APPRAISAL OF EXISTING AGROFORESTRY SYSTEMS IN SUB-TROPICAL REGION OF HIMACHAL PRADESH

Thesis

By

NARESH KUMAR

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Dedicated to

My

Family

Dr. R.K. Nayital,
Sr. Scientist

Department of Silviculture & Agroforestry,
College of Forestry,
Dr. Y.S. Parmar University of Horticulture
and Forestry, Nauni, Solan-173 230 (HP)

CERTIFICATE – I

This is to certify that the thesis entitled "**Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh**" submitted in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY** in **AGROFORESTRY** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) is a bonafide research work carried out by **Mr. NARESH KUMAR (F-2K-3-D)** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations have been fully acknowledged.

Place : Nauni, Solan
Dated : 31st July, 2004

(R.K. Nayital)
Chairman
Advisory Committee

CERTIFICATE – II

This is to certify that the thesis entitled "**Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh**" submitted by **Mr. NARESH KUMAR (F-2K-3-D)** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY** in **AGROFORESTRY** have been approved by the Student's Advisory Committee after an oral examination of the same in collaboration with the external examiner.

19/10/04

(R.K. Nayital)
Chairman
Advisory Committee

External Examiner

Professor and Head,
Department of Silviculture & Agroforestry

25/10/04

Dean,
College of Forestry,
Dean,
College of Forestry

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Being a social animal, no body is perfect, so all error, omissions are mine.

Place : Nauni, Solan
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(NARESH KUMAR)

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Acronyms

AF	Agroforestry
AFS	Agroforestry system
AS	Agrisilviculture
AH	Agrihorticulture
ASH	Agrisilvihorticulture
AHS	Agrihortisilviculture
PS	Pastoral silviculture
PSH	Pastoral silvihorticulture
PHS	Pastoral hortisilviculture
LF	Leaf fodder
FW	Fuel wood
M/Straw	Maize straw
W/Straw	Wheat straw
P/straw	Paddy straw
kg	Kilogram
ha	hectare
q	quintal
%	per cent

Chapter – 1

INTRODUCTION

INTRODUCTION

Forests play a very important role in socio-economic and ecological aspects of the life of man. They provide directly extractable products such as timber, fodder, fuel wood, food and many other non timber products in addition to indirect services in the form of contribution to biodiversity, nutrient cycling, and stability of the environment. Forests contribute 1.7 per cent of nation's gross domestic product (GDP). This does not take into account the unrecorded withdrawals (non-wood forest products). Moreover, the environmental benefits of forests also remain to be quantified and calculated (Singhal *et al.*, 2003).

Forest area constitutes about 19.39 per cent of total geographical area of the country (GOI, 2000). India in spite of having 2.2 per cent of the world's geographical area and 1.8 per cent of the world's forests, sustain 16 per cent of the planet's population (Khanna, 1996) and 15 per cent of its livestock (Oberoi, 1999). In India about 100 million people are dependent on the forests directly and 275 million indirectly (Saxena, 1999). Since 78 per cent of the forest area is subjected to grazing coupled with heavy removal of forest products and 51 per cent to occasional fire, hence, the productivity of these forests is low (Singhal *et al.*, 2003).

India with a population of more than one billion has always been concerned with food security for its citizens. Besides basic needs of food, requirement of fuel wood, timber and fodder has equal importance. With tremendous increase in human population, pressure on common property resources for fuel, fodder, timber etc. has increased substantially. This led to a huge gap between demand and supply of many forest products. The gap between the demand and supply of timber, fuel wood, green fodder, and dry fodder is 55, 74, 77 and 52 per cent, respectively (Roy, 1999). To feed the growing population, India followed the path of extensive agriculture, relinquishing the forests in favour of agriculture. This led to large-scale

deforestation and concomitant environmental problems. There is no further land available for extensive agriculture.

Under the conditions of unending heavy pressure of human and livestock population, decreasing land-man ratio, acute shortage of food, fuel wood, fodder, timber and other tree based products, continued land erosion, depletion of soil fertility and ecological imbalance, agroforestry has a great scope as a practical solution to many of these challenging problems.

Farmers have integrated trees in their farming systems for centuries (de Foresta *et al.* 2000). Agroforestry as a management practice is relatively new but as integral approach to land use, it has existed since the Neolithic period (Raintree, 1990). Agroforestry practices in India is old, traditional and practised in various forms (Solanki, 1998 and Sharma, 1996) and is based on the socio-economic, cultural, communication and demographic factors of the population, experiences of farmers and other related factors. It has received increased attention in recent years due to realization of its benefits over pure agriculture and forestry. One of the essential characteristics of agroforestry systems is the site specificity. The distinct agroforestry practices that constitute the major agroforestry systems in different places are only a few; the same practice takes various forms in different places depending on site, specific biophysical and socio-economic conditions (Nair, 1990). The improvement in traditional farm level tree growing/ agroforestry can be brought if site specific characteristics of the farms are studied and appropriate recommendations are made to remove the constraints and realize the potential.

Himachal Himalaya is basically an agro-ecosystem where 90 per cent of its total population lives in villages whose economy is dependent on agriculture, horticulture, sericulture and animal husbandry (Atul *et al.* 1994). Forests in Himachal Pradesh support the rural economy by providing fuel wood, fodder, timber, herbs, and medicinal plants (Sharma *et al.*, 1989 and Singh, 1995). Various fodder, fuel wood and timber trees are deliberately retained on the bunds

of agriculture fields and species composition varies depending on land holdings and basic requirements of the farmers of the state (Toky *et al.* 1989). There is preponderance of marginal (less than 1 ha) and small (1-2 ha) farmers in the state (GOHP, 1981). The recorded forest area in Himachal Pradesh is 63.5 per cent but the actual tree cover is 25.79 per cent of the total state's geographical area (FSI, 2001). Farm level tree growing or agroforestry can play a major role in meeting the wood and non-wood demands of farming community and relieving the pressure on existing forests. This will, consequently, enhance the tree cover in the state.

The weak scientific knowledge base about socio-economic and technical aspects of agroforestry systems and the value of local farmers' experiences make on farm research important in agroforestry. Moreover, diagnosis and descriptive research is required prior to long-term experimental programs. In order to improve the efficiency of indigenous agroforestry systems, as well as to assess the performance of improved technologies, we need to have a systematic procedure to evaluate such systems. These studies also help in assessment of profitability and acceptability of the systems.

Keeping in view its importance, the present study "**Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh**" was carried out with the following objectives:

(i) Study and analyze the socio-economic status of farmers

(ii) Identification of the existing agroforestry systems and to suggest potential tree-crop systems

(iii) Evaluation of biological yield and economic returns from existing agroforestry systems

(iv) Find out the technological gaps in the systems and suggest ways and means to over come them

Chapter – 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature pertaining to present investigation entitled **"Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh"** have been reviewed and presented in this chapter under the following heads :

2.1 Diagnostic survey of agroforestry (AF) systems

2.2 Agroforestry/farming systems' research

2.3 Biological yield and economic return from agroforestry systems

2.4 Relevance of AF systems' research to meet social as well as technological constraints in farming systems

2.1 Diagnostic survey of agroforestry (AF) systems

Diagnosis and design is a methodology for the diagnosis of land-management problems and the design of agroforestry solutions. It was developed by International Centre for Research in Agroforestry (ICRAF) to assist agroforestry researchers and field-workers to plan and implement effective research and development projects. The basic procedure of diagnosis and design consists of five stages, viz., (i) pre-diagnostic, (ii) diagnostic, (iii) design and evaluation, (iv) planning and (v) implementation (Raintree, 1987).

Diagnostic surveys help in preparing agroforestry systems inventory. These inventories enable the researchers to bring to the light the enormous magnitude of a complexity and diversity of existing agroforestry systems which in turn help in evaluation of systems and identifying the most common research gaps (Nair, 1987). It also identifies valuable local issues, which can be translated directly into practice as well as day to day management decisions relating to agroforestry (Gibson and Muller, 1987).

Diagnosis surveys of land use system are generally undertaken using systematic approaches to diagnose land management problems (e.g. social, biological and technical) and designing of appropriate solutions. Several

methodologies have been developed for holistic evaluation and analysis of landuse systems. The most significant among them are (i) Farming Systems Research/ Extension (FSR/E) (Shaner *et al.*, 1982; Hildebrand,1986) (ii) Land Evaluation Methodology (FAO 1976), (iii) Diagnosis and Design (D&D) in agroforestry (Raintree,1987).

Many studies have been made in different regions of various countries to understand the complex nature and diversity of existing agroforestry system using diagnostic surveys.

Shah (1988) analysed the potential of agroforestry landuse technologies in Gujarat and concluded that agroforestry is an ideal landuse for rural people as it reduces difference between rainfed and irrigated conditions enabling the drought to withstand.

Jha *et al.* (1989) in the hill regions of Bihar studied awareness of the farmers about their planting preference for the tree species, existing agroforestry practices along with the farmers' attitude toward the adoption of agroforestry systems. They found an increasing awareness regarding the importance of trees in their daily life.

Chauhan and Dhyani (1989) identified economically important tree species on hill slopes, farm boundaries, in homesteads, in five agroclimatic zones of Meghalaya. They furnished a list of 80 species showing their uses and zone of occurrence for each of these tree species.

Verma (1990) on the basis of survey conducted in Gujarat, reported that peripheral planting was more popular than mixed planting under normal conditions but under irrigated conditions both peripheral as well as mixed planting were equally preferred . Diagnostic survey of farms and local markets by Verinumbe

(1991) indicated the prevalence of local agroforestry practices in arable farming, livestock rearing, fishing and forestry in north-eastern Nigeria.

Zou and Sanford (1990) classified natural existing agroforestry systems in China on the basis of system type and system unit into seven system types and 26 system units. They defined system type as a homogenic group whose major components are closely related economically, socially and environmentally, while system unit was defined as a basic functional unit that reveals the specific biological relationship among the major component and require similar management strategies and techniques.

Verinumbe and Jarvis (1991) also reported the use of local agroforestry practices in farming, livestock rearing, fishing and forestry while diagnosing the farms and local markets.

Fujisaka (1991) carried out a diagnostic survey of shifting cultivation in northern Laos to understand the practice from a farmer's perspective . He observed that farmers cannot adopt higher labour and cash cost innovations.

The process of interactive diagnosis and design with the active participation of farmers and extension agents is effective in identifying appropriate agroforestry system for different socio-ecological situations. If the researchers and development agents do not consider the farmer's real needs, circumstances, available resources and management capacity with regard to tree planting, they will fail in identifying and extending suitable agroforestry systems for any region (Pinners and Balasubramanian, 1991). The results of an appraisal made by the All India Coordinated Project on agroforestry have indicated that three types of agroforestry systems, namely, silvihorticultural, hortiagricultural and agrisilvicultural are promising for Sikkim (Singh *et al.* 1991).

Dvorak (1991) in an economic assessment approach to on-farm diagnostic research on alley cropping with an objective to evaluate the adoption potential of the technology, used three activities viz., panel surveys, topical survey and intensive data collection .He suggested that this combination of methods will contribute to development of more rapid and readily accessible methods of evaluating agroforestry technologies on-farm.

Adegbehin and Omijeh (1993) carried out a diagnostic survey in Niger state of Nigeria, revealed that agrisilvopastoral and the 'scattered farm trees' systems were most common agroforestry practices adopted by the farmers. The attitude of the farmers towards the tree planting was also studied and it was found that most of the farmers were aware of tree planting on the fields.

Patma *et al.* (1994) reported that the village located closer to forest had more number of trees on its farms than those situated farther from the forest. This is due to the higher availability of forest resources closer to the village so that the trees on the farms were used less, while the distant village had to rely more on their farm trees because of the lower availability of the forest resources.

Saroj and Arora (1994) conducted a survey to study the fruit based agroforestry systems on farmer's fields in Sahaspur-Vikasnagar block of Doon valley. They found that mango based agroforestry system was most popular (57.8 %) followed by litchi (15.6 %), guava (11.2 %), kinnow (7.8 %), peach (4.4 %), lemon and olive (1.1 %). Wheat was the main ground storey crop.

Dadhwal *et al.* (1995) conducted a diagnostic survey for appraisal of existing land use systems and agroforestry practices in north-western plains of U.P. They identified the major farming constraints and suggested potential agroforestry interventions. They, also, reported that farmers showed greater interest for agrihorticulture followed by agrihortisilviculture system, combined with livestock component for immediate cash returns.

A survey was conducted by Sharma *et al.* (1995) to know the present status of agroforestry systems in Bundelkhand region during 1990. The existing agroforestry systems in the region were found to have two trees per 100 m running length of bund. The prominent tree species of the area were *Zizyphus*, *Acacia nilotica*, *Leucaena leucocephala*, *Butea monosperma* and *Azadirachta indica*. *Zizyphus* had been identified as the most important tree of the area.

Rana (1995) identified four traditional agroforestry systems in mid hill zone of Himachal Pradesh. These were agrisilviculture, agrisilvipastoral, agrisilvihortipastoral and pasture. According to survey conducted by Mazumdar (1991) five farming systems were identified at Nauni (H.P.) viz. agricultural system, hortiagriculture, hortisilvipastoral, grasslands and wastelands. He found that out of these five, agrihorticulture system was dominating agroecosystem in the study area.

Kachru (1997) conducted a diagnostic survey and productivity appraisal of agroforestry systems in sub-temperate and sub-humid region of Himachal Pradesh and reported eight agroforestry system types viz., agrisilviculture, agrihorticulture, agrisilvihorticulture, pastoral silviculture pastoral hortisilviculture, agrihorticulture, pastoral silviculture and pasture. The diagnostic survey of agroforeastry systems conducted in Balh valley of Himachal Pradesh revealed that in uplands six agroforestry system types viz., agrisilviculture, agrisilvihorticulture, pastoral silviculture, pastoral silvihorticulture, pastoral horticulture and hortipastoral were prevalent among farmers of different categories. In lowlands six agroforestry system types namely, agrisilviculture, agrisilvihorticulture, pastoral hortisilviculture, pastoral silvihorticulture and silviculture have been identified (Upadhyaya, 1997). Agrisilviculture and agrihortisilviculture systems have also been reported by Atul *et al.* (1990) in the temperate regions of Himachal Pradesh. Tejwani (1987) has also reported agrisilviculture and silvipasture system in temperate region of India. Singh and Dagar (1990) have identified agrisilvicultural,

agrihortisilvicultural and silvipastoral systems, besides homesteads in Mussoorie hills in western Himalayas.

Sood *et al.*, (2000) listed the agroforestry systems of Arunachal Pradesh. The most prominent systems were agrisilvicultural, silvipastoral and agrisilvipastoral. The other agrforestry systems include agrisilvifishery, agrisilvisericulture. They also highlighted the common constraints of existing agrforestry land use of Arunachal Pradesh. Mughal *et al.*, (2000) identified agrforestry systems, namely: agrisilviculture, hortisilvipasture, hortisilviculture, hortisilviagriculture, kitchen gardens and boundary plantations, in rural Srinagar of Kashmir valley.

Singh (2002) carried out a diagnostic survey and productivity potential of khair based agroforestry systems and identified three major khair based agrforestry systems namely agri-silviculture, pastoral-silviculture, and pastoral-silvihorticulture in Kuthar and Arla-Kalyana village of Solan district.

2.2 Agroforestry/Farming systems' research

Okigo (1974) defined the farming system's research as the one including understanding of farm environment, existing methods of farming and potential value of improved technology. He also suggested that the co-operation and integration among different disciplines such as crop science, soil science, farm economics, extension and other related field is very important for developing more useful and practicable farming system.

Speeding (1978) described farming system research as a group of interacting components operating together for a common purpose capable of reacting as a whole to external stimuli. Collinson (1979) explained the farming system research as a way in which farm resources are allocated subject to location based needs and practices of the cultivators keeping in view the existing economic and institutional infrastructure.

Bhati and Gopalakrishnan (1978) suggested that in western Himalayan region diversified farming systems which include crop husbandry, animal husbandry, orchards and forestry, should be optimally developed in an appropriately integrated manner depending on land capability. They further suggested that regional development plans should be based on the principles of comparative advantages, agro-climatic conditions and ecological considerations.

Anandajaysekeram (1981) identified three phases in farming systems' research i.e. study of the existing farming systems along with its components and linkages; technology development and its testing under farmers' condition; and finally the extension activities. Norman and Collinson (1985) divided farming systems' research concept into four stages i.e. description and diagnosis, design and planning, testing and evaluation, and recommendations and dissemination of knowledge to farming community. They explained the farming systems' research as a research methodology for understanding the farming systems and their problems. The primary object of farming systems' research, according to authors, is to improve the well-being of individual farming families by increasing the productivity of their farming systems under the set of constraints imposed by resources and environment.

Desai (1982) reported that agriculture crops, horticulture plantation crops, livestock, fisheries and forestry are the vital components of farming systems.

Khosla (1983) reported that agroforestry is the best land management system which bring harmony between forestry and agriculture for meeting the rural people's requirement for the food, fuel, fodder, timber etc., without disturbing the ecosystem. Agroforestry has been defined as the land use system that involves deliberately retention of trees or other woody perennials in crop/animal production to benefit from the resultant ecological and economic interactions (Nair, 1984). Whereas, Roche (1974) stressed the need for integrating farm forestry with crop

keeping in view the strong socio-economic and ecological advantages of agroforestry.

Remenyi and Coxhead (1985) described the usefulness and effectiveness of farming system's research in terms of multi-disciplinary and complexity of farming. They explained the critical characteristics of farming system's research in terms of its relation to small holders, viz., multidisciplinary and holistic approach, inclusion of farmers in research, aiming at generating viable technology and, also, testing and verifying the research results.

Conway (1985) opined that farming systems' research offers greater opportunity for developing more productive farming systems. Sabrani *et al.* (1985) listed the main aims of farming system's research as to develop stable cropping pattern, maintenance of soil fertility, efficient utilization of land and labour and the provision of sustained cash income. Whereas, Remenyi and Coxhead (1985) reported agroforestry as multi-disciplinary and found it to improve agricultural productivity involving the farmers in the process of research.

Jones and Price (1985) suggested that since the interactive benefits of agroforestry systems are often not immediately apparent, a holistic interpretative framework such as the farming system research (FSR) methodology is necessary to understand or suggest adaptations in these systems.

Balasubramanian and Egli (1986) in their description of the intensive system of organic agriculture prevalent among Rawandan farmers with the combination of food, fodder and tree crops, identified the role of agroforestry in the farming system. They have also acknowledged the use of multipurpose low-input technologies and agroforestry approaches designed to improve the productivity of these traditional systems. Nair and Sreedharan (1986) also advocated the optimum utilization of available resources of land, solar energy, and technological inputs along with efficient recycling of farm waste through the use of

agroforesry farming systems e.g. homesteads of Kerala in India which were evaluated for their stability, productivity and sustainability.

Mahat (1986) emphasized the need for integrated management of resources in mountain watershed after analyzing the interrelationship of forestry with agriculture and livestock husbandry. He further suggested that the forestry through appropriate activities and investments can generate diversified income and off-farm employment opportunities for rural people in hills. Nair and Dagar (1991) proposed an approach to develop methodology for evaluating agroforestry systems in India. They were of the opinion that the evaluation procedure should encompass productivity, sustainability and social acceptance.

Keli (1988) while studying the prospects of introducing agroforestry systems amongst the rubber growers spread around three rubber growing regions of lower Ivory coast (Africa) by assessing food crop cultivation system by collecting the data pertaining to type of crops grown, rotation system, crop mix production technique and utilization of harvest and classified the farming systems on the basis of production rationale and constraints.

Srivastava and Rao (1989) made an outline of agroforestry system suitable for sustained production from marginal lands in semi arid black soil regions of India which include agrisilvicultural system (intercropping between wide rows of trees; farm boundary, bund or peripheral tree planting, block planting on farm lands and alley cropping); silvipastoral system; and alternate landuse-the growing of perennial vegetation in the arable lands of semi arid regions to restore land productivity and promote soil conservation.

Wiersum (1991) suggested that agroforestry development should be directed at the creation of diversified system of land use, which is adapted to locality specific environment, socio-economic and land use conditions. As a consequence, an agroforestry development action plan should not be restricted to a

strategy for technology change only. The ultimate objectives for agroforestry development may be diverse but it should, at least partially, be related to the desire to improve the standard of living for the poor and to sustain the land use pattern. A problem solving approach rather than a technology diffusion approach should be sought.

In a study of agriculture on the slopes of Mount Kilimanjaro, Aminu-Kana *et al.* (1992) identified three distinct farming systems: coffee/ banana farming system; maize/ beans farming system; and extensive livestock farming system. They also recommended that research priority should be given to research on improved fallow land and planting on borderlines. Moss (1995) believed that more integration of trees into farming systems could contribute towards achieving sustainable landuse and by increasing the number of tree crops through domestication of under-exploited tree crops would increase the scope for integration of trees into agricultural systems.

2.3 Biological yield and economic return from agroforestry systems

2.3.1 Biological yield

Templeton (1968) reported that trees are known for their higher potential for converting radiant energy into organic matter as compared to the annuals.

A study conducted by Gupta *et al.* (1982) on the intercropping of rabi and kharif crops with peach in Doon valley of Uttar Pradesh revealed that on an average, three years old tree provides about 10 - 15 kg of prunned wood and 10 kg of leaf litter during November and December. In another study conducted by Dhukia *et al.* (1988) in Harayana (India) found that among the fodder crops *Trifolium alexandrium*, oats, *Vicia faba* and *Triagonella foenum-graecum* grown under *Dalbergia sissoo* and *Albizzia lebbeck* plantations, *T. alexandrium* gave the highest dry matter yield followed by oats. In the same experiment, wheat gave higher yield than cicer under both plantations. Yield of all crops under *D. sissoo* plantations was found higher than *A. lebbeck* plantation.

Janicki (1983) reported that lima bean, cow pea, soybean, ground nut and pigeonpea yielded 332, 91, 330, 308 and 573 kg seed/ha, respectively, when intercropped with coffee plants in the first year and coffee yield was un-affected.

Tokey *et al.* (1989) analysed the species composition, biomass and productivity patterns of three types of traditional agroforestry systems, namely : agrisilviculture, agrihorticulture and agrihortisilviculture in western Himalayas and reported that species composition in the systems varied depending upon the size of land holding and the basic requirements of the farmers. Agrihortisilviculture system was highly diverse in vegetation, with 13 trees and 5 agricultural crops mixed together and gave the highest porductivity upto 25.5t/ha/yr with only 27 per cent contribution by the trees. Total above ground biomass in agrihortisilvicultural system was around two times higher than the agrisilvicultural system.

While studying the biomass production pattern in traditional agroforestry systems in western Himalayas, Mazumdar (1991) reported that hortisilvipastoral system gave the highest standing biomass (355.5 q/ha) compared to hortiagricultural system (301.5 q/ha) and grassland (63.2 q/ha). Horticultural trees in hortiagricultural system produced the maximum biomass of 55.8 q/ha/yr at the highest rate of 18.5 per cent. They also put the major portion of the annual biomass by 53.5 per cent to hortisilvipastoral system followed by fodder trees (26.0 %) and timber/fuelwood trees (20.7 %). In grassland system, timber/fuelwood species contributed the maximum share by 51.1 per cent to system productivity.

Khybri *et al.* (1992) studied tree crop interactions under rainfed conditions in Dehradun valley for 13 years (1977 to 1990) and reported that *Grewia optiva* could produce 1.08 t/ha/yr of branch biomass and 0.26 t/ha/yr of leaf fodder. In Rajashan, Bhimaya *et al.* (1964) obtained an output of 69 kg of fresh leaves from a full grown tree of *Prosopis cineraria* on complete lopping when only the central leading shoot was left. Similarly, 25-30 kg of fresh leaves were obtained from moderately sized tree of *P. cineraria* (Bohra and Ghosh, 1980).

Dinssa (1993) reported that the growth and yield of soybean, blackgram, horsegram and cowpea was higher under monoculture as compared to intercropping with *Morus alba*. Sharma *et al.* (1993) studied the influence of *Acacia tortilis* and *Zizyphus rotundifolia* trees on the productivity of under storey grasses viz. *Cenchrus ciliaris* and *Lasiurus sendicus* in arid environment. Dry forage yield of *Cenchrus ciliaris* and *Lasiurus sendicus* grown in association with trees decreased as compared to sole grasses. The reduction in yields under *Acacia tortilis* were higher than *Zizyphus rotundifolia*. *Lasiurus sendicus* suffered greater reduction as compared to *Cenchrus ciliaris*.

Maiti *et al.* (1993) reported the maximum yield of maize (herbage), rice (grain), sorghum (herbage) and mustard (grain) up to 69.1, 19.2, 87.9 and 10.2 q/ha, respectively, under sole cropping as compared to the yield obtained under alley cropping with *Leucaena* as 32.0, 8.6, 19.9 and 4.9 q/ha, respectively. Whereas, Srivastava and Rao (1993) observed 15, 33, and 53 per cent decrease in grain yield of sorghum, safflower and Bengalgram, respectively in alleys of Leucaena over pure crop. Similarly, a negative effect on growth on tree seedlings up to three years period was observed in an *Acacia tortilis* plantation with *Cenchrus ciliaris* (Harsh and Tewari, 1993).

Korwar and Radder (1997) evaluated the potential of alley cropping post rainy season sorghum between Leucaena hedge rows. Leucaena produced on an average 2.47 t/ha of pruning biomass and 1.57 t/ha of wood annually. Hocking *et al.* (1997) while studying the effect of traditionally managed mature trees on adjacent crop yield reported that there was a variable depression of rice and wheat yield levels under all tree species which ranged from 18 per cent for light canopied *Acacia catechu* to a little over 40 per cent for the dense canopied *Artocarpus heterophyllus* and *Mangifera indica*.

Yadav (1997) evaluated the biomass productivity and nutrient contents of *Morus alba* and *Leucaena leucocephala* based silvipastoral systems. He observed

that in *M. alba* based silvipastoral system the biomass productivity was 5.03 q/ha leaf biomass and 14.03 q/ha branch wood biomass at 2.0 m of pollarding height. Where as, in Leucaena based silvipastoral system maximum tree leaf biomass was found to be 12.73 q/ha and branch wood biomass 58.58 q/ha at 2.0 m pollarding height.

Chamshma *et al.* (1998) carried out a study to see the growth and yield of maize alley cropped with *Leucaena leucocephala* and *Faidherbia albida* in Morogoro, Tanzania and concluded that maize grain yield was little affected by the tree-crop interaction as competition for resources was reduced through periodic pruning and clean weeding. There was no gain in maize grain yield due to the presence of *Leucaena leucocephala* and *Faidherbia albida.* These results suggested that alley cropping was justified for wood production but not for increasing maize grain yield. Where as, Mugendi *et al.* (1999) reported that inclusion of calliandra hedges on crop land adversely affected maize yield. On the other hand, alley cropping with leucaena was advantageous. Kushwaha *et al.* (2000) conducted an experiment in which they pollarded the eight years old multi purpose tree species i.e. *Leucaena*, *Eucalyptus*, *Moringa* and after that black gram and sorghum were intercropped. They reported that the yield of arable intercrops after pollarding were 268.3, 254.2, 225.2 and 241.9 kg/ha of black gram and 93.43, 29.72, 89.57 and 88.80 q/ha of sorghum fodder under no tree, *Leucaena, Eucalyptus* and *Moringa*, respectively.

2.3.2 Economic return from agroforestry systems

Tewari (1985) while estimating the economics of various agroforestry systems showed that per hectare net returns could be increased up to three times by introducing *Leucaena leucocephala* in the existing cropping systems in lower hills of Himachal Pradesh.

Rilley (1986) suggested that it would be better to compare the biomass in terms of money to get a conclusive idea about the system. Chaturvedi (1991)

inferred that the incorporation of trees in agriculture will increase the overall productivity. He also reported that for individual farmer, the financial returns from sale of wood compensate the reduction in agricultural yields.

Majumdar (1991) while studying the agroforestry systems in the mid hills of Himachal Pradesh reported that hortiagricultural systems furnished the highest gross returns annually than hortisilvipastoral and grassland systems.

Grewal *et al.* (1992) conducted a field study at the research farm of the Central Soil and Water Conservation Research Center, Chandigarh and reported that the agri-silvi-horticulture system integrating leucaena, lemon, papaya and turmeric in class I irrigated land provided sustainable mean net returns of Rs. 17066/ha/yr against Rs. 7852/ha/yr from double cropped agricultural system.

Harsh and Tewari (1993) reported that overall economics favour tree-crop combinations rather than the sole crop cultivation or simple plantation of a tree species.

In a comparative study of different landuse options viz. annual cropping, agrihorticulture and agrisilviculture on a semi-arid alfisol, Das *et al.* (1993) found that the agrihorticultural system required more cash input but gave a benefit : cost ratio of 2.16 compare to 1.95 with annual cropping, and 1.52 with agrisilviculture.

Dyal *et al.*, (1996) evaluated agrisilvihorticulture system whose components were *Leucaena leucocephala*, *Citrus aurantifolia*, *Carrica papaya* and *Curcuma longa*. They found that the mean annual returns were Rs. 17,746 and Rs. 15,092 under agrisilvihorticulture as against Rs. 7,752 and Rs. 3,342/ha from agricultural cropping system (maize + black gram/wheat + mustard/maize + wheat) under irrigated and rainfed conditions, respectively.

Rana *et al.* (1996) in a socio-economic analysis of traditional agroforestry systems of western Himalayas reported that in agrisilviculture, agripastoralsilviculture and agrihortipastoral systems, major proportion of returns over variable cost (ROVC) was contributed by agriculture followed by animal husbandry sector. However, in tea based horti-agri-silvicultural system, more than 83 per cent of the ROVC came from horticulture (tea) section.

Kumar (1996) conducted a study on bio-economic appraisal of agroforestry systems in Himachal Pradesh and found that agrihorticulture system furnished the highest net returns followed by agri-horti-silviculture, agrisilviculture and minimum in sole cropping. While evaluating the effect of row arrangement on yield and monetary benefits in mulberry + soybean intercropping, Yadav and Kumar (1998) reported that net income under intercropping was higher than in pure stand either of mulberry or soybean.

Upadhyaya (1997) conducted a study in Balh valley of Himachal Pradesh and reported that in marginal, small and medium group of farmers, more net returns were obtained from agrisilvihorticultural system as compared to agrisilvicultural, pastoral silviculture, pastoral silvihotriculture and pastoral horticulture systems of agroforestry. Singh *et al.* (1998) evaluated the productivity and economics of eight intercrops in four crop sequences and indicated that the vegetable intercropping did not cause any adverse effect on the yield and income of eucalyptus. However, yield of all intercrops reduced with the increase in the age of the trees. Among the crop sequences faba bean-colocasia (Rs. 51,037) was the best followed by French bean-turmeric (Rs. 39,121), potato-onion (Rs. 37,861) and tomato-cowpea (Rs. 32,797).

Deshmukh (1998) conducted a study to see the performance of wheat and soybean as intercrop with *Grewia optiva* pollarded at different heights and reported that from an economic view point, the net returns as well as gross returns from wheat based system were much limited as compared to soybean based system. The

net returns from fodder tree i.e. *Grewia optiva* (leaf + branch) was also found to be commercially viable.

Sood (1999) conducted an experiment on tree crop interaction studies in agrihorticulture system and reported that total cost incurred as well as net returns were higher in agrihorticulture system as compared to sole crop. Kumar (1999) reported that total costs, gross returns, and net returns were higher from combinations involving plum as one of the components with soybean while least from pomegranate-soybean combination.

2.4 Relevance of AF systems' research to meet social as well as technological constraints in farming systems

Roche (1974) suggested that integration of forestry in the farming system would help in soil conservation, enhancing the soil productivity and meeting the day to day fuel and fodder needs. Kushwaha *et al.* (2000) also suggested that in addition to biomass production multipurpose tree species also contributed to productivity and moisture conservation of soil. Therefore, it has been recommended to grow arable crops in association with multipurpose tree species for higher returns. Newbold (1977) recommended a landuse system that combines the forestry with agriculture.

Bhati and Gopalakrishnan (1978) pined that in western Himalayan region, diversified farming systems which include crop husbandry, animal husbandry, orchards and forestry, should be optimally developed in an appropriately integration manner depending on land capability. They furthure advocated that regional development plans should be based on the principles of comparative advantages, agroclimatic conditions and ecological considerations.

Singh and Rahim (1978) opined that traditional cropping pattern followed in the hill regions need adjustment keeping in view the increasing needs of the people for higher production and income as well as for maintaining ecologically sound environment. They further reported that orchards and pastures, besides

protecting the soil could yield good monetary returns. In order to a stabilize income in hilly areas, which is always risky and uncertain, integration of animal husbandry and forestry schemes will give satisfactory results (Patil, 1978).

Shah (1979) suggested that an optimal farming system for the hills should include cultivation of arable lands and plantation crops, animal husbandry, fishery, sericulture, forestry, medicinal plants, fodder grasses etc. Agrisilvihorticulture system often yield more biomass per unit area besides the conservation and protection of natural resources. The agrisilvihorticulture system has also been found better as compared to agricultural cropping system for efficient utilization of land and labour resources (Arora and Mohan, 1986; Gwyer, 1978). It was suggested that such system should be developed for each agro-ecological region depending upon the local conditions (Grewal *et al.*, 1992). Livestock is an important component of farming system and often reflects its importance as a major source of income particularly on small farm holdings. The animals also act as financial buffer against yearly fluctuations in crop productions and provide valuable manure to improve soil fertility (Kalita and Sharma, 1980).

Rapid technological and social changes taking place in recent years have resulted in adoption of short term solutions by farmers which are not sustainable (Mansfield, 1981). Integration of soil conservation efforts, livestock, horticulture and forestry programmes along with crop husbandry for the overall development of the hill farms is necessary. New action plans demand overall changes to have single line of administration in order to sustain the farming and to strengthen the fragile hill ecosystem through agroforestry interventions (Bist,1984).

Becker (1987) suggested that complex agroforestry systems are not suitable for the farmers having small holding, but that a more limited development strategy (low-input improvement of crop production, including intercropping systems; improvement of soils by incorporation of crop residues and introducing livestock;

and afforestation programmes on marginal land, subsistence crop production on the farm) should be adopted.

Tejwani (1987) prepared a comprehensive review of various tree based traditional practices. He concluded that there were many systems and practices yet to be adequately described e.g. apiculture, sericulture etc. and that much research is needed in order to define practices and improved systems.

The potential and fragility of tropical ecosystem were identified by Vergara (1987) and he discussed the strategies for maintaining productivity of ecosystem with respect to nutrient balance. He also emphasized the importance of adoption of new technologies and support systems for existing practices and to tackle the problems in marketing of surplus.

Sanchez (1987) advocated that the proper agroforestry systems improve soil physical properties and promote nutrient cycling. He also suggested the need for systematic scientific testing of effect of agroforestry systems on different soils (and vice-versa). Lessons must be learnt from micro level farming systems' research and incorporate these lessons in the future plans for sustainable agriculture by striking to judicious balance between appropriate use of natural resources to meet out present needs without jeopardizing the future potentials (Maji, 1991).

Seikh (1987) stated that besides the improvement in environment, trees also provide food and income earning in the form of wild fruits, nuts etc.

Thakur (1988) suggested the hill development through scientific transformation of agriculture including horticulture and animal husbandry which forms the mainstay of the people in hills as their economies are basically agropastoral.

Salam *et al.* (1990) examined the economics of homestead agricultural farm in Kerala state and concluded that integrated homestead faming was a sustainable and profitable system for small farmers and should be encouraged.

While studying the traditional agroforestry practices in Zimbabwe, Compbell *et al.* (1991) suggested that those agroforestry systems which improve the fodder production will make significant contribution to farm productivity because of the importance of the cattle in the farming system and the present fodder shortage. They further stated that interventions involving the planting of fruit trees are likely to be very successful as there is much interest in such planting.

Sharma *et al.* (1991) identified the existing farming systems followed in different agro-climatic zone of Himachal Pradesh. They advocated that fruit based farming systems were found to be the harbinger of profitability and surplus in the state's economy. Pathania and Uppal (2000) suggested agrihorticultural, hortipastoral, agrisilvicultural and hortipastoralsilvicutural agroforestry systems for Himachal Pradesh.

Tabora (1991) examined the role of agroforestry as a landuse concept and as environment design in Phillippines, covering social, economic and biophysical concepts. The study concluded that agroforestry has a significant role as an environmental design but its usefulness has limitations due to some physical constraints and socio-economic values which need redressal. Holden and Joseph (1991) were of the view that paramount need of the hour is to reach the resource poor farmers with suitable agriculture technology so that small farmers involved in the technology development research are motivated enough to accept the nobel technology.

Budelman *et al.* (1992) reported that technical solutions are available that make agriculture sustainable, but its output is likely to be reduced when accepting the need for environmental protection at various levels of integration (cropping

system, field/farm, village territory, etc.); since marginal land must be left under natural vegetation.

Adegbehin and Omijeh (1993) did agroforestry diagnostic survey of some parts of Niger State of Nigeria and reported that the farmer's earning could be increased by intensified practices, while the later can be achieved by intensified agroforestry extension and provision of incentives.

Karki and Gold (1994) conducted a study on forage and biomass yield response of fodder tree species in Nepal. It was observed that native fodder species of the region, if carefully selected and planted on the farmer's fields have potential to improve the poor fodder stands commonly throughout the middle hills of Nepal.

Rugalema *et al.* (1995) conducted a questionnaire survey in Bukoba district to compare three potential farming systems; namely the rehabilitation of the home gardens, the cultivation of two annual crops ,i.e. maize and beans, as inter crops, and the continuation of the current non-rehabilitated home gardens. They supported the rehabilitation of home gardens by the use of cattle manure and proper crop and live stock husbandry practices. A rehabilitated home garden has the highest net present value and is not very sensitive to change in price of inputs and outputs. Leuscher and Khaleque (1987) made a survey involving seven districts representing all the agroecological zones of Bangladesh. It was concluded that the prospects for improving homestead systems are good because most of homesteads have room for more trees. They suggested that the use of multipurpose trees and involvement of women in specific operations will likely to enhance the success of agroforestry.

Cardozo (1995) used the rural appraisal technique to evaluate qualitative and quantitative data on the use of agroforestry systems on small holdings in Paraguay and concluded that agroforestry is recommended as an alternative

method of diversification production on small holdings. Dwivedi *et al.* (1995) conducted a diagnostic survey at the state Government dairy farm at Ootacamund, Tamil Nadu, in order to design a suitable land management plan to replace the existing usage. Alongwith watershed management and afforestation measures, various agroforestry systems like agrisilviculture, silvipastoral and agrisilvipastoral were proposed as suitable land uses.

Singh *et al.* (1997) did an evaluation of agriculture, forestry and agroforestry practices in moderately alkali soil in north-western India for six years and reported that agroforestry was a better land use option than forestry and agriculture alone in moderately alkali soil. They further suggested that growing trees along with crops should not be viewed only as better and economically viable food, fodder, timber and fire wood production system but also as promising option to maintain the better soil condition. Poplar and Eucalyptus based agroforestry proved more promising than an Acacia based system, owing to favorable effect of inter crops on tree and better price for Poplar and Eucalyptus wood in market. The soil conditions improved in terms of the build up of soil organic matter, N, P, K when trees were associated with agriculture crops. The improvement in soil condition with different trees was in the order: Acacia based system > Poplar > Eucalyptus > agriculture (sole crop).

Jha (1999) conducted a survey in Bihar to investigate the resource of villages and socio-economic status of agroforestry and non-agroforestry adopting farmers. He found that farmers raising different crops under agroforestry systems were economically better and attained self sufficiency in fire wood and fodder.

Salam *et al.* (2000) conducted a survey to know the factor affecting tree planting in homestead agrforestry in Bangladesh. The study revealed that (i) tree planting increases with the amount of homestead land owned; (ii) farmers whose main source of income is non-agricultural are more likely to decide to plant trees in the homestead; (iii) number of family members has a positive influence on tree

planting decisions; and (iv) knowledge of the activities of the forest extension programs has a positive influence on tree planting decisions.

Jain and Singh (2000) evaluated the performance of poplar based agroforestry in terms of income, employment and environmental impact from the farmers' perspective in the northern region of India. They reported that poplar based agroforestry system was economically viable and more profitable than many of the crop rotations followed in the study area. This land use system was also capable of providing employment opportunities on farms.

Mughal *et al.* (2000) evaluated the socio-economic aspects of agroforestry in rural Srinagar of Kashmir valley. They reported that people in the study area planted only three tree species i.e. *Populus deltoides*, *Salix alba* and *Robinia pseudocacia* under agroforestry system, which were not sufficiently efficient to meet people's requirements of food, fodder, and fuel wood for full year from these models. In order to make the models efficient and productive and generate interest in scientific models, energy need to be diverted for on farm experiments so that people can judge by themselves the performance of scientific models, which in turn will go a long way in fulfilling the requirements of farmers to a great extent. Model devised should be economically feasible so that they can be adopted without much resistance.

Chapter – 3

MATERIALS AND METHODS

MATERIALS AND METHODS

The methodology used for the study consists of site selection, sampling procedure, identification of existing agroforestry systems, data collection, analytical framework and valuation.

3.1 Selection of area

The study was carried out in Bilaspur Distt. of Himachal Pradesh. The area falls in sub-tropical sub-montane and low hills agroclimatic region of Himachal Pradesh. The Bilaspur district is mostly hilly and elevation of the lowest point is about 290 m amsl and that of the highest point is about 1980 m amsl. It lies between $31^0$12'30" and $31^0$35'30" North latitude and $76^0$55'40" East longitude. Lower part of the district experiences hot summers (44^0C) and upper part mild summers and cold winters with 0^0C as lowest temperature. The meteorological data of the district during 2002-03 is given in appendix I.

3.2 Sampling procedure

The sample for the study was selected through two stage sampling techniques. The Bilaspur district was divided into three altitudinal zones, viz. altitudinal zone I (<- 700 m amsl), altitudinal zone II (700 – 1000 m amsl), altitudinal zone III (1000 - 1400 m amsl). In the first stage, a complete enumeration of villages falling in each altitudinal zone was done and four villages from each altitudinal zone were randomly selected. The selected villages were :

S.No.	Altitudinal zones	Villages
1.	< 700 m amsl	Kotlu Brahamna, Jhabola, Badi Majherwin and Kothi
2.	700 – 1000 m amsl	Jukhala, Makri, Hambar and Brahampukhar
3.	1000 – 1400 m amsl	Bandla, Parnali, Jhanjiyar and Kot

In the second stage, a complete list of households in respect of selected villages was prepared and a random sample of ten households from each village

was selected as ultimate unit of the study. The relevant information about the study was collected through pre-tested schedule for the purpose through personal interviews with each head of the household. Based on the size of their landholdings, selected farmers were divided into four categories : 1. Marginal (< 1 ha), 2. Small (1-2 ha), 3. Medium (2-5 ha) and 4. Large (> 5 ha). Number of farmers falling in each category is given in Table 3.1.

Table 3.1 Category-wise number of farmers found in the study area

Particular of the study area	Categories of farmers			
	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-5 ha)	Large (>5 ha)
Altitudinal zone I	30	7	3	-
Altitudinal zone II	23	12	4	1
Altitudinal zone III	28	10	2	-
Total	81 (67.50)	29 (24.17)	9 (7.50)	1 (0.83)

* Figures in parentheses are per cent values

3.3 Identification of existing agroforestry systems in the study area

Agroforestry systems prevalent in the study area were classified on the basis of structure (nature and arrangement) and function (role of output) of components (Nair, 1985). However, stratified classification of agroforestry practices given by Zou and Sanford (1990) was used to indicate the types of systems and the system units. System types have been named considering the major components whereas system unit termed as basic function unit has been identified as combination of specific crop species within a component with the species from other components. Hence, functional units like food grains, vegetables and pulses, in agriculture; specific fruit trees in horticulture; grasses in pastures and tree species in forestry component have been described.

Primary and secondary components of each system type were identified after recognizing the structure of the system and specific functions of the components.

A) Primary component

The component, which occupies the larger area of the total unit area and serves the major function i.e. production of primary output needed by the farmers, has been considered as primary component.

B) Secondary component

The component, which occupies relatively lesser area of the total unit area compared to area under primary component and yielding secondary output needed by the farmers, has been considered as secondary component.

3.4 Data collection

To fulfill the objectives, data were collected from the farmers on the following parameters, on pre-tested schedule by conducting personal interviews with each head of the household. The observations were made on the below mentioned parameters:

A) Socio-economic factors

B) Landuse statistics/patterns

I. Agriculture

II. Horticulture

III. Forestry

IV. Pasture

C) Animal husbandry

1. Total number of cattle and their type
2. Milking procedure followed
3. Breeding techniques followed
4. Management practices followed
5. Use of FYM (farm yard manure)

D) Pasture

a. Major grass species

b. Yield levels

c. Associate tree species

E) Forestry

1. Tree species available
2. Number of trees
3. Production levels

F) Agriculture

1. Name of the crop
2. Field preparation
3. Irrigation
4. Field planting
5. FYM/fertilizer used
6. Disease and pest control measures
7. Weed control
8. Harvesting
9. Threshing
10. Total output

G) Horticulture

1. Name of fruit crop
2. Total number of fruit trees
3. Planting pattern followed
4. Cultural operations followed
5. Insect-pest and disease control measures
6. Weed control
7. Yield levels

3.4.1 Analytical method used

Tabular method

This method was used to estimate the family structure, demographic feature, livestock status, animal husbandry practices, land utilization pattern, tree inventory and production from various agroforestry systems, etc. The results were

interpreted as sum total of biological production and economic returns, average or percentage depending upon various requirements of the study.

3.4.2 Biological yield

Biological yield was calculated considering the harvestable biomass of each functional unit of the system type.

3.4.3 Economic returns

The present harvestable biomass from each functional unit in a system type was taken for estimating the total returns from the system. Whereas, total investment incurred on production and cultural management was taken into account to estimate the net returns. Net returns were calculated at farm gate based production cost (variable cost) only and no marketing cost was taken into account.

3.4.4 Relative variation

Relative variation in the biomass yield levels and net returns of a system type among the different categories of farmers has been worked out by calculating the co-efficient of variation.

3.5 Technological gaps/constraints and their solutions

The land and crop management practices prevailing among the farmers were compared and contrasted with the standard recommended practices for the region in terms of agriculture crops, tree species and allied activities to point out the technological gaps/constraints. The gaps/constraints so observed in the land utilization, cultivation methods, crop management practices were highlighted. The suitable interventions to bridge the technological gaps were proposed.

3.6 Limitation of the study

There is possibility of memory bias of the farmers to some extent since the data were collected through personal interview method.

Chapter – 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The results of the investigation entitled "**Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh**" have been presented under the following heads:

4.1 Socio-economic profile of the study area

4.2 Identification of existing agroforestry systems and to suggest potential tree-crop systems

4.3 Biological yield and economic return from agroforestry systems

4.4 Variation in biological yield and net return of agroforestry system types among different categories

4.5 Technological gaps/constraints and their solutions

4.1 Socio-economic profile of the study area

The study of socio-economic and demographic conditions of households gives an idea regarding the agroforestry systems and level of management of different types of agroforestry systems existing among the various farm families in an area, constraints of farming system, economic well-being of the households, formulation of plans and framing policies for the existing and new agroforestry systems.

For the purpose of the analysis of the households' socio-economic conditions, the heads of families were classified into four classes based on their landholdings, such as 1) Marginal (<1 ha), 2) Small (1-2 ha), 3) Medium (2-5 ha), 4) Large (>5 ha). Category-wise composition of the families under the study is presented in table 3.1 and reveals that 67.50, 24.17, 7.50 and 0.83 per cent households were found in marginal, small, medium and large categories, respectively, irrespective of altitudinal zones. Thus, there was dominance of marginal and small categories of farmers in the study area. Similarly, Kachru (1997) and Upadhyaya (1997) reported the preponderance of marginal and small categories of farmers during their investigations in different parts of Himachal

Pradesh. Moreover, GOHP (1981) also indicated the dominance of marginal and small categories of farmers in Himachal Pradesh.

Among the socio-economic and demographic features that are useful in the socio-economic analysis is the information of each household showing the family structure, landholding, education level, off farm employment/income and live-stock status etc. Data collected on the above mentioned factors have been described as under:

4.1.1 Family structure

Family structure represented the total individuals in a household comprising adults, children and their male-female population in each group.

Altitudinal zone I

Data given in table 4.1a reveal that the average family size in marginal, small and medium category was 5.83, 6.71 and 11.66 individuals; respectively. However, the overall family size was 6.43. The average family size was maximum in medium category followed by small and marginal categories. This can be ascribed to the reason that medium category contained only three households compared to small and marginal categories consisting of 7 and 30 households, respectively.

Data presented in table 4.1b reveal that male : female (M : F) ratio of adults was found to be maximum (1.00) in medium category, followed by marginal (0.95) and small (0.89) categories. The children M : F ratio was maximum in marginal (0.77), followed by medium (0.60) and small (0.51) categories. The overall M : F ratio of children was found 0.65. The data on M : F ratio showed that M : F ratio of adults was higher than the M : F ratio of children in all the categories.

Altitudinal zone II

A perusal of data in table 4.1a reveals that the maximum average family size (9.50) was observed in medium category followed by small (7.66), large

Table 4.1a Family structure in various categories of farmers in different altitudinal zones

Category	< 5 years	5 – 18 years	> 18 years	Total	Average family size
Altitudinal zone I					
Marginal	14 (8.00)	38 (21.71)	123 (70.29)	175 (100.00)	5.83
Small	6 (12.77)	24 (51.06)	17 (36.17)	47 (100.00)	6.71
Medium	8 (22.86)	5 (14.29)	22 (62.86)	35 (100.00)	11.66
Large	-	-	-	-	-
Total	28 (10.89)	67 (26.07)	162 (63.03)	257 (100.00)	6.43
Altitudinal zone II					
Marginal	11 (8.87)	14 (11.29)	99 (79.84)	124(100.00)	5.39
Small	8 (8.70)	24 (26.09)	60 (65.22)	92 (100.00)	7.66
Medium	4 (10.53)	5 (13.16)	29 (76.32)	38 (100.00)	9.50
Large	2 (28.57)	-	5 (71.43)	7 (100.00)	7.00
Total	25 (9.58)	43 (16.47)	193 (73.95)	261 (100.00)	6.52
Altitudinal zone III					
Marginal	13 (7.78)	49 (29.34)	105 (62.87)	167 (100.00)	5.96
Small	6 (9.84)	15 (24.59)	40 (65.57)	61 (100.00)	6.10
Medium	3 (20.00)	3 (20.00)	9 (60.00)	15 (100.00)	7.50
Large	-	-	-	-	-
Total	22 (9.05)	67 (27.57)	154 (63.37)	243 (100.00)	6.07

* Figures in parentheses are percentage

Table 4.1b Male : Female ratio of adults and children in various categories of farmers in different altitudinal zones

Category	Adults (> 18 years)			Children (< 5years)		
	Male	Female	M : F ratio	Male	Female	M : F ratio
Altitudinal zone I						
Marginal	2.10 (36.00)	2.00 (34.28)	0.95	0.26 (4.57)	0.2 (3.42)	0.77
Small	1.28 (19.15)	1.14 (17.02)	0.89	0.57 (8.51)	0.29 (4.25)	0.51
Medium	3.67 (31.43)	3.67 (31.43)	1.00	1.67 (14.29)	1.00 (8.57)	0.60
Large	-	-	-	-	-	-
Total	2.08 (32.30)	1.98 (30.74)	0.95	0.43 (6.61)	0.28 (4.28)	0.65
Altitudinal zone II						
Marginal	2.30 (42.74)	2.00 (37.09)	0.86	0.21 (4.03)	0.26 (4.83)	1.23
Small	2.83 (36.95)	2.16 (28.26)	0.76	0.58 (7.60)	0.08 (1.08)	0.13
Medium	4.00 (42.10)	3.25 (34.21)	0.81	0.25 (2.63)	0.00 (0.00)	0.00
Large	3.00 (42.85)	2.00 (28.57)	0.66	1.00 (14.28)	1.00 (14.28)	1.00
Total	2.65(40.61)	2.17(33.33)	0.81	0.35(5.36)	0.20(3.06)	0.57
Altitudinal zone III						
Marginal	2.11 (35.32)	1.64 (27.54)	0.77	0.36 (5.98)	0.11 (1.79)	0.31
Small	2.30 (37.70)	1.70 (27.80)	0.74	0.20 (3.28)	0.40 (6.56)	2.00
Medium	2.00 (26.67)	2.5 (33.33)	1.25	1.00 (13.33)	0.50 (6.67)	0.50
Large	-	-	-	-	-	-
Total	2.15 (35.39)	1.70 (27.98)	0.79	0.35 (5.76)	0.20 (3.29)	0.57

* Figures in parentheses are percentage

graduation. Head of the family having minimum education level even up to primary standard was considered literate.

Altitudinal zone I

Data in table 4.2 reveal the educational background of heads of households. Further, a cursory glance of data shows that literacy rate was maximum (66.67 %) in marginal category which was followed by small category (57.14 %). The literacy rate in medium category was zero per cent. This can be ascribed to the fact that medium category contained only three households and the heads of all these households were illiterate. However, the overall literacy rate in altitudinal zone I was 60.00 per cent.

Altitudinal zone II

A perusal of data in table 4.2 shows that the literacy rate of 100 per cent was found in large category, followed by marginal (73.91 %), small (66.66 %) and medium (50.00 %) categories. Higher literacy found in large category could be because of the only household and the head of this household was literate. The overall literacy rate of heads in altitudinal zone II was higher (70.00 %) than the literacy of heads in altitudinal zone I (60.00 %).

Altitudinal zone III

Data in table 4.2 show that the literacy rate of family head in altitudinal zone III followed the same trend as in altitudinal zone I. The literacy rate was found maximum in marginal category (53.57 %) which was followed by small category (40.00 %). Similarly, as in altitudinal zone I, the literacy rate of heads in medium category of altitudinal zone III was found zero percent. The overall literacy rate in altitudinal zone III was 47.50 per cent.

Educational status of heads of families was studied keeping in view that an educated farmer is considered to be more aware of the modern farming practices and can be a better manager of his/her farm as reported by Rai *et al.* (2001).

Table 4.2 Educational status of head of family in various categories of farmers in different altitudinal zones

Category	Education level									
	Primary	Middle	Matric	Sr. Sec.	Graduation	PG	Illiterate	Literate	Total	Literacy (%)
Altitudinal zone I										
Marginal	7(23.33)	4(13.33)	8(26.67)	1(3.33)	-	-	10(33.33)	20(66.67)	30	66.67
Small	1(14.29)	-	-	1(14.29)	1(14.29)	1(14.29)	3(42.86)	4(57.14)	7	57.14
Medium	-	-	-	-	-	-	3(100.00)	-	3	0.00
Large	-	-	-	-	-	-	-	-	-	-
Total	8(20.00)	4(10.00)	8(20.00)	2(5.00)	1(2.50)	1(2.50)	16(40.00)	24(60.00)	40	60.00
Altitudinal zone II										
Marginal	3(13.04)	4(17.39)	5(21.73)	-	5(21.73)	-	6(26.08)	17(73.91)	23	73.91
Small	5(41.66)	2(16.66)	1(8.33)	-		-	4(33.33)	8(66.66)	12	66.66
Medium	-	-	2(50.00)	-	-	-	2(50.00)	2(50.00)	4	50.00
Large	-	-	1(100)	-	-	-	-	1(100.00)	1	100.00
Total	8(20.00)	6(15.00)	9(22.50)	-	5(12.50)	-	12(30.00)	28(70.00)	40	70.00
Altitudinal zone III										
Marginal	9(32.14)	3(10.71)	3(10.71)	-	-	-	13(46.42)	15(53.57)	28	53.57
Small	-	1(10.00)	1(10.00)	-	2(20.00)	-	6(60.00)	4(40.00)	10	40.00
Medium	-	-	-	-	-	-	2(100.00)	-	2	0.00
Large	-	-	-	-	-	-	-	-	-	-
Total	9(22.50)	4(10.00)	4(10.00)	-	2(5.00)	-	21(52.50)	19(47.50)	40	47.50

* Figures in parentheses are percentage

Although 59.16 per cent literacy rate of heads was observed in the study area, irrespective of altitudinal zones and categories, but it is quite clear from the table 4.2 that 20.83 per cent of the heads got education upto primary standard.

4.1.3 Educational status of family (sex-wise)

Education is a key to new information and in this regard it eases the constraints on the families. At the same time, education helps to secure off-farm employment and, also, eases the capital constraints. Thus, the analysis of the educational status of households becomes important.

Altitudinal zone I

The sex-wise educational status of both males and females given in table 4.3 shows that the literacy rate of males and females was found maximum (95.24 % and 85.71 %, respectively) in small category, followed by marginal (91.36 % and 82.14 %, respectively) and medium (71.43 % and 69.23 %, respectively) category of farmers. The data also reveal that the literacy rate of males was higher than the literacy rate of females in all the categories. On an average, the highest family literacy rate was observed among the small category farmers (90.48 %), followed by marginal (86.67 %) and medium (70.37 %) category farmers. The average family literacy in altitudinal zone I was 85.47 per cent.

Altitudinal zone II

Data in table 4.3 reveal that all the males and females in large category were literate and, thus, 100 per cent literacy of males and females was observed in this category of farmers. Whereas, in other categories, viz. marginal, small and medium, the literacy rate of males was higher than the literacy rate of females. The overall scenario on family literacy rate reveals that the maximum literacy of 100 per cent was observed in large category of farmers followed by marginal (84.48 %), medium (83.78 %) and small (82.92 %) category. The average family literacy in altitudinal zone II was 84.16 per cent and it was higher than the average family literacy of altitudinal zone I.

Altitudinal zone III

In altitudinal zone III, the literacy rate of males was found 81.40, 78.13 and 83.33 per cent in marginal, small and medium categories of farmers, respectively (Table 4.3). Whereas, the literacy rate of females was 62.86, 69.23 and 77.78 per cent in marginal, small and medium category of farmers, respectively. Thus, maximum literacy of males (83.33 %) and females (77.78 %) was found in medium category of farmers. On an average, the highest family literacy rate was observed among the medium category (80.00 %), followed by small (74.14 %) and marginal (73.08 %) category farmers. The average family literacy in altitudinal zone III was 73.80 per cent.

It is evident from the results that the percentage of illiterate females was higher than that of males in all the altitudinal zones, irrespective of category. But female literacy plays a key role in the economic and social upliftment of a society. To educate a girl is to educate the whole family, because mother is the first teacher of a child.

The results also reflect that overall family literacy rate was maximum in altitudinal zone I, followed by II and III.

4.1.4 Status of off-farm employment

Off-farm employment can produce diversified farm enterprises. Besides, it gives more risk bearing potential to the farmers. Thus, off-farm income of farmers has always been known to enhance the capabilities of farming community to adopt improved technologies and practices. In present study, government employment/pension, grocery shop-keeping, carpentry, family trade, tailoring, vegetable vendor, private transport and industries, etc. were the sources of off-farm income.

Altitudinal zone I

A perusal of the data in table 4.4 reveals that among different categories of farmers, in altitudinal zone I, maximum number (18.85 %) of individuals of

Table 4.3 Sex-wise literacy of family in various categories of farmers in different altitudinal zones

Category	Literates		Illiterates		Total		Total (Literares + Illiterats)	Family literacy (%)
	Male	Female	Male	Female	Literates	Illiterates		
Altitudinal zone I								
Marginal	74(91.36)	69(82.14)	7(8.64)	15(17.86)	143(86.67)	22(13.33)	165	86.67
Small	20(95.24)	18(85.71)	1(4.76)	3(14.29)	38(90.48)	4(9.52)	42	90.48
Medium	10(71.43)	9(69.23)	4(28.57)	4(30.77)	19(70.37)	8(29.63)	27	70.37
Large	-	-	-	-	-	-	-	-
Total	104(89.66)	96(81.36)	12(10.34)	22(18.64)	200(85.47)	34(14.53)	234	85.47
Altitudinal zone II								
Marginal	58(95.08)	40(72.72)	3(4.91)	15(27.27)	98(84.48)	18(15.51)	116	84.48
Small	44(95.65)	24(66.66)	2(4.34)	12(33.33)	68(82.92)	14(17.07)	82	82.92
Medium	21(91.30)	10(71.42)	2(8.69)	4(28.57)	31(83.78)	6(16.21)	37	83.78
Large	3(100.00)	2(100.00)	-	-	5(100.00)	-	5	100.00
Total	126(94.73)	76(71.02)	7(5.26)	31(28.97)	202(84.16)	38(15.83)	240	84.16
Altitudinal zone III								
Marginal	70(81.40)	44(62.86)	16(18.60)	26(37.14)	114(73.08)	42(26.92)	156	73.08
Small	25(78.13)	18(69.23)	7(21.87)	8(30.77)	43(74.14)	15(25.86)	58	74.14
Medium	5(83.33)	7(77.78)	1(16.67)	2(22.22)	12(80.00)	3(20.00)	15	80.00
Large	-	-	-	-	-	-	-	-
Total	100(80.65)	69(65.71)	24(19.35)	36(34.29)	169(73.80)	60(26.20)	229	73.80

* Figures in parentheses are percentage

Table 4.4 Status of off-farm employment in different altitudinal zones

Category	altitudinal zone I			altitudinal zone II			altitudinal zone III		
	Off-farm employment (No.)	Yearly income (Rs)	Total members	Off-farm employment (No.)	Yearly income (Rs)	Total members	Off-farm employment (No.)	Yearly income (Rs)	Total members
Marginal	33(18.85)	2123000	175	31(25.00)	2512000	124	31(18.56)	1353800	167
Small	8(17.02)	900000	47	18(19.56)	1134000	92	7(11.47)	612000	61
Medium	4(11.42)	291000	35	7(18.42)	574000	38	3(20.00)	183000	15
Large	-	-	-	2(28.57)	192000	7	-	-	-
Total	45(17.51)		257	58(22.22)			41(16.87)		247

* Figures in parentheses are percentage

marginal category were having access to off-farm employment sources, followed by small (17.02 %) and medium (11.42 %). Overall, 17.51 per cent of the total population of altitudinal zone I were having access to the off-farm employment.

Altitudinal zone II

In altitudinal zone II, the percentage of population engaged in off-farm employment was maximum (28.57 %) in large category followed by marginal (25.00 %), small (19.56 %) and the least in medium (18.42 %) category. It was clear from the table 4.4 that 22.22 per cent of the total population of this zone was engaged in off-farm employment.

Altitudinal zone III

Data presented in table 4.4 reveal that in altitudinal zone III, medium category were having the highest (20.00 %) access to off-farm employment followed by marginal (18.56 %) and small (11.47 %) categories. It further showed that 16.87 per cent of the total population of this zone was engaged in off-farm employment.

Thus, the maximum access to off-farm employment was observed in altitudinal zone II. It is quite clear from the tables 4.2 and 4.4 that access to off-farm employment in different altitudinal zones followed the same trend as that of literacy rate of heads. Maximum access to off-farm employment could be because of the highest literacy rate of heads in altitudinal zone II.

4.1.5 Livestock status

A perusal of data in table 4.5 to 4.7 reveals that the major livestock comprised of buffaloes with all the categories of farmers. The others were cows, bullocks, sheep and goats, etc.

Altitudinal zone I

Data in table 4.5 reveal that the average buffaloes per family increased with the corresponding increase in landholding. The maximum (2.33) average buffaloes

per family were observed in medium category, followed by small (1.71) and marginal (1.57) categories of farmers. Cent per cent buffaloes were of local breeds in small category. Whereas in marginal and medium categories, 2.13 and 14.29 per cent buffaloes were of improved breeds, respectively. Further, it was observed that 59.57, 50.00 and 71.43 per cent buffaloes were found lactating in marginal, small and medium categories of farmers, respectively. The results also show that cent per cent cows were of improved breeds with all the categories. In marginal and small categories, 100 per cent cows were found lactating, whereas 100 per cent cows were dry in small category.

Altitudinal zone II

The results regarding livestock status in altitudinal zone II have been presented in table 4.6. Data reveal that buffaloes per family increased with the corresponding increase in landholding. The maximum (2.00) average buffaloes per family were observed in large category, followed by medium (1.75), small (1.42) and marginal (1.17) categories. It was observed that the cent per cent buffaloes in medium and large categories were of local breeds. Whereas, in marginal and small categories, 92.59 and 88.23 per cent buffaloes were of local breeds. Cent percent buffaloes in large category were found lactating, whereas in marginal, small and medium categories 59.25, 58.82 and 71.42 per cent buffaloes were found lactating, respectively. It can be seen from the data that cows were found only in marginal and small category farmers and cent per cent cows were of improved breeds. In marginal category, 88.88 per cent cows were found lactating, whereas in small category only 50.00 per cent cows were found lactating.

Altitudinal zone III

Data in table 4.7 show that on an average the maximum buffaloes (6.00) were found in medium category, followed by small (3.70) and marginal (1.64) categories. In marginal category, 95.65 per cent buffaloes were of local breeds and only 4.35 per cent of improved breeds. Whereas, in medium category 75.00 per cent buffaloes were of local breeds and 25.00 per cent of improved breeds. It was

Table 4.5 Livestock status in different categories of farmers in altitudinal zone I (per household)

Category	Animal type	Total numbers	Average	Local breed	Improved breed	Dry	In milk
Marginal	Buffalo	47	1.57	1.54(97.87)	0.03(2.13)	0.63(40.43)	0.93(59.57)
	Cow	3	0.09	-	0.09(100)	-	0.09(100)
	Young stocks:						
	Buffalo	15	0.50				
	Cow	2	0.06				
	Bullock	4	0.19				
	Goat	1	0.03				
	Sheep	3	0.09				
Small	Buffalo	12	1.71	1.71(100)	-	0.85(50.00)	0.85(50.00)
	Cow	2	0.29	-	0.29(100)	0.29(100)	-
	Young stocks:						
	Buffalo	-	-				
	Cow	-	-				
	Bullock	-	-				
	Goat	-	-				
	Sheep	-	-				
Medium	Buffalo	7	2.33	2.00(85.71)	0.33(14.29)	0.66(28.57)	1.66(71.43)
	Cow	1	0.50		0.50(100)	-	0.50(100)
	Young stocks:						
	Buffalo	4	1.33				
	Cow	1	0.33				
	Bullock	4	1.33				
	Goat	-	-				
	Sheep	-	-				

* Figures in parentheses are percentage

Table 4.6 Livestock status in different categories of farmers in altitudinal zone II (per household)

Category	Animal type	Total numbers	Average	Local breed	Improved breed	Dry	In milk
Marginal	Buffalo	27	1.17	1.09(92.59)	0.08(7.40)	0.48(40.74)	0.70(59.25)
	Cow	9	0.39	-	0.39(100.00)	0.04(11.11)	0.35(88.88)
	Young stocks:						
	Buffalo	5	0.21				
	Cow	4	0.17				
	Bullock	16	0.69				
	Goat	31	1.34				
	Mule	3	0.13				
Small	Buffalo	17	1.42	1.25(88.23)	0.17(11.76)	0.58(41.17)	0.83(58.82)
	Cow	10	0.83	0.00(0.00)	0.83(100.00)	0.42(50.00)	0.42(50.00)
	Young stocks:						
	Buffalo	2	0.16				
	Cow	1	0.08				
	Bullock	16	1.33				
	Goat	15	1.25				
Medium	Buffalo	7	1.75	1.75(100.00)	-	0.50(28.57)	1.25(71.42)
	Young stocks:						
	Buffalo	1	0.25				
	Cow	-	0.00				
	Bullock	8	2.00				
	Goat	5	1.25				
	Sheep	2	0.50				
Large	Buffalo	2	2.00	2.00(100.00)	-	-	2.00(100.00)
	Young stocks	2	2.00				

* Figures in parentheses are percentage

Table 4.7 Livestock status in different categories of farmers in altitudinal zone III (per household)

Category	Animal type	Total numbers	Average	Local breed	Improved breed	Dry	In milk
Marginal	Buffalo	46	1.64	1.57(95.65)	0.07(4.35)	0.79(47.83)	0.86(52.17)
	Cow	18	0.64	0.36(55.56)	0.29(44.44)	0.32(50.00)	0.32(50.00)
	Young stocks:						
	Buffalo	6	0.21				
	Cow	8	0.29				
	Bullock	29	1.04				
	Goat	86	3.07				
	Sheep	-	-				
	Mule	-	-				
Small	Buffalo	37	3.70	3.70(100)	-	2.00(54.05)	1.70(45.94)
	Cow	-	-				
	Young stocks:						
	Buffalo	2	0.20				
	Cow	-	-				
	Bullock	17	1.70				
	Goat	7	0.70				
	Male buffalo	1	0.10				
	Mule	3	0.30				
Medium	Buffalo	12	6.00	4.50(75.00)	1.50(25.00)	2.50(41.67)	3.50(58.33)
	Cow	-	-				
	Young stocks:						
	Buffalo	-	-				
	Cow	-	-				
	Bullock	-	-				
	Goat	19	9.50				
	Sheep	-	-				

* Figures in parentheses are percentage

observed that cent per cent buffaloes were of local breeds in small category. Data also show that 52.17, 45.94 and 58.33 per cent buffaloes were found lactating in marginal, small and medium categories, respectively. Cows were found only in marginal category and their occurrence was on an average 0.64 per cent per household. Further it was found that 55.56 per cent of total cows were of local breeds and 44.44 per cent of improved breeds. It was found that 50.00 per cent of total cows were lactating. Bullocks were found only in marginal and small categories. Goats were found in all the categories. The maximum goats (9.50) per household were found in medium category, followed by marginal (3.07) and small (0.70) categories. Among other animals, three mules, though with a single farmer, were noticed in small category. One male buffalo was also found in the same category.

4.1.6 Animal husbandry practices

Altitudinal zone I

The data in table 4.8 reveal that 93.33, 85.71 and 100 per cent farmers possess animals in marginal, small and medium categories, respectively, in this zone. It was found that traditional livestock management practices were dominating e.g. traditional milking procedure was in vogue among all the categories. Other practices like vaccination against Foot Mouth Disease (FMD) was carried out by 50.00, 66.67 and 66.67 per cent farmers in marginal, small and medium categories, respectively. Regular de-worming of animals was missing in all the categories. Data also reveal that majority of farmers adopted traditional breeding techniques for their animals. It was found that traditional breeding technique was adopted mainly for buffaloes, whereas scientific breeding technique was adopted exclusively for cows. The study also revealed that in marginal category, 85.71 per cent farmers utilized the whole of animal dung for crop production. Whereas, 14.29 per cent farmers utilized a part of animal dung as fuel in addition to crop production. Farmers from small and medium categories utilized cent per cent animal dung for crop production.

Altitudinal zone II

In altitudinal zone II, it was observed that 86.95 per cent farmers of marginal category possessed animals (Table 4.8). While in small, medium and large categories cent per cent farmers were having animals. The mechanical milking procedure and regular de-worming in animal were also missing in all the categories of this zone. Vaccination against FMD in animals was done by 100, 75.00, 66.66 and 65.00 per cent farmers in large, medium, small and marginal categories, respectively. Breeding techniques followed the same trend as in altitudinal zone I. Farmers of large category utilized the animal dung for crop production only, whereas 75.00, 50.00 and 45.00 per cent farmers of medium, small and marginal categories utilize a part of animal dung as fuel in addition to crop production.

Altitudinal zone III

Data in table 4.8 reveal that cent per cent farmers of this zone possessed animals in all the categories. Similarly, as in altitudinal zone I and II, the traditional milking procedure was in vogue in all the categories. Vaccination against FMD in animals was carried out by only 17.86. 30.00 and 50.00 per cent farmers in marginal, small and medium categories, respectively. Breeding techniques followed for the animals were same as in altitudinal zone I and II. It was also observed that 75.00 per cent farmers in marginal and 50.00 per cent each in small and medium categories utilized a part of animal dung as fuel in addition to crop production. On an average, 67.50 per cent farmers in altitudinal zone III utilized a part of animal dung as fuel in addition to crop production and remaining 32.50 per cent farmers utilized the animal dung for crop production only.

A perusal of data in table 4.8 reveals that the vaccination against FMD in animals was done by the maximum number of families in altitudinal zone II. It could be because of the highest literacy of heads in this zone. Further it was observed that in altitudinal zone III, maximum number of households was using animal dung as fuel. It may be ascribed to the fact that the less number of trees

Table 4.8 Animal husbandry practices followed by various categories of farmers in different altitudinal zones

Category	Total no. of farmers	No. of farmers possessing animals	Milking procedure		Disease management		Breeding method			FYM	
			Mechanical	Traditional	Regular deworming	FMD vaccination	Mechanical	Traditional	Both	Crop production	Crop production +fuel purpose
Altitudinal zone I											
Marginal	30	28(93.33)	-	28(100)	-	14(50.00)	3(10.71)	25(89.29)	-	24(85.71)	4(14.29)
Small	7	6(85.71)	-	6(100)	-	4(66.67)	-	4(66.67)	2(33.33)	6(100)	-
Medium	3	3(100)	-	3(100)	-	2(66.67)	-	2(66.67)	1(33.33)	3(100)	-
Large	-	-	-	-	-	-	-		-	-	-
Total	40	37(92.50)	-	37(100)	-	20(54.05)	3(8.11)	31(83.78)	3(8.11)	33(89.19)	4(10.81)
Altitudinal zone II											
Marginal	23	20(86.95)	-	20(100)	-	13(65.00)	1(5.00)	13(65.00)	6(30.00)	11(55.00)	9(45.00)
Small	12	12(100)	-	12(100)	-	8(66.66)	1(8.33)	6(50.00)	5(41.66)	6(50.00)	6(50.00)
Medium	4	4(100)	-	4(100)	-	3(75.00)	-	4(100)	-	1(25.00)	3(75.00)
Large	1	1(100)	-	1(100)	-	1(100)	-	1(100)	-	1(100)	0(0.00)
Total	40	37(100)	-	37(100)	-	25(67.56)	2(5.00)	24(60.00)	11(27.50)	19(51.35)	18(48.64)
Altitudinal zone III											
Marginal	28	28(100)	-	28(100)	-	5(17.86)	8(28.57)	16(57.14)	4(14.29)	7(25.00)	21(75.00)
Small	10	10(100)	-	10(100)	-	3(30.00)	0(0.00)	10(100)	0(0.00)	5(50.00)	5(50.00)
Medium	2	2(100)	-	2(100)	-	1(50.00)	0(0.00)	2(100)	0(0.00)	1(50.00)	1(50.00)
Large	-	-	-	-	-	-	-	-	-	-	-
Total	40	40(100)	-	40(100)	-	9(22.50)	8(20.00)	28(70.00)	4(10.00)	13(32.50)	27(67.50)

* Figures in parentheses are percentage

were found on their farms. So, they were using the animal dung as an alternate to fuel wood.

4.1.7 Land use statistics

Altitudinal zone I

Land use statistics presented in table 4.9 reveal that agriculture and pasture were the major land use systems prevalent in the study area. Irrigation facility was not available in any of the zone. Data further show that more than half of the total land was used for agriculture by the farmers in all the categories in altitudinal zone I. In marginal category, maximum (59.16 %) land area was found under agriculture, followed by small (55.49 %) and medium (52.06 %), whereas, for pasture opposite trend was observed. The maximum land area (47.93 %) was found under pasture in medium category followed by small (44.50 %) and marginal (40.84 %). Average land holding was found maximum (2.781 ha) in medium, followed by small (1.501 ha) and marginal (0.666 ha) categories. The average land holding per household of this zone was found to the tune of 0.970 ha.

Altitudinal zone II

Data in table 4.9 reveal that more than 50 per cent of total land area was under agriculture irrespective of farmers' category in this zone. In small category, maximum proportion (61.36 %) of total land was found under agriculture followed by marginal (60.49 %), medium (50.85 %) and large (30.94 %) category. Maximum land area under pasture was found in large (69.06 %) category followed by medium (49.15 %), marginal (39.51 %) and small (38.64 %). Average land holding was found in the following order : large (5.56 ha) > medium (2.365 ha) > small (1.328 ha) > marginal (0.518 ha). Data also reflect that average land holding per household of this zone was 1.072 ha.

Altitudinal zone III

A perusal of data in table 4.9 shows that marginal category of farmers had 55.97 per cent land area under agriculture and 44.03 per cent under pasture. Small

category of farmers put 44.55 per cent of land area under agriculture and 55.45 per cent under pasture. Likewise, 42.19 per cent land area among medium category of farmers was under agriculture and 57.81 per cent of area under pasture. Data further reflect that the average land-holding per household was maximum (2.710 ha) in medium category followed by small (1.367 ha) and marginal (0.640 ha) categories. The average landholding per household of this zone was 0.925 ha.

4.2 Identification of agroforestry systems

Seven agroforestry system types prevalent among the farmers in study area have been identified and described for each altitudinal zone. The common and scientific names of all the species found in various agroforestry system types are listed in appendix II.

4.2.1 Altitudinal zone I

There were seven agroforestry system types prevalent among the different categories of farmers in zone-I. Each of the system types category-wise has been described as under:

Marginal category

In marginal category six types of agroforestry systems were identified viz. agrisilviculture, agrihorticulture, agrisilvihorticulture, agrihortisilviculture, pastoral silviculture and pastoral silvihorticulture. The system units of each of the above said system types are given in table 4.10.

The functional units under agricultural component were cereals e.g. wheat, maize and paddy; oil-seeds and pulses – mustard, taramira and mash; vegetables - cauliflower, colocassia, bhindi, ginger, onion, garlic, chilli, brinjal and potato. Under horticultural component mango, guava, lemon, banana, lime, plum, kinnow and walnut were the functional units. The forestry component was represented by *Grewia optiva, Leucaena leucocephala, Morus alba, Dalbergia. sissoo, Emblica officinalis, Eucalyptus* sp, *Toona ciliata, Ficus palmata, Bauhinia variegata,*

Table 4.9 Land use statistics per household in different altitudinal zones

Category	Agricultural land (ha)	Pasture (ha)	Total (ha)	Average land holding (ha)
Altitudinal zone I				
Marginal	0.394(59.16)	0.272(40.84)	19.980	0.666
Small	0.833(55.49)	0.668(44.50)	10.507	1.501
Medium	1.448(52.06)	1.333(47.93)	8.343	2.781
Total	0.550(56.66)	0.421(43.37)	38.830	0.970
Altitudinal zone II				
Marginal	0.313(60.49)	0.205(39.51	11.920	0.518
Small	0.815(61.36)	0.513(38.64)	15.943	1.328
Medium	1.203(50.85)	1.163(49.15)	9.460	2.365
Large	1.72(30.94)	3.84(69.06)	5.560	5.560
Total	0.588(54.85)	0.484(45.15)	42.883	1.072
Altitudinal zone III				
Marginal	0.358(55.97)	0.282(44.03)	17.920	0.640
Small	0.609(44.55)	0.758(55.45)	13.670	1.367
Medium	1.190(42.19)	1.52(57.81)	5.420	0.271
Total	0.462(49.93)	0.463(50.04)	37.01	0.925

* Figures in parentheses are percentage

Table 4.10 Agroforestry system types and their system units in marginal category of farmer of altitudinal zone I

A. Agrisilviculture system (AS)

1. Wheat/Garlic/Onion - Maize/Colocassia + Grewia + Leucaena + Morus
2. Wheat/Garlic/Onion - Maize + Grewia + Dalbergia + Leucaena
3. Wheat/Potato/Cauliflower - Maize/Ginger/Colocassia + Grewia + Leucaena + Morus
4. Wheat - Maize/Ginger/Chilli + Grewia + Morus
5. Wheat - Maize + Eucalyptus + Morus + Toona
6. Wheat/Onion/Garlic - Maize/Colocassia/Chilli + Morus + Grewia + Leucaena + Dalbergia
7. Wheat/Onion/Garlic/Mustard/Taramira - Maize/Colocassia/ Chilli/Bhindi/Brinjal + Morus + Grewia + Toona + Leucaena + Dalbergia
8. Wheat/ Mustard/Taramira - Maize/Colocassia + Morus + Grewia + Leucaena
9. Wheat/Garlic - Maize/Bhindi + Leucaena + Morus + Grewia
10. Wheat - Maize + Morus + Dendrocalamus + Leucaena
11. Wheat - Maize/Colocassia + Grewia + Bauhinia
12. Wheat - Maize + Grewia
13. Wheat/ Mustard/Onion/Garlic - Maize/Bhindi/Brinjal + Grewia
14. Wheat/ Mustard – Maize + Dalbergia
15. Wheat/ Mustard/ Taramira - Maize + Grewia + Dalbergia
16. Wheat - Maize/Colocassia + Leucaena + Morus + Toona + Grewia + Dendrocalamus
17. Wheat/Cauliflower/Potato - Maize/Colocassia/Bhindi/Chilli + Grewia + Leucaena + Morus + Dalbergia + Bauhinia

B. Agrihorticulture system (AH)

1. Wheat/Garlic - Maize/Mash/Bhindi + Mango + Kinnow
2. Wheat - Maize/Paddy/Colocassia + Mango

3. Wheat/ Mustard – Maize + Mango
4. Wheat - Maize + Mango
5. Wheat - Maize + Mango + Kinnow
6. Wheat/Mustard/Garlic - Maize/Paddy/Colocassia/Bhindi + Mango + Walnut

C. Agrisilvihorticulture system (ASH)

1. Wheat - Maize/Colocassia + Leucaena + Morus + Grewia + Toona + Ficus + Guava + Mango
2. Wheat - Maize/Colocassia + Leucaena + Grewia + Dalbergia + Morus + Acacia + Toona + Pinus + Bauhinia + Guava + Plum + Mango + Lemon
3. Wheat - Maize + Grewia + Morus + Leucaena + Albizzia (Siris) + Terminalia (Alsan) + Mango
4. Wheat - Maize + Grewia + Morus + Populus + Dendrocalamus + Mango + Kinnow
5. Wheat - Maize + Melia + Acacia + Eucalyptus + Mango + Lemon
6. Wheat - Maize/Colocassia + Acacia + Melia + Eucalyptus + Mango
7. Wheat - Maize + Grewia + Morus + Dendrocalamus + Morus + Kinnow

D. Agrihortisilviculture system (AHS)

1. Wheat – Maize + Banana + Lemon + Mango + Eucalyptus
2. Wheat – Maize + Mango + Guava + Walnut + Toona

E. Pastoral silviculture system (PS)

1. Natural grasses + Albizzia (Siris) + Bauhinia + Grewia + Dalbergia
2. Natural grasses + Bauhinia + Acacia + Dalbergia + Eucalyptus
3. Natural grasses + Leucaena + Morus + Mallotus + Grewia + Acacia + Eucalyptus
4. Natural grasses + Pinus + Bauhinia

5. Natural grasses + Dalbergia + Mallotus + Grewia + Pinus + Bauhinia + Syzygium
6. Natural grasses + Pinus + Dalbergia + Mallotus + Leucaena + Grewia + Albizzia (Siris)
7. Natural grasses + Dalbergia + Wendlendia + Salix + Pinus + Emblica + Albizzia + Syzygium + Mallotus + Acacia
8. Natural grasses + Acacia + Pinus + Eucalyptus + Bauhinia
9. Natural grasses + Acacia + Dalbergia + Eucalyptus + Pinus + Albizzia (Siris) + Dendrocalamus
10. Natural grasses + Acacia + Dalbergia
11. Natural grasses + Dalbergia + Acacia + Leucaena + Morus + Pinus + Albizzia + Grewia + Dendrocalamus
12. Natural grasses + Pinus + Acacia + Eucalyptus + Mallotus + Bauhinia
13. Natural grasses + Pinus + Acacia + Eucalyptus + Albizzia
14. Natural grasses + Acacia + Grewia
15. Natural grasses + Acacia
16. Natural grasses + Acacia + Grewia + Dalbergia + Toona + Leucaena + Ficus + Melia + Bauhinia + Dendrocalamus
17. Natural grasses + Acacia + Pinus + Eucalyptus + Toona
18. Natural grasses + Acacia + Dalbergia + Melia + Albizzia + Grewia
19. Natural grasses + Acacia + Bombax + Bauhinia + Grewia + Dalbergia + Albizzia (Cheoli)
20. Natural grasses + Dalbergia + Grewia + Leucaena + Eucalyptus + Dendrocalamus + Albizzia (Siris)
21. Natural grasses + Acacia + Dalbergia + Mallotus
22. Natural grasses + Pinus + Mallotus

F. Pastoral silvihorticulture system (PSH)

1. Natural grasses + Acacia + Grewia + Dalbergia + Mallotus + Toona + Leucaena + Ficus + Bauhinia + Dendrocalamus + Mango + Guava + Lime
2. Natural grasses + Grewia + Morus + Mallotus + Syzygium + Bauhinia + Toona + Melia + Pinus + Mango

Terminalia tomentosa, *Albizzia lebbeck*, *Acacia catechu*, *Pinus roxburghii*, *Mallotus philippinensis*, *Salix* sp, *Syzygium cumini*, *Bombax ceiba*, *Melia azedarach*, *Populus* sp., *Wendlendia exserta* and *Dendrocalamus* sp.

Among shrubs and bushes, *Carrisa carandus*, *Lantanna camara*, *Rubus ellipticus*, *Berberis lycium*, *Justacea adhatoda*, *Princepia utilis*, *Woodfordia floribunda*, *Leptodermis lanceolata*, *Murraya koenghii*, *Ageratum conzoides* and *Parthenium hysterophorus* were prominent. Major grass species present were *Heteropogon contortus*, *Chrysopogon montanus*, *Themeda anathera*, *Panicum maximum*, *Apluda mutica*, *Pennisetum* sp. and *Cynodon dactylon*.

Small Category

Date presented in table 4.11 reveal that five types of agroforestry systems were identified in small category of farmers in altitudinal zone I. These systems were agrisilviculture, agrihorticulture, agrisilvihorticulture, pastoral silviculture and pastoral silvihorticulture. The functional units under agricultural component were cereals e.g. wheat, maize; oil seeds and pulses - mustard, taramira and gram; vegetables - colocassia, ginger, potato, turmeric, brinjal, onion, garlic, bhindi, chilli. Among horticultural components mango, guava, lime, peach, pear, lemon, kinnow, papaya were identified as functional units. The functional units found under forestry component were consisted of *Morus alba*, *Grewia optiva*, *Toona ciliata*, *Dalbergia sissoo*, *Leucaena leucocephala*, *Bauhinia variegata*, *Bombax ceiba*, *Albizzia lebbeck*, *Eucalyptus* sp, *Acacia catechu*, *Emblica officinalis*, *Pinus roxburghii*, *Wendlendia exserta*, *Albizzia chinensis*, *Mallotus philippinensis*, *Ficus palmata*, *Melia azedarach* and *Dendrocalamus* sp.

Medium category

In medium category five types of agroforestry systems were identified (Table 4.12). These were agrisilviculture, agrisilvihorticulture, pastoral silviculture, pastoral silvihorticulture, pastoral hortisilviculture. The functional units under agricultural component were cereals e.g. wheat, maize and paddy;

vegetables - colocassia, turmeric, bhindi, onion, garlic; oil seeds and pulses – mustard, taramira and gram. Among horticultural component mango, lime and kinnow were the functional units. Forestry component consisted of *Grewia optiva*, *Bauhinia variegata*, *Albizzia lebbeck*, *Acacia catechu*, *Leucaena leucocephala*, *Pinus roxburghii*, *Dalbergia sissoo*, *Toona ciliata*, *Eucalyptus* sp., *Terminalia tomentosa*, *Morus alba*, *Emblica officinalis* and *Dendrocalamus* sp.

4.2.2 Altitudinal zone II

There were six agroforestry system types prevalent among the different categories of farmers in altitudinal zone II. Each of the system types category-wise has been described as under :

Marginal category

Six agroforestry system types seen in this group were agrisilviculture, agrihorticulture, agrisilvihorticulture, agrihortisilviculture, pastoral silviculture and pastoral silvihorticulture (Table 4.13). The specific functional units under agricultural component were cereals e.g. wheat, maize, paddy; oil seeds - mustard; vegetables - colocassia, onion, garlic, ginger, tomato, cauliflower, bhindi and pea. Mango, litchi, guava, lemon, lime and kinnow were the major functional units under horticultural component. *Toona ciliata*, *Grewia optiva*, *Bombax ceiba*, *Bauhinia variegata*, *Ficus palmata*, *F. roxburghii*, *Dalbergia sissoo*, *Albizzia chinensis*, *Melia azedarach*, *Albizzia lebbeck*, *Aegle marmelos*, *Wendlendia exserta*, *Pyrus pashia*, *Acacia catechu*, *Eucalyptus* sp., *Leucaena leucocephala*, *Populus* sp. and *Dendrocalamus* sp. formed the specific functional units of the forestry component.

Small category

Data in table 4.14 reveal that six agroforestry system types found in this group were agrisilviculture, agrihorticulture, agrisilvihorticulture, agrihortisilviculture, pastoral silviculture and pastoral silvihorticulture. The specific functional units under agricultural component were cereals e.g. wheat, maize; oil seeds and

Table 4.11 Agroforestry system types and their system units in small category of farmers of altitudinal zone I

A. Agrisilviculture system (AS)
    1. Wheat – Maize/Colocassia + Morus + Leucaena + Grewia + Toona
    2. Wheat/Garlic/Onion – Maize/Colocassia/Bhindi + Dalbergia + Grewia + Leucaena + Bauhinia
    3. Wheat/Potato/Garlic + Maize + Morus + Ficus
    4. Wheat/Garlic/Onion – Maize/Colocassia/Bhindi + Morus + Leucaena

B. Agrihorticulture system (AH)
    1. Wheat/Garlic/Onion/Mustard – Maize/Colocassia/Ginger/Chilli/ Bhindi/Brinjal/Turmeric

C. Agrisilvihorticulture system (ASH)
    1. Wheat/Onion/Garlic – Maize + Dalbergia + Albizzia + Eucalyptus + Mango + Kinnow
    2. Wheat – Maize/Garlic/Bhindi + Grewia + Morus + Eucalyptus + Dendrocalamus + Dalbergia + Mango + Kinnow + Lemon + lime
    3. Wheat/Onion/Garlic/ Gram/Taramira – Maize/Colocassia/ Turmeric/Bhindi + Leucaena + Grewia + Morus + Albizzia (Siris) + Dalbergia + Dendrocalamus + Mango + Guava + Lemon
    4. Wheat – Maize/Colocassia + Grewia + Morus + Dalbergia + Eucalyptus + Papaya + Mango

D. Pastoral silviculture system (PS)
    1. Natural grasses + Acacia + Dalbergia + Toona + Grewia + Leucaena + Bauhinia + Melia + Albizzia (Siris) + Eucalyptus
    2. Natural grasses + Acacia + Dalbergia + Albizzia (Siris) + Grewia + Leucaena + Morus + Eucalyptus + Ficus + Mallotus
    3. Natural grasses + Wendlendia + Dalbergia + Acacia + Pinus + Grewia + Leucaena + Morus + Melia + Eucalyptus

4. Natural grasses + Pinus + Dalbergia + Grewia + Leucaena + Wendlendia + Bombax + Mallotus + Emblica + Acacia + Eucalyptus + Dendrocalamus
5. Natural grasses + Acacia + Pinus + Bauhinia + Dalbergia + Albizzia + Grewia + Dendrocalamus
6. Natural grasses + Dalbergia

E. Pastoral silvihorticulture system (PSH)

1. Natural grasses + Dalbergia + Toona + Leucaena + Bauhinia + Melia + Albizzia (Siris) + Dendrocalamus + Morus + Acacia + Wendlendia + Pinus + Lemon + Peach + Kinnow + Pear + Mango

Table 4.12 Agroforestry system types and their system units in medium category of farmers of altitudinal zone I

A. Agrisilviculture system (AS)

1. Wheat/Mustard/Onion/Garlic - Maize/Colocassia/Turmeric/Bhindi + Grewia + Toona + Dalbergia

B. Agrisilvihorticulture system (ASH)

1. Wheat/Onion/Garlic/Mustard/Taramira/Gram – Maize/Colocassia/ Turmeric/Bhindi + Grewia + Albizzia + Bauhinia + Acacia + Mango
2. Wheat/Onion/Garlic/Mustard – Maize/Paddy/ + Acacia + Dalbergia + Pinus + Bauhinia + Leucaena + Grewia + Mango

C. Pastoral siviculture system (PS)

1. Natural grasses + Dalbergia + Acacia + Toona + Eucalyptus + Leucaena + Bauhinia + Terminalia

D. Pastoral silvihorticulture system (PSH)

1. Natural grasses + Acacia + Dalbergia + Dendrocalamus + Bauhinia + Albizzia + Toona + Terminalia + Pinus + Grewia + Mango

E. Pastoral hortisilviculture system (PHS)

1. Natural grasses + Mango + Lime + Kinnow + Bauhinia + Albizzia + Grewia + Morus + Dendrocalamus + Emblica + Dalbergia

Table 4.13 Agroforestry system types and their system units in marginal category of farmers of altitudinal zone II

A. Agrisilviculture system (AS)

1. Wheat/Onion/Mustard – Maize/ Ginger + Toona + Grewia + Bombax + Bauhinia + Albizzia (Siris)
2. Wheat – Maize/Ginger + Grewia + Toona
3. Wheat – Maize/Ginger/Tomato + Grewia + Toona + Bauhinia
4. Wheat/Mustard/Garlic/Onion - Maize + Toona + Grewia + Bauhinia + Populus + Bombax
5. Wheat/Mustard - Maize + Toona + Grewia + Morus + Leucaena
6. Wheat/Garlic/Onion - Maize + Grewia + Toona + Morus
7. Wheat/Mustard - Maize + Toona + Grewia + Acacia + Bombax + Eucalyptus
8. Wheat/Mustard/Garlic/Onion - Maize + Toona + Grewia + Morus + Bombax
9. Wheat – Maize/Tomato + Grewia + Dendrocalamus + Dalbergia + Ficus roxburghii

B. Agrihorticulture system (AH)

1. Mustard - Ginger + Mango + Litchi + Lemon
2. Wheat - Maize + Mango + Lemon + Guava
3. Wheat – Maize/Colocassia + Mango + Kinnow

C. Agrisilvihorticulture system (ASH)

1. Wheat/Mustard - Maize/Colocassia/Ginger + Toona + Bombax + Dalbergia + Grewia + Morus + Leucaena + Mango + Guava + Lemon
2. Wheat/Mustard – Maize/Colocassia + Grewia + Toona + Mango + Lemon
3. Wheat – Maize/Bhindi + Grewia + Toona + Dendrocalamus + Mango + Lemon + Guava + Lime

4. Wheat/Mustard – Maize/Colocassia/Ginger/Tomato + Grewia + Bauhinia + Bombax + Populus + Morus + Mango + Lemon + Guava
5. Wheat/Mustard – Maize/Ginger/Colocassia/Tomato + Grewia + Leucaena + Toona + Morus + Mango + Lemon + Litchi
6. Wheat – Maize/Cauliflower/Bhindi + Grewia + Eucalyptus + Toona + Mango

D. Agrihortisilviculture system (AHS)

1. Wheat/Mustard – Maize/Paddy/Colocassia/Ginger + Mango + Toona + Grewia
2. Wheat – Maize + Mango + Lime + Guava
3. Wheat/Mustard/Onion/Garlic/Pea – Maize/Colocassia/Ginger/ Tomato + Mango + Grewia + Leucaena
4. Wheat/Mustard – Maize/Paddy + Mango
5. Wheat/Garlic/Onion – Maize/Ginger + Mango

E. Pastoral silviculture system (PS)

1. Natural grasses + Albizzia (Cheoli) + Toona + Bombax + Dalbergia + Albizzia (Siris)
2. Natural grasses + Acacia + Dalbergia + Bauhinia + Albizzia (Siris)
3. Natural grasses + Albizzia (Cheoli) + Bombax + Grewia + Toona + Melia + Bauhinia + Albizzia (Siris)
4. Natural grasses + Albizzia (Cheoli) + Acacia + Bauhinia + Albizzia (Siris)
5. Natural grasses + Albizzia (Siris) + Bombax + Grewia + Toona + Melia + Bauhinia
6. Natural grasses + Albizzia (Siris) + Dalbergia + Acacia + Bauhinia + Dendrocalamus + Wendlendia
7. Natural grasses + Acacia + Wendlendia + Toona + Melia
8. Natural grasses + Acacia catechu + Albizzia (Siris) + Melia + Toona + Grewia

9. Natural grasses + Acacia + Bombax + Toona + Ficus + Dalbergia + Eucalyptus
10. Natural grasses + Acacia + Bombax + Albizzia (Siris)
11. Natural grasses + Acacia + Bombax + Toona + Bauhinia
12. Natural grasses + Acacia + Bombax + Wendlendia + Dalbergia + Albizzia (Siris) + Dendrocalamus
13. Natural grasses + Acacia + Bauhinia + Bombax + Toona + Dalbergia + Eucalyptus + Dendrocalamus
14. Natural grasses + Albizzia (Siris) + Acacia + Bombax
15. Natural grasses + Albizzia (Siris) + Leucaena + Acacia + Grewia

F. Pastoral silvihorticulture system (PSH)

1. Natural grasses + Acacia + Populus + Bombax + Dalbergia + Albizzia (Cheoli) + Grewia + Leucaena + Bauhinia + Mango
2. Natural grasses + Acacia + Toona + Albizzia (Cheoli) + Albizzia (Siris) + Bauhinia + Mango + Lime
3. Natural grasses + Acacia + Bombax + Grewia + Toona + Leucaena + Albizzia (Cheoli) + Aegle + Eucalyptus + Mango

Table 4.14 Agroforestry system types and their system units in small category of farmers of altitudinal zone II

A. Agrisilviculture system (AS)
   1. Wheat - Maize + Toona + Bauhinia
   2. Wheat/Onion/Garlic – Colocassia/Ginger + Toona + Grewia + Bombax
   3. Wheat/Onion/Garlic - Maize + Toona + Bombax + Leucaena + Grewia
   4. Wheat - Maize + Toona + Bauhinia + Grewia + Bombax
   5. Wheat - Maize + Toona + Bauhinia
   6. Wheat - Maize + Toona + Eucalyptus + Populus + Grewia
   7. Wheat – Maize/Colocassia/Ginger + Toona + Grewia

B. Agrihorticulture system (AH)
   1. Wheat – Ginger/Colocassia/Tomato + Mango
   2. Wheat - Maize + Mango + Litchi + Guava
   3. Wheat – Maize/Ginger + Mango
   4. Wheat/Mustard – Maize/Colocassia + Mango
   5. Wheat – Ginger/Colocassia/Tomato + Mango

C. Agrisilvihorticulture system (ASH)
   1. Wheat/Garlic/Onion – Maize/Bhindi/Chilli + Grewia + Morus + Toona + Mango
   2. Wheat – Maize/Colocassia + Toona + Grewia + Morus + Mango
   3. Wheat – Maize + Grewia + Toona + Morus + Mango + Guava + Lime
   4. Wheat/Garlic/Onion – Maize/Colocassia/Turmeric + Toona + Albizzia (Cheoli) + Grewia + Albizzia (Siris) + Mango
   5. Wheat/Garlic/Onion – Maize/Bhindi/Chilli + Grewia + Morus + Toona

D. Agrihortisilviculture system (AHS)

1. Wheat – Maize/Colocassia/Ginger/Tomato/Chilli/Bhindi/Brinjal + Lemon + Mango + Litchi + Lemon + Lime + Papaya + Guava + Toona + Grewia
2. Wheat/Cauliflower/Mustard – Maize/Ginger/Tomato + Mango + Litchi + Guava + Eucalyptus + Toona + Dendrocalamus
3. Wheat/Pea/Mustard/Taramira – Maize/Colocassia/Mash + Mango + Kinnow + Grewia + Morus + Toona
4. Wheat/Cauliflower – Maize/Tomato/Turmeric/Ginger + Mango + Papaya + Lime + Lemon + Toona + Grewia + Leucaena + Morus

E. Pastoral silviculture system (PS)

1. Natural grasses + Albizzia (Cheoli) + Grewia + Acacia + Leucaena + Bombax + Toona + Ficus + Bauhinia + Dalbergia + Morus + Dendrocalamus
2. Natural grasses + Acacia + Toona + Grewia + Leucaena + Dalbergia
3. Natural grasses + Acacia + Toona + Grewia + Albizzia (Siris) + Melia + Ficus + Dalbergia +Wendlendia
4. Natural grasses + Bombax + Acacia + Dalbergia
5. Natural grasses + Bombax + Toona + Dalbergia
6. Natural grasses + Bauhinia + Bombax + Acacia + Albizzia (Cheoli)
7. Natural grasses + Grewia + Leucaena + Toona + Acacia + Bombax + Morus + Bauhinia + Ficus + Albizzia (Cheoli) + Dendrocalamus
8. Natural grasses + Acacia + Bauhinia + Bombax + Dalbergia + Toona

F. Pastoral silvihorticulture system (PSH)

1. Natural grasses + Grewia + Toona + Bombax + Leucaena + Albizzia (Siris) + Dalbergia + Acacia + Pyrus + Wendlendia + Mango
2. Natural grasses + Acacia + Bauhinia + Toona + Populus + Albizzia (Cheoli) + Dalbergia + Ficus + Mango
3. Natural grasses + Grewia + Toona + Bombax + Acacia + Mango + Guava + Lemon

pulses – mustard, taramira and mash; vegetables - ginger, colocassia, tomato, garlic, onion, bhindi, chilli, brinjal, cauliflower, turmeric, pea. Among horticultural component mango, papaya, guava, lemon, litchi, lime, kinnow were observed the major functional units. The forestry component consisted of *Toona ciliata*, *Bauhinia variegata*, *Grewia optiva*, *Bombax ceiba*, *Acacia catechu*, *Leucaena leucocephala*, *Eucalyptus* sp., *Populus* sp. *Melia azedarach*, *Albizzia lebbeck*, *Albizzia chinensis*, *Ficus palmata*, *Wendlendia exserta*, *Pyrus pashia*, *Dalbergia sissoo*, *Morus alba* and *Dendrocalamus* sp.

Medium category

In medium category five types of agroforestry systems viz. agrisilviculture, agrihorticulture, agrisilvihorticulture, pastoral silviculture and pastoral silvihorticulture were identified (Table 4.15). The specific functional units under agricultural component were cereals e.g. wheat, maize, paddy; oil seeds- mustard and taramira. Under horticultural component mango, lime, guava, lemon, litchi, papaya were the functional units. The forestry component included *Toona ciliata*, *Grewia optiva*, *Morus alba*, *Leucaena leucocephala*, *Salix* sp., *Eucalyptus* sp., *Acacia catechu*, *Wendlendia exserta*, *Albizzia lebbeck*, *Bauhinia variegata*, *Dalbergia sissoo*, *Albizzia chinensis*, *Bombax ceiba*, *Populus* sp. and *Dendrocalamus* sp. functional units.

Large category

In large category only one household was found (Table 4.16). There were three types of agroforestry systems prevalent in this category. These were agrihorticulture, agrisilvihorticulture and pastoral silvihorticulture. The functional units under agricultural component were wheat, maize; oil seeds – mustard and taramira; vegetables - ginger, colocassia, bhindi, onion, garlic. Horticultural component was represented by mango, pear, lime, guava. *Grewia optiva*, *Toona ciliata*, *Leucaena leucocephala*, *Morus alba*, *Acacia catechu*, *Dalbergia sissoo*, *Ficus palmata*, *Wendlendia exserta*, *Bombax ceiba*, *Albizzia lebbeck*, *Melia*

azedarach, *Eucalyptus* sp., *Pyrus pashia*, *Bauhinia variegata* constituted the major functional units of forestry component.

The species of shrubs, bushes and grasses found in altitudinal zone II were identical to that of altitudinal zone I.

4.2.3 Altitudinal zone III

There were five agroforestry system types prevalent among different categories of farmers in altitudinal zone III. Each of system types category-wise has been described as under :

Marginal category

In Marginal category, three types of agroforestry systems, namely : agrisilviculture, agrisilvihorticulture and pastoral silviculture were identified. (Table 4.17). The functional units irrespective of the system units under agricultural component were represented by cereals e.g. wheat, maize; oil seeds and pulses – mustard, mash, soybean; vegetables - colocassia, onion, garlic, chilli, turmeric and bhindi. Under horticultural component banana, lemon mango, guava and papaya were identified as functional units. The forestry component consisted of *Acacia catechu*, *Grewia optiva*, *Bauhinia variegata*, *Ficus palmata*, *Dalbergia sissoo*, *Toona ciliata*, *Albizzia chinensis*, *Melia azedarach*, *Albizzia lebbeck*, *Bombax ceiba*, *Pinus roxburghii*, *Morus alba*, *Leucaena leucocephala*, *Olea* sp., *Phoenix* sp., *Wendlendia exserta*, *Ficus roxburghii*, *Mallotus philippinensis* and *Dendrocalamus* sp. as functional units.

Small category

Five agroforestry system types found in this group were agrisilviculture, agrihorticulture, agrisilvihorticulture, pastoral silviculture and pastoral silvihorticulture (Table 4.18). The specific functional units under agricultural component were represented by cereals e.g. wheat, maize; oil seeds and pulses – mustard, mash, soybean; vegetables - ginger, colocassia, garlic, onion, bhindi,

Table 4.15 Agroforestry system types and their system units in medium category of farmers of altitudinal zone II

A. Agrisilviculture system (AS)
   1. Wheat/Mustard/Pea/Onion/Garlic – Maize/Bhindi/Paddy + Toona + Grewia + Leucaena
   2. Wheat/Mustard/Taramira/Onion/Garlic - Maize/Ginger/Bhindi/Paddy + Toona + Grewia + Morus + Leucaena

B. Agihorticulture system (AH)
   1. Wheat – Maize/Ginger + Mango + Guava + Litchi + Lemon

C. Agrisilvihorticulture system (ASH)
   1. Wheat/Mustard/Taramira/Onion/Garlic - Maize/Colocassia + Grewia + Toona + Leucaena + Morus + Mango + Guava + Papaya + Lemon
   2. Wheat/Onion/Garlic/Mustard - Maize/Ginger/Colocassia/Tomato/ Bhindi + Grewia + Toona + Morus + Mango + Lemon
   3. Wheat/Mustard/Colocassia - Maize + Grewia + Morus + Toona + Leucaena + Eucalyptus + Salix + Mango + Litchi + Lime

D. Pastoral silviculture system (PS)
   1. Natural grasses + Acacia + Toona + Grewia + Wendlendia + Albizzia (Siris) + Bauhinia + Dendrocalamus
   2. Natural grasses + Acacia + Bauhinia + Albizzia (Siris) + Toona + Grewia
   3. Natural grasses + Acacia + Albizzia (Siris) + Bauhinia + Grewia + Dalbergia + Albizzia (Cheoli) + Populus + Eucalyptus

E. Pastoral silvihorticultural system (PSH)
   1. Natural grasses + Acacia + Toona + Grewia+ Bombax + Mango

Table 4.16 Agroforestry system types and their system units in large category of farmers of altitudinal zone II

A. Agihorticulture system (AH)

1. Wheat - Maize + Mango

B. Agrisilvihorticulture system (ASH)

1. Wheat/Mustard/Taramira/Onion/Garlic - Maize/Ginger/Colocassia/ Bhindi + Grewia + Toona + Leucaena + Morus + Bombax + Mango + Pear + Lime + Guava

C. Pastoral silvihorticulture system (PSH)

1. Natural grasses + Acacia + Toona + Dalbergia + Ficus + Pyrus + Wendlendia + Bombax + Albizzia (Siris) + Pinus + Grewia + Leucaena + Melia + Eucalyptus + Bauhinia + Mango + Lime

Table 4.17 Agroforestry system types and their system units in marginal category of farmers of altitudinal zone III

A. Agrisilviculture system (AS)

1. Wheat/Mustard/Garlic - Maize/Chilli/Mash/Colocassia + Albizzia (Cheoli) + Ficus + Leucaena + Grewia
2. Maize + Melia + Olea + Ficus + Leucaena + Grewia
3. Wheat - Maize/Colocassia + Albizzia (Cheoli) + Grewia + Ficus
4. Wheat/Mustard/Garlic - Maize/Mash/Colocassia + Ficus + Morus + Toona + Ficus roxburghii
5. Maize/Colocassia + Grewia + Olea
6. Wheat - Maize + Morus + Ficus + Toona + Grewia
7. Wheat/Garlic/Onion - Maize/Colocassia + Albizzia (Cheoli) + Ficus (Tiamli)
8. Wheat - Maize + Grewia
9. Wheat/Mustard/Garlic/Onion - Maize/Mash + Albizzia (Cheoli) + Olea + Ficus + Bauhinia
10. Wheat/Mustard/Garlic/Onion - Maize/Colocassia + Grewia + Ficus + Leucaena + Morus
11. Wheat/Mustard/Onion/Garlic - Maize/Colocassia + Albizzia (Cheoli) + Ficus (Tiamli) + Grewia + Leucaena
12. Wheat - Maize + Grewia + Leucaena + Morus
13. Wheat/Garlic/Onion - Maize + Olea + Grewia + Morus + Leucaena
14. Wheat/Garlic/Onion/Mustard - Maize/Colocassia + Grewia + Olea + Ficus + Morus + Leucaena
15. Wheat - Maize + Grewia + Dalbergia + Olea + Ficus + Morus + Leucaena
16. Wheat - Maize/Mash/Colocassia + Olea + Grewia + Morus + Leucaena + Bauhinia

17. Wheat/Mustard - Maize/Mash/Colocassia/Chilli + Bauhinia + Olea + Palm
18. Wheat/Garlic – Maize + Grewia + Bombax
19. Wheat - Maize/Chilli + Grewia + Ficus (Tiamli)
20. Wheat/Garlic/Onion - Maize/Colocassia + Grewia + Morus + Leucaena
21. Wheat – Maize/Colocassia + Grewia + Leucaena + Acacia + Dalbergia
22. Wheat - Maize + Leucaena + Morus + Toona

B. Agrisilvihorticulture system (ASH)

1. Wheat/Mustard - Maize/Soybean/Colocassia + Albizzia (Cheoli) + Olea + Ficus + Bauhinia + Banana + Lemon
2. Maize/Colocassia/Turmeric + Grewia + Olea + Dalbergia + Ficus (Fegra) + Ficus (Tiamli) + Leucaena + Morus + Lemon + Guava + Mango
3. Maize + Grewia + F roxburghii + Albizzia (Cheoli) + Olea + Bauhinia + Mango
4. Maize/Soybean + Leucaena + Dendrocalamus + Olea + Melia + Guava
5. Wheat/Mustard/Garlic - Maize/Colocassia/Turmeric + Grewia + Albizzia (Cheoli) + Pinus + Mango + Guava
6. Wheat/Garlic - Maize/Colocassia/Turmeric/Bhindi + Grewia + Albizzia (Cheoli) + Dendrocalamus + Mango
7. Wheat/Garlic - Maize/Colocassia/Bhindi + Grewia + Albizzia (Cheoli) + Leucaena + Pinus + Mango + Papaya
8. Wheat - Maize/Colocassia + Grewia + Dalbergia + Leucaena + Mango + Papaya + Lemon

C. Pastoral silviculture system (PS)

1. Natural grasses + Palm
2. Natural grasses + Albizzia (Cheoli) + Dendrocalamus + Palm

3. Natural grasses + Olea + Palm
4. Natural grasses + Melia
5. Natural grasses + Olea + Albizzia (Cheoli) + Melia + Grewia
6. Natural grasses + Grewia + Olea + Palm + Albizzia (Cheoli) + Dendrocalamus
7. Natural grasses + Melia + Olea + Grewia + Palm
8. Natural grasses + Palm + Olea
9. Natural grasses + Palm + Olea + Grewia + Albizzia (Cheoli)
10. Natural grasses + Dalbergia + Olea + Palm
11. Natural grasses + Olea + Grewia + Dendrocalamus
12. Natural grasses + Dalbergia + Olea + Melia + Phoenix + Grewia + Albizzia (Cheoli)
13. Natural grasses + Olea + Palm
14. Natural grasses + Pinus + Acacia + Mallotus
15. Natural grasses + Acacia + Pinus + Mallotus
16. Natural grasses + Acacia + Albizzia
17. Natural grasses + Grewia + Pinus
18. Natural grasses + Pinus
19. Natural grasses + Pinus + Acacia + Melia + Toona + Dalbergia
20. Natural grasses + Acacia + Dalbergia + Wendlendia + Toona + Mallotus
21. Natural grasses + Acacia + Dalbergia + Mallotus
22. Natural grasses + Pinus
23. Natural grasses + Dalbergia + Pinus
24. Natural grasses + Olea + Melia + Phoenix
25. Natural grasses + Dalbergia
26. Natural grasses + Acacia + Dalbergia
27. Natural grasses + Pinus + Acacia + Melia

Table 4.18 Agroforestry system types and their system units in small category of farmers of altitudinal zone III

A. Agrisilviculture system (AS)
   1. Wheat/Onion/Garlic - Maize/Colocassia/Bhindi/Mash/Soybean + Grewia
   2. Wheat/Onion/Garlic - Maize/Colocassia + Grewia + Tectona + Leucaena + Eucalyptus + Morus
   3. Wheat/Garlic/Onion - Maize/Colocassia + Grewia + Acacia + Leucaena + Dalbergia + Ficus
   4. Wheat - Maize/Colocassia + Leucaena + Dalbergia + Grewia + Toona + Acacia
   5. Wheat/Mustard – Maize + Grewia + Albizzia
   6. Wheat/Mustard – Maize/Colocassia + Morus + Grewia
   7. Wheat – Maize/Soybean/Mash + Grewia + Leucaena
   8. Wheat/Mustard – Maize/Colocassia + Grewia + Acacia
   9. Wheat/Garlic/Onion – Maize/Bhindi/Colocassia + Grewia + Leucaena + Morus

B. Agihorticulture system (AH)
   1. Wheat/Mustard/Garlic/Onion - Maize/Colocassia/Bhindi/Chilli/Brinjal/ Turmeric + Mango + Lemon
   2. Wheat/Mustard/Garlic - Maize/Colocassia/Bhindi/Chilli/Ginger/ Turmeric + Mango

C. Agrisilvihorticulture system (ASH)
   1. Wheat - Maize + Grewia + Toona + Leucaena + Mango
   2. Wheat - Maize + Morus + Grewia + Bauhinia + Albizzia + Olea + Ficus + Banana + Lemon
   3. Wheat - Maize + Morus + Bauhinia + Grewia + Mango + Papaya

D. Pastoral silviculture system (PS)

1. Natural grasses + Pinus + Acacia + Zizyphus
2. Natural grasses + Grewia + Leucaena + Pinus + Acacia + Albizzia (Siris) + Bauhinia + Toona + Dalbergia + Wendlendia + Morus
3. Natural grasses + Acacia + Toona + Dalbergia + Anogeissus
4. Natural grasses + Acacia + Dalbergia + Morus + Grewia + Eucalyptus + Mallotus + Anogeissus + Wendlendia
5. Natural grasses + Acacia + Grewia + Dalbergia + Mallotus
6. Natural grasses + Acacia + Toona + Dalbergia + Leucaena + Albizzia (Siris) + Eucalyptus + Wendlendia + Mallotus + Anogeissus
7. Natural grasses + Acacia + Dalbergia + Anogeissus + Grewia + Leucaena
8. Natural grasses + Acacia + Mallotus + Dalbergia + Melia + Dendrocalamus

E. Pastoral silvihorticultural system (PSH)

1. Natural grasses + Pinus + F roxburghii + Ficus - Mango
2. Natural grasses + Acacia + Toona + Pinus + Zizyphus + Mallotus + Albizzia (Siris) + Emblica + Mango

Table 4.19 Agroforestry system types and their system units in medium category of farmers of altitudinal zone III

A. Agrisilviculture system (AS)

1. Wheat/Mustard/Onion/Garlic/Taramira - Maize/Colocassia/Bhindi + Grewia + Ficus + Leucaena + Acacia + Eucalyptus
2. Wheat/Onion/Garlic/Mustard/Taramira - Maize/Colocassia/Turmeric/ Brinjal/Bhindi + Acacia + Grewia + Morus + Leucaena + Albizzia (Siris) + Tectona + Bauhinia

B. Pastoral silviculture system (PS)

1. Natural grasses + Acacia + Dalbergia + Toona + Leucaena + Grewia + Anogeissus + Albizzia (Siris) + Eucalyptus + Mallotus + Wendlendia + Bombax
2. Natural grasses + Acacia + Dalbergia + Mallotus + Bombax + Albizzia (Siris) + Leucaena + Grewia + Toona + Anogeissus

chilli, brinjal and turmeric. The horticultural component consisted of mango, papaya, lemon and banana as functional units. Under forestry component *Acacia catechu*, *Zizyphus* sp., *Grewia optiva*, *Melia azedarach*, *Albizzia lebbeck*, *Bauhinia variegata*, *Eucalyptus* sp., *Toona ciliata*, *Mallotus philippinensis*, *Dalbergia sissoo*, *Anogeissus latifolia*, *Pinus roxburghii*, *Morus alba*, *Ficus palmata*, *Albizzia chinensis*, *Leucaena leucocephala*, *Ficus roxburghii*, *Emblica officinalis*, *Tectona grandis*, *Olea* sp., *Wendlendia exserta*, *Phoenix* sp. and *Dendrocalamus* sp. were observed.

Medium category

In medium category of farmers only two types of agroforestry system types were identified, viz. agrisilviculture and pastoral silviculture (Table 4.19). The functional units under agricultural component were represented by cereals e.g. wheat, maize; oil seeds – mustard and taramira; vegetables – colocassia, onion, garlic, bhindi, brinjal and turmeric. The forestry component was represented by *Toona ciliata*, *Dalbergia sissoo*, *Anogeissus latifolia*, *Leucaena leucocephala*, *Grewia optiva*, *Albizzia lebbeck*, *Eucalyptus* sp., *Mallotus philippinensis*, *Bombax ceiba*, *Tectona grandis*, *Morus alba*, *Bauhinia variegata*, *Acacia catechu*, *Ficus palmata and Wendlendia exserta*.

4.2.4 Comparative status of agroforestry systems in different altitudinal zones

The farmers' category-wise status of various agroforestry system types prevalent in altitudinal zone I, II and III is given in table 4.20 and described as below:

Altitudinal zone I

In this zone, there were seven major agroforestry system types each occurring with varying number of specific system units in different categories. A perusal of data shown in table 4.20 and fig. 1 reveals that marginal category of farmers practised six major agroforestry system types out of seven. Of the six system types present, a total of 56 system units were in use. The number of system

units found under individual system type were : AS-17, AH-6, ASH-7, AHS-2, PS-22 and PSH-2. In small category, five agroforestry system types having a total of 16 units such as AS-4, AH-1, ASH-4, PS-6 and PSH-1. In medium category, also, five agroforestry system types were found to be practised with six units viz. AS-1, ASH-2, PS-1, PSH-1 and PHS-1.

Altitudinal zone-II

A perusal of the data (Table 4.20, Fig. 2) indicates that marginal group of farmers represented six types of agroforestry system types. In total 41 units viz. AS-9, AH-3, AHS-5, ASH-6, PS-15 and PSH-3 were found. Small group of farmers practised six agroforestry system types, however total units found were 32 viz. AS-7, AH-5, ASH-5, AHS-4, PS-8 and PSH-3. Among medium category, five agroforestry system types were present with 10 units viz. AS-2, AH-1, ASH-3, PS-3 and PSH-1. In large category, only three agroforestry system types were practised with three system units viz. AH-1, ASH-1 and PSH-1.

Altitudinal zone III

A perusal of the data (Table 4.20, Fig. 3) shows that marginal category of farmers represented only three types of agroforestry systems. In total 57 units existed comprising AS-22, ASH-8 and PS-27. In small category, five types of agroforestry systems with 24 system units (AS-9, AH-2, ASH-3, PS-8 and PSH-2) were observed. Among medium group two agroforestry system types having four system units viz. AS-2 and PS-2 were found.

4.2.5 Inventory of most preferred farm trees

In the study area, trees were found to be an integral component of farming systems. Farmers were observed to grow/retain many forest/fruit tree species on their farm. Forest/fruit tree species which occurred with the highest percentage in comparison to other trees per farm were worked out.

Table 4.20 Comparative status of various agroforestry system types among different altitudinal zones

AFS types	Altitudinal zone I			Altitudinal zone II				Altitudinal zone III		
	Marginal	Small	Medium	Marginal	Small	Medium	Large	Marginal	Small	Medium
AS	17	4	1	9	7	2	-	22	9	2
AH	6	1	-	3	5	1	1	-	2	-
ASH	7	4	2	6	5	3	1	8	3	-
AHS	2	-	-	5	4	-	-	-	-	-
PS	22	6	1	15	8	3	-	27	8	2
PSH	2	1	1	3	3	1	1	-	2	-
PHS	-	-	1	-	-	-	-	-	-	-

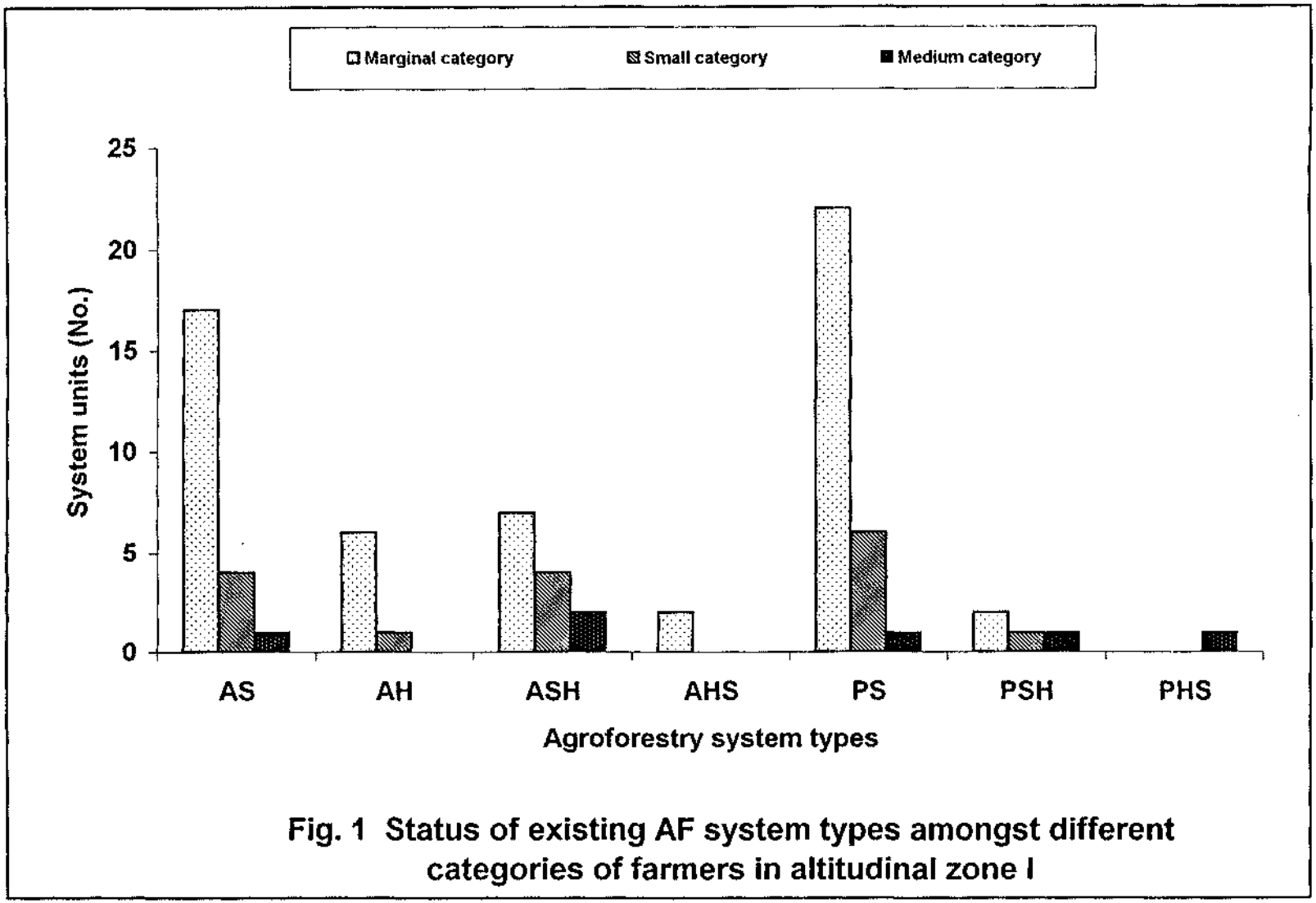

Fig. 1 Status of existing AF system types amongst different categories of farmers in altitudinal zone I

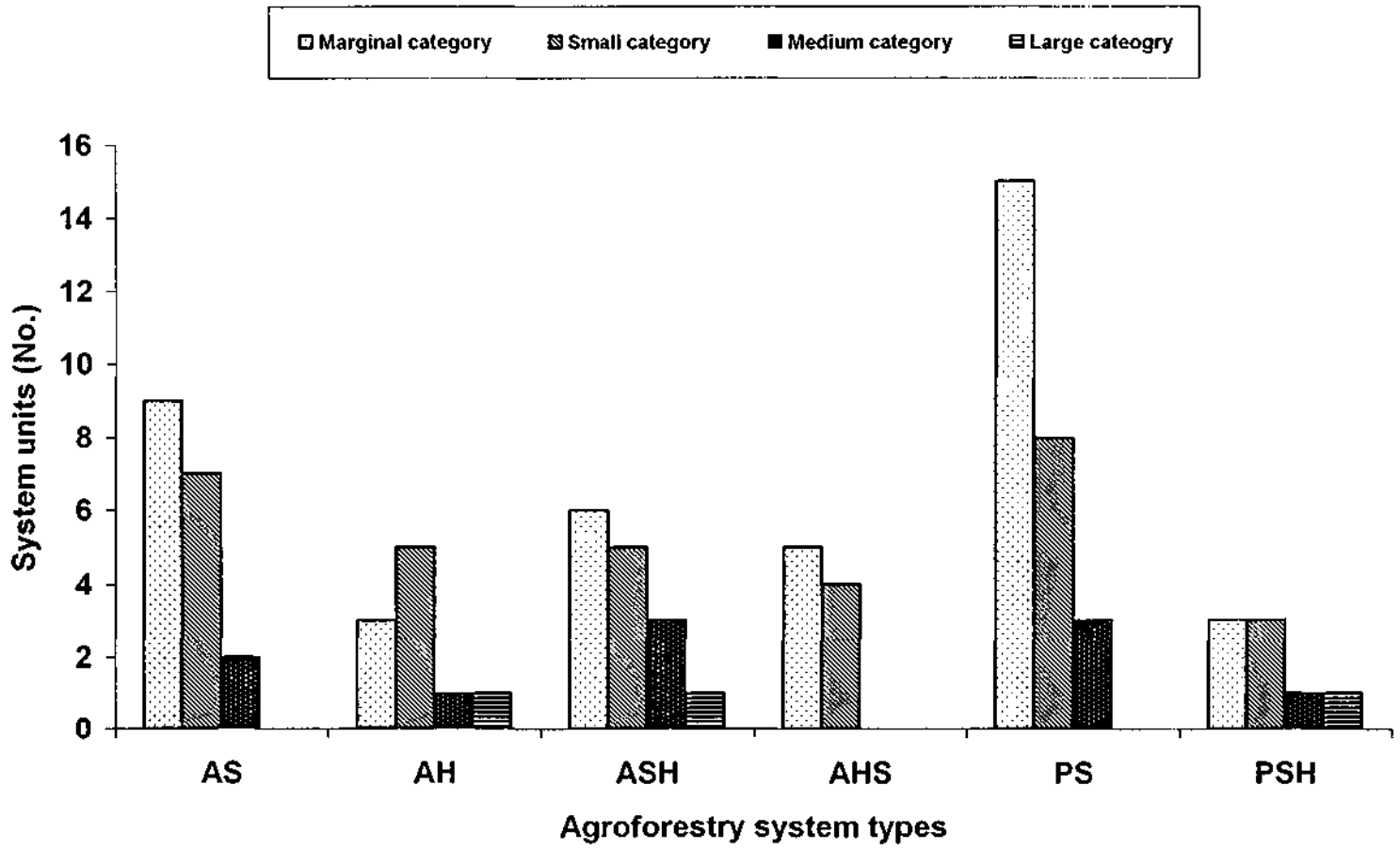

Fig. 2 Status of existing AF system types amongst different categories of farmers in altitudinal zone II

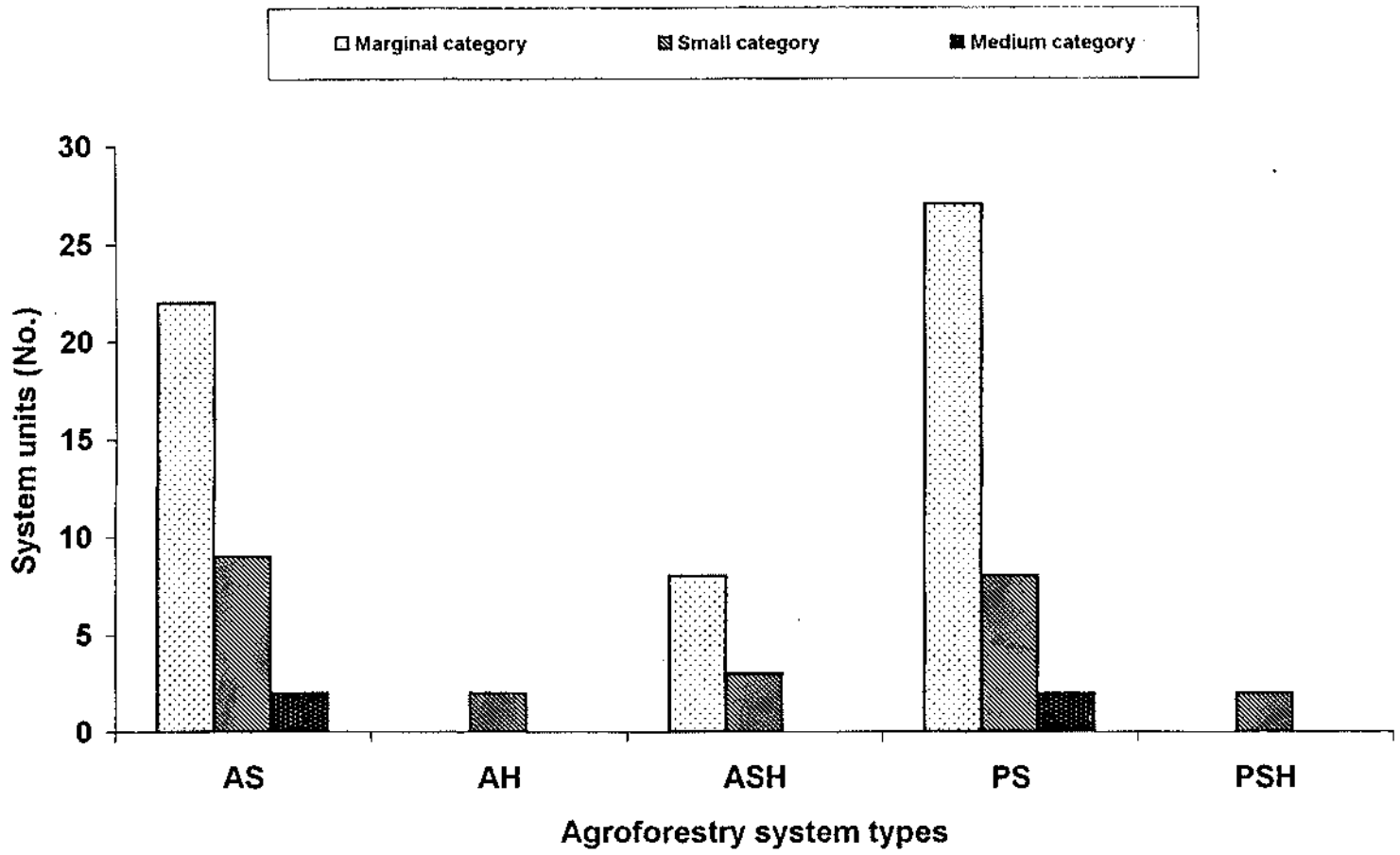

Fig. 3 Status of existing AF system types amongst different categories of farmers in altitudinal zone III

Agrisilviculture (AS) system type was prevalent among the marginal, small and medium categories of farmers in all the altitudinal zones. Data presented in table 4.21 reveal that *G. optiva* was most preferred tree under AS system type in all these categories except small category of altitudinal zone I and II, in which *Leucaena leucocephala* and *Toona ciliata*, respectively, were found dominant/most preferred forest trees with their respective value of 31.94 and 34.60 per cent. Occurrence of *G. optiva* varied from 22.80 to 54.21 per cent in AS system type irrespective of category and also altitudinal zone.

Agrihorticulture (AH) system type was practised by all the categories of farmers in all altitudinal zones, except medium category in altitudinal zone I and marginal and medium categories in altitudinal zone III. Among fruit trees in this system type, mango was most preferred tree with the value ranging from 55.55 per cent to 100 per cent irrespective of category and also altitudinal zone (Table 4.21).

All the categories of farmers of all the altitudinal zones practised the ASH system type, except medium category in altitudinal zone III. Data presented in table 4.21 show that among forest trees, *G. optiva* was found dominant in all these categories, except in medium category of altitudinal zone I, in which *Acacia catechu* registered the maximum value (32.80 %) among forest tree. Occurrence of *G. optiva* in this system varied from 26.37 to 46.25 per cent irrespective of category and also altitudinal zone. Data further reflect that *Albizzia lebbek* got the same value (26.37 %) as that of *G. optiva* in small category of farmers in altitudinal zone I.

Among fruit trees, mango was dominating in all the categories of farmers in all the altitudinal zones, except small category of zone III, in which banana got maximum rank of 55.67 per cent. Occurrence of mango varied from 33.33 per cent to 100 per cent irrespective of category and also altitudinal zone.

Agrihortisilviculture (AHS) system type was practised by marginal category in altitudinal zone I, and marginal and small categories of farmers in altitudinal zone II. A perusal of data in table 4.21 shows that in altitudinal zone I, most preferred fruit and forest trees were banana (33.33 %) and *Eucalyptus* sp. (80.00 %), respectively. Whereas, in altitudinal zone II, *Leucaena leucocephala* (35.29 %) and *Toona ciliata* (35.52 %) were dominant forest trees in marginal and small categories, respectively. *Grewia optiva* also got the same value (35.29 %) as that of *L. leucocephala* in marginal category of farmers in altitudinal zone II. Among fruit trees, mango was most preferred fruit tree in both the categories of farmers in altitudinal zone II showing 92.30 and 65.90 per cent values in marginal and small categories of farmers, respectively.

Pastoral silviculture (PS) system type was prevalent among all the categories of farmers, except large category in altitudinal zone II, of three altitudinal zones. It can be seen from table 4.21 that *Acacia catechu* was most dominant tree in these categories with values varying from 31.37 to 86.69 per cent.

Pastoral silvihorticulture (PSH) system type was found in all the categories of altitudinal zone I and II; and small category of altitudinal zone III. Data (Table 4.21) show that in small category of altitudinal zone I, lemon was most preferred (40.00 %) fruit tree. Whereas, in all other categories of farmers of three altitudinal zones, mango was most preferred fruit tree with value varying from 69.23 to 100 per cent. Among forest trees, *A. lebbek* and *Pinus roxburghii* in small category of farmers in altitudinal zone I and III were most preferred with their respective value of 25.21 and 30.37 per cent, respectively. Whereas, in all other categories, *A. catechu* was found most dominant with the value ranging from 26.45 to 91.54 per cent.

Pastoral hortisilviculture (PHS) system type was found only in medium category of farmers in altitudinal zone I. In this system type, most preferred fruit

Table 4.21 Inventory of most preferred forest and fruit trees among agroforestry systems in different altitudinal zones

		Altitudinal zone I			Altitudinal zone II				Altitudinal zone III		
AF systems	Forest/ fruit trees	Marginal	Small	Medium	Marginal	Small	Medium	Large	Marginal	Small	Medium
AS	Grewia	3.82 (33.62)	-	6.00 (42.85)	6.88 (36.49)	-	12.50 (33.73)	-	4.27 (22.80)	7.55 (46.98)	22.50 (54.21)
	Leucaena	-	5.75 (31.94)	-	-	-	-	-	-	-	-
	Toona	-	-	-	-	6.71 (34.60)	-	-	-	-	-
AH	Mango	3.50 (72.56)	7.00 (87.50)	-	12.66 (79.22)	9.20 (88.46)	20.00 (68.96)	7.00 (100.00)	-	2.50 (55.55)	-
ASH	Grewia	6.00 (28.87)	6.00 (26.37)	-	14.16 (46.25)	8.80 (41.12)	20.00 (41.97)	20.00 (31.25)	4.25 (26.38)	11.00 (41.82)	-
	Albizzia	-	6.00 (26.37)		-	-	-	-	-	-	-
	Acacia	-	-	20.50 (32.80)	-	-	-		-	-	-
	Mango	4.86 (73.86)	5.50 (56.41)	11.00 (100.00)	6.00 (52.21)	10.20 (92.72)	11.66 (52.26)	20.00 (66.66)	1.87 (33.33)	-	-
	Banana	-	-	-	-	-	-	-	-	5.00 (55.67)	-
AHS	Eucalyptus	2.00 (80.00)	-	-	-	-	-	-	-	-	-
	Grewia	-	-	-	3.00 (35.29)	-	-	-	-	-	-
	Leucaena	-	-	-	3.00 (35.29)	-	-	-	-	-	-

Contd....

	Toona	-	-	-	-	6.75 (35.52)	-	-	-	-	-
	Banana	2.00 (33.33)	-	-	-	-	-	-	-	-	-
	Mango	-	-	-	12.00 (92.30)	14.50 (65.90)	-	-	-	-	-
PS	Acacia	9.18 (31.37)	29.67 (40.36)	580.00 (86.69)	140.06 (43.55)	57.50 (56.38)	126.66 (63.26)	-	7.14 (32.85)	30.00 (41.15)	(172.50 (65.71)
PSH	Acacia	50.00 (26.45	-	280.00 (64.81)	20.33 (40.28)	25.33 (30.19)	325.00 (91.54)	340.00 (61.59)	-	-	-
	Albizzia	-	30.00 (25.21)	-	-	-			-	-	-
	Pinus	-	-	-	-	-	-	-	-	16.50 (30.27)	-
	Mango	4.50 (69.23)	-	5.00 (100.00)	20.66 (96.90)	11.33 (85.06)	50.00 (100.00)	20.00 (80.00)	-	5.00 (100.00)	-
	Lemon	-	4.00 (40.00)	-	-	-	-	-	-	-	-
PHS	Bauhinia	-	-	45.00 (42.45)	-	-	-	-	-	-	-
	Mango	-	-	150.00 (90.00)	-	-	-	-	-	-	-

*Figures in parenthesis are percentages.

and forest trees were mango (90.00 %) and *Bauhinia variegata* (42.45 %), respectively.

4.3 Biological yield and economic return from agroforestry systems

Biological yield in terms of present utilizable biomass and the economic return accrued from each system unit of a system type has been calculated and represented per farm per annum basis (Appendix III - XLIX). The values represent the averages of all system units available in a particular system type under each category found in altitudinal zone I, II and III.

4.3.1 Altitudinal zone I

There were seven agroforestry system types viz. AS, AH, ASH, AHS. PS, PSH and PHS present among the different categories of farmers in altitudinal zone I. The average biological yield and net return obtained from each system type are given in table 4.22 and explained category wise as under:

Marginal category

This category consisted of 30 households. It was observed that six types of agroforestry systems viz. AS, AH, ASH, AHS, PS and PSH were found to be practised by the farmers of this category. Data presented in table 4.22 show that PSH system gave the maximum (76.490 q) biological yield followed by AH (51.860 q), AS (46.094 q), ASH (45.740 q) and AHS (27.580 q) systems. It was observed that PS system produced the lowest (18.910q) biological yield. Data pertaining to net returns obtained from different system types indicate that PSH contributed the maximum (Rs. 8257.85) net return, followed by AH (Rs. 6447.13), ASH (Rs. 5377.17), AS (Rs. 4868.72) and AHS (Rs. 2588.95) system (Appendix IV to IX). Further perusal of data reveals that minimum net return of Rs 2308.06 was obtained from the PS system.

Small category

This category was represented by seven households. A cursory glance of data (Table 4.22) reveals that AS, AH, ASH, PS and PSH system types were practised by the small farmers. It is evident from data presented in table 4.22 that in small category ASH system produced the maximum (120.08 q) biological yield followed by AH (100.650 q), AS (84.880 q), PSH (53.400 q) and PS (47.070 q) with their respective net return of Rs.15955.59, 16692.00, 10037.31, 5684.50 and 6044.14 (Appendix X to XIV). Data further reflect that the maximum and the minimum net returns were obtained from AH and PS systems, respectively.

Medium category

This category comprised of three households. Five types of agroforestry systems viz. AS, ASH, PS, PSH and PHS were found in this category. Data presented in table 4.22 show that PS system contributed the maximum (163.590 q) biological yield followed by AS (157.570 q), PSH (137.070 q), ASH (133.570 q) and PHS (88.730 q). Whereas, net returns obtained from the agroforestry system types presented in appendix XV to XIX reveal that PHS system generated the maximum (Rs.18972.75) net return, followed by ASH (Rs.17026.77), AS (Rs. 15800.70), PS (Rs. 14415.25) and PSH (Rs. 12909.00).

It is evident from the above findings that in marginal category, PSH system type contributed maximum to biological yield and net returns. In this system, forest trees were found major contributors towards biological yield and net returns followed by grasses and fruit trees. Among forest trees, *D. sissoo* contributed maximum to biological yield followed by *G. optiva*, *B. variegata* and *A. catechu*. Whereas, among fruit trees mango (grafted and local) gave the highest contribution to biological yield. Maximum net returns were obtained from *D. sissoo* and mango among forest and fruit trees, respectively.

Table 4.22 Biological yield and net return obtained from agroforestry system types among different categories of farmers in altitudinal zone I

AF systems types	Altitudinal zone I					
	Biological yield (q)			Net return (Rs.)		
	Marginal	Small	Medium	Marginal	Small	Medium
AS	46.094	84.880	157.570	4868.72	10037.31	15800.70
AH	51.860	100.650	-	6447.13	16692.00	-
ASH	45.740	120.08	133.570	5377.17	15955.59	17026.77
AHS	27.580	-	-	2588.95	-	-
PS	18.910	47.070	163.590	2308.06	6044.14	14415.25
PSH	76.490	53.400	137.070	8257.85	5684.50	12909.00
PHS	-	-	88.730	-	-	18972.75

Table 4.23 Biological yield and net returns obtained from agroforestry system types among different categories of farmers in altitudinal zone II

AF systems types	Altitudinal zone II							
	Biological yield (q)				Net return (Rs.)			
	Marginal	Small	Medium	Large	Marginal	Small	Medium	Large
AS	55.420	51.030	151.990	-	7243.30	6857.14	22033.25	-
AH	41.010	50.590	125.250	137.95	9022.39	11592.03	16295.05	14614.44
ASH	62.480	77.820	148.33	151.27	9612.31	11445.47	23126.57	24071.22
AHS	49.800	174.640	-	-	9007.83	31885.64	-	-
PS	19.050	46.210	103.090	-	2268.09	5306.95	12374.40	-
PSH	27.160	53.610	103.750	248.33	4248.67	7189.79	11817.00	30605.00

In small category, ASH system type produced the maximum biological yield, but the maximum net returns were obtained from AH system type. This can be ascribed to the reason that in AH system type vegetable and oil seed crops gave higher net returns than that of in ASH system type.

In medium category, PS system type gave the maximum biological yield, whereas, the maximum net return was obtained from PHS system type. Fruit trees gave the significant contribution to net returns in PHS, thus, net returns accrued from this system were higher than PS system type. The lowest net return from the PSH system type could be ascribed to the reason that in horticultural component only mango was grown and that too on a small scale.

4.3.2 Altitudinal zone II

In altitudinal zone II, farmers were practising six agroforestry system types namely: AS, AH, ASH, AHS, PS and PSH. Biological yield and net returns obtained from these systems have been given in table 4.23 and appendix XX to XXXIX and discussed category-wise as below:

Marginal category

Marginal category consisted of 23 households and farmers of this group were found practising all the six-agroforestry system types occurring in this zone. It is clear from the table 4.23 and appendix XX to XXV that ASH system type produced the maximum biological yield (62.480 q) and net returns (Rs. 9612.31). While PS system gave the lowest biological yield (19.050 q) and net return (Rs. 2268.09). Data further reveal that AS, AHS, AH and PSH system gave the biological yield of 55.420 q, 49.800 q, 41.010 q and 27.160 q, respectively. The respective values for net returns obtained from these systems were Rs. 7243.30, 9007.83, 9022.39 and 4248.67.

Small category

This category was represented by 12 households. The farmers of this group practised six types of agroforestry systems, viz. AS, AH, ASH AHS, PS and PSH. A perusal of data in table 4.23 and Appendix XXVI to XXXI reveals that the biological yield obtained from these agroforestry system types were in the following order: AHS (174.640 q) > ASH (77.820 q) > PSH (53.610 q) > AS (51.030 q) > AH (50.590 q) > PS (46.210 q) with their respective net returns of Rs. 31885.64, Rs. 11445.47, 7189.79, 6857.14, 11592.03, 5306.95. Thus, the highest and lowest net returns were obtained from AHS and PS systems, respectively.

Medium category

Medium category of altitudinal zone II comprised of four households. The system types prevalent in this category were AS, AH, ASH, PS and PSH. Data pertaining to their biological yield and net returns have been presented in table 4.23 and Appendix XXXII to XXXVI. It is evident from the data that AS system provided maximum (151.990 q) biological yield with net returns of Rs. 22033.25 followed by ASH (148.330 q, Rs. 23126.57) and AH (125.250 q, Rs. 16295.05). Data further reflect that PS (103.090 q) and PSH (103.750 q) systems produced almost same biological yield with their respective net returns of Rs. 12374.40 and Rs. 11817.00.

Large category

In large category only one household was found and the farmers of this household practised three types of agroforestry systems, namely : AH, ASH and PSH. Data related to biological yield and net returns presented in table 4.23 and Appendix XXXVII to XXXIX reveal that PSH system gave the maximum biological yield (248.330 q) and net return (Rs. 30605.00) followed by ASH (151.270 q, Rs. 24071.22) and AH (137.950 q, Rs. 14614.44).

It is clear from the above cited results that in marginal category ASH system type furnished the maximum biological yield and net returns. In this system, agricultural component gave the maximum net return followed by horticulture, forest and pasture. In this category, the lowest biological yield and net return were registered by PS system type. The major share between two components of the system units involved was, however, contributed by grasses followed by forestry component.

In small category, AHS system type produced the maximum biological yield as well as net returns. Highest net return from AHS system type could be attributed to the reason that in this system maximum area was put under vegetables as compared to in other system types which had contributed significant share to the net returns.

In medium category, AS system type generated the maximum biological yield, however, the maximum net returns were obtained from ASH system type. Such a behaviour is explainable as ASH system type is a three component mix, whereas the third component is a horticultural component providing additional returns. Although, PS and PSH system types gave almost same biological yield, but the later system type generated higher net returns than the former. This can also be ascribed to the reason that PSH contained an additional component viz. horticulture over the PS system type, which provided significant contribution to net returns.

Large category of farmers were found to practice only three agroforestry system types viz. AH, ASH and PSH. Among these system types, PSH registered the maximum biological yield and net returns. The reason for this is that in large category maximum area was put under PSH system type as compared to other system types.

4.3.3 Altitudinal zone III

In altitudinal zone III, a total of five agroforestry system types were found in vogue and existed with varying magnitude in each category. Data pertaining to their biological and net returns have been given in table 4.24 and appendix XL to XLIX. The major agroforestry system types in altitudinal zone III were AS, AH, ASH, PS and PSH. Category wise biological yield and net returns obtained from these system types have been given below:

Marginal category

Twenty eight households were found in this category. The farmers of this category were found to practise only three types of agroforestry systems viz. AS, ASH and PS, A critical look of data (Table 4.24 and Appendix XL to XLII) reveal that maximum biological yield was obtained from ASH (58.974 q) system followed by AS (43.512 q) and PS (17.910 q) with their respective net returns of Rs. 6376.04, 3366.85 and 2548.66.

Small category

Small category was represented by ten households. The agroforestry system types prevalent among the farmers of this category were AS, AH, ASH, PS and PSH. An analysis of data (Table 4.24 and Appendix XLIII to XLVII) giving the detailed account of biological yield and net returns from different agroforestry system types indicates that ASH system generate the maximum (87.916 q) biological yield followed by AS (71.566 q) and AH (70.550 q) system. Data further reflect that PS (48.522 q) and PSH (48.130 q) systems gave almost the same biological yield. Net returns obtained from these system were in the following order : AH > ASH > AS > PSH > PS with their respective values of Rs. 10667.53, 7892.51, 7722.94, 7189.25 and 6499.33.

Medium category

This category was consisted of only two households. Out of five agroforestry systems of altitudinal zone III, this group was found to be practising only two types of agroforestry systems viz. AS and PS. Data depicted in table 4.24 and Appendix XLVIII to IL) show that AS system contributed higher biological yield (178.190 q) and net return (Rs. 21309.86) in comparison to PS system which gave biological yield and net return to the tune of 106.180 q and Rs. 12251.00, respectively.

It may be concluded from the results that ASH system type gave the maximum biological yield and net returns over all other system types in marginal category. This may be attributed to the fact that farmers included both fruit and vegetable crops in this system type and considered to be cash crops and subsequently resulted into increased biological yield as well as net return from this system type.

ASH system types gave the maximum biological yield among the agroforestry system types practised in small category. However, AH system types registered the highest net return followed by ASH. It may be ascribed to the fact that in ASH system types farmer grew wheat and maize only as functional unit under agricultural component, whereas, in AH system type, vegetable and mustard crops were also grown in addition to wheat and maize, which gave significant boost to net returns compared to ASH system type. Moreover, the net returns obtained from fruit crop were significantly higher from AH system type than ASH.

Medium group was found to practise only two system types viz. AS and PS. It is clear from the results that AS system type gave higher biological yield and net returns than the PS system. Agricultural component contributed higher to net returns than forest trees in AS system type. Among vegetables, colocassia gave the highest net returns. In PS system type higher biological yield and net returns

were registered by grasses. The crops grown in AS system type were wheat, maize, mustard, taramira, colocassia, onion, garlic, bhindi, turmeric and brinjal. The market price of all these crops was higher than the grasses obtained from PS system type. The higher market price of the agricultural crop products in comparison to grasses obtained from pasture might be the reason for higher net returns received from the AS system type over the PS system type.

It is evinced from the findings (Appendix IV - IL) that in agricultural component, wheat gave very small contribution to biological yield in altitudinal zone III. Moreover, net returns obtained from wheat were in negative among all wheat based agroforestry system types of altitudinal zone III, irrespective of category, except in AS system type practised by the farmers of marginal category. This can be ascribed to the scarce rainfall during rabi season irrespective of altitudinal zone, but the crop was adversely affected in zone III. This may further be attributed to the poor retention of moisture due to sparse vegetation as well as sloppy land terrain.

4.4 Variation in biological yield and net returns of agroforestry system types among different categories

Agroforestry system types practised by the different categories of farmers were found to produce considerably different levels of biological yield and net return. Co-efficient of variation explaining the variability of system type among different categories of farmers has been described below for each altitudinal zone.

4.4.1 Altitudinal zone I

There were seven agroforestry system types namely : AS, AH, ASH, AHS, PS, PSH and PHS prevalent among the farmers in altitudinal zone I irrespective of their categories. AS, ASH, PS and PSH system types were common in all the three categories of the farmers existing in altitudinal zone I, whereas AH system type was prevalent among the marginal and small categories only. Co-efficient of variation explaining the variability of system types among different categories of

Table 4.24 Biological yield and net return obtained from agroforestry system types among different categories of farmers in altitudinal zone III

AF systems types	Altitudinal zone III					
	Biological yield (q)			Net return (Rs.)		
	Marginal	Small	Medium	Marginal	Small	Medium
AS	43.512	71.566	178.19	3366.85	7722.94	21309.86
AH	-	70.550	-	-	10667.53	-
ASH	58.974	87.916	-	6376.04	7892.51	-
PS	17.910	48.552	106.180	2548.66	6499.33	12251.00
PSH	-	48.130	-	-	7189.25	-

Table 4.25 Co-efficient of variation in biological yield and net return of agroforestry system types among different categories of farmers in altitudinal zone I, II and III

AF system types	Altitudinal zone I		Altitudinal zone II		Altitudinal zone III	
	Co-efficient of variation (%)		Co-efficient of variation (%)		Co-efficient of variation (%)	
	Biological yield	Net return	Biological yield	Net return	Biological yield	Net return
AS	48.041	43.624	54.085	58.656	59.349	70.755
AH	31.991	44.275	48.779	21.686	-	-
ASH	38.697	41.117	36.556	38.535	19.703	10.628
AHS	-	-	55.623	55.945	-	-
PS	81.844	66.701	62.400	63.667	63.588	56.110
PSH	39.649	33.404	78.961	76.174	-	-

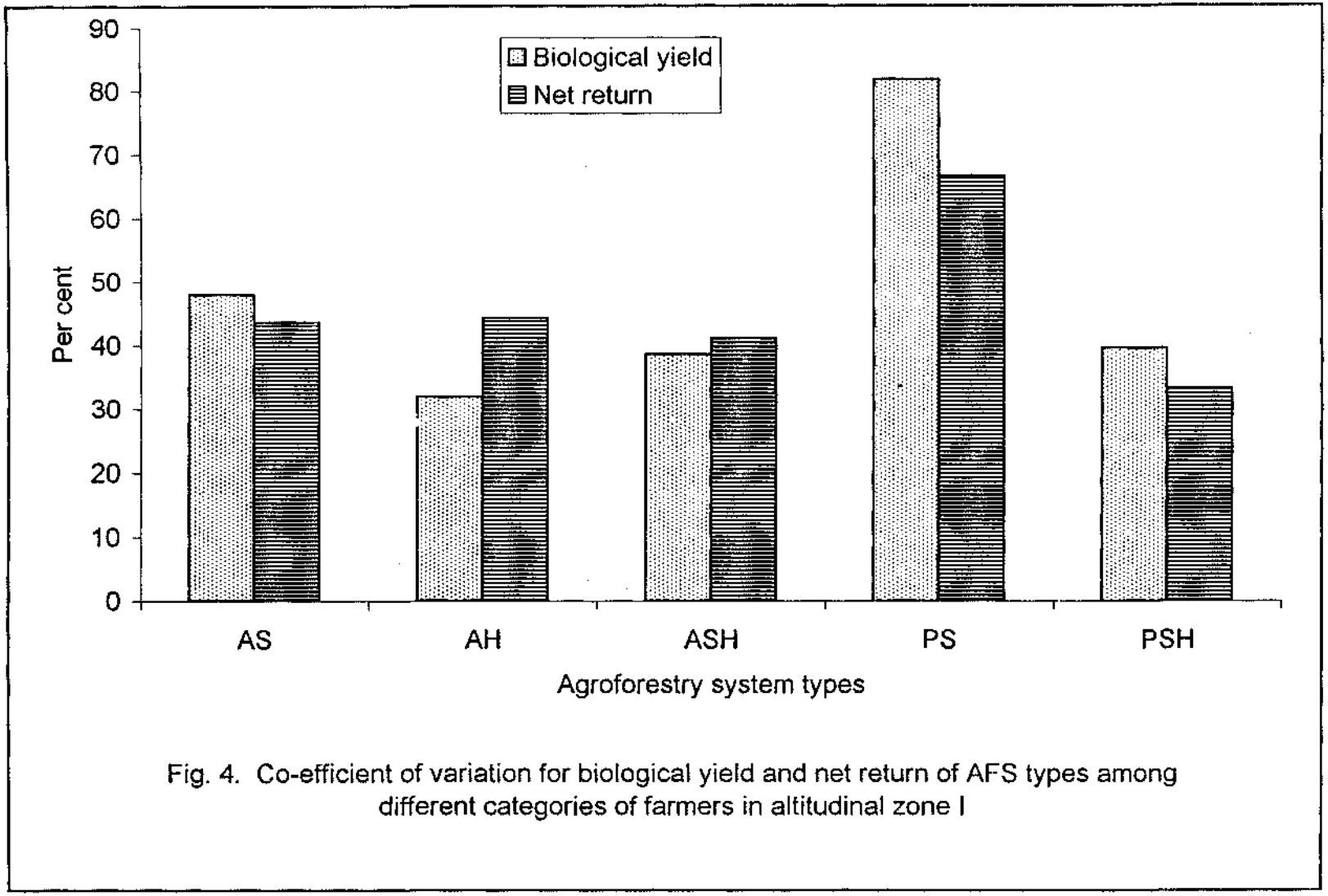

Fig. 4. Co-efficient of variation for biological yield and net return of AFS types among different categories of farmers in altitudinal zone I

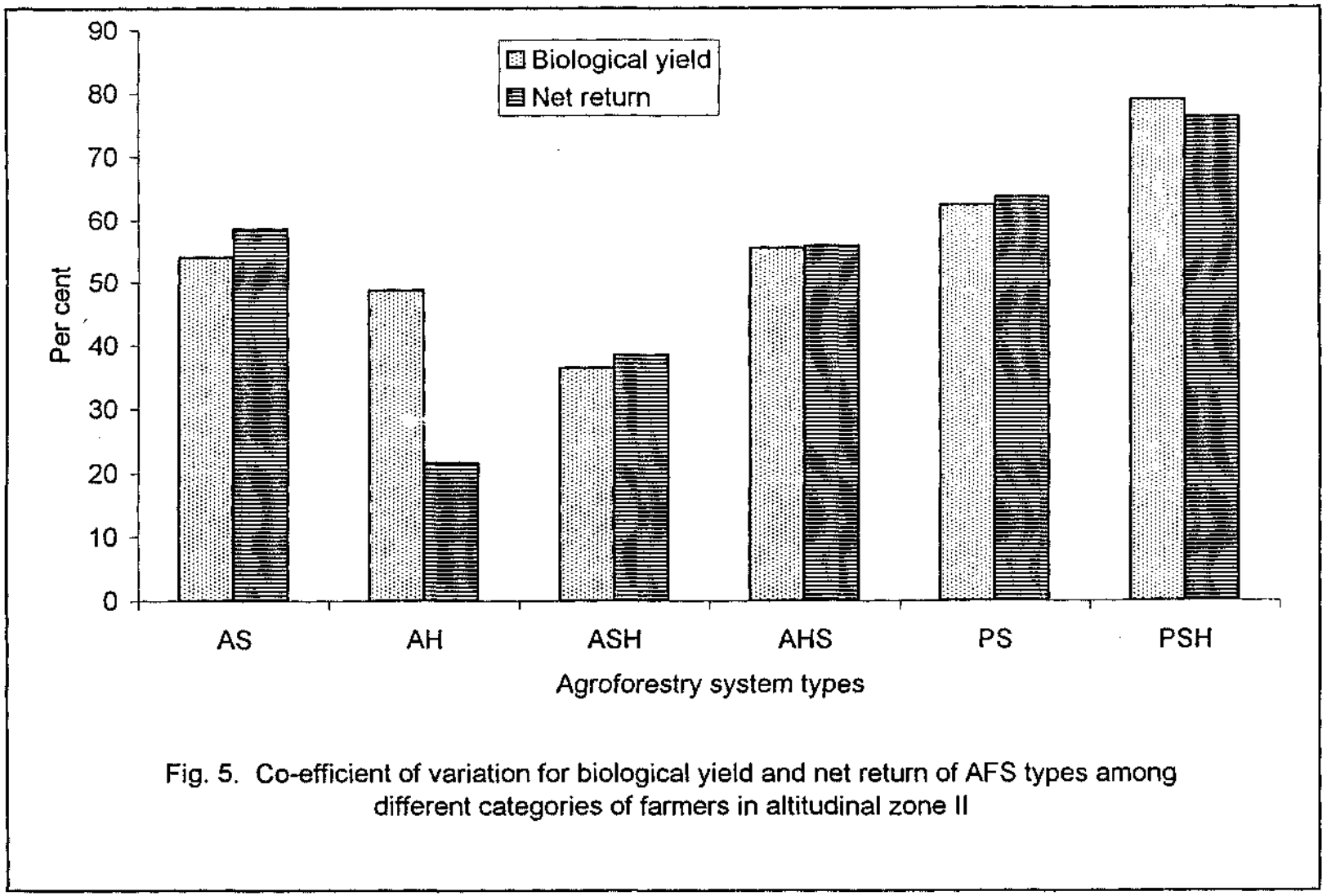

Fig. 5. Co-efficient of variation for biological yield and net return of AFS types among different categories of farmers in altitudinal zone II

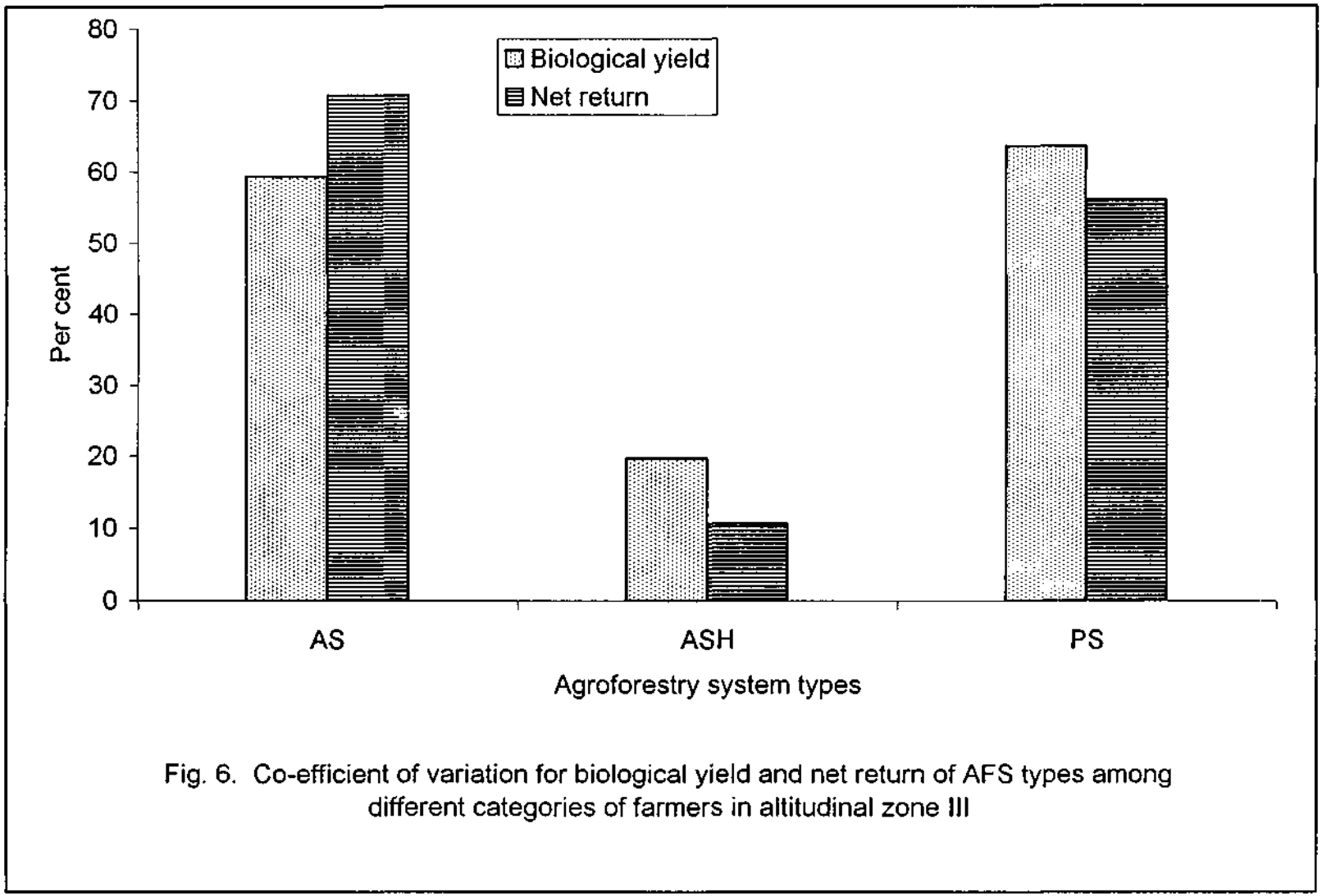

Fig. 6. Co-efficient of variation for biological yield and net return of AFS types among different categories of farmers in altitudinal zone III

farmers (Table 4.25 and Fig. 4) indicates that among the above five common system types, PS had the maximum co-efficient of variation (81.844 %) for biological yield followed by AS (48.041 %), PSH (39.649 %), ASH (38.697 %) and AH (31.991 %). In case of net returns PS system type exhibited the maximum value (66.701 %), followed by AH (44.275 %), AS (43.624 %), ASH (41.117 %) and PSH (33.404 %). The above results reflect that PS was most unstable system type in altitudinal zone I which requires suitable interventions for its refinement.

4.4.2 Altitudinal zone II

The major agroforestry system types prevalent in altitudinal zone II were AS, AH, ASH, AHS, PS and PSH. Out of these six agroforestry system types, AH, ASH and PSH were found present in all the four categories of farmers existing in altitudinal zone II. Whereas, AS system type was present in marginal, small and medium categories only. Another agroforestry system type viz. AHS was prevalent only in marginal and small categories of farmers. Co-efficient of variation explaining the variability of system types among different categories of farmers (Table 4.25 and Fig. 5) show that the variation in biological yield was maximum (78.961 %) in PSH system type followed by PS (62.400 %), AHS (55.623 %), AS (54.085 %), AH (48.779 %) and ASH (36.556 %). The variation in net returns was maximum (76.174 %) in PSH system type followed by PS (63.667 %), AS (58.656 %), AHS (55.945 %), ASH (38.535 %) and AH (21.686 %). From these results it can be concluded that PSH system type in altitudinal zone II was most unstable and needs suitable interventions for its refinement.

4.4.3 Altitudinal zone III

There were five agroforestry system types (AS, AH, ASH, PS and PSH) prevalent in altitudinal zone III. Out of these five system types, AS and PS system types were common in all the three categories of farmers existing in altitudinal zone III. Whereas, ASH system type was prevalent in marginal and small categories only. AH and PSH system types were present only in small category of

farmers. The co-efficient of variation given in table 4.25 and fig. 6 show that the variation in biological yield was maximum (63.588 %) in PS followed by AS (59.349 %) system type. The variation in net returns was maximum (70.755 %) in AS followed by PS (56.110 %) system type.

The above results indicate that considering the variation in biological yield, PS was most unstable system type in altitudinal zone III, which requires suitable interventions for its improvement.

The maximum co-efficient of variation in PS and PSH system types in altitudinal zone I and II may be due to the variation in productivity of this system type in different categories. Moreover, a wide variation in the number of trees of a particular species and area put under this system type in different categories may also be responsible for highest co-efficient of variation.

It is depicted from the results that in altitudinal zone III, PS system type has shown the maximum co-efficient of variation for biological yield, whereas, for net returns, it was registered by AS system type. It may be due to a huge variation in the market prices of the produce generated by these two system types.

Potential tree-crop systems

Diversity of the production components in an agroforestry system and net return to be accrued have been taken as criteria for determining the potential tree-crop systems in each zone. The details of potential tree-crop systems under arable and non-arable lands for different altitudinal zones are presented in table 4.26.

4.5 Technological gaps/constraints and their solutions

Social, technical and infrastructural constraints/gaps inflicting the tree-crop production systems were identified during the appraisal of existing agroforestry practices and systems. The farmers faced almost the same

Table 4.26 Potential tree-crop systems under arable and non-arable lands for different altitudinal zones

Category	Potential tree-crop systems	
	Arable land	**Non-arable land**
Altitudinal zone I		
Marginal	**Agrihorticulture (AH) system** Wheat/Mustard/Garlic – Maize/Colocassia/Mash/ Bhindi + Mango (grafted)	**Pastoral silvihorticulture (PSH) system** Natural grasses* + Acacia + Grewia + Toona + Dalbergia + Leucaena + Bauhinia + Morus + Mango (grafted) + Lime
Small	**Agrihorticulture (AH) system** Wheat/Mustard/Garlic – Maize/Colocassia/Ginger/ Brinjal/Bhindi/Turmeric + Mango (grafted)	**Pastoral silviculture (PS) system** Natural grasses + Dalbergia + Acacia + Bauhinia + Albizzia (Siris) + Grewia + Leucaena + Pinus
Medium	**Agrisilvihorticulture (ASH) system** Wheat/Mustard/Gram/Garlic – Maize/Colocassia/ Turmeric/Bhindi + Grewia + Leucaena + Acaica + Bauhinia + Mango (grafted)	**Pastoral hortisilviculture (PHS) system** Natural grasses + Mango (grafted) + Lime + Kinnow + Bauhinia + Albizzia (Siris) + Grewia + Dalbergia
Altitudinal zone II		
Marginal	**Agrisilvihorticulture (ASH) system** Wheat/Mustard/Cauliflower – Maize/Colocassia/ Ginger/Tomato/Bhindi + Grewia + Leucaena + Morus + Mango (grafted)	**Pastoral silvihorticulture (PSH) system** Natural grasses + Acacia + Dalbergia + Grewia + Leucaena + Bauhinia + Toona + Albizzia (Siris) + Dalbergia + Mango (grafted) + Lime
Small	**Agrihortisilviculture (AHS) system** Wheat/Mustard/Taramira/Pea/Cauliflower – Maize/ Mash/Ginger/Tomato/Bhindi/Turmeric + Mango (grafted) + Litchi + Grewia + Morus + Leucaena	**Pastoral silvichotriculture (PSH) system** Natural grasses + Grewia + Toona + Leucaena + Albizzia + Dalbergia + Acacia + Bauhinia + Mango (grafted) + Guava

Contd....

Medium	**Agrisilvihorticulture (ASH) system** Wheat/Mustard/Taramira/Garlic/Onion – Maize/ Colocassia/Ginger/ Tomato/Bhindi + Grewia + Morus + Leucaena + Mango (grafted) + Litchi + Lime + Papaya	**Pastoral silviculture (PS) system** Natural grasses + Acacia + Grewia + Bauhinia + Dalbergia + Toona + Albizzia (Siris)
Large	**Agrisilvihorticulture (ASH) system** Wheat/Mustard/Taramira/Garlic – Maize/Colocassia/ Ginger/Bhindi – Grewia + Leucaena + Morus + Mango (grafted) + Lime + Pear	**Pastoral silvihorticulture (PSH) system** Natural grasses + Acacia + Toona + Dalbergia + Albizzia + Grewia + Leucaena + Bauhinia + Mango (grafted) + Lime
Altitudinal zone III		
Marginal	**Agrisilvihorticlture (ASH) system** Mustard/Garlic – Maize/Colocassia/Soybean/ Turmeric/Bhindi + Grewia + Bauhinia + Morus + Leucaena + Mango (grafted)	**Pastoral silviculture (PS) system** Natural grasses + Albizzia (Cheoli) + Grewia + Acacia + Toona + Dalbergia + Albizzia (Siris) + Phoenix
Small	**Agrihorticulture (AH) system** Mustard/Garlic/Onion – Maize/Colocassia/Ginger/ Turmeric/Bhindi/Brinjal + Mango (grafted)	**Pastoral silvihorticulture (PSH) system** Natural grasses + Acacia + Pinus + Toona + Albizzia + Mallotus + Ficus + Mango (grafted)
Medium	**Agrisilviculture (AS) system** Mustard/Taramira/Onion/Garlic – Maize/Colocassia/ Brinjal/Turmeric/ Bhindi + Grewia + Leucaena + Morus + Bauhinia	**Pastoral silviculture (PS) system** Natural grasses + Acacia + Toona + Dalbergia + Anogeissus + Leucaena + Grewia + Albizzia (Siris)

* Natural grasses = *Heteropogon contortus, Chrysopogon montanus, Themeda anathera, Panicum maximum, Apluda mutica, Pennisetum* sp. and *Cynodon dactylon.*

constraints/problems in all the altitudinal zones under study. The major social, technical and infrastructural constraints faced by the farmers have been described collectively for all the altitudinal zones as under:

Sr. No.	Constraints/gaps	Solutions
	Social	
1	There was a dominance of marginal farmers in the study area. Out of total sample of 120 households, marginal category represented 81 households, whereas the remaining 29, 9 and 1 household were represented by small, medium and large category farmers, respectively. Thus smaller land holdings offer the limited scope for adoption of agroforestry interventions.	Keeping in view the technological and landholding constraints, agroforestry models aptly matching to the needs of such farmers should be developed and demonstrated extensively on farmers' fields.
2	Literacy rate was unsatisfactory. a) Literacy of heads* of families in different altitudinal zones was found as under: Altitudinal zone — Literacy rate (%) I — 60.00 II — 70.00 III — 47.50 * irrespective of sex b) Literacy rate of females was found less to that of male literacy rate in all zones as given below: Altitudinal zone — Male literacy (%) — Female literacy** (%) I — 89.66 — 81.36 II — 94.73 — 71.02 III — 80.65 — 65.71 **Head irrespective of sex is included	Effective execution of the education schemes for all ages should be undertaken.
3	Majority of animals reared by the farmers were of local breeds.	Cattle Show/Fair, Kisan Mela etc. should be organized from time to time to popularize the improved breeds of animals.

4	The main source of off-farm employment/ income was government jobs/pensions, some farmers were having family trade, business and also employment as daily wagers either in public or private sector. The zone wise split is given below: Altitudinal zone — Off-farm employment (%) I — 17.51 II — 22.22 III — 16.87	Off-farm employment/ income may be generated by giving impetus to the agro-based small scale industries at village level.
	Technical	
1	Use of local seeds of cereals in larger area due to unawareness of high yielding varieties	Popularization of high yielding varieties through demonstrations, exposure visits and trainings to farmers.
2	Use of higher seed rate coupled with imbalance and disproportionate application of fertilizers was observed in wheat and maize. It was also found that farmers were not using the recommended type of fertilizers in required quantity. Moreover, the use of fertilizers also depends up on their availability.	Farmers need to be appraised of the latest package of practices of these crops. Simultaneously there should be agri-clinics/ soil testing laboratories at accessible places to test the nutrient status of soils at reasonable price. Regular and on time adequate supply of required fertilizers should be assured.
3	FYM was being used half decomposed due to the ignorance of farmers to scientific methods of composting.	Farmers should be educated to the latest composting techniques such as vermi-composting by imparting on-farm trainings and demonstration.
4	Hand weeding was a common practice. Being more time intensive, many a time it becomes impractical to execute this practice due to shortage of labour at peak period. Subsequently it reduces the production.	Integrated weed management practices encompassing physical, chemical & bio-logical weed control measures should be encouraged.

5	A serious problem of abnoxious weeds like *Ageratum. Parthenium* and *Lantana* etc. in grass lands, field bunds and cultivated areas were found. Due to invasion of such weeds farm production has been declined considerably.	The farmers should be made aware of the integrated weed management practices by organizing trainings/camps.
6	Pastures were found covered with indigenous and low yielding grass species having poor nutritive values. Although many tree species were present in the pasture yet leaves of only a few were fed to the animals. More over fertilization of pastures was missing.	High yielding and nutritive grass species viz. napier bajra, setaria etc. along with fodder tree species should be introduced in the pastures following the latest improved cultural practices.
7	Low yielding varieties of fruit trees namely guava, lime, lemon, papaya etc. were found grown in the farmers' field to supplement their needs without undertaking any specific management.	Dissemination of knowledge of high yielding fruit varieties and improved management practices should be demonstrated by organizing kisan melas, trainings etc.
8	Occurrence of severe frost led to the drying of some young and old fruit trees especially in Zone I and II.	Frost resistant location specific varieties of fruit trees should be developed.
9	Lack of adequate knowledge regarding selection of location specific varieties of fruit trees was observed among the farmers.	Development and popularization of location specific improved varieties of fruit trees is ought to be done.
10	Agroforestry systems identified were traditional type and less productive.	Poultry, apiculture, floriculture, medicinal and aromatic plants etc. could be introduced in the existing agroforestry systems to make them productive. This could be achieved if the loans are made available to farmers at soft interest rate. Hence, more financial institutions should be opened in the

		rural areas. Additional rural development schemes should be made under which more credit could be advanced to the farmers.
11	Vegetables were grown by the farmers just to supplement their household needs. Only a few farmers were found to grow vegetables viz. colocassia, ginger, tomato etc. as cash crops that too at small scale.	Integration of vegetables with existing cereals dominating land use system should be followed to improve the economic status of the farmers.
12	A serious problem of sudden drying up of *Dalbergia* was observed.	Problem needs to be investigated to find remedies.
	Infrastructural	
1	Absence of government authorized sale centre near the villages.	Government authorized sale centre should be opened at accessible places.
2	Farmers were scared to adopt new technologies due to lack of risk bearing capabilities.	Credit facilities should be made available to farmers at reasonably low rate of interest. On farm trainings be imparted.
3	Communication gap between lab to land due to lack of inadequate and suitable professional staff.	Locality specific diagnostic surveys should be conducted to identify the social and technical constraints faced by the farmers in their farming systems. Moreover, there is a need to strengthen the extension net work so as to impart accurate information to the farmers well in time.
4	Passive and indifferent attitude of the extension staff towards the problems of farmers as well as farmers towards the new inventions.	There must be symbiotic relationship between extension staff and farmers.

5	Lack of success stories of agroforestry.	Keeping in view the social and technical aspects of the farmers, agroforestry models should be demonstrated by developing if possible on the farmers' field for their effective adoption.
6	Lack of agro-processing facilities and sound marketing net work at village, panchayat and block level.	Agro-processing facilities & marketing net work should be strengthened at the village level.
7	Lack of irrigation facilities	Popularization of rain water harvesting techniques through demonstration.
8	Weather predictions made by the farmers were based on their experiences and traditional methods. Many a times it led to losses due to failure of their prediction regarding rainfall. Moreover predictions made by the agro-meteorological Dept. do not hold any significance due to the ignorance of farmers, if at all any one is vigilant, do not readily believe on them due to lack of consistency in accuracy of their predictions.	More precision in prediction of weather conditions should be made by agro-meteorological department.
9	Occurrence of fragmented landholdings was a major hurdle to adopt potential agroforestry interventions.	Effective efforts should be made to consolidate the fragmented landholdings.
	Miscellaneous	
1	Wild and stray animals were a serious problem of the farmers as they caused heavy damage to the crops.	The problem can be overcome up to some extent by maintaining the natural habitat of wild animals viz. by making water ponds and planting wild fruit trees in the forests etc. and for stray animals by maintaining the permanent record of domestic animals at panchayat level

Chapter – 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigation on "**Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh**", aimed to study and analyze the socio-economic status of farmers, identification of existing agroforestry systems and to suggest potential tree-crop systems, evaluation of biological yield and economic returns from existing agroforestry systems, find out the technological gaps in the systems and suggest ways and means to overcome them, were conducted for rabi and kharif crops during 2002-03. The study was conducted in Bilaspur district of Himachal Pradesh. Considering the altitudinal variation, Bilaspur district was divided into three altitudinal zones: Altitudinal zone I (< 700 m amsl), Altitudinal zone II (700 – 1000 m amsl) and Altitudinal zone III (1000 - 1400 m amsl). Four villages from each zone were selected randomly and thereafter ten households from each village were selected as ultimate unit of study. The information was collected through pre-tested schedule through personal interviews. The selected households were categorized as marginal (< 1 ha), small (1-2 ha), medium (2-5 ha) and large (> 5 ha). Households found in marginal, small and medium categories of altitudinal zone I, II and III were 30, 7 and 3; 23, 12 and 4; and 28, 10 and 2, respectively. In addition to above, one household was also found in large category of altitudinal zone II. The results so obtained have been summarized as below:

5.1 Socio-economic status

Socio-economic status of farmers has been evaluated taking into account their average family structure, educational status of the family head, sex-wise literacy of family, status of off-farm employment, livestock status and land holding size.

Average family size, male : female ratio of adults and children were observed to the tune of 6.43, 6.52 and 6.07; 0.95, 0.81 and 0.79; and 0.65, 0.57 and 0.57 in altitudinal zones I, II and III, respectively. Literacy rate of heads of

families was found maximum (70.00 %) in altitudinal zone II followed by altitudinal zone I (60.00 %) and III (47.50 %). Family literacy was 85.47, 84.16 and 73.80 per cent irrespective of farmers category in zone I, II and III, respectively. Overall literacy rate of males was higher than that of females in all the altitudinal zones.

Government employment, family trade, carpentry, tailoring, grocery shop-keeping, private transport and industries etc. were the sources of off-farm employment irrespective of altitudinal zone. 17.51, 22.22 and 16.87 per cent of individuals were having access to these off-farm employment opportunities, in altitudinal zone I, II and III, respectively.

Dominance of local breed buffaloes to the tune of 75 – 100 per cent irrespective of altitudinal zones was observed. Regular de-worming in animals and mechanical milking procedure was found missing in all the altitudinal zones. Scientific breeding method exclusively for cows and traditional method for buffaloes were in vogue in the study area. Vaccination against Foot Mouth Disease (FMD) in animals was done by 54.05, 67.56, 22.50 per cent households in altitudinal zone I, II and III, respectively. Maximum number of households (67.50 %) in altitudinal zone III followed by zone II (48.64 %) and I (10.81 %) were using animal dung as fuel in addition to crop production. Agriculture and pasture were the major land use systems in all the altitudinal zones. The average land holding in altitudinal zone I, II and III was 0.970, 1.072 and 0.925 ha, respectively.

5.2 Identification of agroforestry systems

Seven agroforestry system types were identified irrespective of altitudinal zones.

There were seven agroforestry system types prevalent among the different categories of farmers in altitudinal zone I. Marginal category practised six types of agroforestry system types namely : AS, AH, ASH, AHS, PS and PSH, whereas in small category five AFS types viz. AS, AH, ASH, PS and PSH were found. In

medium category also five types of agroforestry systems viz. AS, ASH, PS, PSH and PHS were identified.

Six agroforestry system types viz. AS, AH, ASH, AHS, PS and PSH were identified among the different categories of farmers in altitudinal zone II. Marginal and small categories of farmers practised all the above said system types. In medium category, agroforestry system types were AS, AH, ASH, PS and PSH. Only three system types namely AH, ASH and PSH were found in vogue with the farmers of large category.

Five agroforestry system types viz. AS, AH, ASH, PS and PSH were identified irrespective of a particular category in altitudinal zone III. Marginal category of farmers were found to practise only three types of agroforestry system namely : AS, ASH and PS, whereas small category of farmers practised all the agroforestry system types found in this zone. In medium category, only two agroforestry system types viz. AS and PS were observed.

Grewia optiva, Leucaena leucocephala, Toona ciliata, Albizzia lebbeck, Acacia catechu, Eucalyptus spp., *Bauhinia variegata* and *Pinus roxburghii* were among the most preferred trees in various agroforestry systems, irrespective of altitudinal zones. Whereas, among fruit trees, mango, lemon and banana were found dominating in various agroforestry systems irrespective of altitudinal zone.

5.3 Biological yield and economic return

In marginal, small and medium categories of farmers in altitudinal zone I, PSH, ASH and PS system types gave the maximum biological yield. PSH, AH and PHS system types generated the maximum net returns, whereas the minimum from PS, PSH and PSH in marginal, small and medium categories, respectively.

ASH, AHS and PSH system types provided the maximum biological yield and net return in marginal, small and large categories of farmers, respectively, in altitudinal zone II. Whereas, in medium category, AS and ASH system types gave

the maximum biological yield and net returns, respectively. PS system type in all the categories, except large category of farmers in which AH system type, gave the lowest biological yield. The lowest net return in marginal and small categories was produced by the PS system type. Whereas, in medium and large categories, PSH and AH system types gave the lowest net return, respectively.

ASH system type in marginal and small, whereas, AS in medium category of farmers gave the maximum biological yield in altitudinal zone III. The maximum net return in marginal, small and medium categories was obtained from ASH, AH and AS system types, respectively. PS system type gave the lowest biological yield and net return to the farmers of marginal and medium categories. Whereas, in small category PSH and PS system type gave the lowest biological yield and net return, respectively.

5.4 Variation in biological yield and net return of agroforestry system types among different categories

The maximum value of co-efficient of variation for biological yield and net return was registered by PS in altitudinal zone I and by PSH system types in altitudinal zone II. PS system type also showed the maximum co-efficient of variation for biological yield in altitudinal zone III, whereas, for net return, it was shown by AS system type. Thus, PS system type in altitudinal zone I and III; PSH in altitudinal zone II were found most unstable system types.

Potential tree-crop systems

Category-wise potential tree-crop systems under arable and non-arable land identified were :

	Altitudinal zone I			Altitudinal zone II				Altitudinal zone III		
	Marginal	Small	Medium	Marginal	Small	Medium	Large	Marginal	Small	Medium
Arable land	AH	AH	ASH	ASH	AHS	ASH	ASH	ASH	AH	AS
Non-arable land	PSH	PS	PHS	PSH	PSH	PS	PSH	PS	PSH	PS

5.5 Technological gaps/constraints and their solutions

Dominance of marginal and small categories of farmers and local breeds of animals, unsatisfactory literacy rate as well as limited off-farm employment opportunities were the major social constraints. The solutions viz. development of agroforestry models aptly matching to the needs of farmers, cattle fairs/Kisan mela to popularize the improved breeds of animals, effective execution of the education schemes for all ages, and strengthening the agro-based small scale industries at village level were suggested.

Unawareness regarding package of practices of major cereal crops viz. wheat and maize; selection of location specific fruit varieties; lack of proper management of pastures and fruit trees, use of half decomposed FYM, invasion of abnoxious weeds, prevalence of less productive traditional agroforestry systems, etc. were the major technical constraints/gaps identified. Need to appraise the farmers with the latest technical know-how of major crops and scientific composting techniques, development and popularization of location-specific improved varieties of fruit trees, integrated weed management practices, introduction of high yielding enterprises in the traditional agroforestry systems were suggested.

Among infrastructural constraints/gaps, lack of government authorized sale centres near the villages and effective finance policies; communication gap between lab to land, lack of success stories of agoroforestry as well as agro-processing facilities and sound marketing network, and irrigation facilities etc. were identified. Government authorized sale centre near the villages, credit facilities at soft interest rate, strengthening the agro-processing facilities, marketing and extension network; development and demonstration of agroforestry models on the farmers' fields, popularization of rain water harvesting techniques were suggested.

Problem of wild and stray animals was also observed. Maintenance of natural habitat of wild animals and permanent record of domestic animal at panchayat level were suggested to overcome the problem.

Conclusion

After critical evaluation of different agroforestry system types, the following potential agroforestry system types were identified for arable and non-arable land:

Altitudinal zone	Category of Farmers	AFS types	
		Arable land	Non-arable land
I	Marginal	**AH** : Wheat/Mustard/Garlic – Maize/Colocassia/ Mash/Bhindi + Mango (grafted)	**PSH** : Natural grasses* + Acacia + Grewia + Toona + Dalbergia + Leucaena + Bauhinia + Morus + Mango (grafted) + Lime
	Small	**AH** : Wheat/Mustard/Garlic – Maize/Colocassia/Ginger/ Brinjal/Bhindi/Turmeric + Mango (grafted)	**PS** : Natural grasses + Dalbergia + Acacia + Bauhinia + Albizzia (Siris) + Grewia + Leucaena + Pinus
	Medium	**ASH** : Wheat/Mustard/Gram/ Garlic – Maize/Colocassia/ Turmeric/Bhindi + Grewia + Leucaena + Acacia + Bauhinia + Mango (grafted)	**PHS** : Natural grasses + Mango (grafted) + Lime + Kinnow + Bauhinia + Albizzia (Siris) + Grewia + Dalbergia
II	Marginal	**ASH** : Wheat/Mustard/ Cauliflower – Maize/Colocassia/ Ginger/ Tomato/Bhindi + Grewia + Leucaena + Morus + Mango (grafted)	**PSH** : Natural grasses + Acacia + Dalbergia + Grewia + Leucaena + Bauhinia + Toona + Albizzia (Siris) + Dalbergia + Mango (grafted) + Lime
	Small	**AHS** : Wheat/Mustard/Taramira/ Pea/Cauliflower – Maize/ Mash/Ginger/Tomato/Bhindi/ Turmeric + Mango (grafted) + Litchi + Grewia + Morus + Leucaena	**PSH** : Natural grasses + Grewia + Toona + Leucaena + Albizzia + Dalbergia + Acacia + Bauhinia + Mango (grafted) + Guava
	Medium	**ASH** : Wheat/Mustard/Taramira/ Garlic/Onion – Maize/ Colocassia/Ginger/ Tomato/Bhindi + Grewia + Morus + Leucaena + Mango (grafted) + Litchi + Lime + Papaya	**PS** : Natural grasses + Acacia + Grewia + Bauhinia + Dalbergia + Toona + Albizzia (Siris)

	Large	**ASH** : Wheat/Mustard/Taramira/ Garlic – Maize/Colocassia/ Ginger/Bhindi – Grewia + Leucaena + Morus + Mango (grafted) + Lime + Pear	**PSH** : Natural grasses + Acacia + Toona + Dalbergia + Albizzia + Grewia + Leucaena + Bauhinia + Mango (grafted) + Lime
III	Marginal	**ASH** : Mustard/Garlic – Maize/Colocassia/Soybean/ Turmeric/Bhindi + Grewia + Bauhinia + Morus + Leucaena + Mango (grafted)	**PS** : Natural grasses + Albizzia (Cheoli) + Grewia + Acacia + Toona + Dalbergia + Albizzia (Siris) + Phoenix
	Small	**AH** : Mustard/Garlic/Onion – Maize/Colocassia/Ginger/ Turmeric/Bhindi/Brinjal + Mango (grafted)	**PSH** : Natural grasses + Acacia + Pinus + Toona + Albizzia + Mallotus + Ficus + Mango (grafted)
	Medium	**AS** : Mustard/Taramira/Onion/ Garlic – Maize/Colocassia/ Brinjal/Turmeric/ Bhindi + Grewia + Leucaena + Morus + Bauhinia	**PS** : Natural grasses + Acacia + Toona + Dalbergia + Anogeissus + Leucaena + Grewia + Albizzia (Siris)

Further looking at the identified agroforestry system (AFS) types, it becomes crystal clear that irrespective of category of farmers and altitudinal zones, horticulture component seems to play a significant role in generating net returns. Hence, incorporation of fruit trees of improved varieties requires immediate attention of the farmers of the study area.

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APPENDICES

Appendix I

Month-wise temperature and rainfall in district Bilaspur (2002-03)

Month	Temperature (°C)		Rainfall (mm)
	Maximum	Minimum	
2002			
September	28.97	18.30	486.8
October	28.21	12.92	2.8
November	24.78	7.07	-
December	20.70	2.78	-
2003			
January	19.78	2.54	23.2
February	20.42	6.37	61.2
March	24.52	9.13	72.8
April	31.42	13.07	10.0
May	35.65	15.55	16.0
June	36.07	21.14	102.4
July	31.08	23.21	356.0
August	29.50	23.08	390.3
September	29.34	20.80	252.4

Source : Meteorological Observatory, Krishi Vigyan Kendra, Berthin, Dist. Bilaspur (H.P.)

Appendix II

Inventory of trees (forest/fruit) and agricultural crops identified in the study area

Common/English name	Scientific name
Forest trees	
Toot/Mulberry	*Morus alba*
Beul	*Grewia optiva*
Losuni	*Leucaena leucocephala*
Shisham/Tahli	*Dalbergia sissoo*
Tooni	*Toona ciliata*
Kachnar	*Bauhinia variegata*
Bamboo/Bans	*Dendrocalamus* sp.
Safeda	*Eucalyptus* sp.
Khair	*Acacia catechu*
Darek	*Melia azedarach*
Siris	*Albizzia lebbeck*
Alsan	*Terminalia tomentosa*
Dagla/Fegra	*Ficus palmata*
Poplar	*Populus* sp.
Chir/Chil	*Pinus roxburghii*
Kamal	*Mallotus philippinensis*
Jamnu	*Syzygium cumini*
Beuns	*Salix* sp.
Aonla/Amla	*Embilica officinalis*
Simal	*Bombax ceiba*
Ratela	*Wendlendia exserta*
Kainth	*Pyrus pashia*
Cheoli	*Albizzia chinensis*
Tiamli	*Ficus roxburghii*
Bil	*Aegle marmelos*
Khajur/Palm	*Phoenix* sp.
Thira/Kahu	*Olea* sp.
Bair	*Zizyphus* sp.
Chhal/Chalayan	*Anogeissus latifolia*
Sagwan/Teak	*Tectona grandis*
Fruit trees	
Mango	*Mangifera indica*
Lime	*Citrus aurantifolia*
Guava	*Psidium guajava*
Lemon	*Citrus pseudolimon*
Litchi	*Litchi chinensis*
Papaya	*Carica papaya*
Pear	*Pyrus pyrifolia*

Banana	*Musa* sp.
Walnut/Khor	*Juglans regia*
Plum	*Prunus salicinia*
Peach	*Prunus persica*
Kinnow	*Citrus reticulate*
Agricultural crops	
Wheat	*Triticum aestivum*
Maize	*Zea mays*
Paddy	*Oryza sativa*
Gram	*Cicer arietinum*
Mustard	*Brassica campestris*
Mash	*Phaseolus mungo*
Taramira	*Eruca sativa*
Colocassia	*Colocassia esculentum*
Potato	*Solanum tuberosum*
Ginger	*Gingiber officinalis*
Onion	*Allium cepa*
Garlic	*Allium sativum*
Chilli	*Capsicum frutisense*
Bhindi	*Abelmoschus esculentus*
Brinjal	*Solanum melongena*
Cauliflower	*Brassica oleracea var. botrytis*
Turmeric	*Curcuma longa*
Tomato	*Lycopersicon esculentum*
Pea	*Pisum sativum*
Soyabean	*Glycine max*

Appendix III

Local cost of agricultural inputs and outputs in Bilaspur district during the year 2002-03

S.No.	Particulars	Rate (Rs.)
	Input	
1.	Labour cost	
	a) Labour charges around year 2002-03 (Mandays)	80.00
	b) Bullock labor (per day)	300.00
	c) Ploughing by tractor (per hour)	200.00
2.	Seed cost (per kg)	
	a) Miaze	10.00
	b) Wheat	9.00
	c) Paddy	8.00
	d) Mustrad	25.00
	e) Taramira	18.00
	f) Mash	22.00
	g) Gram	25.00
	h) Soybean	60.00
	i) Colocassia	10.00
	j) Potato	9.00
	k) Garlic	20.00
	l) Onion (seedlings)	10.00
	m) Peas	30.00
	n) Bhindi	40.00
	o) Brinjal	80.00
	p) Chilli	100.00
	q) Cauliflower	1200.00
	r) Turmeric	15.00
	s) Tomato	15000.00
	t) Ginger	20.00
3.	Manure and fertilizers (per quintal)	
	a) FYM	35.00
	b) Urea	422.00
	c) N P K 12 : 32 : 16	700.00
4.	Diathane M-45 (per kg)	170.00
	Output	
1.	Agriculture (per quintal)	
	a) Wheat grain	700.00

	b) Wheat straw	200.00
	c) Maize grain	500.00
	d) Maize stover/straw	100.00
	e) Paddy	700.00
	f) Paddy straw	100.00
	g) Mustard	2500.00
	h) Taramira	1800.00
	i) Mash	1800.00
	j) Soybean	3000.00
	k) Gram	1800.00
	l) Ginger	1200.00
	m) Colocassia	1000.00
	n) Onion	500.00
	o) Garlic	1400.00
	p) Bhindi	600.00
	q) Brinjal	600.00
	r) Turmeric (fresh)	1000.00
	s) Pea (pods)	700.00
	t) Tomato	500.00
	u) Chilli (green)	1000.00
	v) Potato	300.00
	w) Cauliflower	500.00
2.	Fruits (per quintal)	
	a) Mango (improved)	1000.00
	b) Mango (local)	200.00
	c) Guava	300.00
	d) Kinnow	1000.00
	e) Plum	400.00
	f) Lemon	100.00
	g) Lime	900.00
	h) Litchi	1500.00
	i) Pear	350.00
	j) Papaya	400.00
	k) Banana (100 dozen = App. 1 quintal)	1200.00
	l) Peach	300.00
3.	Pastures (per quintal)	
	a) Green grass	100.00
	b) Dry grass	200.00
	c) Leaf fodder	100.00
4.	Fuel wood (per quintal)	125.00

Appendix IV Biological yield and economic return from AS system in marginal category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.311	4.34	3038.00	1500.45
		W/straw	-	4.34	868.00	
		Maize	0.308	4.92	2460.00	1451.96
		M/straw	-	24.60	2460.00	
		Sub-Total	**0.619**	**38.20**	**8826.00**	**2952.41**
	B)	**Oil seeds**				
		Mustard	0.047	0.20	500.00	176.50
		Taramira	0.010	0.05	90.00	48.50
		Sub-Total	**0.057**	**0.25**	**590.00**	**225.00**
	C)	**Vegetables**				
		Colocassia	0.0290	2.00	2000.00	1175.50
		Potato	0.0041	0.25	75.00	-10.00
		Ginger	0.0020	0.10	120.00	48.50
		Onion	0.0012	0.12	60.00	13.00
		Garlic	0.0010	0.06	84.00	28.00
		Chilli	0.0020	0.03	30.00	-8.00
		Bhindi	0.0023	0.10	60.00	36.00
		Brinjal	0.0020	0.20	120.00	80.00
		Cauliflower	0.0010	0.05	25.00	10.00
		Sub-Total	**0.0446**	**2.91**	**2574.00**	**1373.00**
Pasture	**D)**	**Grasses***	0.030	1.50	150.00	90.00
Forest	**E)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		M alba	3.12	0.25	0.37	25.00	46.25	6.28	27.53
		G optiva	3.82	0.57	0.87	57.00	108.75	26.44	78.19
		L leucocephala	2.71	0.27	0.35	27.00	43.75	13.45	30.20
		D sissoo	0.65	-	0.16	-	20.00	-	14.80
		T ciliata	0.18	-	0.06	-	7.50	-	6.06
		B variegata	0.47	0.07	0.11	7.00	13.75	3.24	9.99
		Dendrocalamus sp.	0.12	0.12	-	12.00	-	10.20	-
		Eucalyptus sp. sp..	0.29	-	0.034	-	4.25	-	1.93
		Sub-Total	**11.36**	**1.280**	**1.954**	**128**	**244.25**	**59.61**	**168.7**
Total (A+B+C+D+E)				**46.094**		**12512.25**		**4868.72**	

Appendix V Average biological yield and economic return from AH system in marginal category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	Food grains				
		Wheat	0.32	5.38	3766.00	2474.56
		W/straw	-	5.38	1076.00	
		Maize	0.24	5.70	2850.00	2601.49
		M/straw	-	28.50	2850.00	
		Paddy	0.12	1.80	1260.00	202.50
		P/straw	-	2.70	270.00	
		Sub-Total	0.68	49.46	12072.00	5278.55
	B)	Oil seeds and pulses				
		Mustard	0.053	0.24	600.00	244.50
		Mash	0.004	0.03	54.00	15.00
		Sub-Total	0.057	0.27	654.00	259.50
	C)	Vegetables				
		Colocassia	0.0060	0.30	300.00	162.75
		Bhindi	0.0025	0.10	60.00	36.00
		Garlic	0.0015	0.08	112.00	41.00
		Sub-Total	0.0100	0.48	472.00	239.75
Pasture	D)	Grasses*	0.025	1.00	100.00	73.33
Horticulture	E)	Fruit tree	No.	Fruit yield (q)	Gross return (Rs)	Net return (Rs)
		Mango	3.50	0.50	500.00	458.00
		Kinnow	1.00	0.15	150.00	138.00
		Walnut (nb)	0.33	-	-	-
		Sub-Total	4.83	0.65	650.00	596.00
Total (A+B+C+D+E)				**51.86**	**13948.00**	**6447.13**

Appendix VI Average biological yield and economic return from ASH system in marginal category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	0.257	3.91	2733.00	1560.88
		W/straw	-	3.91	782.00	
		Maize	0.24	4.50	2250.00	1813.48
		M/straw	-	22.50	2250.00	
		Sub-Total	0.497	34.82	8015.00	3374.36
	B)	**Vegetables**				
		Colocassia	0.008	0.50	500	288.25
Pasture	**C)**	**Grasses**	0.038	2.50	250.00	192.06

Forest	D)	Tree	No.	LF	FW	LF	FW	LF	FW
		L leucocephala	4.86	0.48	0.63	48.00	78.75	23.70	54.45
		M alba	2.43	0.19	0.29	19.00	36.25	4.42	21.67
		G optiva	7.00	0.90	1.38	90.00	172.50	42.00	124.50
		B variegata	1.43	0.21	0.35	21.00	43.75	9.56	32.31
		D sissoo	0.71	-	0.17	-	21.25	-	15.57
		Dendrocalamus sp.	0.71	0.71	-	71.00	-	42.60	-
		A catechu	0.71	0.04	0.06	4.00	7.50	0.45	3.95
		M azedarach	0.71	-	0.10	-	12.50	-	6.82
		Eucalyptus sp.	0.71	-	0.08	-	10.00	-	4.32
		A lebbeck	1.51	0.22	0.37	22.00	46.25	12.94	37.19
		T. tomentosa	0.29	0.14	0.21	14.00	26.25	11.68	23.93
		T ciliata	0.29	-	0.10	-	12.50	-	10.18
		F palmata	0.14	0.01	0.01	1.00	1.25	0.16	0.41
		Populus sp.	0.14	-	0.01	-	1.25	-	0.69
		P roxburghii	0.14	-	0.02	-	2.50	-	1.38
		Sub-Total	20.78	2.90	3.78	290.00	472.50	147.51	337.37

Horticulture	E)	Fruit tree	No.	Fruit yield (q)	Gross return (Rs)	Net return (Rs)
		Mango	4.86	1.0	1000.00	941.68
		Guava	0.71	0.10	30.00	27.16
		Kinnow	0.29	0.06	60.00	56.52
		Plum	0.29	0.02	8.00	6.26
		Lemon	0.43	0.06	6.00	6.00
		Sub-Total	6.58	1.24	1121	1048.34

Total (A+B+C+D+E)	**45.74**	**10631.50**	**5377.17**

Appendix VII Average biological yield and economic return from AHS system in marginal category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	0.24	2.78	1942.50	498.57
		W/straw		2.78	556.00	
		Maize	0.24	3.18	1590.00	1137.48
		M/straw	-	15.9	1590.00	
		Sub-Total	0.48	24.64	5678.50	1636.05
Pasture	**B)**	**Grasses***	0.012	1.50	150.00	134.40
Horticulture	**C)**	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Banana	2.0	0.02	24.00	20.00
		Lemon	1.0	0.30	30.00	30.00
		Walnut (nb)	1.0	-	-	-
		Mango	1.5	0.60	720.00	708.00
		Guava	0.5	0.10	30.00	28.00
		Sub-Total	6	1.02	804.00	786.00

Forest	D)	Trees	No.	LF	FW	LF	FW	LF	FW
		Eucalyptus sp. sp.	2.0	-	0.24	-	30.00	-	14.00
		T ciliata	0.5	-	0.18	-	22.50	-	18.50
		Sub-Total	2.5	-	0.42	-	52.5	-	32.5

Total (A+B+C+D)	**27.58**	**6685.00**	**2588.95**

Appendix VIII Average biological yield and economic return from PS system in marginal category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.316	12.63		2526.00		1853.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A lebbeck	1.86	0.28	0.46	28.00	57.50	16.84	46.34
		B variegata	1.77	0.26	0.44	26.00	55.00	11.84	40.84
		G optiva	1.68	0.25	0.38	25.00	47.50	11.56	34.06
		D sissoo	4.68	-	1.17	-	146.25	-	108.81
		A catechu	9.18	0.55	0.83	55.00	103.75	9.10	57.85
		Eucalyptus sp.	1.63	-	0.20	-	25.00	-	11.96
		L leucocephala	0.95	0.09	0.12	9.00	15.00	3.96	11.96
		M alba	0.45	0.03	0.05	3.00	6.25	0.75	4.00
		P roxburghii	3.14	-	0.56	-	70.00	-	44.84
		M philippinensis	1.86	-	0.23	-	28.75	-	13.87
		T ciliata	0.05	-	0.01	-	1.25	-	0.85
		S cumini	0.32	-	0.08	-	10.00	-	7.44
		Salix	0.18	-	0.04	-	5.00	-	3.56
		E. officinalis	0.14	-	0.02	-	2.5	-	1.38
		Dendrocalamus sp.	0.14	0.14	0	14.00	-	8.40	-
		B. cieba	0.32	-	0.04	-	5.00	-	2.44
		W. exserta	0.86	-	0.04	-	5.00	-	1.56
		M azedarach	0.05	-	0.01	-	1.25	-	0.85
		Sub-Total	**29.26**	**1.6**	**4.68**	**160.00**	**585.00**	**62.45**	**392.61**
Total (A+B)				**18.91**		**3271.00**		**2308.06**	

Appendix IX Average biological yield and economic return from PSH system in marginal category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.60	23.00		4600.00		3396.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	50.0	3.0	4.50	300.00	562.50	50.00	312.50
		G optiva	30.	4.5	6.90	450.00	862.50	210.00	622.50
		D sissoo	50.0	-	12.50	-	1562.50	-	1162.50
		M azedarach	3.0	-	0.45	-	56.25	-	32.35
		Dendrocalamus sp.	0.5	0.5	-	50.00	-	10.00	-
		M philippinensis	3.5	-	0.44	-	55.00	-	27.00
		T ciliata	12.5	-	4.50	-	562.50	-	462.50
		L leucocephala	7.5	0.75	0.97	75.00	121.25	37.50	83.75
		F palmata	7.5	0.60	0.90	60.00	112.50	15.00	67.50
		B variegata	20.0	3.00	7.50	300.00	937.50	140.00	777.50
		M alba	1.0	0.08	0.12	8.00	15.00	2.00	9.00
		S cumini	1.5	-	0.37	-	46.25	-	34.25
		P roxburghii	2.0	-	0.36	-	45.00	-	29.00
		Sub-Total	189	12.43	39.51	1243	4938.75	464.5	3620.35
Horticulture	**C)**	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango (grafted)	3.5	0.60		600.00		558.00	
		Mango (local)	1.0	0.80		160.00		160.00	
		Guava	1.0	0.10		30.00		26.00	
		Lime	1.0	0.05		45.00		33.00	
		Sub-Total	6.5	1.55		835.00		777.00	
Total (A+B+C)				**76.49**		**11616.75**		**8257.85**	

Appendix X Average biological yield and economic return from AS system in small category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.52	9.25	6475.00	4691.81
		W/straw	-	9.25	1850.00	
		Maize	0.52	9.38	4690.00	4500.00
		M/straw	-	46.90	4690.00	
		Sub-Total	1.04	74.78	17705.00	9191.81
	B)	**Vegetables**				
		Colocassia	0.003	0.20	200.00	100.00
		Onion	0.001	0.15	75.00	33.50
		Garlic	0.001	0.08	112.00	45.00
		Bhindi	0.0025	0.16	96.00	38.00
		Potato	0.0025	0.25	75.00	8.00
		Sub-Total	0.0100	0.84	558.00	224.50
Pasture	C)	**Grasses***	0.060	4.50	450.00	349.00

Forest	D)	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		M alba	4.0	0.32	0.48	32.00	60.00	8.00	36.00
		D sissoo	2.5	-	0.62	-	77.50	-	57.50
		G optiva	2.0	0.30	0.46	30.00	57.50	14.00	41.50
		L leucocephala	5.75	0.57	0.74	57.00	92.50	28.25	63.75
		B variegata	0.25	0.03	0.06	3.00	7.50	1.00	5.50
		T ciliata	3.0	-	1.08		135.00	-	11.00
		F palmata	0.5	0.04	0.06	4.00	7.50	1.00	4.50
		Sub-Total	18	1.26	3.50	126.00	437.50	52.25	219.75

Total (A+B+C+D)	**84.88**	**19276.50**	**10037.31**

Appendix XI Average biological yield and economic return from AH system in small category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	0.44	9.00	6300.00	4719.00
		W/straw	-	9.00	1800.00	
		Maize	0.48	12.00	6000.00	7429.00
		M/straw	-	60.00	6000.00	
		Sub-Total	0.92	90	20100.00	12148.00
	B)	**Oil seeds**				
		Mustard	0.08	0.44	1100.00	589.00
	C)	**Vegetables**				
		Colocassia	0.028	0.80	800.00	422.00
		Onion	0.002	0.25	125.00	25.00
		Garlic	0.002	0.14	196.00	77.00
		Ginger	0.004	0.20	240.00	108.00
		Chilli	0.004	0.10	100.00	12.00
		Bhindi	0.002	0.15	90.00	30.00
		Brinjal	0.002	0.18	108.00	58.00
		Turmeric	0.004	0.25	250.00	105.00
		Sub-Total	0.048	2.07	1909.00	837.00
Pasture	**D)**	**Grasses***	0.048	3.00	300.00	220.00
Horticulture	**E)**	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango (grafted)	5	2.00	2400.00	2340.00
		Mango (local)	2	3.00	600.00	520.00
		Guava	1	0.14	42.00	38.00
		Sub-Total	8	5.14	3042.00	2898.00
Total (A+B+C+D+E)				**100.65**	**26451.00**	**16692.00**

Appendix XII Average biological yield and economic return from ASH system in small category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.68	12.375	8662.50	6253.38
		W/straw	-	12.375	2475.00	
		Maize	0.70	12.91	6455.00	6160.46
		M/straw	-	64.55	6455.00	
		Sub-Total	1.38	102.21	24047.5	12413.84
	B)					
		Oil seeds and pulses				
		Taramira	0.0100	0.04	72.00	22.00
		Gram	0.0100	0.07	126.00	42.00
		Sub-total	0.0200	0.11	198.00	64.00
	C)	**Vegetables**				
		Colocassia	0.0020	0.17	170.00	85.00
		Onion	0.0015	0.13	65.00	15.00
		Garlic	0.0010	0.18	252.00	98.00
		Bhindi	0.0025	0.15	90.00	30.00
		Sub-Total	0.0070	0.63	577.00	228.00
Pasture	D)	**Grasses***	0.084	5.50	550.00	325.00

Forest	E)	Trees	No.	LF	FW	LF	FW	LF	FW
		G optiva	4.75	0.71	0.97	71.00	121.25	33.00	83.50
		M alba	2.25	0.18	0.27	18.00	33.75	4.50	20.25
		D sissoo	2.00	-	0.50	-	62.50	-	46.50
		Eucalyptus sp.	1.25	-	0.15	-	18.75	-	8.75
		Dendrocalamus sp.	1.00	1.00	0	100.00	-	60.00	-
		L leucocephala	1.00	0.10	0.13	10.00	16.25	5.00	11.25
		A lebbeck	6.00	0.90	1.50	90.00	187.50	54.00	151.50
		T ciliata	2.50	-	0.90	-	112.50	-	92.50
		A catechu	2.00	0.12	0.18	12.00	22.50	2.00	12.50
		Sub-Total	22.75	3.01	4.6	301.00	575.00	158.50	426.75

Horticulture	F)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Papaya	0.50	0.10	40.00	40.00
		Guava	0.75	0.15	45.00	42.00
		Mango (grafted)	4.50	1.80	1800.00	1746.00
		Mango (local)	1.00	1.50	300.00	300.00
		Lemon	1.00	0.25	25.00	25.00
		Kinnow	1.00	0.12	120.00	108.00
		Lime	1.00	0.10	90.00	78.00
		Sub-Total	9.75	4.02	2420.00	2339.00
Total	**(A+B+C+D+E+F)**			**120.08**	**28668.50**	**15955.59**

Appendix XIII Average biological yield and economic return from PS system in small category of farmers in altitudinal zone I

Component	Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A) Grasses**	0..713	30.58		6116.00		4839.76	
Forest	**B) Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
	D sissoo	11.00	-	2.75	-	343.75	-	252.00
	A catechu	29.67	1.78	2.67	178.00	333.75	29.65	185.40
	P roxburghii	8.67	-	2.16	-	270.00	-	200.64
	B variegata	4.33	0.64	1.08	64.00	135.00	29.34	100.36
	A lebbeck	4.17	0.62	1.04	62.00	130.00	36.98	104.98
	G optiva	4.00	0.60	0.92	60.00	115.00	28.00	87.00
	Dendrocalamus sp.	0.50	0.50	0	50.00	0	30.00	-
	W. exserta	3.00	-	0.15	-	18.75	-	6.75
	L leucocephala	3.33	0.33	0.43	33.00	53.75	16.35	37.10
	M azedarach	0.67	-	0.10	-	12.50	-	7.14
	Eucalyptus sp.	1.17	-	0.14	-	17.50	-	8.14
	B. cieba	0.50	-	0.07	-	8.75	-	4.75
	M philippinensis	1.00	-	0.12	-	15.00	-	7.00
	E. officinalis	0.17	-	0.02	-	2.50	-	1.14
	T ciliata	0.67	-	0.24	-	30.00	-	24.64
	M alba	0.33	0.026	0.039	2.60	4.87	0.62	2.89
	F palmate	0.33	0.026	0.039	2.60	4.87	0.62	2.89
	Sub-Total	73.51	4.522	11.968	452.20	1495.99	171.56	1032.82
Total (A+B)			**47.07**		**8064.19**		**6044.14**	

Appendix XIV Average biological yield and economic return from PSH system in small category of farmers in altitudinal zone I

Component	Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	A) Grasses	0.40	15.00		3000.00		2280.00	
Forest	B) Trees	No.	LF	FW	LF	FW	LF	FW
	D sissoo	6.0	-	1.50	-	187.50	-	139.50
	G optiva	15.0	2.25	3.45	225.0	431.25	105.00	311.25
	A lebbeck	30.0	4.45	7.50	445.0	937.50	265.00	757.50
	T ciliata	15.0	-	5.4	-	675.0	-	555.00
	Dendrocalamus sp.	1.0	1.00	0	100.0	-	60.00	-
	M azedarach	6.0	-	0.90	-	112.50	-	64.50
	L leucocephala	12.0	1.20	1.50	120.0	187.50	60.00	127.50
	B variegata	1.0	0.15	0.25	15.0	31.25	7.00	23.25
	M alba	28.0	2.24	3.36	224.0	420.00	56.00	252.00
	A catechu	2.0	0.12	0.18	12.0	22.50	2.00	12.50
	W. exserta	2.0	-	0.12	-	15.00	-	7.50
	P roxburghii	1.0	-	0.18	-	22.50	-	14.50
	Sub-Total	119	11.41	24.34	1141	3042.50	555.00	2265.00

Horticulture C)	Fruit tree	No.	Fruit yield	Gross return	Net return
	Lemon	4.0	0.80	80.00	80.00
	Peach	3.0	0.60	180.00	168.00
	Kinnow	1.0	0.10	100.00	88.00
	Pear	1.0	0.15	52.50	48.50
	Mango (local)	1.0	1.00	200.00	200.00
	Sub-Total	10	2.65	612.50	584.50

Total (A+B+C)	**53.40**	**7796.00**	**5684.50**

Appendix XV Average biological yield and economic return from ASH system in medium category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	Food grains				
		Wheat	1.08	12.5	8750.00	4530.77
		W/straw	-	12.50	2500.00	
		Maize	1.08	12.13	6065	4249.00
		M/straw	-	60.65	6065.00	
		Paddy	0.08	1.00	700.00	220.00
		P/straw	-	1.50	150.00	
		Sub-Total	2.24	100.28	24230.00	8999.77
	B)	**Oil seeds and pulses**				
		Mustard	0.08	0.40	1000.00	489.00
		Taramira	0.04	016	288.00	88.00
		Gram	0.04	0.30	540.00	212.00
		Sub-Total	**0.16**	**0.86**	**1828.00**	**789.00**
	C)	**Vegetables**				
		Colocassia	0.08	4.50	4500.00	2570.50
		Turmeric	0.004	0.25	250.00	105.00
		Bhindi	0.004	0.26	156.00	98.00
		Onion	0.004	0.40	200.00	64.00
		Garlic	0.004	0.25	350.00	136.00
		Sub-Total	0.096	5.66	5456.00	2973.50
Pasture	**D)**	**Grasses***	0.08	6.50	650.00	475.00

Forest	E)	Trees	No.	LF	FW	LF	FW	LF	FW
		G optiva	12.0	1.80	3.45	180.00	431.25	84.00	335.25
		A lebbeck	5.5	0.82	1.37	82.00	171.25	54.50	143.75
		B. variegata	5.0	0.75	1.25	75.00	156.25	35.00	116.25
		A catechu	20.5	1.23	1.84	123.00	230.00	20.50	127.50
		L leucocephala	4.5	0.45	0.58	45.00	72.50	22.50	50.00
		P roxburghii	6.0	-	1.08	-	135.00	-	87.00
		D sissoo	9.0	-	2.25	-	281.25	-	209.25
		Sub-Total	62.5	5.05	11.82	505.00	1477.50	216.50	1069

Horticulture	F)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Mango (grafted)	8.0	2.40	2400.00	2304.00
		Mango (grafted)(nb)	2.0	-	-	-
		Mango (local)	1.0	1.0	200.00	200.00
		Sub-Total	11	3.4	2600	2504

Total (A+B+C+D+E+F)	**133.57**	**36746.50**	**17026.77**

Appendix XVI Average biological yield and economic return from PS system in medium category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	A)	Grasses	1.60	52.00		10400.00		8144.00	
Forest	B)	Trees	No.	LF	FW	LF	FW	LF	FW
		D sissoo	16.0	-	4.00	-	500.00	-	372.00
		A catechu	580.0	34.80	52.20	3480.00	6525.00	580.00	3625.00
		T ciliata	12.0	-	4.32	-	540.00	-	444.00
		L leucocephala	48.0	4.80	6.24	480	780.00	240.00	540.00
		Eucalyptus sp.	9.0	-	1.08	-	135.00	-	63.00
		B variegata	1.0	0.15	0.25	15.00	31.25	7.00	17.00
		T tomentosa	3.0	1.50	2.25	150.00	281.25	126.00	257.25
		Sub-Total	669	41.25	70.34	4125.00	8792.5	953.00	5318.25
Total (A+B)				**163.59**		**23317.50**		**14415.25**	

Appendix XVII Average biological yield and economic return from PSH system in medium category of farmers in altitudinal zone

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	1.20	36.00		7200.00		5472.00	
Forest	**B)**	**Trees**	No.	LF	FW	LF	FW	LF	FW
		A catechu	280	16.80	25.20	1680.00	3150	280.00	1750.00
		D sissoo	85	-	21.25	-	2656.25	-	1976.25
		Dendrocalamus sp.	15	15.0	-	1500.00	-	900.00	-
		B variegata	22	3.30	5.50	330.00	687.50	154.00	511.50
		A lebbeck	4	0.60	1.00	60.00	125.00	36.00	121.00
		T ciliata	5	-	1.80	-	225.00	-	185.00
		P roxburghii	6	-	1.08	-	135.00	-	87.00
		G optiva	13	1.95	2.99	195.00	373.75	91.00	269.75
		T tomentosa	2	1.0	1.50	100.00	187.50	68.00	155.50
		Sub-Total	432	38.65	60.32	3865.00	7540.00	1529.00	5056.00
Horticulture	**C)**	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango (grafted)	4	0.60		600.00		552.00	
		Mango (local)	1	1.50		300.00		300.00	
		Sub-Total	5	2.10		900.00		852.00	
Total (A+B+C)				**137.07**		**19505.00**		**12909.00**	

Appendix XVIII Average biological yield and economic return from PHS system in medium category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Pasture	**A)**	**Grasses**	1.20	36.00	7200.00	5551.00
Horticulture	**B)**	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango (grafted)	50	10.00	10000.00	9400.00
		Mango (grafted)(nb)	100	-	-	-
		Lime	12	0.72	648.00	504.00
		Kinnow	3	0.30	300.00	264.00
		Sub-Total	165	11.02	10948.00	10168.00

Forest	C)	Trees	No.	LF	FW	LF	FW	LF	FW
		B variegata	45	6.75	11.25	675.00	1406.25	315.00	1100.25
		A lebbeck	28	4.20	7.00	420.00	875.00	280.00	735.00
		G optiva	15	2.25	3.45	225.00	431.25	105.00	311.25
		M alba	12	0.96	1.44	96.00	180.00	24.00	108.00
		Dendrocalamus sp.	4	4.00	0	400.00	-	240.00	-
		E. officinalis	1	-	0.16	-	20.00	-	12.00
		D sissoo	1	-	0.25	-	31.25	-	23.25
		Sub-Total	106	18.16	23.55	1816	2943.75	964	2289.75

Total (A+B+C)	**88.73**	**22907.75**	**18972.75**

Appendix XIX Average biological yield and economic return from AS system in medium category of farmers in altitudinal zone I

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	1.44	17.00	11900.00	6694.78
		W/straw	-	17.00	3400.00	
		Maize	1.44	17.50	8750.00	5072.67
		M/straw	-	87.50	8750.00	
		Sub-Total	2.88	139.00	32800.00	11767.45
	B)	**Oil seeds**				
		Mustard	0.08	0.39	975.00	464.00
	C)	**Vegetables**				
		Colocassia	0.08	4.0	4000.00	2170.00
		Onion	0.004	0.50	250.00	60.50
		Garlic	0.004	0.25	350.00	134.50
		Bhindi	0.004	0.20	120.00	58.00
		Turmeric	0.004	0.25	250.00	105.00
		Sub-Total	0.096	5.20	4970.00	2528.00
Pasture	**D)**	**Grasses***	0.16	8.50	850.00	652.00

Forest	**E)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		D sissoo	6.0		1.50	-	187.50	-	139.50
		G optiva	5.0	0.75	1.15	75.00	143.75	35.00	103.75
		T ciliata	3.0	-	1.08	-	135.00	-	111.00
		Sub-Total	14	0.75	3.73	75.00	466.25	35.00	354.25

Total (A+B+C+D+E)	**157.57**	**40136.25**	**15800.7**

Appendix XX Average biological yield and economic return from PS system in marginal category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.250	11.46		2292.00		1765.50	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	14.06	0.84	1.26	84.00	157.50	13.70	86.70
		T ciliata	1.13	-	0.40	-	50.00	-	40.96
		W. exserta	1.40	-	0.07	-	8.75	-	3.15
		M azedarach	1.13	-	0.16	-	20.00	-	10.96
		G optiva	1.13	0.25	0.28	25.00	35.00	15.96	25.96
		P pashia	0.13	-	0.02	-	2.50	-	1.46
		A lebbeck	3.46	0.51	0.86	51.00	107.50	30.24	86.74
		Eucalyptus sp. sp.	0.4	-	0.40	-	50.00	-	1.80
		B cieba	3.33	-	0.49	-	61.25	-	34.61
		D sissoo	1.26	-	0.31	-	38.75	-	28.67
		F palmata	0.53	0.04	0.06	4.00	7.50	0.82	4.32
		A chinensis	1.86	0.24	0.42	24.00	52.50	9.12	37.62
		B variegata	1.60	0.24	0.40	24.00	50.00	11.20	37.20
		Dendrocalamus sp.	0.20	0.20	-	20.00	-	12.00	-
		L leucocephala	0.66	0.06	0.08	6.00	10.00	2.70	6.70
		Sub-Total	32.28	2.38	5.21	238	651.25	95.74	406.85
Total (A+B)				**19.05**		**3181.25**		**2268.09**	

Appendix XXI Average biological yield and economic return from AS system in marginal category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	0.264	4.36	3052.00	1894.38
		W/straw	-	4.36	872.00	
		Maize	0.26	6.22	3110.00	4010.50
		M/straw	-	31.10	3110.00	
		Sub-Total	0.524	46.04	10144.00	5904.88
	B)	**Oil seeds**				
		Mustard	0.026	0.10	250.00	157.50
	C)	**Vegetables**				
		Ginger	0.0150	0.60	720.00	215.00
		Onion	0.0022	0.18	90.00	32.50
		Garlic	0.0022	0.12	168.00	108.50
		Tomato	0.0150	1.11	555.00	258.50
		Sub-Total	0.0344	2.01	1533.00	614.50
Pasture	**D)**	**Grasses***	0.015	1.50	150.00	120.00

Forest	E)	Trees	No.	LF	FW	LF	FW	LF	FW
		T ciliata	5.33	-	1.38	0	172.50	0	129.86
		G optiva	6.88	1.03	1.58	103	197.50	47.96	142.46
		M alba	1.22	0.09	0.14	9.00	17.50	1.68	10.18
		L leucocephala	1.33	0.13	0.17	13.00	21.25	6.35	14.60
		B ceiba	1.22	-	0.18	-	22.50	0	12.74
		B variegata	0.66	0.09	0.16	9.00	20.00	3.72	14.72
		Populus sp.	0.33	-	0.02	0	2.50	-	1.18
		Eucalyptus sp. sp.	0.11	-	0.01	-	1.25	-	0.37
		Dendrocalamus sp.	0.22	0.22	-	22	-	13.20	-
		F roxburghii	0.22	0.02	0.03	2.00	3.75	0.68	2.43
		A lebbeck	1.33	0.19	0.33	19.00	41.25	11.02	33.27
		Sub-Total	18.85	1.77	4	177	500	84.61	361.81

Total (A+B+C+D+E)	**55.42**	**12754.00**	**7243.30**

Appendix XXII Average biological yield and economic return from AH system in marginal category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.20	1.83	1281.00	256.33
		W/straw	-	1.83	366.00	
		Maize	0.20	4.33	2165.00	1705.48
		M/straw	-	21.65	2165.00	
		Sub-Total	0.4	29.64	5977	1961.81
	B)	**Oil seeds**				
		Mustard	0.12	0.48	1200.00	576.50
	C)	**Vegetables**				
		Colocassia	0.04	1.40	1400.00	660.00
		Ginger	0.08	4.50	5400.00	1840.00
		Sub-Total	0.12	5.9	6800	2500
Pasture	E)	**Grasses***	0.01	0.80	80.00	60.00
Horticulture	F)	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango (grafted)	9.33	3.73	3730.00	3618.00
		Mango (nb)	3.33	-	-	-
		Litchi	0.66	0.13	195.00	187.08
		Lemon	0.66	0.10	10.00	10.00
		Guava	1.00	0.15	45.00	41.00
		Kinnow	1.00	0.08	80.00	68.00
		Sub-Total	15.98	4.19	4060.00	3924.08
Total (A+B+C+D+E+F)				**41.01**	**18117.00**	**9022.39**

Appendix XXIII Average biological yield and economic return from AHS system in marginal category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture		**Food grains**				
A)						
		Wheat	0.235	4.21	2947.00	1771.38
		W/straw	-	4.21	842.00	
		Maize	0.22	4.75	2375.00	2686.20
		M/straw	-	23.75	2375.00	
		Paddy	0.02	0.50	350.00	110.00
		P/straw	-	0.75	75.00	
		Sub-Total		38.17	8964.00	4567.58
	B)	**Oil seeds**				
		Mustard	0.028	0.10	250.00	88.25
	C)	Vegetables				
		Colocassia	0.03	2.00	2000.00	1155.50
		Ginger	0.01	0.60	720.00	310.00
		Tomato	0.005	1.00	500.00	210.00
		Pea	0.01	0.40	280.00	174.50
		Onion	0.011	0.57	285.00	98.50
		Garlic	0.001	0.08	112.00	48.00
		Sub-Total	0.067	4.65	3897.00	1996.50
Pasture	D)	Grasses*	0.0150	2.00	200.00	160.00
Horticulture	E)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Mango	8.00	2.00	2000.00	1904.00
		Lime	0.5	0.05	45.00	39.00
		Guava	0.5	0.10	30.00	28.00
		Sub-Total	9	2.15	2075.00	1971.00

Forest	F)	Trees	No.	LF	FW	LF	FW	LF	FW
		T ciliata	2.5	-	0.90	-	112.50	-	92.50
		G optiva	3.0	0.45	0.69	45.00	86.25	21.00	62.25
		L leucocephala	3.0	0.30	0.39	30.00	48.75	15.00	33.75
		Sub-Total	8.5	0.75	1.98	75.00	247.5	36.00	188.50

Total (A+B+C+D+E+F)	**49.80**	**15708.50**	**9007.83**

Appendix XXIV Average biological yield and economic return from PSH system in marginal category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.32	14.66		2932.00		2508.97	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	20.33	1.21	1.82	121.00	227.50	19.35	125.85
		Populus sp.	0.50	-	0.03	-	3.75	-	1.75
		B cieba	3.16	-	0.47	-	58.75	-	33.47
		D sissoo	1.00	-	0.25	-	31.25	-	23.25
		A chinensis	4.66	0.60	1.07	60.00	133.75	22.72	96.47
		G optiva	3.16	0.47	0.72	47.00	90.00	21.72	64.72
		L leucocephala	7.33	0.73	0.95	73.00	118.75	36.35	82.10
		B variegata	2.00	0.30	0.50	30.00	62.50	14.00	46.50
		T ciliata	4.33	-	1.55	-	193.75	-	159.11
		A lebbeck	1.33	0.19	0.33	19.00	41.25	11.02	33.27
		Eucalyptus sp.	1.00	-	0.12	-	15.00	-	7.00
		A marmelos	1.66	-	0.13	-	16.25	-	2.97
		Sub-Total	50.46	3.5	7.94	350	992.5	125.16	676.46
Horticulture	C)	Fruit tree	No.	Fruit yield		Gross return		Net return	
		Mango	9	1.00		1000.00		892.00	
		Mango (nb)	11.66	-		-		-	
		Lime	0.66	0.06		54.00		46.08	
		Sub-Total	21.32	1.06		1054.00		938.08	
Total (A+B+C)				**27.16**		**5328.50**		**4248.67**	

Appendix XXV Average biological yield and economic return from ASH system in marginal category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	0.26	4.00	2800.00	1583.74
		W/straw	-	4.00	800.00	
		Maize	0.253	5.75	2875.00	3220.00
		M/straw	-	28.75	2875.00	
		Sub-Total	0.513	42.50	9350.00	4803.74
	B)	**Oil seeds**				
		Mustard	0.043	0.20	500.00	176.50
	C)	**Vegetables**				
		Colocassia	0.013	0.90	900.00	498.00
		Ginger	0.013	1.00	1200.00	422.00
		Tomato	0.006	1.33	665.00	362.25
		Cauliflower	0.006	1.00	500.00	357.00
		Bhindi	0.005	0.20	120.00	78.50
		Sub-Total	0.043	4.43	3385.00	1717.75
Pasture	**D)**	**Grasses***	0.020	3.00	300.00	250.00

Forest	E)	Trees	No.	LF	FW	LF	FW	LF	FW
		T ciliata	5.16	-	1.85	-	231.25	-	189.97
		B ceiba	2.83	-	0.42	-	52.50	-	29.86
		G optiva	14.16	2.12	3.25	212.00	406.25	98.72	292.97
		M alba	2.16	0.17	0.25	17.00	31.25	4.04	18.29
		L leucocephala	2.33	0.23	0.30	23.00	37.50	11.35	25.85
		B variegata	0.66	0.09	0.16	9.00	20.00	3.72	14.72
		Populus sp.	1.16	-	0.12	-	15.00	-	10.36
		Dendrocalamus sp.	0.16	0.16	-	16.00	-	9.60	-
		Eucalyptus sp.	1.33	-	0.15	-	18.75	-	8.11
		D sissoo	0.66	-	0.16	-	20.00	-	14.72
		Sub-Total	30.61	2.77	6.66	277	832.5	127.43	604.85

Horticulture	F)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Mango	6.00	1.80	1800.00	1728.00
		Guava	2.00	0.40	120.00	112.00
		Lemon	3.16	0.69	69.00	69.00
		Lime	0.33	0.03	27.00	23.04
		Sub-Total	11.49	2.92	2016	1932.04
Total (A+B+C+D+E+F)				**62.48**	**16660.50**	**9612.31**

Appendix XXVI Average biological yield and economic return from PSH system in small category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	A)	Grasses	0.64	32.66		6532.00		5108.00	
Forest	B)	Trees	No.	LF	FW	LF	FW	LF	FW
		T ciliata	8.00	-	2.88	-	360.00	-	296.00
		B. ceiba	10.00	-	1.50	-	187.50	-	107.50
		G optiva	12.33	1.84	2.83	184	353.75	85.36	255.11
		L leucocephala	4.00	0.40	0.52	40.00	65.00	20.00	35.00
		A lebbeck	2.00	0.30	0.50	30.00	62.50	20.00	52.50
		D sissoo	2.66	-	0.66	-	82.50	-	61.22
		A catechu	25.33	1.51	2.27	151.00	283.75	44.35	157.10
		P pashia	3.33	-	0.60	-	75.00	-	48.36
		W. exserta	3.33	-	0.16	-	20.00	-	6.68
		B variegata	3.33	0.49	0.83	49.00	103.75	22.36	77.11
		Populus sp.	1.33	-	0.10	-	12.50	-	7.18
		A chinensis	6.66	0.86	1.53	86.00	191.25	32.72	137.97
		F palmata	1.60	0.12	0.19	12.00	23.75	2.40	14.15
		Sub-Total	83.9	5.52	14.57	552.00	1821.25	227.19	1255.88
Horticulture	C)	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango	6.33	0.63		630.00		554.04	
		Mango (nb)	5.0	-		-		-	
		Guava	1.33	0.13		39.00		34.68	
		Lemon	0.66	0.10		10.00		10.00	
		Sub-Total	13.32	0.86		679.00		598.72	
Total (A+B+C)				**53.61**		**9584.25**		**7189.79**	

Appendix XXVII Average biological yield and economic return from AH system in small category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.268	4.00	2800.00	1526.88
		W/straw	-	4.00	800.00	
		Maize	0.208	5.00	2500.00	2829.50
		M/straw	-	25.00	2500.00	
		Sub-Total	0.476	38.00	8600.00	4356.38
	B)	**Oil seeds**				
		Mustard	0.010	0.07	175.00	60.50
	C)	**Vegetables**				
		Ginger	0.008	0.60	720.00	210.00
		Colocassia	0.048	2.20	2200.00	1225.25
		Tomato	0.012	2.80	1400.00	775.50
		Sub-Total	0.068	5.60	4320.00	2210.75
Pasture	**D)**	**Grasses***	**0.018**	**2.00**	**200.00**	**150.00**
Horticulture	**E)**	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango	9.20	4.60	4600.00	4489.60
		Litchi	0.80	0.20	300.00	290.40
		Guava	0.40	0.12	36.00	34.40
		Sub-Total	10.4	4.92	4936.00	4814.4
Total (A+B+C+D+E)				**50.59**	**18231.00**	**11592.03**

Appendix XXVIII Average biological yield and economic return from AHS system in small category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.88	15.50	10850.00	7173.69
		W/straw	-	15.50	3100.00	
		Maize	0.80	18.75	9375.00	12429.20
		M/straw	-	93.75	9375.00	
		Sub-Total	1.68	143.50	32700	19602.89
	B)	**Oil seeds and pulses**				
		Mustard	0.070	0.32	800.00	381.50
		Taramira	0.010	0.05	90.00	44.50
		Mash	0.040	0.25	450.00	110.00
		Sub-Total	0.120	0.62	1340.00	536.00
	C)	**Vegetables**				
		Ginger	0.08	4.00	4800.00	3012.50
		Tomato	0.050	5.00	2500.00	1342.75
		Cauliflower	0.020	2.00	1000.00	572.25
		Pea	0.020	0.60	420.00	200.00
		Chilli	0.006	0.12	120.00	30.00
		Brinjal	0.002	0.15	90.00	30.00
		Bhindi	0.002	0.18	108.00	58.00
		Turmeric	0.020	0.50	500.00	320.00
		Sub-Total	0.200	12.55	9538.00	5565.50
Horticulture	D)	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango	14.50	4.35	4350.00	4176.00
		Litchi	2.50	0.50	750.00	720.00
		Lemon	1.00	0.25	25.00	25.00
		Lime	0.75	0.06	54.00	45.00
		Papaya	1.00	0.22	88.00	88.00
		Guava	1.75	0.35	105.00	98.00
		Kinnow	0.50	0.05	50.00	44.00
		Sub-Total	22	5.78	5422	5196
Pasture	E)	**Grasses***	**0.030**	**5.00**	**500.00**	**425.00**

Forest	F)	Trees	No.	LF	FW	LF	FW	LF	FW
		T ciliata	6.75	-	2.43	-	303.75	-	249.75
		G optiva	4.00	0.60	0.92	60.00	115.00	28.00	83.00
		Dendrocalamus sp.	2.00	2.00	-	200.00	-	120.00	-
		M alba	2.00	0.16	0.24	16.00	30.00	4.00	18.00
		L leucocephala	3.00	0.30	0.39	30.00	48.75	15.00	33.75
		Eucalyptus sp.	1.25	-	0.15	-	18.75	-	8.75
		Sub-Total	19	3.06	4.13	306	516.25	167	393.25

Total (A+B+C+D+E+F)	**174.64**	**50322.25**	**31885.64**

Appendix XXIX Average biological yield and economic return from ASH system in small category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	0.352	6.20	4344.00	2844.77
		W/straw	-	6.20	1240.00	
		Maize	0.322	8.20	4100.00	5003.75
		M/straw	-	41.00	4100.00	
		Sub-Total	0.674	61.6	13784	7848.52
	B)	**Vegetables**				
		Colocassia	0.024	2.00	2000.00	1075.50
		Turmeric	0.004	0.10	100.00	42.25
		Onion	0.004	0.38	190.00	105.25
		Garlic	0.004	0.26	364.00	220.00
		Bhindi	0.004	0.16	96.00	42.00
		Chilli	0.006	0.12	120.00	30.00
		Sub-Total	0.046	3.02	2870.00	1515.00
Pasture	**C)**	**Grasses***	0.030	4.50	450.00	380.0

Forest	D)	Trees	No.	LF	FW	LF	FW	LF	FW
		G optiva	8.80	1.32	2.02	132.00	252.50	61.60	182.10
		M alba	3.60	0.28	0.43	28.00	53.75	6.40	32.15
		T ciliata	7.40	-	2.66	-	332.50	-	273.30
		A lebbeck	1.60	0.24	0.40	24.00	50.00	14.40	40.40
		Sub-Total	21.4	1.84	5.51	184	688.75	82.4	527.95

Horticulture	E)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Mango	9.60	1.15	1150.00	1034.80
		Mango (nb)	0.60	-	-	-
		Guava	0.80	0.20	60.00	56.80
		Sub-Total	11	1.35	1210.00	1091.60

Total (A+B+C+D+E)	**77.82**	**19186.75**	**11445.47**

Appendix XXX Average biological yield and economic return from PS system in small category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.53	25.00		5000.00		3960.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A chinensis	3.25	0.42	0.74	42.00	92.50	16.00	66.50
		T ciliata	6.12	-	2.20	-	275.00	-	152.54
		G optiva	7.00	1.05	1.61	105.00	201.25	49.00	145.25
		L leucocephala	4.75	0.47	0.61	47.00	76.25	23.25	52.50
		F palmate	1.75	0.14	0.21	14.00	26.25	3.50	15.75
		B variegata	2.62	0.39	0.65	39.00	81.25	18.04	60.29
		Dendrocalamus sp.	0.25	0.25	0	25.00	-	15.00	-
		B cieba	7.50	-	1.12	-	140.00	-	80.00
		D sissoo	4.87	-	1.21	-	151.25	-	112.29
		A catechu	57.50	3.45	5.17	345.00	646.25	58.75	360.00
		M alba	1.00	0.10	0.13	10.0	16.25	4.00	10.25
		A lebbeck	2.50	0.37	0.62	37.00	77.50	22.00	62.50
		M azedarach	1.62	-	0.24	-	30.00	-	17.04
		W. exserta	1.25	-	0.06	-	7.50	-	2.50
		Sub-Total	101.98	6.64	14.57	664	1821.25	209.54	1137.41
Total (A+B)				**46.21**		**7485.25**		**5306.95**	

Appendix XXXI Average biological yield and economic return from AS system in small category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.27	4.14	2898.00	1867.75
		W/straw	-	4.14	828.00	
		Maize	0.24	5.14	2570.00	2640.35
		M/straw	-	25.70	2570.00	
		Sub-Total	0.5	39.12	8866	4508.1
	B)	**Vegetables**				
		Colocassia	0.022	1.70	1700.00	892.50
		Ginger	0.022	1.42	1704.00	508.50
		Onion	0.007	0.36	180.00	48.50
		Garlic	0.007	0.17	238.00	168.00
		Sub-Total	0.058	3.65	3822	1617.5
Pasture	C)	**Grasses***	0.0350	2.50	250.00	215.00

Forest	D)	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		T ciliata	6.71	-	2.41	-	301.25	-	274.41
		B variegata	1.28	0.19	0.32	19.00	40.00	8.76	29.76
		G optiva	4.71	0.70	1.08	70.00	135.00	32.32	97.35
		B ceiba	3.85	-	0.57	-	71.25	-	40.45
		L leucocephala	1.70	0.17	0.22	17.00	27.50	8.50	19.30
		Eucalyptus sp.	0.57	-	0.06	-	7.50	-	2.94
		Populus sp.	0.57	-	0.04	-	5.00	-	2.75
		Sub-Total	19.39	1.06	4.7	106	587.5	49.58	466.96

Total (A+B+C+D)	**51.03**	**13631.50**	**6857.14**

Appendix XXXII Average biological yield and economic return from PSH system in medium category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.96	44.00		8800.00		6992.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	325.00	19.50	29.25	1950	3656.25	325.00	2031.25
		T ciliata	5.00	-	1.80	-	225.00	-	185.00
		G optiva	15.00	2.25	3.45	225	431.25	105.00	311.25
		B cieba	10.00	-	1.50	-	187.50	-	107.50
		Sub-Total	355	21.75	36	2175	4500	430	2635
Horticulture	**C)**	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango	20.00	2.00		2000.00		1760.00	
		Mango (nb)	30.00	-		-		-	
		Sub-Total	50	2		2000.00		1760.00	
Total (A+B+C)				**103.75**		**17475.00**		**11817.00**	

Appendix XXXIII Average biological yield and economic return from AH system in medium category of farmers in Altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	**A)**	**Food grains**				
		Wheat	1.04	11.50	8050.00	3648.55
		W/straw	-	11.50	2300.00	
		Maize	0.92	14.50	7250.00	5196.50
		M/straw	-	72.50	7250.00	
		Sub-Total	1.96	110.00	24850	8845.05
	B)	**Vegetables**				
		Ginger	0.08	4.00	4800.00	2595.00
Pasture	**C)**	**Grasses***	0.040	6.00	600.00	480.00
Horticulture	**D)**	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango	10	4.00	4000.00	3880.00
		Mango(nb)	10	-	-	-
		Lemon	3	0.45	45.00	45.00
		Guava	4	0.60	180.00	174.00
		Litchi	2	0.20	300.00	276.00
		Sub-Total	29	5.25	4525.00	4375.00
Total (A+B+C+D)				**125.25**	**34775.00**	**16295.05**

Appendix XXXIV Average biological yield and economic return from ASH system in medium category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.67	7.66	5362.00	1791.22
		W/straw	-	7.66	1532.00	
		Maize	0.72	15.66	7830.00	8296.55
		M/straw	-	78.30	7830.00	
		Sub-Total	1.39	109.28	22554.00	10087.77
	B)	**Oil seeds**				
		Mustard	0.16	0.65	1625.00	578.00
		Taramira	0.04	0.25	450.00	176.50
		Sub-Total	0.20	0.9	2075.00	754.5
	C)	**Vegetables**				
		Colocassia	0.1000	5.50	5500.00	2916.25
		Ginger	0.0300	1.70	2040.00	1078.50
		Tomato	0.0266	5.00	2500.00	1096.00
		Onion	0.0200	1.50	750.00	450.00
		Garlic	0.0200	0.80	1120.00	670.50
		Bhindi	0.0200	0.40	240.00	110.50
		Sub-Total	0.2166	14.9	12150.00	6321.75
Pasture	D)	**Grasses***	0.030	3.50	350.00	310.00

Forest	E)	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		G optiva	20.00	3.0	4.60	300.00	575.00	140.00	415.00
		M alba	10.66	0.85	1.27	85.00	158.75	21.04	94.79
		T ciliata	8.33	-	2.99	-	373.75	-	307.11
		L leucocephala	4.00	0.40	0.52	40.00	65.00	20.00	35.00
		Eucalyptus sp.	3.00	-	0.36	-	45.00	-	21.00
		Salix sp.	1.66	-	0.39	-	48.75	-	35.47
		Sub-Total	47.65	4.25	10.13	425.00	1266.25	181.04	908.37

Horticulture	F)	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango	11.66	3.50	3500.00	3360.08
		Litchi	3.33	0.66	960.00	920.04
		Lemon	3.66	0.73	73.00	73.00
		Lime	1.33	0.10	90.00	74.04
		Guava	1.00	0.12	36.00	32.00
		Papaya	1.33	0.26	104.00	104.00
		Sub-Total	22.31	5.37	4763	4563.16
Total (A+B+C+D+E+F)				**148.33**	**43583.25**	**23126.59**

Appendix XXXV Average biological yield and economic return from AS system in medium category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	Food grains				
		Wheat	0.68	13.50	9450.00	7003.00
		W/straw	-	13.50	2700.00	
		Maize	0.66	15.50	7750.00	8300.00
		M/straw	-	77.50	7750.00	
		Paddy	0.12	2.00	1400.00	380.00
		P/straw	-	3.00	300.00	
		Sub-Total	1.46	1250	29350	15683.00
	B)	Oil seeds				
		Mustard	0.12	0.50	1250.00	545.50
		Taramira	0.04	0.12	216.50	48.00
		Sub-Total	0.16	0.62	1466.50	593.5
	C)	**Vegetables**				
		Pea	0.060	1.50	1050.00	715.25
		Ginger	0.040	2.20	2640.00	1110.00
		Onion	0.001	0.08	40.00	10.00
		Garlic	0.001	0.05	70.00	35.00
		Bhindi	0.002	0.10	60.00	30.00
		Colocassia	0.080	3.80	3800.00	2365.00
		Sub-Total	0.184	7.73	7810.00	4265.25
Pasture	**D)**	**Grasses***	0.0450	7.50	750.00	630.00

Forest	**E)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		T ciliata	8.00	-	2.88	-	360.00	-	296.00
		G optiva	12.50	1.87	2.87	187.00	358.75	87.00	258.75
		M alba	9.00	0.72	1.08	72.00	135.00	18.00	81.00
		L leucocephala	7.55	0.75	0.975	75.00	121.25	37.50	83.75
		Sub-Total	37.05	3.34	7.805	334	975	142.5	719.5

Total (A+B+C+D+E)	**151.995**	**40535.50**	**22033.25**

Appendix XXXVI Average biological yield and economic return from PS system in medium category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	1.32	59.00		11800.00		9479.50	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	126.66	7.59	11.39	759.00	1423.75	125.70	790.42
		A lebbeck	20.66	3.09	5.16	309.00	645.00	185.04	521.04
		B variegata	9.66	1.44	2.41	144.00	301.25	66.72	223.97
		G optiva	18.33	2.74	4.21	274.00	526.25	127.36	379.61
		Dendrocalamus sp.	1.00	1.00	-	100.00	-	60.00	-
		A chinensis	6.00	0.78	1.38	78.00	172.50	30.00	124.50
		Populus sp.	2.00	-	0.15	-	18.75	-	10.75
		Eucalyptus sp.	1.00	-	0.12	-	15.00	-	7.00
		D sissoo	1.25	-	0.31	-	38.75	-	28.75
		T ciliata	5.33	-	1.91	-	238.75	-	196.11
		W. exserta	8.33	-	0.41	-	51.25	-	17.93
		Sub-Total	200.22	16.64	27.45	1664	3431.25	594.82	2300.08
Total (A+B)				**103.09**		**16895.25**		**12374.40**	

Appendix XXXVII Average biological yield and economic return from ASH system in large category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Agriculture	**A)**	**Food grains**							
		Wheat	0.72	10.00		7000.00		3515.22	
		W/straw	-	10.00		2000.00			
		Maize	0.80	15.00		7500.00		6428.00	
		M/straw	-	75.00		7500.00			
		Sub-Total	1.52	110.00		24000.00		9943.22	
	B)	**Oil seeds**							
		Mustard	0.08	0.38		950.00		439.00	
		Taramira	0.08	0.28		504.00		101.00	
		Sub-total	0.16	0.66		1454.00		540.00	
	C)	**Vegetables**							
		Ginger	0.0200	1.20		1440.00		530.00	
		Onion	0.0050	0.28		140.00		42.00	
		Garlic	0.0050	0.15		210.00		108.00	
		Colocassia	0.080	3.50		3500.00		2400.00	
		Bhindi	0.0050	0.20		120.00		70.00	
		Sub-Total	0.115	5.33		5410		3150	
Pasture	**D)**	**Grasses***	0.0450	7.50		750.00		630.00	
Forest	**E)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		G optiva	20.00	3.00	4.60	300.00	575.00	140.00	415.00
		T ciliata	10.00	-	3.60	-	450.00	-	370.00
		L leucocephala	15.00	1.50	1.95	150.00	243.75	75.00	168.75
		M alba	12.00	0.96	1.44	96.00	180.00	24.00	108.00
		B cieba	7.00	-	1.05	-	131.25	-	75.25
		Sub-Total	64	5.46	12.64	546	1580	239	1137
Horticulture	**F)**	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango	20.0	8.00		8000.00		7760.00	
		Lime	4.0	0.30		270.00		222.00	
		Pear	5.0	1.20		420.00		400.00	
		Guava	1.0	0.18		54.00		50.00	
		Sub-Total	30	9.68		8744.00		8432.00	
Total (A+B+C+D+E+F)				**151.27**		**42484.00**		**24071.22**	

Appendix XXXVIII Average biological yield and economic return from AH system in large category of farmers in Altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.80	11.00	7700.00	4282.44
		W/straw	-	22.00	4400.00	
		Maize	0.80	16.00	8000.00	7428.00
		M/straw	-	80.00	8000.00	
		Sub-Total	1.60	129	28100.00	11710.44
Pasture	B)	Grasses*	0.0500	6.50	650.00	538.00
Horticulture	C)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Mango	7	2.45	2450.00	2366.00
Total (A+B+C)				**137.95**	**31200.00**	**14614.44**

Appendix XXXIX Average biological yield and economic return from PSH system in large category of farmers in altitudinal zone II

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	3.84	140.00		28000.00		22500.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	340	20.40	30.60	2040.00	3825.00	340.00	2125.00
		T ciliata	25	-	9.00	-	1125.00	-	925.00
		D sissoo	22	-	5.50	-	687.50	-	511.50
		F palmata	8	0.64	0.96	64.00	120.00	16.00	72.00
		P pashia	15	-	2.70	-	337.50		217.50
		W. exserta	20	-	1.00	-	125.00	-	45.00
		B ceiba	18	-	2.70	-	337.50	-	193.50
		A lebbeck	25	3.75	6.25	375.00	781.25	225.00	631.25
		P. roxburghii	6	-	1.08	-	135.00	-	87.00
		G optiva	30	4.50	6.90	450.00	862.50	210.00	622.50
		L leucocephala	12	1.20	1.56	120.00	195.00	60.00	135.00
		M azedarach	15	-	2.25	-	281.25	-	161.25
		Eucalyptus sp.	2	-	0.24	-	30.00	-	14.00
		B variegata	14	2.10	3.50	210.00	437.50	98.00	325.50
		Sub-Total	552	32.59	74.24	3259	9280	949	6066
Horticulture	**C)**	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango	10.00	1.20		1200.00		880.00	
		Mango (nb)	10.00	-		-		-	
		Lime	5.00	0.30		270.00		210.00	
		Sub-Total	25	1.50		1470.00		1090.00	
Total (A+B+C)				**248.33**		**42009.00**		**30605.00**	

Appendix XL Average biological yield and economic return from PS system in marginal category of farmers in altitudinal zone III

Component	Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A) Grasses**	0.292	14.344		2868.80		2307.60	
Forest	**B) Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
	Phoenix sp.	4.70	-	0.14	-	17.50	-	12.8
	A chinensis	1.14	0.14	0.26	14.0	32.50	4.88	23.38
	Dendrocalamus sp.	0.11	0.11	-	11.00	-	6.60	-
	Olea sp.	2.33	-	0.27	-	33.75	-	15.11
	M azedarach	0.48	-	0.07	-	8.75	-	4.91
	G optiva	1.40	0.21	0.32	21.00	40.00	9.80	28.80
	P roxburghii	0.96	-	0.17	-	21.25	-	13.57
	A catechu	7.14	0.42	0.64	42.00	80.00	6.30	44.30
	M philippinensis	0.55	-	0.06	-	7.50	-	3.10
	T ciliata	0.33	-	0.11	-	13.75	-	11.11
	D sissoo	1.33	-	0.33	-	41.25	-	30.61
	W. exserta	0.52	-	0.026	-	3.25	-	1.17
	A lebbeck	0.74	0.11	0.18	11.00	22.5	6.56	18.06
	Sub-Total	21.73	0.99	2.576	99.00	322.00	34.14	206.92
Total (A+B)			**17.91**		**3289.80**		**2548.66**	

Appendix XLI Average biological yield and economic return from ASH system in marginal category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.140	0.963	674.10	-147.70
		W/straw	-	0.963	192.60	
		Maize	0.288	6.821	3410.50	2501.00
		M/straw	-	34.105	3410.50	
		Sub-Total	0.428	42.852	7687.70	2353.30
	B)	**Oil seeds and pulses**				
		Mustard	0.040	0.15	375.00	125.00
		Soybean	0.006	0.05	150.00	61.00
		Sub-Total	**0.046**	**0.20**	**525.00**	**186.00**
	C)	**Vegetables**				
		Colocassia	0.08	4.80	4800.00	2665.00
		Turmeric	0.002	0.08	80.00	38.50
		Bhindi	0.004	0.15	90.00	30.00
		Garlic	0.001	0.05	70.00	36.00
		Sub-Total	0.087	5.80	5120.00	2825.00
Pasture	D)	**Grasses***	0.069	4.00	400.00	248.00

Forest	E)	Trees	No.	LF	FW	LF	FW	LF	FW
		P roxburghii	1.50	-	0.27	-	33.75	-	21.75
		A chinensis	2.87	0.37	0.66	37.00	82.50	14.04	59.54
		Olea sp.	2.00	-	0.24	-	30.00	-	14.00
		F palmate	1.37	0.10	0.16	10.00	20.00	1.78	11.78
		B variegata	0.12	0.01	0.03	1.00	3.75	0.04	2.79
		M alba	0.75	0.06	0.09	6.00	11.25	1.50	6.75
		L leucocephala	1.75	0.17	0.22	17.00	27.50	8.25	19.00
		F roxburghii	0.50	0.04	0.06	4.00	7.50	1.00	4.50
		D sissoo	0.50	-	0.12	-	15.00	-	11.00
		G optiva	4.25	0.63	0.97	63.00	121.25	29.00	87.25
		Dendrocalamus sp.	0.25	0.25	-	25.00	-	15.00	-
		M azedarach	0.25	-	0.03	-	3.75	-	1.75
		Sub-Total	16.11	1.63	2.85	163	356.25	70.61	240.11

Horticulture	F)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Banana	1.50	0.015	18.00	15.00
		Lemon	1.00	0.35	35.00	35.00
		Mango (G)	1.25	0.25	250.00	235.00
		Mango (L)	0.62	0.75	150.00	150.00
		Guava	1.12	0.22	66.00	61.52
		Papaya	0.12	0.03	12.00	12.00
		Sub-Total	5.61	1.615	531.00	508.52
Total	**(A+B+C+D+E+F)**			**58.947**	**14702.95**	**6376.04**

Appendix XLII Average biological yield and economic return from AS system in marginal category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	Food grains				
		Wheat	0.141	1.27	889.00	92.23
		W/straw	-	1.27	254.00	
		Maize	0.246	5.647	2823.50	2572.50
		M/straw	-	28.235	2823.50	
		Sub-Total	0.387	36.422	6790.00	2664.73
	B)	Oil seeds				
		Mustard	0.020	0.07	175.00	65.00
	D)	Pulses				
		Mash	0.01	0.05	90.00	30.00
	E)	Vegetables				
		Colocassia	0.0030	0.22	220.00	112.50
		Onion	0.0010	0.08	40.00	10.00
		Garlic	0.0010	0.05	70.00	35.00
		Chilli	0.0023	0.04	40.00	2.00
		Sub-Total	0.0073	0.39	370.00	159.5
Pastures	F)	Grasses*	0.03	1.80	180.00	125.00

Forest	G)	Trees	No.	LF	FW	LF	FW	LF	FW
		A chinensis	1.36	0.17	0.31	17.00	38.75	6.12	27.12
		F palmate	2.45	0.19	0.29	19.00	36.25	4.30	21.55
		F roxburghii	0.86	0.06	0.10	6.00	12.50	0.84	7.09
		L leucocephala	3.77	0.37	0.49	37.00	61.25	18.15	42.40
		G optiva	4.27	0.64	0.98	64.00	122.50	29.84	88.04
		M azedarach	0.41	-	0.06	-	7.50	-	4.22
		Olea sp.	1.72	-	0.21	-	26.25	-	12.49
		M alba	2.04	0.16	0.24	16.00	30.00	3.76	17.76
		T ciliate	0.31	-	0.11	-	13.75	-	11.27
		B. cieba	0.09	-	0.01	-	1.25	-	0.53
		B variegata	0.72	0.10	0.18	10.00	22.50	4.24	16.74
		A catechu	0.54	0.03	0.04	3.00	5.00	0.30	2.30
		D sissoo	0.18	-	0.04	-	5.00	-	3.56
		Sub-Total	18.72	1.72	3.06	172	382.50	67.55	255.07

Total	(A+B+C+D+E+F+G)	43.512	8159.50	3366.85

Appendix XLIII Average biological yield and economic return from PS system in small category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.737	34.312		6862.40		5501.60	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	30.00	1.80	2.70	180	337.50	30.00	187.50
		Phoenix sp.	0.62	-	0.02	-	2.50	0	1.88
		Zizyphus sp.	1.75	0.03	0.26	3.00	32.50	-7.50	22.00
		G optiva	2.66	0.39	0.61	39.00	76.25	17.72	54.97
		M azedarach	0.14	-	0.02	-	2.50	-	1.38
		L leucocephala	0.38	0.03	0.04	3.00	5.00	1.10	3.10
		A lebbeck	1.62	0.24	0.40	24.00	50.00	14.28	40.28
		M alba	0.25	0.02	0.03	2.00	3.75	0.50	2.25
		B variegata	1.75	0.26	0.43	26.00	53.75	12.00	39.75
		Eucalyptus sp.	0.50	-	0.06	-	7.50	-	3.50
		T ciliata	1.50	-	0.54	-	67.50	-	55.50
		M philippinensis	1.37	-	0.17	-	21.25	-	10.20
		D sissoo	7.62	-	1.90	-	237.50	-	176.54
		W. exserta	2.00	-	0.10	-	12.50	-	4.50
		A. latifolia	1.87	0.24	0.43	24.00	53.75	9.04	38.79
		Dendrocalamus sp.	0.12	0.12	0	12.00	-	7.20	-
		P roxburghii	18.75	-	3.37	-	421.25	-	271.25
		Sub-Total	72.9	3.13	11.08	313.00	1385.00	84.34	913.39
Total (A+B)				**48.552**		**8560.40**		**6499.33**	

Appendix XLIV Average biological yield and economic return from PSH system in small category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	0.84	35.00		7000.00		5580.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		P roxburghii	16.50	-	2.97	-	371.25	-	239.25
		F roxburghii	1.00	0.08	0.12	8.00	15.00	4.00	11.00
		F palmate	1.00	0.08	0.12	8.00	15.00	4.00	11.00
		A catechu	16.00	0.96	1.44	96.00	180.00	16.00	100.00
		T ciliata	4.00	-	1.44	-	180.00	-	112.00
		Zizyphus sp.	5.00	0.10	0.75	10.00	93.75	-20.00	63.75
		M philippinensis	9.00	-	1.12	-	140.00	-	68.00
		A lebbeck	1.00	0.15	0.25	15.00	31.25	9.00	25.25
		Emblica	1.00	-	0.16	-	20.00	-	12.00
		Sub-Total	54.5	1.37	8.37	137	1046.25	13	642.25
Horticulture	**C)**	**Fruit tree**	**No.**	**Fruit yield**		**Gross return**		**Net return**	
		Mango (g)	3	0.39		390.00		354.00	
		Mango (l)	2	3.00		600.00		600.00	
		Sub-Total	5	3.39		990.00		954.00	
Total (A+B+C)				**48.13**		**9173.25**		**7189.25**	

Appendix XLV Average biological yield and economic return from AS system in small category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.351	2.30	1610.00	-434.74
		W/straw	-	2.30	460.00	
		Maize	0.386	9.411	4705.50	4928.55
		M/straw	-	47.055	4705.50	
		Sub-Total	0.737	61.066	11481.00	4493.81
	B)	**Oil seeds and pulses**				
		Mustard	0.070	0.300	750.00	315.50
		Mash	0.004	0.025	45.00	12.50
		Soybean	0.004	0.035	105.00	44.50
		Sub-Total	0.078	0.360	900.00	372.50
	C)	**Vegetables**				
		Colocassia	0.08	3.80	3800.00	2365.00
		Onion	0.002	0.12	60.00	8.00
		Garlic	0.002	0.08	112.00	42.00
		Bhindi	0.002	0.08	48.00	21.00
		Sub-Total	0.086	4.08	4020.00	2436.00
Pasture	D)	**Grasses***	0.030	1.50	150.00	100.00

Forest	E)	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		G optiva	7.55	1.13	1.73	113.00	216.25	52.60	155.85
		T ciliata	0.88	-	0.31	-	38.75	-	31.74
		M alba	2.11	0.16	0.25	16.00	31.25	3.34	18.59
		A chinensis	0.11	0.01	0.02	1.00	2.50	0.12	1.62
		A catechu	2.66	0.15	0.23	15.00	28.75	1.70	15.45
		F palmata	0.77	0.06	0.09	6.00	11.25	1.38	6.63
		T grandis	0.22	-	0.03	-	3.75	-	1.99
		L leucocephala	1.11	0.11	0.14	11.00	17.50	5.45	11.95
		Eucalyptus sp.	0.11	-	0.01	-	1.25	-	0.37
		D sissoo	0.55	-	0.13	-	16.25	-	11.85
		Sub-Total	16.07	1.62	2.94	162	367.5	64.59	256.04

Total (A+B+C+D+E)	**71.566**	**17080.50**	**7722.94**

Appendix XLVI Average biological yield and economic return from AH system in small category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.16	1.00	700.00	-224.47
		W/straw	-	1.00	200.00	
		Maize	0.28	9.50	4750.00	5632.50
		M/straw	-	47.50	4750.00	
		Sub-Total	0.44	59.00	10400.00	5408.03
	B)	**Oil seeds**				
		Mustard	0.04	0.14	350.00	102.00
	C)	**Vegetables**				
		Colocassia	0.12	6.00	6000.00	3700.00
		Onion	0.001	0.08	40.00	8.00
		Garlic	0.001	0.05	70.00	34.00
		Ginger	0.020	0.12	144.00	53.50
		Chilli	0.003	0.04	40.00	9.00
		Bhindi	0.003	0.15	90.00	56.50
		Brinjal	0.003	0.12	72.00	38.50
		Turmeric	0.020	0.50	500.00	320.00
		Sub-Total	0.171	7.06	6956	4219.5
Pasture	D)	**Grasses***	0.019	2.00	200.00	160.00
Horticulture	E)	**Fruit tree**	**No.**	**Fruit yield**	**Gross return**	**Net return**
		Mango (grafted)	1.0	0.45	450.00	438.00
		Mango (local)	1.0	1.50	300.00	300.00
		Mango (nb)	0.5	-	-	-
		Lemon	2.0	0.40	40.00	40.00
		Sub-Total	4.5	2.35	790.00	778.00
Total (A+B+C+D+E)				70.55	**18696.00**	**10667.53**

Appendix XLVII Average biological yield and economic return from ASH system in small category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	**Food grains**				
		Wheat	0.373	2.10	1470.00	-390.67
		W/straw	-	2.10	420.00	
		Maize	0.53	11.666	5833.00	6890.78
		M/straw	-	58.33	5833.00	
		Sub-Total	0.903	74.196	13556.00	6500.11
Pasture	B)	**Grasses***	0.060	3.50	350.00	270.00

Forest	C)	Trees	No.	LF	FW	LF	FW	LF	FW
		G optiva	11.00	1.65	2.53	165.00	316.25	77.00	228.25
		T ciliata	0.66	-	0.23	-	28.75	-	23.47
		L leucocephala	6.66	0.66	0.86	66.00	107.50	32.70	74.20
		M alba	1.00	0.08	0.12	8.00	15.00	2.00	9.00
		B variegata	0.66	0.09	0.16	9.00	20.00	3.72	14.72
		A chinensis	5.00	0.65	1.15	65.00	143.75	25.00	103.75
		Olea sp.	0.66	-	0.08	-	10.00	-	4.72
		F palmata	0.66	0.05	0.07	5.00	8.75	1.04	4.79
		Sub-Total	26.3	3.18	5.2	318.00	650.00	141.46	462.9

Horticulture	D)	Fruit tree	No.	Fruit yield	Gross return	Net return
		Mango (G)	1.33	0.20	200.00	180.04
		Mango (L)	0.66	0.99	198.00	198.00
		Papaya	0.33	0.10	40.00	40.00
		Lemon	1.66	0.50	50.00	50.00
		Banana	5.00	0.05	60.00	50.00
		Sub-Total	8.98	1.84	548.00	518.04
Total	**(A+B+C+D)**			**87.916**	**15422.00**	**7892.51**

Appendix XLVIII Average biological yield and economic return from AS system in medium category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)	Gross return (Rs.)	Net return (Rs.)
Agriculture	A)	Food grains				
		Wheat	0.60	3.50	2450.00	-298.22
		W/straw	-	3.50	700.00	
		Maize	0.88	24.50	12250.00	14281.33
		M/straw	-	122.50	12250.00	
		Sub-Total	1.48	154	27650	13983.11
	B)	Oil seeds				
		Mustard	0.12	0.40	1000.00	450.00
		Taramira	0.04	0.10	180.00	27.00
		Sub-Total	0.16	0.50	1180.00	477.00
	C)	Vegetables				
		Colocassia	0.1600	7.50	7500.00	5510.00
		Onion	0.0020	0.10	50.00	18.50
		Garlic	0.0020	0.07	98.00	54.00
		Bhindi	0.0040	0.25	150.00	92.00
		Turmeric	0.0040	0.12	120.00	43.00
		Brinjal	0.0015	0.08	48.00	22.00
		Sub-Total	0.1735	8.12	7966.00	5739.50
Pasture	D)	**Grasses***	0.06	3.50	350.00	270.00

Forest	E)	Trees	No.	LF	FW	LF	FW	LF	FW
		G optiva	22.50	3.37	5.17	337.00	646.25	157.00	466.25
		T. grandis	1.00	-	0.15	-	18.75	-	10.75
		L leucocephala	6.00	0.60	0.78	60.00	97.50	30.00	67.50
		Eucalyptus sp.	0.50	-	0.06	-	7.50	-	3.50
		M alba	0.50	0.04	0.06	4.00	7.50	1.00	4.50
		F palmate	1.50	0.12	0.18	12.00	22.50	3.00	13.50
		B variegata	0.50	0.07	0.12	7.00	15.00	7.00	11.00
		A catechu	9.00	0.54	0.81	54.00	101.25	9.00	56.25
		Sub-Total	41.5	4.74	7.33	474	916.25	207	633.25

Total (A+B+C+D+E)	**178.19**	**38536.25**	**21309.86**

Appendix IL Average biological yield and economic return from PS system in medium category of farmers in altitudinal zone III

Component		Functional unit	Area (ha)	Biological yield (q)		Gross return (Rs.)		Net return (Rs.)	
Pasture	**A)**	**Grasses**	1.52	60.00		12000.00		9344.00	
Forest	**B)**	**Trees**	**No.**	**LF**	**FW**	**LF**	**FW**	**LF**	**FW**
		A catechu	172.5	10.35	15.52	1035.00	1940.00	172.50	1077.50
		T ciliata	6.50	-	2.34	-	292.50	-	240.50
		D sissoo	24.00	-	6.00	-	750.00	-	558.00
		A latifolia	6.00	0.78	1.38	78.00	172.50	30.00	124.50
		L leucocephala	8.00	0.80	1.04	80.00	130.00	40.00	90.00
		G optiva	4.50	0.67	1.03	67.00	128.75	31.00	92.75
		A lebbeck	6.50	0.97	1.62	97.00	202.50	58.00	163.50
		Eucalyptus sp.	1.00	-	0.12	-	15.00	-	7.00
		M philippinensis	14.50	-	1.81	-	226.25	-	110.50
		W. exserta	11.00	-	0.55	-	68.75	-	24.75
		B ceiba	8.00	-	1.20	-	150.00	-	86.00
		Sub-Total	262.5	13.57	32.61	1357	4076.25	331.5	2575.50
Total (A+B)				**106.18**		**17433.25**		**12251.00**	

*** Grasses harvested from bunds**

CURRICULUM VITAE

Name	:	Naresh Kumar
Father's Name	:	Sh. Sunder Ram
Mother's Name	:	Smt. Sandhya Devi
Date of birth	:	11th October, 1975
Sex	:	Male
Marital status	:	Unmarried
Nationality	:	Indian

Educational Qualifications :

Certificate/Degree	Class/ Grade	Board/University	Year
Matric	First	HPBSE, Dharamsala	1991
10+2	First	-do-	1994
B.Sc. Forestry	First	Dr YSP UHF, Solan	1998
M.Sc. (Forest Products)	First	-do-	2001

Whether sponsored by some State/ Central Govt./Univ./SAARC : No

Scholarship/Stipend/Fellowship/any Other financial assistance received during :

M.Sc. : University Stipend
Ph.D. : University Scholarship

RESEARCH TOPIC

"APPRAISAL OF EXISTING AGROFORESTRY SYSTEMS IN SUB-TROPICAL REGION OF HIMACHAL PRADESH"

Researcher : NARESH KUMAR

DEPARTMENT OF SILVICULTURE AND AGROFORESTRY, COLLEGE OF FORESTRY, UHF NAUNI, SOLAN (HP)

SOCIO-ECONOMIC FACTORS

1. **Village**.....**Height (amsl)**.....mts
2. **Tehsil/Block**.....
3. **Name of respondent (Head)**.....
4. **Family size**.....5. No. of children. adult (<5.5-18. >18 years.....)
6. **Educational status of head/family** .....

i)	Illiterate (Male & Female)	v)	Sr. Sec. (Male & Female)
ii)	Primary (Male & Female)	vi)	Graduate (Male & Female)
iii)	Middle (Male & Female)	vii)	Post Graduate (Male & Female)
iv)	High School (Male & Female)		
	Literacy per cent.....		

7. **Main occupation of the head**.....
8. **Subsidiary occupation of the head**.....
9. **No. of employees in the household and Income**.....
10. **Off-farm employment and income**..... 11. LPG Yes/No
12. **General landuse statistic** .....

	Area (bighas)				
	Irrigated	un-irrigated	Total	No. of fragments	Size (bighas)
Agriculture					
Pasture					
Orchard					

13. **Livestock Status and their management**

Animal	Local breed	Improved breed	Total
i. Cows (in milk/dry)			
ii. Buffaloes (in milk/dry)			
iii.			
iv.			

14. **Milking procedure** : Traditional/Mechanical
15. **Regular de-worming practices** : Yes/No, FMD Vaccination: Yes/No
16. **Breeding method** .....
17. **How do you utilize the cattle manure**.....
18. **Use of FYM** : Fuel/Crop Production/Both

Agroforestry systems
Part (i. ii. iii.....)

Crop grown	Varieties	Area	Associated trees (Name and No)	Associated grasses (Name and Area)
Kharif (i. ii. iii....)				
Rabi (i. ii. iii....)				

Detailed description:

Pasture

Parts and Area (i. ii. iii.....)

Major grass spp. ..... Major bushes/shrubs.....

Area (Grasses)	Trees		Yield		
	Name	Number	Fuel wood	Fodder	Fruits

Management Cost.....

19. Agricultural cycle and production

Parts (i. ii. iii.....)

Crop	Irrigated	Un-irrigated	Production				*Return	
	(Area)	(Area)	Grain ...	Straw Stover	Forest Trees (Fuelwood fodder)	Fruit Trees	Gross return	**Net returns
Kharif (i. ii. iii....)								
Rabi (i. ii. iii....)								

*Return = For each component
**Net return = Gross return - Variable costs

Variable cost : seed. fertilizer. FYM. ploughing. irrigation. weeding. mulching. insecticides. pesticides. harvesting/extraction. threshing. pruning. training.....etc.

Detailed description:

Other relevant informations.....

Farmers views and comments.....

Dr. Y S Parmar University of Horticulture and Forestry
Nauni, Solan (HP) 173 230 India
Department of Silviculture and Agroforestry

Title of Thesis	:	**Appraisal of existing agroforestry systems in sub-tropical region of Himachal Pradesh**
Name of Student	:	Naresh Kumar
Admission No.	:	F-2K-3-D
Major Advisor	:	Dr. R K Nayital (Sr. Scientist)
Major Field	:	Agroforestry
Minor field(s)	:	i) Silviculture ii) Soil Science
Degree Awarded	:	Doctor of Philosophy
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Abstract

The study was carried out in Bilaspur district of Himachal Pradesh in order to know the socio-economic status of farmers, identification of existing AFSs and to suggest potential tree-crop systems, estimate the biological yield and economic returns from the existing AFSs and also to highlight the technological gaps in the systems and suggest ways and means to over come them. Considering the altitudinal variation, the whole area was divided into three altitudinal zones viz. altitudinal zone I (<700 m asl), II (700- 1000 m asl) and III (1000-1400m asl). Four villages from each altitudinal zone were selected randomly; thereafter 10 households from each selected village were taken randomly which formed the ultimate unit. The selected farmers were categorized into four categories based on the size of their landholdings viz. marginal (<1 ha), small (1-2 ha), medium (2-5 ha) and large (>5ha). Data were collected through pre-tested schedules by conducting interviews with the head of each selected household.

Socio-economic study showed the dominance of marginal (67.50%) farmers. Each household on an average was comprised of 6-7 members. The average land holding was 0.970 ha, 1.072 ha and 0.925 ha in altitudinal zone I, II and III, respectively. Agriculture and pasture were the major land use types. Literacy rate of heads of families was found maximum in altitudinal zone II, Whereas the family literacy rate was maximum in altitudinal zone I. Maximum (22.22%) access to off-farm employment was observed in altitudinal zone II. Majority of livestock was of local breeds, maintained by using traditional animal husbandry practices.

In altitudinal zone I seven AFS types viz. AS, AH, ASH, AHS, PS, PSH and PHS were prevalent. PSH, AH and PHS system types gave the maximum net returns in marginal, small and medium categories, respectively. In altitudinal zone II six AFS types viz. AS, AH, ASH, AHS, PS and PSH were in practice. ASH, AHS, ASH and PSH systems generated the maximum net return in marginal, small, medium and large categories, respectively. Whereas, in altitudinal zone III only five AFSs viz. AS, AH, ASH, PS and PSH were identified. ASH, AH and AS system types generated the maximum net returns in marginal, small and medium category, respectively in altitudinal zone III. Considering the variation in biological yield PS system in altitudinal zone I and III; PSH in altitudinal zone II were found most unstable system types.

The prominent constraints identified were; limited off farm employment opportunities, unsatisfactory literacy rate, unawareness regarding package of practices of major cereal crops, prevalence of less productive traditional AFSs, lack of irrigation facilities, government authorised sale centers, sound marketing network and communication gap between lab to land. Potential tree crop systems in addition to probable solutions to the constraints have been suggested.

Major Advisor

Signature of Student

Professor and Head
Department of Silviculture and Agroforestry,
Dr. Y S Parmar University of Horticulture and Forestry,
Nauni, Solan (HP)