8.8 bhari/household/annum) belonged to "without" project category ($p<0.1$). The results show that farmers in with project situation have more fuelwood supply from other sources and possibly increased supply from their own farmlands. In case of accessibility, there is no significant difference in the use of crop residues as fuelwood even at 0.1 level of significance (Table 8.8).

Table 8.8 Amount of crop residues per year used by households as fuel-wood by accessibility

Use of crop residue as fuel wood	Land Use Type		Total	Accessibility	
	WP (n= 82)	WOP (n=141)	(n=223)	AETA (n=112)	ADTA (n=111)
Percentage of households	95.0 (77)	98.0 (138)	96.4 (215)	95.5 (107)	97.3 (108)
Average amount (Bhari/HH)	7.1 *	8.8 *	8.2	7.6 **	8.8 **
Standard Deviation	5.5	7,1	6.6	5.2	7.7
Range (minimum to maximum)	1- 40	1 - 50	1 - 50	1 - 30	2 - 50

Source: Field Survey, 1998
Figures in parenthesis are frequencies of households.
* Significant at 0.067 level of significance ($p<0.1$)
** Not significant even at 0.1 level of significance.
WP= With Project; WOP = Without Project; AETA= Area Easy to Access;
ADTA= Area Difficult to Access

Use of crop residues as animal fodder as well as fuel by the households takes away the important source of soil nutrients and thus fertility maintenance. There are no studies to show the economic rational of substituting the fuel wood by crop residues and buying fertilizers to substitute the use of crop residues as the source of plant nutrients. Crop residues not only return the important plant nutrients to the soil but also serve the conservation purpose. It may be said here that immediate use of crop residues for other purpose like animal fodder, roof thatching and household energy will eventually overshadow the long-term advantage of soil conservation. The effect of crop residue removal is sometimes more pronounced than not applying fertilizers. Research study carried out at IITA showed that when maize residue was returned, there was an increase in yield of 2 t ha^{-1} over that obtainable when residue was removed and optimum fertilization applied (Agboola, 1990:239). Argument presented here highlights the important role of agroforestry in the hills to provide farming families' fodder and fuel wood needs which in turn have positive effects on soil fertility because farmers will then increasingly be able to return larger amount of crop residues in the fields.

8.8 Constraints

There are some constraints in the fertility improvements of the farmlands in the study area in particular and in the Hills of Nepal in general. Consideration on those constraints, greater attention needs to be given to bring substantial improvements in the fertility status of the soil and thus the level of production. Some of the important constraints are listed as follows;

- The land area, particularly the cultivated land area owned by the farmers is not enough to have sufficient production to meet the family food needs as well as to invest in soil fertility improvements.
- Declining quantity of FYM/compost application due to decreased family labor, reduced livestock herd size and decrease in availability of composting materials,
- Only a small area is under the irrigation and cultivation is basically rainfed,
- Fragmentation of the land and scattered holdings, *bari* land parcels located far most distance from the households are generally marginalized but still biomass in the form of fodder/grasses/fuelwood are harvested,
- Crop intensification and use of high yielding varieties (HYV) without sufficient fertilization have extracted higher amounts of nutrients from the soil,
- Declining forest resources have created more pressure on farm land for sustaining farm animals fodder requirements,
- Growth of outputs have been limited by geographical inaccessibility (no road, weak transportation, communication), and use of HYVs without desired levels of inputs,
- Lack of marketing information and network which is closely linked to weak institutional and partly to geographical inaccessibility,
- Unavailability of mineral fertilizers in right time and quantity and the unavailability of small agro-processing facilities, and
- Unavailability of appropriate technology and extension services to suit the local socio-economic and geographical conditions.

8.9 Summary

Analyses on fertility maintenance of soils, farmers' strategies, and comparison of soil fertility management between <u>gharbari</u>, <u>bari</u> and <u>khet</u> lands were carried out. Results show that the farmers efficiently manage land parcels located near to the household area, such as <u>gharbari</u>. The results indicate that manure is the principle source of soil fertility maintenance in the study area and <u>bari</u> soils, (which also includes <u>gharbari</u>) being the upland slopping terraces, receives higher amount of manure compared to <u>khet</u> soils. By employing different strategies, farmers' have been able to maintain the soil fertility and sustain the productivity in their farmlands. Farmers have observed changes in soil in terms of soil tillage operations, soil depth and nutrient depletion. Over the years, farmers have noticed gradual hardening of the soil particularly in their <u>khet</u> lands and subsequently making tillage difficult. Many of the farmers put blame on the increasing amount of chemical fertilizer use. Removal of topsoil by continuous soil erosion particularly in the sloping terraces (<u>bari</u> lands) may have contributed in the decreasing soil depth. Practice of growing same types of crop particularly cereal crops by farmers in the same piece of land year after year without replenishing the amount of nutrient losses have contributed to nutrient depletion. However, farmers continue with their old practice except for the few who have changed to more commercial oriented cash crops and have been aware of soil degradation problems.

Analysis on use of fertilizers by accessibility factor shows that higher amount of fertilizer was used in easily accessible areas than areas difficult to access. Similarly the manure/compost use comparison between now and before 10 years confirmed that households are applying less manure in recent years. Crop residues, which are potential source of soil nutrients, have been diverted to feed livestock and household energy supplement. This study shows that farmer adept different management practices in different types of land. Location of different parcels of land plays very important role in the production and availability of organic matter to enrich soil fertility. The parcels located at farther distance, which are mostly the marginal uplands, from the households have not received adequate attention from the farmers as well as planners and policy makers. Any technologies for marginal uplands (bari) require more location specificity due to higher heterogeneity in comparison to more homogenous homestead areas (gharbari) and lowlands (khet). The analysis on soil fertility status and possible contribution of agroforestry shows that fertility issue in the study area in particular and the Hills in general are more location specific. Further more, the results indicate that priorities should be given on the basis of variations between different parcels of land units within the household levels.

Chapter IX

Economic Impact of Agroforestry

In the Hills, the agroforestry systems have been practiced traditionally and are integral parts of the farming system. The introduction of modern techniques and practices with exotic species are the recent interventions into the existing farming system. In recent years, the agroforestry interventions are being increasingly adopted in the different parts of the country. The emerging challenge is to develop and disseminate agroforestry as a viable option for the local people living under various biophysical, socioeconomic, and institutional constraints. Generally, farmers under traditional farming system, assign less or no priority to planting trees in the efforts of getting more cereal grain production from the existing farmland. They fear of decrease in yield due to shading effect from the tree crop. This was evident more when community forests and other public lands were used freely as open access property and the available natural resources were abundant to sustain the existing human and livestock population.

9.1 Introduction

After the introduction of community forestry program and transfer of ownership and management responsibilities back to the users, the access to such common properties have been severely curtailed. Farmers are then forced to see alternatives of open access forest resource. One of alternatives adopted is the plantation of tree species in the private land as agroforestry have been recognized as viable intervention. Although the farmers in the Hills already have some experience of growing tree, shrubs and grasses in their farm lands the adoption of improved agroforestry practices is not so encouraging. Because the intervention technology will only be adopted by the farmers if the proposed alternative to their present system is more attractive, profitable and can be easily fit in their farming system. In this regard, costs and benefits of agroforestry systems are necessary to help farmer and different end users in adopting agroforestry.

Although agroforestry is recognized as a viable land use system, the economics of agroforestry are not documented well. Economic of agroforestry is a high priority and challenging area of research because the potential impact and adoption of agroforestry depend on the appraisal of its true value for farmers, and project implementers (Avilla, 1990). Similarly it is challenging because agroforestry is a complex technology involving many components, multiple interactions, and numerous tangible and intangible outputs. On hill slopes where soils are subjected to accelerated soil erosion and mass movement, forestry based farming would be an economically efficient form of land use, if its economic and environmental benefits are accounted (Thapa and Weber, 1994). It is necessary to evaluate the management and performance of existing production systems as well as recommended improvements to determine the benefits obtained, sacrifice made, and the full implications of the proposed changes. But agroforestry, in its economic form under the present farmer context is not well understood in the Hills of Nepal and studies on economic performances are very limited. Agroforestry economics differs from other sub-disciplines of agricultural and natural resource economics only in the practical problems of implementing a theoretical economic framework, which is common to all. Therefore any agroforestry can be evaluated according to its impact on the objective of private income generation (Reiche, 1991: 193-205).

Positive impacts of agroforestry on farm income generation have been evident and documented in the agroforestry literature. Agroforestry can be evaluated according to its impact on the objective of farmer income generation. The farmer may have an added means of income from underutilized labor and other resources. Indigenous agroforestry has been the major land use in the hills but not much is known in terms of it economic impact as they are biologically complex. The main potential impact of the agroforestry project is on the increase of the farm's gross income over time.

9.2 Agroforestry's contribution to household economics

Trees and other perennials in an agroforestry system affect field crop production in many ways. The effect of tree-crop interaction is apparent on soil fertility, competition for growth substances, such as nutrients, water and sunlight and ultimately on farm income through crop yields. The higher share of the income from agroforestry sources among the project households shows agroforestry's relatively higher contribution in the total farm income (Table 9.1).

Table: 9.1 Agroforestry's contribution to household income from farm sources

(Rupees/hectare)

Income from the farmlands	With project		Without project	
	Total	Percentage	Total	Percentage
Crop yields	60604	34.1	56712	45.1
Grain legumes	11340	6.4	10220	8.1
Vegetables	26190	14.7	14910	11.8
Fruits	3839	2.2	882	0.7
Fodder/grasses	30074	16.9	11230	8.9
Fuelwood, poles/timber	22216	12.5	15620	12.4
Crop residues	19018	10.7	14083	11.2
Herbs/green manure	656	0.4	318	0.3
Agroforestry seeds	3689	2.1	1853	1.5
Total (Rupees)	177626	100.0	125828	100.0
Break down of the farm income				
Farm income- non-agroforestry sources	105812	59.6	85705	68.1
Farm income - agroforestry sources	71814	40.4	40123	31.9

Source: Field Survey, 1998

The results indicates that project households obtained 40% of the total farm income per hectare from agroforestry sources whereas the contribution of agroforestry in total farm income was 32% in case of non-project household. The higher share of agroforestry among project household was mainly due to the increased production of fuelwood/timber, and fodder/grasses. The results further revealed that contribution from cereal crop production to total farm income was found higher among non-project households (45%) than crop yields of project households (34%). This was because project farmers either allocated certain portion of their total land for agroforestry production or crop yields decreased due to negative tree-crop interaction. With respect to per hectare average income from crop yields, the project households had slightly higher than non-project.

9.3 Financial Analysis of Agroforestry

The complexity of agroforestry does not require new theories but rather innovative approaches to applying standard economic theory. Some of these are already documented in various agroforestry literature but rigorous field studies applying these concepts and methods are underrepresented. Correctly applied, traditional cost-benefit is deemed appropriate for analyzing agroforestry (Evans, 1992). Because cost benefit analysis techniques provide a coherent framework for integrating information on the biological and economic environments faced by farmers (Lutz, et al., 1994). The benefit cost analysis on agroforestry project attempt to bridge the empirical gap, to investigate the profitability of the agroforestry interventions in the Hill farming systems. Cost Benefit analysis permits selection of the most profitable enterprise out of several defined alternatives, maximizes return to given resources, takes an account of uneven streams of costs and benefits as well as provide guidelines for whether money or other resources should be used for a given investment. But the analysis ignores the effect of investment on cash and labor flows, farmers' capacity to manage the system, and possible resource constraints, (Scherr, 1992).

In this analysis, financial profitability is calculated using the market prices. Costs and benefits are measured in terms of local prices and an individual farm is used to demonstrate the feasibility of incorporating agroforestry in the farming system. Although it is recognized that not all the production will be marketed but will be consumed by the household itself, all production are valued at local market price. The prevalence of non-market and external benefits and costs associated with agroforestry are not included. Ex-ante economic assessments (studies done prior to project implementation) were not undertaken in the study area. Farmers started to adopt agroforestry practices once it was introduced by the project through a few NAF trained demonstrator farmers. The perceived economic benefit by the household needs to be analyzed to evaluate the impact and cost-effectiveness of the agroforestry program under farmers' condition. This analysis is based on the farmers' real cost and benefits from the agroforestry intervention. As farm level studies can elucidate key social and economic factors affecting farmer use and management of agroforestry practices and the effects of agroforestry practices on household resource base (Scherr, 1990:3-12).

Agroforestry is considered to be useful but difficult to implement activity in the study area where most farm households are deriving their livelihoods from agriculture on miniature and fragmented land holdings. Initially the NGO (NAF) promoted the plantation of fodder/grasses in the farms of some selected farmers who were interested to try some of the species (mainly *Leucaena, Flemingia, Morus* and NB 21, a hybrid grass crossed between Napier and Bracheria grass species) recommended. Subsequently other farmers made decisions to adopt the practices upon consultations with fellow farmers as well as NAF field workers.

NAF provided extension service to the farmers. It was taken for granted that farmers adopt because they found it more profitable. Farmer often face problems while making decision to start agroforestry, such as fear to crop yield decrease due to shading effect, difficulty in tillage operations caused by tree root systems. They desperately need to think on such issues that might be detrimental to the crop yield as they need to meet consumption requirements from very small-sized farmlands. From the household perspectives, the decision will be based on whether returns from new practice (with agroforestry) are greater than existing practice. If system produces more outputs, does not necessarily be in the form of cash, farmers will have incentive to adopt the practice. Therefore, any interventions should hold tangible potential to improve the household economy of participating farmers, if it has to be adopted. To bring changes in the land use and have greater participation of people in the proposed initiative, the analysis of costs and benefits of a agroforestry project *vis-à-vis* the existing system is deemed to be necessary.

Cognizant of agroforestry's environmental and economic significance this study is geared to examine the profitability of agroforestry in farming systems under farmers' condition. Financial analysis is directed towards determining whether the contributions of the production process are large enough to justify the use of farmers' scarce resources. The study's main focus is on the profitability of the intervention from the farmers' point of view. No serious attempts have been made to estimate the returns and costs of including agroforestry in the system under the condition prevailed in the hills. Given the site-specific characteristics of the farming system and specific nature of the NGO supported agroforestry intervention in the study area, this analysis does not pretend to extrapolate results to other areas. This is followed by the financial viability analysis of some other crops grown in the study area, like vegetables, sericulture and bee-keeping as an very useful but less exploited non-land based activity which fits with the agroforestry program. Only a few farmers have taken initiation to start such activities.

9.4 Design of the financial analysis

Farming systems in the Hills have production enterprises and other activities, crops, livestock, trees, and off-farm employment. These activities are managed in a mixed and interactive manner. At farmers' level, agroforestry provides a variety of products for subsistence and substitution of some purchased goods. Agroforestry for farmers means the output produced from field crops, vegetables, trees, shrubs and grasses as well as ecological and economic interactions. Ecological functions, such as soil erosion protection, soil fertility maintenance and improvements, maintenance of biological diversity, and efficient utilization of other limited resources at farm level in isolation are difficult to analyze. Although the crops overwhelmingly dominate the farming system in the study area, the other products from agroforestry, such as fodder, grasses, poles, timber and fuel wood are the integral and important components of the system. The production of fodder from the farm significantly influence the overall productivity of the system due to the inter-linked nature of the farming system where the soil fertility has been maintained through the recycling of plant nutrients within different components of the system. This makes the analysis of the production system difficult therefore only the benefits those farmers derive and the costs incurred are included in this study. After all the basic objective of the research is to develop technologies to solve the farmer's problem.

Therefore the key variables considered are the inputs and outputs. The main inputs are labor, seeds/planting materials, fertilizers, and cash whereas as multiple outputs are produced by the agroforestry system.

Farmers are likely to consider only the costs and benefits that actually accrue to them from the decision they make on how to allocate their labor, land and cash resources. They value these costs and benefits at the price they actually encounter. The benefits of the system consists of returns from field crops, other crops mostly grain legumes grown in combination, fodder/grasses produced, fuelwood,/timber/poles harvested from the system. Therefore in this study no attempt is made to assess the other returns, such as competition between tree and crops, influence of trees on the microclimate, and effect of nutrient pumping from the deeper soil layer. Certain other benefits to farmers, like trees acting as windbreaks, soil conservation, and overall conservation enhancement to other farms in the area are also not taken as benefits. Similarly, the farmers do not consider shading around farm households and livestock sheds during excessive hot and dry periods as benefits. These positive benefits caused by the tree component as such means relatively little to the farmers. These potentials need to be turned into the tangible benefits. The benefits, for farmers' point of view, must be reflected in the form of higher outputs or particularly the higher yields. Only then, farmers consider these yields or output as a good indicator of benefits received from the interventions.

9.4.1 Information Collection

Out of the several villages within the study area, Majhitar of Kumpur VDC area was selected for the data collection on economic analysis. Fifteen (15) farmers involved in agroforestry intervention were randomly selected and similar numbers (15) were selected for the control group. A separate set of record sheets were used to obtain the information on inputs used and outputs produced, in addition to the household survey questionnaire. These record sheets were obtained from 15 randomly selected farmers from both the with and without project intervention. Data on various output produced and inputs used within one agricultural year from parcels of land were collected. The analyses were carried out at the farm level prices that are actually faced by farmers. This case study had to rely on farmers' recall for data. The farmers in the study area do not maintain farm records. For this reason only one-year data was asked from the farmers. The figures on costs and returns given by farmer is considered accurate with minimum variations because they could easily recall the data covering only last one year. During the fieldwork, it was found that farmers are able to remember easily about activities carried out, number of labor used, inputs applied and outputs produced from the particular parcels of land. The most important task was to dig out all the possible outputs from the farm, mostly the amount of grain legumes, grass/fodder, poles and fuel-wood harvested within a year. Because farmers mainly report the amount of food grains produced from the field as major outputs.

For analysis on bee keeping, sericulture, and vegetable cultivation, the necessary information was obtained through group discussion and observation during the visit to a farmers farm household to observe the activity undertaken. The discussions were held with individuals involved in the activities concerned as well in-groups. Particularly for sericulture activity, the

Focus Group Discussion was conducted with the NAF Women agroforestry groups whose members are involved in the enterprise.

9.4.2 With agroforestry Project situation

Agroforestry is practiced as a traditional method to supplement household's requirements in the form of food, fodder, fuel-wood and timber. With agroforestry project then refers the situation where farmers have adopted improved agroforestry practices by planting additional native and exogenous fodder, fuelwood, fruit trees, shrubs, and grasses. The planting of trees mostly in the terrace risers, bunds and land not used for cultivation was initiated in 1993/94 after the interventions by a NGO. Therefore, with agroforestry project situation actually refers to the improved agroforestry practices adopted by farmers from 4-5 years. Farmer involved in agroforestry project reported that losses from shade is much more less than as expected during the initial years because the tree species planted in terrace risers are pruned periodically for fodder harvest and height of the trees are kept at the minimum (normally at breast height). NAF trains the farmers to maintain the tree species at breast height to avoid losses due to shading. Discussions with the farmers showed that trees planted at the middle face of the terrace risers shows negligible interference in the crop production. Farmers revealed that planting k*imbu (Morus alba)* at the edge of terrace risers was found to be disadvantageous because their roots interfere with the crops planted in the terraces. Whereas in the case of Ipil-Ipil (*Leucaena leucocephala* or *L. diversifolia*), similar phenomenon of root interactions does not occur, as their root system goes straight to the terrace risers. Visualizing this effect of *kimbu* roots, farmers have now changed the planting location of *kimbu* from top of the terrace risers to somewhat below to the terrace bunds or towards the middle of the terrace risers depending upon the height of the terrace risers.

9.4.3 Without agroforestry project situation:

Without agroforestry refers those farming households which are not involved in adopting improved agroforestry practices. But these households have some naturally grown and managed trees on their farmlands. Although indigenous agroforestry is an important land use practice, little is known about these systems in terms of their financial profitability. The numbers of trees maintained in the farmlands traditionally have been decreased drastically due to multiple reason. Farmers reported that the traditionally maintained tree cover of the farmlands have been decreased due to fragmentation of land caused by the practice of inheritance of parental property and tradition of dividing land equally among the successive generations of sons. The resultant miniature sized farmlands forced the farmers to fell down old trees having wider canopy because they caused shading and were problematic for increased food production to feed the family. Similarly, farmers reported that the reduction on number of trees and shrubs was the consequences of increased pressure on available trees, shrubs of private land to fulfill the fodder, fuel-wood and timber needs created by widespread deforestation. During the discussions, many farmers were recalling that number of trees maintained in their farmlands were cut when they constructed houses, animal sheds and they sold to fellow farmer to construct his similar structures. Now, they are feeling of fear for how their future generations will construct such structures in future, as the timber in the forest is either not available or not allowed to cut as well as no adequate number of timber trees are left in their private lands. This has awakened farmers and they feel that they need to plant trees in their private lands as the way their forefathers did in the past. This was one of the reasons that motivated farmers to start planting trees in their private lands.

9.4.4 Production Estimation

Analyzing comparative costs and benefits of the "existing" and "intervened" modes of agroforestry land use requires production and investment data. The production data represent field crops (cereal grains and grain legumes), fodder, fuel-wood, grasses, poles, fruits, vegetables, and crop residues which are converted into monetary value by multiplying the actual amount of production of each crop by its respective average farm gate prices. Finally the average financial benefit pre unit area (1 hectare = 19.6579 ropanis) of land was calculated. The returns are calculated from all the possible outputs produced from a single parcel of land under study within an agricultural year. The output prices taken were those of local prices prevailed in the study area.

The rates of tree fodder, grasses, fuel-wood, poles and timber are taken as average local prices. Valuation of fuelwood is taken as a local price of a *bhari* (a back load) of fuel-wood offered by, restaurants, lodges, and teashops located along the Prithvi Highway in and around Gajuri, a small market center of the study area. Therefore no attempt is made to convert the fresh weights into dry weights. Similarly the price of a back load of tree fodder, grasses is taken as the prices offered in the village when some farmers purchase from each other. In the district or regional center the prices are higher than that are offered at the village level. Therefore, the prices used in the estimation are considered lower than the prices offered in and around district and regional market centers.

9.4.5 Cost Estimation

Information on costs of field crop cultivation and agroforestry were obtained through a standard questionnaire survey. The major items that were expected to involve expenses were labor for land preparation, planting/transplanting, cultural operations, fertilizers and harvesting. Labor is the major input provided by the extended family. The evaluation of labor cost was based on the local wage rates. Normally a male laborer in the study area is paid at the rate of Rs. 45 a person day (PD) and a female laborer Rs. 40 a person day. For draft animal used in the different stages of the cultivation is paid at the rate of Rs. 120 per *Hall* (a pair of oxen) per animal day (AD). The valuation of labor use for the system was done by asking the farmers to give figures on labor required for different crops grown in a year in the particular parcels under study from land preparation to post harvest activities. In such case, farmers' memory plays a vital role but farmers do know the amount of labor used in their farmlands very well due to their several years of experience. They are able to tell the number of labor, inputs used and amount of outputs produced from the individual plots/parcels of land. Interestingly it was observed during the interview that farmers can even give such cost estimations for individual terraces or plots within separate parcels of land they own. Although they do not maintain any farm records, the filing system in their mind is properly maintained. This is possible because of repetitiveness as they have been employing the same level of inputs every year for individual crops and getting almost similar levels of outputs.

Interestingly, the numbers of labor used for specific activity and specific crop concerned is almost the same each year, for example, labor needs for *makei godne* (maize weeding), or *dhan ropne* (rice transplanting). Traditionally, these activities are normally done in a labor sharing system known as "*perma*" approach, where community members come together to perform the task one by one in each household's field during particular cropping season. The labor is not paid in cash but shared, as everyone needs to go to every ones' farm to perform the activity. Therefore, even neighbors are knowledgeable about the numbers of person days needed to complete particular activity for particular crop in a particular parcel of land concerned.

Although efficiency of work done by *Perma* group each year may differ, the unfinished work in a less efficient day will be compensated by extending normal working hours or the group will take off from the field early in case they happened to be more efficient. Normally, it was found during the discussion that they set the target according to the number of persons working together. The system of "*Perma*" is still in practice. In comparison to the past, the systems of '*Perma*' is decreasing slowly as some household, with no sufficient family labor, not takes part in "*Parma*" and are forced to pay for the labors. Technology may bring changes in the efficiency of work done. In case of the Hills, farmers have been using traditional farm implements, therefore efficiency in terms of changes in technology is not expected under prevailing farming system. Other costs includes, the purchase of seeds and planting materials, seeding or transplanting costs, purchase of fertilizers and costs for insecticide and pesticides. In the Hills, only a nominal land tax is levied on the land.

9.5 Benefit Cost Analysis

The analysis is based on the primary information collected through the household survey, inputs and outputs recording and Focus Group Discussion with farmers involved in agroforestry activities. FGDs were conducted with agroforestry groups formed by the farmers and in most cases such groups comprised of women members in absolute majority. During the field assessment, discussions were held with key informants such as the farmer involved in bee keeping, sericulture project and vegetable cultivation. Both individual and group discussions were very useful to gather relevant information. Since only a few farmers are involved in bee keeping and sericulture activities, the income obtained was not included in the financial analysis of "with" and "without" agroforestry project intervention. This is done for the simple reason that majority of the farmers are not involved.

There are some limitations as well, the activities analyzed as case studies were selected based on the discussion with the agroforestry group members and only limited number of farmers are involved in such activity in different locations. The analyzed activities are indicative of the local potential that could be integrated with agroforestry interventions to make the system more profitable. Further more, agroforestry intervention has provided good farm environment to start those activities. For example, plantation of mulberry plants was done primarily to increase the availability of livestock fodder, but some women farmers found that starting a sericulture project is more profitable. As it provide green fodder during the drier months when there is severe shortage of animal fodder in the study area, some women farmers have planted them in larger quantities which have enabled them to use for sericulture project.

The specific financial indicators used to analyze the profitability of the project are Net Returns, Net Present Value (NPV), Gross Margin (GM), Benefit Cost Ratio (B-C Ratio) and Financial Internal Rate of Return (FIRR). In case of apiculture, sericulture, and vegetable cultivation enterprises, the sensitivity of the activity with respect to the changes in output price and operational costs were also analyzed.

9.6 Analysis and discussions

Financial comparison (total returns, costs and financial indicators) between "with" and "without" agroforestry project shows that intervened system is more profitable than existing (Table 9.2). In a system where perennials are integrated with field crops and livestock, the waste from one component is utilized by other component as inputs. Animal manure becomes food for crops while crops provide animal feeds. Perennial crops draw nutrients from the soils, which are fertilized by animal manure and plant organic residues. This helps to reduce production costs. Similarly, integrated systems acts as buffer against price fluctuations than monocropping systems. To find out the profitability of incorporating agroforestry in the existing farming system A total farm analysis was carried out taking into account the amount of outputs produced, inputs used and other costs within one agriculture year.

The benefit cost analysis of agroforestry intervention in comparison to "with" and "without" project situation shows that system was more profitable with agroforestry interventions under the prevailing conditions faced by farm households. Only those inputs and outputs within the farm area were included in the analysis and the prices used to value the various elements were those faced by the farmers (Table A9.1). The benefit-cost ratio (BCR) based on actual cost is the ratio between the total returns and total costs, whereas BCR at farmers' opportunity cost is the ratio between total returns and retained cost. The retained cost is obtained when opportunity costs are deducted from total costs. Farmers' opportunity costs include the costs for male and female family labor. During the focus group discussion farmers revealed that despite profitability, in terms of more fodder, fuelwood and other products, many other factors such as land tenure issue, poor extension services, lack of technical know how, and unavailability of planting materials discourages farmer to adopt the practice. The results of the case study however, show that farmers' decision to adopt agroforestry is based on the benefits and cost considerations under farmers' condition. This is specific to location and agro-ecological condition, therefore can not be generalized. And the study was however limited to observations made during the one-year period.

Table 9.2 Cost/returns and financial indicators of agroforestry intervention (per hectare)

Returns, Costs and Financial Indicators		With Project	Without Project
Returns (Rs.)		177,625.0	120,586.0
Costs (Rs.)	Total	70,078.0	65,906.0
	Variable Costs	47,870.0	45,795.0
	Fixed Costs	22,208.0	20,111.0
Gross Margin (Returns – Variable Costs)		129,755.0	74,791.0
Net Return (Returns – Total Costs)		107,547.0	54,680.0
Benefit - Cost Ratio		2.5	1.8
B-C Ratio at Farmers' Opportunity Costs		4.6	3.4

Source: Field Survey, 1998

The financial benefit-cost analysis revealed that the farming system with agroforestry intervention was more profitable than the system without any intervention (i.e., traditional/conventional system). The mean annual net return of farming 'with' agroforestry intervention was estimated to be Rs. 107,547/ha ($1582/ha) compared to Rs. 54,680/ha ($804/ha) 'without' agroforestry intervention. Similarly, the higher gross margin (Rs.129755.0) was found in "with" than "without" project (Rs.74,791.0) situation. As shown in Table 9.2, the benefit-cost ratio for the improved agroforestry-based farming system (2.5) was found to be considerably higher than that for the conventional system (1.8). Similarly benefit cost ratio at farmer's opportunity costs was also found slightly higher in with project (4.6) than without project (3.4) situation. It is found that project households have a higher proportion of khet to bari land than non-project households. The ratio was found to be 0.63 for project and 0.42 for non-project household. When kharbari is added on to the bari land then ratio gets slightly reduced in both the project (0.53) and non-project (0.37) cases. But the difference in khet to bari ratio between the project and non-project households is narrowed down slightly.

In the hills condition, farmers with higher amount of khet will have higher amount of income per hectare because of irrigation, addition of green manure, and adequately managed for cereal crop production (but differs widely with the location, slope, and soil quality). It is also the case that farm households with higher proportions of khet to bari land in the hills are generally considered the wealthier ones. Therefore it is important know that how much of the difference in net returns per hectare is accounted by this factor. It is estimated that about one-third of the (~31%) total net returns per hectare in the project situation was contributed by this factor (or the factors other than improved agroforestry intervention), whereas agroforestrys' contribution was found to be about two-thirds of the total net returns. Farmers' of the study area own relatively small and fragmented farm lands. The analysis shows that even operating under small land holding sizes, example of economically viable agroforestry have been developed by the farmers and it is possible to incorporate the tree component into their existing farming systems to bring positive changes in the household economy.

Farmers involved in agroforestry project were not found to be putting substantially more input than done by farmers without agroforestry intervention. This is the major reason that multiple outputs produced have given higher incomes for farmers involved in improved agroforestry practices. Likewise, farm household spent very little for the maintenance of the system. Apart from the estimated higher value of agroforestry in with project situation, farmers reported that they had an added means of income in the form of agroforestry products from underutilized family labor and other resources. They also reported that other than initial planting of tree saplings, there were few conflicts in the use of labor for agroforestry and the farmer's other crop cultivation. Because tree planting need to be done during the monsoon season where farmers are busy for rice crop cultivation. Farmers have been found using their own family labor for the systems maintenance and only very few farmers hired any labor. During the peak season and for the activity which are normally completed in a single day for a single parcel of land (such as rice transplanting), where family labors alone will not be sufficient, the work is shared between the neighbors as '*perma*' system.

The conflict in the use of labor in the agroforestry activities and field crop cultivation during peak season (planting and harvesting) is minimized through "*perma*" system. However, no perma system is in practice for tree planting and management activities. The labor cost, which accounts for approximately 44% of the total variable costs in both the cases, represents 1/3 of the total capital costs. The labor cost is only slightly higher for "with" project (Rs. 20,636.0) than "without" project (20,292.0) situation. This result shows that agroforestry intervention in the existing farming system is no more labor-intensive than the existing system, which in itself a labor-intensive system.

The cost benefit analysis revealed that the intensification of traditional farming system with the introduction of agroforestry in the study area is economically viable. Number of introducing species are performing well and are compatible with the local environment the intervention is also technically feasible. Not only in terms of cost and benefit the perspective agroforestry interventions are suitable, but also important to relieve pressure on forest resources, such as community forests. The use of agroforestry in the private land is an important alternative for community people to supplement their fodder/fuelwood, timber and food requirements and thus act as a powerful tool for successful implementation of the community forestry program. The analysis shows that intervention of agroforestry into the existing farming system have enabled farmers to diversify their farm income through the introduction of other activities, such as, bee keeping, silk worm rearing and vegetable cultivation. Improved vegetation and available of flowering plants have been found useful to start bee keeping as an income generating activity. Similarly, availability of mulberry plants has provided an opportunity for farmers to increase the farm income by involving in sericulture project as well as creating self-employment opportunities.

9.7 Analysis on Apiculture and Sericulture

After the interventions of agroforestry and exposure to the various training, study visit programs organized by NAF, farmers have become more aware to their own conditions and the use of available resources around them. Although NAF is not involved in providing financial and technical assistance to agroforestry groups comprised of farmers involved in agroforestry intervention for other income generating activities, farmers have found ways and means of involving themselves into diversified activities to maximize the farm incomes. Some of such activities related to the agroforestry are vegetable cultivation, sericulture and bee keeping. Being practiced by majority of farmers, vegetable cultivation has increasingly become a commercial enterprise for some farmers. In case of apiculture and sericulture enterprise, only a few farmers have started. The cost and production estimates obtained for bee keeping, sericulture and vegetable cultivation activities were based on the information provided by the farmers during field survey through, household survey, focus group discussion, and discussion with individual and group members.

9.7.1 Bee Keeping

Bee Keeping (**Apiculture**) is a useful practice adopted by the farmers and entrepreneurs in the Hills of Nepal since generations. Traditionally bee keeping was carried out through indigenous methods of using wood logs and walls of the house for household consumption and religious purpose. It is important both for economic and religious purposes. In recent years, this has been promoted in some pockets as an income generation activity for rural people. Different types of improved hives have been introduced and small cottage industry department distributes beehives in subsidized rates. Improved beehives with technology have been able to minimize the limitations, such as hygiene and crude methods of honey extraction, imposed by the traditional methods of bee keeping. Apiculture, an important economic activity utilizes the under utilized resources like pollens, and nectars of the flowers from various plants. Honeybees have very special position in agriculture productivity through their vital role in pollination. Honeybees are thus become very important in productivity increase and nutrient-recycling agents in the agroforestry based farming system.

Being a non-land based activity, bee keeping can be carried out in the wood logs or walls of the households as done in traditional methods or by using modern bee hives with improved technology. Since no land as such is required to undertake bee-keeping activity, peoples of all ethnic groups, and all economic strata can participate to improve their household income level. This is of significance importance in the study area as there is no prospects for the expansion of agricutural land. Similarly, in the context of miniature land holdings caused by rapidly growing population arable farming alone can not provide even adequate food to the people. Under agroforestry activity, bee keeping flourishes as bees collect nectars from crops, trees, flowers, fruits, and other plants. Useful tree species for bee keeping can be introduced in the system.

Tree species, such as *Chiuri* (*Aesandra butyracea*), *Tooni* (*Cedrela toona), Jamun (Syzygium cumini*), and *Sal (Shorea robusta*) are important for honeybees sources of nectar. Therefore, bee keeping is technically feasible activity under agroforestry. This activity does not require many manpower and capital investments. In the study areas, it was observed that in some bee keeping households family members have been sufficient to look after 10-15 hives without any problem. Due to quick short-term returns and non-land based activity, it has already been adopted by very few farmers of the study area and there is potential to expand among other farmers. Few farmers have already got training on bee keeping that could act as potential resource farmers for future expansion. Arguably such activities of alternative employment generation and income opportunities are conducive to alleviate pressure on the land as well as help to improve economic condition of the people.

In terms of marketing, honey has good market opportunity. Presently, the bee keeping farmers sell their products among the local farmers and rarely to local markets. But farmers from study area can sell their products to Dhading besi, Gajuri, Malekhu, Narayangarh and Kathmanudu in case of surplus production. Mr. Keshab Aryal, a farmer from Nalang reported that he sells around 70 Kg of honey annually at his homestead. Government officers from the district headquarters place their purchase orders during important festivities, such as Durga Puja and Deepawali (festival of lights). He had been selling bee colonies also. Therefore, there is no problem of marketing the honey, which sells in comparatively high prices. With commercial production the reduction in farm gate price due to competition can be mitigated by exploring marketing outlets to other regional (Pokhara and Narayangadh) and wider national markets (such as Kathmandu).

To assess the financial viability of bee keeping, a model consisting of 5 hives have been adopted in this study. The details of the output produced & its prices, inputs required and all the costs associated with the bee keeping activity under the existing farmer's practice have been considered for analysis (Table A9.2). Costs and benefits of apiculture vary with the location therefore the analysis presented represents specifically to the study area situation. The financial requirements depend upon the size and scale of the project. For a 5 bee hives model taken into consideration in the present analysis, it requires Rs. 10,250.00 amount of an initial investment plus an annual operating cost of Rs. 8,25.00 Based on the analysis under different scenario, the bee keeping is found to be financially viable. However the enterprise is more sensitive to fall in output price than increase in operational costs. Even under the condition when both the unfavorable events occur simultaneously, the enterprise turns out to be financially viable (Table 9.3). The details of cash flows are presented in Table A9.3. The sensitivity analysis shows that even under the fall in output price and increase in operation cost taking place simultaneously, the project still is profitable (Table A9.4 and A9.5).

Apiculture, having been associated with benefits, is also faced with constraints. This can be a good source of income for women. Although considered as a gender neutral activity women are more involved in running this business than men, because women mostly stay at the farm household. Apart from accruing benefits beekeepers are also facing different problems. Attack by predators, mites, absconding of honeybees, insufficient technical and financial support, relatively low price of hive products and availability of suitable bee flora are the main constraints of bee keeping. To provide enough bees forage, farmers are needed to be encouraged to plant more fruit trees of different types in the farmland. Planting of flower plants around the household areas, and incorporation of honey bees' preferred tree and shrub species in the agroforestry system will increase the production from the project considerably.

Table 9.3 Indicators on financial viability of bee keeping under agroforestry

Financial Indicators	Normal Condition	10% fall in Farm Gate output price	10% increase in operational costs	All changes taking simultaneously
NPV (Rs.)	5,461.3	3,793.2	4,339.4	2,671.3
B-C Ratio	1.5	1.3	1.3	1.2
FIRR (%)	54	43	44	34

Source: Field Survey, 1998

Apiculture project with *Apis cerena* using improved hives has great potentiality of improving farm households' income. Availability of honey rich plants, growing interest of farmers in fruit cultivation through agroforestry interventions are promoting factor for bee keeping. The presence of mild climates and diverse geographical terrain with different plant species in the study area is conducive for honeybees. Ecological difference within a short distance provides opportunities for growing diverse plant species with different flowering seasons and maturity. Which is important for beekeepers, as it ensures the bee forage for honeybees round the year. Similarly growing interest of farmers to involve in agroforestry activities has widened the potentiality of apiculture. Like wise, improvement in community forests after the hand over to the local Forestry User Group have ensured the availability of adequate bee flora within honeybee's forage distance.

9.7.2 Sericulture

Sericulture is a rural intensive agro-industry producing silk yarn, which is natural fiber like cotton and wool. Mulberry silk worm (*Bombax mori*) feed on kimbu (mulberry) leaves (*Morus alba*) to produce silk worm. There are other silk worms belonging to different species and feed on non-mulberry leaves. Study area, with a large rural labor force, has the comparative advantage in sericulture industry. This will also help to provide some income to the family labor by providing employment. Agroforestry intervention has enabled farmers to plant sufficient quantities of *kimbu* for fodder and silk worm rearing. Few farmers have been able to make use of their available time more effectively by initiating sericulture project. The mulberry plantations have been used both for feeding livestock and feeding the silkworms. The activity is environmentally sustainable because of the increased vegetation in the farmlands.

The activity is also considered technically feasible. Mulberry plants have good growth in the study area. The plants have been introduced by NAF and farmers have heavily planted in tar areas, such as Majhitar, Parewatar, Pipaltar and ridegs, such as Naya basti, Nalang, Adamara, Salang, Gauthale, and Gajurichhap. NAF introduced this species to improve the livestock fodder situation especially during dry seasons when farmers are in acute shortage of fodder. During the discussion, farmers revealed that this species is one of the most preferred species by the farmers in this area. In most of the areas these plants are used for livestock feeding. In Naya Basti of Nalang, some women farmers took initiative of rearing silkworm when one of their group members was trained from the sericulture development project. These areas have high potential for sericulture development. But the activity has not yet been initiated systematically. The women members of the NAF agroforestry group who have taken initiation reported that the activity is profitable even under their condition. Some women members of agroforestry group have started to sell their mulberry leaves to others involved in rearing silk worm. One of the women member from that group was trained by Sericulture Development Office (SDO) situated at Dhunibesi of Dhading district. Under the government policy, initially SDO will provide technical assistance and inputs supply like mulberry seedlings, silk worm eggs, equipment and marketing facilities to farmers involved in sericulture particularly to those who are trained by the project. Farmers complained that the services provided by SDO are not reliable and their extension workers do not visit the village.

Marketing is an important factor for the promotion of any rural enterprises. Since government has created guaranteed market for output produced through SDO, there is no problem of marketing the cocoons as such. The DSO at a fixed price purchases raw cocoons from the farmers. Different SDO office from the various location send purchased cocoons to the central sericulture development project located at Khopasi, Kavrepalanchowk district for processing and reeling. Although the government controls the prices of cocoons, farmers have opportunity to sell their products to the government organization and not to worry for marketing. If farmers wish to sell to any other marketing outlets for higher prices, they are free to do so.

The analysis results show that sericulture is a profitable enterprise for farmers (Table 9.4). The analysis is based on the actual costs that farmer incurred and the benefits obtained under present price levels prevalent in the study area. The results showed that taking up sericulture with one ropani (0.05 hectare) of mulberry plantation requires initial investment of Rs. 9,260.00 and average annual operating expenditure of Rs. 650.00. An average farmer planting mulberry in one ropani and raising silkworm under his/her own management condition is estimated to make a net profit of Rs 2,610.00. Details of cash inflows, outflows and cash flows are presented in annex. The NPV estimated for the activity over the five year period is Rs 2,610.00. The B-C ratio has been estimated at 1.3:1. The financial internal rate of return is estimated at 54 percent (Table A9.6 and A9.7). The financial indicators are more sensitive to drop in cocoon prices than increase in operational costs. Even under the most critical conditions when both the unfavorable changes takes place simultaneously, the enterprise remains financially viable. Therefore, all the financial indicators show that the project is viable under the prevailing farmer's condition (Table A9.8).

Table 9.4 Financial Indicators Analysis for viability of Sericulture in the study area

Financial Indicators	Normal Condition	10% fall in Farm Gate output price	10% increase in operational costs	All changes taking simultaneously
NPV (Rs.)	2610.0	1520.6	1781.2	873.7
B-C Ratio	1.3	1.2	1.2	1.1
FIRR (%)	46	34	35	25

Source: Field Survey, 1998

During the discussions with women members involved in mulberry cultivation and silk worm rearing, they reported that they are in need of technical back up and more skill training. One women member from their group who took part in the training also need more training because she did not had any experience previously when she underwent a week long training at the center. When she started rearing silkworm together with other members of her group, she confronted with many problems. Now she too felt the need of more training and technical support. Being an active member of NAF executive board, the researcher had to face with women group members to solve their problems and listen carefully their request on to include sericulture component under the present agroforestry promotion activities. They came up with request for more training, technical, financial support, and extension services during the focus group discussion.

As mentioned earlier, silkworms raising using mulberry have been an additional source of cash earnings to some farmers involved in the NAF project. In doing the benefit-cost analysis of agroforestry intervention, it can be more appropriate to analyze the situation 'with' and 'without' sericulture. Results of the cost-benefit analysis of the agroforestry intervention 'with' and 'without' sericulture showed that introduction of multipurpose tree species, such as mulberry trees for silkworm raising, could be more profitable than just using agroforestry species in fulfilling subsistence requirements of fodder, fuelwood and timber. In addition to subsistence use, the utilization of mulberry plants for sericulture could generate an annual net return of Rs. 190,134/ha ($2796/ha) from agroforestry-based farming as compared to Rs. 107,547/ha ($1582/ha) 'without' sericulture (Table 9.5). Thus, in terms of annual net return, the agroforestry-based system 'with' sericulture appeared to be almost twice as profitable as the conventional farming system. The introduction of mulberry and its utilization in sericulture could increase the benefit-cost ratio of the improved agroforestry-based farming system from 2.5 to 2.9. Thus, the promotion of agroforestry, particularly the mulberry plantation for sericulture, has great potential for helping subsistent farmers improve their economic conditions substantially.

Table 9. 5. Benefit-cost analysis of agroforestry intervention with and without sericulture

Financial indicators	With agroforestry project		Without project
	Without sericulture	With sericulture	
Gross income (Rs. ha^{-1})	177,625	289,624	120,586
Total costs (Rs. ha^{-1})	70,078	99,491	65,906
Variable costs (Rs. ha^{-1})	47,870	53,070	45,795
Fixed costs (Rs. ha^{-1})	22,208	46,421	20,111
Gross margin[a] (Rs. ha^{-1})	129,755	236,554	74,791
Net return[b] (Rs. ha^{-1})	107,547	190,134	54,680
Benefit-cost ratio[c]	2.5	2.9	1.8

[a]Gross margin = Gross income – Variable costs.
[b]Net return = Gross income – Total costs.
[c]Benefit-cost ratio = Gross income/Total costs.

It was observed during the field survey that farmers require technical and market support at various stages of the sericulture operation. There are chances of farmers being in loss, due to their poor knowledge on silk worm rearing in case certain diseases or unfavorable conditions occurs to the growing silk worm. A strong extension service is felt for the expansion of sericulture in the study area. Farmers also felt the need of integrating other alternative activities with the agroforestry project, such as better livestock management and vegetable cultivation. Some of the farmers involved in agroforestry project have started including vegetables as commercial cultivation. Fodder trees, shrubs and grasses have been plated in the terrace risers while vegetable cultivation is integrated in annual cropping patterns. Intervention of agroforestry program in the existing farming system provides opportunity for inter-cropping of several vegetables.

During the field survey researcher had an opportunity to attend two meetings organized at Nalang-7, Baireni and Nayabasti villages for discussing on the formation of women cooperative by bringing several agroforestry women groups into one organization. Women groups had now collected considerable amount of "saving deposits" in their saving funds, started after the project intervention, to start a cooperative. The meetings decided to proceed ahead for the establishment of a cooperative by forming adhoc committees. NAF will be assisting the committee for technical and legal matters as well as provide training on the cooperatives management to the prospective women members managing the cooperative in future. These cooperatives when start operating their activities will facilitate the agroforestry project implementation group saving fund mobilization and marketing of farm products.

9.8 Other possibilities

Agroforestry provides ample opportunity to integrate different plant species found in the area and to increase household earning. Farmers have been utilizing different species for different purpose and their wise use in the improved agroforestry systems will ultimately lead to the improvement in systems' overall productivity.

9.8.1 Bamboo cultivation

Bamboo is widely used in the Hills for activities ranging from house construction, fencing, animal fodder, firewood, weaving of *Doko*, *Dalo* (baskets), *Mandro* (mattresses), *Nanglo* (shallow flat trays), *Bhakari* (grain storage structure) to using as food and vegetables in curries. In Hindu religion bamboo place a unique position where fresh bamboo is used to carry dead bodies for cremation. With the traditional use of bamboo, in recent years bamboo have been used extensively to produce different decoration goods, handicrafts, photo-frame, pen stand, tea mats, trays of different types, letter box and hangers of various shapes and sizes. Bamboo handicrafts making as income generating activity have been promoted by different NGOs in various parts of the country. Bamboo farming is also important for soil and water conservation. It helps to check soil erosion through its networks of underground rhizomes. They bind and stabilize soil and thus minimize soil erosion. They are extensively used in conservation along riverbanks, roadsides, periphery of landslides, gullies, gully heads and other areas prone to erosion. Apart from conservation function, Bamboo leaves are used as fodder to feed animals particularly during dry season.

NAF is helping farmers to promote bamboo plantation. Bamboo, which occupies considerable space and cause soil around it to dry out, has a negative effect on crops at its peripheral areas. Therefore its plantation is confined to either in wasted land or nonarable and dry lands not used for any type of crop or plant growing. Farmers can not afford to plant it in the cultivable land at the expense of food crops. Although some of the farmers have been maintaining in some terrace risers. But this is a very useful species to be planted in non-cultivated inclusions, landslide areas and gullies. Bamboo planting can be done easily without much investment and management. Bamboo is one of the fast growing species, which generates naturally. Although financial analysis is not carried out, farmers reported that it is profitable provided marketing facilities are available.

9.8.2 Non-Timber Forest Products (NTFP)

During the field survey it was found that farmers from the study areas as well as adjoining areas have been involved in the collection of non-timber forest products from the forest and selling them to the nearest local NTFP collector. Two of such NTFP collectors based within the study area (Gajuri) were visited during the fieldwork and information was obtained through discussion meetings. The talks were tape-recorded and the necessary information obtained from these two collectors was later analyzed. The types of NTFP received by the collectors, names of the village developments committee areas from where the farmers come to sell the products, time of the collection and amount of royalty paid to the district forest office is presented (Table 9.6). According to the farmers and the collectors, NTFP is a new area of activity involving higher income to the people if managed and utilized properly for sustainable harvest and yields.

Table 9.6 Type, sources and month of NTFP collection by Gajuri collectors

NTFP Species	Available Places (VDCs)	Month of collection	Royalty (Rs/Kg)
Jatamasi	Lapa, Jharlang, Chintang	Ashoj to Magh (Sept-March)	15
Jhyau	Gajuri, Pida, Mahadevsthan, Kiranchok, Beireni, Bhumesthan	Mangshir to Beisakh (Dec.- April)	10
Chiraito	Upper elevation villages	Bhadra to Kartik (Sept-Nov)	3
Majito (Lahara), Majitha	Gajuri, Pida, Mahadevsthan, Kiranchok, Beireni, Bhumesthan	Mangshir to Beisakh (Dec.- April)	2
Kurilo	Kumpur, Gajuri, Mahadevsthan	Mangshir to Jestha	2
Kukur Tarul (Bhyakur)	Gajuri, Kiranchok, Bhumesthan, Mahadevsthan, Pida, Beireni,	Mangshir to Jestha (Dec.- April)	10
Pilajari (plant)	Gajuri, Kiranchok, Pida, Mahadevsthan, Bhumesthan	Mangshir to Cheitra (Dec.- March)	6
Kutki	Lapa, Sertung	Mangshir to Cheitra	10

Source: Field Survey, 1998

The NTFP collectors revealed that they could obtain higher profit margin from this business. But there is no certainty of products being available and they have to pay certain amount of under the table money to the district forest officials in addition to the amount of royalty fixed by the government. They even said that due to haphazard collection practices from the forest by farmers, the amount of NTFP collected is decreasing and they are not able to tell their traders on which and which types of products would be with them previously. Farmers revealed that they had to walk long distance and spent more time to collect each year. The amount of NTFP collected during 3 years (1995/96 – 97/98) at Gajuri by the two collectors is tabulated in Table 9.7. The buying and selling rates presented in the Table 9.7 are the average rates they paid to farmers and obtained from the traders.

Table 9.7 Amount of major NTFP collected during 3 years period in Gajuri

NTFP Species	Buying rate (Rs./Kg)	Selling rate (Rs/Kg)	Amount collected and supplied (Kg)		
			1995/96	1996/97	1997/98
Jatamasi	80	105	0	0	200
Jhyau	15	38	195000	120000	50000
Chiraito	80	105	10500	9400	9300
Majito (Lahara), Majitha	13	20	8500	7500	6500
Kurilo	85	110	23000	22000	62000
Kukur Tarul (Bhyakur)	10	15	1000	1500	300
Pilajari (plant)	15	30	750	650	650
Kutki	80	110	3000	0	0

Source: Field Survey, 1998

The analysis on the actual amount paid to the farmers and amount earned by selling indicated that the collectors were able to earn big amount of money. There is no any value addition to the product sold on the part of the collectors and they even do not store the products for long owing to the lack of proper storage facility available. The amount of royalty calculated may not have been paid to the government but instead used to spend in pleasing the concerned officials (ranging from security, district administration, local government to the district level forestry officials and filed workers) both at the district and local level (Table 9.8). Only a small fraction of the actual amount may have been deposited as royalty. Collectors refrained from answering the question on amount of money they actually paid as royalty and for other purpose. Therefore in official figures, the rate of actual NTFP collected from the forest by the farmers will always be very nominal.

Table: 9.8 Amount of profit obtained by the collectors (in Rupees)

Year	Amount purchased	Amount sold	Total Royalty	Estimated Profit
1995/96	6091750	11580000	2089000	3399250
1996/97	4544250	8159000	1306100	2308650
1997/98	6877250	9871500	674800	2319450

Source: Field survey, 1998

The analysis showed that farmers as the initial collectors of the NTFP from the forest receive very nominal amount of money for the products. Similarly, the collectors based in the certain market centers, such as those in Gajuri, who purchase from farmers and sell to the regional traders, also receive quite a low rates compare to what the regional traders receive from the national NTFP traders.

9.8.3 Agroforestry for harnessing plant energy source

Agroforestry can bring substantial improvements in using plants for energy sources both by cultivated and natural plant resources. There are wide varieties of plants having considerable amount of oil content in their kernels of seeds and nuts. They are either cultivated at the farm or planted as live fence or fodder and timber trees. Some of such plants are fruit plants in and around the farmland or they grow naturally in the natural reserve of forest and in the common wastelands. Apart from the oil content these plants are very important to provide animal fodder, foods, conserve soil, check soil erosion, and land slides. If utilized properly for oil extraction, the oil cakes as the by-products can be a good source of biofertilizers to maintain the soil fertility in the hills. But due to adequate knowledge and policy such plant species have not been used to their most efficient and effective way. Although these species in one way or the other have been in use by the farmers, their natural properties (such as using for edible oil) have not been used properly. They could be used to substitute the expensive edible oil that is imported to the country to fulfill the basic domestic needs.

Hills have comparative advantage of growing different types of oil seed crops in the farmlands, community forests and national reserve forests. The commonly grown oil seeds crops in the farmlands are *Tori*- rapeseed mustard (*Brassica campestris), Rayo (B. juncea*), aalas-linseed (*Linum usitatissimum*), *Til*- sesame (*Sisamum indicum*), *Jhusetil*- niger (*Guizotia abyssinica*), bhatmas-soybean (*Glycine max*), suryamukhi-sunflower (*Helianthus annuus*), and *Badam*-groundnut (*Arachis hypogaea*). Apart from these cultivated crop species there are other naturally grown species, such as *chiuri* (*Madhuca butyracea*), *sajiwan* (*Jatropha curcas*), walnut (*Juglans regia*) and andir-castor (*Ricinus communis*) having higher potential (Table 9.9). Reports indicates that even the wasted seeds of *Chiuri*, butter tree (*Madhuca butyracea*) has a potentiality of supplying more than half of the edible oil requirement of the country, if properly managed (Shrestha, G.L., 1997).

Similarly the proper use of a commonly use live fence species called *Sajiwan*- physic nut (*Jatropha curcas*) oil alone will cover more than half of the annual diesel and kerosene oil requirement (GEM, 1996). Pine trees are another species crucial for plant oil production as vast area of the country is under pine forests. The indigenous species- chir pine (*Pinus roxburgi*) and blue pine (*P. wallichiana*) occur in plenty in the mid hills having tremendous commercial potentiality. Commercial cultivation of different aromatic plants, such as palmarosa (*Cymbopogon martinii*), citronella (*C. winterianus*) lemongrass (*C. flexuosus*), japanese mint (*Mentha arvensis*), wild marigold (*Tagetes minuta*), german chamomile (*Maricaria chamomilla*) and french basil (*Ocimum basilicum*) can be of potential source of higher income.

The farmers have planted these tree/shrub species since generations as live fence around the farmlands, and in non-cultivated or wasted lands. Presently, such resources capable of bringing significant contribution to the economic upliftment of the people have been either underutilized, not utilized at all, limited to the live fence or not planted in larger scale and even wasted. Several plant species capable of yielding potential oil, grow in natural condition, yield seeds and die out naturally. Massive production of oil is possible through the incorporation of such species in the appropriate agroforesty system. At the same time agroforestry makes it possible to grow different plant species for non-edible plant oil which can be used as regenerative alternative energy at farm level to substitute fuel wood, agricultural residues and animal waste that are being used as energy sources. At the same time, massive plantation of such species will improve the environmental condition and alternative sources of income for rural people. But this is not going to occur from the farmers' efforts alone, there should be external intervention in the form of policy, resource and institutional reformations.

Out of the total energy consumption, 91% is consumed in the residential sector and remaining 9% in other sectors. The traditional source of the energy fulfills the majority (92%) of the energy needs. Of the traditional sources, fuel wood supplies the highest (69%), followed by agricultural by-products (15%), and animal wastes (8%) (WECS, 1994). These figures in it-self show the importance of agroforestry in rural energy supply. There is excessive dependence on biomass for energy demands. As supply of fuel wood from the forest resources is being curtailed due to deforestation, land degradation, and introduction of community forestry program the rural people's needs are to be fulfilled by intensifying the plantation of suitable species in their farmlands.

Table: 9.9 important agroforestry species for oil energy with percent of oil content

Scientific name	Nepali Name	Type of species	% oil content
Aesandra butyracea	Chiuri	Tree	42%
Annona sauamosa	Sarifa	Shrub	30
Axeedirachta indica	Neem	Tree	45
Ricinus communis *	adir	Shrub	50%
Terminalia bellerica	Barro	Tree	39
Terminalia chebula	haroo	Tree	35
Morringa oleifera	Soijan	Tree	35
Melia azedarach	Bakaino	Tree	40
Jatropha curcas*	Sajiwan	Shrub	46-56
Citrullus vulgaris	Kharbuja	vine	20-40

Source: Adopted from Adhikari et al., 1993 as cited by Baral (1996).
* Commonly used live fence species.

9.9 Summary

Economic of agroforestry is a high priority and challenging area of research. Because the potential impacts and adoption of agroforestry depend on its true value for households. From household perspective, the discussion on the adoption of technology depends on whether the returns from new initiatives are greater than the existing practices. For economic impact of agroforestry analysis, detail information on costs and benefits was obtained based on only the actual cost and benefits that farm households from both project and non-project accrued. Farmers in hills normally do not consider environmental benefits, such as trees acting like wind breaks, fertility improvement, nutrient recycling and pumping from deeper soil layer and overall conservation enhancement. Farmers value these costs and benefits at the price they actually encounter.

The cost-benefit analysis revealed that introduction of agroforestry and intensification of traditional farming is economically viable. The intensification enabled farmers to diversify their farm income through the introduction of bee keeping, sericulture, vegetable production, cultivation of bamboo, NTFP and species with valuable plant energy sources. Financial comparison between project and non-project showed that intervened system was more profitable than existing system under the prevailing farmers' condition. Even operating under small land holding size, economically viable agroforestry system has been developed by farmers and it is possible to integrate tree component into the system. Agroforestry have enabled farmers to diversify their farm income. Availability of mulberry plants provided an opportunity to start sericulture and provide self-employment. Promotions of agroforestry species enhance bee keeping, as numbers of agroforestry species, such as chiuri, tooni, jamun and sal are important to supply valuable nectar. Apiculture project with *Apis cerena* using improved beehives showed great potential to improve farm income. Analysis on sericulture showed that project is viable under farmers' condition. Agroforestry with sericulture appeared to be almost twice profitable than without sericulture system. There is enormous potential to raise income through including NTFPs in agroforestry and community forests. Hills have comparative advantage of growing different types of oil seeds crops in the farmlands, community forests and national reserve forests. Similarly, commercial cultivation of different aromatic plants could become the potential source of farm income.

Chapter X

Agroforestry Adoption and Extension

The adoption of a new idea or practice is not a simple act but a complex process involving a series of mental activities combined with various actions. Knowledge of diffusion and adoption would enable extension agents to increase the rate of adoption of a new technology. The diffusion theory explains the process of the spread of farming innovation, where new ideas are communicated to the members of a social system (Rogers and Shoemaker, 1971). Innovation is an idea perceived as new by the individuals (Rogers, 1983). The characteristics of innovations, such as relative economic advantage, compatibility, complexity, trialability, and observability, are very important factors affecting their adoption by farmers. Farmers are most likely to adopt those practices that exhibit better characteristics than current practices. Communication is a vital element throughout the social change process in order to let potential adopters know the positive benefits of the improved practices. Four main channels of communication namely informal friends and neighbors, salesmen and dealers, government extension agencies and mass media are involved in the diffusion of innovation (Rogers, 1960). The adoption of innovations involves five stages, which are awareness, information/interest, evaluation, small-scale trial, and finally adoption or rejection. The adoption of innovations is a time consuming process in which some innovations are readily accepted while others get rejected. The fact that some ideas or practices are accepted while others are rejected indicates that there are some factors which are affecting their adoption or rejection.

New ideas may affect the existing social order or system. The cultural beliefs and perceptions of the social system can influence adoption. The new practice (such as improved agroforestry) should be relatively superior to the traditional practice it is intended to replace. The relative advantage is often expressed in terms of economic gains. The new practice should also be compatible with the farmer's existing community values, traditional management and the level of farming system. The degree of compatibility of a new technique with the existing one determines its adoption. The more farmers consider a practice to be compatible with their existing practice, the more likely they will adopt it. The new practice should be easy to understand and to test on a limited scale. Innovations, whose results and advantages are readily visible to farmers are more likely to be adopted. As people adopt innovations at different times, they are classified as early adopters, early majority, late majority and laggards. Adopter's personal characteristics, such as age, level of formal education, level of income, size of farm, extension contacts and membership in organizations influence the adoption process. For example, young farmers are said to be more interested in making changes in their farming practices than older ones. Regression analysis in this study showed that the adoption of agroforestry was negatively associated with the age of the respondents (refer Chapter XI).

Farmers' repeated experimentation and verifications of their observations are important to their decision on adopting a new technology. Most farmers adopt new technology only after observing it being practiced by some of their fellow farmers. Farmers, on their own initiatives, conduct trials with new tree species and crop varieties (Garforth et al., 1997). In one observation, these authors have found that farmers have learnt to plant *Leucaena spp.* on the top of the terrace and *Moras spp.* on the middle of the terrace risers mainly due to their different rooting characteristics. The roots of *Leucaena spp.* go straight down into the ground, while those of *Moras spp.* spread laterally, thereby obstructing the field plowing. Farmers are also trying out various combinations of tree species depending upon their needs and the tree characteristics. Apart from their own experiences, information from various sources also determines farmers' willingness to adopt agroforestry technology. It is important for agroforestry planners to understand why farmers adopt certain species but not others, sources of their information and advice they receive from extension agents to promote hill agroforestry.

10.1 Adoption of agroforestry

The analysis of the level of agroforestry adoption revealed that 27% of project and 12% of non-project households in the sample have adopted new fodder tree species. Considerably higher numbers of project households have established fodder (28%) and fruit trees home nurseries (26%) in their farmlands compared to 25% and 8% of the non-project households. More than 25% of farmers have established fodder tree nurseries under both project and non-project conditions (Table 10.1). Among different agroforestry species, the highest percentages of project farmers have adopted fodder tree species (27%) followed by grass (14%) and fuelwood/timber species (13%). In case of non-project farmers, the highest proportion have adopted fuelwood/timber (16%), followed by grasses (13%) and fruit species (12%). A large section of the both types of farmers reported that they have heard and are aware of the new agroforestry species while only a few have actually seen them.

Table: 10.1 Knowledge and adoption of different agroforestry species among the sample households

Species	With project (n=82)				Without project (n=141)			
	HA	SAW	NRSTD*	ADOP	HA	SAW	NRSTD*	ADOP
Fruit Species	41 (50)	11 (13)	21 (26)	6 (7)	92 (65)	14 (10)	11 (8)	10 (7)
Fodder tree species	44 (54)	14 (17)	23 (28)	22 (27)	14 (10)	45 (32)	35 (25)	17 (12)
Fuelwood/timber sp.	4 (5)	4 (5)	8 (10)	11 (13)	8 (6)	9 (6)	14 (10)	22 (16)
Medicinal species	-	1 (1)	-	1 (1)	-	-	-	4 (3)
Grasses	-	3 (4)	3 (4)	12 (14)	4 (3)	5 (4)	7 (5)	19 (13)

Figures in parentheses indicate percentages
* Pearson Chi-square significant at the 0.10 level (p = 0.052)

HA = Heard and aware of the improved agroforestry technology and species;
SAW = Seen and known the improved agroforestry practices but not practiced;
ADOP = Adopted improved agroforestry practices
NRSTD = Nursery (home nursery) established by the farm households

10.1.1 Motivating factors for agroforestry adoption

NAF uses different motivational programs, such as farmers training, exposure or educational visit to different agroforestry farms or farmer managed demonstration farms to create awareness of agroforestry in the study area. Respondents were asked as to how they were motivated to grow different agroforestry species. For the overwhelming majority of both project (83%) and non-project (87%) farmers, fodder scarcity was the main reason for planting fodder species in their farmlands followed by rearing of improved breeds of livestock for 40% of the project and 38% of non-project households. A sizable number of farmers also cited the closure of community forests as being one of the reasons for planting fodder trees in their farmlands. Farmers in both with and without project situation were found to be motivated to plant fruit tree species because of their income generation potential. Similarly, usefulness of species for multiple purposes motivated around two thirds of the project farmers (66%) and above three fourths of the non-project farmers (77%) to plant fruit tree species. Limited access to the community forests motivated 61% of project and 69% of non-project farmers to plant grass species (Table 10.2). Therefore, a restriction imposed on free access to the community forests was one of the reasons for farmers to start agroforestry in their private lands. This corraborates finding of another study conducted elsewhere in the hills of Nepal (Thapa and Weber, 1990).

Table: 10.2 Factors motivating agroforestry adoption

Factors	With project				Without project			
	FRT	FOD	FWT	GR	FRT	FOD	FWT	GR
Fodder scarcity	1(1)	68(83)	2 (2)	10(12)	2 (1)	122(87)	2 (1)	14(10)
Fuelwood/timber scarcity	0	1 (1)	61(74)	0	0	2 (1)	117(83)	2 (1)
Closure of community forests	0	12(14)	17(21)	50(61)	0	17(12)	23(16)	97(69)
Long fodder/fuel collection time	0	5(6)	21(26)	2 (2)	0	14(10)	30(21)	12 (8)
Rearing improved animals	3 (4)	34(41)	0	3(4)	1(0.7)	53(38)	1(0.7)	07(5)
High income from trees	60(73)	0	0	0	82(58)	0	0	0
Market for tree and tree products	3(4)	2 (2)	24(29)	0	15(11)	1(0.7)	39(28)	0
Manure production for farms	2(2)	5 (6)	0	21(26)	2 (1)	14(10)	1	34(24)
Multiple outputs produced	54(66)	1 (1)	0	0	109(77)	0	0	3 (2)
Others	2 (2)	0	0	1 (1)	2 (1)	0	0	1 (0.7)

Source: Field Survey, 1998
Figures in parentheses are percentages

FRT = Fruit trees; FOD = Fodder trees
FWT = Fuelwood and timber trees; GR = Grass species

10.1.2 Constraints to agroforestry adoption

Almost all of the project (98%) and overwhelming majority of the non-project (90%) farmers expressed their willingness to plant different agroforestry species in their farmlands to meet the increasing demands of fodder, fuelwood, timber and other products. In response to the question as to why they were not able to do so in the past, farmers provided several reasons. Farmers are confronting with multitude of problems in planting additional tree/shrub species in their farmland. More than two thirds of the project households (70%) and the majority (56%) of the non-project households revealed that lack of knowledge about the improved and high yielding fruit tree species and their management is the most important constraint (Table 10.3). The lack of improved agroforestry knowledge was another cause for not adopting agroforestry in the past for nearly three-fourths of project (73%) and about half of the non-project (47%) farmers.

Regarding fuelwood and timber species, about one-third of the both categories of farmers (32%) reported that they were not provided with necessary advice by any one to grow fuelwood or timber trees. This shows farmers' consciousness towards the state's responsibility in providing them with information through proper extension services. A very small percentage of project and non-project respondents expressed fear in planting trees, especially fuelwood and timber species in their farmlands due to inconsistent government policies. They feared that the government may not allow them to cut and sell their trees in the market. Half of the project (50%) and more than two-fifths of the non-project households (44%) reported that they were not motivated to plant grasses as naturally grown grass was available. Although there is restriction on frequent entrance into community forests, villagers are allowed to cut grasses in the different seasons and times fixed by the forest users committee. For a small number of both project and non-project households, shortage of labor was a limiting factor for the expansion of agroforestry.

The availability of enough trees in the farmlands, fear of declining crop yields due to trees, inadequate marketing facilities, long time required to get returns from the tree species, lack of land were other constraints mentioned by farmers.

Table: 10.3 Farmers' constraints in agroforestry expansion

Constraints	With project				Without project			
	FRT	FOD	FWT	GR	FRT	FOD	FWT	GR
Do not have own land	7 (9)	3 (4)	2 (2)	0	15 (11)	2 (1)	6 (4)	0
Do not know improved species	57 (70)	13 (16)	1 (1)	2 (2)	79 (56)	28 (20)	1 (0.7)	2 (1)
Lack of improved AF knowledge	11 (13)	50 (73)	3 (4)	1 (1)	32 (13)	66 (47)	2 (1)	2 (1)
Enough trees in farmland already	0	1 (1)	6 (7)	2 (2)	1 (0.7)	1 (0.7)	10 (7)	1 (0.7)
Fulfilling the need through farm and non-farm sources	0	2 (2)	8 (10)	41 (50)	0	8 (6)	17 (12)	62 (44)
Fear of reduced crop yield	1 (1)	1 (1)	2 (2)	1 (1)	2 (1)	3 (2)	9 (6)	1 (0.7)
No market for products & take long time to get returns	4 (5)	2 (2)	1 (1)	0	11 (8)	5 (4)	4 (3)	1 (0.7)
Insufficient landholdings	1 (1)	0	6 (7)	0	3 (2)	4 (3)	11 (8)	1 (0.7)
No one taught us the practice	5 (6)	10 (12)	26 (32)	5 (6)	8 (6)	11 (8)	45 (32)	20 (14)
Insufficient labor	5 (6)	0	4 (5)	0	4 (3)	3 (2)	2 (1)	0
Fear of not being allowed to cut trees by the government	1 (1)	0	3 (4)	0	1 (0.7)	0	5 (4)	0

Source: Household Survey, 1998

FRT = Fruit trees; FOD = Fodder trees
FWT = Fuelwood and timber trees; GR = Grass species

Project households felt that shift towards livestock raising would provide higher amount of income, provided that they have relevant technical knowledge and access to market. In regard to the profitability of agroforestry and possibility of shifting from crop to livestock production, overwhelming majority (94%) of the respondents believed that agroforestry-based farming system is more profitable than the exclusively field crop-based system. However, when farmers were further asked to comment on whether the shift from cereal crop cultivation to livestock raising was possible or not, only less than one-third of the project farmers (29%) and about one-fifth of non-project farmers (18%) responded positively (Table 10.4) and recommended such shift to improve the household economy.

Table: 10.4 Respondents' view on Profitability of agroforestry and possibility of shift from crop to livestock production.

Situation	Agroforestry more profitable than purely crops-based system		Possible to shift from crop to livestock production	
	Yes	No	Yes	No
With Project	77 (94)	5 (6)	24 (29)	56 (71)
Without Project	132 (94)	9 (6)	26 (18)	115 (82)

Figures in parentheses are percentages.

However, the majority of farmers in both project and non-project areas were of the view that shifting from crop to livestock production is not possible under the present farming system. For 44% project and 39% non-project respondents, the shift towards improved livestock raising through improvement in agroforestry is not possible because they have to produce cereal grains to fulfill their food requirement. This requires cultivation of cereals in available small land holdings. Thus farmers are not be able to allocate sufficient area to planting fodder species. They even feared of loosing crop yields if they planted tree species in the terrace risers, which remain normally fallow. About one-third of non-project and one-fourth of the project households cited lack of drinking water, unproductive livestock breeds, small land holdings and shortage of manpower as other constraints in changing the existing production system (Table 10.5). Only a few farmers reported that they are constrained with inadequate capital for investment.

Table: 10.5 Constraints in shifting from cereal crop to livestock production

Constraints	With project		Without project	
	Frequency	Percentage	Frequency	Percentage
Need to produce cereals to fulfill family food requirements	36	44.0	55	39.0
Lack of technical knowledge and skill	14	17.0	10	07.0
Unavailability of market for products	10	12.0	16	11.0
Amounts of livestock feeds not available	01	01.0	02	01.0
Inadequate capital	03	04.0	14	10.0
Others (shortage of manpower, no suitable livestock breeds, less land and water)	18	22.0	44	31.0
Total	·82	100.0	141	100.0

Source: Field Survey, 1998

Credit is considered one of the essentials for bringing improvements. Credit permits farmers to enhance conventional efficiency of overcoming capital inadequacy and adopt new technology. In a study of production credit for rural women (PCRW) project in Dhading district, Ojha and Weber (1993) revealed that project group borrowed a significant amount of institutional credit as compared to control group, which borrowed mostly from friends and moneylenders. The project group also showed strong indication of a budding trend towards the adoption of improved varieties and diversification. The adopters of the technology will also be able to avail the available institutional facility. Ojha and Weber further stated that in terms of advancing women participants to social recognition equal to men, PCRW project had limited impact but placed more burdens on women.

Respondents were also asked to mention about the problems facing livestock production in the study area. Various reasons mentioned by the farmers were more or less similar for both the project and non-project groups. Inadequate fodder and feed for livestock, higher incidence of animal diseases and lack of water were the three most frequently problems constraining livestock production. Specifically, inadequate fodder availability was the single most important factor constraining livestock raising for both project and non-project farm households. This indicates the need and potential for agroforestry promotion in the study area. Higher incidence of animal diseases was found to be the second most important problem among both groups of farmers, followed by insufficient water and family labor shortage (Table 10.6). Due to fodder shortage and diseases the majority of livestock are skinny with exposed skeleton. Since farm animals are under-fed and are reared in low nutrition condition, they are susceptible to diseases and parasites.

Table: 10.6 Major problems reported by respondents in increased livestock raising

Problems	With Project		Without Project	
	No.	%	No.	%
Insufficient family labor	08	10	09	06
Higher incidence of diseases	18	22	39	28
Inadequate fodder and feed	62	76	124	88
Insufficient water for drinking & other use	08	10	36	25
Inadequate/lack of capital	02	02	03	02

Respondents were also asked to suggest alternatives to field crop cultivation in order to improve their farm productivity. More than three-fourths of project farmers (78%) and two-thirds of the non-project farmers (67%) reported vegetable cultivation as one of the highly profitable alternatives. Fruit production was suggested as an alternative by nearly one-fourth of non-project farmers (24%) compared to 15 % of project farmers (Table 10.7). There are good prospects for incorporating vegetable cultivation and plantation of fruit trees in the agroforestry system to increase the households' income. The proximity to roads linking the important cities of the country including Kathmandu, Pokhara and Narayangardh offers opportunities of promoting agroforestry-based commercial crop cultivation thereby exploiting the comparative advantage of the hill farming.

Table: 10.7 Alternatives to cereal crop production

Alternatives	With project		Without project	
	Frequency	Percentage	Frequency	Percentage
Vegetables	64	78	94	67
Fruits	12	15	34	24
Others	6	07	13	09
Total	82	100.0	141	100.0

Source: Field Survey, 1998

10.1.3 Activities suggested to integrate with the agroforestry system

Farmers revealed that complete shift from subsistent cereal production to livestock production with improved agroforestry and commercial cultivation of either vegetables or fruit from cereal grain production is not feasible in the study area under the prevailing socio-economic conditions. Owing to marginal land holdings and lack of off-farm employment opportunity, the hill farmers are facing increasingly the problem of food shortages. The involvement of women in particular is increasingly becoming hard in cultivation of terraces, which have begun to face severe and chronic soil erosion problems. Therefore, a suitable alternative to cereal crop cultivation is required. Due to constraints in increasing agricultural production, particularly cereal grains, alternatives activities need to be integrated with the present farming system to improve fagricultural productivity. Farmers, who have accumulated experience with the existing geophysical situation of their locality, can suggest some appropriate alternative activities to cereal crop production.

Realizing the importance of indigenous knowledge, farmers were asked to suggest alternative agriculture activities that can be promoted to increase their farm productivity. Farmers from both project and non-project categories indicated improvements in cattle and buffalo raising, followed by fruit trees as economically most attractive activities. Interestingly, both men and women responses were quite similar (Table 10.8).

Table 10.8 Alternative agriculture activity suggested by farmers

Alternative	With project (n =82)		Without project (n=141)	
	Women (n=43)	Men (n=39)	Women (n= 44)	Men (n=97)
Cattle and buffalo raising	20 (47.6)	22 (56.4)	20 (45.4)	43 (44.3)
Fruit production	11 (26.2)	8 (20.5)	14 (31.8)	29 (29.9)
Others	8 (19.0)	6 (15.4)	5 (11.4)	14 (14.4)
Do not know	3 (7.1)	3 (7.7)	5 (11.4)	11 (11.3)
Total	42 (100.0)	39 (100.0)	44 (100.0)	97 (100.0)

Source: Field Survey, 1998

10.1.4 Policy changes as suggested by farmers

Respondents suggested some policy changes to bring substantial improvements in agroforestry. As planners and implementers of the agroforestry project advocate for policy changes to bring improvements in certain situations, farmers too believed that policy changes are required for agroforestry development. More than one-third of non-project (35%) and more than one-fourth of project households (27%) suggested that the government should have better marketing policy and facilities for fruit production. Similarly, about one-third of the both project and non-project households suggested that the government should have the policy of providing subsidies to farmers who wish to convert their land from field crop cultivation to fruit plantation. Likewise, one-fourth of the both project and non-project households recommended the provision of educational and training opportunities for the promotion of fruit cultivation. However, both (17%) and non-project households (19%) reported improvements in irrigation as major aspect of policy changes required for higher adoption of non-fruit trees (Table10.9). Although the government already has irrigation policy, farmers still want to have policy changes that are in favor of small farmers and policies are implemented. In terms of irrigation prospects, there is still untapped potential to improve irrigation but not in all areas.

Table: 10.9 Farmers' recommendations on policy changes to improve agroforestry

Policy changes	With project		Without project	
	Fruit trees	Non-fruit trees	Fruit trees	Non-fruit trees
Better marketing facilities	22 (27)	05 (6)	50 (35)	01 (0.7)
Improvement in irrigation	06 (7)	14 (17)	15 (11)	27 (19)
Education and training	20 (24)	11 (13)	30 (21)	18 (13)
Provision of financial subsidies	27 (33)	04 (5)	49 (35)	16 (11)

Source: Field Survey, 1998

Figures in parentheses are percentages.

10.2 Agroforestry extension

Agroforestry extension bridges gap between technical knowledge and current practices. Extension is considered cost effective having a significant and positive impact on farmers' knowledge, adoption of new technologies and productivity. To bring substantial improvement in agroforestry, improvements in extension services are required. The dissemination of the technological innovations that are technically sound and economically profitable is required to ensure greater production and higher income than the existing traditional practices followed by the farmers. The technological development and dissemination need to be sensitive both to the characteristics of biophysical and socioeconomic environments (Kabila, et al., 1997). Extension contacts can influence adoption behavior, as farmers with more extension contacts adopt more innovation (Chitere, 1998). The results indicated that the services provided by the extension worker particularly among the non-project households was insufficient although the majority of farmers in project (80%) and more than one-third (35%) in non-project group revealed that extension worker visit their village. Interestingly, the majority of non-project farmers (63%) have never seen the extension worker in their village (Table10.10).

Table: 10.10 Distribution of households by access to extension service

Statement	With project (n = 82)			Without project (n = 141)		
	Yes	No	DK	Yes	No	DK
Extension worker visit their village	80 (66)	20 (16)	00	35 (49)	63 (89)	02 (3)
EW provides extension services	67 (55)	11 (9)	2 (2)	24 (34)	06 (9)	04 (6)

Figures in parenthesis are frequency of households.
DK = Do not know; EW = Extension Workers
Note: frequency not matching with total sample due to no responses from the respondents.

Of the total households, 72% project households and less than one-third (28%) of non-project households reported that they had obtained agroforestry training, particularly on nursery management. Thus a higher percentages of project farmers were involved in agroforestry nursery training than the non-project ones. This was due to the fact that NAF provides home nursery training to all the interested agroforestry group members. Out of the different extension services received by the project households, nearly 40% had received technical training on agroforestry, 25% had participated in cross visit and very few (2%) households had obtained animal checkup services and veterinary health training. None of the non-project farmers obtained any kind of animal checkup and veterinary health training, while 28% of them received home nursery training and 14% received technical training on agroforestry (Table 10.11).

About 6% of the non-project respondents also had been involved in cross visits. It may be the case that while selecting farmers for the cross visit program, local NGOs, who are given the responsibility of selecting farmers, may have included some farmers from adjoining non-project areas. Although they participated in the cross visit to study agroforestry species and practices, some of the farmers were not interested in agroforestry activities. The purpose of their participation may have been simply to travel and see other areas, but not to learn agroforestry. The other possible reasons could be that they did not like the species and system practiced or they found their own land different than what they saw during the cross visit program.

Although only 13% of the non-project farm households have been visited by extension worker compared to 39 % of project households, the mean number of visits in both cases was almost equal. Similar pattern was observed in case of farmers' visits to the extension office.

Table: 10.11 Frequency of households visited by extension agents and service provided

Extension services and visits by extension worker and farmers	With project			Without project		
	No. of farmers	%	Mean	No. of farmers	%	Mean
Extension services						
Agroforestry sursery training (numbers)	59	72	1.81	40	28	2.1
Agroforestry technical training (number)	31	38	2.6	24	17	1.8
Animal checkup services (Times)	05	02	1.4	00	00	0
Vet. and animal health training (Nos.)	05	02	1.0	00	00	0
Cross visit to demonstration site (Times)	21	25	3.0	09	06	1.1
Animal vaccination (Times)	03	04	1.7	02	01	1.5
Veterinary treatment received (Nos.)	04	05	1.7	00	00	0
Extension visits (number of visits)						
Extension Workers' visit to frm (times)	32	39	3.8	19	13	3.6
Farmers' visit to extension Office	12	15	1.7	06	04	1.8

Source: Field Survey, 1998

Both male and female have attended training on agroforestry. Percentage of project households' members who attended training on agroforestry was found to be more than double (38%) in comparison to non-project household members' (17%) involvement in training. However, among the participants, the participation of females (74%) in the agroforestry training was found more than three folds higher than that for males (23%) among the project households. Among the non-project households, the participation of each gender in the agroforestry training was almost equal (Table 10.12). Higher number of women participation in training among the project households is related to NAF promoted agroforestry program, where involvement of women is much higher than that of men, as there are agroforestry groups composed up of only women. This is in line with NAFs' policy of according higher priority to females while selecting participants for agroforestry training and cross visit programs.

Table: 10.12 Frequency of household members who attended agroforestry training

Gender	With project (n = 82)		Without project (n = 141)	
	Frequency	Percentage	Frequency	Percentage
Males	07	22.6	11	45.8
Females	23	74.2	12	50.0
Both	01	03.2	01	04.2
Total	31	100	24	100

Source: Field Survey, 1998

10.2.1 Sources of information

Information dissemination is an important aspect of the agroforestry promotion. Because information does not simply pass from person to person- it is continually transferred through process of selection, interpretation and communication (Garforth and Usher, 1997). When asked about the source of information, around 30 % of the project group said that they received most of the information on planting shrubs/bamboo, grasses, fruit trees, and fuel wood/timber trees, from the local non-governmental organizations (LNGOs) and NAF. Under the village setting, where newspapers and other modern sources of information are very limited, farmers have to depend on traditional sources of information, such as friends, relatives, and neighbors. However, increasingly higher number of project respondents obtained agroforestry information from local NGO and NAF, who are disseminating information through staffs, volunteers, brochure, training and meetings. Regarding non-project households, the majority of them still relied on neighbors, relatives, friends and other sources for information (Table 10.13). The local NGO also played very important role in providing information to non-project households.

The project farmers obtained information on fruit trees mainly from local non-governmental organizations, Nepal Agroforestry Foundation, while non-project households received it from neighbors/friends/relatives, and local non-governmental organization. Similar pattern was observed for information on fodder, fuelwood/timber, and grass species among the project households. Non-project farmers received information on fodder trees from neighbors, relative, and friends (47%), while for fuelwood/timber they received information from neighbors/friends (27%), others (23%) and local NGO (23%). On the other hand, for grass species neighbors/friends (24%), local NGO (23%), and others (23%) served as the main sources of information for non-project group. Only around 5% of the non-project farmers were able to receive information on agroforestry from NAF. For project households, information on grass species was obtained mainly from local NGO (29%) and NAF (28%). The project households may have been the source of information for non-project households as the spill over effect of NAF promoted agroforestry project.

Table: 10.13 Respondent's sources of information on agroforestry by species.

Agroforestry species	Sources							
With project *	NBF		LNGO		NAF		OT	
	No.	%	No.	%	No.	%	No.	%
Fruit trees species	16	20	32	39	25	31	8	10
Fodder trees species	10	13	32	39	31	39	7	8
Fuel/timber species	21	26	29	36	24	30	7	8
Shrubs and bamboo spp.	22	28	26	34	22	28	7	8
Grass species	16	20	24	29	23	28	7	8
Without project *								
Fruit trees species	65	47	33	23	8	6	31	22
Fodder trees species	65	47	35	26	8	6	28	20
Fuel/timber species	64	47	33	23	6	5	33	23
Shrubs and bamboo spp.	65	47	37	28	6	5	26	18
Grass species	60	43	33	23	7	5	33	23

Source: Field Survey, 1998

* Chi -square test significant at 0.000 ($p < 0.0001$)
NBF = Neighbors and friends; LNGO = Local NGO/groups
NAF = Nepal Agroforestry Foundation; OT = Other sources

The results indicated that role of local groups and organizations in the dissemination of information on agroforestry were found to be very important both project and non-project households, while NAF played a crucial role in providing necessary information to project households. Neighbors, friends and relatives were still very important source of information, for non-project households. The relative effectiveness of a source of information to adopters will vary depending upon the type of new practice/ species.

10.2.2 Advice on agroforestry

As just discussed, farmers received information from various sources. Farmers were also asked to indicate those who advised them to grow more agroforestry species in their farmlands. Such advice might have come from different sources and vary depending upon the agroforestry species to be promoted. The project group received the advice for fruit tree plantation mainly from NAF (27%), neighbor, relative and friends (26%) and local NGO (17%) while the majority of the non-project households (51%) were advised by their neighbors, relative and friends to adopt agroforestry. For fodder trees, NAF (23%), local NGO (21%) and extension workers (17%) in the project group and local NGO (30%), and others (12%) in the non-project group were the main sources of advice for farmers to get involved in agroforestry (Table 10.14). The advice for adopting grass species came mainly from local NGO and NAF for both groups.

Local institutions played a major role in promoting fodder, fuelwood and grass species, while neighbors, relative and friends were responsible in promoting the plantation of fruit trees. In addition to respondents' own awareness about the agroforestry, awareness level of the other household members is also very crucial for the dissemination of information and subsequent adoption. The findings indicated that apart from the importance of sources of information to farmers in their adoption decision, the advice they receive for agroforestry adoption encourage them to opt for improved agroforestry. After receiving the information from different sources on a new technique, a farmer may likely to solicit advice from his/her spouse, relative, neighbors/friends or others before making decision to adopt the practice.

Table: 10.14 Sources of advice on adoption of agroforestry.

Species	Major sources of information									
	With project					Without project				
	NBF	EW*	NAF**	LNGO	OT	NBF	EW*	NAF**	LNGO	OT
Fruits	21 (26)	05 (6)	22 (27)	14 (17)	6 (7)	72 (51)	5 (4)	08 (6)	15 (11)	12 (9)
Fodder	03 (4)	14 (17)	19 (23)	17 (21)	9 (11)	11 (8)	13 (9)	11 (8)	43 (30)	17 (12)
Fuel	02 (2)	02 (2)	07 (8)	12 (15)	5 (6)	2 (1)	11 (8)	05 (4)	11 (8)	20 (16)
Herbs	01 (1)	00	00	02 (2)	00	00	00	04 (3)	02 (1)	00
Grasses	02 (2)	00	03 (4)	08 (10)	4 (5)	3 (2)	2 (1)	10 (7)	12 (9)	06 (4)

Source: Field Survey, 1998
Figures in parentheses indicates percentages
* Pearson Chi-square significant at the 0.10 (p= 0.086)
** Pearson Chi-square significant at the 0.01 (p =0.004)

Source of information: NBF = Neighbors, relatives and friends; LNGO = Local NGO/groups
NAF = Nepal Agroforestry Foundation; OT = Other sources

For planners and implementers of agroforestry, it may be of interest to know as to how the farmers came to know about the new agroforestry species and who provided them with necessary information for the first time. More than two-fifths (43%) of the project and two-thirds (67%) of non-project farmers got information about fruit tree species through observation of fellow farmers, followed by local institutions and their members (20%), friends/relatives (16%) for the project households and radio program and friends/relatives for the non-project ones. First time information on fodder trees by project household was obtained from friends/relatives (27%), local institutions/members (23%), farm visits (16%) and NAF project (12%). Similarly, friends/relatives (45%) followed by observation of the practices somewhere else (15%) and local organizations were the main source of first time information for the non-project households (Table 10.15). For both cases, local organizations were responsible for providing first time information on grass species. Chi-square test showed that first time information provided by local organization and their members on different agroforestry species was significantly higher ($p<0.01$) in project households than non-project households. Significantly higher ($p<0.10$) number of non-project households received first time information from their neighbors, friends and relatives.

Irrespective of the agroforestry group, the results indicated that considerable proportions of the respondents received first time information about fuelwood and timber species from the training and group meetings. Interestingly, village elders and leaders had played an important role in providing information on fuelwood and timber tree species in both with and without project situations. Some respondents got information through the Radio program, which was more important for the non-project than the project group. Surprisingly, the government extension workers, who are supposed to provide extension services and are deployed in the study area, provided very little agroforestry information to the farmers in both project and non-project conditions.

Table: 10.15 First time source of information on agroforestry

Sources	With project				Without project			
	FRT	FOD	FWT	GRS	FRT	FOD	FWT	GRS
Observing somewhere practiced	35 (43)	6 (7)	1 (1)	0	95 (67)	21 (15)	1 (0.7)	1 (0.7)
Friends and relatives **	13 (16)	22 (27)	3 (4)	2 (2)	15 (11)	64 (45)	13 (9)	1 (0.7)
Training, and group meeting	7 (9)	6 (7)	18 (22)	4 (5)	6 (4)	6 (4)	32 (23)	4 (3)
Local NGOs & members *	16 (20)	19 (23)	3 (4)	20 (24)	9 (6)	13 (9)	12 (9)	48 (34)
NGO field staffs and visitors	7 (9)	3 (4)	4 (5)	5 (6)	5 (4)	4 (3)	2 (1)	8 (6)
Village elders and leaders	4 (5)	1 (1)	7 (9)	1 (1)	10 (7)	9 (6)	26 (18)	7 (5)
From farmers exposure visits	10 (12)	13 (16)	5 (4)	0	8 (6)	9 (6)	2 (1)	5 (4)
NAF extension materials/staff	6 (7)	10 (12)	2 (2)	5 (4)	7 (5)	8 (6)	1 (0.7)	4 (3)
Radio program	5 (4)	4 (5)	5 (4)	3 (4)	19 (13)	9 (6)	10 (7)	9 (6)
Govt. extension workers	5 (4)	3 (4)	3 (4)	6 (7)	7 (5)	5 (4)	4 (3)	2 (1)
Others	1 (1)	1 (1)	0	3 (4)	2 (1)	4 (3)	5 (4)	1 (0.7)

Source: Field Survey, 1998
Figures in parentheses are percentages.

* Pearson Chi-square significant at the 0.01 ($p<0.01$)
** Pearson Chi-square significant at the 0.10 ($p=0.064$)
FRT = Fruit species; FOD = Fodder species;
FWT = Fuelwood species; GRS = Grass species

10.2.3 Motivators for adoption of agroforestry (agents of influence)

Motivation is an important to promoting agroforestry. For many of the farmers, receiving information and soliciting advice may not be sufficient to adopt certain practices/species. Those who are important or intimate in motivating them to pursue certain innovation may therefore determine the adoption behavior of the farmers. Before adopting certain agroforestry species, farmers were likely to have been motivated by certain persons or activities. The agents for influence can be different for different species. Sampled farmers were asked to provide information on who were their main motivators of agroforestry. The results indicated NAF, village NGO, agroforestry group members and relatives/friends/neighbors as the most important motivating agents for the project households. For the non-project households, family members, village NGO, and relative/friends/neighbors were the main motivating agents. By agroforestry species, NAF was the main motivator for households (30%) planting fruit trees in the project group, while family members themselves acted as main motivating agents to promote fruit trees among the non-project farm households (57%). Village NGO and user groups followed by NAF motivated project households to plant fodder species but in case of non-project households, motivation on agroforestry came mostly from village NGO/groups, followed by relatives, friends, neighbors. Motivation to promote fuelwood and timber trees on farmlands was mostly done by relatives, friends and neighbors (Table 10.16).

Table: 10.16 Frequency of respondent's important motivators to start agroforestry

Motivating agents	With project (n = 82)				Without project (n = 141)			
	FRT	FOD	FWT	GR	FRT	FOD	FWT	GR
Family members	9 (11)	03 (4)	4 (5)	1 (1)	80 (57)	04 (3)	03 (2)	3 (2)
NAF	25 (30)	15 (18)	1 (1)	2 (2)	08 (6)	19 (13)	03 (2)	1(0.7)
Village NGO/groups	15 (18)	25 (30)	6 (7)	1 (1)	11 (8)	53 (38)	11 (8)	4 (3)
RF and Neighbors	14 (17)	07 (8)	12 (15)	1 (1)	28 (20)	24 (17)	42 (30)	8 (6)
AF group members	11 (14)	11 (14)	6 (7)	3 (4)	09 (6)	11 (8)	08 (6)	9 (6)
Cross visits	05 (6)	02 (2)	5 (6)	5 (6)	05 (4)	08 (6)	06 (4)	7 (5)
Extension workers	03 (4)	05 (6)	7 (8)	5 (6)	11 (8)	09 (6)	01 (0.7)	3 (2)
Others	04 (5)	03 (4)	3 (4)	3 (4)	08 (6)	16 (11)	06 (4)	8 (6)

Figures in parentheses are percentages
FRT = Fruit species; FOD = Fodder species; AF = Agroforestry
FWT = Fuelwood species; GRS = Grass species; RF = Relatives and friends

In an overall, the results indicated that local groups/organizations, and farmers themselves were involved in motivating farmers to promote agroforestry species. Therefore, creating greater awareness among the people is important. It was observed that farmers' decisions are found to be affected by neighboring farmers' opinions and advice.

10.2.4 Communication methods used in agroforestry extension

Effective communication is very important in the dissemination of innovations to farmers. Potential adopters are more likely to adopt if they are informed about the benefits associated with new parctices. As agroforestry is the priority area for women, innovation message must be effectively conveyed to women. In the study area it was found that NAF used three methods of communication in its extension approach, namely the mass, group and individual methods. Mass communication having the ability to reach a large audience in a short time has been found to play an important role in extension especially at the awareness stage. NAF has been distributing wall newspapers, flip charts, posters and booklets on agroforestry to farmers. Some of the materials developed by NAF, such as *Terrace Planting of Fodder Trees and Grasses*, *Homestead Agroforestry*, and *How Soil Fertility is Gained and Lost*, presents information on improved agroforestry technology in a simple way for farmers to understand. Such materials have been displayed in some of the farmers' houses, teashops, farmer leader/promoter houses and NAF training center in the study area.

The individual communication included conversation, individual farm visit, office calls and informal contacts. Farm visits are made to establish a friendly working relationship among the farmers, supply technical information on forestry practices and carry out observation/follow ups. Farmers visit NAF office mainly for the collection of seeds, training resource kit, publications and nursery materials. Frequent field visits to field and discussions with community members by NAF staff, volunteers and researchers were another important ways of information dissemination and source of inspiration.

Group approach has been the important means of communication and extension in NAF agroforestry program. Group meetings at various levels, such as quarterly meeting of farmer promoters, monthly meeting of agroforestry groups, and regular meetings between farmers' group and NAF extension worker, were organized at one of the demonstration farms to discuss problems, identify training needs, learn new skills, share experiences/results and to review and develop farm/forestry management plans. Training and follow up visits, method and result demonstrations, cross visits and study tours have been the other group activities and important tool to motivate farmers in agroforestry. According to farmers, cross visit program have been the most successful and effective to motivate and encourage farmers, particularly the women, to convince the adaptability of the species and systems practiced by fellow women farmers, form groups and start improved agroforestry practices.

10.2.5 Decision making criteria

Further clarifications were sought from the respondents on their decision-making criteria of choosing desired agroforestry species. It is of interest to know which factor(s) influenced farmers on making decision to include certain agroforestry species and practice (s) in their farmlands or not. For fruit trees, about one-thirds of the project farmers (29%) and half of the non-project farmers (47%) made decision on the basis of what other growers said about the species. About one-fourths of both project (23%) and non-project (28%) households decided on the basis of high yielding characteristics. About one-fifth (18%) of the project households decided on the basis of what NGO staff said about the beneficial aspects of certain species and their motivation to adopt. Asking with the fellow farmers was the main criteria for making fruit tree planting decisions to about 15% of the non-project farmers (Table 10.17).

Decision making criteria was slightly different in selecting fodder tree species. For the project households, it was the NGO staff (26%) who motivated to adopt particular species, followed by advice from fellow farmers (22%) who have adopted the particular species, and what other people in and outside the community say about the performances of species (17%). In case of non-project households, asking with the fellow farmers was the main decision criteria (42%) on fodder tree selection followed by what other people say about the species (17%) and motivation from NGO staff to adopt the particular species. In contrary to the fruit and fodder tree selection, the fuelwood and timber tree species were selected on the basis of farmers' own observation of the agroforestry practice for both project (27%) and non-project (28%) households. Likewise, motivation of NGO staff and high yielding characteristics of the species concerned were the important criteria in making decision on selection of grass species for both project and non-project households.

Table: 10.17 Respondent's criteria for making decision on selecting the desired species

Decision Criteria	With project (n = 82)				Without project (n = 141)			
	FRT	FOD	FWT	GR	FRT	FOD	FWT	GR
What others say about the sp.	24 (29)	14 (17)	02 (2)	00	66 (47)	24 (17)	04 (3)	03 (2)
Asked with fellow farmers	12 (15)	18 (22)	06 (7)	02 (2)	21 (15)	59 (42)	03 (2)	1(0.7)
After observing AF practices	08 (10)	07 (08)	22 (27)	02 (2)	05 (4)	09 (06)	40 (28)	03 (2)
NGO staff motivated to adopt	15 (18)	21 (26)	02 (2)	11 (14)	03 (2)	19 (13)	03 (2)	15 (11)
Species found in village nursery	06 (07)	03 (04)	04 (5)	02 (2)	06 (4)	06 (04)	08 (6)	14 (10)
High yielding improved species	19 (23)	04 (05)	02 (2)	09 (11)	40 (28)	13 (09)	13 (9)	05 (4)
Known species from cross visits	05 (06)	04 (05)	03 (4)	06 (7)	11 (8)	10 (07)	05 (4)	05 (4)
Others	03 (04)	06 (07)	10 (12)	03 (4)	08 (6)	15 (11)	19 (13)	03 (2)

Source: Field Survey, 1998
Figures in parentheses are percentages.

FRT = Fruit tree species; FOD = Fodder tree species;
FWT = Fuelwood tree species; GRS = Grass species

10.2.6 Gender and agroforestry decision making

The decision making process in the farm household is a complex process, and it is extremely difficult to pinpoint exactly which member has the most influence on a particular decision. The joint family system is still dominant in the study area. In the family, for many of the decisions, joint decision-making is the norm. But during the interview, both men and women respondents were found generally clever enough not to put either gender in awkward position by putting blame on one gender for taking lone decision for various activities. Usually male guardians make the decision for most activities, but for some activities women make the decisions (such as planting, weeding, livestock management etc.). The experience gained during the field survey indicated that the factual information regarding the decision making within the farm household are not easily obtainable from a questionnaire survey, if the proper care is not given while asking the questions to either of the genders. For instance, when a question, such as "Who made the decision on introducing improved agroforestry?" was asked, the answer was invariably the husband or the male head of the family. However, when they were probed for further details, it was revealed that in actual practice the women also exercised a great deal of influence. Great care was, therefore, taken while administrating the survey questionnaire on issues regarding the participation of gender in agroforestry. Although adult males are considered the main decision-maker in the household, other members of the household also provide inputs to the household decisions, particularly the wife of the household head. The male members of the household were found to be consulting with their wives before taking major decisions. This fact is reflected in the analysis that more than 50% of the respondents indicated that the decisions are made jointly by both genders (Table 10.18 and 10.19).

Decision making within the family is important because increased production and productivity is related to intra-household management and resource allocation decisions. Who makes the decision is thus important and can have policy significance. For example, the selection of crops, seeds and use of inputs (fertilizer, labor) has major effects on productivity. Who is implementing the farm household decision is also equally important. The bargaining literature on farm management and farming system has given scant attention to issues of gender influence on intra- household decision making. Women's control over decision making in the family is indeed an indicator of their socioeconomic status in the household, but it does not mean that their status has improved. Their increasing control over household resources also does not necessarily reflect their position in the society. Although, not profitable enough, farming is still an important basis for survival in the Hills. Discussions with women group members involved in agroforestry activities revealed that womens' involvement in household decision making in agricultural production has increased due to agroforestry interventions.

Women were found to exercise more influence on family income, crop production, tree farming and children work after their involvement in the project. However, women's control over cash earnings is still limited. The distribution of benefit in the household is another issue in gender relationships. In case of handling cash incomes, women reported that although their husbands usually hand over all the cash they receive, the use of cash income is largely under the control of their men. Women members revealed that whoever controls the cash income, in most cases the rational husbands always uses them for family welfare and most cases their wives are also consulted. However, wives are not allowed to spend by their own decision and they are required to take permission if they wish to do so. Women argued that they are just the keepers and guardians of the money, while their husbands are the masters of it because they are the household heads. Improvements in women's condition do not necessarily lead to improvement in their position.

10.2.7 Decision making from men's perspective

The gender responses on decision making for different activities are tabulated separately as role of gender on decision making needs to be studied with respect to both genders and not only focused on women as it is normally practiced in gender studies. According to men's response, in almost all operations directly related to crop production, such as planting, selection of species and seeds, weeding, fertilizer application, about half of decisions are made jointly by both genders (Table 10.18). However, in plant species and seed the participation of both genders was higher in project than in non-project situation. The Chi-square test showed that the difference was significantly different ($p<0.05$). It is often argued that male responses are biased towards their own involvement by saying that even women dominated activities are carried out jointly rather than solely by women. The results showed that response from both the genders are in agreement in most of the cases.

Table: 10.18 Decision making from men's perspective

Decision	With project (n =39)			Without project (n=97)		
	Women	Men	Both	Women	Men	Both
Planting field crops	13 (33.3)	06 (15.4)	20 (51.3)	29 (30.2)	25 (26.0)	42 (43.8)
Plant species/seed selection ##	11 (28.2)	6 (15.4)	22 (56.4)	28 (28.9)	37 (38.1)	32 (33.0)
Weeding time and number	12 (30.8)	5 (12.8)	22 (56.4)	22 (22.7)	27(27.8)	48 (49.5)
Fertilizer application	12 (30.8)	07 (17.9)	20 (51.3)	39 (40.2)	17 (17.5)	41 (42.3)
Harvesting, threshing and storing	03 (07.7)	14 (35.9)	22 (56.4)	09 (09.3)	29 (29.9)	59 (60.8)
Grain buying and selling	03 (07.7)	15 (38.5)	21 (53.8)	13 (13.4)	46 (47.4)	38 (39.2)
Agroforestry species introduction #	18 (46.1)	05 (12.8)	16 (41.0)	14 (14.4)	45 (46.4)	38 (39.2)
Animal buying, selling and price fixing	02 (05.1)	21 (53.8)	16 (41.0)	10 (10.3)	54 (55.7)	33 (34.0)
Fodder and fuel wood collection	22 (56.4)	1 (2.6)	16 (41.0)	56 (57.7)	08 (08.2)	33 (34.0)
Keeping a new breed and herd size	02 (05.1)	11 (28.2)	26 (66.7)	15 (15.5)	34 (35.0)	48 (49.5)
Fruit tree planting and species selection	14 (35.9)	10 (25.6)	15 (38.5)	17 (43.6)	42 (43.8)	37 (38.4)
Fodder/timber tree and shrub planting*	17 (43.6)	10 (25.6)	12 (30.8)	22 (23.4)	46 (48.9)	26 (27.7)
Nursery establishment and care **	19 (48.7)	03 (07.7)	17 (43.6)	31 (31.9)	26 (26.8)	40 (41.2)
Hiring labor for farm work	4 (10.2)	20 (51.3)	15 (38.5)	13 (13.4)	45 (46.4)	39 (40.2)
Rent in land or share cropping	20 (05.1)	14 (35.9)	23 (59.0)	05 (05.1)	45 (46.4)	47 (48.5)
Rent out own land	01 (2.6)	15 (38.5)	22 (56.4)	04 (04.1)	43 (44.3)	50 (51.6)
Buying and Selling the farm lands	02 (5.1)	17 (43.6)	20 (51.3)	02 (02.0)	51 (52.6)	44 (45.4)

Source: Field Survey, 1998
Figures in parentheses are percentages.
Frequencies or percentage not adding up to the total indicates no response from some respondents.
Chi-square test significant at 0.001 (p = 0.000; Pearson value = 20.446; df = 2)
Chi-square test significant at 0.05 (p = 0.015; Pearson value = 8.404; df =2)
* Chi-square test significant at 0.05 (p = 0.024; Pearson value = 7.444; df = 2)
** Chi-square test significant at 0.05 (p = 0.031; Pearson value = 6.927; df = 2)

Irrespective of the project situation, men's response revealed that in activities like nursery establishment and care, fruit tree planting and species selection, fodder and fuel wood collection, fodder/timber tree and shrub planting, and agroforestry species introduction women have greater role in decision making. Handling of forest resources, particularly for household needs, are not generally considered a male concern in the household. However, the decisions on livestock buying and selling, hiring labor for work, and buying and selling of farmlands, and food grain buying and selling, are made by men.

10.2.8 Decision making from women's perspective

Women's response was found to be in close agreement with men's response on various aspects (Table 10.19). The analysis clearly shows that women decision making in agroforestry related activities, such as nursery establishment and care, fodder/timber tree species selection and planting, and agroforestry species introduction, is higher among the project than non-project households. This is attributed to the NAF's efforts to increase women's decision-making role in the family. Since agroforestry activities are focused on women, their involvement is higher than men. NAF arranges study visit program to other agroforestry sites within and outside the district and training on nursery, propagation techniques, agroforestry management, for women members involved in agroforestry activities.

Table: 10.19 Decision making from women's perspective.

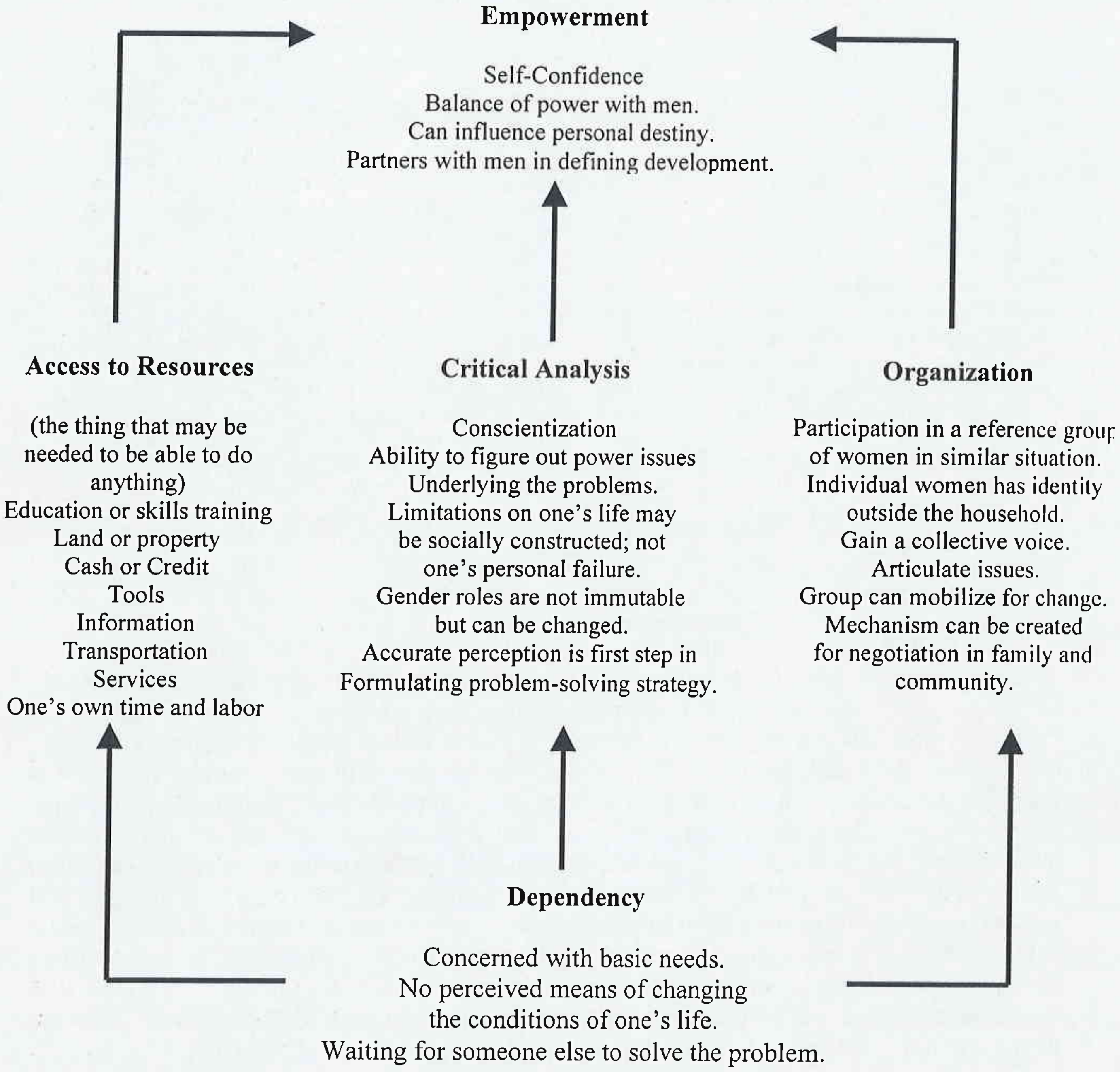
Decision making farm activities	With project (n =43)			Without project (n=44)		
	Women	Men	Both	Women	Men	Both
Planting field crops	12 (27.8)	11 (25.6)	20 (46.5)	14 (31.8)	09 (20.3)	21 (47.7)
Plant species/seed selection	17 (39.5)	12 (27.9)	14 (32.6)	14 (31.8)	13 (29.5)	17 (38.6)
Weeding time and number	14 (32.6)	07 (16.3)	22 (51.1)	13 (29.5)	06 (13.6)	25 (56.8)
Fertilizer application	20 (46.5)	05 (11.6)	18 (41.9)	22 (50.0)	03 (06.8)	19 (43.2)
Harvesting, threshing and storing	08 (18.6)	12 (27.9)	23 (53.5)	04 (09.1)	15 (34.1)	23 (52.3)
Grain buying and selling	10 (23.2)	19 (44.2)	14 (32.6)	10 (22.7)	16 (36.4)	18 (40.9)
Agroforestry species introduction	17 (39.5)	15 (34.9)	11 (25.6)	18 (40.9)	13 (29.5)	13 (29.5)
Animal buying, selling and price fixing	07 (16.3)	25 (58.1)	11 (25.6)	07 (15.9)	17 (38.6)	20 (45.4)
Fodder and fuel wood collection	29 (67.4)	04 (09.3)	10 (23.2)	27 (61.4)	04 (09.1)	13 (29.5)
Keeping a new breed and herd size	06 (14.0)	18 (41.9)	19 (44.2)	09 (20.3)	10 (22.7)	25 (56.8)
Fruit tree planting and species selection	16 (37.2)	11 (25.6)	16 (37.2)	13 (29.5)	18 (40.9)	13 (29.5)
Fodder/timber tree and shrub planting	21 (48.8)	08 (18.6)	14 (32.6)	15 (34.1)	14 (31.8)	15 (34.1)
Nursery establishment and care	22 (51.1)	08 (18.6)	13 (30.2)	16 (36.4)	06 (13.6)	22 (50.0)
Hiring labor for farm work	11 (25.6)	22 (51.1)	10 (23.2)	07 (15.9)	18 (40.9)	19 (43.2)
Rent in land or share cropping	03 (07.0)	18 (41.9)	22 (51.1)	05 (11.4)	13 (29.5)	26 (59.1)
Rent out own land	04 (09.3)	18 (41.9)	21 (48.8)	05 (11.4)	13 (29.5)	26 (59.1)
Buying and selling the farm lands	05 (11.6)	20 (46.5)	18 (41.9)	04 (09.1)	17 (38.6)	23 (52.3)

Source: Field Survey, 1998
Frequencies or percentages not adding up to the total indicate no response from some respondents.
Figures in parentheses are percentages

Interesting results on variations of opinion between men and women are obtained on decision making regarding renting in/out land and buying and selling farmlands. Although women's involvement in decision making regarding such activities are found to be nominal from the responses of both genders, women put themselves in better condition for decision making than their male response. This shows that the generally perceived and taken-it-for-granted traditional pattern of women's confinement to "internal affairs" and men's to "external domain" is seen changing in the project area. During discussions with women members, they also revealed that their role in decision making within the household has increased and they attributed that to NAF playing an important role in womens' empowerment. Any development intervention should therefore open important avenues to women to create and sustain gender balance. Critical assessment of women's' greater dependency on someone else to solve their own problems, finding out appropriate mechanisms to enhance their access to resources, increased role in household decision making through improved self-esteem and increased participation in local organizations will lead towards empowerment (Figure 10.1).

Women involved in agroforestry activities are pursuing cash earning activities and attending training, workshops and study tours. With the improved decision making power within the household, many women are taking up the role of making major decisions on issues, which are traditionally considered to be the men's domain in the society. During focus group discussion sessions conducted with NAF project households, men too agreed that their wives in

Figure 10.1 The Paths to Empowerment



Source: Adopted from Barbara Earth (2000), Gender and Development Studies, AIT recent years have learnt to decide on many activities particularly those related to the selection of agroforestry species, animals and crop.

The relationship between intra-household division of labor and decision making over the resources are important to sustainable agroforestry system. The issue of which gender should be included in the agroforestry training, demonstration and observation visit programs for particular activities concerned is important for successful implementation of the agroforestry program. The field survey and the previous experience showed that higher women's involvement in such activities always enhanced the promotion of agroforestry activities. The physical exhaustion due to the long working hours together with the duties of family crop production and the restrictions on once freely available resources has proved extremely stressful to rural households particularly to women. In recent years women's hardship increased due to restrictions on access to community forests which was used freely in the past. Although, women's authority is determined by their decision making power within the household and the extent of land available for planting, NAF field staff, key informants and farmers involved in agroforestry project revealed that women take up the agroforestry activities more seriously than men. This is because women have the sole responsibility of collecting fodder and fuelwood from the forest for household needs. They have to spend long hours to collect them from distance national forests as close by forests have been protected by community users. It is their immediate need and the hardship they face that makes them more serious at work. At the same time, men do not consider planting fodder trees as their priority and in many occasions they have been preventing their wives from planting trees in farmlands. It was observed that almost all the home nurseries in the study area were maintained and managed by women members. Therefore gender roles in planting of introduced species and its management decisions have impact on the promotion of agroforestry.

10.3 Role of institution in agroforestry promotion

NAF, being an outsider, implements agroforestry activities through local NGOs and farmers' groups. As a result, various groups have emerged ranging from women agroforestry group, saving credit group to local NGO. The role of local institutions, such as NGO, user groups, farmers associations and women groups, are considered crucial in natural resource management. The analysis presented in Table 10.20, indicates that in both project and non-project conditions, considerably higher percentages of the sample respondents (42%) have been involved in the local institutions of various types, such as NGO, farmers' group, community forestry user groups, saving credit groups and women groups. These institutions have been involved in promoting agroforestry with the technical and financial assistance from NAF. The analysis indicated that the participation of project respondents in various organizations was almost double (61%) compared to the non-project respondents (31%). The result further unveiled that the participation of women in the project group (33%) in women group was higher than in the non-project group (14%). However, the participation of women in other groups was distributed evenly between the project and non-project households. The results revealed that higher proportions of project respondents had membership in different types of local organizations than non-project ones. The project's spillover effect facilitated the emergence of local institutions, formation of women saving and credit groups and increased participation of users among the non-project households.

Table: 10.20 Respondents' involvement in local organizations by types of groups

Type of organization and groups	With project (n=82)		Without project (n=141)		Both (n =223)	
	f	f'	f	f'	f	f'
Local NGO	05	06	04	03	09	04
Farmers' Group	09	11	09	06	18	08
Forest users' group	05	06	06	04	11	05
Saving credit group	04	05	05	04	09	04
Women group	27	33	20	14	47	21
Total	50	61	44	31	94	42

Source: Household Survey, 1998

In overall, the participation of men in all kinds of users groups, committees and other local NGOs was always higher than that of women, as women due to their involvement in household chores have limited opportunities to participate in local organizations and developmental activities. The membership in organizations is an important attribute to promote adoption of agroforestry. Of all respondents who participated in local organization, the participation of men (52%) was slightly higher than that for women (48%) (Table 10.21). However, when total number of sampled respondents was considered separately by gender, considerably higher number of women respondents (52%) participated in the local organization than men (36%). This has become possible mainly due to greater emphasis given to the women on NAF agroforestry project activities.

Table: 10.21 Respondent's memberships in local organization by gender

Gender	Participated		Not participated	
	Number	%	Number	%
Women (n = 87)	45	48.0	42	33.0
Men (n = 136)	49	52.0	87	67.0
Total	94	100.0	129	100.0

Source: Household Survey, 1998

Besides respondents, the participation of other family members in local organization may also have an effect on the promotion of agroforestry. Fifty percent of the project respondents revealed that their family members had participated in the local organization while for the non-project households the participation of other family members in the local organization was found to be less than 30%. As mentioned earlier, considerably higher proportion of non-project households have shown interest to join local organizations to improve their socioeconomic condition. This is what they observed happening in project households and got motivated. The results showed that the proportion of other family members who participated in local organizations was almost similar for both women (37%) and men respondents (36%) (Table 10.22).

Table: 10.22 Family members' participation in local organizations

Participation	Participation by project		Participation by gender		
	With project	Without project	Women	Men	Both
Participated	41 (50)	40 (28)	32 (37)	49 (36)	81 (36)
Not participated	41 (50)	101 (72)	55 (63)	87 (64)	142 (64)
Total	82 (100)	141 (100)	87 (100)	136 (100)	223 (100)

Source: Household Survey, 1998

Figures in parentheses are percentages

10.4 Summary

The adoption of a new idea or practice is a complex process involving a series of mental activities. The characteristics of innovations are very important factors in adoption as farmers are most likely to adopt those agroforestry practices, which performs better than current practice. The improved practice should be relatively superior to the practice it is intended (traditional farming) to replace. Those innovations, whose results and advantages are readily visible to farmers, are more likely to be adopted. Most farmers adopt certain technology only after observing it practiced by their fellow farmers.

About one-third of the sample project households have adopted improved fodder tree species. Nearly the same equal proportions of project households have established fodder and fruit tree nurseries. For an overwhelming majority of farmers, scarcity of fodder was the main motivating factor to adopt fodder tree plantation. The closure of community forests or restrictions imposed on free access motivated farmers to opt for agroforestry. Almost all of the project and non-project farmers expressed their willingness to plant different agroforestry species in their farmlands. The lack of proper knowledge of improved and high yielding fruit tree species and their management was the most important constraint limiting agroforestry adoption. The majority of farmers believed that agroforestry-based farming is more profitable than field crop cultivation. Although, livestock raising was reported to be profitable, most farmers in both project and non-project group believed that the complete shifting from cereal crop cultivation to livestock production is not possible under the present farming system. Inadequate fodder and feed, higher incidence of animal diseases, and insufficient drinking water were the most frequently reported problems constraining livestock production.

Extension services are required to bring about substantial improvements in agroforestry. Service provided by extension workers were considered insufficient, particularly among the non-project households. Both males and females had attended training on agroforestry. Information dissemination is an important component of the agroforestry program. The majority of project farmers obtained information from local NGO and NAF, while non-project farmers obtained it mainly from neighbor/friend and relatives and local NGOs. The results indicated that the role of local groups and organizations in the dissemination of information was found to be very important under both project and non-project conditions. Neighbors, friends and relatives were still found to be very important source of information. Farmers obtained advice from different sources, which differed with the type of agroforestry species. Similarly, farmers received first time information on agroforestry from different sources. Motivation is an important tool to promote agroforestry. The results indicated that NAF, village NGOs, agroforestry group members and relative/friends/neighbors were the most important motivating agents for project households. While for the non-project households, family members, village NGOs, as well as relatives, friends/neighbors were main source of motivation to adopt agroforestry. Farmers choose different agroforestry species based on the different criteria, such as observation, availability of seedlings, experience of fellow farmers, NGO staff motivation, high yields of improved species. Among the project households, the decision on planting fodder trees on their farmlands was mainly based on recommendation from their fellow farmers.

As regards decision making within the family, more than 50% of the respondents indicated that decisions are usually made jointly by both sexes. However, men's response revealed that in activities like nursery establishment and care, fruit tree planting and species selection, fodder and fuelwood collection, fodder/timber tree and shrub planting and agroforestry species introduction women have greater role to play in decision making. Men usually make the decisions involving cash. Women's response was found to be in close agreement with men's response. Decision making powers of project women within family have increased than non-project women. The role of local NGOs, user groups, farmer associations and women groups are found to be very crucial in agroforestry development. The participation of women is higher in the project than the non-project group. Higher participation of women in project households was possible mainly due to greater emphasis given to women on NAF agroforestry activities.

Chapter XI

Socioeconomic and Institutional Factors Influencing the Adoption of agroforestry

Several technologies do not perform well in farmers' fields and so are not adopted by farmers, though they had performed better under the controlled conditions of research stations. Farmers' willingness to adopt agroforestry depends on many factors. Different socioeconomic and institutional factors constrain the adoption of improved technology. The technology development and dissemination need to be sensitive not only to the characteristics of the biophysical environments but also to the socioeconomic and institutional factors, which are often neglected or not taken care of. For any institutions or professionals involved in agroforestry promotion and want farmers to improve their condition by adoption, it is imperative to understand the important factors limiting the adoption.

11.1 Introduction

Hill farmers have traditionally practiced agroforestry in farmlands to maintain land productivity and to provide for household subsistence needs, such as fodder for livestock and fuel wood for cooking. However, the tree population maintained under traditional agroforestry has declined over the recent years for several reasons. These include diminution in landholdings due to continuous land fragmentation in successive generations, increased pressure on limited land to meet growing food requirements of the increasing population, and decline in fodder, fuel wood, and timber production in public and community forests due to widespread deforestation. The consequent decline in vegetative cover has increased soil erosion, lowered soil fertility, and reduced farm productivity in the hills of Nepal. This has raised serious concern over maintaining sustainability of land use and hence providing for the subsistence needs of the population in a sustainable basis. There is growing evidence that agroforestry can be a promising solution to these problems and hence it can be a key to achieving sustainability in the hill farming system.

The ability of traditional farming system to meet food demands of an increasing population on a sustained basis has decreased over time (Pandey et al., 1995, p. 43). Studies carried out in Nepalese hills have indicated a continuous decline in soil fertility due to soil erosion and depletion of organic matter. Average soil loss figure ranging from 18 to about 60 tons ha^{-1} yr^{-1} (detail discussed is presented in chapter VII) from the private farmlands have been reported in different watershed areas, which shows the severity of soil erosion problem. These estimations based on the universal soil loss equation, have not take into account the other factors, such as collapse of terraces risers during heavy monsoon rains, type of terraces and management practices adopted by farmers, governing the soil management in the hills. Soil erosion and excess removal of surface litter and crop residues from the farmlands are serious constraints to land management and to sustain agricultural production in the hills (CBS, 1998, p. 359; Schreier et al., 1995, p. 249). The decline in vegetative cover is considered to be the main factor contributing to rainfall-induced topsoil erosion. These problems are likely to be aggravated further unless timely and effective measures are undertaken (Jodha, 1995, p. 142).

There is growing evidence that agroforestry has promising potentials for reducing deforestation and related environmental problems, such as soil erosion and depletion of soil fertility, while increasing food, fodder, and fuel wood production (Benge, 1987; Caveness and Kurtz, 1993). Amatya and Newman (1993) discuss various agroforestry's potentials in the Nepalese context. It has been reported that the improvement in vegetative cover through agroforestry in terms of contour hedgerows and grass strips has substantially reduced soil loss in sloppy lands of Chiang Rai in Thailand (Syers, 1994). Likewise, live hedges of *leucaena* and *calliandra* have resulted in substantial reduction of soil loss in Rawanda (Roose and Ndayizigiye, 1997). As noted by Benge (1987), besides counteracting soil erosion, hegdegrows also provide fuel wood and fodder to the rural people. Significant reductions in nitrogen (N) and magnesium (Mg) losses from the soil through hedgerow integration have also been reported (Schroth et al., 1995). Furthermore, several studies have shown that improved agroforestry practices are more productive (Sanchez et al., 1997; Vonmaydell, 1991) and profitable compared to conventional practices over the long run (Kurtz et al., 1991). Combining useful trees and shrubs (Saxena, 1994) and bee keeping and trees (Hill and Webster, 1995) have been reported to increase economic benefits to farmers. By including multipurpose trees, for example mulberry for sericulture, fruits, and medicinal plants farmers can earn extra income through agroforestry.

Despite these potentials, the promotion of agroforestry has never been a priority issue in the national agricultural and forestry development plans for the country (Shah, 1996). In the past, no particular attention was ever directed toward agroforestry research and innovation, resulting in a lack of appropriate agroforestry technologies for farmers (Tamang, 1991; Carson, 1992; Shrestha and Katuwal, 1992). However, in recent years there has been growing concern over the importance of agroforestry to sustain the hill agriculture and some efforts are being made to promote agroforestry at the farm level. Improved agroforestry with and exotic fodder and grass species is still a relatively new practice to the hill farming system. In the past, farmers gave less or no priority to planting trees in their private lands due mainly to easy access to public forests for fodder, fuel wood and timber collection. Because of widespread deforestation and the transfer of community forests' ownership and management to users under the recent community forestry program, the access to such resources has been severely curtailed forcing farmers to seek alternatives. One of such alternatives is adoption of improved agroforestry in private farmlands.

It is possible to improve farm income to a considerable level through the adoption of improved agroforestry species, such as *Leucaena leucocephala, Calliandra calothyrsus, Gliricidia sepium, Cassia siamea, Flemingia congesta*, *Sesbania sesban, and Cajanus cajan* (ICRAF, 1992). However, developing and disseminating agroforestry as a viable alternative for farmers living under various biophysical and socioeconomic conditions has become a challenging constraint to promote agroforestry. Moreover, as noted by Raintree (1983), no agroforestry technology, regardless of its ecological and economical soundness, will have significant impacts on land management, production and income unless it is adopted by a significant proportion of farmers. Similar to any other new technologies, agroforestry adoption is a complicated process that may be influenced by a number of factors, such as socioeconomic characteristics of farmers, access to and level of resources, provision of extension, infrastructure and market, and other institutional factors. Farm level studies can elucidate key social and economic factors affecting farmer use and management of agroforestry practices and their effects on household resource base (Scherr, 1990, p. 3-12). Despite considerable research directed to the issues of technological adoption in agriculture,[1] except for a very few studies (e.g., Raintree, 1983; Evans, 1988; Caveness and Kurtz, 1993; Alavalapati et al., 1995) very little attention has been given to studying adoption of agroforestry technology, particularly in the Nepalese context. Therefore, there is limited empirical information why some farmers adopt agroforestry and others do not. Against this background, the impacts of various factors on agroforestry adoption by subsistence farm households in Nepal is analyzed, with a particular reference to an agroforestry project initiated by Nepal Agroforestry Foundation (NAF) in Kumpur, Nalang, Salang Village development Committee (VDC) areas of Dhading district.

Aiming to increase fodder production, NAF has been engaged in promoting agroforestry in Kumpur, Nalang, and Salang VDC areas of Dhading district since 1993/94. Households involved in the NAF project have planted improved fodder and grass species as part of a NAF promoted agroforestry program. Promoted species include ipil ipil (*Leucaena leucocephala* and *Leucaena diversifolia)*, calliandra (*Calliandra calothyrsus*), *bhatmase* (*Flemingia congesta)*, *kimbu* (*Morus alba*), gauzuma (*Gauzuma ulmiformis*), NB 21 (*Pennisetum sp.*), Napier (*Pennisetum purpureum*), and Stylo (*Stylosanthes guianensis*). Unlike typical agroforestry designs, such as alley cropping and strip cropping, fodder species in the study area are planted on terrace risers, edges of farmlands and fallow lands. However, trees/grasses planted on terrace risers and crops grown in terraces resemble the typical alley cropping. As recommended by NAF, trees are managed at breast height to minimize potential adverse effects on crop yields.

The NAF program has helped strengthen the capacity of local farmers to implement agroforestry program through the provision of technical know-how, materials support, extension and training. NAF also conducts on-farm trials and farmer-managed agroforestry demonstration plots. Interested farmers from selected communities are taken for study visits to farm trials and demonstration plots to provide them with an opportunity of actually seeing the adoption of improved agroforestry species and practices by fellow farmers with similar socioeconomic conditions. Such study visits to nearby villages and districts are arranged every year by NAF to create awareness of and build farmers' confidence in agroforestry. After such visits, interested farmers are organized into groups to start desired agroforestry practices and receive NAF support.

11.2 Sample characteristics

The sample households were analyzed by dividing into two categories depending upon the adoption of improved agroforestry, namely "adopters" and "non-adopters". The "adopter" households had adopted improved agroforestry practices that were introduced under the NAF project, while the "non-adopter" ones had not adopted improved agroforestry but continue to practice traditional agroforestry as a supplementary source of food, fodder, fuel-wood and timber by maintaining some naturally grown trees on their farmlands. Despite the NAF project, a sizable proportion (37%) of the sample households from the project villages had not adopted improved agroforestry. On the other hand, more than half (51%) of those from non-project areas had adopted agroforestry, i.e., through the process of demonstration effects generated by NAF activities and the adopters in the project area. The adoption of improved agroforestry practices was defined in terms of a dichotomous or binary variable. The variable was assigned 1 if the farmer had adopted agroforestry practices, and 0 otherwise, and then explained in terms of relevant variables using a logistic regression technique, to be described in the following section of this chapter.

Some key characteristics of "adopter" and "non-adopter" households are presented in Table 11.1. This information is not presented separately for project and non-project households as the differences between project and non-project households were very small. With respect to various socioeconomic characteristics (such as occupational status, landholding, household size and composition, and education level), on average, the "adopter" and "non-adopter" households were quite similar. However, "adopters" and "non-adopters" differed considerably in terms of livestock herd size and the number of improved fodder trees in their farm lands. For example, the average livestock herd size in terms of livestock units (LSUs) was 4.7 for "adoptors" and 3.7 for "non-adoptors". This difference was significant at the 0.01 level. Similarly, the number of improved fodder trees (such as *kimbu* - *Morus alba*, ipil ipil - *Leucaena leucocephala* and *Leucaena diversifolia*, calliandra - *Calliandra calothyrsus*, *bhatmase* - *Flemingia congesta*, and gauzuma - *Gauzuma ulmiformis*) averaged 228 for "adopters" and 71 for "non-adoptors". This difference was significant at the 0.05 level. Except for a relatively higher proportion of Brahmins/Chhetries among "adopters" and higher proportion of Magars/Ghartis among "non-adopters", the two groups of households had similar ethnic composition (Table 11.1).

11.3 Conceptual framework and model specification

11.3.1 Conceptual framework

Following Rogers (1983), agroforestry adoption can be described as a mental process, commonly knows as the innovation-decision process, farmers go through a stage of being aware or knowledgeable of a new agroforestry technology, to forming positive or negative attitude towards agroforestry, and ultimately to deciding whether to adopt the technology or not. This process can be influenced by wide variety of factors, including households (socioeconomic, resource-base, and outside contacts), community (access to extension, education, market, infrastructure, etc., and ecological factors), and institutional factors (extension services, training, material support, etc. through government and national/local NGOs).

Table11.1: Key characteristics of "adopter" and "non-adopter" households

Characteristics	Adopters	Non-adopters	Both
Population engaged in agriculture (%)	93	91	92
Land holding			
Average total farm size (ha)	0.81	0.73	0.77
Average lowland farm size (ha)	0.21	0.19	0.20
Average upland farm size (ha)	0.60	0.54	0.57
Household size and composition			
Average household size	6.7	6.3	6.5
Children below 5 years of age	0.96	0.99	0.97
Children aged between 5-10 years	0.94	0.96	0.95
Males aged between 10-59 years	2.30	2.10	2.20
Females aged between 10-59 years	2.10	2.00	2.06
Adults aged 60 years and above	0.40	0.33	0.37
Mean education			
Male (years)	3.1	3.1	3.1
Female (years)	1.5	1.3	1.4
Mean livestock herd size (LSUs)	4.7	3.7	4.2
Average number of improved fodder trees	228	71	159
Ethnicity: (%)			
Brahmin/ Chhetri (B/C)	29	22	26
Magar/Gurung (M/G)	29	41	34
Majhi/Tamang/Ghale (M/T/G)	17	13	15
Newar/Banda (N/B)	17	16	17
Other castes (Sarki/Kami/Damai)	8	8	8

Figure 11.1 provides a simple schematic framework for studying adoption of agroforestry at the farm level for farmers involved in this study. This framework has been widely applied to investigate the adoption pattern of various agricultural technologies, especially the adoption of high yielding cereal varieties and related practices (Feder et al, 1985). Raintree (1983), Evans (1988) Caveness and Kurtz (1993), and Alavalapati et al. (1995) have applied similar framework for studying adoption of agroforestry. The framework provided in Figure 11.1 forms the basis for selecting relevant variables influencing agroforestry adoption.

Previous empirical and theoretical studies indicate that the adoption pattern of new technologies by farmers can be characterized fairly well in terms of the logistic function (Feder and O'Mara, 1982; Jarvis, 1981; Rogers, 1983). Accordingly, when a new technology is first introduced, adoption is slow. Through the process of 'demonstration effects' of the early adopters, information, knowledge, and experience of new technology spread to other potential adopters and the rate of adoption increases. This process will continue until all of the potential adopters are exposed to and adopt the new technology. Given that improved agroforestry practices were introduced in 1993/1994, and the data were collected in 1998, perhaps most "adopters" were still early adopters and lied on the lower end of the logistic curve.

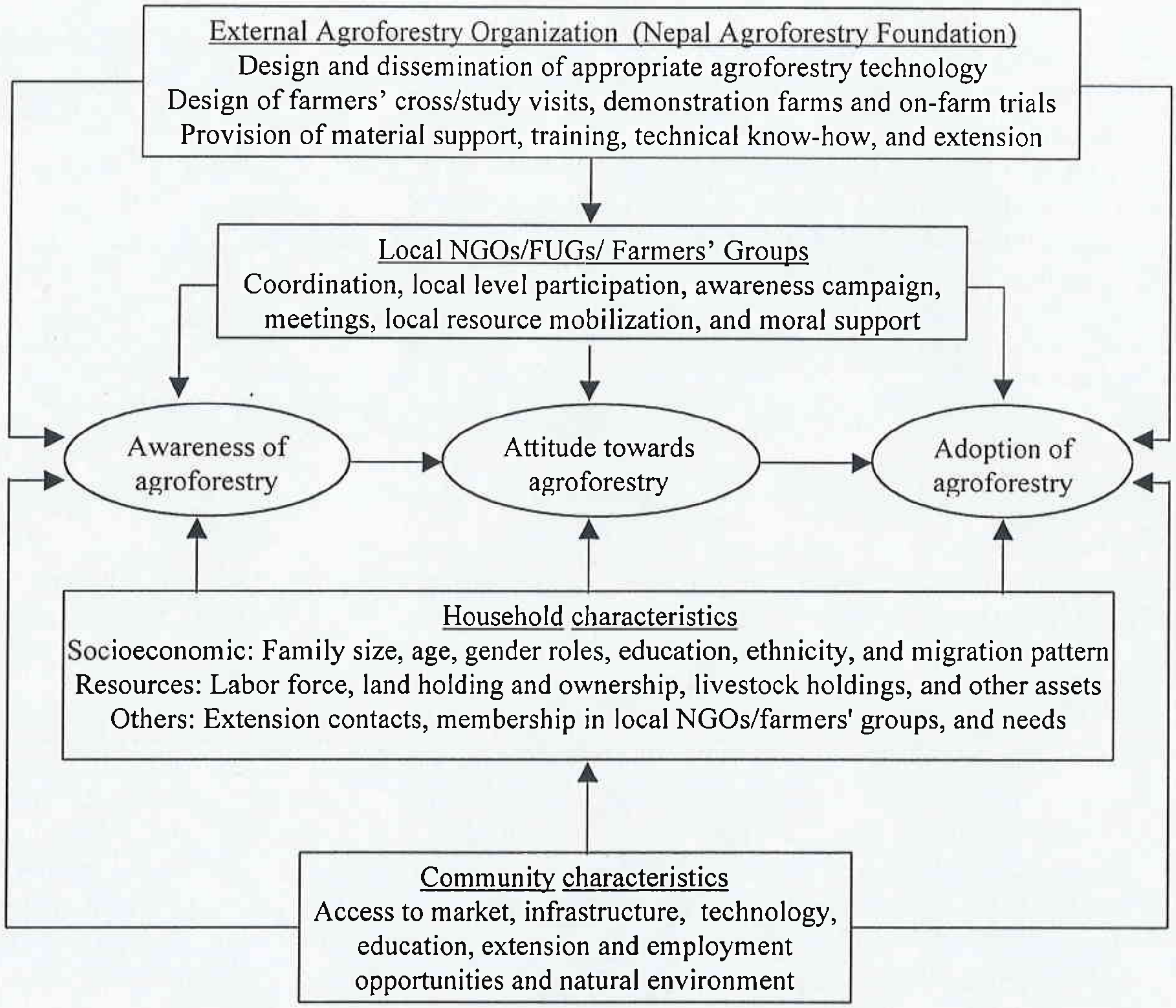


Figure 11.1. Agroforestry adoption framework

For empirical analysis it is important to define adoption in terms of an appropriate quantitative measure. For farm-level adoption analysis, adoption is usually defined either in terms of a dichotomous (use/no use) or a continuous (such as the amount of land under new technology, the quantity of input used, and so on) variable depending upon the nature of technology under consideration and study objectives. For the purpose of this paper, adoption is defined in terms of a dichotomous or binary variable. The variable was assigned 1 if the farmer had adopted improved agroforestry practices, and 0 otherwise. For longitudinal analysis a continuous measure (e.g., the number of improved fodder trees/ha) would perhaps be a more appropriate measure to use.

11.3.2 Model specification

Logistic regression is a popular statistical technique in which the probability of a dichotomous outcome (such as adoption or non-adoption) is related to a set of explanatory variables that are hypothesized to influence the outcome.[2] The logistic regression model characterizing agroforestry adoption by the sample households is specified as follows:[3]

$$\mathrm{Ln}[P_i/(1-P_i)] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots + \beta_k X_{ki}$$

where subscript i denotes the i-th observation in the sample, P is the probability of the outcome, β_0 is the intercept term, and β_1, β_2, ..., β_k are the coefficients associated with each explanatory variable X_1, X_2, ..., X_k. It should be noted that the estimated coefficients do not directly indicate the effect of change in the corresponding explanatory variables on probability (P) of the outcome occurring. Rather the coefficients reflect the effect of individual explanatory variables on its log of odds $\{\mathrm{Ln}[P/(1-P)]\}$. The positive coefficient means that the log of odds increases as the corresponding independent variable increases. However, it is possible to interpret the coefficients in terms of odds $[P/(1-P)]$ or probability (P) of the outcome by observing the relationship between P, $[P/(1-P)]$, and $\mathrm{Ln}[P/(1-P)]$. It can be shown that $[P/(1-P)]$ is a monotonically increasing function of P and $\mathrm{Ln}[P/(1-P)]$ is a monotonically increasing function of $[P/(1-P)]$.[4] Consequently, if the log of odds $\{\mathrm{Ln}[P/(1-P)]\}$ is positively (negatively) related to an independent variable, both odds $\{[P/(1-P)]\}$ and probability (P) of the outcome are also positively (negatively) related to that variable. Only difference is that this relationship is linear for the log of odds and nonlinear for odds and probability of the outcome. The coefficients in the logistic regression are estimated using the maximum likelihood estimation method.

11.3.2.1 Mathematical details of logistic regression

Logistic regression model is derived as follows

$$P_i = \mathrm{Prob}(Y_i = 1) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_{1i}+\ldots\ldots+\beta_k X_{ki})}} = \frac{e^{(\beta_0+\beta_1 X_{1i}+\ldots\ldots+\beta_k X_{ki})}}{1+e^{(\beta_0+\beta_1 X_{1i}+\ldots\ldots+\beta_k X_{ki})}} \qquad \text{(i)}$$

Similarly,

$$\Pr ob(Y_i = 0) = 1 - \Pr ob(Y_i = 1) = \frac{1}{1 + e^{(\beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki})}} \quad \text{(ii)}$$

Dividing (i) by (ii) we get

$$\frac{\Pr ob(Y_i = 1)}{\Pr ob(Y_i = 0)} = \frac{P_i}{1 - P_i} = e^{(\beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki})} \quad \text{(iii)}$$

where P_i is the probability that Y_i takes the value 1 and then $(1-P_i)$ is the probability that Y_i is 0 and e the exponential constant.

Now taking natural log in both sides of equation (iii) we get

$$\text{Ln}[P_i/(1-P_i)] = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki} \quad \text{(iv)}$$

Holding the rest of the variables constant, odds $\{P/(1-P)\}$ and probability (P) of the outcome given the k-th independent variable is equal to e^{B_k} and $1/(1+e^{-\beta_k})$, respectively. Hence,

$\beta_k = 0 \Rightarrow$ odds = 1 and probability (P) = 0.5,

$\beta_k > 0 \Rightarrow$ odds > 1 and probability (P) > 0.5, and (v)

$\beta_k < 0 \Rightarrow$ odds < 1 and probability (P) < 0.5.

11.3.2.2 Explanatory Variables

As discussed in the conceptual model, the adoption of agroforestry in the study area, is influenced by number of variables ranging from the community, household, and farmers' individual characteristics to perception, awareness, institutional factors and external intervening organization. The name and description of the explanatory X-variables involved in the logistic regression model for agroforestry's adoption are defined in Table 11.2.

Table 11.2: Description of explanatory variables used in the agroforestry adoption model

Variable name	Description
Kumpur (X_1)	Value 1 if the household is from Kumpur village, 0 otherwise[a]
Nalang (X_2)	Value 1 if the household is from Nalang village, 0 otherwise[a]
Brahmin (X_3)	Value 1 if ethnicity is 'Brahmin' or 'Chhetri', 0 otherwise[b]
Maghtagu (X_4)	Value 1 if ethnicity is 'Magar', 'Majhi', 'Tamang', 'Gurung', and 'Ghale', 0 otherwise[b]
Child: < 5 (X_5)	No of children (male + female) aged below 5 years
Child: 5-10 (X_6)	No of children (male + female) aged 5-10 years
Male: 10-59 (X_7)	No of males aged 10-59 years
Female: 10-59 (X_8)	No. of females aged 10-59 years
Old: > 59 (X_9)	No of old people (male + female) aged 60 years and older
Maledu (X_{10})	Male education (years)
Femedu (X_{11})	Female education (years)
Malmemb (X_{12})	Value 1 if at least one male has membership in local NGO, 0 otherwise
Femmemb (X_{13})	Value 1 if at least one female has membership in local NGO, 0 otherwise
Age (X_{14})	Respondent's age (years)
Sex (X_{15})	Value 1 if the respondent is male, 0 otherwise
Lowland (X_{16})	Amount of lowland (ropanies)
Upland (X_{17})	Amount of upland (ropanies)
Tenant (X_{18})	Value 1 if the farmer is tenant-operated, 0 otherwise
Livestock (X_{19})	Number of livestock units
Extension (X_{20})	Index for extension visits, training, and field visits
Perception (X_{21})	Index for farmer's perception toward agroforestry
Migration (X_{22})	Value 1 if a family member has migrated out for at least two months , 0 otherwise

[a]Salang village is treated as the reference village.
[b]Other ethnic group, including 'Newar', 'Banda', 'Sarki', 'Kami', and 'Damai' is the reference group.

Most variables used in the agroforestry adoption model are self-explanatory except for extension (X_{20}) and perception towards agroforestry (X_{21}). Multiple variables that were used to gather information on agroforestry extension, such as number of visits made by extension worker, study visits of farmers to the demonstration farm and number of training attended by farmers are combined to compute an overall extension index. For explanation on the computation of extension index (X_{20}), the details are given in Table 11.3. The analysis presented in the extension index computation table shows that majority of farmers from project household have attended the agroforestry training, while considerable portion of non-project household members had also attended the training.

Table 11.3: Computation of extension index (Extension)[a]

Items included	Project households		Non-project households	
	Mean	Percent[b]	Mean	Percent[b]
No. of agroforestry nursery training (AFNTR)	1.30	72.0	0.60	28.4
No. of agroforestry management training (AFMTR)	1.00	39.0	0.23	12.8
No. of visits by extension workers to the farm (VEWF)	1.50	39.0	0.48	13.5
No. of cross visits made by the farmer (CVF)	0.78	25.6	0.07	6.4
No. of farmer's visits to extension office (FVEO)	0.26	14.6	0.08	4.3

[a] Extension = AFNTR + AFMTR + VEWF + CVF + FVEO
[b]Percentages of households that had taken at least one training or had at least one extension contact.

Agroforestry perception index (X_{21}) used in the adoption model, was obtained from the information on farmers perception towards agroforestry. Farmers were administrated the total of 12 statements regarding the important aspects of agroforestry (6 positive statements and 6 negative statements). The percentage of respondent's perception on the each statement and the subsequent computation of agroforestry perception index is presented in Table 11.4.

Table 11.4: Computation of agroforestry perception index (Perception) (Percent of respondents)

Perception	Project households			Non-project households		
	Agree	Dis-agree	Do not know	Agree	Dis-agree	Do not know
Positive perceptions towards agroforestry						
1. Has economic benefits (PPCEPT1)	96.3	1.2	2.4	87.9	7.1	5.0
2. Provides natural beauty (PPCEPT2)	97.6	2.4	0.0	93.6	0.0	6.4
3. Reduces soil erosion (PPCEPT3)	96.3	0.0	3.7	85.8	5.0	9.2
4. Improves soil fertility and productivity (PPCEPT4)	35.4	57.3	7.3	27.7	56.0	16.3
5. Increases crop yields (PPCEPT5)	18.3	65.9	15.9	15.6	66.0	18.4
6. Improves livestock productivity (PPCEPT6)	87.8	9.8	2.4	85.8	7.8	6.4
Negative perceptions towards agroforestry						
1. Hampers tillage operations (NPCEPT1)	73.2	20.7	6.1	82.3	12.8	5.0
2. Not needed because fodder, fuelwood and grasses are found abundant in the forest (NPCEPT2)	32.9	62.4	4.9	36.9	50.4	12.8
3. Benefits are realized after a long time period (NPCEPT3)	85.4	11.0	3.7	79.4	12.8	7.8
4. Reduces area for cereal crop production (NPCEPT4)	73.2	13.4	13.4	74.5	32.0	3.5
5. Reduces crop yields due to competition for growth factors (NPCEPT5)	92.7	6.1	1.2	93.6	6.4	0.0
6. Harbors crop insects and pests and reduces yields(NPCEPT6)	70.7	13.4	15.9	68.1	13.5	18.4

As shown in the above table, the respondents' perceptions to each statement about agroforestry were recorded as either they "Agree", "Disagree" or "Do not know". These were converted to an index by assigning numerical value of 1, −1 and 0 for "Agree", "Disagree", and "Do not know" responses respectively, for positive statements. For negative statements, the numerical value of −1, 1 and 0 were assigned for "Agree", "Disagree", and "Do not know" responses, respectively. Then the agroforestry perception index was derived as follows:

Perception = Positive perception + Negative perception

where Perception = Agroforestry perception index,
Positive perception = Agroforestry positive perception index = $\sum_{j=1}^{6} PPCEPT_j$, and
Negative perception = Agroforestry negative perception index = $\sum_{j=1}^{6} NPCEPT_j$.

The summary statistics for the explanatory variables involved in estimating the agroforestry adoption model are presented in Table 11.5.

Table 11.5: Descriptive statistics for the explanatory variables involved in estimating the agroforestry adoption model

Variable name	Project households (n = 82)		Non-project households (n = 141)	
	Mean	Std. error	Mean	Std. error
Kumpur	0.37	0.05	0.36	0.04
Nalang	0.33	0.05	0.28	0.04
Brahmin	0.38	0.05	0.19	0.03
Maghtagu	0.52	0.06	0.48	0.04
Child: < 5	0.83	0.10	1.06	0.09
Child: 5−10	0.93	0.10	0.96	0.08
Male: 10−59	2.24	0.15	2.18	0.11
Female: 10−59	1.89	0.11	2.16	0.11
Old: > 59	0.33	0.07	0.40	0.06
Maledu	3.54	0.31	2.83	0.23
Femedu	1.69	0.18	1.23	0.14
Malmemb	0.18	0.04	0.12	0.03
Femmemb	0.39	0.05	0.17	0.03
Age	38.50	1.35	41.61	1.06
Sex	0.48	0.06	0.69	0.04
Lowland	4.70	0.50	3.48	0.36
Upland	9.01	0.74	12.72	0.64
Tenant	0.15	0.04	0.06	0.02
Livestock	4.42	0.27	4.15	0.20
Extension	4.84	0.76	1.46	0.26
Perception	−0.06	0.28	−0.62	0.25
Migration	0.29	0.05	0.38	0.04

Among the explanatory variables used (Table 11.2), the first two are dummy variables accounting for various community factors affecting agroforestry adoption. The next two are also dummy variables representing household ethnicity, which is also hypothesized to influence agroforestry adoption through its effects on farmer's values, beliefs, and socioeconomic status. Unlike previous studies, household labor availability is broken down to several components in terms of age and sex of the household members in order to examine possible gender roles in agroforestry adoption. The roles of education and membership to local NGOs have also been analyzed in terms of gender. In view of potentially different patterns of agroforestry adoption between upland and lowland, the amounts of upland and lowland are considered separately instead of using an aggregate landholding as in previous studies on adoption of other agricultural technologies. Since the primary objective of NAF agroforestry project was to increase fodder production, livestock population is included to examine its effect on agroforestry adoption and in turn agroforestry's role in livestock productivity.

11.4 Results and discussion

Maximum likelihood estimates of parameters in the logistic regression models characterizing agroforestry adoption behavior of project and non-project households are presented in Table 11.6. Also presented in Table 4 are the effects of independent variables on odds and probability of agroforestry adoption. The log-likelihood ratio (LR) tests showed that for both project and non-project households the estimated models, including a constant and the set of explanatory variables, fit the data better compared to those containing the constant only. In other words, there was a significant relationship between the log of odds and hence odds and probability of adoption of improved agroforestry practices and the explanatory variables included in the model, suggesting that these variables contribute significantly as a group to the explanation of agroforestry adoption behavior of the sample farmers, although several coefficients were not significant individually. The R^2 values and percentages of correct predictions also suggested that the estimated adoption models had a fairly good explanatory power, especially the one for the project households (Table 11.6). Overall, the majority of the variables had expected signs and those with unexpected signs were mostly insignificant. For several variables, the estimated coefficients differed between project and non-project households both in terms of sign and significance. These differences will be discussed next. Of explanatory variables, only livestock population and male membership in a local NGO had a consistently positive and significant effect on agroforestry adoption by both project and non-project households.

For the project households, the number of females aged between 10-59 years, male membership in a local NGO, female education level, sex of the head of the household, the amount of lowland, livestock population, and extension, farmer's perception toward agroforestry, and migration of household member were positively associated with the log of odds of adoption of agroforestry, suggesting that these variables were positively associated with agroforestry adoption. Note that, after controlling the effects of other variables, effect of each of these variables on odds of agroforestry adoption is greater than one and in probability terms the effect is more than 50%. Of these variables, the coefficient for livestock population was most significant (P value < 0.01), followed by male membership in a local NGO (P < 0.05), and female education and perception about agroforestry (P < 0.10). Thus, the number of livestock kept by the households was found to be the most important determinant of agroforestry adoption.

Table11.6: Maximum likelihood estimates of the agroforestry adoption model

Variable	Project households (n = 82)				Non-project households (n = 141)			
	β	T-ratio	Exp(β)	Prob (P)	β	T-ratio	Exp(β)	Prob (P)
Kumpur	0.980	0.72	2.666	0.727	1.320**	2.27	3.743	0.789
Nalang	-1.279	-0.87	0.278	0.218	1.730***	2.86	5.639	0.849
Brahmin	-1.430	-1.14	0.239	0.193	-0.489	-0.57	0.613	0.380
Maghtagu	-1.567	-1.12	0.209	0.173	-0.215	-0.37	0.806	0.446
Child: < 5	-1.392*	-1.91	0.249	0.199	0.169	0.74	1.184	0.542
Child: 5-10	-0.180	-0.45	0.836	0.455	0.050	0.21	1.051	0.512
Male: 10-59	-0.921**	-2.05	0.398	0.285	0.033	0.16	1.033	0.508
Female: 10-59	0.502	0.96	1.652	0.623	-0.243	-1.11	0.784	0.439
Old: > 59	-0.293	-0.40	0.746	0.427	-0.163	-0.48	0.849	0.459
Maledu	-0.398*	-1.92	0.671	0.402	-0.133	-1.30	0.876	0.467
Femedu	0.530*	1.86	1.699	0.629	-0.043	-0.25	0.958	0.489
Malmemb	6.308**	2.21	548.672	0.998	1.570**	2.06	4.806	0.828
Femmemb	-1.470*	-1.77	0.230	0.187	0.355	0.61	1.426	0.588
Age	-0.082*	-1.80	0.921	0.479	0.023	1.28	1.024	0.506
Sex	0.368	0.40	1.444	0.591	-1.086**	-2.13	0.338	0.252
Lowland	0.068	0.72	1.071	0.517	-0.110	-1.63	0.896	0.473
Upland	-0.089	-1.09	0.915	0.478	0.024	0.71	1.024	0.506
Tenant	0.966	0.99	2.628	0.724	-1.354	-1.34	0.258	0.205
Livestock	1.059***	3.08	2.885	0.743	0.361**	2.44	1.434	0.589
Extension	0.042	0.65	1.043	0.511	-0.023	-0.33	0.978	0.494
Perception	0.305*	1.64	1.356	0.576	0.014	0.17	1.014	0.504
Migration	1.543	1.30	4.678	0.824	0.174	0.38	1.190	0.543
Constant	3.698	1.38			-1.792	-1.61		
Maddala R^2	0.434				0.241			
McFadden R^2	0.433				0.198			
LR test[a]	46.73***				38.78**			
No. of correct predictions	70 (85%)				105 (74%)			

[a]Likelihood ratio (LR) test is used to test the null hypothesis that there is no relationship between the log of odds of adoption of improved agroforestry practices and the set of independent variables included in the model (i.e., $H_0 : \beta_1 = \beta_2 = ... = \beta_{23} = 0$). ***, **, and * denotes 0.01, 0.05, and 0.10 levels of significance.

This finding is consistent with NAF's focus on the promotion of fodder trees and grasses in its activities as farmers with higher number of livestock are severely constrained by the shortage of fodder and hence are more likely to adopt the practice. Similarly, the male membership in local NGO may be associated with increased awareness of agroforestry benefits through better access to technical know-how, extension, and training provided by NAF. Educational programs for women could have a positive influence in agroforestry adoption.

Most of the dummy variables associated with VDCs and ethnicity and variables representing household size and composition had negative impacts on the log of odds of agroforestry adoption by project households. Note that, as shown in Appendix A, the effect of each of these variables on odds of agroforestry adoption is less than one and in terms of probability terms less than 50%. Compared to households from Salang VDC, the households from Kumpur were more likely to adopt and those from Nalang VDC were less likely to adopt agroforestry. Likewise, compared to occupational ethnic groups (such as "Newar," "Banda," "Sarki," "Damai," and "Kami") other ethnic groups were less likely to adopt improved agroforestry practices. However, none of these differences were significant at the 0.10 level. Demographic characteristics such as number of children below 5 years, number of males aged 10-59 years, male education, female's NGO membership, and respondents' age had a significantly negative influence on the farmers' decision to adopt agroforestry. While the number of females aged 10-59 years in the family had, although not significant, a positive effect on agroforestry, the number of males aged between 10-59 years had a negative effect. Similarly, unlike the female's educational level, the male's education was negatively associated with agroforestry adoption. These findings are quite expected given the fact that males are likely to out-migrate in search of employment while females are mostly engaged in household and farming activities, including agroforestry. Likewise, compared to educated males educated females are more likely to stay within the village and are likely to contribute more to the adoption of improved technologies. If there are small children in the family, females will have to spend more time in child care and other household production activities and less time in farming activities such as agroforestry. The female membership in the local NGO was negatively associated with agroforestry adoption. This may perhaps be due to the involvement of female NGOs more in non-agricultural activities (such as family planning, health and nutrition) than in farming activities. Moreover, even if females were members in NGOs involved in agroforestry, in the Nepalese context they usually have little influence in the household decision-making process. Consistent with adoption literature, the adoption of agroforestry was negatively associated with the age of the respondent or household head. Older people are generally believed to be more risk averse toward a new technology.

In case of non-project households, farmers from Kumpur and Nalang were more likely to agroforestry than those from Salang and ethnicity had the similar effect on agroforestry adoption as project households. In contrary to project households, the number of females aged 10-59 years had a negative impact on agroforestry adoption, while number of males aged 10-59 years had a positive impact. However, both of these coefficients were not significant at the 0.10 level. Both male and female education years were negatively related to agroforestry adoption, while their membership in the local NGO was positively associated. Only the coefficient associated with male membership was significant at the 0.05 level. This is because local NGOs, community forestry user groups and farmers groups are dominated by men and they are the principal decision makers in the household. Amount of upland was found to be a positive determinant in agroforestry adoption, while lowland affected negatively. This is also expected as farmers under traditional farming condition are more reluctant to plant fodder trees in the lowland because of their perception that trees reduce crop yields. However, it is customary to plant trees in upland to fulfill the subsistence requirements of fodder for livestock and fuelwood for cooking. Although migration and positive perception of agroforestry had positive influence in adoption, the extension was not contributing to the adoption. This was not unexpected that even though farmers had frequent contacts with extension worker they may not have received necessary information and support for agroforestry as most of government extension workers are not knowledgeable in agroforestry and hence not able to deliver the technology and practices suitable for farmers. More importantly, extension department has not given any attention towards agroforestry in their extension program. They are more concerned with cereal crops. Unlike project households, the probability of agroforestry adoption by non-project households was positively associated the respondent's age and female-headed households were more likely to follow agroforestry.

11.5 Summary

Traditionally maintained agroforestry in the hills has declined due to growing requirements of the increasing population, widespread deforestation resulting in decline in vegetative cover, increased soil erosion and reduced productivity. Agroforestry has been recognized as promising remedial measures to overcome such problems. Despite its potentials, agroforestry has never been a priority issue in the government planning but concern over its importance is growing particularly owing to restricted accessibility to forests after the transfer of community forests' ownership and management to users. But developing and disseminating agroforestry as a viable alternative to hill farmers has become a challenging constraint for promotion. Because like any other technologies, adoption of agroforestry is a complicated process influenced by number of factors ranging from socioeconomic characteristics of farmers, access to land, provision of extension, market to institutional factors. In this regard, NAF promoted ipil-ipil, calliandra, bhatmase, kimbu, and gauzuma fodder trees and NB 21, napier and stylo grass species and developed farmer managed agroforestry demonstration plots for its wider adoption through provision of technical know-how, extension, training and support services.

Despite NAF project, a sizable proportion (37%) of the sample household from the project had not adopted improved agroforestry while 51% of the non-project household had adopted. This is mainly due to the demonstration effect generated by NAF activities and project's spill over effects. The logistic regression analysis was undertaken to explain the agroforestry adoption. The variable was assigned 1 if the farmer had adopted agroforestry practices and 0 otherwise. The differences between project and non-project households with respect to socioeconomic characteristics were very small. The adopters and non-adopters differed considerably in terms of livestock herd size and the number of improved fodder trees in their farm land. The agroforestry adoption framework shows that farmers go through a stage of being aware or knowledgeable of a new agroforestry technology, to forming positive or negative attitude towards agroforestry and ultimately making decision whether to adopt the technology or not. The process can be influenced by a wide variety of factors including household, community and institutional factors. Through the spill over effect, the information, knowledge of a new technology spread to other potential adopters and rate of adoption increases.

The logistic regression, a popular statistical technique for dichotomous outcome, is related to a set of explanatory variables that are hypothesized to influence the outcome. The coefficients in the logistic regression are estimated using the maximum likelihood estimation method. The log-likelihood ratio (LR) tests showed that both project and non-project households the estimated models, including a constant and the set of explanatory variables, fit the data better compared to those containing the constant only. The R^2 values suggested that the estimated adoption models had a fairly good explanatory power. Of the explanatory variables, only livestock population and male membership in a local NGO had a consistently positive and significant effect on agroforestry adoption by project and non-project households. For the project households, the number of females aged between 10-59, male membership in a local NGO, female education level, the amount of low land, livestock population, extension and farmers perception toward agroforestry were positively associated with the log of odds of adoption of agroforestry. The coefficient for livestock population was most significant ($p<0.01$), followed by male membership in a local NGO ($p<0.05$) and female education and perception about agroforestry ($p<0.10$). In case of non-project households, male aged 10-59 years, both male and female membership in a local NGO, amount of upland, migration and positive perception of agroforestry had positive influence in adoption. The findings that livestock to be the most important determinant of agroforestry adoption is consistent with NAF focus on the promotion of fodder trees and grasses.

Notes

1.See Feder et al. (1985) for a survey of literature on adoption of technological innovation in developing agriculture.
2. Another method when the dependent variable is a binary variable is the probit regression model. Unlike the linear probability model, the predicted probabilities under both logistic and probit approaches always lie between 0 and 1. Since both approaches are known to yield similar results, logistic approach is used in this analysis.
3. The underlying mathematical details for the logistic model are presented in the above section on Mathematical details of logistic regression.
4. See Rotherford and Choe (1993) for further explanation.

Chapter XII

Strategies for Agroforestry Promotion

This study provides consolidated evidence of agroforstry's contribution to subsistence hill agriculture in a context of small and fragmented land holdings, poor soil fertility, difficult accessibility and poor extension and support services. The next step entails the formulation of area specific, economically viable, environmentally sound and socially acceptable agroforestry promotion strategies and planning framework. However, designing of realistic strategies and their effective implementation is a challenging task. This requires analysis of the nature of the problems, land capability and locational development potential to harness the comparative advantage of the area. At the outset of developing any strategies, its goal and objectives should be clear and precise. From the perspective of this research study, the promotion of agroforestry in the hills is its goal. This can be achieved by setting the objectives of bringing improvements in farmers' participation in agroforestry promotion, on-farm research, effective extension and service delivery mechanism through tri-partriate partnership between local users, governmental, and non-governmental organizations.

The majorities of hill farmers have been engaged in subsistence farming system and have not been able to extricate themselves from this system. The strategies should aim to bring substantial improvement in attitudinal, behavioral and occupational changes through better planning. Planners, policymakers and project implementers face enormous challenges to bring transformation in the existing system to fulfill subsistence requirements of the growing population without inflicting damage on the environment.

Seeking strategies to optimize the use of locally available resources by combining different components of the farming system should take into consideration the locational specificities. There are several potential ways to improve the economy in the study area. There also exist potential to intensify livestock production, apiculture, sericulture and vegetable production. Accessibility and proximity to the important market centers allows farmers to adopt high value commercial crops. There is also greater potential to integrate cut flower production into the agroforestry system for higher income. Women's involvement in cut flower production may improve their economic condition provided they are able to make decisions over the incurred benefits. Road linkages to the capital city of Kathmandu and regional towns of Narayanghat, Birganj, Butwal and Pokhara provide an excellent opportunity to bring radical transformation of the local economy by adopting a shift from subsistence to commercial farming and from predominantly cereal based to an agroforestry based economy.

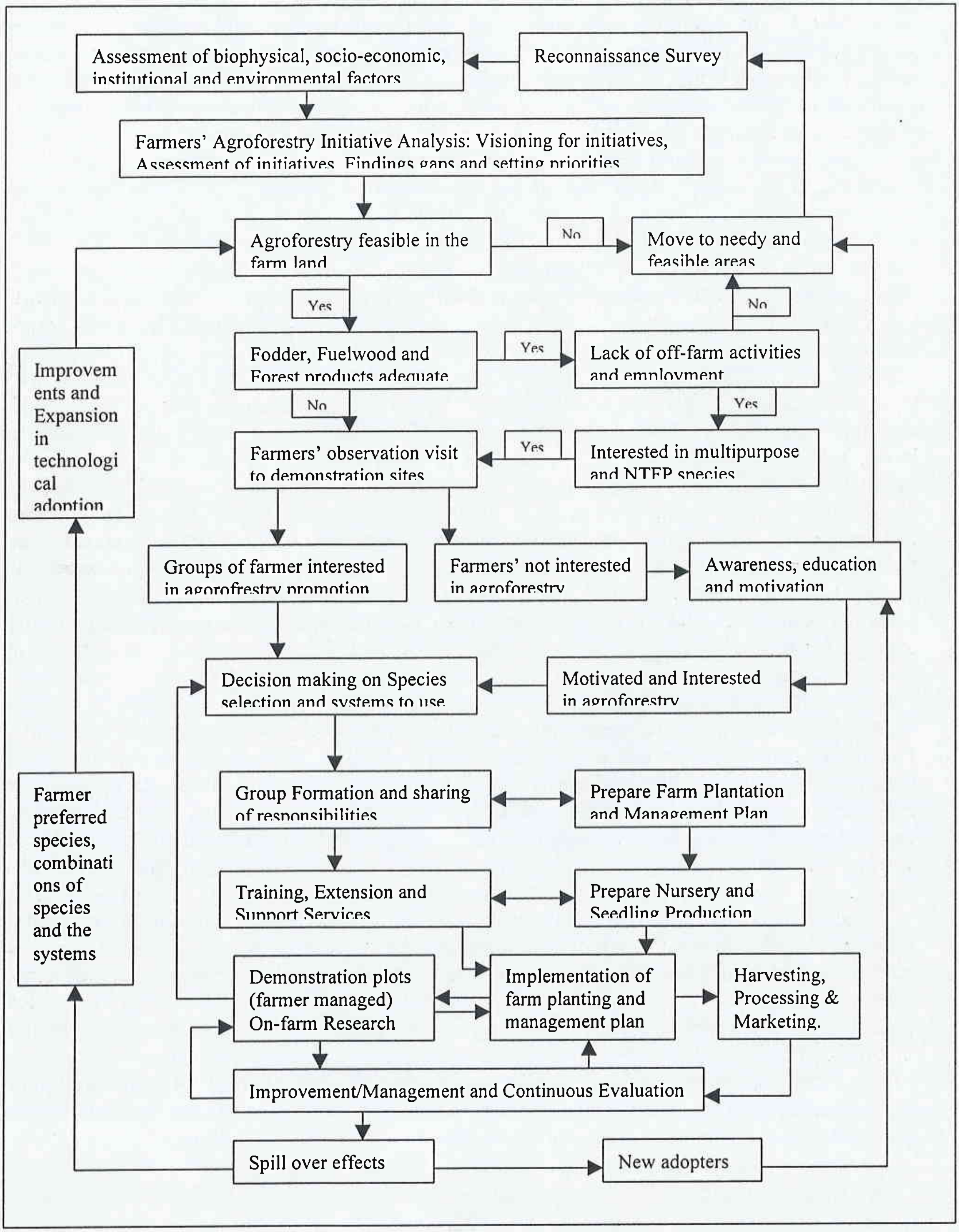
Despite the potential, several factors, such as variability in price and yield, lack of secure market, and absence of insurance policy restricts the adoption of suitable agroforestry practices. Changes in thinking and necessary skills with appropriate strategies are required to facilitate desired transformations. In the study area, NAF and local NGOs have been promoting agroforestry. In this regard, need assessments and socio-economic analysis are carried out and farmers have been sensitized on agroforestry. Involvement of local NGOs, availability of trained human resources for enabling local organizations to promote agroforestry are other favorable conditions for agroforestry promotion in the study area. To promote agroforestry program in other areas, experiences gained by NAF and results of this study should be the basis of planning. Participation of local people in the entire planning process is very crucial for the successful implementation and continuation of the project. Based on the findings of this study and the work experiences gained on implementing agroforestry projects in the past, development of a participatory agroforestry-planning framework (PAPF) has become necessary. A coherent pattern of planning process is an important aspect to foster and redesign land use system through agroforestry promotion in the hills.

12.1 Agroforestry Promotional Framework

To proceed with the actual implementation of the strategies suggested, a participatory agroforestry promotional framework (PAPF) is developed to analyze the biophysical, socio-economic, institutional, and environmental situation, farmers initiatives, problem prioritization, formulation of action plans, provision of educational, training and support services and follow up activities (Figure 12.1). The macro level assessment of biophysical and socioeconomic situation after the reconnaissance survey would be the initial steps of the proposed framework. In contrast to the conventional practice of need analysis, the framework emphasizes the farmers' **initiative analysis**. The planning should start with the analysis of farmers' "**initiatives**" instead of "**need**" as normally practiced. The initiative analysis includes visioning and assessment of initiatives, finding gaps and setting the priorities. If agroforestry becomes the feasible alternative after the initiative analysis, then promotional activities will have to be followed thereafter. According to farmers' priorities the external intervening organization (both GOs and NGOs) or local institution/groups will arrange farmers' observation visit (specially focused for women farmers) to agroforestry farms managed by farmers already involved in improved agroforestry in and outside of the district.

Farmers will make decisions on planting the agroforestry species of their choice after they themselves see the performance of the species and the systems practiced by fellow farmer under similar biophysical and socio-economic conditions. The series of promotional programs ranging from the mass awareness, motivation, training, nursery establishment, farm plan preparation and implementation, establishment of demonstration plots to on-farm research would become the integral part of the planning framework. Through the built- in system of continuous evaluation and improvements, new adopters would be able to adopt a suitable agroforestry system that is already adopted by other farmers in the area. In the mean time, the early adopters would find further improvements in introducing new species and species combinations leading to the expansion in technological adoption. The proposed model, based on participatory planning, would be a most powerful tool to find out appropriate strategies, actions and activities to bring substantial improvements in existing farming systems through agroforestry.

Figure: 12.1 Participatory Agroforestry Planning Framework (PAPF)



12.2 Getting to know people and the community: Initiative Analysis

Before implementing agroforestry programs, we need to know the people, the community and the farmers' initiatives to enable us achieve our goals. Any programs aimed at development should be implemented after analyzing potential problems, strengths and opportunities. Detailed fact-finding analysis has to be done after the reconnaissance survey of the area under consideration. Several methodological approaches are available for this. It is of greater significance to get to know people and community so as to find out their real needs and aspirations. It is recognized that rapport building is essential to have full participation of the target population. It is proposed that apart from the conventional feasibility analysis based on broader biophysical, socioeconomic, and institutional factors, **initiative analysis** be carried out prior to formulating promotional programs. This analysis would be the process of understanding achievements of the efforts made by farmers, learning about and building on local knowledge and skills, helping farmers to develop their vision and self-help capacity to assess their situation.

The proposed initiative analysis is a slight deviation from the conventional need assessment analysis. Experience based on discussions with farmers during the field survey shows that farmers normally aspire to things not directly linked to their economy, such as roads, and electricity. Therefore, to find out their real needs and assess the situation we should bring some modifications into our assessment methods. The proposed initiative analysis should start with assessing what initiatives or mitigating measures farmers have either already undertaken or thinking to undertake to solve problems, such as planting trees for livestock fodder, buying highbred animals, and cultivating cover crops for fertility improvements (Figure 12.2). The Initiative analysis should also explore initiatives that farmers have planned or thought of experimenting to bring improvements.

Participation of all kinds of community members including men, women, ethnic groups, and deprived community and the existing local institutions is necessary for successful planning. For disadvantaged groups and women, discussion should be conducted separately to secure their inputs and participation. PRA exercise could become important tool for carrying out the exercise. Activities would then be prioritized in view of available resources, ease of adaptation, required time frame, technical feasibility, social acceptance, economic viability and benefit sharing. If agroforestry appears to be a feasible alternative, then work planning should proceed.

The planning exercise would also develop strong sense of ownership among users, improve planning capabilities and institutionalize the process of participatory planning. To alleviate the pressure on the hills, forests, private lands and to promote agroforestry, the suggested management strategies includes, the creation of mass awareness, carrying out research and strengthen local institution, adoption of high yielding multipurpose species, and provision of training. Better use of improved agroforestry for livestock production, promotion of tree based agri-enterprises and employment generation, utilization of different land units, improvement and strengthening of extension, support services and facilities with appropriate policy recommendations are suggested for improvements.

Initiative Analysis

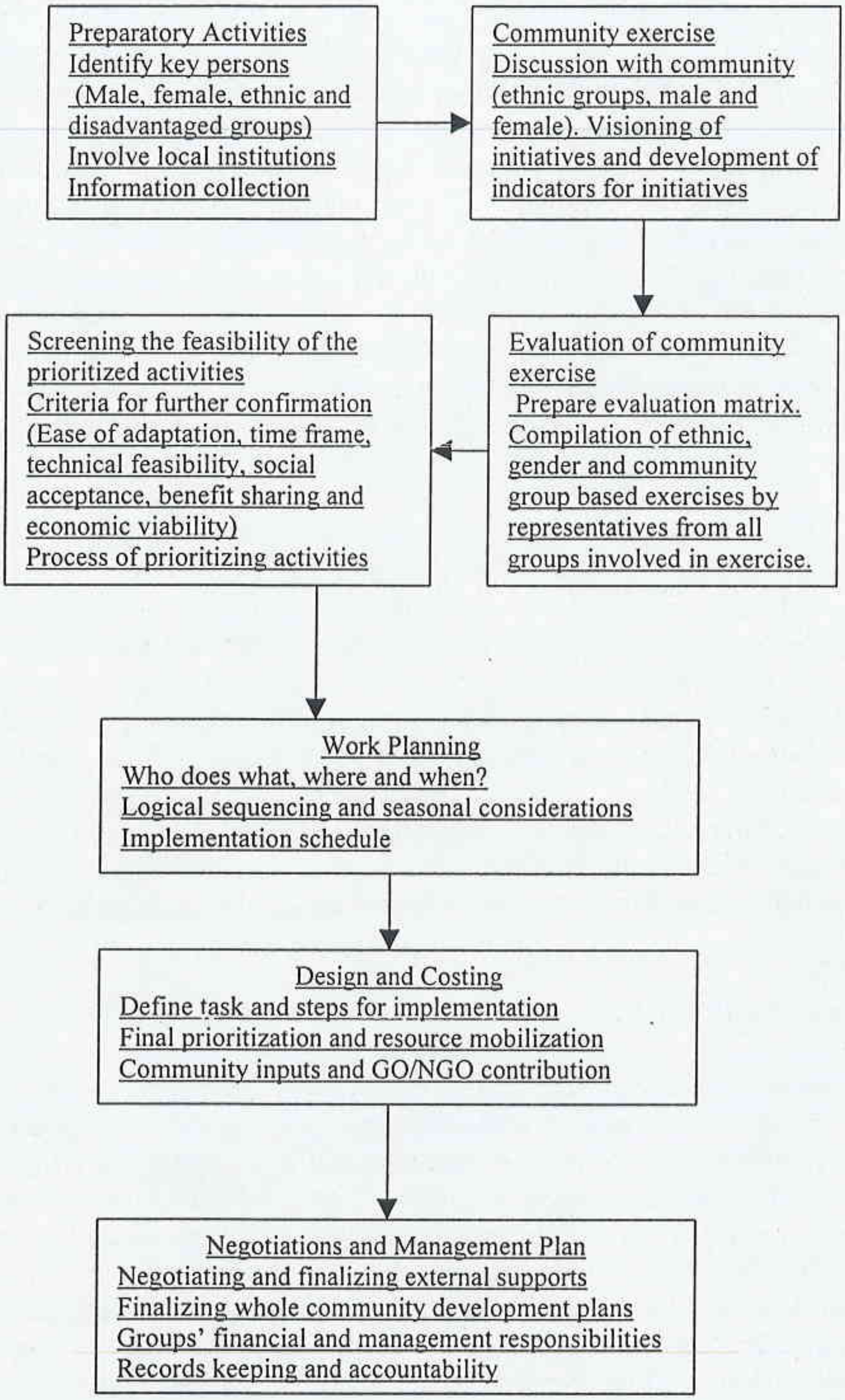


Figure: 12.2 Process of the Farmers' Agroforestry Initiative Analysis

12.3 Mass Awareness on improved agroforestry

Farmers, caught up in a state of illiteracy and unaware of innovation and alternatives for change, have not received sufficient assistance to enable them to adopt improved agroforestry innovations. Literacy program for rural adults in general and women in particular would enhance agroforestry promotion, as women are the major users and managers of the agroforestry species. Women should be educated on basic literacy and simple calculation. Women's education was a positive factor in agroforestry adoption analysis. The level of awareness among the people would be high with improved literacy. It is observed in the study areas that enrollment of girl children in school has increased due to on-farm availability of fodder for livestock. Improved fodder availability has been the reason for some households to release their girl children to school. This has in turn acted as an agent to motivate other households to practice improved agroforestry because their children could also join school. Therefore, improved literacy and increased awareness on agroforestry bring multiple benefits to the families.

Based on the available resources, different awareness raising programs could be carried out. Extension methods, such as filmstrips, documentary shows, observation visit, results and practice demonstrations would be desirable to bring awareness on specific practices and species. Although national educational policy is in place, large sections of the people, particularly women are still out of reach. The program should be geared towards mass education and vocational training through both formal and informal education. Holding meetings with villagers and training them would not help much to pursue them to adopt the practice. Therefore, extension workers should frequently visit the target groups and educate them about the agroforestry species and practices. Local NGOs and existing farmer groups should be mobilized for creating greater awareness among the rural population on agroforestry.

12.4 Agroforestry Research

Agroforestry research in the Hills should be directed towards management and adaptability involving both basic and applied research. The need is to undertake problem oriented research involving exploratory (what, why and how type research questions) research and moving towards specific management trials of selected components and systems. These then lead to the development of prototype technologies based both on biophysical aspects (soil, environmental factors, components of the system) and socioeconomic issues (social acceptability, economic benefits, policy matters). Adoptive research is required to develop location-specific technologies that address the actual problems and to harness the mountain potentials. Modification of alley cropping practices by farmers and organizations to meet soil conservation objectives in some locations is an example of certain location specific practices. On-farm trials conducted by farmers have been found to be very effective, therefore research conducted in farmers' field by the farmers embracing multiple species and combinations of different components should be emphasized to exploit the ecological and economic interactions among the different components of the agroforestry system.

Farmers' tested practices produce higher output and benefits and conceivably offer a higher degree of soil sustainability. Similarly, they are sustainable, cheaper and easy to disseminate. Research is required to bring changes in hill production systems from a subsistence type of production to a agroforestry based commercial production. The changes are not going to come easily and without the interventions. External interventions are required to bring the structural changes in the hill production system. Because the law of market forces alone bringing changes in the production patterns of hill farmers' may not be enough. Changes or improvements from within the system, as a response to the external pressure can not be ruled out as farmers are continuously making efforts and experimenting to cope with the situation.

But the changes may not be sufficient for any substantial improvements due to strong structural factors prevailing in the entire production system. Thus the changes have to be deliberately planned and organized through appropriate interventions at farm production level. But there are also problems on conducting on-farm research particularly in resource poor farmers' condition, as it uses their scarce resources, time, can risk their crops and livelihood. The risk factors also depend on how experiments are conducted. Therefore, NAF practice on-farm research on demonstrator farmer and leader farmers' field providing some monetary incentives for their resource use, time and risk factors involved. These leader and demonstrator farmers are involved in farmer to farmer extension process to disseminate knowledge of the new technology.

Great expectation of agroforestry system particularly for use in difficult or fragile environment and resource poor conditions have lead policy makers and donor agencies to support and perceive as possibly most cost-effective systems to mitigate farmers multiple problems. Therefore, it is important to integrate information dissemination and on-farm research facilitated by agroforestry promoters and researchers. Though not intended, on-farm research also serves as demonstration plot. Furthermore, good extension requires that appropriate technology be available through research. In this regard, the role of researcher, extension worker and subject matter specialist (SMS) would be that of facilitator. They should provide necessary technical and support services to the farmers.

The proper coordination between NGO, farmer, farmer group and government organizations will be very much desired for the successful implementation of on-farm research and delivery of extension services. This will obviously have some institutional implications regarding existing institution's capability to deal with the expected changes. Therefore the program should envisage the required institutional support and their creation, as improvements in cropping demands improved institutional base. The specialized system in turn ensures a stronger institutional base for resource management in the hills.

12.5 Institutional arrangements for agroforestry development

Institutional shortcomings in the agroforestry sector and other supporting sectors represent an impediment to developing a strong and suitable system. Lack of institutions to regulate the production and distribution of seeds and seedlings of agroforestry species and to optimally facilitate the integration of agroforestry into land-use development programs and research, extension, and training requires promotion of suitable government policies both at the national and local level. Coordination and linkages between governmental and non-governmental organizations involved in agroforestry promotion should be developed and strengthened. So far the coordinated role from the governmental organizations is very ineffective. Government forestry and agriculture agencies must work closely with NGOs and community groups to maximize their effective service delivery in rural areas. Technical and financial assistance should be provided to develop their capabilities of managing agroforestry.

The regression analysis on adoption revealed that male membership in a local NGO had a consistently positive significant effect on agroforestry adoption by both project and non-project households. Agroforestry adoption framework indicates that local NGOs/FUG /farmer groups greatly influence the adoption by contributing to coordination, local level participation, awareness raising, meeting, local resource mobilization and moral support to the adopters. In this regard, farmer-led organization is indispensable for agroforestry program effectiveness. Local organizations may act as means to mobilize knowledge to solve problems through improved land husbandry. They will be the basis for a successful grass-roots approach to finding solutions, partnering with local government, fostering entrepreneurship, obtaining outside technical and financial resources and diffusing new information throughout the community. Assistance and guidance through affinity groups increases the community's capacity to move forward. They may play important role in arranging marketing of agroforestry products and improve farmer's benefits.

12.6 Agroforestry in bari land

As typical of the hills, the major portion of the land holdings comprise bari land where maize is the dominant crop. Therefore, emphasis should be given for maize-based Agroforestry system in the hills as it is the staple diet of over 55% of the hill people. Number of improved varieties of grain legumes tested for highlands under rain-fed conditions should be introduced to farmers. Despite farmers' growing awareness of certain high potential farm enterprises, the lack of support services, marketing and financial resources has hindered their adoption. As the complete diversion of farmers from cereal crop to cash crop is unlikely, fruit plantation in terrace risers, edges and cereal crop cultivation in terraces is a socially, economically and environmentally suitable system in the *bari* lands. Farmers are likely to prefer such system, as it does not constrain food grain production. Government policies should encourage farmers and private enterprises to adopt such system and facilitate the process of diffusion.

12.7 Agroforestry in khet land

Despite conventional belief that farmers are reluctant to practice agroforestry in khet land findings of this study indicate farmers' willingness to plant trees on khet land. Therefore with awareness raising, technical backups, extension and motivational programs, promotion of agroforestry in khet land bunds, boundaries and path ways, which was considered to be not possible, is actually possible. This will help to provide a special opportunity for supplementary production from khet land. This is also reflected in adoption analysis where khet land in project households contributed positively towards agroforestry adoption. Silvicultural manipulation, particularly for khet land, is very important in agroforestry to control tree density and spacing, pruning, species combination and tree height maintenance. In case of khet land where farmers would normally be reluctant to plant tree species, manipulation of tree heights, as seen practiced by farmers in project area, reduces shading effects, and is preferred by farmers.

12.8 Agroforestry adoption for diversified needs

Due to possible problems involved in promoting only the monocrop of agroforestry species, emphasis should be given to species diversification with emphasis on those species that provide higher benefits. It is also observed that farmers do not necessarily adopt technologies as a package, rather adopt single technology or clusters of technologies over total package adoption. They adopt technologies on a stepwise basis based on their initial and envisaged benefits, risk, resource requirements and availability. Farmers adopt species that exhibit positive benefits and would continue adopting others once they experience further benefits. This is reflected in the way farmers started adopting mulberry and NB 21 grass species in the study area. As a result project staffs are no longer involved in motivating farmers to adopt these species, as farmers are now self motivated because of accrued benefits and ease of establishing the plantation.

The present practice of over dependence on cereals, mainly rice, maize, millet and wheat is not only adversely affecting the soil but it is limiting prospects for higher income. Farmers in the hills are reluctant to change the present land use patterns because of associated risk. The possible means to convince farmers is to provide several options with different incentives. In this regard, it is necessary to encourage farmers to diversify the cropping systems as much as possible. Agroforestry improves bio-diversity in regard to the flora and the fauna, as multiple species are integrated into the system. This would help to maintain soil fertility, reduce risk of crop failure and achieve greater motivation to include tree crops in the system. Integration of pulses, vegetables, oilseeds, and other cash crops with perennials in suitable agroforestry system that generate quick income would enhance farm income. In the initial stage, farmers' concern about food security should also be taken into account and enable them to pronge gradually to commercial farming whereby farmers can purchase food grains due to increased income from marketable agroforestry based products. Leguminous species are vital for the tree-crop-integrated system.

Planners and managers need to be aware of legumes' use and their role within the household economy, which are changing with increasing commercialization. Tree component in farming system, particularly multipurpose leguminous tree species, play a vital role to maintain land productivity in situation of scarce capital through the substitution of trees for purchased inputs of fertilizer and to strengthen risk management through diversification of outputs, wider seasonal spread of inputs and outputs. Integration of leguminous trees, green manure, cover crops, and grain legumes with field crops improves soil fertility and increase productivity. Farmers reveal that fast growing, multiple use, easy to propagate and establish, good coppicing, less shady and deep rooting characteristics of species would be the criteria for selection. Farmers need to be motivated with suitable species to promote legume cultivation during fallow periods and between the two crop-growing periods. Legume cultivation, during winter and early summer when the lands are barren, could considerably increase fodder availability and maintain soil fertility. Introduction of variety of legumes with improved agronomic practices and quality seeds in the agroforestry system will yield good profit for the farmers. For hill farmers the product diversification act as contingency against risk of agroforestry adoption.

Diversification to commercial activities, such as sericulture, bee-keeping, and seed production, can generate employment opportunity to a large number of rural people at various levels, such as small farmers, seed growers and tenants. Emphasis should be given to market-led production of livestock, fruits, vegetables and cash crops based on comparative agro-ecological potentiality, storage and transportation facilities, market accessibility and the demand and supply conditions. Development of crafts/industrial and service activities by utilizing the seasonally idle labor force could contribute substantially to their earnings. The number of agroforestry based location specific local species, such as chiuri (*Bassia butyraceae*), amala (Emblica officinalis), harro (*Zizyphus rugosa*), lapsi (*Malia dubia*), kafal (*Merica esculenta*), timmur (*Zanthoxylum armatum*), ainselu (*Rubus ellipitcus*), babbyo (*Pollinidium angustifolia*), nigalo (*Arundinaria*) and bamboo (*Dendrocalamus strictus*) could be promoted. Community initiated institutional sales cooperative will have to be created to cater the marketing needs. Since the people have already started the saving and credit program, the group can be motivated pursue fund for such activities and recover the cost in the long run. With regard to the transportation facilities the project area is linked to important road networks.

Agroforestry promotion strategies should utilize farmers' available resources particularly land to fulfill subsistence and economic requirements ranging from fodder/fuelwood, soil fertility, and soil conservation to income and employment generation. Block plantation on private farmland with mixed species should also be encouraged in areas where the land is unsuitable for growing agricultural crops. Such areas normally would be of Char quality land or permanently covered with thatch (*Typha angustata*) grasses. If such land were in hill slopes and erosion prone areas, the dense and permanent tree cover would protect from accelerated erosion. The species combination should be such that farmers are able to get multiple returns and also relatively short term benefits while waiting for long term gains. Availability of diversified climatic conditions and species provide tremendous potential to produce quality agroforestry seeds particularly vegetable seeds and other high value crops. These fetch high price and farmers could get higher returns as compared to field crops. Agroforestry could thereby generate employment.

Any agroforestry promotion program should envisage creating employment in the study area. The result show that the employment creation through income generation in non-project areas has to be set out from the traditional, integrated subsistence agriculture based on small and fragmented landholdings and local breeds of livestock. In project areas on the other hand, improved agroforestry activities through tree-crop-livestock integration system may lead to higher non-food grain and value added products. Given the higher income-elasticity of non-food grains and value-added products, farm households will eventually be able to increase the income by stimulating the demands for high value farm products. Therefore, radical changes in the existing farming system through agroforestry in the hills should be the strategy for diversifying income sources. Depending upon the land suitability and soil characteristics, cardamom, ginger and other high value medicinal and aromatic herbs could be cultivated.

Furthermore, the employment creation should be designed to suit people with low educational attainment and skills, lacking entrepreneurship and subsistence oriented. Private entrepreneurs could take leading role to take initiative towards establishing relevant industries that are likely to generate employment in the rural areas. Livestock production is one of the appropriate activities for private entrepreneur. This would eventually lead to alleviating poverty and institutionalizing the natural resource management.

12.9 Agroforestry for livestock production

On-farm and forest fodder plus the crop residues forms the total livestock fodder supply in the hills. The findings show that farmers in the study area keep large number of livestock and they are an inseparable component of the farming system primarily responsible for sustaining the farm land productivity through nutrient recycling. Agroforestry is closely linked to livestock production system. The analysis presented on factors motivating agroforestry showed that for majority of both project and non-project households, fodder scarcity is the main factor that motivated the farmers to plant fodder trees in their farmland. Likewise, number of livestock kept by household was found to be most important determinant of agroforestry adoption in both the project and non-project households. It is important to consider in any agroforestry planning activities that the decision to plant trees by farmers on their cultivated land is based on their response to a number of external and internal factors that are acting together in their farming and livelihoods systems, which are subjected to change with new opportunities and situations (refer chapter 8 for more discussion).

Improvements in agroforestry are vital to sustain livestock production in the study area in particular and in the Hills of Nepal in general. In the national scenario 8.6 million livestock thrive on 14.7 million hectares of land including 1.6 million ha of rangeland, 1.0 million ha of degraded forest and shrubland and about 0.6 million ha of cropland. The large sections of the farmland in the Hills are terraced having considerable size of terrace risers for fodder production. The current average productivity of range, degraded lands, marginal land and terrace risers is estimated at 0.5 – 1.0 metric ton (green matter) per hectare. With proper technology there is tremendous potential to increase the present production level to at least 10-20 tons green matter/ha (World Bank, 1997). Therefore support is needed to strengthen the farmers groups and local organization to implement agroforestry programs to harness the on-farm production potential, maintain soil fertility, fulfill fodder deficit, and alleviate rural poverty.

As traditional practice of raising livestock through forest and range land browsing is not possible, economical and sustainable, efforts are required to emphasize the stall feeding practices by promoting on-farm fodder production. The expansion of stall-feeding practices can also increase manure supply leading to increased farmyard manure production. Promoting traditional farm manure and encouraging compost making would be more cost effective and environmentally friendly. Apart from improving livestock productivity through agroforestry promotion, an animal health program should be integrated to reduce the losses caused by animal diseases. To enhance the livestock production potential, selection of superior native breeds and upgrading through cross breeding and introduction of improved breeds need to be undertaken. Strategies to modernize livestock production by introducing contract-rearing system involving private companies needs to be initiated and encouraged enhancing agroforestry development. Availability of good and sufficient fodder from farmland is already enhancing stall feeding practices and practice of replacing weak and unproductive livestock by improved animal breeds capable of producing high yields have been emerging.

12.10 Agroforestry in soil fertility improvement and soil conservation

Agroforestry provides possibility to farm in the sloping landscape of the hills, as cropping beyond 10-15% slope is considered unsuitable. The large portion of the hill population in Nepal live in sloping lands often considered not suitable for human habitation and farming. Research has remained largely unable to find solutions for such areas but in contrary people do cultivate these areas for living and they need scientific help the most. Vegetative cover type improved production systems and agroforestry management strategies can be as effective as forest cover to protect soil against erosion. Combining trees with other soil conservation measures can greatly expand the possibilities of crop production on sloppy land. Therefore, the ultimate policy measure should be to reverse deforestation, improve ground cover by convincing farmers to abandon their destructive farming practices on slopes. For example, cultivation of cardamom under an agroforestry system or in community forests is both ecologically and economically promising. Areas with high population densities may need to be targeted for perennial plantation based high value production system. Because of fragile and infertile soils, hills have strong comparative advantage for agroforestry. Food crop farmers will adopt tree-crop systems when markets are available and they have reasonably secure tenure to their land and trees.

Depletion of the vegetative cover seemed to be the root cause of a nexus of economic, environmental and social problems in the area. Agroforestry system comprising contour hedgerows, sloping agricultural land technology, and biological terracing are some of the appropriate and economically sound systems designed to limit soil erosion. Production system consisting of grasses and legumes in hedgerows and alley farming will be suitable combinations to engage population in conservation and non-farm activities. Therefore, rethinking a new set of strategies to formulate ecologically and economically sustainable land use practices is necessary. This seeks the integrated use of a wide range of management technologies and increased diversity of enterprises within farms combined with linkages and flows between them. It is to be noted that ability of vegetative cover to intercept rain is determined by the diversity of the vegetative cover. Therefore agroforestry management techniques should focus on maintaining ground cover with variety of agroforestry species and combinations. The greater the cover of the land, the less the erosion, soil nutrient loss and water run off and more stable the production.

The study showed that intensive cropping has reduced soil nutrients as inadequate biomass production both on farm and forest, inadequate application of chemical fertilizer has limited nutrient replacement. Inefficient use and inappropriate management practices employed by farmers have been the major cause of soil fertility decline. But labor intensive contour vegetative strips (hedgerows) systems are very effective to create natural terraces, land management intensification, control soil erosion and minimize nutrient losses. Numbers of agroforestry species in hedgerow planting along the terraces have been useful to incorporate in terraces to enhance fertility. Fiber yielding and soil holding plants like baabyo (*Pollinidium angustifolia*) are effectively grown in eroded and sloping areas. Species that are already planted and adapted by farmers include *Leucaena leucocephala, L. diversifolia, Flemingia congesta*, and *Calliandra calothyrus*.

In the context of modern technology, overexploiting the resources and creating natural imbalances, a shift towards more sustainable and environmentally friendly technology for soil fertility management is essential. But there is lack of adequate research information. A blanket recommendation is not suitable for specific locations. Organic sources of plant nutrients are critical for sustaining soil fertility in the study area. Improvements in the supply of fodder and forest materials and livestock management systems as well as better production techniques with efficient application of compost/FYM can be made for increasing farmland productivity. This study shows that interdependence between crops, livestock, forests, fodder and compost are the key issues of fertility dynamics in the hill farming systems. The biomass production needs to be increased through promotion of agroforestry. It was observed during the fieldwork that substantial portion of FYM and its nutrients are lost due to careless handling and open dumping in the field for long time before they are incorporated in the field. Better composting would reduce the nutrient loss as well as provide opportunity to include household organic wastes of different types to increase the supply of organic fertilizers. Needless to say, organic fertilizers alone may not be sufficient to supply desired level of plant nutrients, at least during the initial years of large scale agroforestry species adoption, therefore farmers should be educated to use chemical fertilizer wisely.

12.11 Gender Balanced Promotion Program

Agroforestry promotion programs need to take into consideration roles and responsibilities of both women and men in the livelihood system. For example, gender roles in fertility management suggests that all activities are shared between men and women although degree of involvement varies according to the nature of the work. Women play major role in carrying FYM and bedding materials, cleaning animal sheds, spreading FYM on the field, cutting and carrying grasses. Planting and managing agroforestry species also falls in their domain. Agroforestry may aggravate their workload if efforts are not directed towards gender balance. Community in general and men in particular should be sensitized on women's condition and need for gender balanced program. Dialogue and discussion at the community level (involving VDC, wards representatives, NGOs, and grass root organizations) on how burdens are borne and benefits accrued within the households due to agroforestry project should be initiated. The discussion should also be effective in sharing and disseminating the experiences and research results. Such efforts could increase public awareness about gender roles to improve women's overall conditions and reduce pressure. Agroforestry program should increase and strengthen women's active participation through organizational involvement at the local level.

The results showed that women's involvement in NGOs is not necessarily the important reason for improvement in decision making. Although involvement of women in local organization is high among the project households, its effects are not pronounced in agroforestry adoption. They normally remain as passive members due mainly to the dominating roles played by their male counterparts in all the decision-making issues. Their participation in executive decision-making bodies should also assure representation in decisions. The active participation of women in such meetings also depends on how the meetings are conducted as well as the gender composition. A good experienced facilitator with sufficient gender sensitivity would encourage active participation of women. It would be unfair to assume that women in the hills are inactive and unable to speak in front of their male counterparts. If facilitated properly, women are now able to speak and represent their concerns in the decision-making bodies. For example, in some of the Forestry User Group Executive Committee women representatives have been participating actively though they are a minority. But there should be provision for effective inclusion of the disadvantaged communities and groups. The problem of passive participation is not going to be solved just by provisions for involvement. They need to be trained on how to conduct meetings, bring out agenda for discussion and push for the approval of their concerns at the decision making level (either at VDC or district level). External support to strengthen group capability is required at least during the initial stage.

12.12 Agroforestry Extension Services: Tri-patriat partnership

This study revealed that the present extension service is neither appropriate nor adequate for agroforestry promotion. It requires more intensive extension services that focus on women farmers' needs and constraints, on site-specific conditions and the existing cropping systems. The biophysical diversity, which offer opportunities for land use diversification, would generate substantial employment and income when scientific land management and farming opportunities reaches to the people through public awareness. The current extension approach and education is not enough and serious attention to educational program is needed. People need to be trained at various levels to promote agroforestry. Apart from the usual process of seedling production, farmers should also be trained in other propagation methods, such as stem and tuber cuttings and grafting techniques. A comprehensive extension approach by bringing together all the diverse resources of the GO and NGOs to meet the single objective of promoting agroforestry is needed. Recognizing the essentiality, a **tri-partite** type of extension approach is proposed to strengthen the process of enhancing agroforestry.

The present extension practice emphasizing individual contacts has led to inadequate coverage of farmers. The anticipated 'trickle down' of information to poor and marginal farmers via 'contact' farmers did not occur much. Therefore, group approach of extension through partnership with the concerned community people is considered to be efficient and effective. This will increase farmers' participation in the planning and management by strengthening linkages between research, extension and individual farmers. However, there are a number of constraints that have to be considered. The adoption of agroforestry should be fostered through the provision of extension services, credit and marketing. Adequate and timely availability of inputs such as credit, seeds and seedlings are prerequisite for adoption. Extension services should also be improved and strengthened by provision of adequate number of extension worker and frequent interactions among the extension agents and farmers. In view of government's inability to provide required number of extension workers and recently promulgated local governance act, it would be appropriate that VDCs should consider employing at least one extension worker. Some of the community groups, such as FUG, are now able to allocate certain amount of funding for such purpose. Based on the analysis, extension strategies have been formulated.

12.12.1 Extension strategy

1. It is recognized that farmers need initial external support to adopt the new technology. The mid-way approach between the conventional and recent extension needs to be adopted. The conventional extension rationale assumes farmers as ignorant and passive and advocates for top-down support system of providing everything to farmers as the sole receiver. The recent approach assumes rural people as virtually interested in change and completely capable of transforming their communities. In the mid-way approach rural people are assumed to be neither ignorant nor wise but more capable and responsive with less able to change their lives on their own. This evolves farmer to farmer extension to develop partnership between the receiving mechanism and delivery services. Where farmers may be assisted by researchers or technology transfer workers to perform their own experiments (Garforth and Usher, 1997). Link of self-help group with banking institution, extension services and marketing agencies are vital for the partnership. The group based farmer to farmer extension would be most appropriate and cost effective approach to transfer known technologies to farmers (Figure 12.3). The trust building and strengthening farmers' capacity by working closely with community based organizations and resource users' groups to undertake agroforestry activities is the key element of the proposed farmer led agroforestry extension approach.

2. Training on agroforestry to field extension worker of the existing extension structure (Agriculture and forestry extension) is imperative to understand the magnitude of diversity and relevance of agroforestry in hill farming system. Being a complex form of land use system with higher bio-diversity, agroforestry requires professional laborpower having basic knowledge and skills on both the agricultural and forestry sciences. In the vital function of interfacing of natural, human and technical resources, conservation and protection of bio-diversity becomes feasible only, once human resources are qualified for this task and equipped with the required technical resources (Weber, 1998). Training is needed at different levels, such as government officials, government extension worker, NGO staff and local communities. Educational programs ranging from degree courses at academic institutions to non-degree training with short duration of one to several weeks that covers the topics of farming system, soil conservation, natural resource management are required. Degree courses in IAAS Rampur and IOF Pokhara and non-degree courses in other organizations such as NAF could be initiated.

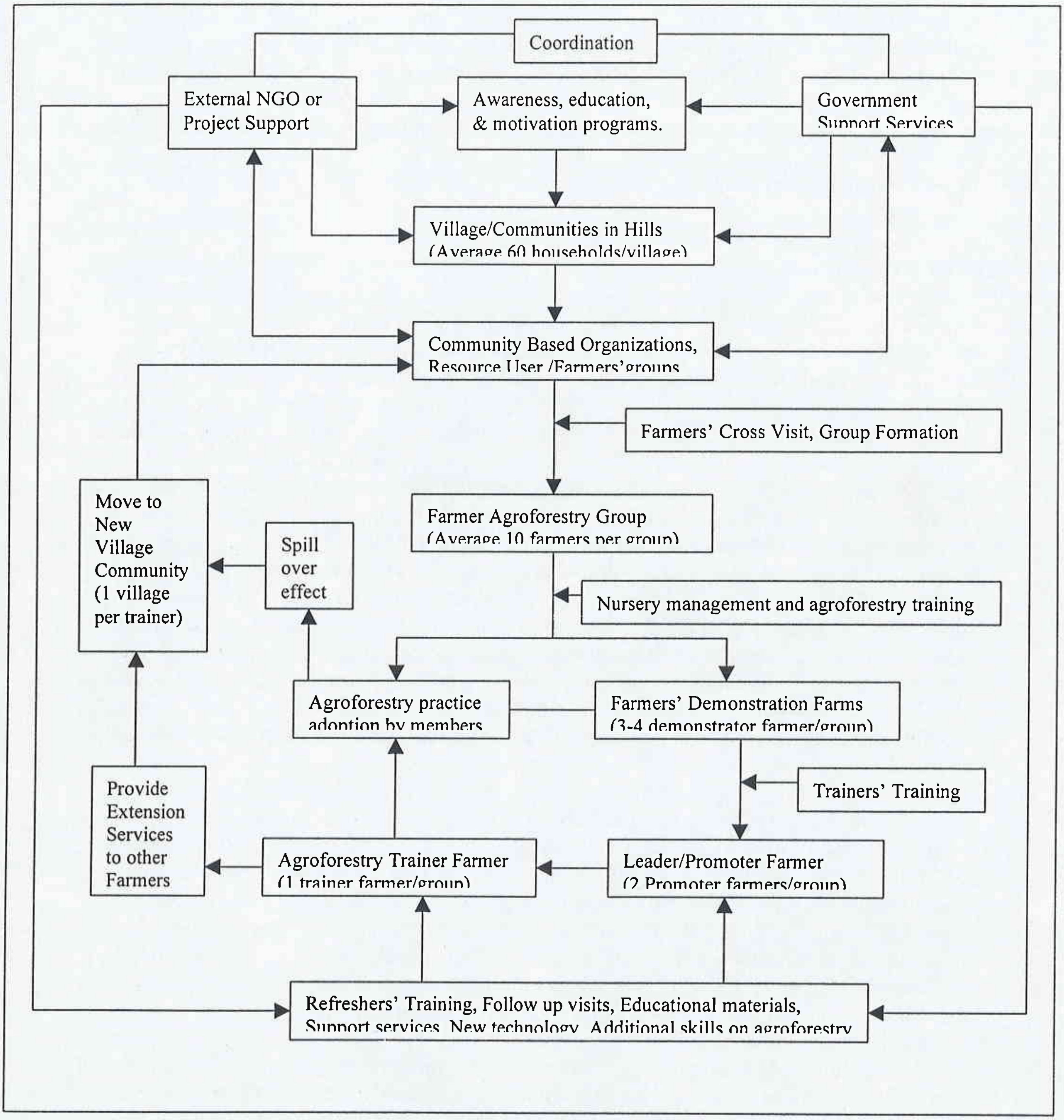


Figure: 12.3 Process of Farmer to Farmer Led Agroforestry Extension

3. Project staffs should be encouraged to work through farmers' organization and they must be trained in-group organizations. NAF has well recognized farmers' group approach in its agroforestry extension but the important issue here is the organization of such groups. The point of concern is how such groups emerged and who should organize for what purpose at the initial stage. The better option would be to facilitate the process whereby farmers themselves organized into group. For example, during the field survey it was found that NAF staffs were not involved in organizing farmers into groups but were only engaged in facilitating the group formation. The process eventually led to the group formation by farmers themselves after the initial cross (educational) visits to the demonstration farms. Farmers knew that NAF support will be available only through the group. The process of group formation initiated by farmers after the field visits ensures the congregation of interested farmers who like to work together with common interests and aspirations.

   In the broader sense, neither the government organizations nor the external NGOs should take responsibility in the formation of self-reliant group. The local organizations and NGOs should be given the responsibility. NGOs would do the resource mobilization and local capacity building. The extension worker would work with the group in technology transfer, skill development and motivation for adoption. Group approach of extension is not only cost effective due to larger coverage of farmers but it also empowers farmer groups to articulate their needs, makes more accountable and responsive to farmers. This would helps to improve the effectiveness of extension services, as the pressure from empowered groups for the services become stronger and stronger. The farmer selection for training should be the responsibility of the group and not of the government officials or extension worker. This ensures their accountability towards the group. Some guideline might be necessary for full participation of the community. Otherwise the minorities, lower caste and females will be left out.

4. Establishment of on-farm and community demonstration plots and use for training purpose should be the integral part of agroforestry extension strategy. Farmers' visits to demonstration plots, distribution of demonstration kits, and visits to research stations will ensure effective information flow between farmers and facilitate the process of **seeing is believing**. Experimental plots should respond to needs for research, training and development. Demonstration of SALT (sloping agricultural land technology) could be arranged for dissemination of improved technology for hill farmers. Demonstration plots showing the integration of high value cash crops, such as cardamom, ginger, medicinal herbs and other non-timber forest products with the field crops would motivate people to follow the practice. It is highly desirable to establish demonstration plots at locations accessible to large numbers of villagers and they must be established and managed by the farmers or farmer groups.

5. Adaptation of training methods and educational programs is indispensable for agroforestry promotion. In non-project households, the education of women facilitated the adoption of agroforestry. Therefore educational program for women will have positive effect on adoption. There are immense prospects for agroforestry promotion by strengthening the human resource through the provision of education and technical training. Apart from

agroforestry, training courses for women should focus on income-generating activities, such as raising small animals, animal health, vegetable and seeds production, bee keeping, sericulture, processing, micro-credit and marketing. As the farmers and farmer groups are unskilled, the training on agricultural tool making, bamboo basket, weaving and handicrafts making, carpentry, furniture making, and skills related to wood industries, such as managing a saw mill, would be important to encourage agroforestry projects. Agroforestry training program requires an integrative and comprehensive approach, as there is no single education or training model that is of general applicability. The approaches to education and training must be location-specific depending on ecological, socioeconomic and cultural needs.

6. Mass media are effective in dissemination of information on agroforestry. The results indicate that large sections of the farmers are not aware of the improved agroforestry technology and they have not been able to receive good services from the extension workers. It was observed that mass media program, such as Radio program, may play a vital role in addressing this issue in view of the accessibility and illiteracy problems prevailing in the hills. The message should also be supplemented by slide shows, leaflets, flip charts, pamphlets, posters and newsletter. The rational of the message should be to raise awareness of the problem and to offer knowledge on how to solve the particular problem when it is recognized. One of the important venues to disseminate information is the village secondary school, where school competitions among the students of grade 8, 9 and 10 can be organized on issues related to agroforestry and conservation. Important village, region and district level occasions, such as local fairs, and festivals, should be suitably utilized in disseminating the intended ideas and information to larger masses. Extension worker need to visit regularly and provide information to students through some formal programs organized with the help of schoolteachers.

7. The contribution of women is higher than men in agroforestry activities but they are seldom the targets of training and extension services. Women have major responsibilities in the farm activities, but they lack decision making power and access to resources. Therefore, priority needs to be given to women's participation in all facets of agroforestry promotion. But there are socio-cultural constraints that restrict women's participation. Therefore, extension services for women must take into account the various limitations on women and adjust training services accordingly (meetings sessions, field trips arranged at suitable times). Women must be given opportunities to organize and attend meetings, increase awareness, achieve literacy and gain financial security so that they themselves are able to identify their critical economic, social, cultural and psychological needs. To meet this end, strategies would be to facilitate the access to all forms of resources (credit, property, training and information), reduce the workload and establish and promote women's groups for collective action. The results showed that most farm families particularly women are illiterate and have very low level of technical know how about agroforestry. It is detected in this study that literacy has direct impact on production and productivity. Policies to favor improvements in literacy particularly women literacy would ultimately enhance agroforestry promotion.

8. The trend of agriculture extension in Nepal is that government should provide the services free of cost. There is already a large organization set up for the extension under the Department of Agriculture in Nepal. Extension department has been largely recognized as grossly inefficient and a burden. Farmers always complain that they have not been able to receive extension services. Therefore, the time has come to think of some alternative technology delivery systems with a view to reducing the costs of public extension services over time and making the existing extension more effective. Possibilities of funding for the services obtained by the farmers' groups should be explored. Such initiatives will be successful in areas where opportunities can be exploited for private gains, such as high value cash crops, non-timber forest products, medicinal herbs, horticultural crops and livestock/veterinary services. This demand-driven approach of extension in place of the conventional supply-side approach will reflect farmers' needs and address their main problems and constraints.

   In the short to medium run, projects should be developed to carry out collaborative activities between farmers, farmer groups, cooperatives, representative from the public, private and NGO sectors. The collaboration should move towards adopting cost-sharing mechanisms with farmers to provide information on technology, train farmers and furnish marketing information and support. Once the beneficiaries start paying for the services they obtain (even partly in the initial stage), the mechanism then ensures efficiency in delivery of the services and becomes sustainable over time.

12.12.2 Provision and Supply of Planting Materials

Availability of quality seeds and planting materials at the appropriate time is very crucial for agroforestry promotion. Farmers have reported that unavailability of good quality planting materials in time and required quantity is one of the constraints in agroforestry adoption. Therefore, efforts should be directed to satisfy such needs. This can be done by training farmers on establishing nurseries in their farms. For the timely availability of seeds, the need of seed collection and distribution becomes important activity. Training to impart technical knowledge on seed production, collection, processing and storage for seed grower farmers is crucial for good quality seed production. Organizational mechanism needs to be developed to collect seeds from grower farmers and distribute them to other needy farmers in the area. In this regard, formation of the farmers' cooperative managed by network of existing local user groups, such as community forestry user group, could become very effective in supplying seeds and planting materials. Taking up the leading role, NAF has already facilitated the establishment of a farmer cooperative named Nepal Agroforestry Seed Cooperative Company Ltd. (NAFSCOL) through the network of farmers involved in agroforestry from different hill districts. The cooperative will collect seeds from the grower farmers, government and private seed producers while it collects demand from farmer and other institutions. Seed grower farmers would be motivated to produce quality seeds as they hold their own share in the cooperative.

12.12.3 Credit facility for agroforestry

Profitability alone may not be a sufficient criterion for farmer acceptance of an intervention. The intervention may require a change in the farming system that requires more labor at a peak period than the farmer can release or manage through Perma system or additional equipment. In such condition they need to hire labor or purchase equipment-requiring cash in hand. Though highly profitable, the intervention may require capital beyond the farmers' capability to finance and in the absence of proper credit facility, farmers may not be able to adopt the practice. Hill farmers and poor farmers in particular are constantly confronted with credit scarcity. A long process of obtaining the credit, which is common with many formal credit institutions, may limit the adoption. Agricultural credit for necessary inputs like fertilizer and seeds will have to be made available without procedural delays. There is no existing policy as such for credits in agroforestry. Therefore, credit institutions are reluctant to provide credits to farmers for many agroforestry activities. Though formal credit institutions have been established small farmers are often unable to make effective use and forced to opt for non-institutional sources of credit mainly from moneylenders at high interest rates. Policies favoring the access of small farmers to institutional credit should be facilitated through necessary improvements in delivery mechanism. Linking banks and farmer groups may be carried out to facilitate flow of credit. Like wise, the possibility of strong rural financial sector is emerging due to saving programs initiated by the agroforestry groups.

Besides formal credit sources, there is an enormous opportunity to mobilize informal credit as most of the farmer groups involved in agroforestry have started their own saving collection. During the field survey it was found that agroforestry farmer groups were not able to utilize their savings for productive purpose owing to risk factors associated with investment. So far they have been distributing credits among the group members, who are now no longer able to take the amount of savings collected over the years. The money was kept in the bank in the group name on joint account operated by the group representatives, mostly the President and the Treasurer. Although, there is high demand of credit outside their own group in the village, they were not able to provide credit owing to the risk of non-protection. Visualizing the problem and prospects for investment and distributing loans to the wider population, some groups in consultation with NAF have come forward with the proposal of forming a inter-group association (IGA). One such IGA has been already formed and NAF provided training on financial management to the executive members. In order to run as a rural financial institution, groups can institutionalize their saving and credit program. This would develop into a rural bank providing credit facilities to the people. On the part of the government, policies favoring such institutions and legal protection for their savings mobilization are required.

12.12.4 Market Improvements

Improved marketing facilities are fundamental to enhance agroforestry promotion. The information collection, dissemination, product processing and transportation of products to the market centers are the important issues under market improvements. Improvements in value addition of the raw product, packaging and grading are important activities that could be done under product processing to increase the income. To promote adoption, it is necessary to increase available storage, processing and marketing facilities. The exploitation of full potential is feasible only by establishing local agro-based or natural resource base value adding processing plants. For example, farmers involved in sericulture could do the primary processing of raw silk cocoons before selling to the market. Farmer groups could be organized to install some herb processing plant unit in the village and carry out primary processing. This will reduce the bulkiness for transportation and fetch high prices. There is high potential for fruit processing plant, such as for citrus. The primary processing facilities in the village would also create some jobs for the youths, who would otherwise have migrated for work outside the community. Collection and dissemination of information on prices and demand for particular products becomes very important for farmers. This can be done at farmers' organizational level, such as Forestry User Group or Farmers Cooperative as it would be impossible for individual farmers to obtain such services separately. The cooperative can collect the products from individual farmers and arrange transportation. This will significantly reduce the cost of transportation to individual farmers and contribute in getting good market price for the products. The value addition and primary processing at local level develops skilled manpower locally as it demands skill training for farmers. This gives a strong foundation to develop agro-based village industries with availability of markets, its potential size and location.

The project areas, in particular and the district, in general are connected by two national highways, Prithvi Rajmargh and Tribhuvan Rajmargh, connecting the capital city of Kathmandu and regional towns of Hetauda, Narayangarh and Pokhara. There are 22 small market centres in the district and most of them have developed along the roads including Malekhu-Dhadingbesi-Sallyantar road. Accessibility to the study area has been improved after the construction of bridge across Trishuli River in Malekhu in 1993. Thus the round the year access to important market centres, within and outside the district has enhanced the opportunity for promotion of commercial activities including agroforestry. Recently connected telephone lines through VHF system at Gajuri, a market centre in the study area, provide improved communication system. Therefore, with the enhanced transportation and communication facilities and other economic activities, more markets are emerging in accessible areas.

Farmers, as rational decision-makers, shift their farm activities based on the market response. In this regard, market is the pull factor for agroforestry adoption. It is seen that farmers in the study area in general and in Naya Basti of Nalang in particular, were first motivated by NAF to plant *Morus alba* species in terrace risers for fulfilling dry season fodder requirement. When they came to know that mulberry plants would produce higher income when used for silkworm rearing, they gradually shifted towards establishing small mulberry plantation allocating some parcel of land to plant *Morus alba* species rather than just planting on the terrace risers for fodder. Initially, they planted on farmland having marginal production capability but slowly on farm plots with good soil fertility. The improvements not only changed the farmers' behavior but also brought changes in the agroforestry system. Such pattern of changes employed by farmer shows that over time and with improved technology, the changes in species, combination of species, and major shift in agroforestry system is inevitable. Therefore locating a reliable market becomes the important motivation for farmers.

Provision of market and envisaged profit may motivate farmers to bring substantial changes to conventional cereal dominated cropping system. Some farmers have already started vegetable cultivation on a commercial scale by bringing changes in traditional cropping pattern once they learnt about the market for vegetables and potential profit margins. Similarly, farmers in the study area have started planting NB 21 grass in terrace bunds by replacing traditionally grown grain legumes because they experienced benefits from green grasses and improved milk production. The increased milk selling practices in local market facilitated this transformation. This also saved farm labor for fodder collection and which could be utilized for other productive farm activities.

Once many farmers start producing multiple products, the problem of marketing becomes apparent. The Farmers' cooperative could be formed to cater for the marketing. The existing groups can come together to form a network which can facilitate marketing and explore new market avenues for their products. Group approach of marketing is considered appropriate as well as cost effective. This would generate employment opportunity for some people in the village. At the same time, it would save time and energy of individual farmers to send their products to the market, as cooperative takes the responsibility of marketing. This will also facilitate the development and strengthening of local institutions.

Chapter XIII

Summary, Conclusions and Recommendations

The main findings of this study are summarized based on the specific summary section composed in each chapter. Conclusions presented below are based largely on the findings obtained from the analysis and supplemented by observation and comprehension of the overall situation in the study area. They are integrated with appropriate recommendations coinciding with proposed strategies for the promotion of agroforestry. The summary, conclusions and recommendations are conferred according to the analysis carried out in this study, which are pertaining to a specific issue and are furnished in different chapters.

13.1 Summary

Over time, internal pressure on the land resources and environment have grown, with increase in both human and livestock population, decline in fertility management, declining livestock fodder and household energy sources and deteriorating situation of natural resources in the hills. Primarily, the land use is determined by subsistence farming, where agroforestry is an indivisible component in the individual farm - the basic unit of crop-livestock-tree integrated system. The households are also engaged in limited practices of inter-household economic transactions (labor sharing-*Perma* and land renting *Adhiya)*. Farmers have grain subsistence mentality owing to family food requirements. Their farm manure production, which is the main source of fertility maintenance, is dependent on animals, which are also important for draught power, sources of family diet, income and religious significance. Traditional farming practices have now been insufficient to reduce the pressure on the fragile land resources. Average farm families were found to be holding relatively less land with major portion under upland rainfed conditions with gradually declining soil fertility.

The reduction in soil OM levels from cultivation is a significant aspect of changes that are taking place in the traditional farming system. While such changes are inevitable in future, the declining fertility emphasizes the need to adopt agroforestry practices for integrated plant nutrient system to sustain or increase soil fertility levels. The land units located at proximity to the households were found more fertile and managed efficiently than land parcels located at distant from the house. Analysis shows that the management of soils for optimum OM content may be achieved through integration of useful trees and perennial species into the farming systems. The potential benefits of agroforestry systems to the soil include erosion control, efficient recycling of nutrients, improvements of soil OM and physical properties. Therefore, agroforestry is a positive alternative for the enhancement of soil fertility in the hills and to increase farm income.

Comparative advantage of hills in fruit trees, diversification (such as apiculture, sericulture), vegetable production and their integration with the cereal crops clearly suggests that there are higher possibilities of improving farmers' economic conditions through agroforestry. Cereal crops cultivation can be intensified in khet while bari lands can be used to optimize through tree based commercial cropping allowing farmers to benefit more through trading than producing everything in the farm for their own consumption. Shift to commercial enterprises within the existing farming system requires better information and extension services.

The results showed that extension was ineffective in disseminating information. For project households the main sources of information were the local institutions while non-project households received from friends and relatives. Among project households, male membership in a local NGO, female education level, livestock population, and farmer's positive perception towards agroforestry had significantly positive effects in agroforestry adoption. While the number of children below 5 years, number of males aged 10-59 years, male education, female's NGO membership and respondents' age had significantly negative effects. Under non-project conditions, households with more livestock and male membership with local NGO were more likely to adopt, while the households headed by males were less likely to adopt agroforestry. A significantly positive relationship between livestock population and adoption is not only consistent with NAF's emphasis on fodder production, but shows the importance of agroforestry to livestock productivity.

While male membership in local NGO indicated significant influence in the adoption, the education for women could have strong positive influence on adoption as female are more likely to remain in the village than men and adopt agroforestry practices. Building positive perception about agroforestry by increased awareness among the beneficiaries through better access to technical know-how, support services and training would increase agroforestry adoption. As found in this study, more than 50% of both project and non-project farmers did not believe that agroforestry improves soil fertility and productivity and nearly two-thirds did not think that agroforestry increases crop yields, although these are considered to be positive effects. However, the majority of sample farmers believed on negative effects of agroforestry. Despite their negative perceptions, project farmers practiced improved agroforestry in both khet and bari lands.

A positive association between the amount of upland and agroforestry adoption indicated general belief of hill agroforestry as an upland practice by non-project households. In contrary, the results showed that the adoption of agroforestry was positively associated with the amount of lowland for project-households. This has been possible due to improved awareness among project-households through training and awareness. However, the amount of lowland was negatively associated with agroforestry adoption by non-project households, perhaps due to their perception that agroforestry reduces crop yields. The results showed that with proper support services, agroforestry could be promoted in both lowland and upland conditions. The adoption of agroforestry needs to be sensitive not only to the characteristics of the technology and biophysical environment but also to the socioeconomic conditions which is often not given due attention.

13.2 Conclusions

Development of the hills that are facing multiple problems and challenges in relation to the degradation, particularly farmland, is very crucial to sustain the already saturated populations. Reversing the process of degradation for sustained production and bringing improvements in existing situation through better managed agroforestry is imperative to sustain growing population and to protect the environment. In contrast to capital intensive and specialized modern agriculture, agroforestry-based system is regenerative, low input oriented, diversified, nutrient recycling and the most pertinent land use system for the hills. It emphasizes on improved management and conservation of natural resources with greater reliance on the potentials of plants and animals. Which is very crucial for the hills that are more fragile, critical and vulnerable to degradation.

Agroforestry has been contemplated to be the most effective and feasible alternative to bring economic development of the rural hill population living under difficult terrain, steep slopes, shallow soils and unique subsistence type of farming system. Further more, the indigenous technical knowledge of agroforestry that farmers have developed over the years provides a solid foundation for greater technological interventions. The specific conclusions drawn on the basis of analysis conferred in various chapters presented.

13.2.1 Socio-economic issues

The study revealed that majorities of farm households with higher household size depend on subsistence agriculture. The extreme dependence on forest resources and depletion of both farm and forest vegetation are creating a negative spiral of land management and productivity. The presence of diverse socio-cultural system with different ethnic communities and enormous form of norms, values, perceptions, beliefs and customs provides both richness as well as drawback in the process of social change and economic improvements through agroforestry. Though highly fragmented and miniature size holdings, majority of farmers own their land of different categories and fertility status and have grown assorted variety of agroforestry species. Presence of cultural harmony and understanding between the ethnic groups, availability of land space not utilized or suitable for food crop cultivation and indigenous technical knowledge on agroforestry would provide substantial foundation to institute further improvements. The program should therefore take into account the existing agroforestry systems in relation to the socioeconomic conditions while planning agroforestry project.

13.2.2 Agroforestry Systems

As a traditional practice, several types of agroforestry systems have been evolved depending upon the farmers need and strategies to manage private lands. The practice of agroforestry, which is basically the *agrisilvicultural* type, is more in bari and less common in khet lands. Home gardens, systems of growing perennials in terrace risers and field crops in terraces, traditional crop-livestock-tree integration system, field crops under fruit trees, perennials combined with animal production, green manure and live fence around farmlands, alley cropping, hedgerow and small scale mulberry plantation were the prevailing agroforestry systems of the area. The different components of the systems namely – crop, livestock and tree production subsystems are inseparably inter-linked within the system. The women's share of responsibility in overall agroforestry management and promotion was found higher than that of men.

13.2.3 Gender role in Agroforestry

Both men and women farmer work together, but their work in terms of total working hours, kind of work and domestic responsibilities differs widely. Within a household the man as the breadwinner is primarily involved in productive work outside home, while the women as a housewife and homemaker takes responsibility of overall reproductive and domestic work. Men are increasingly migrating to cities for job and women remain in the village to take care of farming. The trend of "feminization of agriculture" (women's dominance in farming) is emerging. Allocation of different tasks and responsibilities within a household reflects women's subordination. Although women's share of household work is vital to maintain the living, their contributions in economic terms is often unrecorded. It is the power relationship of political, economical and a social context that puts women in the lower position and creates inequalities. Without political empowerment, it is hard to hope for significant advances in rural women's rights of appropriation over resources and access through agroforestry improvements alone.

Empowering needs improvements in both condition and position. NAF has mainly focused in improving the condition of women. Women's needs are not the same as men's but it has been the wrong conception to equate both while planning. In cognizant of women's disadvantageous situation in relation to men, it is useful to differentiate between women's practical needs and strategies gender interests. Practical needs responds to women's immediate necessity, such as access to income and employment, reduce household drudgery, access to education, easy access to fodder and fuelwood, skill development training and provision of credit. The active participation of women in agroforestry project revealed that project had to a limited extent achieved the fulfillment of certain practical needs. But strategic gender interests associated with particular cultural and socio-political contexts, such as women's subordination, exploitation, discrimination and violence against women needs more attention.

The fulfillment of strategic needs requires certain legal establishment, institutionalization of their interest, elimination of several forms of discrimination, control and decision making over productive resources and improvement on women's position in the society. Women's participation in local organization and farmers groups has already shown some buds of improvement in gender equality. NAF was found to be involved in improving the women's status by training, encouraging to form women organizations, and increase participation in existing organizations, such as FUG, village cooperatives, school management committees and local NGO. Meeting certain practical needs also require changes to the existing legal and institutional systems and reforms become apparent, such as consolidation of fragmented land to promote agroforestry.

13.2.4 Land fragmentation and agroforestry

The hills have passed through different stages of interaction between population, agriculture and the environment. The rise in population and division of farmland resulted in land fragmentation. Hill farmers adopted several strategies to cope with the deteriorating situation as traditional means and ways were not enough to meet the needs. Construction of terraces, integration of agroforestry and livestock and adoption of diverse plant species were some of the important strategies. In addition, migration to the plain areas (Tarai) provided a temporary safety valve. But these too, came under serious pressure from continued population growth coupled with other problems on natural resource management. Farmers hold a variety of land types with several scattered plots as an insurance against adverse environmental conditions. The least productive land was usually cultivated with lower degree of intensity. The cereal grains were given greater attention and planted on more productive land. This traditionally established system of land use is coming under increasing pressure as more fertile and productive parcels are becoming less fertile due to intensive cultivation whereas less productive parcels are marginalized owing to continuous nutrient withdrawal and inappropriate management practices. Because methods of cultivation and survival strategies adopted in different land parcels by farm households are not adequate for sustainable production under the present environmental conditions.

Improved cropping techniques incorporating leguminous species (lentils, beans and peas) in agroforestry system can enhance productivity in the study area. As most of the farmers have been adopting these techniques since generations, the main concern is the increment in the scale of adoption. Farmers have been continuously employing the same practice in somewhat similar fashion in terms of number of species integration and area covered. However, rise in population, decrease in soil fertility, increased soil erosion, deterioration in genetic quality of existing crop varieties and overall decrease in productive natural resources at the household level demands further improvements in the existing practice. It was observed during the field survey that farmers being aware of the existing situation have not been able to bring changes in the traditionally adopted practices. They feel vulnerable and insecure to opt for shift in present system.

The important question is how the farmers have managed their limited resources to cope with the declining food security. Basically their resources comprise two things- one being the private farmlands and other is the public resource (community land, rangeland and forest resources). The management of farmlands comes under the individual farmer's jurisdiction, while management of public resources is concerned with the community. These two types of management are highly interactive because changes in one directly influence the other. Increase in cropping intensity, gradual shift to commercial cropping, building vegetative terraces to replace structural means were some of farmers' strategies to increase farmland productivity. Similarly, improvements in resource management, such as increase stall-feeding of livestock and fire wood consumption (use of improved stove and installation of biogas plant) were visible. In addition to fodder, fuel wood supply, farmers have started adopting improved agroforestry for maintaining soil fertility.

13.2.5 Agroforestry's impact on soil fertility

Agroforestry systems in general are more complex and complexity requires system approach of analysis. Soil sample analysis for some important soil nutrients and comparison between project and non-project situation alone may not be sufficient to assess the agroforestry's contribution in soil fertility improvements. But analyses were carried out to supplement the information obtained through household survey. This is particularly important in the context of the hills where agroforestry is a traditional practice and all the farmers have maintained tree/shrub species scattered throughout their farmlands. The soil fertility evaluation in hill agroforestry systems demand additional analysis on nutrient recycling, nutrient budgeting, and soil conservation aspects for the proper explanations.

However, the analysis indicated that the low levels of N and OM content found in the soils may be increased by adoption of green manuring practices, incorporation of legume crops, introduction of more leguminous fodder species, increased use of farm yard manure/compost and chemical fertilizer. Although farmers are employing these useful management practices but the magnitude of such adoption is very small. It needs to be increased up to the greater extent because traditional practices in their similar strength are not being able to cope with the changes that are taking place in the entire farming systems. Although test results show that soils of the study area have no serious nutrient deficiency problems, the farmlands are undergoing productivity decline.

13.2.6 Agroforestry and soil fertility management

Over centuries, Hill farmers have adopted different soil fertility management practices, such as the use of organic manure, inclusion of legumes and keeping land fallow in crop rotation. But these have not been adequate to sustain the outputs and present level of food requirements under the dwindling natural resources. The introduction of high yielding varieties, pressure to produce more from cereal crops and intensification of cropping have increasingly posed threats to the sustainability of the systems. Nutrient are lost via soil erosion, leaching, volatilization and de-nitrification and removal by crop harvest, animal feed, fodder/fuel harvest and organic matters burning. Use of agroforestry and mineral fertilizers has been the increasing alternatives to replace nitrogen, phosphorus, potassium and other nutrients removed from the system.

Organic fertilizer, through increased use of appropriate agroforestry species, such as crop residues, farm yard manure/compost, biological nitrogen fixation by leguminous plants and green manure will remain a major factor contributing to increased agriculture production in the Hills. Substantial changes in the production level can be achieved through optimum use of chemical fertilizers, minimize nutrient losses by leaching and crop removal, integration of useful trees and perennials into the existing cropping system and minimum disturbance of the soil surface. This demands for the greater adoption of agroforestry practices. Declining yield trends, according to farmers' perception, suggests that the present state of art in fertility research in the Hills is not adequate to address the problem. Realizing the gravity of the problem, government, in its 20 years agriculture prospective plan (APP, 1994), has also stressed the need of making substantial improvements in the land fertility.

The APP's production target is not achievable in the Hills only through a six-fold increase in chemical fertilizer use at least for some years. Alternatives to chemical fertilizer, such as increased use of farmyard manure and green manure, become indispensable. The prevention of natural OM decline from the farmlands demands for the maintenance of good ground cover and prevention of soil loss through better conservation practices. Agroforestrys' resource-conserving and resource-sharing potentials to reduce soil erosion, nutrient leaching, diminish top soil loss by reducing run-off water and higher amount of manure production must be enhanced. The magnitude of benefits that can be derived depends on number of factors, including the biophysical condition, tree and crop characteristics, soil conditions and management practices. Species potential to bring improvements in farm income is an equally important issue.

13.2.7 Economic Impact of Agroforestry

Profitability of agroforestry interventions within the existing farming system reveals that tree based cropping system have economic advantages in the use of scarce resources. Hills are generally the food deficit areas and the situation has been further deteriorating with the steadily swelling size of population and limited alternatives to increase farm income. Change in cropping patterns through productivity increase of existing crops, switching to off-season production by taking advantages of hill environment, diversification of activities and integration of high value tree crops into existing farming system are highly desirable to bring substantial changes.

Generation of capital to invest in farming activity demands for the development of non-land based and diversified activities. On the part of the subsistence farmers, there is a grain-subsistence mentality in decision making and land uses are thus determined primarily by the subsistence farming practices. Even when there are relative and absolute advantages of growing other non-grain crops, cereal crop becomes farmers' first priority. Attitudinal changes are obligatory to harness the hills' potentials from adopting high value tree crops to ensure greater profits. They are also highly commendable from the environmental considerations. Awareness on improved technology through improved extension and support services enhances agroforestry adoption.

13.2.8 Agroforestry Adoption and Extension

Information dissemination through effective extension is important to agroforestry promotion. Sound understanding of how farmers receive information on agroforestry and the factors that enhance the adoption of certain species is also important for its promotion in a large scale. The results indicated that there is a gradual shift in flow of information as households involved in agroforestry project received more information through local NGO staffs, volunteers, information brochure, training and meeting in place of the traditional source of information, such as friends, relatives and family members. Varieties of criteria ranging from the experiences of fellow farmers, available species in the village, to the superior characteristics of the species were considered in making adoption decisions. Therefore, creating greater awareness and disseminating useful information to farmers, particularly women farmers, becomes vital for higher adoption.

Women contribute significantly to family survival needs but have insignificant role in decision making. In many agroforestry systems women are responsible for decision making, planting, tending and gathering in addition to performing their role in crop and animal production system. To overcome certain gender related obstacles, women should be specifically targeted and regarded as key actors in implementation. Agroforestry is also constrained by small land holding, insufficient knowledge on suitable species and technology and poor marketing facilities. Despite difficulties in promoting agroforestry species, farmers revealed that reformulation of the policies congenial to agroforestry development are required. They also indicated that integration of profitable activities, such as growing fruit trees, sericulture, commercial vegetables, bee keeping and high yielding livestock breeds, with agroforestry with strong institutional sector, is possible to bring substantial improvements in the hill farming system.

13.2.9 Socioeconomic and Institutional factors influencing agroforestry adoption

In view of agroforestry's proven potentials different government and non-governmental organizations have initiated agroforestry promotion programs in Nepal. The adoption of improved agroforestry at the farm level is slow and very limited to realize its potential benefits due to farmers' negative perception towards agroforestry, lack of appropriate technologies at farm level, lack of agroforestry extension, and most importantly the need for producing cereal crops to fulfill food demands. Given the diverse ecological and socioeconomic conditions and local needs, the design and dissemination of an appropriate agroforestry technology at a large scale is really difficult. Furthermore, the development of an appropriate technology alone does not mean anything unless a significant percentage of farmers are willing to use it. The adoption decision by farmers is a function of myriad of factors, such as farm size, local needs, farmer's education, beliefs, and perception, access to market, technology, and so on. The knowledge of the role of each of these factors in adoption of agroforestry at the farm level is indispensable to promoting agroforestry.

13.2.10 Thinking beyond private farmland: Agroforestry in community forests

Forestry user group (FUG) managed community forestry programs provides an excellent opportunity to introduce agroforestry in the community forests and degraded lands. Agroforestry offers an adoptive technology to domesticate NTFPs in marginal land and degraded community forestland where cultivation of crops is not feasible. Similarly, heavily degraded community land around the farms can be improved to increase productivity by agroforestry management. Apart from the domestication possibilities, improved management practices in the community forests and sustainable harvesting technology used would significantly contribute to improve local economy. At the same time, this would lead to improve natural resource management resulting in conservation of the ecosystem and biodiversity of an area.

Production and harvesting management, property rights and institutionalization, local value addition and marketing would be some of the important issues that need to be addressed adequately for successful implementation of the agroforestry in the community forests. There are several options, such as improving production from the wild, domestication and adopting better harvesting technology, to increase NTFP production in a sustainable way. The domestication of promising under-exploited species in private land, community and leasehold forestland can contribute significantly by producing high valued products. Besides high income, domestication provides product diversification and several environmental benefits. The problem of reckless harvesting practices employed by collectors and destruction of the species from the wild can be improved by controlled harvesting. Similarly, improvements in harvesting technology bring reduction in losses at storage and transportation leading to increase production. Improvement in providing information on price, product quality and markets may confer incentives for promotion and conservation.

13.3 Recommendations

The detailed analysis of the agroforestry systems and its multifarious impact on hill agriculture revealed that improvements in the living conditions of the farming households were found feasible through enhancing agroforestry practices. Based on the conclusions drawn from the analysis of the field survey and the critical observations and comprehension of the tangible situation, the following policy and research recommendations are made. Though targeted specifically for the study area, the recommendations may be applicable to many other areas in the Hills with similar biophysical, environmental and socioeconomic conditions.

13.3.1 Policy Recommendations

Recognizing that farmers' economy is heavily dependent on land, crop, livestock, water and forest resources, the plan of action for policy recommendation is directed towards promoting agroforestry in a sustainable way.

1. Under the situation of subsistence farming, majority of farmers will never be able to earn a sufficient livelihood from farm production alone even adopting improved technology. Therefore, formulation of policies to support them by creating farm and non-farm based income opportunities based on the local resource is recommended. Appropriate policy needs to be formulated for the conservation, domestication and trading of herbal plants. To open the avenue for non-farm related activities, the available rural labor force could be employed to utilize the degraded agricultural, forest and public lands. The research finding showed that some farmers particularly women had practiced diversified farming enterprises, such as sericulture and bee-keeping that were commercial in nature and generated significantly higher income than other sampled farm households. As the farmers start producing

diversified products, they need the facilities for value additions and markets to sell the products. This entails promotion and development of agro-processing industries, such as herbs processing, wood processing, fruit canning, jam and juice making which could generate multiplier effects on the rural economy. Therefore, an appropriate policy needs to be formulated to strengthen and promote local potentials.

2. As education, particularly the women's education and diversity were found to be the most important aspects of agroforestry promotion in the study area, policies favoring education reforms and maintaining diversity are necessary. Educational policy measures, such as reforms at the levels of occupational training and vocational education, including entrepreneurship skill development would be extremely effective in building productive communities in rural areas while ensuring environmental conservation. Education enables population to raise their political awareness and ensures that people are endowed with the capacity to become engaged productively and gainfully in their local economy, (Weber, 1998). For example the initiation of programs like sericulture would to some extent reduce labor migration out of the rural areas.

3. For farmers, agroforestry indicate the measure to fulfill their family subsistence needs (food, fodder, fuelwood, and manure) and its beneficial environmental impacts are not considered. Farmers do not consider this important criterion of improving degraded farmland through selecting species, which contribute to soil fertility. Agroforestry's inherent capacity to minimize productivity decline (meaning nutrient loss) in the hills, which are caused mainly by erosion, leaching and runoff, and biomass harvest and removal, needs to be capitalized through policy measures. Unlike natural forests, agroforestry provides opportunity to artificially arrange trees in contour rows and spaced closely (as desired) along the rows to serve as effective barriers against soil erosion and nutrient loss. The farmers need to be made aware of the possibility of reducing nutrient loss by removing only the usable parts and recycling the rest, adopting contour tree strips and nitrogen fixing leguminous species. These most promising land-use options for hill farmers where trees help stabilize slopes, reduce erosion, maintain productive capacity, and meet the needs of fuelwood, fodder, timber, fruits and nuts demand higher priority for action.

4. Financial analysis has proved that tree production is often more profitable than food crop production in the study area. Multipurpose tree species, such as mulberry, performed significantly better than other introduced tree species. Wide varieties of multipurpose plant species are either already practiced in some parts of the country or available for multiple use. Therefore, it is recommended to introduce such species with provisions for farmers to have easy access to seeds, management strategies and markets. They also contribute positively to environment while economically benefiting the poor. It is widely recognized that to solve the environmental problem, the economy of the people living in that area needs to be improved. The research finding further highlighted that as soon as it became evident to the farmers that mulberry plants would earn more money than growing them in terrace risers with field crops as fodder, they shifted to specialized mulberry plantation. Once farmer upgrade their technological knowledge and find that there are better options available, further changes are inevitable. Therefore, there is possibility and urgency to

increase investment in agroforestry for transition from subsistence food crops based system to perennial cropping with trees and livestock systems.

5. In the context of weak policy/legal/and institutional framework governing natural resource management, policies to support community-driven resource management, strong institutions at the local level to manage communal resources and legal framework to encourage communities to conserve and invest in local resources needs to be developed. Though available in some form, existing legislative regulations have not been able to implement at its best level. Tax and subsidy regimes to penalize undesirable land uses, and reward environmentally sustainable alternatives could be developed to harness opportunities for promoting agroforestry. New institutional structures and policies are required that recognize the integrated land-use system and role of agroforestry in Hill agricultural systems. Suitable government structure with clear mandate for agroforestry research, extension, education and training should be in place. New investment is needed in more innovative extension strategies to spread the appropriate systems to the resource poor. Agroforestry systems can also be attractive model for buffer zone management, as they provide livelihood while enhancing the level of biodiversity.

6. Land fragmentation has become the pertinent problem for agroforestry promotion. Family holdings are the most common farming units in the hills. The continuous disintegration of such units widely dispersed over different altitudes, faces and slopes create major problems in exploiting scale economics through specialization. Since land consolidation, though desirable, is a sensitive issue and difficult to implement task, government should formulate policies favoring cooperative type of farming to promote agroforestry in a group approach. Through cooperative farming agroforestry program can be initiated in larger areas involving many adjoining farmers. Policy changes that encourage such cooperative type farming would be highly desirable to bring about significant changes in the land use patterns and hence improvements in productivity.

7. Likewise, improvements in access to market, technical knowledge, skills and institutions favor household decision making towards agroforestry. Better infrastructure, such as roads and communications, is imperative to facilitate the flow of goods and services from and to the markets and settlements. To mitigate the backwash effects of roads in the rural areas it is indispensable that road construction and communication installation be implemented either after or simultaneously with the production promotion activities. This has particular relevance to Nepal because numbers of backwash effects of improved transportation have been observed.

13.3.2 Recommendations on Research

1. In view of land management and maintaining soil fertility, as the vital component in the hills farming system, further research is necessary to assess the detail production potential of different land parcels, status of soil nutrient mining in each parcel of land owned by farmer. Research on different source of mulching and composting materials, and green manure with respect to their capability to enhance soil fertility and compatibility with the different agroforestry systems need to be carried out.

2. A detailed feasibility study on agroforestry based enterprises, that use local resources (such as the example of sericulture in this study), is felt necessary to identify potential cottage industries for rural households. The activities should be adaptable to the local needs, can be maintained by available resources, more profitable and environmentally suitable.

3. Further research on identification of high valued multipurpose native agroforestry species, particularly herbal plants, their adaptation to agroforestry species combination and domestication in the farmlands is essential to promote large-scale agroforestry and improve economic condition of the farmers. Detailed research, covering the present status, production, domestication and marketing aspects, is recommended.

4. The further research on the integration of agoroforestry into the community forests is required. In view of large amounts of non-timber forest products being harvested from the community forests, an appropriate rotational period for harvesting needs to be identified through research and farmers' knowledge for the sustainable production. Apart from the higher income from domestication possibilities, the further research and development work on intensive management, such as weeding, thinning and natural propagation can ensure high yield from wild production.

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Appendix: A

Prospects of Agroforestry Promotion in the Hills of Nepal.

Coordination Schema

Parameters	Complex Variables	Simple Variables	Values	Source of Information
Bio-physical aspects	Topography Climate Soil	Hill slopes Valley Slope aspects Temperature Land capability	Name Name Tar, river basin, ridges Types	Observation Topographic map Land capability map, Aerial photographs
		Soil types	Fertility status	Soil map
	Natural resources	Forest, Irrigation, Rivers and streams,General Vegetation, Nurseries	Number, type, conditions	Observation, documents.
Social aspects	Ideographic information	Gender Age Education Occupation	M/F Years Level (s) Types	Household Survey " " "
	Household Composition	HH size	Number	"
		Gender		
		Age structure		
		Education	Number	"
		Occupation		"
		Migration	Number	
		Causes of migration		

Parameters	Complex Variables	Simple Variables	Values	Source of Information
Land holding	Type and area	Gharibari Bari Khet Kharbari Parti	Area in Ropani	Household Survey "
		Quality of land Abal, Dyoam, Seem , Chahar	Area in ropani	" "
		Land fragmentation	No. of plots & distance to plots	" "
	Land Tenure	Types of Ownership	Area	"
	Land Use Gharbari, Bari, Kharbari, Khet Non-cultivated inclusions	Field crops Fruits Khar Agroforestry Bari terraces Khet terraces	Area in ropani or fractions of ropani	"
	Amount of uncultivated land	Marginal Bari land (abandoned terraces) Parti, Terrace edges	# of terraces " of Kanlas Ropani/fractions of ropani	" " "
Crop Production	Cereal Crops	Rice, maize, millet, wheat, legumes, others Sales	Area in Ropani and yield in Kg. Qty. sold and per unit price	Household Survey " "
	Cash Crops	Vegetables, Potato, Ginger, Pulses, other Sales	Area in ropani Yield in Kg. Qty. sold and per unit price	"
	Problems	Specific problems	Check list Yes/ No	"

Livestock	Types of animals	Cattle, Buffalo, Goats, Pig, Poultry	Number	Household Survey
		Preferred animal herd size with types	Species name and Number	"
	Fodder/ feeds	Availability by season &sources	Figure (Kg, & Bhari)	"
		Scarcity months	Name	RRA
		Type of fodder for higher milk production	List of species	"
	Production	Dairy products Livestock heads	Amount in figures	" "
	Sale	Animal, meat, eggs,	Figures	
	Existing Problems & recommendations for solutions	List of Problems And farmers solutions	Yes/ No answers	HH Survey
Nonfarming activities	Earnings	Activities		HH Survey

Agroforestry practices	Trees	Fuelwod/fodder, Timber, Fruit, Others, Exotic and Local Naturally grown and planted	Species	Household Survey "
	Shrubs and Grasses	" "	Species	"
	Production	Fodder, Fruits/ nuts, Fuelwood Timber Fertilizers bedding, Medicinal herbs Honey and Others	Production in bhari, Kg., or number as appropriate.	RRA "
	Shrubs Grasses	Species & #s Types	Production # of Kanlas, Bhari prodn.	
	AF product sale	Type of product	Income Rs.	
	Input used	Chemical Fertil. Manure, Equipment Labor	Amount applied by types Cost involved Working days	
	Gender role in management and production	Labor used for: Seedling pdn Land preparatn. Planting,harvest	Average hours per day by season and gender	HH Survey
	Agroforestry Uses	Productive uses Food, Fodder Fuelwood Timber, Poles	Yes, No responses	HH Survey
		Protective uses Soil Fertility Soil Protection Fence/boundary Aesthetic,Others	"	

	Types	Living fences Wind Breaks Home gardens Fodder shrubs/ trees on bunds, terrace risers	Tick Mark	Household Survey
	Problems	Storage Perishability Transport Fruits, nuts, and Vegetable cultivation Problems	Check List Yes/ No	Tick Mark
Agroforestry Marketing	Location of the markets where products are sold	Name and Distance	Name and time taken to walk	P/RRA
	Possible marketable products	Fruit, Fodder Vegetables Bamboo, Nigalo, others Medicinal herbs	Listing of names Selling price	
	Transportation	Mode of transport	Listing the names	RRA
		Transportation costs	Rupees	"
	Marketing Channel	Fruits and Other NTFPs	Traders at market center Middlemen Itinerant traders Direct to market centers	RRA
	Problems in marketing the agroforestry products	Storage Low price Facility Transportation Others	Tick off	HH Survey

Parameters	Complex Variables	Simple Variables	Values	Source of Information
Tree-crop interactions	Role of agroforestry	Above ground (shade effect) Under ground (Root effects)	Yes/ No "	Household Survey
		Shade loving and tolerant Crops	List of crops/plant species	P/RRA
		Farmers' perception of yield losses	Tick mark (On severity of damage and tree location)	P/RRA, Field Observation
	Soil erosion control	Suitable tree, shrub and grass species	Listing the names and other uses	RRA
	Nutrient Supply	Leaf litter Animal bedding materials (Sottar) Farm yard manure Green manuring Crop residues In-situ manuring	Amount in Kg, Bhari	Household Survey " " "
		Management practices	Listing the types	RRA
	HH Income	Agroforestry's contribution	Amount	HH Survey
Agroforestry interventions	Process	Site selection, Assess needs,	Criteria and processes	Group discussion, project documents and Observations
	Impact	Fodder/fuelwod collection time, Income level, Income sharing	Saved and uses Increased or decreased	
	Stakeholders	Farmers, Local groups, External agents (NAF)	Roles and responsibilities, levels of interventions	"

Parameters	Complex Variables	Simple Variables	Values	Source of Information
Agroforestry Adoption	Process	Characteristics Time of adoption	Year of initiation	RRA
	Influencing factors	Biophysical, Socio-economic	Regression, Correlation	
	Information	Sources, Motivators, Motivating factors, Species selection	Name and Check list	HH Survey
		Perception of tree planting	"	
Extension	Existing extension program	Extension worker (EW) Visits by EW Observtion tour	Number	Household Survey
		Demonstration Sites, Extension materials	Places, species, types and numbers	Observation
	Training	Types: Crops, livestock, Horti, Agroforestry, Forestry, Others	Number by men and women trained	Household Survey
	Method of Communication	Received by: Mass, Group Individual	Yes/No	RRA session
Institutional role in agroforestry promotion	Type of Institutions	NGO/ FUG local group Saving & Credit organization	Name and number,	P/RRA, HH Survey
	Role in AF promotion	Memberships in organization Awareness NGO support Training and marketing	Number, Male and Female Yes/No	Group Discussion, HH Survey

Parameters	Complex Variables	Simple Variables	Values	Source of Information
Indigenous knowledge about Agroforestry	Classification of Financially attractive agroforestry species	With respect to: Soil fertility Soil erosion control Fodder Quality Moisture Bulky ness Preference by animals Pest control Manuring Others	Local terminology, statements, key words	P/RRA, informal discussions
		Type of Trees	List of names	RRA
	Classification lands	By elevation, slope, fertility status, moisture regimes, fragmentation, distance from the household, tenure arrangements.	Local names, statements, keywords	P/RRA, literature search, validation and cross checking
	Indigenous knowledge on insect pest control	Species used for particular insect or pests and the process	Listing the information	"
	Classification of forest, shrub grazing and pasture lands	By different types	Terminology, and significance	
	Generation of knowledge	On new technology, new variety of crop or a new breed	Qualitative information Who? And how	P/RRA

	Dissemination of knowledge	By Farmers: Means of communication Communicator, Character of message, Character of communicator By Local NGO: Characteristics of NGO, Method of dissemination , approach and the content	Qualitative information	"
	Retention of knowledge	Influencing factors	Listing the factors	P/RRA sessions
Forestry	Community Forest	FUG No of Users Accessibility Opening time of the year Benefits : Fodder Fuelwood Leaf litter Poles/ Timber Others	Yes /No Number Yes, No Number of days, time/season Bhari " Bhari Number	P/RRA " " " P/RRA, Household Survey
Government policies	Sectoral policies	On agriculture and Forestry	Rules and regulations Problems, Farmers perceptions	Literature, Discussions

Cost and Benefit of Agroforestry Project:

Parameters	Complex Variables	Simple Variables	Values	Source of Information
Economic and Financial analysis	Output from the system	Amount Produced from Crops, Trees, livestock; Amount consumed, Crop sale, Animal or animal product sale, Cash crop sale, Wage/ service Business Agroforestry product sale (Crop residue, fodder/grasses, Fuelwod/timber Medicinal product sale Soil fertility and Protection gain	Selling Price per Unit of the products sold and the amount sold in Kg, or equivalent cash conversion	Household Survey for Case study
	Expenditure/ Input Costs	Seedling/ Seeds Production, Fertilizers Labor (Planting to harvesting) Draft animals Cash, Loans Feed/ Fodder Taxes Interest paid	Rs. Per unit input used and amounts of inputs used.	Household Survey

APPENDIX - B

Questionnaire for Household Survey

Name of village development committee: Date :

Village: Ward no:.............

Household sample no: Interviewer:

Respondents' Ideographic data

Name of the respondent: Caste:

Age: Occupation: Education:

A. Demographic Information

Q. No. A. 1. Household size, sexes composition and age structure

Age group	Male	Female
Below 5		
5 - 10		
10 - 59		
60 and above		
Total		

Q.No. A. 2. Educational status of household members above 5 years (number)

	Literate				Illiterate
	Just literate	Primary school	Secondary School	Higher Education	
Male					
Female					

Q.No.A.3. Occupation of household member above 10 year (# of persons)

Occupation	Female	Male
Agriculture		
Agriculture and Service		
Agriculture and business		
Business/ Tea shops		
Public services/Teaching		
Private Services/ Construction work		
Cottage industry		
Study		
Without any occupation		
Other ....Specify		

Q. No.A.4. Has any member of your family been out of home for more than three months?
Yes ( ) continue Q. No. A.5 ; No ( ) Go to Q.No. B.1

Q.No.A. 5. Where and on what occupation they are working?

S.No	M	F	Age	Occupation	Place of work	Period of Stay

Occupation: 1. Agriculture 2. Business/Trade 3. Industry 4. Service 5. Teaching 6. Military/police services 7. Study 8. Construction 9. Wage labor

B. Land Holding Size and Tenure Status

Q.No.B.1 How much land of the following type do you hold? (land owned by the household).

RECORD THE RESPONSE IN THE TABLE BELOW (AREA IN ROPANI)

Land Uses	Lowland (Khet)		Upland (Bari)		Kharbari	Bagaicha	Private forest
	Irrigated	Rain-fed	Gharbari	Other bari			
1 Owner operated							
2 Rented in							
3 Rented out							
4 Others							
Total							

Q. No.B.2 Do you have some land, which is not in use and could be used for planting tree/grasses? Yes ( ) continue Q.No. B.3 No ( ) Go to Q. No. C.1

Q. No. B.3 If yes, how many more Fruit, fodder trees and grasses can you plant on such land (terrace risers, non-cultivated inclusions) without decreasing your present level of crop yield?
Please mention in number of trees and # of Kanlas of grass as appropriate.

Types	Number	Place of planting
Fruit trees/ shrubs		
Fodder trees / shrubs		
Medicinal shrubs		
Grasses (# of Kanlas left without)		

C. Farm activities

Crop production:

Q.No.C.1 What Crops did you cultivate last agriculture year?(Baisakh 2054 - Chaitra 2054)
Q.No. C.2 How much area did each crop cover?
Q.No. C.3 How much quantity was produced?

READ OUT THE LISTED ITEM AND RECORD THE RESPONSE AS APPROPRIATE

Q. N. C.1 Crops	Q. C.2 Area Covered	Q. N. C.3 qty. produced
Paddy		
Maize		
Wheat		
Millet		
Potato		
Kidneybean		
Horsebean		
Soybean		
Vegetables		
Others		

Note: Area = in Ropani Production = in Muri
Please record the selling and buying prices of the major crops separately.

Q. No. C.4 How long the field crop production can meet your household food demand?

3 months	6 months	9 months	whole year

D. Livestock

Q. No. D.1 Livestock herd size and type

Livestock species	Adult		Young		Breed	
	Male	Female	Male	Female	IMPVD	Local
Buffalo						
Cattle						
Sheep						
Goat						
Pig						
Chicken /Duck						

Q.No. D.2 How much milk produced last year? (No. of lactating animals and milk yield)

Livestock	Total number	Annual milk prodn (Pathi)
Local Buffalo		
Improved Buffalo		
Local Cow		
Improved Cow		

Q.No. D.3 What livestock and livestock products did you sold last year and total earnings?
RECORD THE RESPONSE

Q. D.3 Livestock / Livestock products	Earnings (Rs.)
1. Sale of animals (cow, buffalo, goats, sheep, pigs)	
1. Fresh milk	
2. Milk products	
3. Bullock rented out	
4. Manures	
5. Eggs and Chickens	
6. Meat selling	
7. Others (Specify)	
Total:	

Q. No. D.4 Do you graze some or all of your livestock in forest and rangeland? (Tick off)

Grazing area	Frequency			
	Daily	Every 2 days	Twice a week	Thrice a week
Forest				
Rangeland				

Q. No. D.5 Problems being confronted in regard to livestock raising?

1...

2...

3..

4..

Q.No. D.6 Please mention the type of animals and the prospects for development in this area.

Type of animal	Dairy products	Meat
1		
2		
3		
4		

E. Agroforestry:

Q. No.E.1 Please provide information on land use and fragmentation (Please write the every piece of land separately with the location).

Plot # and identification of the different plots of Bari and Khet land***	Distance from house*	Type of land**	Area (ropani)	Total annual Production (Muri)				
				Maize	Millet	Ric e	W hea t	Leg ume
1. Gharbari								
2								
3								
4								
5								
6								
7 Khet								
8								
9								
10								
11								
12								
13 Kharbari								
14								
15 Others								

*** Please include the rented in land but exclude the rented out (Area in ropani and ana)

** Type of Land: 1= Aul; 2= Doam; 3= Sim ; 4= Chahar
* Walking distance in minute; # Including all the crops grown in one year

Q. No.E.2 Please mention the number of agroforestry species and practices in different plots.

Plot # and name (Sameas above)	Total number of trees/shrubs						BN	G @	LF Y/N	OT
	FT	FS	Fruit	FFW	OCT	MP				
1. Gharibari										
2. Bari										
3.										
4.										
5.										
6.										
7. Khet										
8										
9										
10										
11										
12										
13 Kharbari										
14										
15 Others										

Note: FT= Fodder Trees; FS= Fodder Shrubs; FFW= Fodder/Fuelwood Trees;
OCT= Other Commercially Valuable Trees; MP= Medicinal plants;
BN= Bamboo, Nigalo etc. G= Grasses/ Hedgerows; (# of kanlas)
LF= Live Fence (Y= Yes ; N= No); OT= Other shrubs and nuts

Q. No E.3 Do you have a homegarden (Bagaicha)?

Yes (.........) Continue Q. No. E.4 No (......) Go to Q. No. E.6

Q. No. E.4 If yes, how big? ....ropani

Q. No. E.5 Please mention composition of agroforestry species and their number in your Bagaicha?

Type of species	Area covered (Ropani)	Total number
Fruits:		
Fodder:		
Timber/Fuelwood:		
Cash crops:		
Medicinal:		
Others:		

Q.No. E.6 Which types of trees/shrubs/grasses do you have and how many? Also mention amount produced?

LIST ALL THE FRUIT, FODDER, SHRUB, TREES AND GRASSES OF FARMERS FARM

Fodder, shrubs and trees	# of trees Naturally protected	# of trees planted		Lopping cycle/yr	Prodn per Lopping
		Exotic	Local		
1 Phosro					
2 Gayo					
3 Khanyu					
4 Kutmero					
5 Siris					
6 Badahar					
7 Dabdabe					
8 Bans					
9 Tanki					
10 Painyu					

11 Newaro					
12 Ipil Ipil					
13 Bhatmase					
14 Gajuma					
15Nigalo/Bambo					
16					
17					

Fruit	# of trees Naturally protected	# of trees planted		Productionn per harvest		
		Local	Exotic	1	2	3

Medicinal Or NTFP	Naturally grown clumps	# of tree/ clumps planted		No. of harvest and Production per harvest		
		local	Exotic	1	2	3

Fuel /fodder and Timber trees	Naturally grown trees	# of trees planted		No of harvest and Production per harvest		
		Local	Exotic	1	2	3

Type of Grasses	# of Kanla or area	No.of Cuttings /yr.	Yield/ Kanla (Bhari)

Other Economically valuable trees:

Type of species	Total number	Total earnings
Chiuri		
Rittha		
Lokta		

Q. No. E.7 Kindly mentions proportional contribution of fodder from each source.

READ OUT THE LIST AND TICK OFF (MULTIPLE CHOICE)

Sources	Q. 30 Proportional Contribution			
	1/4	1/2	3/4	All
Forest				
Grazing land				
Kharbari				
Stream/River bank/degraded land				
Farmland (Fodder, crop residue)				

Q. No. E.8 How much fodder/grasses do you use in a day for your livestock from each source, for each season?

RECORD THE RESPONSE (Amount in Bhari per Season and Source)

Sources		Rainy Season	Winter Season	Dry Season
Tree and shrub fodder	Forest			
	Farmland			
Grasses	Forest			
	Farmland			
Agricultural by-products				

Summer(Pha-Jest).. Rainy (Ash-Aswin).. Winter (Kartik-Magh)..

Q. No. E.9 Is there possibility of fulfilling the entire fodder requirement of livestock by improving your farm tree fodder and grass production?

Yes ( ); Continue Q. No. E. 10No ( ) Go to Q. No. E. 11

Q. No. E. 10 If yes, why did not you make any efforts? Please give reasons.

1
2
3
4

Q. No. E. 11 If no, Please explain why?

1
2
3

Q. No. E.12 Fuelwood and Fodder Collection time from Non-farm sources (record in hours and minutes)

Type of resource	Before 10 years	Present time
Fuelwood collection		
Fodder		
Grasses		

Q. No. E.13 Approximately how much of fuelwood do you collect from different sources per week?

READ OUT THE LIST AND RECORD THE RESPONSE

Sources of fuelwood	Quantity (Bhari) per Season		
	winter	Dry summar	Rainy Summar
Forest			
Private land			
Community land			
Others			

Q. No. E.14 Do you use some of the crop residues as fuelwood?

Yes ( );Continue Q. No. E.15; No ( ) Go to Q. No. F. 1;
Don't know ( ) Go to Q. No. F.1

Q. No. E. 15 If yes, How much did you use last year? ....Bhari

F. Tree-crop interaction

Q. No. F.1 Please tell whether crop yield is adversely affected by trees/shrubs/grasses grown in association with crops? (Place the type of crops as appropriate- see coding for crops)

RECORD THE RESPOSE AS APPROPRITE (MULTIPLE RESPONSE)

Type of vegetation	Not affected	Slightly affected	Moderately affected	Highly affected
Trees				
Shrubs				
Grasses				

1= Maize; 2= Rice; 3= Wheat; 4= Millet; 5= Legumes crops

Q. No. F.2 Farmers view on losses due to tree/shrub/ crop interactions (Please write the species name as appropriate in the given column)

Location of tree	Severity of Damage			
	High	Medium	Low	None
Near water or water canals				
Terrace risers				
Non-cultivated inclusions				
Corners of the terraces/plots				
Along the road sites				
Along the fences, boundary				

Q. No. F.3 Please express your degree of agreement in regard to farm trees/shrub formation?

READ OUT THE LIST AND TICK OFF AS APPROPRIATE

Statement	Degree of agreement		
	A	D	DK
Positive Responses			
Trees provide economic benefits			
Trees provide Natural beauty			
Trees conserve soil & reduce soil erosion			
Increase soil fertility			
Increase crop yield			

Increase livestock productivity			
Negative Responses			
Roots hinder plowing operation			
Trees are available in the forest			
Trees takes long time to get return			
Trees occupies crop land			
Trees cause damage to the field crops through shading effect			
Trees harbour insects and pests that damage field crops			

Note= A= Agree D = Disagree DK= Do not know

Q. No. F.4 Do you have experience to what extent trees on terrace risers, bunds adversely affect crop yields?

Yes ( ) continue Q. No. F.5; No. ( ) Go to Q. No. F.7
Don't Know ( ) Go to Q. F.7

Q. No. F.5 Please record the following yield figures

Crop	Estimated Yield (Muri per ropani)	
	Yield "with" Trees	Yield "without" trees
Maize		
Millet		
Rice		
Wheat		

Q. No. F.6 If yes, what can be done to minimize the loss of crop yield? Please suggest

1

2

3

Q. No. F.7 Do you think that managing tree height by regular pruning to control negative interaction effect with the field crops is a better practice than the old system of keeping taller species.

Yes ( )Go to Q. No.F.9; No ( ) Continue Q. No. F.8; Don't know ( )

Q. No. F.8 If No, why? Please give reasons

....

....

....

Q. No.F.9 Relative advantage and disadvantage of planting trees on terrace risers with controlled heights .

Statements	Agree	Disagree	Don't know
Less Shade			
Better use of empty terrace risers			
Becomes more fertile			
Not much negative effect on crop yield			
Easy to cut fodder by women and children			
Increased terrace stabilization			
Obstruction by roots for ploughing			
Higher labor requirement			
Higher Cost of establishment			
Reduce soil erosion			

Q. No. F.10 Please specify your preferred tree, shrub and grass species?

Use of species		Species
Fodder	Trees	
	Shrubs	
Fuelwood	Trees	
Fruits	Tree	
	Shrubs	
Grasses		
Timber	Trees	
Commercially Valuable	Trees	
	Shrubs	

Q. No.F.11 What factors do you think makes people to plant more trees/shrubs on their farm? (Please tick off the responses but do not read out the statements below)

.

Statements	FD	FT	F	IT	G	H
Relatively higher land holding size encourages planting						
Encourages to plant trees for industrial purpose						
Market facilities induces plantation of						
Improved livestock breeds increases the planting of						
People with buffalo and cows for milking will plant						
When people know the better quality species, they plant						
Others (specify)						

Note: FD= Fodder; FT= Fuelwood/Timber; F= Fruits; IT= Industrial trees
G= Grasses; and H= Herbal medicinal plants

Q. No. F.12 Are you aware of some species of shrub fodder which are as good as tree fodder in terms of amount and quality of production?

Yes ( ) Continue Q. No. F.13   No ( ) Go to Q. No. F.14

Q. No. F. 13 If yes, what are those species? Record the names

1
2
3
4

Q. No. F.14 Please comment on the use of existing Agroforestry technologies and their role in solving the various farmers' problems (Tick Mark as appropriate: Multiple answers)

Agroforestry Technologies	F	FD	SF	SE	FW	M	P	T	FB	A	O
Hedgerow intercropping											
Mixed intercropping											
Trees in marginal land											
Living Fences											
Trees in the homegarden											
Trees/grass on terrace risers											
Trees in Kharbari											
Boundary planting											
Trees on non-cultivated inclusions, shelter/wind belts											

F= Food   FD=Fodder   SF=Soil Fertility   SE= Soil Erosion   FW= Fuelwood

M= Medicine P= Protection T= Timber   FB= Field boundaries A= Aesthetic O= Others

G. Land Fertilization

Q. No. G.1 Please mention the yields of staple crops compared with 10 years ago.

Land type	Same	Low	High
Bari			
Maize			
Millet			
Wheat			
Khet:			
Rice			

Maize			
Wheat			
Gharbari:			
Maize			
Millet			
Wheat			

Q. No. G.2 If yields of some crops declining, please give reasons? (Tick Mark as appropriate)

Causes	Tick off
Aggravating soil fertility caused by inadequate fertilizer supply	
Low yields due to land fragmentation	
Increased intensity of cropping and higher soil nutrient mining.	
Incidence of increased pest and diseases	
Poor genetic quality of the local variety	

Q. No. G.3 How much fertilizer did you applied in your field last year?

Type of land	Chemical Fert. (Kg)	Compost (Doko)	Green Manure (Bhari)
Gharibari			
Bari			
Khet			

Q. No. G.4 How much leaf litter did you collect last year for utilizing livestock beddings?

Use of different materials in different season (Bhari per season)			
	Winter	Dry	Rainy
Forest			
Farmland			

Q. No.G.5 How much manure was produces last year and compare with 10 years before?

Year	Farm Yard Manure production (Bhari)
Last one year period	
Before 10 years (Figure for one year only)	

Q. No. G. 6 Please give information on Agroforestry management practices

Farm agroforestry activities	A	B	C	D	E
Land Preparation					
Seedling and seedbed preparation					
Planting and Weeding					
Plant care and manuring					
Harvesting the products					
Others					

Code: A= All by women; B= All by men; C= Both (50% each);
D= 75% by Women & 25% by Men; E= 25% by Women & 75% by Men

H. Extension and Adoption

Q. No. H.1 Whether Extension workers visit your village?

Yes ( ) Continue Q. No. H.2 No ( ) Go to Q. No. H.4

Q. No.H.2 What kind of support services you got from extension worker?

Yes ( ) No ( ) NA ( )

READ OUT THE LIST

Type of support services	Frequency per year
Training on agroforestry (livestock, nursery, fruit & vegetable cultivation)	
Technical advice on agroforestry	
Check up services for your animals	
Training on veterinary and animal health	
Number of visits by an extension worker to you	
Observation visit	
Breeding and Vaccination	
Treatment of diseases	

Q. No. H.3 Have you ever been to the district local agriculture extension office for their service?

Yes ( ) continue Q.No. H.5 ; No ( ) Go to Q. No. H.7

Q. No. H.4 If yes, frequency of visit during last year. .... times

Q. No. H.5 Whether they informed you about the agroforestry?

Yes ( ); No (........)

Q. No. H.6 Did any of your family member (s) are trained in livestock, agroforestry activities?

Yes ( ) No ( )

Q. No. H.7 If yes, who? Male ( ) Female ( ) Both ( )

Q. No. H.8 Have you ever heard about or observed somewhere the improved agroforestry species and practices? (Please mentions the practices and tick marks as appropriate).

Agroforestry species	Yes heard	No	Specific practices (Please list)
Fruit			
Fodder			

Fuelwood/Timber			
Other shrubs/trees			
Grasses			

Q. No. H.9 Please indicate from whom you heard about the particular species and practices.

Species	From Whom you heard about the species/practices
Fruit	
Fodder	
Fuelwood/ Timber	
Other shrubs/trees (Bambo, Chieuri)	
Grasses	

Q. No. H.10 What are you considering in regard to these practices? (Tick mark as appropriate)

Present Situation with respect to adoption	Fruit	FD	FT	OS	GR
I have heard only and am simply aware of it					
I have observed and know the practices					
I started Nursery and will start some species in my farm					
I have already adapted certain practices					

Code: F= Fruit; FD= Fodder; FT= Fuelwood/ Timber; OS= Other shrubs/tree; GR= Grasses

Q. No. H.11 If already started or adopted, who advised you to do so, in each case?

Source of advice on adoption	Fruit	FD	FT	OS	GR
Family members					
Extension worker					
Village NGO/ Beneficiaries group					
Others (specify)					

Q. No. H.12 Do you know about some exotic fruit, fodder, grasses and other plant species?

Species of	Yes	No
Fruit		
Fodder		
Fuelwood / Timber		
Other important shrubs/trees		
Grasses		

Q. No. H.13 If yes, how did you know this for the first time? MULTIPLE ANSWERS

Source of information	Fruit	Fodder	FT	Grass
Observing somewhere else practiced				
Friends, and relatives				
Training, group meetings, information brochures				
Local institutions, and Group members				
NGO field staff and visitors				
Village elders and leaders				
Exposure visit, or farmers' study tour to AF sites				
Observing the NGO agroforestry project implemented				
Radio program				
Extension worker				

Q. No. H.14 Who is the main motivator that influenced you to start agroforestry?

MULTIPLE ANSWERS

Motivator (s)	Fruit	Fodder	FuelTimber	Grass
Household member				
NGO (Nepal Agroforestry Foundation)				
Local/ Villager NGO (……………………..name)				
Relatives, friends, village elders, neighbors				
Agroforestry group members in the village				
Own initiative after observation/ exposure visit				
Extension worker				
Others ………………………………….(Specify)				

Q. No. H.15 How did you decide to choose agroforestry species for planting?

MULTIPLE ANSWERS

Criteria for choosing the species	Fruit	FD	FT	Grass
What others in the village said about the species				
Asked with another farmer who had tried the species before?				
After observing the benefits from the particular species?				
NGO people motivated to adopt certain species				
What was available in the village or the nearby nursery				
Others ……………………………………………(specify)				

Note: FD= Fodder; FT= Fuelwood/ Timber

Q. No. H.16 What are the main motivating factors to start agroforestry?
TICK OFF THE PRIORITIES

Factors	1= high	2= Medium	3= Low	4= Least
Fodder Scarcity				

Fuelwood/ Timber scarcity				
Closure of the community forests				
More time taken to collect fodder & fuelwood				
High animal production from good breeds				
For Fruit cultivation to sell				
Better markets for tree and tree products				
Manuring the field				
Multiple outputs from the per unit land				
Others............................(specify)				

Q. No. H.17 Are you considering to plant additional tree/shrub/grasses for fodder, fuelwood and fruits in your farmland due to high demand for family needs?

Yes ( ) Continue Q. No. H.18; No ( ) Go to Q. No. H.19

Q. No. H. 18 If yes, why did not you plant so far? (MULTIPLE RESPONSE); Go to Q. H.20

Reason for not planting	Tick mark as appropriate
Do not have land right	
Can not decide on which species to plant	
Do not know about the improved species and practices	
Have enough trees in the farm already	
Are able to manage somehow/ Life is maintaining as it is	
Due to fear of loosing the crop yield	
No market for tree products and less monetary returns	
It takes longer time to get returns from trees	
Do not have sufficient land for planting tree species	
Availability of household labor is a problem	
No one is telling us to practice such practices	
Fear of Government policies towards not allowing to cut trees	
Others	

Q. No. H. 19 If no, Why?

1.
2.
3.

Q. No. H.20 What type of the plant species do you prefer to plant? Please prioritize with 1 as the most preferred and 5 as the least. (PRIORITIZE 1-5 as appropriate)

Type of plant species	F	FD	FT	Food	MP	SP
Tall trees (fodder, fruit, timber, food)						
Shrubs (fodder, fruit, food, medicinal, NTFPs)						
Other economically valuable tree and shrubs						

Grasses						
Others............ (specify)						

Note: F=Fruit: FD= Fodder; FT= Fuelwood/ Timber; MP= Medicinal plant
SP = Soil protection/conservation

Q. No. H. 21 In what condition (s) you would be interested to increase agroforestry practices? Tick off as appropriate.

	Fruit	Fodder/Fue l	Timber	Medicinal	Industrial raw material
Provision of Market					
Improved animal breeds					
Have more lands					
If forest/ grazing land is closed					
Provision of cutting trees freely from the farm land					
Have more non-cultivated inclusions					
Have higher empty terrace risers					
Others (specify)					

Q. No. H. 22 Where and to whom do you sell the agroforestry products? And earning from last year.

Products	Amount sold	Earning (Rs.)	Where to sell*	Whom to sell**

* Place of selling: 1= Village; 2= Local Market Center; 3= District Market;
4= Hat bazar; 5= Regional market center; 6= Kathmandu
** Whom to sell: 1= Fellow Villagers; 2= ItinerantTraders; 3= Traders at the market centre 4= Retailer at the market center; 5= Consumer at the market center

Q. No. H.23 Do you know that there is demand for the agroforestry products?

Yes ( ) continue Q. No. H. 24; No ( ); Don't Know ( ) Go to Q. No.H.25

Q. No. H. 24 If yes, specifically what product? Please mention the type of products.

1.
2
3
4
5
6
7

Q. No. H. 25 Who goes for marketing? PLEASE TICK MARKS AS APPROPRIATE.

Cases	Tick Marks
Always men do the marketing	
Always women do the marketing	
Both men and women do in equal proportion	
Women do by 75% of the times	
Men do by 75% of the times	
Rarely done by women	

Q. No.H.26 Who makes the decision in the family in the different conditions? Please mention as appropriate.

Conditions	Female	Male	Both
Planting the field crops			
Seed/Plant species selection			
Weeding time and number of weeding			
Fertilizer application			
Harvesting, threshing and storing			
Grain buying and Selling			
Introduction of new agrforestry species			
Livestock buying, selling and fixing the prices			
Collection fuelwood and fodder for animals			
Keeping a new breed and Size of the livestock			
Fruit tree planting and species selection			
Fodder/ timber tree and shrub planting			
Nursery establishment and care			
Introducing the new agroforestry species			
Hiring the labor for work			
Taking land on rent or for share cropping			
Renting out the land to some one in the village			
Buying and selling the land resource			
Others			

Q. No. H.27 Who feeds, takes for grazing and collect fodder/grasses for the animals? And by how much proportions? (Tick Mark as appropriate)

Proportion of the work done	Animal Care		Collection of	
	Feeding	Herdin g	Fodder	Fuelwood
Done by women' only				
Done by men only				

Done by both (50% each)				
75% by women and 25% by men				
25% by women and 75% by men				
Others..............................				

Q. No. H. 28 What are the best alternatives or practices to start in this village which brings more profit to your family? (Please mention the type of crops, animals, trees, medicinal plants and other non-farming activities).

1

2

3

4

I. Institutional

Q. No. I.1 Are you a member of any organization?
Yes ( ) Continue Q. No. I.2; No. ( ) Go to Q. No. I.3; Don't Know ( )

Q. No. I.2 If yes, what type?

NGO ( ) Farmer's group ( ) FUG ( ) CDC ( )
Saving and Credit group ( ) Women's group ( )

(CDC= Community Development Committee; FUG= Forest Users Group)

Q. No. I.3 Do any of your family members belong to any organization?

Yes ( ) Continue Q. No. I. 4; No. ( ) Go to Q. No. I.5

Q. No. I. 4 If yes, who? Women ( ) Men ( ) Both ( )

Q. No. I.5 Is (are) the NGO in your village is involved in agroforestry promotion?

Yes ( ) No ( ) Don't Know ( )

Q. No. I.6 In your opinion what are most feasible alternatives to the field crop production in this area?

1

2

3

Q. No. I.7 What do you think, the farmers can do best to increase production from their farm? If some organization or Government want to promote?

1.

2

3

4

Q. No. I.8 Do you believe that growing of timber, fruit and medicinal trees and shrubs is more profitable than field crops? If markets are available.

Yes ( ) No ( )

Q. No. I.9 Is it possible to shift from crop cultivation to livestock raising only?

Yes ( ) continue Q. No. I.10; No. ( ) Go to Q. No. I.11

Q. No. I. 10 If yes, why so far you have not done so?

1
2
3

Q. No. I.11 If no, why?

1
2
3

Q. No. I.12 What policy changes of the government will motivate farmers to plant more trees? (Please suggest the desired policies to promote planting and tick mark as appropriate).

Desired Policies	Fruit	Fodder	Fuelwood/Timber	Other economically valuable tree/shrubs

Appendix C: Supplementary Tables

Table: A4.1 Basis of Converting Livestock Heads into Livestock Standard Units (LSU)

Sr. No.	Species	Categories	LSU
1	Buffalo	An adult milking buffalo	1.00
		An adult he-buffalo used for power or breeding	0.95
		Young stock	0.71
		Calf	0.30
2	Cattle	An adult milking cow	0.69
		Bullocks used for animal power	0.95
		Young stock	0.38
		Calf	0.25
3	Goat/Sheep	Adult males	0.25
		Adult females	0.22
		Young stock	0.07
4	Pig	Adult pig	0.30
		Young piglets	0.10

Source: Regmi, (1999)

Regmi, P.P. (1999). Agricultural Development through Eco-Restructuring in different ecological zones across Nepal, Ph.D. Dissertation, AIT.

Table A5.1 Fodder trees and shrubs found in the study area

Species	Nepali Name	Scientific Name
Local species	Bamboo	*Dendrocalamus spp.*
	Badahar	*Artocarpus lacochha*
	Bakaino	*Melia azedarach*
	Bhotepipal	*Populus species*
	Khanyu	*Ficus semicordata*
	Khasru	*Quercus semacerpifolia Sm.*
	Berulo	*Ficus subinsiza*
	Koiralo	*Bauhinia variegata*
	Khasreto	*Ficus hispida L.*
	Malingo Nigalo	*Arudinaria racemosa*
	Pakhuri	*Ficus glaberrima*
	Ginderi	*Premna barbata/ integrifolia*
	Kutmiro	*Litsea monopetala*
	Kapro	*Ficus lacor*
	Paiyu	*Prunus cerasoides*
	Bhimsenpati	*Buddleja asiatica*
	Chiple	*Villebrunnea frutescens*
	Chuletro	*Brassaiopsis hainla*
	Dabdabe	*Garuga pinnata*
	Dudhilo	*Ficus neriifolia*
	Dumri	*Ficus glomerata*
	Nimaro	*Ficus auriculata*
	Tanki	*Bauhinia purpurea*
	Siris	*Albizia spp.*
	Rato siris	Albezzia julibrison
	Raikhanyu	*Ficus semicordata*
	Rahari	*Cajanus cajan*
	Timilo/ timila	*Ficus auriculata*
	Ginderi	*Premna integrifolia*
Introduced fodder tree species	Ipil-Ipil	*Leucaena leucocephala*
	Ipil- Ipil K-156	*Leucaena diversifolia*
	Ipil-Ipil	*Leucaena pallida*
	Kimbu	*Morus alba*
	Bhatmase Flemengia	*Flemengia congesta*
	Guazuma	*Guajuma ulmifolia*
	Bhatmase	*Flemingia macrophylia*

Table A5.2 Major tree species found in the study area

Nepali Name	Scientific Name
Bakhre	*Reinwardtia indica*
Botdhayaro	*Lagerstromia parviflora*
Barro	*Teminalia bellerica*
Champ	*Michelia champaca*
Chilaune	*Schima wallichii*
Dar	*Boehmeria regulona*
Gayo	*Bridelia retusa*
Gogan	*Saurauia nepaulensis*
Gedulo	*Ficus clavata*
Harro	*Terminalia chebula*
Katus	*Castanopsis indica*
Kharsu	*Quercus semicarpifolia*
Kyamuno	*Syzygium cerasoides*
Jamuna	*Eugenia jambolana Lam.*
Kali kath	*Myrsine semiserrata wall.*
Madan (Maidal)	*Randia dumetorum*
Phalant	*Quercus gluaca*
Sajh	*Terminalia tomentosa*
Sal	*Shorea robusta*
Sisau	*Dalberzia sisoo*
Utis	*Alnus nepalensis*

Table A5.3 Fodder/ Grass species commonly found in the study area

Agroforestry Species	Nepali Name	Scientific Name
Local species	Banso	NA
	Khar	*Typha angustata*
	Kharuki	*Pogonatherum incans*
	Musekhari	*Pogonatherum paniceum*
	Phurki	*Arundineria falcata*
	Siru	*Imperata sp.*
	Titepati/ Gandhe Jhar	*Arteminia vulgaris*
	Amliso (Broom grasss)	*Thysanolaena maxima*
	Kans	*Vetiverra zizanioides*
	Kaule/Kaulo	*Machilus oderatissima*
	Rahari (pigeon pea)	*Cajanus cajans*
Introduced species	Berseem	*Trifolium alexandrinum*
	Lucerne	*Medicago sativa*
	Oat	*Avena sativa*
	Bhatmase (Flemengia)	*Flemengia congesta*
	Stylo	*Stylosanthes humilis*
	NB 21	*Napier and Brachheria cross*
	Rye grass	*Lolium perenne, L. multiflorum*
	Molasses grass	Melinis minutiflora
	Cocksfoot	Dactylis glomerata
	Stylo	Stylosantes guinensis
	Velvet bean	Stizolobium pruriens
	White clover	Trifolium guinensis
Green manure species	Asuro	*Adhatoda vasica*
	Titepati	*Artemisia vulgaris*
	Dhaincha	*Sesbania species*
	Sesame	*Seasmum indicum*
	Albizia	*Albizzia species*

Table A7.1 Summary of soil test results by type of land use

Soil variable	With Project		Without Project		Total		F-Value	Sig.
	Mean	CV	Mean	CV	Mean	CV		
pH	6.4590	3.84	6.5650	2.68	6.5061	3.38	1.036	0.324
OM	1.8600	55.41	1.5325	54.8	1.7144	54.75	0.526	0.479
N	0.0900	58.77	0.0740	58.65	0.083	58.07	0.489	0.494
P_2O_5	60.3680	75.79	59.1387	79.65	59.8217	75.18	0.003	0.956
K_2O	152.5370	32.38	126.3987	43.68	140.92	37.05	1.122	0.305
Sand	33.1800	54.67	39.5750	46.09	36.022	49.81	0.550	0.469
Silt	43.600	31.17	38.750	47.30	41.444	37.55	0.417	0.528
Clay	23.240	28.82	21.6750	18.98	22.5444	24.84	0.333	0.572

Source: Soil test results, 1998

Table: A 7.2 Soil test results comparison between bari and khet land

Soil variables	Bari (n= 10)	Khet (n=8)	F-statistic	Significance
pH	6.54	6.455	0.768	0.394
Organic Matter (%)	1.327	2.198	4.659	0.046
Nitrogen (%)	0.063	0.1075	4.578	0.048
P_2O_5 ($kgha^{-1}$)	76.617	38.827	3.622	0.075
K_2O ($kgha^{-1}$)	155.92	122.166	1.964	0.180
Sand (%)	42.76	27.6	3.672	0.073
Silt (%)	34.80	49.75	5.086	0.038
Clay (%)	22.44	22.67	0.007	0.933

Source: Soil test results, 1998

Table A9.1 Financial benefit costs analysis of agroforestry

Benefit Cost Ratio per ha of agroforestry and non agroforestry production

			With agroforestry			Without agroforestry	
	Items	Unit	Rate/unit	Amount	Total Value	Amount	Total Value
Value of Outputs	Rice Yield	q	834	29.6	24686.4	28.3	23602.2
	Maize Yield	q	1112	19.1	21239.2	17.3	19237.6
	Millet Yield	q	834	0	0	4.5	3753
	Wheat Yield	q	1112	13.2	14678.4	9.1	10119.2
	Legume Grain Yield	q	1400	8.1	11340	7.3	10220
	Vegetable Yield	Rs	1	26189.9	26189.9	14909.9	14909.9
	Fruit Yield	Rs	1	3838.7	3838.7	881.9	881.9
	Tree fodder Yield	Bhari	20	498.5	9970	306.9	6138
	Grasses Production	Bhari	20	1005.2	20104	254.6	5092
	Fuelwood Yield	Rs	1	3593.6	3593.6	1905.2	1905.2
	Timber Yield	Rs	1	5920.9	5920.9	4082.5	4082.5
	Wheat/ Millet Straw	Bhari	25	44.2	1105	32.2	805
	Rice Straw	Bhari	60	114.7	6882	83.9	5034
	Maize Stalk	Bhari	30	167.5	5025	140.2	4206
	Maize Cobs Prodn.	Bhari	60	85.2	5112	48.4	2904
	Legume straw	Bhari	60	14.9	894	18.9	1134
	Poles Production	Rs	1	12701	12701	4389.8	4389.8
	Herbs Yield	Rs	1	20.2	20.2	0	0
	Green Manure prodn.	Bhari	20	31.8	636	15.9	318
	Vegetable Seeds	Rs	1	1468	1468	1415.3	1415.3
	Fruit Seeds	Rs	1	144	144	382.2	382.2
	Fodder/Grass Seeds	Rs	1	2076.5	2076.5	56.1	56.1
	Sericulture-cocoon sale		1	0	0	0	0
	Total Returns Rs.				177624.8		120585.9
Variable Costs	Seeds	Rs.	1	997.4	997.4	1661.41	1661.41
	Chemical Fertilizer	Rs.	1	3104.8	3104.8	2446.4	2446.4
	Farm Yard Manure	Bhari	20	776	15520	719	14380
	Insecticides	Rs.	1	1024	1024	1639.9	1639.9
	Draft animals	Days	120	54.9	6588	44.8	5376
	Male labor	Days	45	236.7	10651.5	260.7	11731.5
	Female Labor	Days	40	249.6	9984	214	8560
	sericulture raising			0	0	0	0
Total Var. Cost	Total Inputs	Rs.	0	0	47869.7	0	45795.21
Fixed	Irrigation	Rs.	200	1	200	1	200

Costs	Land Revenue	Rs.	10	0	10	10	10
	Depreciation	Rs.		560	560	560	560
	Credit	Rs.		7875	7875	6585	6585
	sericulture raising			0	0	0	0
Total Cost	Capital	Rs.			56514.7		53150.21
	Interest on capital	%	24		13563.53		12756.05
	Total capital Cost	Rs.			70078.23		65906.26
B- Cost Analysis	Net Returns	Rs.		107546.6		54679.64	
	BC Ratio	Rs.		2.534665		1.829658	
Opportunity	Male Family Labor	Days	45	197.7	8896.5	228.7	10291.5
	Female family Labor	Days	40	232.6	9304	193	7720
Farmer's Opportunity Cost	Family Labor	Days		430.3	18200.5	421.7	18011.5
	Hired Male Labor	Days	45	39	1755	32	1440
	Hired Female Labor	Days	40	17	680	21	840
Retained Cost	Total Cost	Rs.		38314.2		35138.71	
Return to Management	Total Return	Rs.		139310.6		142486.1	
BCR at Farmer's Opportunity Cost		Ratio		4.64		3.43	
NKR at Farmers' Opportunity		Ratio		3.636004		4.054961	
GM (Total Return - total Variable Cost)				129755.1		74790.69	

NKR at Farmers' Opportunity (Return to management/retained cost)
BCR at Farmer's Opportunity Cost (Total return /Retained Cost)
Return to Management (Total return- retained cost)
Retained Cost (Total Cost - Farmers' Opportunity cost)
Net Returns (Total Return - total capital cost)
BC Ratio (total return/total cost)

Table A9.2 Returns and investments on bee keeping

A case study on Bee Keeping: Nalang, Dhading.		
Details:		
Number of Hives		5
Production/hive/year	Honey (Kg)	8
	Wax (2% of honey)	0.16
Percentage of honey sold		90
Sugar (Kg/hive/year)		1
Labor (Persondays/hive/year)		5

Investment Required:			
Particulars	Quantity	Unit cost	Amount (Rs.)
Bee colonies	5	600	3000
Bee hives (improved Newton type)	5	1000	5000
Bee Veil	1	110	110
Swarm Bag	1	100	100
Smoker	1	90	90
Honey extrator	1	800	800
Queen excluder	1	100	100
Gloves	1	30	30
Feeding bottle	2	20	40
Hive tools	5	200	1000
Total			10270

Table A9.3 Financial cash flow analysis on bee keeping

1. Normal Case									
Cash flow analysis									
						Year			
A. Cash inflow	unit	Quantity	Unit price		1	2	3	4	5
Sales of honey	kg				14	35	35	35	35
Value	Rs.			180	2520	6300	6300	6300	6300
Sales of wax	Kg.				0.28	0.7	0.7	0.7	0.7
Value	Rs.			100	28	70	70	70	70
Total inflows	Rs.				2548	6370	6370	6370	6370
B Cash outflow									
Investment	Rs				10270	0	0	0	0
Sugar	Rs			25	50	125	125	125	125
Maintenance	Rs		LS		475	475	475	475	475
Labor	PD	5/Year		45	225	225	225	225	225
Total outflow					11020	825	825	825	825
Net cash flow (A-B)					-8472	5545	5545	5545	5545
NPV									5,461.35
B- C Ratio									1.487458
FIRR									54%
Debt service									
Interest @ 18%					0	1478.88	1109.16	739.44	369.72
Repayments					0	2054	2054	2054	2054
Outstanding loan					8216	6162	4108	2054	0
Debt service					0	3532.88	3163.16	2793.44	2423.72

NPV and Financial Internal Rate of Return (IRR) calculation

Year	Benefits	Costs	cashflow	Discount Factor 18%	PVB	PVC	NPV
1	2548	11020	-8472	0.847	2158.156	9333.94	-7175.78
2	6370	825	5545	0.718	4573.66	592.35	3981.31
3	6370	825	5545	0.609	3879.33	502.425	3376.905
4	6370	825	5545	0.516	3286.92	425.7	2861.22
5	6370	825	5545	0.437	2783.69	360.525	2423.165
NPV					16681.76	11214.94	5,461.35
B-C Ratio							1.487458
FIRR							54%

Table A9.4 Financial cash flows of bee keeping activities

2. 10% fall in output price
Cash flow analysis

				Year				
A. Cash inflow	unit	Quantity	Unit price	1	2	3	4	5
Sales of honey	kg			14	35	35	35	35
Value	Rs.		162	2268	5670	5670	5670	5670
Sales of wax	Kg.			0.28	0.7	0.7	0.7	0.7
Value	Rs.		90	25.2	63	63	63	63
Total inflows	Rs.			2293.2	5733	5733	5733	5733
B Cash outflow								
Investment	Rs			10270	0	0	0	0
Sugar	Rs		25	50	125	125	125	125
Maintenance	Rs		LS	475	475	475	475	475
Labor	PD	5/Year	45	225	225	225	225	225
Total outflow				11020	825	825	825	825
Net cash flow (A-B)				-8726.8	4908	4908	4908	4908
NPV								3,793.24
B- C Ratio								1.338713
FIRR								43%
Debt service								
Interest @ 18%				0	1478.88	1478.88	1109.16	739.44
Repayments				0	0	2054	2054	2054
Outstanding loan				8216	8216	6162	4108	2054
Debt service				0	1478.88	3532.88	3163.16	2793.44

	Year	Benefits	Costs	DF @18%	PVB	PVC	Cash flow
	1	2293.2	11020	0.847	1942.34	9333.94	-8726.8
	2	5733	825	0.718	4116.294	592.35	4908
	3	5733	825	0.609	3491.397	502.425	4908
	4	5733	825	0.516	2958.228	425.7	4908
	5	5733	825	0.437	2505.321	360.525	4908
NPV					15013.58	11214.94	3,793.24
B-C Ratio							1.338713
FIRR							43%

Table A9.5 Financial viability analysis on bee keeping

3. 10% increase in costs							
	Year	Benefits	Costs	DF @18%	PVB	PVC	Cash flow
	1	2548	12122	0.847	2158.156	10267.33	-9574
	2	6370	907.5	0.718	4573.66	651.585	5462.5
	3	6370	907.5	0.609	3879.33	552.6675	5462.5
	4	6370	907.5	0.516	3286.92	468.27	5462.5
	5	6370	907.5	0.437	2783.69	396.5775	5462.5
NPV					16681.76	12336.43	4,339.38
B-C Ratio							1.352235
FIRR							44%

4. 10% fall in output price and 10% increase in costs							
	Year	Benefits	Costs	DF @18%	PVB	PVC	Cash flow
	1	2293.2	12122	0.847	1942.34	10267.33	-9828.8
	2	5733	907.5	0.718	4116.294	651.585	4825.5
	3	5733	907.5	0.609	3491.397	552.6675	4825.5
	4	5733	907.5	0.516	2958.228	468.27	4825.5
	5	5733	907.5	0.437	2505.321	396.5775	4825.5
NPV					15013.58	12336.43	2,671.27
B-C Ratio							1.217011
FIRR							34%

Table A 9.6 Returns and investments of sericulture activity

	A Case Study: Sericulture (Naya Basti, Nalang, Dhading)					
	Cash Flow Analysis Area: 0.05 Hectares					
A.	Production of cocoons	1	2	3	4	5
	(Kg/year)	0	21	40	40	40
B.	Investment					
	1 Purchase of equipment	qty.	Unit cost	Amount (Rs.)		
	Secature	1	500	500		
	Pruning Saw	1	120	120		
	Spade	1	90	90		
	Mulberry cuttings	1000	0.1	100		
	Total			810		
	2 Rearing house & equipment					
	House construction	1	4500	4500		
	Leaf storage box	1	500	500		
	Rearing Stand	1	500	500		
	Rearing trays	10	90	900		
	Hygrometer	1	300	300		
	Cleaning nets	10	30	300		
	Leaf chopping board	1	100	100		
	Leaf chopping knife	1	100	100		
	Bucket	1	150	150		
	Montages	10	100	1000		
	Miscellaneous	1	100	100		
	Total			8450		
	Total (1+2)			9260		
C	Variable Cost	1st yr.	2	3	4	5
	Labor cost for cultivation	100	350	350	350	350
	Silkworm rearing cost	0	200	300	300	300
	Total	100	550	650	650	650

Table A9.7 Financial cash flow analysis of sericulture

1. Under Normal Condition							
			Year				
Inflows and Outflows	Unit	Price/unit	1	2	3	4	5
Cash flow							
Sales of Cocoons	Kg	140	0	21	40	40	40
Sales proceeds			0	2940	5600	5600	5600
Total inflows			0	2940	5600	5600	5600
Investment	Rs		810	8450	0	0	0
Cost of Cultivation	Rs.		100	350	350	350	350
Silk worm rearing cost			0	200	300	300	300
Total out flows			910	9000	650	650	650
Net cash flow before debt service			-910	-6060	4950	4950	4950
NPV							2610.05
B-C Ratio							1.31
FIRR							46
Debt Service							
Interest (@18%)			145.8	1666.8	1111.2	555.6	555.6
Principle			0	0	3086.667	3086.667	3086.667
Loan outstanding			810	9260	6173.333	3086.667	0
Total debt service			145.8	1666.8	4197.867	3642.267	3642.267

NPV and IRR calculations							
Year	Benefits	Costs	DF@18%	PVB	PVC	NPV	Cashflow
1	0	910	0.847	0	770.77	-770.77	-910
2	2940	9000	0.718	2110.92	6462	-4351.08	-6060
3	5600	650	0.609	3410.4	395.85	3014.55	4950
4	5600	650	0.516	2889.6	335.4	2554.2	4950
5	5600	650	0.437	2447.2	284.05	2163.15	4950
NPV				10858.12	8248.07	2610.05	2,606.18
B-C Ratio						1.316444	
FIRR							45%