SOCIO-ECONOMIC FACTORS THAT INFLUENCE FARMER PARTICIPATION IN AGROFORESTRY IN AINABKOI AND MOIBEN DIVISIONS, KENYA

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any University for a degree.

Signature ***Date***

ABSTRACT

Kenya's economy depends largely on agriculture for growth and development and yet only 20% of the total land area lies in high potential farming areas that support 80% of the total population and 50% of the total livestock in the country. Intensified cropping as a result of the high population concentration on high potential areas has put pressure on land and other resources to an extent that potential productivity of these areas has been degraded. Loss of soil nutrients through soil erosion has caused decreased food production, deterioration of croplands and, siltation and eutrophication of water bodies. Over reliance on forest resources by the communities in the study area has led to deforestation as well as the general disturbance of watershed areas and its functions. There is need therefore to find alternative ways of retaining and/or restoring lost fertility through community participation so as to increase food production.

The aim of this study was to investigate the socio-economic factors that influence farmer participation in agroforestry activities in Moiben and Ainabkoi Divisions of Uasin-Gishu District. Data was collected using participatory methods. One set of data was collected using a questionnaire that had both open and closed ended questions. Through random sampling, a total of 300 farmers were interviewed. Additionally, key informants from various government departments were interviewed. The other set of data was obtained through resource assessment in a forest adjacent to the communities in the study area.

This study found that the majority of the farmers had not practised agroforestry despite many being aware of it. Socio-economic problems that hindered them from adopting and practising agroforestry technologies included lack of forest extension services as a reliable source of information about suitable tree species, and how to plant and best locate them within the farm, gender-related issues hindered vulnerable groups, particularly women and children and lack of secure land tenure was a disincentive to those farmers who live on trust land and the married sons who have not been allocated land by their parents. Farm labour during peak farming period was found to scarce due to farmer prioritisation of farm activities. Farmers mentioned that trees occupy land that is already becoming scarce and only give returns in the long term yet farmers need immediate benefits. Forest extension services were ineffective due to scarcity of resources that would enable officers to discharge their duties efficiently. Resources within the gazetted forests were being over exploited since that was the only source with cheaply available wood and non-wood products. It was also found in this study that the majority of the farmers faced environmental problems that included soil erosion, decreased crop yields as well as shortage of wood products.

In the future, affordable extension techniques need to be employed in order to reach the farmers. The current regulations that govern private land ownership should be streamlined so as to enable all family members participate in decision-making on utilisation of land. There is need to incorporate agroforestry adult literacy classes as well as in local school curricula. Being multi disciplinary, agroforestry can be spread to the farmers by involving stakeholders at every stage. The current crop of extension

agents should be re-trained or should be attending in-service courses regularly. This could transform them into facilitators. Further research should be done on farmers' attitude towards trees, cheaper techniques of disseminating information on agroforestry should be investigated while the current extension techniques should be evaluated for their strengths and weaknesses.

OPSOMMING

Kenia se ekonomie is grootliks afhanklik van landbou vir groei en vooruitgang. Slegs 20% van die totale beskikbare landbougrond in hoe-potensiele landbou areas ondersteun 80% van die totale bevolking en 50% van die totale lewende hawe. Hoë bevolkingsdigtheid vereis intensiewe oesverbouing wat weer hoë druk op landbougrond en ander bronne plaas. Dit het tot gevolg dat die moontlike produktiwiteit van hierdie areas agteruit gaan. Die verlies van voedingstowwe as gevolg van gronderosie het verlaagde voedselproduksie, agteruitgang van landbougrond en toeslikking van waterbronne tot gevolg. Die algehele afhanklikheid van gemeenskappe op bosprodukte het tot ontbossing en algemene versteuring van opvanggebiede gelei. Dit is dus noodsaaklik om alternatiewe maniere te kry om die grondvrugbaarheid te behou en/of te herstel deur gemeenskapsamewerking en om sodoende voedselverbouing te verhoog.

Die doel van die studie is om ondersoek in te stel na die sosio-ekonomiese faktor wat die landbouer se samewerking in Moiben en Ainabkoi gebiede van Uasin-Gishu distrik beïnvloed. Die inligting is ingesamel deur deelnemende metodes te gebruik. 'n Vraelys met keuse- en ander soortige vrae is gebruik om die inligting in te samel. 'n Totaal van 300 landbouers is deur toevallige keuring ondervra asook segsmanne van verskeie regeringsdepartemente is vir inligting genader. Nog inligting is verkry deur hulpbronopnames in die gebied aangrensend tot die gemeenskappe van die studiegebied.

Hierdie studie het gewys dat die meerderheid van die landbouers nie agrobosbou toepas nie alhoewel hulle wel daarvan bewus is. Sosio-ekonomiese faktore wat hulle verhinder om agrobosbou toe te pas sluit die gebrek aan lanboudienste as betroubare bron van inligting oor geskikte boomspesies en boomaanplantingmetodes in. Ook het geslagverwante probleme, kwesbare groepe veral vroue en kinders, gehinder. 'n Tekort aan gewaarborgde grondbesit vir landbouers wat op trustgrond werk en die getroude seuns aan wie nog nie grond deur hulle ouers toegeken is nie, was terughoudende faktore. Plaasarbeid was ook nie standhoudend nie. Landbouers het ook gevoel dat bome waardevolle en skaars grond gebruik en slegs voordele op die lange duur gee terwyl die landbouers die voordele dringend moet kan benut. Landbouvoorligtingsdienste was nie effektief nie as gevolg van die skaarsheid van hulpbronne wat personeel kan help in hulle verpligtinge. Voedsel- en ander bronne uit die bosreservate word uitgeput aangesien dit die enigste goedkoop bron is. Die studie het ook bevind dat die meerderheid landbouers omgewingsverwante probleme soos erosie en swak oeste asook 'n tekort aan houtprodukte ondervind.

Voortaan behoort bekostigbare landbouvoorligtingstegnieke gebruik te word om landbouers te bereik. Die huidige bepalings wat privaatbesit reguleer behoort vereenvoudig te word sodat al die lede van een gesin 'n aandeel kan hê in die besluitnemingsproses oor die gebruik van die grond. Daar is ook 'n behoefte aan volwasse-geletterdheidsonderrig vir landbouers as deel van die skoolprogram. Aangesien agrobosbou verskeie gebiede raak, kan landbouers in

enige stadium betrek word. Die huidige groep personeel behoort heropgelei te word of behoort gereeld indiensopleiding te ontvang. Dit kan hulle tot fasiliteerders bevorder. Verdere navorsing is nodig om landbouers se houding teenoor bome te verander en om goedkoper landbouvoorligtingstegnieke vir agrobosbou te vind. Huidige landbouvoorligtingstegnieke behoort ook ondersoek te word om die sterk – en swakpunte te bepaal.

DEDICATION

To My wife, Susan Jepkoech Kurgat, My daughter,

Mercy Jepng'etich, My father and late mother.

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1.0 Introduction

1.1. Kenya: Overview

The Republic of Kenya is situated in East Africa and covers an area of 582 646 km². It lies on the equator between 4°30'N and 4°40'S and 34°E to 42°E (Figure 1.1). It is bounded on the North by Sudan and Ethiopia, to the South by Tanzania, to the West by Uganda and Lake Victoria and to the East by Somalia and the Indian Ocean (Coger, 1996)

Kenya attained independence from British rule in 1963. The country is divided into eight administrative provinces namely: Nairobi, Coast, eastern, North-eastern, Central, Rift valley, western and Nyanza provinces. There are approximately 63 Districts of which Uasin-Gishu is one (GOK, 1996).

Kenya's heterogeneous population currently stands at 28.4 million (FAO, 1999). The Bantu, being the largest group constitutes 65% of the total population, second is Nilo-hamitic 16%, then Nilotic 14% and fourth is Cushitic 4% (GOK, 1994). These four groups are further subdivided into slightly over 40 sub-ethnic groups that are officially recognised. The Asian and European immigrants constitute 1% of the population (CBS, 1999). The annual population growth rate of 3.9% is among the highest in the world (GOK, 1996a).

Most of the rural population (80%) rely on agriculture for their livelihood. Regional population densities are remarkably diverse, being dependent on the agricultural potential of the land. Densities range from over 230 persons per km^2 in high potential areas to as low as 3 persons per km^2 in arid areas (GOK, 1996a).

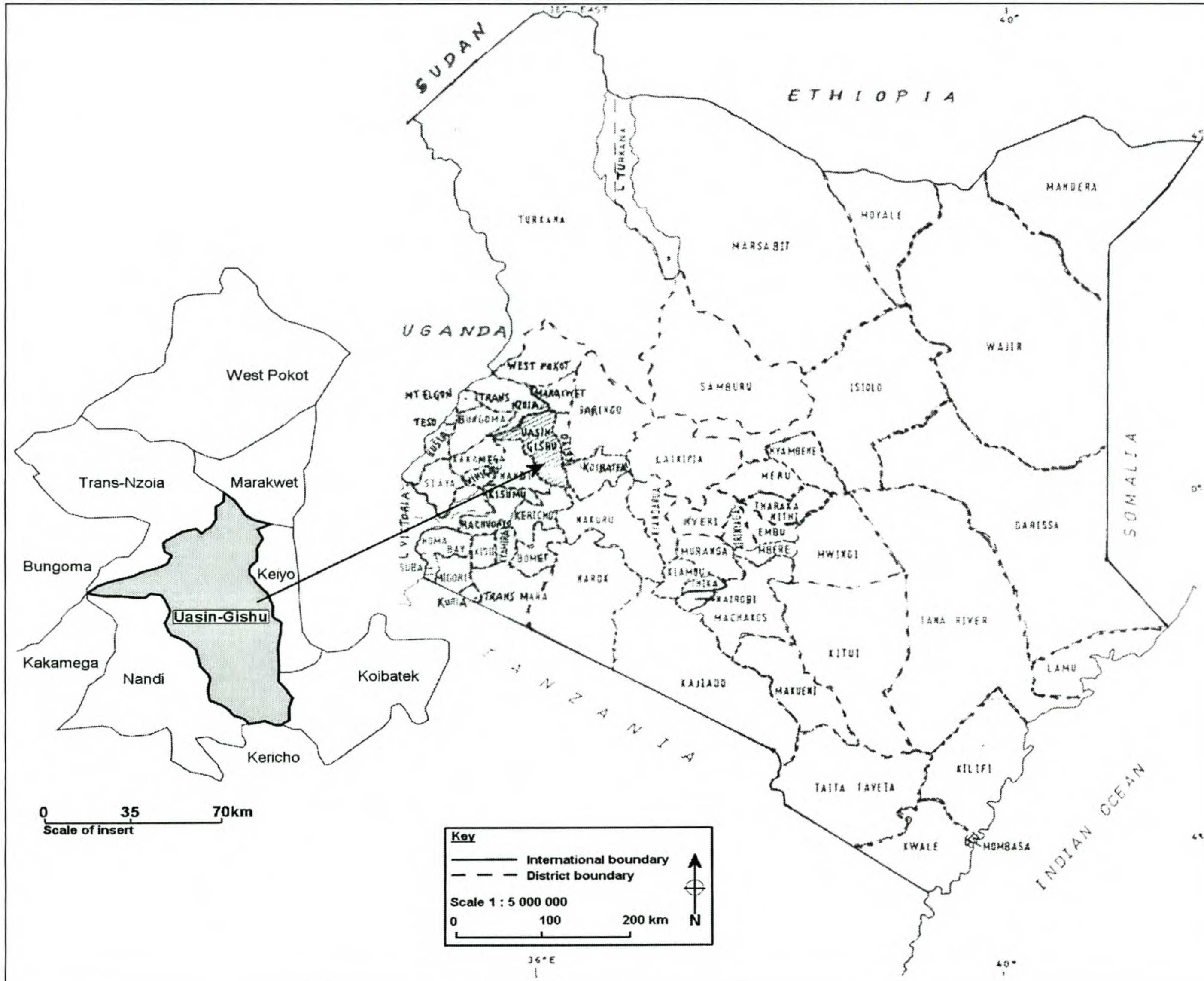

Figure 1.1: Kenya, showing District boundaries

Source: GOK (1996).

1.1.1. Topographic, climatic and edaphic features

Kenya's topography varies highly, ranging from sea level up to the highest point of Mount Kenya at an altitude of 5199 metres a.s.l. Outside the mentioned extremes, the altitude undulates between plateau, steep slopes and relatively high mountain ranges. The climate cuts across the agriculturally low potential, near-desert-like areas such as the Turkana region to the comparatively well-watered highlands near Mount Kenya (Coger, 1996). In between there is a whole range of varying rainfall and temperature regimes. In the arid to semiarid zones, the mean annual rainfall lies slightly below 200 mm and increases to above 2000 mm in the highlands (Teel, 1984).

Vegetative cover changes with altitude as a result of the amount of precipitation, so that the dry areas are least vegetated while the highlands have a high vegetation cover. Between the dry areas and highlands lie the savannas. The country's forested area covers approximately 2% of the total land surface most of which is within the gazetted forest estates. However, deforestation has reached such an alarming proportion that forest reserves are now diminishing in size. This problem is compounded by the failure of plantations since the mid 1980s due to suspension of the *shamba system* of raising plantations (GOK, 1996a). With its high population, the demand for timber and fuelwood in Kenya is estimated at 14.8 m m^3 per annum and hence a shortage of wood was anticipated beyond the year 2000 (GOK, 1996a).

The Kenyan soils are classified as zonal (mature) and azonal (young). The mature are subdivided into latosols, pedocals, nitosols, phaeozems and sierozems while the young soils are subdivided into lithosols, regosols alluvial and mountain soils. Latosols and pedocals are generally found in high potential areas and are the most fertile, while the sierozems (desert soils), are least fertile and mostly occupy the semi-arid to arid lands of the country (Jaetzold and Schmidt, 1982 cited in GOK, 1987)

1.1.2. Agro-ecological Zones

There are six broad agro-ecological zones in Kenya. They are Tropical Alpine (TA), Upper Highland (UH), Lower Highland (LH), Upper Midland (UM), Lower Midland (LM) and Inner Lowland (IL) (Jaetzold & Schmidt, 1983 cited in Rees *et al.*, 1997). The above zonations are widely used in Kenya for they were developed on the basis of temperature belts and the probability of receiving sufficient rainfall to meet the water requirements of the crops. They are further subdivided according to soil type (Rees *et al.*, 1997). The zones reflect the highly diverse climatic factors, like altitude, soils, rainfall, temperature, tree cover, and topography that dictate land uses in various parts of the country.

1.1.3. Agricultural Activities

Kenya has since independence relied on the agricultural sector as the base for economic growth, employment creation and foreign exchange generation (GOK, 1996a). However more than 80% of the land area falls into arid and semi-arid zones, together with 25% of the total population and 50% of the total livestock. Although agriculture's contribution to Gross Domestic Product (GDP) of 26.2% has been declining over the past few years, it remains one of the most important sectors for economic growth since it supports 80% of the total population and constitutes 65% of the exports. Some important Kenyan agricultural products include maize, tea, wheat, coffee, sugarcane, rice, cotton, horticulture oil crops and livestock (GOK, 1996a).

1.2. Influence of Human Activities on the Environment

1.2.1. Community Utilisation of Forest Resources

It has been estimated that one quarter of the world's poor depends directly or indirectly on forests for their livelihood (World Bank, 2000a cited in Warner, 2000). Forests are the source of variety of products: food that supplements and complements what is obtained from agriculture, woodfuels with which to cook food and a wide range of traditional medicines (Warner, 2000). Despite such vast benefits from the forests, the impacts of humans in the moist tropical forests for example have been evident since prehistoric times and presently these impacts are increasing at an exponential rate. The area currently under forests in the world is estimated to be twenty nine million km^2 with annual tropical deforestation rate of 130 000 km^2 (WR, 2000; van Gelder and O'Keefe, 1995). Between 1980-1995, approximately 211 million hectares of natural tropical forests have been cleared and degraded impairing their capacity to contribute to food security among other humans needs (FAO, 1997 cited in Lipper, 2000).

In developing countries, most intensive agricultural activities are found on the forested highlands that are characterised by a high rate of population increase with resultant effects of land scarcity, poverty and natural resource degradation (FAO, 1999). These areas are also watersheds and therefore are under threat. Statistics show that in developing countries, the area under forest decreased by 2 million km^2 three years, which is 10% of the world forests (FAO, 1997 cited in WR, 2000) and that nearly 30% of the world's major watersheds have lost three quarters of their original forest cover (WR, 2000). The annual loss of forest cover poses a threat to soil stability and even worse environmental hazards such as the accumulation of carbon dioxide in the atmosphere since trees act as carbon 'sinks' (van Gelder and O'Keefe, 1995). High conversion rates of forests to agricultural lands have been noted to contribute to loss of biological richness, spread of diseases among humans and livestock, environmental changes in energy and water vapour, loss of soil protection and increased rates of run off, changes in the fixation and release carbon dioxide as well as from other aerosols (Spears, 1979, cited in Holzner *et al.*, 1983). In as much as sufficient food has to be produced, other environmental aspects such as managing of fragile environments that have been transformed into croplands have to be taken into consideration for sustainability of their watershed functions other than agriculture and forest products (Colman, 1953).

Forest degradation and depletion in Kenya has continued unabated despite government efforts to reduce it. The Government perceived some of the forest activities to have run out of control and these were banned in the 1980s through presidential decrees, Forest Department orders and rules (Mogaka *et al.*, 2001). In the category of banned activities were logging of indigenous tree species and charcoal burning as a step toward curbing overexploitation of these resources by stakeholders, among them local communities. Indeed it is estimated that wood resources yield 71% of the energy that Kenya consumes and that rural areas are solely dependent on fuel wood (ICRAF, 1997). As Warner (1998) points out, with increased urbanisation, the demand for wood products such as charcoal as a source of energy for cooking increases. Unfortunately, growing markets for wood fuel and poles tend to initially stimulate increased exploitation of existing natural woodstock rather than the planting of more trees on farms leading to increased loss of these resources (Arnold and Dewees, 1997). For example although readily grown from seed, mature trees of *Juniperus procera* are now rare and protection and re-planting deserves high priority (Noad and Birnie, 1992; ICRAF, 1992). Apart from human exploitation of forests, tree species diversity and availability is the compounded by growth characteristics of trees particularly indigenous species. For example the slow growth of *Juniperus procera* discouraged its establishment in Shuma region of Tanzania (Mbuya *et al.*, 1994). These calls for sustained use of forest resources in order to reduce risks associated with lose of gene pool.

According to Colman (1953), vegetation significantly influences the way rain collects on the land and drains to streams, because impact of rainwater and wind on soil surface is drastically reduced. Forests, grasses and agricultural crops influence the rate at which rain can seep into the soil and ground water reservoirs differently. Vegetation slows runoff of water, checks erosion of soil and reduces flooding. Therefore, every vegetation management practice introduced on watershed lands that is designed to control water flow on the land and in the streams benefits both the immediate area and the downstream water-users because the greater protection of soil upstream lead to improved water quality. Equally, unsustainable harvesting and/or conversion of forest areas to agricultural land should be avoided since it contributes to more loss of biodiversity, increased shortage of wood products and environmental damages arising from eroded croplands.

1.2.2. Effects of Agricultural Activities on the Environment

The most important basic resources for human and biological production systems are land, air and water (Tewari, 1995). The development of a society therefore is determined by its capacity to exploit these basic resources sustainably to avoid overexploitation or deterioration (Holy, 1982). The continuous degradation of these basic resources by humans has eroded the earth's capacity to support life, however (Tewari, 1995). These can readily be observed through the adverse environmental effects of floods, severe soil erosion, reduced water quality and yield, drought, decreasing productivity and low harvestable biomass.

Land as a resource can be used repeatedly and in many ways, one of which is as agriculture both for crop and animal production, subsistence, cash or both. However, the danger that serious misuse of land may not only waste its present value but also almost irreparably damage its future usefulness as eroding slopes and desertification testify is ever present (Evans, 1996). Principal soil degrading processes include water and wind erosion, water logging, loss of soil organic matter, soil nutrient depletion and accumulation of pollutants (WR, 2000).

As a limited and irreplaceable resource, the intensive exploitation of soil has gradually disturbed the natural soil cover and has exposed the soil surface to erosion agents and in its absence, the biospheric environments of man, will collapse with devastating outcomes (Holy, 1982). Depending on its quality, land and other natural resources have been known either to support or not civilisations as historical evidence from regions like Middle East and China show. The rise and fall of civilisation in those areas have been attributed to land degrading processes especially soil erosion because exploitation of soil and other natural resources for economic benefits has been practised since time immemorial by pioneer developers in those regions (Lowder-Milk, 1953 cited in Schwab *et al.*, 1996).

Agricultural activities can damage the local environment through soil erosion caused by ploughing land as well as application of fertiliser and pesticides. The United States of America soil conservation service estimated that 20 million hectares of land had its topsoil eroded by 1934 and that the area was already gullied and useless or uneconomical for agriculture (Holy, 1982). It is also estimated that prior to 1998, China suffered an annual loss of 2.4 billion metric tons of soil washed into streams silting lakes and further reducing buffers that formerly absorbed floodwater as a result of not constructing soil conserving structures (Koskela *et al.*, 1999 cited in WR, 2000). This is further compounded by the long-term process of soil formation (Juo and Freed, 1995; Holy, 1982). Erodibility of the topsoil depends on soil management practices among other factors (Holy, 1982)

Land degradation in developing countries is widespread and in some places severe (Oldeman, 1994, cited in Young, 1997). In sub-Saharan Africa, land degradation threatens the economic development and social welfare of millions of people due to an estimated annual loss of nearly 5 million hectares of arable land attributed to soil erosion with an estimated incidence of 25% of all the vegetated land while Asia's erosion incidence is 30% (WR, 2000). An estimated crop yield loss of eight percent in Africa between 1970 and 1990 was due to water erosion (Lal, 1995 cited in WR, 2000). In Africa, the rapid population increase, lack of agricultural technology and its largely rural population that relies on agriculture for income, has increased pressure on the limited arable lands leading to shortened fallow cycles and subsequent extension into unsustainable marginal lands. Encroachment into these fragile ecosystems has led to an estimated 750 million hectares of Africa losing its productivity (Cook and Grut, 1989).

A degraded soil lowers response to fertiliser and other inputs and therefore, a lowered economic margin on fertiliser application, perpetuates a low input and low output situation (Young, 1989). Apart from reducing soil fertility and hence the capacity for production of food and fibre, agricultural soil erosion from farmlands is one of the major causes of water pollution (Schwab *et al.*, 1996). The eroded sediments can carry nutrients, particularly phosphates, to the waterways, causing eutrophication in lakes and other water bodies. Silt raises the level of water reservoirs and a subsequent reduction in its storage capacity subsequently limiting its use as a water source (Holy, 1982).

As population growth increases in developing countries, the demand for wood-based products like fuel wood, building materials, medicine and other extractable wood products increases. This requires communities to adopt viable technologies that can sustain the heavy utilisation of the resource base. Kenya is not an exception to global deforestation and land degradation as reported by Mentel *et al*. (1997 cited in WR, 2000) who affirm that agricultural productivity has declined by about 16% in the agricultural lands in Africa and that in the next twenty years, crop yields will have dropped by between 25-50 % in Kenya.

In this regard, efforts targeted at increased production have to be stepped up through counteracting negative food production. Encouraging farmers to adopt integrated farming activities, as a viable alternative for greater and diverse farm outputs is one way to achieve this objective. This calls for new orientations in agriculture that carry less risks, are resource-conserving and which selectively include the advances of modern science and technology (Taylor, 1991a cited in Underwood, 1994).

Through the use of conventional earth structures, soil conservation measures used on small-scale farms were successful before independence in most African colonies (Young, 1989). However a decline during the independence period (1960s) was observed in most of the previous colonies due to an association with colonialism, high labour demanding nature of the structures and top-down, legally enforced policies making them unfavourable to many farmers in the tropics (Young, 1989). For example policies such as those that require farmers to erect earth structures before cultivation or those that prohibited cultivation of steep slopes were unfavourable to most communities who depended on marginal areas for their livelihood (Young, 1997).

Modern technologies (from temperate zones) introduced to increase food production by continuous cultivation have not been successful particularly in developing countries. Reports indicate that these 'green' revolution technologies and high mechanisation were adopted based on people's wealth leading to selective exclusion of the poor who are smallholders (Buck *et al*., 1999; Nair, 1993). This led to displacement of local peoples' food resources and employment opportunities. This partially explains the differential adoption of technologies and depicts 'modern' agricultural technologies as being environmentally unfriendly (Buck *et al.*, 1999).

Conservation of natural resources implies sustainable utilisation without waste to make possible continuous high crop production while improving the environment. There are many conservation practices that can improve the environment with little or no cost to agriculture. Such practices include programmes that promote reduced fertiliser and pesticide use, minimum tillage practices and other cost reduction measures (Schwab *et al.*, 1996). Failure to conserve the soil reduces crop production, impairs water quality and a long-term effect of destruction and eventual abandonment of land as well as in the loss of civilisation itself (Lowdermilk, 1953 cited in Schwab *et al.*, 1996). For example Scheren *et al.* (2000) attribute one of the outcomes of increased human activities as the pollution of Lake Victoria[1]. The eutrophication and problems associated with it are as a result of nutrient input mainly from atmospheric deposition and land runoff that account for 90% of phosphorus and 94% of nitrogen input into the lake. Human activities such as land exploitation for agriculture and forest burning by communities in the lake surroundings are to blame given the lake's catchment area of approximately 194 000 km^2.

In order to improve and subsequently increase soil conservation, most policies have shifted away from old 'soil-preserving' policies to more socially acceptable methods (Young, 1997). This new approach focuses on effects of soil loss on crops yields, biological soil conservation techniques, ways of sustainably cultivating steep areas (since they cannot be prohibited) and introduction of conservation as an integral part of an improved farming system since farmers need to see tangible benefits before embarking on any piece of work (Young, 1997).

In support of Young's argument, Altieri (1990 cited in Underwood, 1994) points out that in an effort to balance food production and enhance a productive environment for humans, agricultural objectives should search for environmentally sound and socially

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[1] The world's largest tropical lake bounded by Uganda, Tanzania and Kenya, which is a source of livelihood for the region's 30 million people. Its biodiversity collapse has been attributed to pollutants from changed land-use in the watershed, among others (WR, 2000).

acceptable agricultural techniques that are more beneficial than detrimental. One such technique or approach is to use agroforestry which has the potential to alleviate soil loss because it is less labour intensive compared to conventional earth structures, combines conservation with production due to its low capital requirement, and improves soil structure, water infiltration and subsequently water retention through litter fall (Young, 1997).

1.3. Agroforestry

1.3.1. Introduction

Agricultural practices involving cultivation of trees in combination with crops have been in existence since the dawn of civilisation and therefore agroforestry is an age-old practice (Nair, 1993). Tree-crop combinations have been practised in different parts of the world under different names and in different ways; such has jhum, shifting cultivation, kumn system, taungya system, agri-silviculture, silvo-pastoral system, agri-silvopastoral system among others. Despite this, it is only in recent years that incorporation of trees on farmlands has been given more attention (Tewari, 1995).

Until the Middle Ages, bush clearing, slashing, burning and cultivation of crops and planting of trees was done in Europe (King, 1987; Tewari, 1995). It was done as late as 1920s in Finland and Germany. In tropical America, people simulated forest conditions on their farms by cultivating a variety of crops with different growth characteristics in order to obtain beneficial effects of forest structure (Tewari, 1995). According to Wilken (1977 cited in Nair, 1993) farmers in Central America, have traditionally planted up to a dozen species of plants on plots no larger than a tenth of a hectare. For example, they planted coconut or papaya with a lower layer of citrus or bananas and a shrub layer of coffee or cacao, annuals of different heights such as maize and a spreading ground cover such as squash that resembled the tropical forests.

In Asia, the Hanunoo of Philippines practised shifting cultivation whereby certain selected tree species were left during clearing to prevent excessive exposure of soil to the sun at a time when moisture is important for the maturing rice grain at the end of its growing season. So they either planted or conserved the original forests to provide products and services (Conklin, 1957 cited in Tewari, 1995). Trees also provided the Hanunoo with food, medicine, cosmetics and construction material. In India, cultivation of trees has been recognised since time immemorial because the peoples' religious beliefs are tied to raising, caring for and worshipping trees (Tewari, 1995).

In Africa, growing together yams, maize and pumpkins under cover of scattered trees, was practised in regions such as southern Nigeria (Forde, 1937 cited in Tewari, 1995). The Yoruba of western Nigeria claim that the traditional practice of mixing herbaceous shrub and tree components was a means of energy conservation through utilisation of the limited space won from the forests and that the system maintained soil fertility, reduced erosion and checked leaching of nutrients (Ojo, 1966 cited in Nair, 1993). In many African countries, traditional farming systems combined trees, crops and animals and in itself, the system was sustainable. More recently however, population increase has caused a dramatic decrease in available resources resulting in subsequent changes from traditional to 'new' agroforestry practices (Cook and Grut, 1989; Evans, 1996).

By the end of 19th century, foresters had noticed the advantages of these traditional 'agroforestry' systems for tree plantation establishment giving rise to one of the most well-known agroforestry practices, taungya, where crops are interspersed with tree seedlings until the tree canopy closes upon which new forested areas are opened up for further cultivation (Tewari, 1995). By 1896 this system of plantation establishment had spread from Burma and across India to Bengal. It was used in South Africa as early as 1887 (Hailey, 1957 cited in Steppler and Nair, 1987).

Until the mid 1970s, minimal or no attention had been given by commercial agriculturalists and foresters to agroforestry (King, 1987). In the late 1970s however, there was a renewed interest in tree crops because of the energy crisis, mounting concerns about the high rate of agrochemical and energy use in industrial agriculture and the realisation of the potential role of trees as an effective component and as a possible solution to these problems (Gold and Hanover, 1987 cited in Nair, 1993).

1.3.2. "New" Agroforestry

According to Ashton and Montagnini (2000), agroforestry was recognised as an important management system during the 1960s to 1970s by western aid donors that were attempting to develop marginal farming areas for food production. Since the 1980s the 'new' agroforestry has learnt from traditional agroforestry systems to work closely with the fertility of marginal lands through the use of less intensive cultivation and fallow periods. For centuries these traditional farming systems, that are now called agroforestry, deliberately retained trees on farmlands with an ultimate objective of producing food (Nair, 1993).

As a land management option that is applicable to farm and forest settings, the concept of agroforestry was adopted as a result of failure of development policies and approaches of the early 1970s that aimed at the provision of basic needs to the rural poor (King, 1987). This culminated in the formulation of new world Forestry Sector Policy paper by the World Bank that was designed to assist the peasant and ordinary farmer through social forestry programmes and which contained many elements of agroforestry. These World Bank policies that dealt with increased food production, conservation of the environment and assisting traditional forest services to produce and process wood also led to scientific recognition of traditional agroforestry systems (Spears, 1987 cited in Nair, 1993). It was against this backdrop of concern for the rural poor that an internationally financed council for research in agroforestry was created to administer a comprehensive programme leading to better land-use in the tropics. The council was named the International Centre For Research in Agroforestry (ICRAF) (King, 1987).

1.3.3. Definitions of Agroforestry

Agroforestry as a land-use concept and word was rapidly accepted internationally but not without difficulty and has been defined in several ways (Nair, 1993; 1989). There was no clear definition even from those people who were experienced in agroforestry in the late 1970s and early 1980s (Nair, 1993). Among the earliest definitions were agroforestry as " *a sustainable management system for land that increases overall production, combines agricultural crops, tree crops and forest plantations and/or animals simultaneously with the cultural patterns of local population"* (Bene *et al.*, 1977, Nair, 1979 and King and Chandler, 1978 cited in Tewari, 1995; 14). Its complexity encompasses structural descriptions (trees, crops and annual combinations), production objectives (sustained yield) and socio-economic objectives (cultural practices of local community), which encompasses myriads of problems and needs of the local community.

Other earlier definitions such as by McQueen, 1977 (cited in Tewari, 1995; 14) included aspects such as agroforestry being a future and alternative source of income to farmers, source of intermediate income to the forest companies, a means of erosion control and as an economic use of land currently marginally profitable. Lundgren and Raintree (1982 cited in Nair, 1993; 14) defined agroforestry as "*a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos etc) are deliberately used on the same piece of land management unit as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence"*. In this system, both ecological and economical interactions between the different components exist.

These definitions stress that attributes such as productivity, sustainability and adoptability, must be possessed by an agroforestry system. It also means that there should be two or more interacting components both of which should be plants or an animal and that one of the plants should be a woody perennial, there should be two or more outputs, greater than one year cycle, therefore an ecologically (structurally and functionally) and economically complex system. The definition by Lundgren and Raintree has been used in most ICRAF publications and therefore has received wide acceptance although it is not assumed to be a 'perfect' one (Nair, 1993). However, it has helped in the recognition of agroforestry as a science on its own, away from being attached to agriculture (Sanchez, 1995).

Despite many initial definitions, it is widely accepted that agroforestry is a practice that involves deliberate mixing of trees and/or animals (Nair, 1993). However, Rocheleau *et al.* (1988) point out that the rural people can derive agroforestry benefits by treating agroforestry as a land-use rather than a practice with fixed components. Nair (1993) is also of the view that agroforestry is practised with varying objectives based on the needs and/or benefits of the people.

Despite the consensus on what agroforestry is, several terms such as farm, social and community forestry with a 'forestry' ending have since emerged although they stress tree growing through people's participation with social goals as having same importance as tree products. These terms stress tree planting often as woodlots while agroforestry stresses interaction between trees, shrubs and annual crops and/or animals (Nair, 1993; Singh *et al.*, 1995). However, irrespective of the term used, the planted trees will provide products and services and hence they are often used synonymously (Nair, 1993).

Although agroforestry as an old practice had been institutionalised, it lacked clarity on the possible diversities that were in-use at that time and therefore the inventory of agroforestry systems began in the early 1980s (Nair, 1987b cited in Steppler and Nair, 1987). The outcome showed an array of agroforestry systems all over the world that varied from simple two to three components, to complex home gardens which could contain more than fifty species and animals including fish (Fernandes and Nair, 1986 cited in Steppler and Nair, 1987).

The vast number of agroforestry practices and systems had to be classified so that more insight gained on the practices, new or modified systems could be designed to achieve the same goals as the current and to possibly introduce systems with additional functions such as soil erosion control and improvement of soil fertility (Steppler and Nair, 1987). Some classifications were based on role of components such as increased overall yield of the land, temporal arrangement of components, yet others tried to integrate several of these criteria in simple hierarchies. In all, Nair (1993) suggested that the most preferred criteria for classification should be:

- Functional basis - role of the system

- Socio-economic basis - level of inputs of management, intensity or scale of management and commercial nature or goals
- Ecological basis - environmental condition and ecological suitability of systems
- The structural - composition of the components that includes spatial, vertical stratification and the temporal arrangement of the different components. The above classifications are neither mutually exclusive nor independent.

These broad classifications can be further narrowed down based on the nature of the components so as to give criteria that are simple, purpose-oriented and pragmatic. The three major categories according to Nair (1993) are:

- Silvopastoral - tree and pasture/animal/interaction
- Agrisilvicultural - tree/crop interaction
- Agrosilvopastoral - tree/crop/animal interaction

Nair (1989; 1993) points out that current agroforestry systems and practices in the tropics and sub-tropics, have a close relationship with ecological characteristics of a region and will be divided into the following types: shifting cultivation, taungya, plantation-crop combinations, multi-layer tree gardens, intercropping systems, silvopastoral systems, windbreaks and shelterbelts, multipurpose trees and soil conservation hedges. As a site-specific technology, agroforestry needs to be developed according to the location of people's requirements (Singh *et al.,* 1995; Tewari, 1995).

The system allows farmers to diversify their production ultimately reducing the risk of total crop failure and increases income potential of the farmer. Currently, agroforestry is viewed as a set of distinct prescriptions for land-use. This view falls short of its eventual potential as a way to take the edge off deforestation and thus assuage poverty (Leakey, 1996). Leakey suggests that agroforestry is a phase in the development of a productive agro-ecosystem that shows dynamism and therefore it be defined anew as "*a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangelands, diversifies and sustains smallholder production for increased social, economic and environmental benefits*".

1.3.4. Benefits of Agroforestry

Agroforestry practices contribute to a wide range of products and services. Agroforestry systems are decision-making units that correspond to specific or generalised agroforestry land utilisation types designed to meet farmers' objectives (Tewari, 1995). These benefits include:

- Trees on agricultural fields have been considered as savings and as insurance against risk of crop failure or low yield of field crops (Nair, 1993).
- As a multiple land-use system, agroforestry is capable of meeting the challenges such as improvement of agricultural land, environmental degradation, shortage of wood-based resources and even protection of watersheds that are currently problematic (Tewari, 1995).
- Compared to monocropping where only one type of product is obtained from a unit of land, agroforestry has immense potential through multiplicity of products from same land unit and therefore it can ensure a stable and sustainable production as well as ecological security (Tewari, 1995).
- Agroforestry is an approach to solving problems created by the pressure to convert upland forests to crop production. It allows production of multiple products and helps to maintain the stability of watershed (Juo and Freed, 1995).
- Selection of the right type of tree and planting configuration, can minimise run-off, increase income diversity for the farmer and can enhance nutrient availability to crops (Nair, 1984 and Kang *et al.*, 1985 cited in Juo and Freed, 1995).
- Trees also sustain rural based household economies through provision of products like fuelwood, fodder and activities that provide employment opportunities to community members among others (Arnold and Dewees, 1997).
- Agroforestry combines erosion control and production so that it becomes acceptable to the farmers and unlike conventional techniques, it is affordable to the small-scale farmers to implement (Young, 1989). Trees

on conservation structures have a direct and supplementary function. Direct uses include: Increased soil cover by litter and prunings, provide partly permeable hedgerow barriers, progressive development of terraces through soil accumulation upslope of hedgerows and increases soil resistance to erosion by maintaining of soil organic matter. Supplementary tree uses include: stabilising earth structures such as terraces, ditches and grass strips by root system, the productive use of the land occupied by conservation works and reduced deterioration of water quality and quantity (Young, 1989; Evans, 1996).

- Trees also serve a psychological function by making it more likely that the structures and the long-term presence of trees makes them an integral part of soil conservation hence will be perceived as beneficial and thus maintained (Young, 1989).
- Agroforestry has the potential to increase effective production space through vertical expansion of the three dimensional arrangements and through the functional exploitation of niche in rural land use systems. It can achieve synergy through creative placement and management of trees, crops, pasture and animals in more tightly integrated systems (Young, 1989).
- The tree component in agroforestry is more efficient in capturing and recycling of nutrients, creates hospitable micro-climates for under storey plants, staggers timing of management tasks and multiple products harvested as well as greater overall value and diversity of products (Rocheleau, 1984 cited in Buck *et al*., 1999; Evans, 1996). Evans further adds that the planting of trees to provide animal feed especially in dry regions where grass is not always available is an important additional form of integration between farming and forestry.
- Agroforestry serves to diversify the output from farms to a broader economic base with greater food security and provides services that include shade, windbreaks, weeds, erosion control and maintenance and improvement of soil fertility (FAO, 1989 cited in Young, 1997). It has the potential to play an important role in avoiding land degradation and achieving sustainable land use with beneficial effects like watershed protection and regulation of water flow, absorption of rain and evaporation

and protection of agricultural lands downstream (Cooper *et al.*, 1996 cited in Young, 1997).

- By complexing aluminium ions, trees make nutrients available to plants. Many observations on soil fertility improvement by nitrogen fixing trees show that the 'tree effect' results from the cumulative benefits of factors like biological nitrogen fixers, nutrient cycling and its accumulation under trees via excreta from animals and birds that take shelter under or in the trees (Buck *et al.*, 1999).
- Agroforestry practices such as home gardens can offer the poor, especially women and those from marginal communal lands, many benefits such as reduced workload. Women are known to carry large headloads of fuelwood for many kilometres in deforested areas (ILO, 1966 cited in Dankelman and Davidson, 1997).

According to the world strategy programme on environmental conservation, its objective is to maintain essential ecological processes and life support systems through maintenance of soil fertility and soil structure by soil regeneration and protection by forest conservation, water management and the prevention of water and air pollution. As such, agroforestry fits in well with the goal (Dankelman and Davidson, 1997). However, Kelty (1992 cited in Ashton and Montagnini, 2000) argues that agroforestry may produce products and services but the main interest frequently has been with food crops, particularly in modern research and development efforts, due to their higher value. Agroforestry is a logical extension of agricultural intercropping and hence development of appropriate technology depends on understanding the processes affecting sustainable production.

1.4. Factors that Influence Farmer Participation in Agroforestry Practices

Despite many agroforestry benefits and its wide agro-ecological distribution, Nair (1993) cautions that the type of agroforestry system found in a particular area is not only determined by agro-ecological but also by socio-economic factors such as availability of labour among others.

1.4.1. Land and Access to Property on Land

Research carried out on agroforestry practices in a number of countries indicate that the complex relationship between land ownership and access to resources on that land influences farmer participation in agroforestry activities, and vary from one community to another. In most countries, a large majority of the population depend either directly or indirectly on land for their sustenance and therefore a change in the distribution of land ownership or in peoples' rights to use it frequently results in major changes in patterns of land-use, agricultural productivity and even settlement (Caldwell, 1999).

Different communities have different ways of claiming rights to land and accessing property on it. These rights of access have often been overlooked in land tenure reform programmes leaving conflicts to be resolved by customary laws. This has resulted in rights of individuals or communities to trees and tree production being less clear than the rights to land. As a basis of agroforestry development, rules of use and access must be clear (Rocheleau, 1988).

Land tenure and its associated problems have long been recognised as some of the most difficult obstacles to development in the tropics (Phillips, 1966 cited in Evans, 1996). A well-functioning land tenure system should provide security of tenure for stakeholders so that they can gain adequate livelihoods and promote productive and sustainable use of resources (Evans, 1996). In a survey in Zimbabwe, it was observed that land and tree tenure are often not synonymous in that different people may have rights to the trees and to the land on which they grow (Nhira and Fortmann, 1993). It is also essential to understand land tenure and community organisation because farmers are only motivated to plant trees for sustainable development if they are assured of land (Cook and Grut, 1989; Tengnas 1994). However, in parts of India for example, uses of trees on private land may be governed by rules, which are collectively designed, managed and regulated through social and economic sanctions. Therefore, land privatisation is not the complete answer to sustainable agroforestry-based land-use (Singh *et al.*, 1995).

Ashton and Montagnini (2000) contend that in the agroforestry context, local inhabitants must be considered not merely as beneficiaries of some outside design process, but as participants. A critical step in technology transfer is to identify who the participants are because property rights, land tenure and social regulations vary widely and may dictate different roles for different participants and often lead to controversy over resource use and allocation.

As observed in SriLanka by Gunasena (1995), constraints to adoption of agroforestry include socio-economic factors such as land availability, sources and amount of family income and household requirements. Farmers would rather plant crops for food than trees because of their small parcels of land. In cultures where a group such as a clan controls land, individual tree planting may be considered anti-social because user-rights are individualised on a short-term basis as a result of land tenure being controlled by the clan. For example, certain ethnic groups in Cameroon plant trees to secure land-use rights (Hoskins, 1987). However, in some instances, cutting of trees is a way of securing land-use, as practised in Mauritania (Colfer, 1982, cited in Pimentel and Kidd, 1992). Therefore understanding the details of the existing systems of property rights is an important factor in the functioning or adjustment of an agroforestry system.

Kenyan communities have varying traditions, values, community organisations and levels of development. Therefore when dealing with agroforestry issues, socio-economic factors such as land and tree tenure, gender roles, traditions and beliefs, policy and legislation and the economics of agroforestry have to be taken into consideration (Tengnas, 1994). Although literature is replete with reports that private land ownership is an incentive to farmer participation in agroforestry practices, Barraclough and Ghimire (1995) have however observed that even in areas where private land ownership has been widely introduced as a matter of national policy as in Kenya, customary tenure continues to be influential. The same observation was made in studies on land titling in Kenya that showed among other things that productivity and holding of title deeds were correlated although potential beneficial effects of land titling were available only to farmers already well-positioned in relation to market opportunities. Differences in cropping patterns and choice in technologies due to differential access to land, labour, capital, and insurance, weighed down these potential effects (Carte, Wieber and Blarel, 1994 cited in Maxwell and Wieber, 1999). This study will therefore attempt to clarify whether private land ownership as a secure way of land tenure indeed influences adoption and subsequent farmer engagement in agroforestry activities.

1.4.2. Availability of Farm Labour

Labour is a crucial factor in small-scale production systems because most or all members in a community undergo the same labour demands during the same periods of time. At such like time, cash or paid labour is not available. Studies in the Mantaro valley in Central Peru, showed that farmers were not able to adopt improved agricultural technologies because these new alternatives required more inputs such as labour that farmers had no access to (Chambers *et al*., 1989). Labour is sometimes categorised by age and gender of contributors and is the most important input used on small or subsistence farming (Nair, 1993). It is estimated that labour represents 80-85% of the value of all farm resources utilised in traditional agricultural systems (Stevens and Jabara, 1988 cited in Nair, 1993). Therefore if family labour is employed, there will be an opportunity cost for farm-family employment on-farm.

Agroforestry interventions result in change to some degree in utilisation or demand for labour. It may improve its use efficiency during and/or under employment but it can be a constraint when it is in short supply as in adoption of certain practices e.g. alley cropping (Arnold, 1983 cited in Nair, 1993). In Central Tanzania for example, scarcity of natural woodland resources results in use of up to 250-300 man days for fetching firewood per household per year and therefore planting woodlots near a village, could reduce time spent in collecting firewood and more given to other domestic work such as cultivation and food preparation (Evans, 1996). Related observations on incentives to become involved in agroforestry practices indicate that gendered-roles determine farming activities such as tree planting.

1.4.3. Gender and its Role in Farmer Participation in Agroforestry

Throughout the world, people have experienced a profound shift in the division of land, labour, markets, and organisational affiliations as members of communities and households based on dimensions like gender to an extent that rural people find themselves repositioned relative to each other, to the larger economy and to the ecosystem that support them from their homesteads to the global environment (Rocheleau 1984 cited in Buck *et al.*, 1999). As a result different societies show different responsibilities, user rights and decision-making based on gender.

Gender roles in a household were observed as early as 1935. Gender is a social and psychological trait associated with being masculine or feminine and is therefore socially and culturally determined (Popenoe *et al.,* 1998). According to Mead (1963 cited in Popenoe *et al*., 1998), the males of the Tchambuli of New Guinea stayed home and raised children while the females were the economic providers. As a social characteristic, women and men often play distinctly different roles in communities although it is argued that the changing household and community structures in Africa arising from increasing number of female-headed households are changing women's roles so that in some cases, women are performing men's duties (ICRAF, 1997; Wilde and Mattila, 1995).

As pointed out by Fortmann and Rocheleau (1984), women have traditionally played important roles in agricultural production and in the use and management of trees. However, their importance has often been obscured by myths that include: women, being housewives, are not heavily involved in agricultural activities; women's participation in tree use and production is not significant; every woman is part of a household; and that women are not influential. In certain cultures, men rarely plant trees while in others women have to get permission before using and/or cutting a tree. This has been attributed to cultural division of household activities based on gender (Arnold and Dewees, 1997). Under such cultures, men are not willing to plant trees for products such as firewood because it is the duty of women to fetch it. Even if a woman was willing to plant trees, she may be rendered powerless because it is men who often control resources. Unfortunately, such practices are prevalent even under matrilineal system of inheritance as noted in Malawi and Zambia (Arnold and Dewees, 1997).

As reported by Atta-krah (1989 cited in Nair, 1993), alley cropping was adopted by more farmers over a two-year period in south-western Nigeria compared to a similar site in the south-east Nigeria. The low acceptance in the south-east was attributed to the customary (gender-based) decision-making within the households that were dominated by men. Understanding a community's social structure therefore is vital before embarking on any development activity that may negatively affect a section of the community especially the vulnerable groups like women (Arnold and Dewees, 1997).

1.4.4. Level of Farmer Education and Training and its Effects on their Participation in Agroforestry in the Study Area

Education is the general learning process associated with formal schooling while training is the process of teaching specific functions and skills (Gregersen *et al.*, 1989). Access to technology is essential as a tool to sustainable development. Technologies or information are better understood or can be translated into action by the targets such as farmers if they are better educated. Indeed Campbell *et al.* (1993) emphasise that education among other factors are crucial in farmer engagement in agroforestry activities and therefore without information, tree-planting activities may be hampered. Farmers in states like Alabama use farm magazines and other media to learn about agricultural activities because they are able to read. But in developing countries where these magazines are either not available or are out of reach of many farmers, they rely heavily on other sources of information such as neighbours and extension services (Juo and Freed, 1995). With scarce resources in most economies such as Kenya's, it is a noble idea to educate farmers more, so as to enable them gather agroforestry-related information on their own instead of relying on extension services. This will be subject to having own personal interest however.

In a study of socio-economic aspects of *Grevillea* growing on small-scale farms in Kirinyaga District in Kenya, M'Mutungi (1991 cited in Tengnas 94) concluded that the species had a market but it would be adopted if educated farmers could be taught how to manage aspects such as timber quality and general silvicultural management. Therefore knowledge of a considerable number of ways of production enables a farmer to compare the present methods of farming or farm practices with the alternatives. This goes hand in hand with skills necessary for decision-making therefore putting them into action. One has to have an open mind and ability to influence ideas in order to usefully recognise problems, observe facts and analyse and specify alternatives. Based on the literature, it remains for this study to establish influence if any of formal knowledge on farmer engagement in agroforestry in the study area.

1.4.5. Improved Extension

According to Chavangi and Zimmermann (1987:8), extension forestry is "*an educational process whereby people are able to meet their needs for wood and other tree products by practising farm forestry or by simply planting trees. It combines technical, psychological, sociological, and institutional as well as political tasks*". The success of any agroforestry programme is largely determined by the techniques used by the extension agent.

Several forestry-related extension approaches have been put forward. They include (FAO, 1988 cited in Anderson and Farrington, 1996):

- *The general extension approach.* The approach assumes that despite existing knowledge and technologies, local people are not using land improvement strategies. The process is fairly centralised and government-controlled.
- *The commodity specialised approach.* Oriented towards one commodity, the extension agent has many duties and functions and it is fairly centralised
- *Training and Visit approach.* Extension agents are involved in technology transfer, planned schedule of visits to farmers and training of agents and it is fairly centralised.
- *The agricultural extension participatory approach.* Focuses on expressed farmer needs and it is often decentralised.

- *The project approach.* It is time and location-specific with techniques to demonstrate for other farmers to adopt later.
- *The farming systems development approach.* Involves a holistic approach locally and develops local needs on the ground.
- *The cost-sharing approach.* Shares costs with farmers and provides mainly advice and information that facilitate farmers' self-improvement.
- *The educational institution approach.* Uses educational institutions that have technical knowledge and some research ability to provide extension services.

Anderson and Farrington (1996) suggest that extension should be customised to the local situation and should be demand-driven for success to be achieved. The method employed to pass on the message will also depend on the specific goals and prevailing conditions or circumstances at that time (FAO, 1987).

As Chambers *et al*. (1989) contend, extension becomes more effective when adequate social and economic information about the local people to be involved is gained through participatory techniques such as RRA and PRA, so that the projects will be both acceptable and realistic and contribute positively to the living standards. In extension, it is worth understanding how local farmers use their trees based on indigenous knowledge lest funds are wasted on what might not be adopted by farmers. Extension agents advise the farmers in several ways: mass extension, individual/household approach, group meetings, field days, field demonstration, and through institutions like schools (Tengnas, 1994). As a way of training farmers, forest extension is intended to raise awareness about social issues such as gender, its manifestation at the local level, and how its roles interact with forestry development (Wilde and Mattila, 1995). A successful small-scale social or agroforestry programme is usually preceded by a participatory rural appraisal to determine need, followed by campaigns (when and how to pass the message) to inform and educate the people who it is hoped will plant the trees, especially if the additional interest has not come from them. For example, successful tree planting programmes in Zambia used drama while in Sudan use of puppetry brought success (Skutsch, 1983 cited in Evans, 1996).

Encouraging farmers to teach outsiders how to carry out activities such as tree planting and tending and in turn outsiders can offer suggestions for improvement if necessary, has been found to be among effective methods (Chambers, 1990 cited in Evans, 1996). In Zimbabwe, for example, a conservation tillage project was successful to an extent that it spread to other areas that included agroforestry because right from the on-set of the project, farmers were involved in research and extension. This lowered potential barriers to the application of the results and increased adoption rates (Enters and Hagman, 1996).

In Haiti, the agroforestry outreach project by Cooperative for American Relief Everywhere (CARE) and Pan American Development Foundation (PADF) planted 25 million seedlings between 1982-87 through 110 000 farmers with 39 nurseries. Its success through better extension methods was attributed to sociological studies of past failures, implementation by Non Governmental Organisations (NGOs), extension agents who knew each participant well and both gathered information and provided advice, use of many small-scale nurseries to produce small easily transportable seedlings and promotion of agroforestry leading to supply of over 40 tree species instead of the initially planned 5 species (Conway, 1988 cited in Evans, 1996). Conway did not give the survival percentage of the planted seedlings however. Through appropriate extension techniques that advise and train, farmers are encouraged to engage in tree-planting activities (Evans, 1996; Barraclough and Ghimire, 1995).

1.4.5.1. Poor Extension Methods

Despite such success stories, it is difficult to find general agroforestry technologies and practices to promote, at the same time demonstrating how they can advantageously be integrated into rural people's farming and livelihood systems. Many agroforestry programmes have tended to be small and site-specific. This is attributed to administrative, operational and financial problems such that information gets confined to small pilot plot scale on the ground (Barraclough and Ghimire, 1995). Some agroforestry undertakings have been known to fail due to poor prescription and practices with implementation running ahead of capability to provide adequate extension and technical packages and without sufficient regard being paid to institutions constraints and possibilities (Arnold and Dewees, 1997). They also fail because they do not target those in need i.e. the poor, the less accessible and the landless, but rather the rich who are facing no immediate need since they can purchase tree products. The poor can therefore be reached by including low costs of entry, short waiting period until cash returns begin, market channels, market information and help in marketing specifically for the small-scale producers (Arnold and Dewees, 1997; 1998). Therefore more effective extension techniques need to be developed in order to transfer new knowledge from research stations to the farm level (Cook and Grut, 1989).

Extension efforts so far have indicated that farmers rarely plant trees for firewood as they consider it a by-product. Such was observed in northern Senegal where social forestry programmes initiated with fuel wood as the objective, were not successful because the farmers were interested in fodder, shade, fruit and gum trees. To the farmers, fuel wood was a by-product (Hoskins and Guigorio, 1979 cited in Barraclough and Ghimire, 1995). It is therefore necessary that appropriate extension techniques that meet the farmers' needs and expectations be used in promoting interventions especially if the household head is a man since men present their cases and forget about women's and children. This calls for a need to involve the whole family in the discussion (Tegnas, 1994). In support of this sentiment, FAO (1987) assert that traditional individual or communal work of the people, availability of land and clarification of benefits must be made known to the farmer before information is disseminated to them. There should also be infrastructure in place that favours the dissemination of the information (Juo and Freed, 1995).

Forestry extension workers in small-scale farming areas have acted in the past as transmitters of technical packages rather than facilitators and therefore change agents. Most foresters have been trained as managers of forests and forestry staff as well as engineers of a mono-crop and yet social forestry and agroforestry require interaction with farmers at the social level (Scoones *et al.*, 1993). Nowadays foresters are expected to work together with rural people, and therefore they are caught in two different roles. The extension agent should be aware that farmers have indigenous knowledge that can be tapped and by combining it with acquired school knowledge, the farmer's contribution can be a motivator (van Gelder and O'Keefe, 1995).

Enters and Hagman (1996) contend that a change of attitude and behaviour on the part of the extensionists is an essential determinant for success of any new approach given the observation that formally educated extension agents often find it difficult to accept farmers with their traditional knowledge system as equal partners and to learn from them. Without this acceptance, extension staff will play the inadequate role of messenger. By instituted a pilot study in Malawi and Uganda to ascertain, among other things the way information trickles down to the farmers as well as the quality of such information, ICRAF had realised that farmers in Africa have been by-passed by the green revolution and therefore were not benefiting much from recent farming technologies and improved crops (ICRAF, 1997). This clearly indicates that extension techniques in existence at the moment might not be diverse in their application and that is why it is part of the investigation.

1.4.6. Farmer Awareness on Costs, benefits and risks

Farmer decisions to engage in farm activities such as agroforestry are influenced by a number of factors that dictate the costs and benefits based on relative returns from trees as compared to returns from alternative uses of the resources available to the farmer (Arnold and Dewees, 1997; Nair, 1993). Tree planting entails an opportunity cost of up to six years. Therefore it can easily be taken on by the wealthy since they can accommodate risks such as availability of seedlings, their quality, labour availability and markets. When the opportunity cost of land and risks is high, the wealthy, the labour constrained and the non-resident farmers tend to plant trees. This implies that farmers use trees and their products as a tool in risk management (Chambers and Leach, 1987 cited in Arnold and Dewees, 1997). Aspects such as whether tree components will complement or supplement annual crops to increase yields and subsequently cash income that translate into beneficial effects to family and group livelihood systems are of paramount importance (Barraclough and Ghimire, 1995). For example, farmers are not willing to introduce new agroforestry species into their fields such as those that are shallow rooted or those that can turn into weeds (Tengnas, 1994).

There is need therefore to determine ways in which limited or scarce resources can best be allocated to fulfil the competing wants and needs of a society and to demonstrate to decision-makers the possible repercussions or trade-offs which will result from alternative courses of action. To a farmer, it helps ascertain whether agroforestry implementation will provide greater productivity, farm income and improved social well-being as compared to the more traditional land-use agricultural activities.

In southern and western India for example, farmers planted *Eucalyptus* species in place of the more risk bearing crops such as groundnuts whose prices are unpredictable (Tewari, 1995). In western Rajasthan, farmers have been able to cope with unreliable rainfall by adopting a strategy of mixing extensive and intensive land uses such as by crop fallow rotation, complementary use of annuals and woody perennials with the latter providing reserves of fodder and other biomass in years of poor harvest since trees can be sold (Arnold and Dewees, 1997). Therefore provisions have to be made for such factors considering that agroforestry is a long-term venture (Nair, 1993).

Farmers are motivated to plant trees if production costs and recurring expenditures are low with minimal labour requirement to ease management (Tewari, 1995). A rural survey conducted to ascertain adoption of agroforestry in Bendel state of South Central Nigeria found that social acceptance of agroforestry depended on establishing cost-sharing devices such as free seedlings and availability of less competitive tree species between rural farmers and the government. Therefore tree benefits should exceed those offered by alternative land options (Osemebo, 1987 cited in Nair, 1993).

1.5. Agroforestry in Africa

Agroforestry, as previously thought by some scholars, is not a land use practice for marginal areas only but rather most people see it as a humid area solution. Several traditional agroforestry systems have sustained people for generations in a variety of African environments depending on the climate and soils as exemplified by the Chagga home gardens in northern Tanzania (Nair, 1989). The homegardens are a multi-storey agroforestry cropping system that embodies a variety of multipurpose trees and shrubs in simultaneous combination with animals and/or food crops on the same piece of land. The diversity under homegardens provides crops both for subsistence and cash and enables farmers to keep open their management options. With this system, farmers are 'insured' against adverse environmental and economic effects (Fernandes *et al*., 1984). Associating agroforestry with cropping systems and environments of the humid regions however, often led to agroforestry projects based on species and practices that do not meet the needs and conditions of the people in other types of environments (Rocheleau *et al.,* 1988).

A successful traditional agroforestry system in semi-arid Africa was agro-sylvopastoralism as practised by the Fur people on the lower slopes and highlands of the Jebel Marra massif, Sudan. It involved terracing village fields for rain-fed, semi-permanent millet and other subsistence crops under multipurpose tree species dominated by *Cordia abyssinica*, *Ziziphus spina-christi* and *Faidherbia albida.* For centuries, the retained trees provided wood, food and fodder to the densely settled people although they have reverted to shifting cultivation at present due to out-migration (Miehe, 1989). The *Faidherbia albida* species is leafless during the wet season, which reduces competition with annuals for light and moisture; it is a nitrogen fixer and adds green manure to the fields. *Cordia* species on the other hand, is a dry-season fodder for livestock while *Ziziphus* is browsed by livestock, produces edible fruits and its thorny branches are used as a fence (Kidd and Pimentel, 1992). As an agrosilvopastoral system species, *Faidherbia albida* was intercropped with millet and sorghum in West Africa. The pastoralists realised that the tree did not compete with the annual crops for light since it only shaded its leaves at the beginning of the wet season and that the species provided shed to livestock during dry season hence animal droppings provided manure while the pods were forage for the livestock (Miehe, 1989).

In South-eastern Nigeria, compound farming is being practised. It is a home garden-type of agroforestry system involving trees and shrubs being managed with agricultural crops and small livestock deliberately within individual compounds. This system is important in conserving germplasm of useful trees and shrubs that are on the verge of getting extinct. Apart from that, risks are minimised, improved labour and nutrient-use, diversified production and also soil is conserved (Okafor and Fernandes, 1989).

A well-known southern African agroforestry system is the *chitemene* system practised by the Bemba people in northern Zambia. *Chitemene* is a type of shifting cultivation where land is cleared for cultivation and the felled trees are burnt. The ashes provide additional nutrients in the inherently infertile soils, which allows cropping to be done for a few years. Once fertility diminishes, cultivators move to a new area leaving the cleared area to fallow. This is a complex system with numerous subsidiary and main crops grown together in a mixture (Tewari, 1995).

In Rwanda, farmers have shown that as a low input technology, agroforestry can alleviate land and subsequently food shortage. By practising organic agriculture such as homestead farming, they are able to derive food, fodder and tree crops. These farmers practise intercropping, crop rotation and alley cropping with leguminous trees and shrubs and utilise planted "fallow" (Balasubramanian and Egli, 1989). A variety of trees, such has *Cedrela serrulata*, *Grevillea robusta*, *Maesopsis eminii*, *Erythrina abyssinica*, *Markhamia lutea* and *Sesbania* species among others are incorporated into the farm management system. They are found along roads and paths, in woodlots, dispersed among crop fields, demarcate property boundaries and they are also found in grazing areas. The trees serve to provide wood, mulching material, cash income, and fodder. Hence they diversify products and save on expenses for basic necessities (Kidd and Pimentel, 1992).

With the 'new' agroforestry, some modern agroforestry practices such as alley cropping are being tried and are proving successful in several regions. This practice is being improved as a response to population pressure on resources such as land that is decreasing in size. The technique involves growing crops between hedgerows of planted shrubs and trees preferably leguminous species, which are pruned after a certain period of time to reduce shading effect. Prunings can be a source of mulch while legumes fix nitrogen. Such a practice is showing some success in Machakos, Kenya (Kang and Wilson, 1987). In Ibadan Nigeria, trials of species such as *Leucaena leucocephala* and *Gliricidia sepium* in alleys have been shown to supply between 100-200 kg of nitrogen per hectare per year as green mulch that is left on the farm. This was found to be equivalent to the nutrients removed during harvest (Young, 1989).

In eastern and northern Zambia, short rotation fallows with *Sesbania sesban* are being adopted as a strategy to increase food production through increased soil fertility (ICRAF, 1998). This is an improvement of the traditional agroforestry practises such as the *chitemene* system that required long fallow periods. In other parts of Africa such as in Cameroon, species such as *Calliandra* and *Cajanus cajan* on improved fallows are proving to be popular for increased soil fertility and provision of products such as fuelwood and services such as windbreaks (ICRAF, 1997).

1.6. Agroforestry in Kenya

Surveys done by Tengnas, (1993; 1994) show that traditionally, trees have played important roles in land use systems of East Africa for centuries, long before the colonial era. Land use combined subsistence agriculture and pastoralism. The low population density at that time coupled with long fallow periods favoured shifting cultivation and extensive grazing. Within the same unit area, varieties of crops such as sugar cane, millet, sweet potatoes, cassava, bananas, tobacco and yams were grown in a sustainable agricultural system. Communities within this region also utilised trees for shade and medicine for livestock and humans, fuel wood, fodder and construction material among others (Tengnas, 1994).

Colonisation brought with it agricultural practices that were more harmful to the environment compared to the previous traditional systems. Large tracts of previously forested areas were converted into agricultural land by planting cash crops such as tea and coffee, and the savannas and grasslands that served as seasonal grazing fields for the communities were opened up for large-scale agriculture (Tengnas, 1994). Such monocultural practices of agriculture led to clearing of trees, which decreased the diversity of both flora and fauna. Species diversity was further reduced through the introduction of exotic trees for woodlots and windbreaks, using tree species such as *Cupressus lusitanica* for timber production, *Acacia mearnsii* for production of tannin, *Eucalyptus* species for fuelwood and draining swampy areas around Nairobi and *Grevillea robusta* as shade for coffee (Tengnas, 1993; 1994).

Indirect deforestation and land degradation resulted from restriction of Africans to the infertile 'reserve' areas, and the declaration of the fertile areas as 'White Highlands' by the colonial government. This act shortened traditional fallow periods since the available area for shifting cultivation in the now relatively crowded 'reserves' was insufficient (Tengnas, 1994). Extensive opening up of new areas for cultivation as well as the cultivation of marginal areas in these 'reserves' caused scarcity of tree products and environmental problems such as soil erosion and decline in soil fertility (Tengnas, 1993).

In order to encourage farmers to plant trees, the Government of Kenya, through the Department of Forests, created the Rural Afforestation and Extension Services (RAES) in 1971 to oversee production of seedlings for distribution to the people. RAES was later changed to the Forest Extension Services Division (FESD) so that its initial role of executor could be turned to that of a facilitator (Tengnas, 1993). FESD is charged with the responsibility of encouraging farmers to produce seedlings and plant them on their farms, involving more participation by farmers than in the past (Tengnas, 1993).

Through their sessional paper[2] No. 1 of 1986, the Government of Kenya identified national priorities and objectives for agroforestry development, recognising the role of agroforestry in land resource management. The plan aimed at converting approximately three million hectares of land into agroforestry-related land uses in the high potential agricultural areas, sustaining crop productivity, satisfying demand for wood-based products and converting surplus wood products into cash supplement to the rural economies (GOK, 1986). The sessional paper also aimed at encouraging planting of trees by the communities in semi-arid areas so as to boost their wood-based supply and prevent overexploitation of the existing vegetation cover, ensuring protection of marginal lands, watersheds and forest reserves against unsustainable exploitation of its vegetation cover (GOK, 1986).

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1. Government document outlining plan of action in a particular sector of the economy.

The Government's interest in agroforestry was further strengthened through the second national seminar on agroforestry in 1988 that brought in many key players including various ministries, non-governmental organisations, international research institutes and even universities. Since then these bodies have been cooperating in agroforestry research and dissemination of the findings (Huggan and Wesley, 1988). Such policy changes have over the last few decades seen farmers, particularly in the high potential areas of eastern and central provinces of Kenya, practise intensified tree-crop combinations, especially the use of species such as *Grevillea robusta.* In many parts of western Kenya, *Eucalyptus* species are commonly grown in the form of woodlots (Tengnas, 1993).

Due to secure and clear tree and land tenure and a relative freedom to harvest and sell tree products, Kenyan policy on tree planting is favourable compared to other eastern Africa countries. However, slow subdivision of farms and issuing of title deeds as well as the Chiefs' act, which regulates tree cutting within farmers field, are disincentives at present. Despite farmer efforts, there is much room for improvement (Tengnas, 1994).

The main agroforestry systems in the tropical highlands of Kenya are production systems involving plantation crops such as coffee and tea, or systems using woody perennials in soil conservation and soil fertility maintenance and in improved fallows and silvopastoral systems (Nair, 1993). Other agroforestry systems and practices include: woodlots, boundary, windbreaks and homestead planting as practised in the high potential areas (Chavangi and Zimmermann, 1987; Arnold and Dewees, 1997). In dry lands, agroforestry systems more often include dispersed trees on croplands combined with rangeland management (Rocheleau *et al.,* 1988).

Some of the agroforestry systems in Kenya include the taungya system, which was introduced in the country around 1910, when it became known as the *shamba system.* The clearing of indigenous tree species to pave way for establishment of plantations of exotic tree species in the Kenyan forests used this system since it provided cheap labour to the Forest Department from resident cultivators. Resident workers were allowed to plant annual crops as well as planting tree seedlings within the same land unit. As the trees grew the canopy closed and the cultivators had to move to new areas to clear the vegetation for cultivation. This agroforestry system was used in the densely populated Kenyan highlands with their fertile, volcanic soils (Kiriinya, 1994).

Shamba system was banned by the Government in the mid 1980s as a result of abuse of the system but re-introduced in 1995, and renamed non-resident cultivation since cultivators lived outside the forests. Under the current system, farmers are allowed to cultivate areas that have been clear felled by licencees for as long as the Department of Forests has not replanted. The fee paid is based on size of the plot. In case it is replanted, cultivators continue growing crops and tending of tree seedlings until the tree canopy closes then they are allocated new areas (Kiriinya, 1994).

Other traditional agroforestry systems in Kenya include sylvopastoral systems as practised by the pastoral communities. The Turkana people of Kenya are well-known for their indirect dependence on indigenous woody perennials through the consumption of livestock products such as meat, milk and animal blood. The interaction between trees/shrubs and livestock is a common source of livelihood to the people living in marginal areas (Kidd and Pimentel, 1992). However, these traditional methods are breaking down due to exponential growth in population numbers, and there is now a need to encourage people to participate in agroforestry activities in many parts of the country.

1.7. Problem Statement

East Africa's high population growth rates have increased pressure on the natural resources to an extent that agricultural land use systems have expanded into marginal areas (Arnold and Dewees, 1997). One feature of farming in these areas is that soil fertility is seriously depleted and that farmers often lack cash to buy commercial fertiliser and there are neither government subsidies nor credit schemes that function well (Buck *et al*., 1999). As cropping gets intensified in eastern Africa, loss of soil nutrients becomes a basic problem for farmers and prompting the need to find ways of retaining and or restoring lost fertility so as to increase food crop production (Rao *et al*., 1998).

Kenya's economy largely depends on agriculture for growth and development and yet only 20% of the total land area lies in high potential farming areas that support 80% of the total population and 50% of the total livestock in the country. The high population concentration on high potential areas has put pressure on land and other resources to an extent that general land degradation and deforestation has reached an alarming rate (GOK, 1996a). The former 'white' highlands, (study area) cultivated commercially for crops by settlers prior to independence, suffered from clearing of vegetation including the trees to pave way for movement of machinery during farming operations and for establishment of exotic trees in the plantations (GOK, 1996). To date, most of the lands suitable for rain-fed agriculture as well as the marginal areas are still under cultivation. Population density is increasing in Moiben and Ainabkoi Divisions as a result of natural births and immigration from other districts in search of jobs and at the same time, land fragmentation for sale and for inheritance is on the increase.

There is need to reduce local communities' reliance on Kenya's gazetted forests so as to stave off the pressure on the resources, and contribute to their sustainable utilisation (1996a). At the same time, the demand for food in the study area is increasing exponentially but food production experiences periodic drop in yields (GOK, 1996). The diminishing life-supporting capacity of water bodies such as Lake Victoria is attributed to unsustainable farming methods and human population pressure in the catchment areas that has resulted in proliferation of water weeds such *Eichhornia crassipes* that are a threat to the livelihood of the lake communities as well as its ecosystem (GOK, 1999; Kirugara and Nevejan, 1996; Scheren *et al.*, 2000). This is despite Government's soil and water conservation efforts that started in the early 1930s after it was realised that cultivation practices in many parts of the country were negatively impacting on the environment (Ongugo, 1999 cited in Brown and McDonald, 2000).

There is therefore a need to adopt land-use systems that can withstand intense cultivation while at the same time maintain soil fertility in most regions of East Africa (Rao *et al.*, 1990). Farmers in the study area should be able to reap the benefits of engaging in agroforestry practices as their counterparts in areas such as Machakos

Kenya where escalation in land degradation and food shortage was already at critical stages even before independence due to population increase and 'unscientific' farming methods among other reasons (Tiffen, 1994 cited in WR, 2000). But after farmers in this region were introduced to agroforestry as a land management strategy, coupled their belief that trees bring rain and protect the soil from water and wind erosion, the problem was reversed (Gichuki, 1998). In western Kenya, farmers are now able to combat the crucial problem of soil fertility in the region. Through agroforestry options such as improved fallows using species such as *Tithonia diversifolia* (Amadalo *et al.*, 2000), *Tephrosia vogelii* and *Crotalaria grahamiana*, they are able to restore lost soil fertility and can increase food production and diversify sources of income within the homestead and the region as a whole (ICRAF, 1997).

1.8. Objectives of the Study

The aim of this study was to investigate the socio-economic factors that influence farmer participation in agroforestry activities in Moiben and Ainabkoi Divisions of Uasin-Gishu District. It had the following objectives:

I. To document socio-economic and land-use practices of the farmers in the study area.

II. To establish farmer perceived environmental problems in the study area.

III. To assess farmer awareness of and engagement in agroforestry practices in the study area.

IV. To identify factors that influence farmer participation in agroforestry and needs of villagers and ways of fulfilling them in the study area.

V. To establish impact of Forest Extension Services Division (FESD) in the past on farmer participation in agroforestry in the study area.

VI. To investigate users and uses of forest resources and its influence on farmer adoption of agroforestry practices as well as its effect on the environment in the areas under study.

1.9. Hypotheses

I. Farmers do not believe that soil erosion and pollution of reservoirs is exacerbated by agricultural activities in the study area.

II. For villagers, agroforestry in the future is a viable alternative, to increase soil fertility, reduce soil erosion, and for provision of woody resources.

III. Only awareness influences farmer engagement in agroforestry the study area.

IV. Socio-economic factors such as land and tree tenure, gender, education and training, labour availability, costs, benefits and, risks do not constrain adoption of agroforestry by farmers in the areas under study.

V. Forest Extension Services Division (FESD) agroforestry programmes have had significant impact on farmer participation in agroforestry practices in the study area.

VI. Local villagers do not plant trees for products that they perceive to still be available in the forest and that farmers do not perceive that there is over utilisation of natural woody resources in the study area.

1.10. Significance of the Study

At the end of the research exercise, the study will be able to make recommendations on the following issues:

- Reduced reliance on the gazetted government forests by communities within and outside the study area for fuel wood and other wood based products. By averting overexploitation of the resource base and reducing clearing for agriculture, fewer eroded sediments should filter into water streams and other water bodies.
- Less financial input from the state for policing of the protected areas (indigenous species) and at the same time maintaining biodiversity, especially of the endangered indigenous tree species.
- With participation of more farmers in agroforestry activities, it is expected that surface runoff emanating from agricultural fields will decrease, leading to

decreased siltation of water reservoirs and eutrophication of water bodies. It is also expected that more nitrogen fixing tree species will be incorporated into the crop field with an end result of less use of inorganic fertiliser that is acting as a pollutant. In turn, this is expected to enhance increased food crop yields, less money spent on purchasing fertiliser, a diversity of products from the same unit of land and less negative impacts on the sources of livelihood for the communities that rely on fishing. More so, unnecessary expenditure of large sums of money by the Government in clearing waterweeds such as *Eichornia crassipes* in lakes and de-silting dams will be avoided.

- As a potential source of wood products, more trees on farms will reduce time spent by farmers fetching firewood and other wood products away from their homesteads saving it for other economically productive work and that the sale of surplus wood products will enable them to meet their financial obligations and an improved livelihood at the end.
- The knowledge gap especially on socio-economic factors that influence farmer participation in agroforestry activities in the study area.

1.11. Thesis Structure

Chapter 2 describes the study area that includes its topography, vegetation and the agro-ecological zones. This intends to show suitability of the area to agroforestry activities. The chapter also details the research methods and how data was analysed as well as the demographic characteristics of the target group.

Chapter 3 details the research findings. It covers socio-demographic characteristics of respondents, awareness of agroforestry, experience from agroforestry participants and factors that hinder them from engaging more in agroforestry. This chapter also covers results from key informants and assessed resources.

Chapter 4 provides discussion of the results. It covers influence of land-use practices on the environment as well as effects of utilisation of natural resource by the communities on the environment. The discussion also focuses on influence of socio-economic factors on agroforestry activities in the area.

Chapter 5 concludes the findings of this research, gives recommendations as well as areas for further investigation.

2.0 Research Methods

2.1. Study Area

2.1.1. Location and Size

This study was undertaken in Moiben and Ainabkoi Divisions, being two of the six divisions of Uasin-Gishu District, Rift Valley Province in Kenya (Figure 2.1). The District is located on the western side of the Rift Valley Province. Moiben Division covers an area of 778 km^2 being 23.38% of the District's total area while Ainabkoi covers 472.5 km^2 being 14.1% of the total District land surface. They lie on the northern and eastern parts of the District respectively at longitudes 35°E -35° 30′E and 0°N-0°30′N for Ainabkoi while Moiben Division lies at 35°E-35°30′E and 0°30′N-0°58′N (GOK, 1996).

2.1.2. Topography and Climate

The District is a highland plateau with terrain that varies greatly with altitude. It ranges between 1500 m a.s.l at Kipkaren in the West to 2100 m a.s.l at Timboroa in the East. Ainabkoi Division is located on the highest part of the District with its altitude ranging between 1826 and 2100 m a.s.l. Moiben Division's landscape is that of undulating plateau with no significant mountains or valleys and therefore its altitude generally is 1800 m a.s.l (GOK, 1996).

Rainfall regime and amount is influenced by altitude and wind direction. The rainfall in the two divisions is high, reliable and evenly distributed with an annual average for the years 1991-1996 of 960 mm (GOK, 1996). It is bimodal with a first peak in April/May and a second in July/August. Generally, the wettest areas are found in Ainabkoi, Kapsaret and Kesses Divisions while Turbo, Moiben and Soy Divisions though not dry, receive relatively lower amounts of rainfall (GOK, 1996).

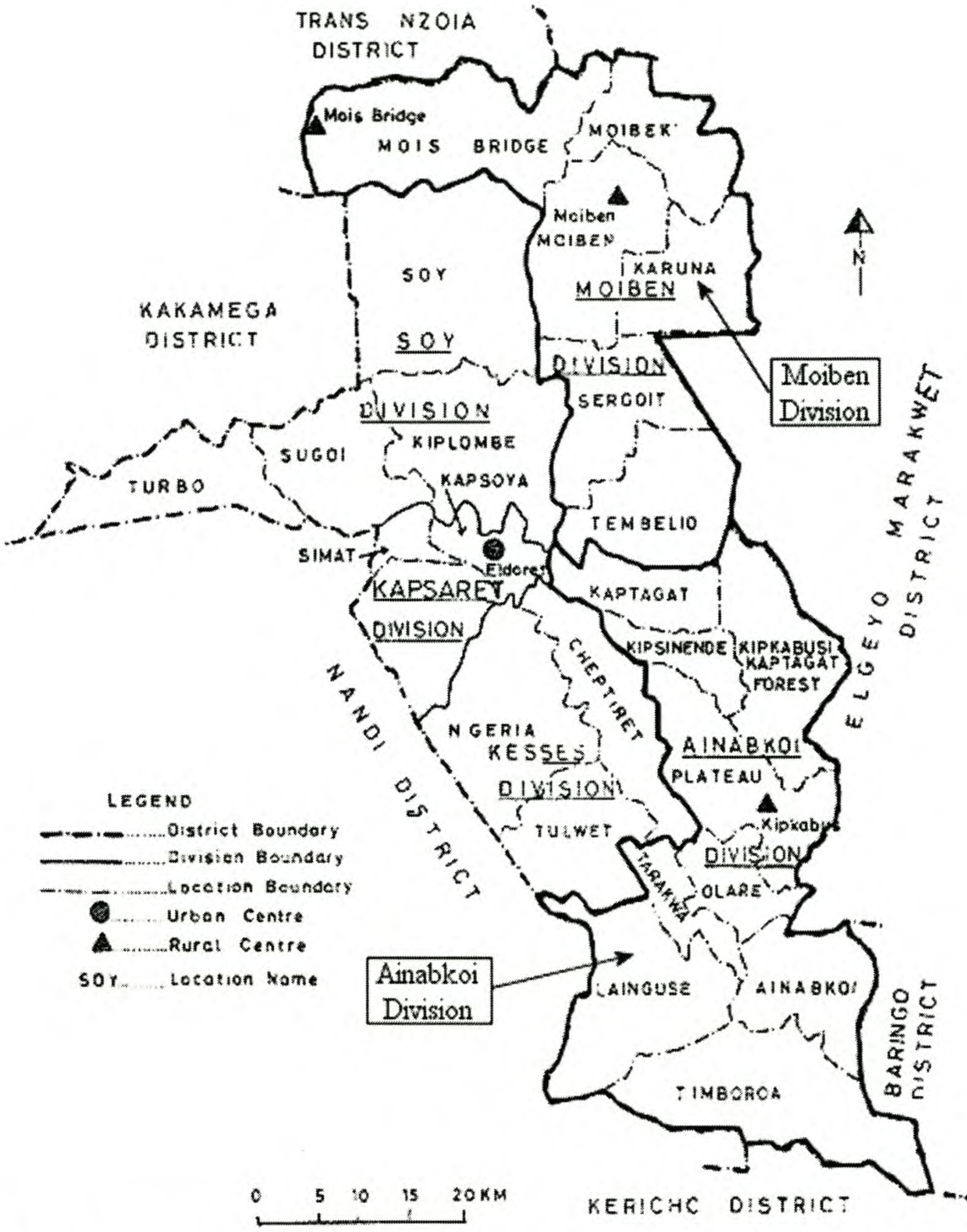

Fig. 2.1: Location of Moiben and Ainabkoi Divisions of Uasin-Gishu District.

Source: (GOK, 1996)

Due to the high altitudes of the study area, the temperatures are relatively low. The highest temperature of 26.1°C occurs during the month of February, being the hottest month during dry season, while the lowest temperature of 8.4°C is recorded especially in Timboroa during the rainy season in the month of July, giving an average temperature of 17°C. The variation in temperature and rainfall within the District can be explained by the relative location of the divisions to one another. The Divisions on the eastern side of the District are generally at higher elevations and hence the rest are at comparatively lower altitudes.

2.1.3. Land and Soils

There are four major soil types in Uasin-Gishu District. They are red loam, red clay, brown clay and brown loam (GOK, 1996). These categories vary with altitude, rainfall, temperature and the underlying rocks and hence determine the land use pattern within the various divisions in the District. While red loam soils are found in the upper parts of the District, the red clay soils that have murram close to the surface are concentrated in upper Moiben and other areas. These soils resulted from disintegration of basement rocks like granite and laterite. Brownclay soils found on the plateau are poorly drained and cover parts of Moiben Division. Brown loam soils are found on high altitudes of Ainabkoi among other areas. These soils are derived from both volcanic and basement rocks (GOK, 1996).

2.1.4. Vegetation

The natural vegetation comprises highland forest, tropical grassland and bushveld. The total forest cover in the District is estimated at 31 496 ha or 10% of the District land area (GOK, 1996). Forest areas (gazetted) are categorised into indigenous that covers 45.9%, plantation that cover 46.6%, bamboos covering 3.35% and treed grassland of 1.33%. Approximately 95% of the gazetted forests form part of Ainabkoi Division. The remaining portion consists of scattered woodlots on farmlands and *Acacia mearnsii* plantations previously owned by a private company, but now subdivided and partially cleared by the new owners. The major plantation species include *Cupressus lusitanica, Pinus patula* and *Pinus radiata*, with small areas of *Eucalyptus* species. However, as the pressure for land continues due to rising population, the forest resource is threatened as more people clear the vegetation to make room for cultivation (GOK, 1996).

Trees from the forest are used both for industrial and domestic purposes. In homes, they are used for fencing, fuel wood, and general construction and for medicinal purposes. With the realisation that fuelwood shortages were on the increase in the District, the Ministry of Energy in conjunction with the government of the Netherlands, established a woodfuel and agroforestry programme that is expected to boost tree planting on farms so as to alleviate fuelwood shortages in the rural areas (GOK, 1996). The impact of the project is yet to be felt. However, at present the Government of Kenya in collaboration with the World Bank, is engaged in catchment afforestation programmes in parts of Rift Valley, western and Nyanza Provinces with the aim of improving tree cover so as to avert the escalating soil erosion problems currently experienced in the region.

2.1.5. Agro-ecological Zones

Uasin-Gishu District has three major agro-ecological zones (AEZs). These are the upper highland (UH), upper midlands (UM) and lower highlands (LH) (GOK, 1996). Each zone is further subdivided into sub zones (Figure 2.2). A summary of climatic data is also shown in Table 2.1. In general, Ainabkoi Division receives more rainfall, it is more fertile and located at a slightly higher elevation hence cooler compared to Moiben Division (Rees *et al.*, 1997). From the AEZs, delineation indicates that the study area is situated in an agriculturally high potential region and hence agroforestry practices have a good chance of being practised despite competition from other agricultural activities with high and quick returns.

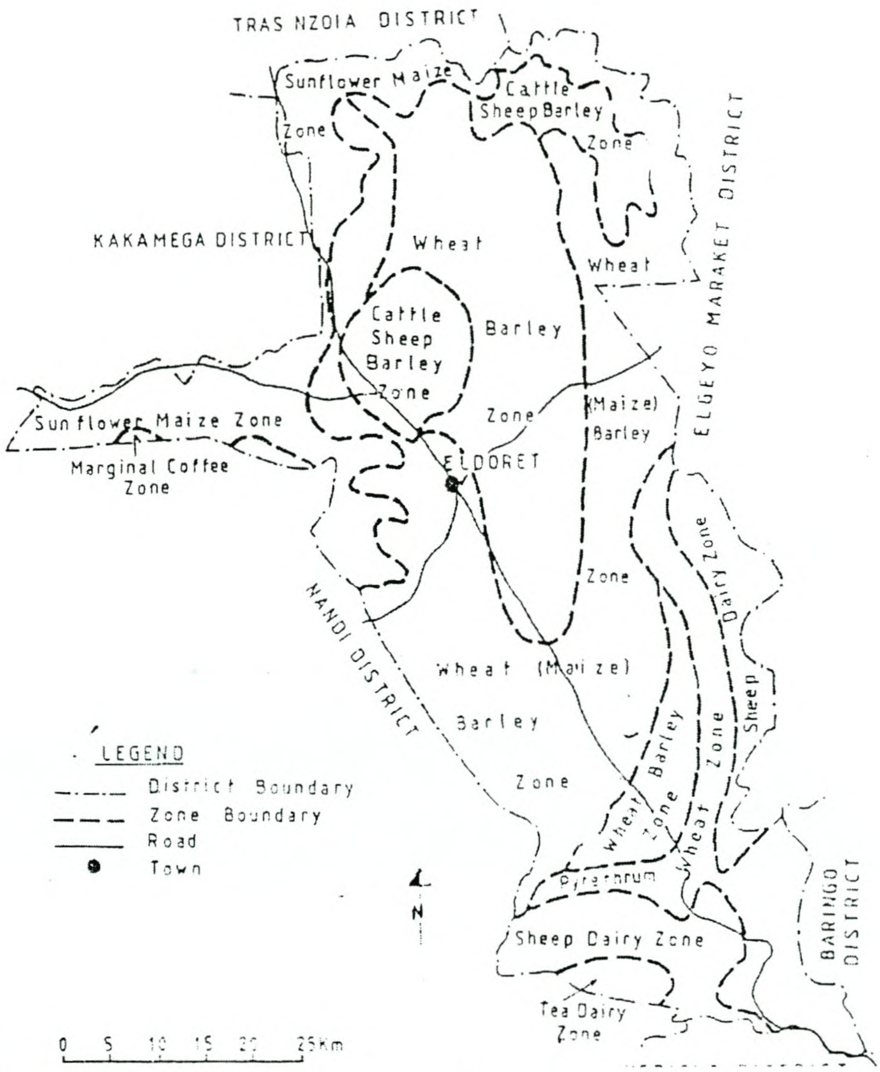

Fig. 2.2: Agro-ecological zones of Moiben and Ainabkoi Divisions. (GOK, 1996)

Table 2.1: A summary of climatic data based on agro-ecological zones. Jaetzold and Schmidt (1982 cited in GOK, 1987).

Agro ecological zone	Altitude (m)	Annual mean temperature ^0C	Annual average rainfall (mm)	66% reliability of rainfall[1]		66% reliability of growing period		
				1st rains (mm)	2nd rains (mm)	1st rains[2] (days)	2nd rains (days)	Total[3] (days)
UH 1 Sheep-dairy zone	Here mainly Forest Reserve because this timber land is too valuable to be cut for grazing							
UH 2 Pyrethrum/ wheat	2300-2700	15.7-13.3	1150-1400	360-600	460-600	110 or more	160-200	270-310
UH 3 Wheat/ Barley zone	2400-2600	15.1-13.9	1100-1200	350-450	450-550	100 or more	150-170	250-270
LH 1 Tea-dairy zone	Here mainly Forest Reserve Very small							
LH 2 Wheat/ Maize-Pyrethrum	Very small 2300-2400	15.7-15.1	1150-1220	360-500	450-560	110 or more	160-190	270-300
LH 3 Wheat/ (Maize)-Barley zone	1900-2400	17.9-15.1	900-1300	250-490	350-600	100 or more	115-140	215-240
LH 4 Cattle-Sheep-Barley zone	1900-2200	17.9-16.3	900-1100	250-320	350-500	100 or more	95-115	195-215
UM 3 Marginal Coffee zone	Very small							
UM 4 Sunflower-Maize-zone	1500-1900	20.5-18.0	900-1400	280-620	380-600	100 or more	115-140	215-240

1. Amounts surpassed normally in 6 out of 10 years, falling during the agro-humid period which allows growing of most cultivated plants.

2. More if growing cycle of cultivated plants continues into the period of second rains.

3. Agro-humid conditions continue from 1st to 2nd rains in the whole District.

2.1.6 Water Resources

Most of the water sources originate from the southern part of the District with a few from the North-east. The northern parts including Moiben receive water from Cheboyit Forest in Marakwet District while the rivers in southern parts of the District receive water from Ainabkoi, Timboroa and Cengalo Forests. Most of the forests that serve as catchments for these rivers are indigenous tree species interspersed with exotic plantation forests (GOK, 1996). The rivers and their tributaries in the District all drain to Lake Victoria. The tributaries converge into larger rivers such as River Sosiani, Kipkaren, Kerita, Kipkurere, Nderugut and Ndaragwa that merge into bigger rivers such as Nzoia that drain into Lake Victoria.

There are several dams constructed during the colonial times that are scattered within the study area. The farmers have used them for both domestic purposes and for livestock as well as flower irrigation for those with financial capabilities in the District. Some serve as sources of water for institutions and trading centres as well. There is a water shortage in rural areas and the little available is of poor quality especially in areas where the existing dams are increasingly silted and putrefied. Since the white settlers left the District after independence, management of the dams has been poor because nobody takes full responsibility for them (GOK, 1996).

2.1.7. Land Use Patterns

Land use varies with AEZs, which determine the type of agricultural activity possible, profitability of the enterprises and cultural practices (Rees *et al*., 1997). The District is largely agricultural, producing more than a third of the total wheat in the country and maize for both food and cash (Rees *et al*., 1997). The small farm sector (farms of 20 ha and less) produces beans, vegetables, pyrethrum and horticultural crops in combination with maize and wheat.

Moiben Division has a large percentage of households with high value cash and food crops that include wheat and maize compared to the rest of the divisions. Apart from crops, the farmers derive the largest amount of income from milk sales through rearing of dairy cattle. In addition, goats, sheep, poultry, honey and sunflower are produced but to a lesser extent especially the lower parts of the division. Ainabkoi Division leads in pyrethrum and potato production in the District. Wheat, oats and barley are produced but on a smaller scale. Most of the forest products utilised within the District are obtained from this Division since it borders the gazetted forests. Horticulture, specifically floriculture, is a relatively new farming practice in certain parts of the District and it is a potentially feasible future source of livelihood for the communities especially those farmers with sufficient capital (GOK, 1996).

2.1.8. Population and Labour

The total District population is estimated at 622 705 of which 315 932 are males and 306 773 females. The annual population growth rate in the District is estimated at 3.7% although the general trend at present is that of a negative growth attributed to natural deaths and use of birth control methods by the younger families (CBS, 1999). The initial population increment besides natural increases from births was attributed to immigrants from other districts in search of formal and informal employment as well as need for settlement (CBS, 1999). With a population density of 163 persons per km^2, Ainabkoi Division has an estimated population of 77 297 (12.4%) of the total District population. Moiben Division has a population of 89 717 (14.8%) of the total District population and a density of 115 persons per km^2 (Table 2.2).

Uasin-Gishu District has a total of 134 490 households of which 17 691 and 15 895 are found in Moiben and Ainabkoi Divisions respectively (CBS, 1999). The labour force in the entire District (described as people aged between 15-59 years) was estimated at 214 241 in 1989 and was projected to reach 339 970 by 2001 (GOK, 1996). The majority of the labour force is made up of females and they are expected to be dominant in future, especially in agriculture and in other unskilled labour employment.

Table 2.2: Population Projections by Division

Division	1989	1997	1999	2001
Soy	118 812	159 739	172 008	185 219
Turbo	80 949	108 833	117 192	126 194
Kapsaret	69 045	92 259	99 341	107 336
Moiben	69 043	92 826	99 956	107 262
Kesses	59 091	79 446	85 348	92 119
Ainabkoi	48 593	65 332	70 349	75 752
Total	445 122	598 435	644 394	693 882

Source: CBS (1999)

The District's population is highly diverse since most of the people settled in it are immigrants who bought these farms from the government, who acquired them from white settlers after independence. There are four main ethnic groups: Kalenjin (55%), Kikuyu (9%), Luhya (16%), Luo (4%) and others minorities make up (6%) (CBS, 1999).

2.1.9. Communication network

Generally, the road network in the District is adequate but most of it is impassable during the rainy season due to poor maintenance, cutting off several productive areas. The most affected is lower Moiben. The Great North Road that enters the District through Timboroa trading centre in Ainabkoi Division is the driving force for farming and industrialisation in the District in that it links the area to both domestic and external markets. Besides this road, the District is served fairly well with other tarmac roads linking it conveniently to other districts (GOK, 1996).

Postal and telecommunication services in the study area are relatively well developed due to the location of the regional office in Eldoret town. Like the road network, Moiben Division is under-served however (GOK, 1996). Generally, there is need for good infrastructure that ensures efficient delivery of services especially to the rural people who are difficult to reach and who are the targets of new technologies such as agroforestry.

Eldoret town is served well by a railway line that passes through it from Mombassa, the country's seaport, to the rest of East Africa and has an international airport. With such facilities, the District and therefore the study area, has a very good agricultural and industrial potential for it can link up with regional trading bodies like the Common market for East and Southern Africa (COMESA), the Preferential Trade Area (PTA) and Southern Africa Development Community (SADC) among others.

2.2. Research Methods

This section describes methods used to collect data in order to achieve the set objectives. Survey research was used in this study to gather the information between December 2000 and March 2001. Two sets of data were collected; one using a pre-prepared questionnaire and the other involving a forest resource assessment. Information from users of natural resources can be collected both quantitatively and qualitatively or the latter only. This study employed both methods so as to comprehensively cover the intended objectives and to support either positively and negatively the postulated hypotheses.

The target groups were the farmers and they varied in terms of education level, land size, marital status, occupation, age and family size. The data contained respondents' demographic information, land-use practices, awareness of agroforestry, sources of tree products, on-farm and off-farm sources of income and farm assets. Some data were also obtained through in-depth discussions with key actors, among them government officials and village headmen on general agroforestry farming practices, farmer perception about trees and community resource use specifically from the state-owned forests. Most of the primary information was collected through techniques such as:

- Formal interviews using a pre-prepared questionnaire
- Informal interviews with key actors such as government officials from mother Ministry of Environment and Natural Resources (MENR) and other related ministries, chiefs and a village head man who doubled up as an elderly man

- Observations during the interview and during farm walks. Through this method, additional information relevant to the study but not covered in the questionnaire was gathered and also it acted as a way of cross-checking or reducing incorrect information given by respondents.
- Group discussions were held with one male and one female group to elicit information about their agricultural and other activities that might hinder or boost their livelihoods on a daily basis as well as matters related to agroforestry in general.

2.2.1. Social Survey

2.2.1.1. Sampling Frame for Household Survey

For the survey, randomly selected households within the two Divisions of the District were obtained through lists of farm blocks and landowners kept by the Department of Lands. Farmers were the target group, since each farm family varies demographically, economically, each faces a variety of different problems with different potential or real solutions based on the decisions made by the head of the household or the whole family.

2.2.1.2. Stratification by Administrative Boundaries.

According to Neuman (1999), stratified sampling involves first dividing the population into sub populations (strata) on the basis of supplementary information. Since Uasin-Gishu District is divided into six administrative divisions (GOK, 1996), the study areas were stratified based on the administrative demarcations and on the relative positions of the two to the gazetted forest within the District. Ainabkoi Division borders state forests while Moiben Division lies further away.

2.2.1.3. Selection of Households

The total number of households in the study area was 33 586 of which 17 691 were in Moiben Division and 15 895 in Ainabkoi Division. Based on Neuman's (2000) suggestion that larger populations permit smaller sampling ratios the size of the sample was then limited to a total of 300 randomly chosen households. Based on number of households in the study area, 0.473% and 0.526% of farm blocks in Ainabkoi and Moiben Divisions were randomly selected. A list of the randomly drawn blocks was made and from it, names of land parcels listed and randomly drawn using the same percentage. Finally a random selection of individual households was made. Hence a multi-stage sampling procedure was utilised in selection of respondents.

2.2.1.4. Group Selection

Groups have characteristics such as common identity, some feeling of unity and share certain goals and expectations about each other's behaviour (Popenoe *et al.,* 1998). They can be used to identify land-users, their land-use practices and systems, the local knowledge, problems and potential solutions (Rocheleau *et al*., 1988). Groups interviewed in this study were selected randomly in the course of data collection and within the already selected households. One female group and one male group were interviewed.

2.2.1.5. Farmer Interviews

Farmer interviews were done with the help of two research assistants. Enumerators in most cases visited each randomly selected household alone but in some cases were accompanied by willing guides or village headmen. Formal introduction to the respondents preceded the interview as suggested by Neuman (1999), who maintains that building rapport with respondents while in the field is a way of winning their trust. The language of communication was in most cases Kalenjin. Occasionally, Kiswahili and or English languages would be used depending on the level of education or the ethnic group of the respondent. At the end of the interview, all respondents were encouraged to discuss general agroforestry issues among others so as to gather further information that may have been left out in the questionnaire.

During the process of data collection, a farm walk was done, depending on the availability of time and willingness of the respondent. A farm walk would augment and reinforce the information from the respondent and give a better view of the general farm layout that would link what the respondent was saying to what was actually observed. Farm walks were also carried out based on how heterogeneous the farmers' tree species were. This helped in identifying the various tree species with them. Also if the respondent mentioned the existence of conservation structures, then a farm walk was done to ascertain their existence and condition.

The selection of the groups followed the questionnaire survey. There were questions in the research instrument that asked about group membership. If a respondent belonged to a group, then on that basis he or she was asked to gather members of his group for a discussion on an agreed date, time and venue. In this way, one female group and one male group were interviewed in order that more diverse or common views on the factors that influence farmer participation in agroforestry could be obtained.

2.2.1.6. Questionnaire Survey

The main research instrument used to collect data in this study was a pre-prepared questionnaire that comprised both closed and open-ended questions. The questionnaire was divided into five sections as shown below:

- Demographic data namely: age, sex, marital status, level of education, occupation, head of household and number of people in the household
- Land origin, land use and land-use practices, the decision maker on general farm as well as household activities, agricultural activities being carried out on the farm and labour availability and its source
- Awareness of agroforestry, whether practised agroforestry, benefits so obtained and or constraints faced by the respondent

- Information on sources of wood products, alternative sources, sources of seeds and or seedlings, decision maker on the harvesting of the tree or tree products and who tends the seedlings
- Sources of on-farm income, ranking of sources of income, expenditure ranking, alternative sources of income (off-farm), group membership, environmental problems faced by the farmer if there are any, possible solutions and farm assets.

2.2.1.7. Discussion with Key Actors

According to Neuman (2000), an informer or a key actor is a person or member of an organisation or group with whom a researcher develops a relationship and who tells them about or informs on the field. They should be totally familiar with their areas of specialisation or administration. The key actors in this study comprised the forest officers from Ministry of Environment and Natural Resources (MENR) both from management and forest extension services divisions. They provided an insight into the current forest extension activities in the District. Officers from the Ministry of Agriculture and Livestock Development (MOALD) gave information on soil conservation measures within the study area and their extension methods. An old man who was also a village elder gave brief information on utilisation of forest resources by the community living around the gazetted forests and some on brief changes in vegetation cover within the study area. Information from key informants were used to cross-check that gathered in the questionnaire.

2.2.2. Forest Resource Assessment

The forest resource assessment was carried out within the gazetted forest bordered by the villages in Ainabkoi Division. A transect leading away from the villages was made. The area was first stratified based on the management regime of the forest. The records obtained from the local forest station indicated that it is a protected area that is not being exploited commercially. The area is estimated at 4360 ha (FD, 1999) although patchy. Kent and Cocker (1996) suggest plot sizes of between 20-50m^2 for woodlands while Mueller-Dombois (1974) and Cunningham (2001) contend that plot size or length of transect lines will depend upon the size and abundance of species and individuals being sampled and that it could range up to $200m^2$. Based on this and the experience of the forest staff, plot sizes measuring 30m by 30m at intervals of 300 metres along the transect were used.

Diameter size class distributions are a way of showing plant population structure and indicating the chance of plants in one size class to survive into the next size class (Cunningham, 2001). In this study, six diameter classes were used each with a five centimetre interval. The smallest class encompassed stems below 10 cm followed by 10-15 cm, 15.1-20 cm, 20.1-25 cm, 25.1-30 cm and the sixth class comprised 30 cm and above. The outcome from the class distribution whether skewed or normally distributed, will enable conclusions to be drawn as to the scarcity or abundance of the resource to the community for future sustainable utilisation. With a total of ten plots, Diameters at Breast Height (DBH) of three indigenous species that had been identified by the farmers as decreasing in availability were taken in each plot using diameter tape.

2.3. Data Analysis

Most of the data collected were checked for any errors, coded and entered into Statistical Package for Social Science (SPSS[3]). Neuman (1999) describes coding as the process of arranging raw data or variables into machine-readable form for statistical analysis. In this context, variables were assigned numbers such as 1, 2,3 and so on. These coded information was then entered into the SPSS programme. In some instances, the detailed and unexpected information from the farmers could not be coded. Such information was used qualitatively through description and as excerpts in order to give a clear picture of the situation in the fields. Similarly, directly observed information was incorporated as supplementary and supportive data in the study. Data on assessed resources were analysed using Chi-Square tests in order to determine whether there existed a significant difference between the diameter classes and along the transect.

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[3] SPSS 10.0 for Windows (SPSS, 2000). http//www.spss.com

In survey research, information obtained from interviewees and that observed or perceived by interviewers need to be precise and accurate as much as possible. In social research terms, they should be reliable and valid. In other words, measures used should be connected to the constructs so as to give research findings some credibility. Reliability is the likelihood that a given measurement procedure will yield the same description of a given phenomenon if that measurement is repeated (Babbie and Mouton, 2001). Questionnaire surveys are about trusting peoples' responses (Babbie and Halley, 1998). This study ensured reliability through pre-testing the questionnaire using a sample of the population within the study area. This helped to ascertain how clear the questions were. In some instances, reliability was also improved by incorporating more than one measure of any subtle or complex concept so as to ensure greater overall measure of the concept. Briefing the enumerators about aims of the study and how to conduct the interview and make observations also ensured reliability.

According to Galtung (1967) and Neuman (2000) validity refers to whether an indicator used is measuring what it is intended to measure. It is the extent to which a specific measurement provides data that relates to commonly accepted meanings of a particular concept under consideration (Babbie and Mouton, 2001). The researcher tried to ensure validity by holding discussions with key informants from relevant government departments especially those who are conversant with social science data collection techniques and agroforestry. Through the discussion, some of their views were incorporated into the questionnaire.

2.4. Scope and Limitations of the Study

The study was limited to 300 respondents out of a total number of 33 586 corresponding households in the two divisions. These farmers, together with a few selected key actors, provided most of the information used in the analysis and subsequent discussion of the research.

However, data collection was hampered by the following factors:

- Respondents were in some cases suspicious of the research motives and took time before accepting the researcher's reasons for the survey. They could take the researcher for a spy on behalf of the government and be concerned that they would be reported for not planting trees, or some could even take the researcher for a thief who had the intention of surveying the homestead for future theft. Whenever such instances arose, the help of the village headman would be solicited to assure the respondents that the research was genuine.

- Some respondents were also fearful that the enumerators were devil worshippers and therefore refused to be interviewed. Under such a situation, a new respondent was chosen by systematically selecting the fifth house from the present one in order to reduce potential biases and curiosity raised by the previous respondent among the neighbouring households.
- Another limitation was the requests by some respondents for material support especially seedlings, fertiliser and some even wanted money after the interview. Later gains by the individuals or community as a result of the survey were emphasised by the enumerators.
- One drawback of the survey technique was the failure of the female respondents especially wives to freely respond to the questions. Most wives would respond by saying they did not know or that they could only answer that question with permission from the husband. This situation depicts a highly gendered society where it is only men who can respond as heads of households.
- Some male respondents gave responses that were opposite of what they were actually practising. Under such a situation, the questions would be reframed in such a manner that the respondent would not easily detect that the same question has been asked differently.
- Some male respondents refused to disclose assets such as the number of livestock they owned or the profits that accrued from their farming activities. Such sensitive information was put last in the questionnaire so as not to discourage further discussion with respondents.
- During group interviews, group leaders tended to respond to most of the questions thus denying other group members a chance to air their views and opinions. This was minimised by directing questions to other members. Occasionally, the researcher would positively acknowledge responses from the leader then seek additional information from other members in the group.

- Frequent data collection from villagers may create a negative attitude from the respondents who at times question outcomes of such surveys done previously by other people. In this survey, it was made clear that the information would be used to improve land management practices in the area if adopted by the relevant authorities.
- Most of the records in the government offices are not updated regularly so that answers to the same requests for information from two reliable offices might result in different figures and different statements.
- During the survey, the company of extension officers or administrators such as chiefs and village headmen who might bias responses by their presence was avoided as much as possible.

3.0. Research Findings

3.1. Introduction

This chapter describes the findings of a field survey carried out in order to determine socio-economic factors that could possibly negatively influence farmer participation in adoption of agroforestry practices in Moiben and Ainabkoi Divisions of Uasin-Gishu District. It also briefly describes forest resources assessed from the nearby state-owned forest that are available and used by the communities living around these gazetted forests.

3.2. Socio-demographic Characteristics of Respondents

The population sample interviewed comprised 56.3% (169) males and the rest females (Table 3.1). The majority were farmers or their wives (Appendix 2.1). It should be noted that the survey targeted the household level and therefore respondents were either the actual heads of the households or their spouses or children of the heads of households. This study will treat them collectively as representing the absent head of household. Respondents were evenly drawn from the different age groups but with fewer young people, as would be expected for heads of households (Table 3.2).

Table 3.1: Distribution of respondents by gender (n=300)

Sex of respondent	Frequency	Percent
Male	169	56.3
Female	131	43.7
Total	300	100.0

Table 3.2: Age distribution of respondents in the study area (n=300)

Age range	Frequency	Percent
<18	7	2.3
18-25	38	12.7
26-35	75	25.0
36-45	88	29.3
>45	92	30.7
Total	300	100.0

Most of the respondents 83.7% (251) indicated that they were married while 8.7% (26) were single (Appendix 2.2). With regard to family size, the majority 41% (123) of the households had between 7 and 10 members, while 9% (28) of the households had three members and below. In general, 56% (168) households had over six members per household indicating that large families are common in the study area and this is typical of most rural societies in the developing world (Fig. 3.1). The responses on the level of education showed that the highest number, 47.7% (143), either completed or dropped out of primary school, only 1% (3) attained university level of education while 19% (57) of the respondents had never been to school (Table 3.3). This is an indication that the level of education is on the average low in the study area.

Table 3.3: Level of education of respondents in the study area (n=300)

Level of education	Frequency	Percent
Primary	143	47.7
Secondary	88	29.3
College	9	3.0
University	3	1.0
Never went to school	57	19.0
Total	300	100.0

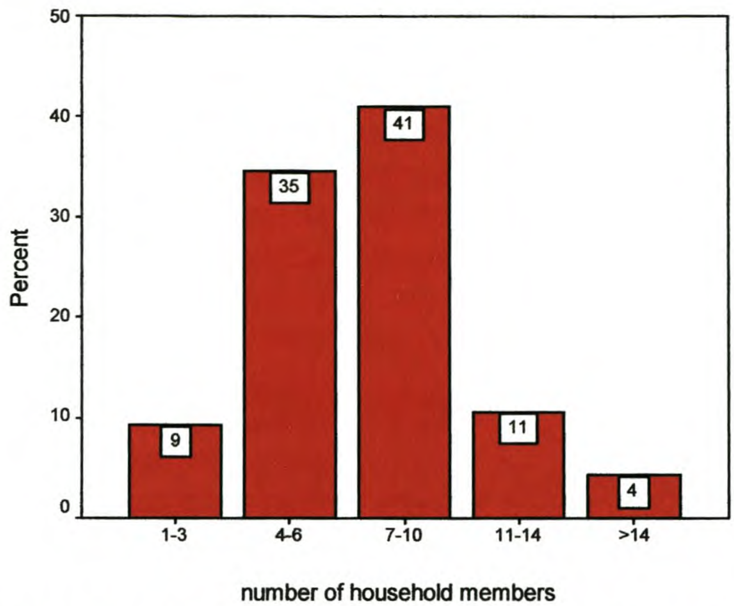

Fig. 3.1: Family size per household in the study area (n=300)

3.3. Socio-economic and Land-use Practices in the Study Area

A question on land tenure revealed that ownership of land is male dominated in that 52.3% (157) of the respondents indicated husbands as owners. This gives a total of 69.7% (209) exclusively male ownership and only 3% (9) female ownership indicating a gendered community in property ownership. However, 24% (72) were living on unregistered land owned by the state under trust lands (Table 3.4).

When asked whether women inherit land in the community, the majority 53.7% (161) of the respondents said they do while 4.3% (13) were not sure what to say (Appendix 2.3). A male group during the interview were of the opinion that women get land where they are married to otherwise a female could be bought for land if she bears children out of wedlock but only if the parent could afford. The female group on the other hand said if it were for them, they would let their daughters inherit land as their sons giving the impression that it is not in the interest of the males to transfer and/or allow females to own property.

Table 3.4: Land ownership by the respondents in the study area (n=300)

Land owners	Frequency	Percent
Husband	157	52.3
Wife	6	2.0
Family	10	3.3
Father in-law	15	5.0
Mother	2	.7
Father	35	11.7
Brother	2	.7
Not registered	72	24.0
Female divorcee	1	.3
Total	300	100.0

Respondents were asked whether the land they were occupying was officially registered as rightfully belonging to them. Most of the population sample 63.7% (191) said it was, while 24% (72) lived on unregistered land. However, some respondents were unclear whether their land was registered or not (Table 3.5). Land sizes of the respondents varied widely. The largest group of respondents, 32.3% (97), had farm sizes ranging from 1 to 5 acres, with only a few, 3% (9) owning farms of either below an acre or over 100 acres (Table 3.6).

Table 3.5: How long land in the study area has been registered (n=300)

Period (years)	Frequency	Percent
1-3	25	8.3
4-7	59	19.7
8-11	48	16.0
12-15	20	6.7
>15	39	13.0
Not yet registered	72	24.0
Not sure whether registered or not	37	12.3
Total	300	100.0

Table 3.6: Land-size distribution of respondents in the study area (n=300)

Farm size (acres)	Frequency	Percent
<1	9	3.0
1-5	97	32.3
5.1-10	56	18.7
10.1-20	62	20.7
20.1-30	27	9.0
30.1-50	26	8.7
50.1-100	14	4.7
>100	9	3.0
Total	300	100.0

Farm utilisation for various agricultural activities was investigated. The results indicated that 51.3% (154) of the respondents planted cash crops and practised mixed farming, 27% (81) practised mixed farming only, while 6.7% (20) incorporated horticulture (mostly vegetables) under mixed farming. This gave a 99.7% land tilling practices (Appendix 2.4). As to the number of livestock owned by the households, the majority of the farmers 51.3% (154) had between one to five head of cattle, while 4.3% (13) had none. Some 24% (72) of the respondents had between one and five goats, only one of the farmers had between twenty-four and fifty goats while 61.7% (185) respondents had none. A number of farmers 31.7% (95) had between one and five sheep while 33.7% (101) respondents had no sheep (Appendix 2.5a & b). In general farmers in the study area have livestock as alternative source of income.

The respondents were asked to rank their sources of income in decreasing order of importance. As shown in Appendix 2.6, 26.3% (79) of the farmers derived most income from cash crops, livestock and lastly food and cash crops, while only one respondent derived his income from sale of tree seedlings and food crops. However, 6% (18) of the respondents were not able to answer this question because their income came from a range of equally important sources or because they have never taken their time to determine which farm activity gives them more income than another. In order to give a clear picture on farmers' priorities, respondents were asked to rank their expenditure in decreasing order of importance. Approximately 25.7% (77) of quantity of maize or other food that can be stored, or by budgeting for food first then school fees followed by money for emergencies such has settling hospital bills. However, some 12.3% (37) were not able to rank their priorities. Those in this category said that when they have money, they address the most immediate problems that arise at that particular time and therefore budgeting according to them, was not necessary (Appendix 2.7). Apparently none of the farmers interviewed budgeted for activities that include agroforestry. The survey shows that the communities within the study area depend almost solely on crop production and livestock rearing as the chief economic activity with minimal consideration of agroforestry as an alternative income earner among other income generating activities. Because of the realisation that the chief source of livelihood was crop production and livestock keeping, further investigation was done on perceived environmental problems arising from these activities.

3.4. Farmer Perceived Environmental Problems in the study area

The respondents were asked whether they were facing any problems related to farming and their daily well-being. These problems were collectively termed as environmental problems for the purpose of this study. Out of the 300 respondents, 70% responded in the affirmative. The majority of the respondents were of the same opinion during group interviews. Respondents cited several major problems including soil erosion, low crop yield, soil infertility, land scarcity, water logging and shortage of fuel wood as mentioned by 74.67% (224) of the respondents, while 23.3% (70) mentioned that they faced no problems. However, 2% (6) respondents did not know what environmental problems they might face (Table 3.7 and Plate 3.1). During group interview, the male group attributed decreasing farm fertility and crop yields to soil exhaustion arising from cultivation that has been going on in the area even before independence, unreliable rainfall, expensive and substandard fertiliser and maize/wheat seeds. They also mentioned increased land fragmentation as contributing to further land degradation. The key informant from the Department of Agriculture was concerned with failure of most of the farmers to take up soil conservation seriously since it contributed most to deteriorating crop production in the area.

Table 3.7: Environmental problems faced by the farmers in the study area (n=300)

Problems	Frequency	Percent
Soil erosion, low crop yield & soil infertility	174	58.0
No problem	70	23.33
Soil erosion, shortage of fuelwood & food	22	7.33
Soil erosion & land scarcity	7	2.33
Not sure of environmental problems	6	2.0
Soil infertility & shortage of fuelwood	5	1.66
Food shortage & shortage of fuelwood	5	1.66
Low crop yield & shortage of fuel wood	4	1.33
Land scarcity	3	1.0
Low crop yield & land scarcity	2	.66
Soil infertility & land scarcity	1	.33
Water logging	1	.33
Total	300	100

Plate 3.1: Cultivation along slopes without soil conservation structures. Possible sources of silt and erodible farm inputs such as fertiliser. Below the slope is a stream (Photo: A. Kurgat)

Asked about the ways and/or methods they employ in tackling these problems, 23.3% (67) of the farmers said that they applied more inorganic fertiliser and practised multiple cropping, 4.0% (12) used trees in crop fields, only one person had terraces with trees on crop fields as a solution, while 17.6% (53) had no solutions to the problems faced. It should be noted that multiple cropping involved incorporation of maize and beans mostly. These farmers' solutions to problems were split into two groups due to multiple responses (Table 3.8).

When probed further on maintenance and/or improvement of soil fertility for increased crop production, 29.3% (88) of the respondents said that they did so by intercropping, rotation of crops and application of inorganic fertiliser, while 28.7% (86) of the respondents indicated that they practised intercropping, applied animal manure as well as inorganic fertiliser. In all, 99% (297) of the respondents used inorganic fertiliser on their crop fields indicating heavy utilisation of chemical fertiliser without which crop yields are generally low. It can be presumed that the highly exhausted soil has necessitated the reliance on inorganic fertiliser in the study area (Appendix 2.8). It should however be noted that the use of animal manure was mostly on vegetable gardens because it was only available in small quantities.

As a land management practice, retaining of crop residues in the fields has been known to enhance soil fertility and reduce erodible material. In this regard, respondents were asked whether they burnt their crop fields in preparation for cultivation, 94.7% (284) of the respondents gave an affirmative answer (Appendix 2.9). Most of the farmers advanced reasons such as ease of manoeuvrability of farm machines in the field and rejection of 'dirty' crop fields by contractors.

Table 3.8: Farmer solutions to the environmental problems faced in the study area (n=300)

Group 1	Frequency	Percent
Apply more inorganic fertiliser & multiple cropping	67	23.3
No problem	70	23.3
No solution	53	17.6
Apply animal manure	35	11.66
None of the above	18	6.0
Animal manure &more inorganic fertiliser	13	4.3
Trees on crop fields	12	4.0
Terraces & multiple cropping	10	3.0
Did not know	7	2.3
Animal manure & multiple cropping	5	1.6
Terraces & animal manure	2	.6
Terraces &use more inorganic fertiliser	2	.6
Use windbreaks	2	.6
Terraces with trees on crop fields	1	.3
Trees on crop fields& inorganic fertiliser	1	.3
Trees on crop fields& multiple cropping	1	.3
Multiple cropping with windbreaks	1	.3
Total	300	100
Group 2	**Frequency**	**Percent**
None of the above	139	46.33
No problem	70	23.33
No solution	53	17.67
Diverted water	9	3.0
Boundary planting	8	2.67
Intend to plant trees	6	2.0
Crop residues	3	1.0
Contour ploughing	3	1.0
Boundary plant, crop rotation and contour ploughing	3	1.0
Woodlot	1	.33
Grand total	300	100

3.5. Farmer Awareness of and Engagement in Agroforestry

Of the 300 respondents interviewed, 89.3% said they were aware of agroforestry practices (defined by farmers as tree planting on the farm) (Table 3.9). But, 32 farmers had never heard of agroforestry. Of those who were aware of the practice, 56.7% were males while the rest were females (Table 3.10). Most of the respondents were found to be aware of agroforestry during group interviews although they were yet to engage in it. Of those aware of the concept, the number who said they actually practised agroforestry reduced to 42.7% (128) (Table 3.11).

Table 3.9: Awareness of agroforestry practices in the study area (n=300)

Responses	Frequency	Percent
Yes	268	89.3
No	32	10.7
Total	300	100.0

Table 3.10: Influence of gender among respondents aware of agroforestry practices in the study area (n=268)

Sex of respondent	Frequency	Percent
Male	**152**	**56.7**
Female	**116**	**43.3**
Total	**268**	**100.0**

Table 3.11: Prevalence of agroforestry practices in the study area (n=300)

Response	Frequency	Percent
Yes	128	42.7
No	172	57.3
Total	300	100.0

During group interviews, farmers were asked whether they knew of some tree species that could be interplanted with crops without any negative effect on the crops. Most of the respondents had no suggestions. The few who knew mentioned tree species such as *Grevillea robusta* (Chepkumiat), *Acacia lahai* (Chebitet) and *Acacia nilotica* (Sertwet). In a nutshell, farmers in the study needed more information on agroforestry. Those respondents aware of agroforestry were asked about sources of information. Most of the people who answered this question had heard of agroforestry from a number of different sources and by far the most common source was a combination of the radio and the chief as mentioned by 51.1% (137) of the respondents (Table 3.12). The observation that the most commonly mentioned source of information was the radio could imply that the media in most cases does not give much detail on the agroforestry practice suitable for the area and the correct tree species to plant among other crucial information related to trees. Both male and female groups mentioned that although most of the information was received through the radio, most of the times the farmers especially the males were not indoors to listen to the information and that the communication was one way.

The groups interviewed gave similar sources of information as mentioned by individual farmers. However, one respondent mentioned one other source as Kenya Wood Fuel and Agroforestry Project (KWAP). Efforts to obtain past works done by the mentioned project were futile however since the project wound up 5 years ago. Despite 89.3% (268) of the sample being aware of agroforestry and its benefits, 57.3% of the total population sample had not engaged in agroforestry (Table 3.11 and Plate 3.2).

However, the minority of the respondents who engaged in agroforestry were asked about the source of tree seedlings. Most of them (42.1%, 54) said that they bought seedlings from Forest Department nurseries, 15.62% (20) collected wildlings while one farmer mentioned that trees regenerated within the farm (Table 3.13). Several types of agroforestry practices were observed within the study area. They included trees along the farm boundary, live fences, windbreaks, and woodlots, among others (Table 3.14).

Table 3.12: Sources of information on agroforestry in the study area for those respondents who were aware (n=268)

Information sources	Frequency	Percent
Radio and chief	137	51.1
Radio, neighbour and taught in school	61	19
Radio and agricultural extension officers	18	6.7
Agricultural extension officers.	12	4.5
Could not mention specific source	9	3.4
Agricultural shows	9	3.4
Radio and forest extension officers	6	2.2
Forest extension officers	5	1.9
Chief and agricultural extension officers	3	1.1
Husband	3	1.1
Seminar	3	1.1
Employer	2	.7
Chief and neighbour	2	.7
Chief and forest extension officers	2	.7
Chief and taught in school	2	.7
Agricultural extension officers and neighbour	1	.4
Agricultural extension officers and taught in school	1	.4
Neighbour and forest extension officers	1	.4
Field day	1	.4
Total	268	100.0

Plate 3.2: A household without a single tree within the homestead. (Photo: B. Rotich).

Table 3.13: Sources of seedlings planted by respondents in the study area (n=128)

Sources	Frequency	Percent
Bought from FD[1] nurseries	54	42.1
Bought from other nurseries	32	25.0
Collected wildlings	20	15.6
Vendors	8	6.3
Own nursery	6	4.7
Sowed seeds directly	6	4.7
Natural regeneration	1	.78
Did not know	1	.78
Total	128	100*

1: Forest Department. *: Rounded off to the nearest figure.

Table 3.14: Agroforestry practices carried out by respondents in the study area (n=128)

Practices	Frequency	Percent
Boundary planting, live fence & windbreak	73	64.9
Windbreaks and woodlot	12	9.4
Boundary planting and woodlots	8	6.3
Woodlot	7	5.5
Boundary planting and trees around homestead	7	5.5
Woodlot and trees on crop fields	4	3.1
Trees around homestead	2	1.6
Trees on crop fields	2	1.6
Woodlots and live fence	2	1.6
Windbreak and trees around homestead	1	.8
Total	128	100.0

When asked for the reasons behind tree planting and why they chose particular tree species, the farmers mentioned reasons such as planting trees for construction materials, firewood, as windbreaks, as boundary markers and for charcoal, among others (Table 3.15).

During group interviews, some male members mentioned that they were able to settle school bills using proceeds from tree sales instead of spending money on wood products and that trees reduced grass desiccation during dry season since grass was the chief livestock feed. The most commonly found tree species in the study area include exotic species such as *Acacia mearnsii*, *Eucalyptus saligna* and *Cupressus lusitanica* and some indigenous species such as S*yzygium guineensis and Dombeya goetzenii* among others (Appendix 2.10). These results show that most of the species planted or retained by farmers are 'Forest Department' species, which are not necessarily suitable for planting close to crops due to unfavourable competition.

Table 3.15: Purposes for practising agroforestry by respondents in the study area (n=128)

	Frequency	Percent
Construction materials, windbreak, boundary markers, charcoal and fuel wood	53	41.3
Fuelwood, construction material, charcoal, medicine, aesthetics & windbreak/boundary markers.	36	28.1
Fuelwood, construction material, charcoal, medicine. & aesthetics.	16	12.5
Fuelwood, construction material, charcoal, medicine, aesthetics, windbreak/boundary markers, cash reserve.	13	10.2
Aesthetics.	3	2.3
Windbreak/boundary and boundary markers & soil conservation and fertility.	2	1.6
Fuel wood and soil conservation and fertility improvement.	1	.8
Construction material and soil conservation and fertility.	1	.8
Aesthetics and windbreak/boundary markers/boundary.	1	.8
Windbreak/boundary, boundary markers & soil conservation & fertility.	1	.8
Construction material & fruits	1	.8
Total	128	100.0

3.6. Forests Resource Utilisation in the Study Area

Due to apparent scarcity of wood products on the farms, farmers were asked about sources of wood products used within the household. Several sources were mentioned and as shown in Figure 3.2, only 3.3% (10) indicated that they obtained wood products from within their farm while the rest either purchased them or collected them free of charge. Several farmers combined their sources however. Most of the respondents (65.7%, 197) claimed that they did not obtain wood products outside their farm areas without paying.

Those who did 89.3% (92) collected them from Forest Reserve exclusively with an implication that the Forest Reserve is treated as a common property for all (Appendix 2.11).

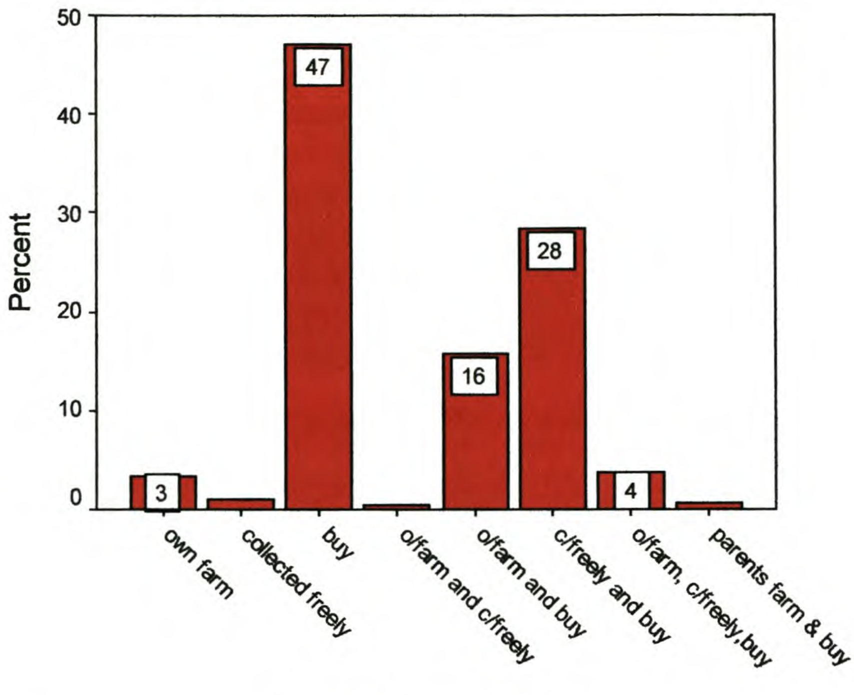

Figure 3.2: Sources of wood products utilised by the respondents in the study area (n=300). O/farm = off farm; c/freely = collect freely.

Asked about the sources of purchased wood products, the majority 59.4% (158) of the respondents bought them from the Government Forest Reserve. In general, the Forest Department supplied up to 62% of the respondents with wood products, meaning that agroforestry practices might not be taken seriously by farmers given such an assured source of supply (Appendix 2.12). Even though fuelwood was the most frequently used source of energy for cooking, 23.3% (70) of the respondents indicated that they used crop residues exclusively as alternative energy source, 20.7% (62) indicated that the supply from the Forest Reserve guarantees them a constant availability of the products while 17.3% (52) combined crop residues and cow dung (Appendix 2.13).

When asked about the average cost of wood products such as firewood commonly used within the household, most of the respondents 43.3% (88) said they spend less than Kshs[4]. 5 per headload of firewood. Generally, up to 81.7% of the respondents spent less than Kshs. 11 per headload of firewood (Appendix 2.14). However, a crosscheck with the Forest Department officer in a nearby forest station revealed that very few members of the community bought firewood. Instead most of them obtained it illegally without buying due to insufficient policing caused by inadequate resources such as personnel and vehicles. The availability of alternatives to wood and the apparently affordable wood materials from state forests, impacts negatively on the farmer adoption of agroforestry practices.

Respondents were asked about the average cost of poles both for fencing and for general construction. Costs varied widely but the majority 49.6% (131) of the respondents said that they spend less than Kshs. 5 to acquire the product, one person spent more than Kshs. 50 to buy one construction/fencing posts however. Generally, 78% (206) of the farmers spent less than Kshs. 11 per piece indicating that the commodity was available cheaply (Appendix 2.15).

Other benefits derived from the forest as mentioned by an old man include honey, housing of initiates and medicinal herbs from trees such as *Prunus africana* (Tendwet) for treating men's reproductive organs, *Olea hochstetteri* (Masaita) for treating foot and mouth diseases in livestock and shrubs such as *Aberia caffra* (Nukiat) that cure coughs among others. The old man further added that by paying only Kshs. 70 the local community was able to collect up to 300 pieces of construction or fencing poles irrespective of the size and in some cases they could exceed that figure.

The officer manning Ainabkoi Forest station was asked about the benefits derived from the forest by the communities living adjacent to it. The officer said that farmers were expected to purchase firewood at Kshs. 30 per headload per month, poles depended on size and grazing fee for Kshs. 30 per beast per month among other forest products. However the number of farmers paying for the products was small since most of the farmers obtained these products illegally having noticed that policing the forest was not frequent, a problem the officer attributed to insufficient personnel and

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[4] 1 Ksh. was equivalent to 0.01US$ at the time of writing.

other resources. This statement contradicted information from a key informant who said that the Department of Forests allowed them to collect treetops for free as well as grazing. The officer concurred with other respondents on other forest benefits to the community however.

3.7. Factors that Influence Farmer Participation in Agroforestry in the Study Area

Several reasons for not engaging in agroforestry were mentioned by farmers among them lack of information, time, labour, lack of seedlings, lack of land and security of land tenure among others. In general, farmers had more than one reason for not practising agroforestry (Table 3.16a and b). It should be noted that due to multiple responses information was split into two tables in order to capture the information. As a key factor of production, more probing on the availability and source of labour during peak agricultural period was carried out. Most of the farmers (63.3%, 190) said that labour was slightly available to very scarce as expected of rural communities that rely on household labour to perform agricultural activities (Appendix 2.16).

The farmers were also asked about sources of farm labour. Most of them (40.3%, 121) indicated that labour was exclusively derived from the family while 14.7% (44) hired labour during peak periods. In all, family labour was used by approximately 93.4% of the respondents (Fig 3.3). This could explain the large family sizes in the study area. As used in this context, group labour means neighbours coming together for purposes of planting, weeding or harvesting of crops. The groups while being interviewed mentioned that most of the labour available during peak period derived from the family, was engaged in planting and weeding of annual crops thereby creating an artificial labour shortage. However, some farmers particularly large-scale used either hired or personal tractors both for planting and weeding of crops.

Table 3.16a: Factors that hinder farmer participation in agroforestry in the study area (n=172)

Group 1	Frequency	Percent
Lack of information, time & labour	53	30.9
Lack of information, seeds/seedlings & time and labour	26	15.1
Lack of security of land tenure, time & labour	15	8.7
Lack of information & security of land tenure	13	7.6
Lack of land & time and labour	10	5.8
Lack of capital, time & labour	10	5.8
Lack information & land	10	5.8
Lack of information & capital	8	4.7
Lack of tree seeds/seedlings & capital	7	4.1
Lack of land & capital	4	2.3
Lack of land & security of land tenure	4	2.3
Lack of interest	4	2.3
Lack of tree seeds/seedlings & security of land tenure	3	1.7
Lack of capital & security of land tenure	2	1.2
Lack of interest & land	2	1.2
Tree seedlings/trees destroyed by fire & lack of labour	1	.6
Total	172	100.0

Among those respondents who engaged in agroforestry, the majority of the respondents (65.7%, 84) indicated that wife and children tended the seedlings while 8.6% (11) mentioned that this was the husband's task indicating that women perform more duties and the most labour within a household (Figure 3.4). It can be inferred that women contribute family labour more yet they participate less in the decision-making process as found when respondents were asked about household head and decision-maker in the family. Eighty three percent of the total 300 respondents indicated that husbands were heads of the households giving a total of 91.7% (275) male-headed households. This shows among other things that the study area is dominated by male-headed households (Fig. 3.5). Since family labour is predominantly used in this area, it could limit agriculturally-based development activities on the farm due to its insufficiency. Labour available dictates whether agroforestry should be practised and the type of agroforestry activity to be engaged in by the farmers.

Table 3.16b: Factors that hinder farmer participation in agroforestry in the study area (n=172)

Group 2	Frequency	Percent
Seedlings eaten by animals & trees interfere with crop growth & machinery movement	89	51.8
Tree seedlings eaten by animals & lack of water	43	25.0
Lack of forest extension services	10	5.8
Lack of water	8	4.7
Lack of interest & trees interfere with crop growth & machinery movement	6	3.6
Lack of water & presence of soil hard pan	5	2.9
Lack of water & soil infertility	3	1.7
None of the above	2	1.2
Tree seeds/seedlings destroyed by pests& diseases	2	1.2
Long gestation period of trees	1	.6
Presence of soil hardpan	1	.6
Lack of capital	1	.6
Total	172	100.0

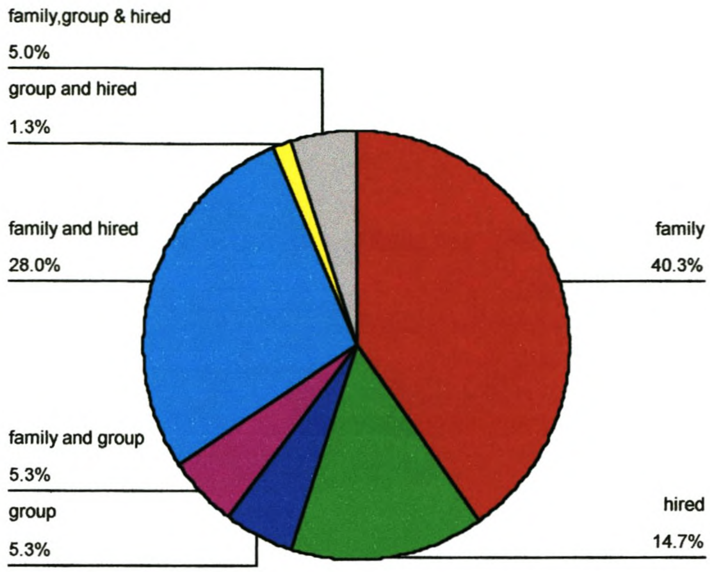

Fig. 3.3: Sources of farm labour during peak farming periods in the study area (n=300)

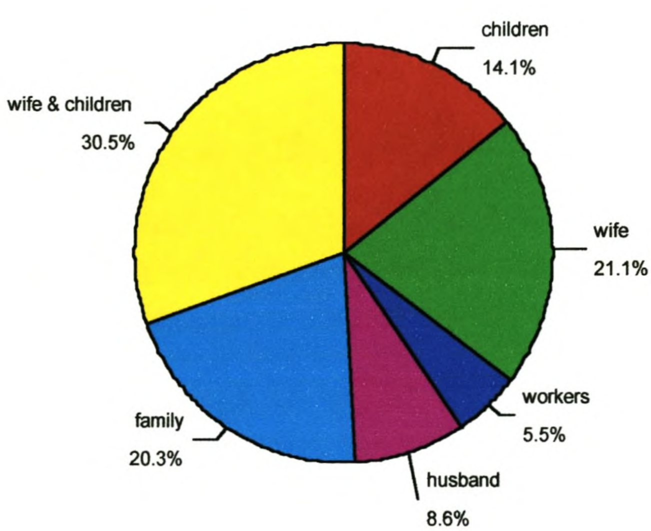

Figure 3.4: Persons responsible for tending of seedlings for those who practised agroforestry in the study area (n=128)

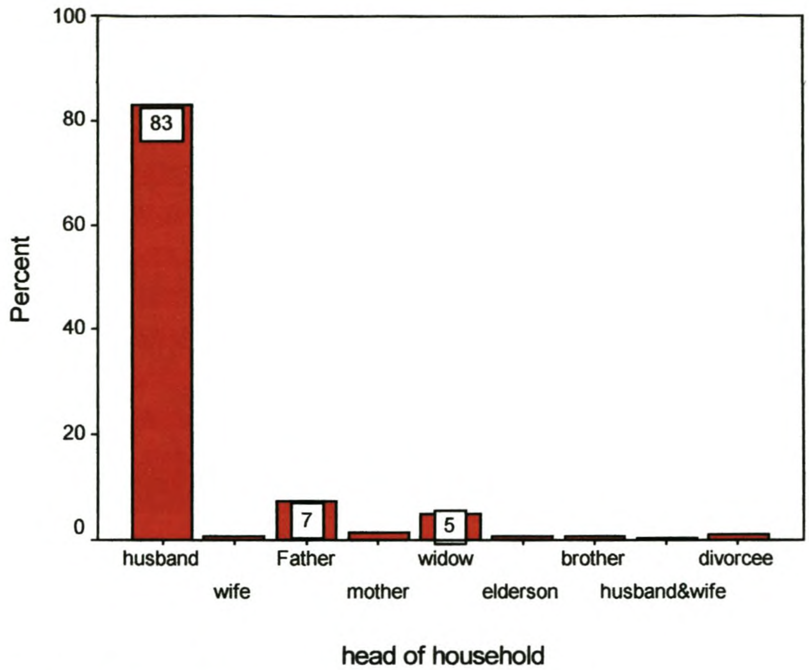

Fig. 3.5: Heads of households in the study area (n=300)

Respondents were also asked about the decision-maker on general farm activities. The Majority of the farmers (80%) mentioned that it was the husband. As expected of a society that has males as heads of households, women make the least decisions or have no chance at all in such households (Figure 3.6). The implication of this result is that women in the study area have the potential to actively participate in agroforestry activities but this potential can only be harnessed by addressing gender imbalances that currently act as barriers to adoption of such technologies. Since most of the decision-makers are males, women's interests are unlikely to be addressed.

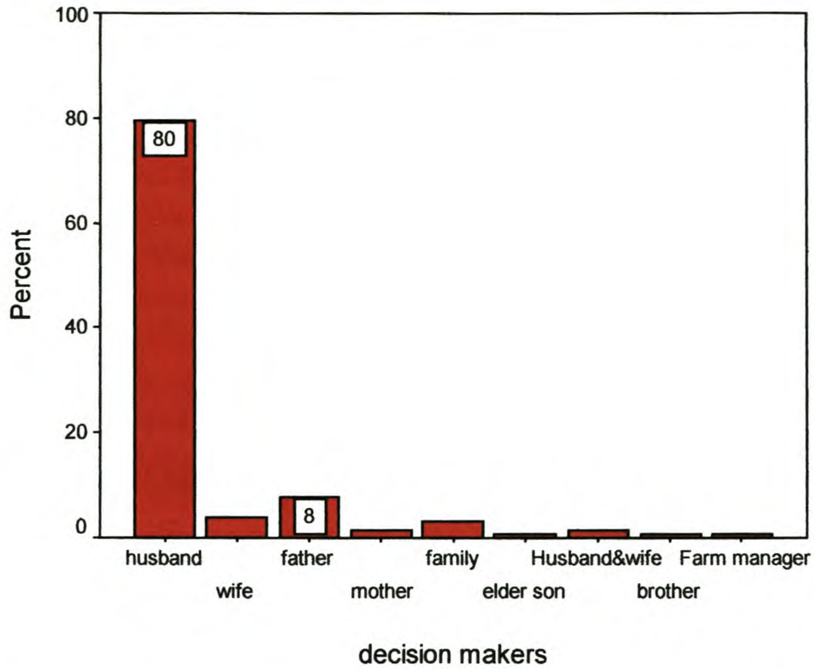

Fig. 3.6: Decision-makers on general farm activities within the study area (n=300)

The observation that males dominate decision-making in the study was also made during group interviews. Women required permission from their husbands in order to attend public meetings, most women were not sure whether there were any environmental problems such has declining soil fertility or soil erosion on their farms. The majority of the women in the group mentioned that they worked under their husbands' instructions reducing their flexibility within the farm. Most of the females in the group could have wished to engage in agroforestry since, they say, it would save them time fetching firewood kilometres away. The saved time could instead be utilised for other productive work although they already participate in daily house cores.

One of the females in the group claimed that her husband threw away tree seedlings she had brought for planting claiming that trees destroyed crops. Women's group revealed that vital information from extension agents could not reach them (women) since, they said, it was the duties of husbands to handle visitors who wanted any information about the farm and therefore they could not easily tell who an extension officer was. Some women claimed that although they belonged to some community groups, they failed at times to attend meetings due to restrictions from their husbands. However the majority of those who attended meetings were either widowed or single mothers.

Respondents were also required to indicate whether they belonged to any agroforestry group and if not whether they belonged to any other community group. Only 11.3% (34) of the respondents said that they belonged to other groups and no agroforestry group was found in the process of data collection (Appendix 2.17). Group membership was 79.4% (27) female and 20.6% (7) mixed male-female (Appendix 2.18). Respondents were asked whether they derived any benefits from those groups. In response, 29.4% (10) mentioned that their group owned a maize milling machine which gave them a daily income, while others indicated that the group was actively involved in constructing water tanks for individual members so as to harvest roof water (Appendix 2.19). The result on community groups shows agroforestry practices can reach women through these groups as exemplified by their high involvement in other development activities.

Land tenure in relation to farmer engagement in agroforestry was investigated. Among those respondents whose land had not been officially registered, 61.1% (44) of them did not practice agroforestry. This could be attributed to lack of tenure of land (Table 3.17).

Table 3.17: Influence of land tenure over agroforestry practices in the study area, for respondents without land title deed (n=72)

Responses	Frequency	Percent
Yes	28	38.93
No	44	61.1
Total	72	100.0

Most of the respondents in this category were the married sons who were yet to be permanently allocated their portions of land by their fathers. Such a scenario depicts a situation where insecure land tenure could be a disincentive to farmer investment in long-term income generating activities. Income from trees and tree products showed that the majority (32.8%, 42) had immature trees, indicating recent planting, while some had already earned some cash through the sale of trees or their products. However, 15.6% (20) of the respondents said that trees on their farms were not for sale (Appendix 2.20).

The level of education of the respondents was investigated in relation to agroforestry practices. When respondents who practised agroforestry were asked whether the formal education they had acquired did help raise awareness on agroforestry its importance, 60.9% (78) of them gave an affirmative response. However, 21.1% (27) of the respondents who engaged in agroforestry had never been to school (Table 3.18). It can be inferred from this result that with more knowledge, farmers' awareness of investment issues is aroused.

Table 3.18: Influence of formal education in creating awareness of tree planting amongst those who practiced agroforestry (n=128)

Responses	Frequency	Percent
Yes	78	60.9
No	22	17.2
Never went to school	27	21.1
I can't remember	1	.8
Total	128	100.0

Farmer perception of tree seedling and maintenance costs as well as risks associated with engagement in agroforestry was also investigated. The majority of the farmers 62% (186) cited the long gestation period of trees as constraining their efforts to engage in agroforestry activities (Table 3.19). The farmers concern was that they needed cash to address immediate needs and therefore if there were tree species that matured within a short period, they would try it out. It can be inferred that farmers need more information on suitable, multipurpose and fast growing species in order that agroforestry can be acceptable to them. Some farmers also mentioned risks such as pests and diseases (Table 3.16b) that attack seedlings and even mature trees.

Table 3.19: Farmer perception of long maturity period of trees as a constraint in the study area (n=300)

Response	Frequency	Valid Percent
Yes	186	62.0
No	114	38.0
Total	300	100.0

The same constraints were echoed during group interviews. Most of the respondents in the male group mentioned that they were not willing to commit their scarce land to agroforestry that among other things took long to realise the outcome and that trees shaded crops. Farmers said that non-availability of seedlings particularly for indigenous trees, high cost of seedlings, the labour needed to maintain the seedlings coupled with high cost of insect and pesticides, were a constraint. They suggested that the government should issue seedlings or establish nurseries for them. This however, goes against the spirit of farmer participation. The farmers complained that owners of hired tractors treated trees on crop fields as obstacles to field operations and therefore could not accept to carry out any field activities. Other minor factors that were found to influence farmer participation included cultural beliefs and taboos such as certain trees causing diseases when planted within the homestead.

3.8. Farmers' Access to and Participation in Forest Department Agroforestry Programmes

When asked about availability and access to forest extension services, the majority of the respondents (77%, 231) said that the services were not forth coming except on rare occasions when extension officers from Department of Agriculture visited them (Table 3.20). Even among the 42% respondents who engaged in agroforestry, 70% (90) affirmed that they had never been visited by extension agents from the Department of Forests (Table 3.21). They asserted that their participation in agroforestry activities was without any technical advice since they relied on other sources for information.

Table 3.20: Non-availability of extension services as a constraint to agroforestry practices in the study area (n=300)

Responses	Frequency	Percent
Yes	231	77.0
No	69	23.0
Total	300	100.0

Table 3.21: Lack of extension services as a constraint among farmers engaged in agroforestry (n=128)

Responses	Frequency	Percent
Yes	90	70.3
No	38	29.7
Total	128	100.0

During group interviews, most of the respondents mentioned that extensionists particularly from the Department of Forests were not common in the field. However those from Department of Agriculture were at times seen and that the officers informed farmers about new varieties of crop seeds, vegetables and how to tend crops among other issues.

Despite farmers concern that extensionists were not common in the field, the extension agents from the Departments of Forestry and Agriculture asserted that they disseminated agroforestry and agricultural information to farmers through methods such as contact farmers, field demonstrations, churches, schools, women groups, youth groups, chiefs' gatherings and Participatory methods such has farmers forming committees. The department facilitated these committees however.

When asked why agroforestry practices that specifically involve tree-crop interaction were not visibly practised in the District, the Forest Department officer mentioned several constraints that corroborated information given by other respondents. The reasons included farmer ignorance as a result of their believe that all trees have a negative effect on crops and the few who choose to plant trees located them away from crops, along the boundaries of their farms. Other reasons were the small size of many farms, mechanisation of large farms, unavailability of seedlings, lack of money for buying the tree seedlings, lack of security of land tenure, destruction of seedlings by pests and insects such as termites, gender-related issues such as women not being allowed to make any decisions regarding utilisation of the farming unit and the belief that a woman will become barren if she plants trees. Mentioned also was that farmers were less interested in engaging in agroforestry practices because they claimed that benefits took too long to be realised and therefore farmers would rather cultivate short-term crops.

The officer however, believed that farmers were not to wholly blame for this situation due to several constraints that were a drawback to the extension agents. The main hindrance were immobility due to lack of resources such as field allowances and fuel for vehicles, which demoralised the extension staff, language was a barrier for those officers who did not speak same language as local farmers, lack of motivation for field officers who need higher pay and fringe benefits and above all, that extension agents were demoralised by farmers' low perception of the benefits of trees in general.

The Department of Agriculture official said that among other information dissemination techniques were educational tours, workshops and seminars if they intended to transfer technologies or new information en-mass to the farmers. Asked about the low observed soil conservation measures taken up by farmers in the study area, the agricultural officer said that most farmers find earth structures cumbersome and that some of the farmers do not believe that soil is conserved using these structures. The farmers said the same. The officer however, was quick to point out that they do not visit farmers as expected due to lack of resources such has those experienced by forest extension agents.

3.9. Resource Assessment

Resources from the nearby state forest were assessed to verify farmers' concern that availability of some tree species, particularly *Olea africana, Podocarpus gracilior* and *Juniperus procera* was diminishing. When asked why those particular species were of interest, many of the respondents said that *J. procera* is good for fencing poles since it does not decay, *O. africana* was mentioned as being good for charcoal production as well a providing a good shade within homesteads while *P. gracilior* was mentioned as providing good shade especially to livestock as well as having high quality timber. The same concern was raised during group interview particularly with the male group. The group said that the three species were visibly scarce on the farmlands as well. These sentiments concurred with those of one of the key informants (an old man) who said that during the early 1940s there were many indigenous tree species both within and outside the forest, but were cleared so that exotic species could be planted instead. According to him, exotic trees do not bring rain. The old farmer believed that people have planted exotic trees because they grow easily and fast and that seedlings are readily available from Forest Department and from nurseries in Eldoret town. The old man however, acknowledged that they were not allowed by the government to utilise indigenous trees from the forest but somehow they still managed to get them.

A Chi-Square test showed a significant ($p < 0.001$; df = 10; n = 10) difference in the distribution of the observed diameter classes of the three species in all the plots (Appendix 2.21). Diameter class I comprised stems of below 10 cm, diameter class II comprised stems in 10-15 cm category, diameter class III consisted stems of 15.1-20 cm, diameter class IV consisted stems of 20.1-25 cm, diameter class V consisted stems of 25.1-30 cm and the sixth class comprised 30.1 cm and above. The general observation is that diameter classes III and IV have the highest density relative to classes V and VI. This indicates that seed bearing trees (V and VI) are being overexploited. Such unsustainable harvesting ultimately leads to the demise of the species, less species diversity and shortage of tree products in the near future.

In the Chi-Square test done for each species to determine the relationship between densities in various diameter classes across the plots for all three species, plots were lumped into three categories. A significant difference in size class distribution was found to exist among all the species. Plot number one represents the beginning point, 300 m from the villages, while plot number 10 represents the furthest distance, 3 000 m from the villages. For *J. procera* ($p < 0.001$; df = 10; n = 10) diameter class III has the highest density, probably as a result of least exploitation while diameter class VI had the least density attributed to intense utilisation by the communities within the study area (Appendix 2.22).

For *O. africana* ($p = < 0.001$; $df = 10$; $n = 10$) the density of trees in diameter class I up to III was observed as being high comparatively. This could be due to non-utilisation and/or high regeneration of the species as a result of excessive opening of the canopy in this category of diameters. A more open canopy favours shade intolerant species since sufficient light creates conducive conditions for seed germination (Appendix 2.23).

For *P. gracilior* ($p < 0.001$; $df = 8$, $n = 10$) density was about the same for classes I, III and IV but quite low for classes II and V and above. It can be inferred that class II could have been harvested for poles, III and IV could have no economic value to the community, while class V and those above it could have been over utilised for timber. Therefore, the low density observed for class I and the seed-bearing classes poses a challenge to the future existence of the species as a result of diminishing seed source (Appendix 2.24).

The three species were also analysed for their distribution along the transect. Plots were located at 300 m intervals along the transect, leading away from the villages. Figure 3.7 shows the distribution of *Juniperus procera* across the plots. This figure indicates that further away from the villages, density is fairly high. As well as the longer distance to carry products, this could due to difficult terrain that restricts harvesting. Further away from the villages, the distribution is more bell-shaped. The middle class (III) shows highest density indicating a possibility of less harvesting. In general, close to the villages, stems with diameters greater than 25 cm are non-existent indicating intense utilisation that eases with distance.

Figure 3.8 shows the distribution of *Olea africana* across the plots. From the figure, it can be observed that closer to the villages, the distribution is inverse-J shaped indicating a stable stand that is capable of regenerating due to all stem sizes being represented. However, further away there is no clear distribution in the pattern although there are larger diameters further away from the villages. Generally, stem density increases with increase in distance. Since certain plots had no stems at all, it

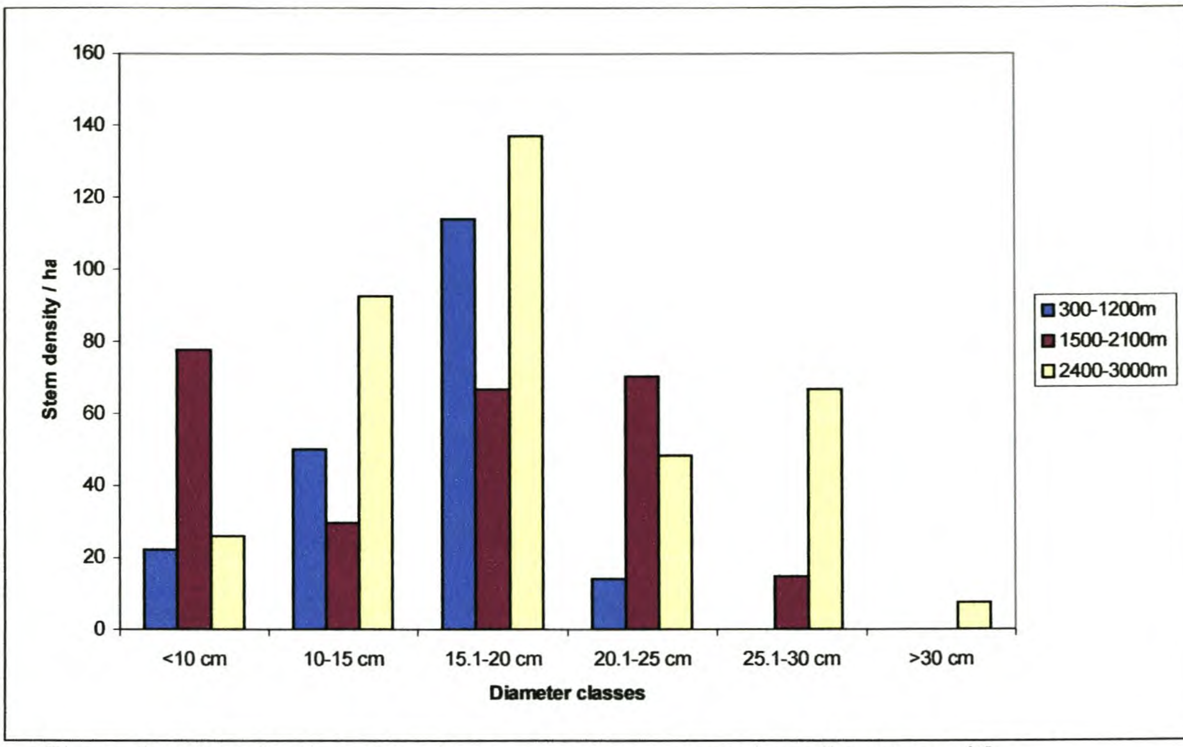

Figure 3.7: Distribution of *Juniperus procera* across various diameters with increase in distance from the village (n=10)

can be inferred that regeneration was hampered by lack of seeds or unfavourable germination conditions. However the high density of small diameters could for the time being ensure existence of the species into the next generation but as human population increases, there is increased pressure on these resources. This could cause premature harvesting leading to harvesting of seed bearing trees and subsequent scarcity of this species.

The distribution of *Podocarpus gracilior* along the transect is shown in Figure 3.9. It can be deduced from Figure 3.9 that further away from the villages, the distribution is bell-shaped but almost flat, as one nears the villages. The species density further away from the villages, suggests that chances of the species regenerating and therefore existing into the next generations is higher because younger seedlings that will mature to seeding stage, are relatively abundant. Apart from diameter class III and IV, the rest of the classes have very low densities especially closer to the villages.

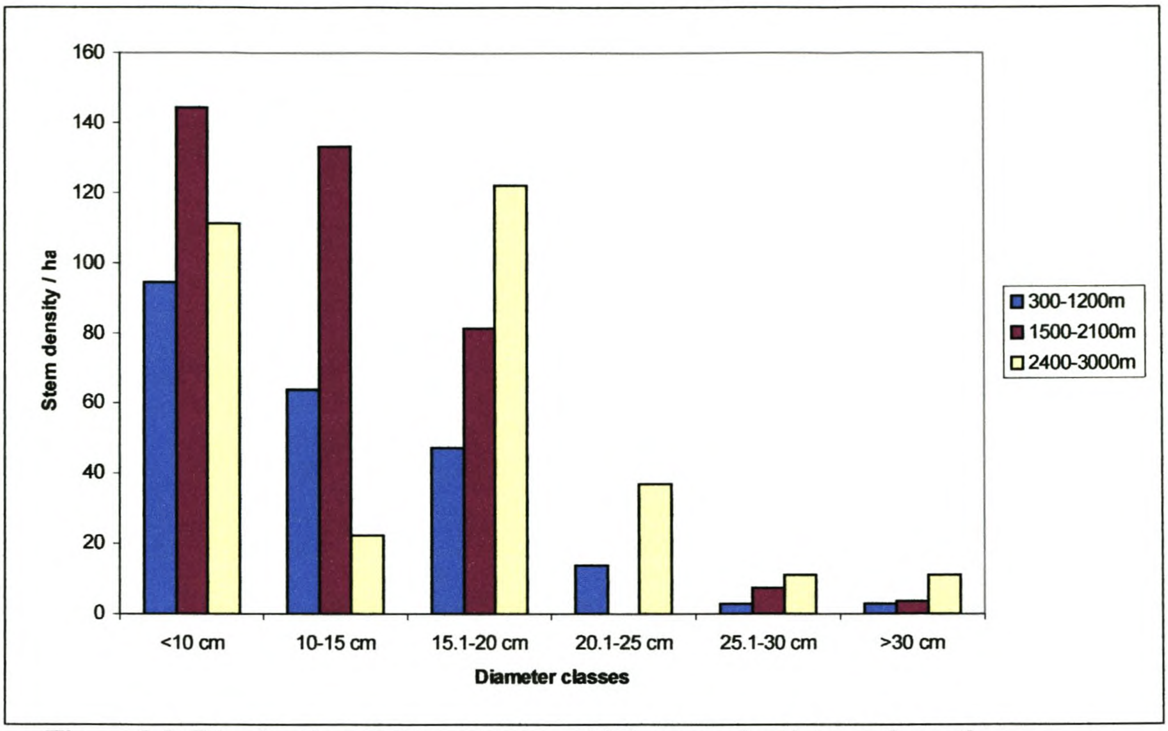

Figure 3.8: Distribution of *Olea africana* with increase in distance from the village (n=10)

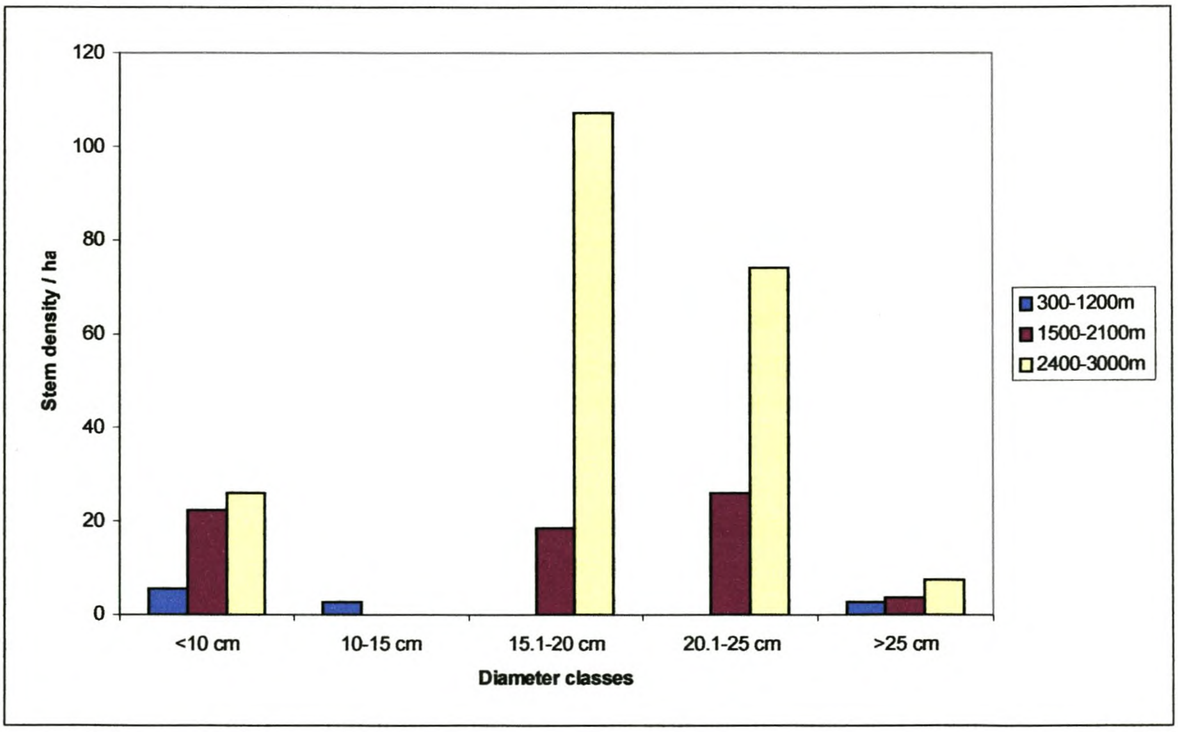

Figure 3.9: Distribution of *Podocarpus gracilior* with increase in distance from the village (n=10)

It can be deduced from Figure 3.9 that further away from the villages, the distribution is bell-shaped but almost flat, as one nears the villages. The species density further away from the villages, suggests that chances of the species regenerating and therefore existing into the next generations is higher because younger seedlings that will mature to seeding stage, are relatively abundant. Apart from diameter class III and IV, the rest of the classes have very low densities especially closer to the villages. It can also be inferred that seed bearing trees as well as young seedlings, are very limited in number. The danger with such a scenario is that the rejuvenation of the species into the next generation is minimal and therefore there is a possible loss of this species in future especially close to the villages. It can also be deduced that classes III and IV could be of less economic value to the community.

In general, among the three species, *O africana* has higher chances of passing on to the next generations because young seedlings are reasonably abundant, although mature trees are decreasing in number while for the species *P. gracilior and J. procera,* their chances of being eradicated as a result of unsustainable utilisation is high and therefore farmers concern can be said to hold. This observation concurs with that of the officer manning Ainabkoi Forest station who among other things said that despite policing efforts aimed at curbing illegal harvesting of the protected indigenous tree species, poaching had reached an alarming state. He contended that the availability of markets for products like charcoal, poles and timber from hardwoods, had accelerated cutting of these prohibited resources.

4.0. Discussion

4.1. Introduction

This chapter presents an analysis of the findings of the survey of socio-economic factors that influence farmer participation in agroforestry in Moiben and Ainabkoi Divisions of Uasin-Gishu District. The results from the previous chapter indicate that some socio-economic factors that include gender, farm labour, farmer perception of tree costs and risks, farmer level of education, land and tree tenure influence farmer participation in agroforestry activities in the study area. It is also apparent that only 44% of the respondents had engaged in agroforestry in the study area largely as a result of less influence from extension services from the department of forests. The potential productivity of the landholdings within the study area is decreasing largely as a result of the constantly dropping soil fertility in the crop fields brought about by the eroded fertile topsoil. This translates into a decrease in crop production both for food and cash and subsequently a decrease in farmer income, as well as food shortage ultimately defeating the Governments efforts in poverty alleviation. At the same time the eroded soil particles from croplands have silted up lakes and rivers and caused eutrophication of these water bodies within the study area and further downstream. It is also evident that there is much pressure on the state forests for its resource as it is the chief source of wood products for the communities within the study area.

The fragile soils of the tropics can be improved and crop production enhanced based on adoption of agroforestry technologies that carry with them certain beneficial farming methods. These include the use of mulches and vegetation cover, use of efficient nutrient cycling cropping systems that minimise nutrient losses through leaching and the prudent use of chemical fertiliser in combination with organic residues for the improvement of soil fertility (Kang, 1993). The use of fertilisers in sub-Saharan Africa has not always been a feasible option due to the high cost, unavailability to the majority of the small-scale farm holders and their harmful environmental effects when used over a long period of time.

providing other tree benefits to the farmers within a very short period. The farmers have been highly receptive of the technology (Kwesiga *et al*., 1999). Studies in western Kenya showed that fast-growing trees such as *Calliandra calothyrsus*, took up nutrients from below the rooting zone of the annual crops and this was a beneficial effect of tree-crop interaction (Buresh and Tian, 1998). Agroforestry technologies such as improved fallows have been shown to enhance crop yields and reduce soil deterioration. From the above, it is clear that agroforestry can provide benefits to poor farmers. Therefore it is necessary to find solutions or ways of reducing if not totally eliminating the socio-economic barriers as incentives to farmer participation in agroforestry in the study area. As such the discussions will focus on:

- Land-use practices by farmers and its influence on the environment in the study area
- Influence of socio-economic factors on farmer participation in agroforestry activities in the study area.
- Influence of forest extension services on farmer participation in agroforestry activities in the study area.
- Utilisation of natural resources from gazetted forests by the communities living within the study area and its effects on the environment.

4.2. Land-use Practices by Farmers in the Study Area and their Influence on the Environment

Most of the population sample in this study practised subsistence, mixed and cash crop farming with a similar figure having livestock (objective 1). The majority of the farmers ranked cash crops, cash and food crops as well as livestock as the leading agricultural enterprises, with less than 2% ranking trees/tree seedlings and fruit trees as their first priority. Like any other agrarian community, the farmers in this area derive their livelihood largely from their farms even though some have other sources of income. The continuous cultivation of land for cash crops such as wheat and food crops such as maize, has contributed immensely to the depletion of soil nutrients resulting in decreased yields as mentioned by most farmers. This continuous cultivation has also increased vulnerability of the topsoil to erosion agents (objective 2). Most of the soils in East Africa are leached and highly weathered and they are low

Farmers in rural areas are striving to make ends meet and therefore any technology that increases their income and decreases monetary needs is a benefit to the majority. Agroforestry has been known to alleviate social and economic problems faced by the largely poor rural households through provision of wood products and fodder for livestock among others (Boffa, 2000; Lal, 1989; Buresh and Tian, 1998; Kwesiga *et al.*, 1999). Through research, some agroforestry technologies aimed at addressing small-scale farmer needs have been shown to be beneficial and workable in many agro-ecological zones. Agroforestry technologies such as alley cropping, parklands and improved fallows are known to reduce soil erosion and increase soil fertility therefore reducing the need to apply inorganic fertiliser, an input that is proving to be beyond the reach of the ordinary farmer (Lal, 1989; Buresh and Tian, 1998 and Kwesiga *et al.*, 1999).

Alley cropping involves incorporation of hedgerows of fast growing and mostly nitrogen fixing trees or shrubs on arable cropland with annual crops in the alley. Periodic prunings from the hedges provide foliage that can be used as green mulch to provide nutrients, improve physical properties of the soil and the hedges acting as barriers to erosion of the soil particles (Kang, 1993). Studies done in humid and sub humid regions of south-western Nigeria have shown that species such as *Leucaena leucocephala* and *Gliricidia sepium* are suitable alley cropping species among others. Lal (1989) showed that in plots tilled and alley cropped with *Leucaena leucocephala* and *Gliricidia sepium* (with prunings used as mulch) erosion was reduced by 73% and 83% respectively as compared to the control. Under alley cropping, Kang and Ghuman (1991 cited in Kang, 1993) observed an improved yield in maize crop compared to no-till plots. Therefore, with proper management and suitable hedgerow species, it is feasible to sustain or increase crop yields and alleviate soil erosion as experienced in the study area.

In many regions of sub-Saharan Africa nitrogen deficiency has been found to decrease food production (Kwesiga *et al.*, 1999). The decrease in maize yield in eastern Zambia has been attributed to continuous cultivation of croplands coupled with little or no nutrient supplement. As an alternative method of replenishing soil fertility, short-period improved fallows using *Sesbania sesban* as the perennial component was introduced and it is showing good potential in increasing yields, reducing erosion and resulting in decreased yields as mentioned by most farmers. This continuous cultivation has also increased vulnerability of the topsoil to erosion agents (objective 2). Most of the soils in East Africa are leached and highly weathered and they are low in plant-available nitrogen (Greenland, 1977 cited in Singh and Vaje, 1998). The high losses are as a result of ever shortening of the traditional fallow period attributed to increasing human population (Lal, 1989), which may lead to land degradation (Singh and Vaje, 1998). This is also exemplified by the high population growth rate in the study area. (Morgan, 1996) asserts that parts of the Rift Valley (including the study area) are categorised as having high erosion rates.

Morgan's argument augments the observation that crop fields are vulnerable to erosion shortly before sowing of seeds of most crops grown in the study area since sowing is done at the onset of rains and therefore the crop field surface remains exposed to water as an eroding agent for some months before the crop provides sufficient cover. This observation concurs with studies on soil loss done in Murang'a District in Central Kenya, which showed that crop fields such as maize fields generally have the highest soil losses, which in turn induces loss of crop productivity due to decreased soil fertility (Lewis, 1985 cited in Ovuka, 2000).

In Kenya, land provides the means to meet the basic subsistence needs of the family and therefore the major factor in economic development, particularly in farming (Mbithi, 1982). Although Mbithi points out the significance of land, unless it is used efficiently for optimal production, generations that follow later will have nothing to inherit. Therefore if farmers are to practice sustainable agriculture in the study area, there must be a balanced approach given to resource conservation, technology utilisation, economic incentives and environmental issues. Unsustainable farming methods in the tropical regions arising from poverty and the demand for food frequently reduce the capacity of the land to support production (Underwood, 1994).

It was found in this study that the majority of the farmers burnt their crop fields shortly before ploughing in preparation for planting a new crop. The farmers argued that burning eases movement of tractors when ploughing and that incorporation of crop residues into the soil make it difficult to control weeds even for those who use herbicides. Those farmers who hire tractors to plough their lands often found contractors refused to work on farms where crop residues are not removed.

As an unsustainable farming technique, burning or removal of crop residues may cause loss of certain nutrients (Place and Dewees, 1999). Burning crop residues exposes the soil surface to agents of erosion and causes loss of vegetation especially trees that are planted along the boundaries and crop fields. During the survey, one farmer mentioned that he lost all trees due to fire that emanated from his neighbours' farm while crop residues were being burnt. Land-use practices in the study area could be appropriate to the farmers but environmentally they carry more negative effects. Therefore more appropriate and sustainable farm management strategies are necessary if farmers in the study area have to increase crop yields among other farm produce.

In the study area, crop residues (maize stalks and maize cobs) other than cow dung were used as an alternative to fuelwood for cooking in the event of physical fuelwood shortage. Crop residues are a source of organic matter that can improve soil physical properties such as infiltration capacity and water retention since the residues have the ability to reduce evapotranspiration rate (Morgan, 1996; FAO, 1965). Crop residues, if left on the crop fields, could have several other advantages to farmers. One of them is a decrease in demand for fertiliser and therefore a saving of some money in that regard. Secondly environmental hazards arising from excess fertiliser use could be reduced. Crop residues have the ability to reduce raindrop impact on soil particles and reduce the velocity of runoff by improving the infiltration capacity of water through improved soil structure (Morgan, 1996). In this regard, agroforestry has the potential of eliminating use of fire on crop fields in that a farmer would be wary of destroying his tree crops and in the end the farmer will doubly benefit through increased farm fertility that will translate into increased crop yields and a subsequent increase in income. At the same time, there will be multiple products from tree crops.

Farmers in the study area mentioned that they use cow dung for cooking in the event of physical firewood shortage. This way, they are denying their crop fields a potential source of soil nutrient enhancing material that is cheaply available. Apart from that, smoke from cow dung poses a health risk resulting in more expenses on medical bills. It is estimated that 400 million tons of dung burned annually depresses the world's grain harvest by over 14 million tonnes (Spears, 1978 cited in Dankelman and David, 1997). Such practices could have been avoided had farmers engaged in agroforestry so that high quality firewood is provided within walking distance. It is difficult to promote agroforestry technologies however, unless farmers are made aware of sustainable land-use practices.

Since farmers destroy these residues in this study, a range of activities needs to be introduced:

- No burning of crop residues
- Encouragement of agroforestry practices
- Integrated pest management
- Wastes and agroforestry products fed to livestock

Intercropping and crop rotations other than application of inorganic fertiliser were among the methods used by farmers to solve problems of soil infertility and food shortage in the study area. Animal manure though not available in large quantities, was used by some farmers to improve fertility, especially on vegetable gardens. Although farmers used these soil-improving methods, agroforestry practices such as improved fallows could be more appropriate in that tree litter will continuously replenish lost fertility from harvested crops.

Despite their complaints of soil erosion and soil infertility, very few farmers were found to take active measures to prevent soil erosion by constructing terraces, practising contour ploughing or use of vegetation such as trees within crop fields. Most of these farmers mentioned that it has been difficult for them to use the conventional ways of curbing soil erosion. They said that the much-needed technical advice from the Department of Agriculture was not forthcoming and visits by frontline staff were minimal. In some cases, farmers' attempts to conserve soil have been frustrated by hired tractor drivers who were not able to manoeuvre along contours. On realising this, they gave up further attempts.

However, extension agents from the Department of Agriculture believe that, although they have been constrained by resources such that they have not able to frequently visit their clients, the few farmers they had managed to visit had a negative attitude toward conservation structures. Even farmers with their own tractors did not like terraces because they claimed that they were fuel consuming, that the structures did not really conserve the soil and that they lost more land because of the bunds. In instances where a farmer had terraces, it was observed that they had been so neglected that the terraces no longer served the intended purpose.

These farmers claimed that they did not have enough time and labour for maintaining these terraces. As Young (1997) suggested, agroforestry is suitable soil conservation technology for it may alleviate labour shortage because less of it is required than for earth structures. This suggestion suits well the study area because of labour insufficiency although laziness could not be ruled out. The observation that farmers are not making conservation a priority is corroborated by Ovuka's (2000) findings in Murang'a District in Kenya where it was observed that there was less land under conservation in 1996 than in 1960. His studies attributed farmers' stigmatisation of conservation structures to top-down methods used during the colonial era. Enforced soil conservation during colonial period in parts of sub-Saharan Africa had negative impacts that left a legacy in terms of attitudes towards intervention in soil and water conservation (Pretty and Shah, 1999 cited in Brown and McDonald, 2000).

As a result of farmers' reluctance to conserve the soil, more money is spend on procurement of fertiliser that is also environmentally unfriendly. As pointed out by Omamo and Mose (2001), fertiliser use by farmers in Kenya is directly proportional to prices of maize. With liberisation of grain marketing in Kenya, prices have declined considerably. It has also been reported that prices of fertiliser in Kenya are on average the highest in East and Central Africa. With decreasing yields in the study area, it is probable that less fertiliser will be utilised by the farmers and since they have no better options of increasing or sustaining fertility of the crop fields, less output will be expected leading to decreased farmer income that translates into increased poverty.

Therefore, in order to safeguard these communities against impending poverty, a holistic approach to promoting agroforestry technologies should be sought so that more farmers can adopt the practice. More emphasis on helping farmers to improve land husbandry and less on efforts to combat erosion alone could provide a more effective solution to this old problem. There is need to take into consideration socio-economic and cultural as well as biophysical or technical factors in order to gain wider acceptance of innovations by recipients. Mazzucato and Niemeijer (2000) found that farmers in eastern Burkina Faso accepted soil and water conservation technologies mostly if they made use of or maintained a social network since, they argue, networks increase exchanges of information. It is essential that before any agroforestry or soil or water conservation technology is taken to the recipients therefore, a study should first be done to identify the role of social institutions that may affect decisions that farmers make about such technologies.

In this study, it was observed that because of shortage of arable land, some farmers were allocated land close to water reservoirs and waterways and due to high costs, farmers had no other options of obtaining alternative land. In most cases these farmers were forced to continue cultivating next to these water points. Such allocations should have been avoided by the land distribution departments or by land planners. Since such land-use practices have detrimental effects such as erosion and siltation of water bodies, it would be advantageous to such farmers to adopt agroforestry technologies that can increase or give more outputs per given unit of land instead of losing all the fertile topsoil through erosion. The cultivation along waterways poses a threat to the livelihoods of people living further downstream because the water carries with it pollutants such as fertiliser and herbicides that affect both marine life and hence livelihoods of those who depend on these waters (Scheren *et al*., 2000).

The study also attempted to establish how the farmers allocate their expenditure in decreasing order of importance. Most of the farmers set aside money for school fees as first priority, then for food expenses or they first reserve some of their crop harvests for food before deciding what to sell. Others set aside money for farm inputs as a first priority. From this it is clear that farmers make no budgetary provision for tree seedlings or for tending of trees. Seedlings were sold cheaply and therefore if farmers were really interested in buying them, they could afford them. What are needed in Moiben and Ainabkoi, are incentives to the farmers in order to secure their acceptance. The current advocating of bottom-up approaches implies that the need should emanate from the farmers. Therefore, farmers should be able to perceive the benefits of agroforestry for themselves.

4.3. Socio-economic Factors that Influence Farmer Participation in Agroforestry in the Study Area

4.3.1. Gender and its Influence on Farmer Participation in Agroforestry Activities in the Study Area

Women and men are both sources of silvicultural knowledge and sustainable resource management practices but each may be knowledgeable about different species and practices according to their daily activities (ICRAF, 1997). Therefore adoption of technologies such as agroforestry interventions is gender-based, irrespective of the agro-ecological zone (Tengnas, 1994; Cook and Grut, 1989). Although farm-level approaches continue to assume that there is a single homogeneous household with unitary interests to which the costs and benefits of forestry accrue, reports of failed agroforestry undertakings have been observed to result from men alone reaping benefits at the expense of women who tended the plants (Jackson and Pearson, 1998). In any household, there is heterogeneity however, and therefore in decision-making, men may decide to engage themselves in one area of agroforestry and women in another (Cook and Grut, 1989). Some reports indicate that what might appear to be gender influence, might in reality just be a division of responsibilities along gender lines.

As observed in Africa, rural women, who produce 80% of domestic food and who constitute 60% of the poorest of the poor (Kabutha, 1999), play a crucial role in agricultural production in the developing world and they are largely responsible for feeding the family and fetching of firewood and water (ICRAF, 1997). Despite their roles, women seem not to have sufficient powers to enable them to make household decisions. In what was termed as 'gender factor' in tree growing in Embu District, Kenya, Wambugu (1999) found that there were differences among male and female family members with respect to priorities, decision-making and user rights, among others. In effect, in many Kenyan families, men are traditionally most influential because they own the land, which is a source of production. In western Kenya, it has been observed that men obtain fruit tree seedlings while women will raise them and eventually gather the fruit as an usufruct right (Cook and Grut, 1989), although this could be because it is women's labour that is utilised for household tasks. In general, however, men prefer trees species that can be sold to generate income while women value trees for food and fuelwood (Fortmann and Bruce, 1993).

The findings of this study on gender-related issues support the evidence from the literature. In this area the majority of the households are male headed. As heads of households, men are vested with authority and therefore they are responsible for making the decisions within the homestead. Decisions that include what crops to plant on the farm, where to plant them, when to plant them, when weeding of the crops should be done and which animal from the farm should be sold, whether his wife should attend a meeting or not and even how many kilograms of sugar should be bought are the kinds of decisions made by heads of households. Most of the land parcels occupied by the respondents in the study area were male owned, compared to only 3% owned by females. Men in this case are the only ones who can alter or use it as they deem fit, including selling it.

The communities living within the study area are patrilineal (the father's side is defined as kin and therefore sons but not daughters inherit and property through the male side of the family (Popenoe *et al.*, 1998)) and patrilocal (the married couple live in the household or community of the husband's parents implying that daughters move to her new husband's household (Popenoe *et al.*, 1998)). The traditional systems of land ownership and land transfers through inheritance have always been vested in the hands of males, with little provision for female access. At the moment, the system is sustained through practices such as registering land holdings in male names. By ensuring that property remains within their control, males in this community will always have an upper hand in everything else denying women a chance to do as they wish. Women in this community also have taken it that they do not have capabilities of making sound decisions before their husbands thus denying themselves humble development opportunities.

Although the traditional land systems have been transformed into the current private land ownership, a married woman or unmarried daughters are not guaranteed legal rights to own, allocate or sell the piece of land. However, the system provides them with usufructuary rights to utilise the land vested on their husbands' or fathers' patrilineage. This ensures women of continued use of the land for production and provision of subsistence crops and other family needs. To date men as heads of households still have an advantage over women in the current land privatisation programmes in many regions. In such cultures women's potential will still go to waste since land titling policies have tended to overlook the multiple user rights on property and land which other users may hold over the same plot (Jackson and Pearson, 1998). In the study area and Kenya as a whole, regulations governing disposal of land stipulate that the family should agree over the action. But despite these requirements, it is still possible for men to just sell land with impunity.

In this study, some respondents indicated that females could inherit land although efforts to identify females who have inherited land from their fathers were fruitless. This finding supports Wambugu's (1999) findings in an investigation into women's role in agroforestry in Embu District Kenya that showed that the current private land tenure in Kenya does allow women to own land under patrilineal inheritance among the Embu people, yet it is rarely practised. In the study area women, especially housewives constitute the silent majority since they are assumed by their husbands to own nothing and therefore husbands largely determined women's participation in any farm activity.

It was found in this study that most of the community groups found were exclusively female. The group members derived several benefits such as buying small plots of land to be used for construction of rental houses, while some groups owned maize milling machines. This is a clear show of female strength and capabilities. The active involvement of women in groups provides an ideal avenue for addressing gender issues as well as agroforestry activities. According to Scherr (1994 cited in Arnold and Dewees, 1997) tree-seedling nurseries in Kenya proved to be appropriate for small scale, informal women's groups because they shared the risk as a group and that the males related to them and who owned the land, would in turn benefit from a few seedlings. Therefore, women can use channels such as these to access male property (land) that in the long run allow them to exploit their potentials fully.

A study by Cooperative for American Relief Everywhere (CARE) Kenya in Siaya and South Nyanza Districts of Kenya revealed that gender and household status were among the constraints that influenced agroforestry practices. It was found that there were more trees on male-headed households if they had interest in tree planting and more tree cover on female-headed households with absentee husbands because women had greater autonomy for managing farms when their husbands were away. They also found that women could plant more trees on croplands and within homestead for fuel wood and fewer trees for timber and poles compared to men (Scherr and Muller, 1994 cited in Arnold and Dewees, 1997). However, findings by Wambugu (1999) in Embu Kenya showed that men preferred tree species for fuelwood more than women did. This could be attributed to commercialisation of fuelwood in the area. Therefore women in the study area can equally engage in agroforestry practices like their counterparts in Siaya given a chance by their husbands and an overall change of attitude between both sexes. Women should look at their capabilities positively while men should recognise those abilities and allow them to be fully exploited.

Other research reports in Kenya indicate that in most communities, male dominance over women is sustained by invoking certain cultural practices and taboos. For example in Kakamega and Kisii Districts in Kenya, Kenya Woodfuel Development Programme (KWDP) found that tree planting efforts were hampered by gender-related issues such as tree tenure, taboos such as woman becoming barren and husband dying if they plant trees, and division of labour based on gender. They found that in general men owned land and the rest of the property on it. However a study in the same area by Chavangi (1989 cited in Kerkhof, 1990) revealed that older women who have had enough children planted trees. Understanding gender-related constraints therefore, can best enhance women's potential in agroforestry among other farming activities. Policy makers however, could derive such information from organisations involved in gender-related research. This will enable the drafting of regulations that empower women at grass root level and/or at decision-making level.

A study of 95 developing countries showed that women comprised 46.2% in sub-Saharan Africa of the total agricultural labour force in 1970 (Fortmann and Rocheleau, 1984). Therefore in the study area, agroforestry practices such as those that involve intercropping of trees with crops should include women, since more often they are the ones who grow crops or care for domestic animals. Women in the study animals. Women in the study area wished that they could engage in agroforestry activities so that they could obtain tree products particularly firewood that consumed a substantial quantity of their time and energy and that is why school-going children were used to accumulate firewood during school holidays in this community because women have less time at their disposal.

By training women to raise seedlings and to plant and care for trees, the Green Belt Movement (GBM) a Non-Governmental Organisation (NGO) in Kenya, has enabled communities through women groups to engage in agroforestry activities. An estimated 65 tree nurseries now exist. With those nurseries, communities have been able to sell the seedlings to the NGO, generating income for them, and already they are aware of tree benefits especially in soil conservation (Mathai, 1985; Bradley, 1991 cited in Evans, 1996). As observed elsewhere, inequality in land ownership patterns results in high inequalities in availability of basic household commodities such as fuelwood due to decreased access to the sources of these commodities (Agarwal, 1986 cited in Dankelman and David, 1997).

Hoskins (1983 cited in Steppler and Nair, 1987) suggested that certain agroforestry practices such as homegardens that are close to the homesteads strengthen women's possible control and access to these resources, especially in cultures that restrict their movement. Therefore by best locating the various agroforestry components, women tend to benefit most since the majority of them spend most of their time within the homestead. Such a practice can be encouraged in Moiben and Ainabkoi Divisions since some farmers mentioned shortage of food and lack of labour as limiting their involvement in agroforestry. It could be appropriate because multi-storey homegardens can provide sufficient food to the households due to utilisation of canopy levels by plant components and that homegardens are not labour intensive. Surplus food could be sold by the women to generate income for other household needs. This would help in alleviating poverty.

The division of labour in agriculture has often resulted in men's involvement with cash crops/trees and women with subsistence crops. As the main providers of farm labour, women in Kisii region in Kenya, in particular those who head households, were found to manage farm work, make decisions and maintain buildings like men

(Fortmann and Rocheleau, 1984). Therefore if women in the study area were allowed to actively participate in decision-making, there are chances that new technologies such as agroforestry might be prioritised and taken up by households, because it is the women's labour that will be used to plant and tend these trees. The division of labour along gender lines however, should be seen in the light of urbanisation, industrialisation and capitalist economic systems that are slowly bringing changes in social and economic roles.

Some households in this survey were found to have absentee male heads of households. Men were employed elsewhere or looking for off-farm employment, leaving women behind to do men's work. Therefore in the study area, men should relinquish some of their cultural fears of losing control of resources in the event that women are allowed to play equal roles within a household. Women with absentee husbands should utilise the opportunity to harness their potential since they are at liberty in their husband's absence to learn new ideas and technologies such as agroforestry and possibly practice them in their absence. Women can also use this opportunity to attend women group meetings that deal with gender as well as those aimed at empowering and enlightening them.

Women in the study area however seem to have inherently accepted male dominance within the household due to cultural practices they have been exposed to. Most of the women might not be in a position to object to some actions or decisions made by their husbands lest they are seen as challenging them. In a nutshell, more has to be done from the cultural point of view so as to turn around these cultural norms of male dominance in order to realise female potential in Moiben and Ainabkoi Division.

4.3.2. Availability of Farm Labour and its Influence on Farmer Participation in Agroforestry

Labour as a factor of production is used by rural agrarian communities for planting crops, weeding, harvesting and herding livestock among other activities within households and therefore farmers prioritise use of farm labour especially during peak farming period (Mbithi, 1982). Seasonal migration of labour arising from income diversification may lead to insufficient agricultural farm labour during certain critical times of the year, with an end result that farm practices such as agroforestry that demand some labour will only be adopted by farmers who can hire it (Cook and Grut, 1989; Raintree and Warner, 1986), this can be a constraint or a disincentive (Hoekstra, 1987; Kang *et al.,* 1990 cited in Nair, 1993).

It was found in this study that among all the respondents, less than one third had sufficient farm labour during peak periods even amongst those respondents who practised agroforestry. The majority of the respondents also mentioned lack of farm labour as a constraint to agroforestry practices. The study area falls into an agriculturally high potential region and therefore it is likely that, despite its abundance, most of the labour is diverted to production of food through planting, weeding and harvesting of annual crops.

As observed in Moiben and Ainabkoi Divisions, all schools (primary and high schools) close for holidays during the month of April and children then at home have to help with planting and weeding of crops such as maize as mentioned by most of the respondents. This could probably explain the large family size observed. At this time of the season, activities such as agroforestry that require labour are not a priority to the farmers as they concentrate first on critical income generating activities and as a way of securing food supplies lest men as heads of households are termed as failures in the event that their families go without food in the course of the year. Similar findings were observed by Wambugu (1999) in Embu District in Kenya that showed that the majority of the households used children's labour in farm activities such as transportation of farm produce either from fields to home or from home to the market among others.

Most of the households in Moiben and Ainabkoi Divisions had family sizes of six members and above. Most of the available labour was derived from the family. It can therefore be deduced that family labour plays a significant role in various agricultural activities in the study area. As observed in this study, no farmer prioritised agroforestry activities when asked to rank expenditure. Most farmers directed their income to what they perceived to be crucial activities such as farm inputs, payment of school fees and other contingencies. This means that farmer engagement in agroforestry activities would be considered last after all other major activities have been achieved. This is worsened by the weather because trees are to be planted at the onset of rain, at the same time as crops. At this time too farmers would have possibly spent all their money on farm inputs such as fertiliser and seeds leaving nothing for tree seedlings or for paying labour in case there is any.

Studies on rural farm labour in eastern Kenya showed that its availability largely depended on or was related to the value of farm activity interlinked with characteristics such as family size and stage in the family development cycles that determines it. Rural farm labour was allocated based on factors such as gender and age and its demand went up during peak period to an extent that it exceeded family labour supply but dropped again during off-peak (Mbithi, 1982). Due to the observation that labour could be constraining farmer engagement in agroforestry in the study area, labour extensive agroforestry activities such as scattered tree species on croplands could be introduced so as to act as an incentive to farmer participation in the activity. Once it has gained acceptance, labour intensive technologies could be introduced. Such a technique may help avoid situations such as those experienced in Chipata Zambia whereby only households that hired labour or used oxen were able to adopt improved fallows because farmers adopt technologies that involve low risk and offer high returns to labour (Kwesiga *et al.*, 1997).

This study however, does not support observations made in Central Kenya by Arnold and Dewees (1997) that shortage of farm labour encourages tree planting. This may be because the term "shortage" is relative and labour in the study area may still be relatively more abundant than in Central Province. The Central Province of Kenya supports high value perennial cash crops that are capital and labour intensive. Comparatively, crops grown in the study area are not that labour intensive. Labour is restricted to approximately two months of planting and weeding and when harvesting only.

In an analysis of returns on cash, land and labour invested in different agricultural activities in Malawi, it was found that returns to labour but not cash, favoured pole production as long as a few farmers made such investments and that the prices of commodities produced remained high. It was also observed that collection of firewood provided low returns to labour with no land and cash costs and therefore the invested labour had low perceived cost to the farmers. Therefore farmers preferred to allocate as much farmland as possible to production of maize since there was little incentive to establish woodlots for firewood needs (Cook and Grut, 1989). Other studies also show that in situations where there are off-farm income earning opportunities, farmers may practice low technology, low input agroforestry systems (Hoskins, 1987). Some farmers in this study had off-farm sources of income. By engaging in businesses that gave quick returns, farmers did not see the need to engage themselves in labour demanding agroforestry practices. Therefore, labour abundance or scarcity can make a farmer decide on various activities such as agroforestry.

Elsewhere in Africa, it has been observed that peasant cultivators seldom perceive population growth as a serious problem. Accelerating land alienation, deforestation and poverty creates strong incentives for the rural poor to have many children as a source of badly needed labour, insurance against old age and as a potential migrant who could send remittances (Barraclough and Ghimire, 1995). It can be inferred from this study that although farmers in the study area claimed that insufficient labour contributes to the observed low engagement in agroforestry activities, laziness on respondents side could be part of the contributing factors in that use of tractors in farm operations were observed to be common in the study area and that initial tree incorporation is not a labour intensive activity as such. Coupled with this assertion are responses from some farmers that they were not interested in agroforestry. This points at lack of interest also as playing some role in lack of adoption of agroforestry technologies.

4.3.3. Land and Tree Tenure Systems and its Effects on Farmer Participation in Agroforestry in the Study Area

Land and tree tenure, including both ownership and usufruct rights, are highly complex issues in Africa and the prevailing rules differ widely from one part of the continent to another. An understanding of who owns land, who owns the trees on that piece of land, and who has the right to harvest some or all of the tree products at certain times of the year is critical to understanding the incentive system that applies to agroforestry interventions in the context of particular cultures (Cook and Grut, 1989; Fortmann, 1985). Cook and Grut assert that these tenure issues have less to do with formality but more to do with customary rights involving individuals and groups within communities and that it is the usufruct rights to land or to resources, that matter in the lineage. In many countries, the land is under the control of the elders who allocate it to their sons for use but not to be sold therefore a corporate resource within the lineage.

Land tenure systems that do not guarantee continued ownership and control are not likely to be conducive to the adoption of long-term strategies such as agroforestry since they determine whether the benefits of agroforestry reach intended beneficiaries (Nair, 1993; Buck *et al.*, 1999). Rights to trees whether planted or not, are not always clear and confusion or uncertainty over who can cut what and when can be a major disincentive in social forestry programmes (Chambers, 1987; Chambers and Leach, 1990 cited in Evans, 1996; Tengnas, 1994; Nhira and Fortmann, 1993). For example, in Zaire and among the Sukuma people of Tanzania, tree planters own the tree while in Lesotho and among the Buganda people, trees customarily belong to those who own land (Fortmann, 1985).

Findings of this study showed that most of the farmers were living on land registered under free hold (private) although some respondents indicated that they were yet to be issued with land title deeds. This same observation was made in Kenya almost a decade ago by Tengnas in 1993. Of those whose land was not registered, the majority did not practice agroforestry. During the survey, some farmers indicated that they had shifted their boundaries up to three times since they inhabited the area. They attributed this to attempts by different land surveyors to adjudicate the land and every attempt resulted in disagreement on how to correctly locate the beacons. In the process, they lost trees that they had planted along the boundary and therefore they were not going to plant any more until they were sure that a final demarcation had been made.

Land is the key source of production in many agrarian societies and therefore every effort is made by owners to ensure that they control it and the resource on it. As Mbithi (1982) points out, land represents social and economic well-being in Kenya. It provides the means to meet the basic subsistence needs of the family. Since there exists no tradition of a landless class, land is assumed as given and without it, one is regarded as poor. Land also provides one with identity and association with one's kin. With these values attached to land, people living on trust lands in the study area do not feel secure and therefore they are not able to engage in long-term investments such as agroforestry. Arnold and Dewees (1997; 1998), found that there are more trees under adjudicated lands in Kenya than unadjudicated for the reason that individual tenure encourages tree planting to establish boundaries needed for adjudication of the land holding, although they argue that security of land tenure alone is not a prerequisite to investments in long-maturity crops like trees. Rather solutions within existing legal and tenurial framework should be sought.

Most financial institutions in Kenya use land title deeds as collateral in order for one to secure a loan. By obtaining loans, farmers are able to carry out investments such as agroforestry even if they are long-term. With a loan, a farmer is also able to spread risks by trying new technologies and innovations. Even if they fail, they are able to repay the loan, especially when the lending terms are favourable. Therefore security of land tenure is vital for enhancing one's financial base because of the capability to invest. A farmer is capable of buying tree seedlings, hire labour for planting and tending of trees (if there is no family labour) and even forgoing part of his fertile land by planting trees on it since he/she can make other investments as the trees grow to maturity.

In this study, it was found that most farms were registered barely seven years ago and that about half of the farmers surveyed had immature trees. This suggests that these farmers only planted trees after official registration. Farmers in the study need time and persistent visits by extensionists as sources of technical know-how. Therefore private ownership of land determines to some extent how we manage natural resources. The question of who owns and/or has rights to use the resources therein, determines the services and products derived from it. Lack of legal property rights like tenure over land, is a disincentive to consider long-term productivity due to lack of assurance of being able to stay and capitalise on any investments in good soil or water management (WR, 2000). In this context, secure land tenure may stimulate farmers to adopt more efficient and more sustainable form of land uses such as agroforestry.

Private land ownership is however still not an assurance that the landowner is in full control of its management because such practices as post-harvest communal grazing still exists. These practices make protection of planted trees and conservation measures difficult (Tengnas, 1993). Among the constraints to agroforestry practices mentioned in this study by most of the respondents was the difficulty of protecting trees because livestock browsed them. Apart from post-harvest free range grazing, a number of respondents were found to own goats and sheep. With such livestock, it is difficult or expensive to fence off areas with tree seedlings since these animals can get through even a small opening. In addition, many of the people living within these villages are closely related and therefore it becomes difficult to the private owner of the farm to deny his or her relatives a grazing field. This reflects private land as being partially communal. For as long as such cultural links still play a role in land management, it will take time before agroforestry activities pick up in Moiben and Ainabkoi Divisions.

As Mbithi (1982) describes, in some sub-cultures, it is the custom for sons to be allocated plots of lands for independent use when they marry although they will not acquire rights to dispose of these parcels until their father's death. In this study, a number of respondents in this category indicated that they were not sure which part of their father's land they would inherit in the end and therefore they could not carry out long-term investments such as engaging in agroforestry. They said that if there were any trees on their father's land, they could only access with permission from their father. These respondents mentioned that their fathers controlled all activities within the farm holding so that any development was not possible without their approval.

Apart from sons not getting free access to land and property on it, this study revealed that land in this community is intertwined with gender in that women were allowed to cultivate a piece of vegetable garden for subsistence purposes only. In other words even if they had the intention of engaging in some agroforestry activity, their chances were limited. This observation ties in with Mbithi's (1982) assertion that women in Kenyan gain land through marriage. With such tight control of land by men, women are likely to develop negative attitudes towards any activity that requires the use of that land. Therefore agroforestry should be promoted by understanding traditional, and legal control of land that translates into current practices of access to and control over resources and that policies should be put forth aimed at reconciling the two forms of resource control in order to reduce stifling of development programmes.

Elsewhere in Kenya, many pastoral communities still own land communally and individual tree planting is viewed as a way of claiming the land. This acts as a disincentive for those who think that they will not benefit from practising agroforestry. For example in the Kenyan coastal region, squatters cultivate annual crops under coconut trees while the tree owners harvest their nuts. Equally one can buy land but not the coconuts on it since they belong to someone else (Tegnas, 1994). Experience from a wide range of agroforestry projects financed by development banks in Kenya and Niger among other countries are of the view that security of land tenure is a major incentive to investment in agroforestry and to the protection of trees and woodland (Steppler & Nair, 1987). From these arguments, it is evident that land tenure systems, particularly those that have an impact on women and young families, need to be addressed in the study area by harmonising both legal and customary resource control practices.

4.3.4. Level of Farmer Education and Training and its Effects on their Participation in Agroforestry in the Study Area

Education and training influence farmer efficiency and participation in farm practices such as agroforestry and forestry in general (Spring, 1986). Knowledge is the key to any planning process and by extension any development activity like agroforestry. It enhances the ability to identify issues with accuracy, consider options and make sound decisions (Munyembe and Sambo, 1999). Therefore, level of education should in theory widen one's scope of acquiring knowledge and new ideas and at times ease acquisition of new skills. A study by Chavangi (1986) in western Kenya for example revealed that women's access to formal education and training are important factors in determining the adoption and implementation of appropriate and recommended agroforestry systems and practices. It showed that women with better educational background had a higher perception of agroforestry systems and practices that could alleviate poverty and reduce environmental degradation in the rural areas.

This survey revealed that the majority of the respondents underwent formal education. However about half of the respondents had only been to primary school and many of those had to leave school before their primary education was complete. Formal schooling as mentioned by the majority of those farmers who were engaged in agroforestry practices, had helped them in creating awareness of agroforestry, although only a few had learnt about agroforestry in school. Although it can be argued that some of those farmers who practised agroforestry had never been to a formal school and that some respondents who had high school education were found not to engage themselves in agroforestry practices, it is clear that a combination of improved awareness of agroforestry within schools and at Government level together with more farmer training is necessary if agroforestry is to become part of the accepted agricultural system in this part of Kenya.

A number of respondents derived medicinal herbs from the adjacent forests indicating that other than formal schooling, farmers in the study area incorporated their indigenous knowledge in agroforestry activities. Therefore it is essential that indigenous knowledge should be harnessed while promoting agroforestry species, practices and activities in the study area. As Sanchez (1995) points out, agroforestry as a discipline draws on traditional knowledge and practices as well as generation of new knowledge related to the integration of trees and shrubs into managed landscapes.

Social forestry programmes involve different groups of people such as landowners, policymakers and farmers themselves among others each playing different roles and as such each has different need in terms of information to help carry out the tasks. Therefore, successful forestry-related programmes are achievable through education and training. A research on farming systems in south-eastern Nigeria identified low educational attainment as one of the constraints to adoption of agricultural innovations. Farmers with better education practised more enterprise combinations compared to the less educated. This was so with new technologies such as alley cropping that required better understanding (Ndaeyo *et al.*, 2001).

4.3.5. Farmer Perception of Tree Costs, Benefits and Risks and its Influence on Agroforestry Activities in the Study Area

In production systems such as agroforestry, farmers' decisions to participate in agroforestry or not are affected by factors such as costs and the returns that accrue as well as other benefits provided by the trees. These are determined by factors such as availability of land and labour among others. Other than costs and benefits, farmers take elements of risks involved in farming into consideration. Risks such as failing to reap benefits after investing, tree component competing with annual crops for nutrients, light and water, the time taken to derive benefits from the perennial component are also considered by farmers before engaging in agroforestry activities (Pegorie, 1990; Barraclough and Ghimire, 1995).

It has been observed elsewhere that farmers weigh the opportunity cost of agroforestry as a new farm activity against all other on-farm and off-farm activities considering that both use factors of production such as land and labour. Farmers also perceive risks based on market availability and environmental policies. Therefore, those who can take risks do adopt or practice new technologies. Agroforestry practices can then be said to succeed if there are reliable markets and support institutions so as to take care of the risk takers (Cook and Grut, 1989).

This study found that some respondents were wary of the destructive effects of pests and diseases on trees. Some farmers remembered the economic cost they incurred due to the break out of an aphid a decade ago in Kenya that destroyed *Cupressus lusitanica,* and which caused farmers to harvest these species prematurely. As a result farmers were reluctant to repeat this experience. Therefore, cost-benefit knowledge can be a factor in the farmer decision making on the kind of agricultural activity a farmer wants to undertake (Kang and Wilson, 1987).

Studies done to evaluate factors influencing the adoption and farmer perceptions of risks associated with agroforestry in Senegal identified labour availability among others as a significant factor contributing to adoption of agroforestry in that by

Studies done to evaluate factors influencing the adoption and farmer perceptions of risks associated with agroforestry in Senegal identified labour availability among others as a significant factor contributing to adoption of agroforestry in that by contributing to the sense of security of a producer, they diminish antipathy to risking adoption of agroforestry practices (Caveness and Kurtz, 1993).

The majority of the farmers in this study were aware about agroforestry and its beneficial effects (objective 3) although only a few of them participated in it. Farmers derived benefits such as cash through sale of trees, tree products, aesthetic values, medicinal herbs and tree seedlings. In general, risks such as diseases, farmers mentioned trees competing with crops leading to low yields and long gestation of trees that deterred them from planting or retaining trees on their land holdings. The scarce labour was also considered part of the risk in that farmers would rather use it for annual crop production than for planting trees, because of the high opportunity costs involved in tree production. (Raintree, 1983; Singh *et al.,* 1995) contend that in labour scarce economies, those technologies that give higher returns to labour and land will have the greater perceived advantage. Therefore farmers tend to adopt technologies that give maximum returns to the most scarce production factor in this case labour. In this regard, the opportunity cost of labour in agroforestry seems high.

Farmers in the study area valued their scarce land. Among those farmers who had trees on their land parcels, a number of them claimed that they were not planting crops close to trees because crop yields were less next to the trees and therefore they perceived that space as wasted. It is for this reason that agroforestry technologies such as hedgerow intercropping that involve direct incorporation of trees on crop fields were not practised by all the respondents in the study area. Farmers need high incomes and therefore trees crops that provide higher returns from the land than the alternative crops could be favourable. For example, in Sudan the leguminous *Acacia senegal* planted as fallow enriched the soil, produced marketable gum arabic for income, provides fuelwood, fodder and fibre (Arnold, 1983). Therefore if multipurpose tree species could be introduced to farmers in the study, there are chances that they will be more acceptable since returns can be realised early depending on the type of product.

The type of tree species provided by extensionists within the study area has aggravated farmer observation that trees reduce crop yields in the study area. The majority of the farmers preferred species such as *Acacia mearnsii, Eucalyptus* and *Cupressus lusitanica* that are not suitable for incorporating with crops. *Eucalyptus* and *C. lusitanica* have been found to be allelopathic, particularly *Eucalyptus saligna* that has been found to have growth inhibiting effects on other crops (Lisanework and Michelsen, 1993). These are plantation species mostly planted by the Forest Department. The prevalence of species such as *Acacia mearnsii* and *Eucalyptus* can be attributed to its ease of regeneration through prolific seeding and coppicing and provision of good charcoal, firewood and fencing posts.

In this regard, extensionists seem not to offer a range of options of tree species that farmers can choose from and therefore the limited number of species is negatively impacting on the adoption of agroforestry in the area, particularly the lack of indigenous tree species. In the extensionists menu, indigenous tree species particularly those that compete least with crops should be promoted through domestication. With more favourable tree species, farmers in the study area might develop a positive attitude towards trees and agroforestry in general. Elsewhere in Africa, a similar situation of supply bottlenecks for tree seed and seedlings and a limited choice of species have constrained the adoption of agroforestry technologies (Place and Dewees, 1999). This could be attributed to an information gap as mentioned by the majority of the farmers, a gap that could be overcome by providing support services such as extension (objective 3).

Farmers in the survey area did not perceive the need to plant trees for their products if they could obtain them from somewhere else although it was apparent that few of them were self sufficient in wood products. The rest either bought wood products cheaply or collected them free of charge especially from the state-owned forests. Farmers would therefore rather use the alternative sources of obtaining wood products at cheaper rates than commit their small portions of land to trees that could take long to mature as respondents considered tree gestation period as a risk because of uncertain future harvest.

The use of available fuel alternatives such as crop residues or dung may have presented a lower opportunity cost to the farmers than creating supplies of tree products in the study area. Almost one third of the respondents said that they did not envisage any shortage because the forest resources are still plentiful and therefore they saw no shortage. With such perceptions of abundance of resources, the respondents found it not worthwhile to lock up their productive land in commodities such as trees that take long before benefits could be reaped. This is in keeping with Arnold and Dewees's (1997) observation that in many rural agricultural systems, household incomes and resource gaps are filled by drawing on off-farm/communal property resources and that aspects such as cultural beliefs and attitude towards risk often condition the adoption of agroforestry activities. Such cheap sources of wood products are counter-productive to farmers who are would-be private investors.

Unless such government subsidies are removed, it could be difficult for a farmer to invest in agroforestry because there might not be any market for surplus produce if alternative sources are cheaper to the consumers. In addition the farmers, especially those who did not practise agroforestry, argued that although they required wood products for several purposes, it was not often that they needed these commodities. For products such as fuelwood, availability and time were not factors to the farmers who said that their wives knew where to collect firewood or else they could hire means to collect firewood if it was scarce locally. In this case, unless there is perceived need, a farmer might not be interested or might not prioritise investments such as agroforestry due to the risks and costs involved. Place and Dewees (1999) argue that for a farmer to make an investment in land, there must be willingness to do so although this requires that a farmer look beyond the household's short-term needs and attribute value to longer-term benefits. Off-farm economic options may offer a better use of labour resources than adding or intensifying tree management. Therefore, households use resources available to them to pursue a strategy that includes food security, social security and risk management as well as income generation among their objectives (Chambers, 1993).

Not all farmers are scared of taking risks however. Farmers in western Kenya have reduced the unknowns by incorporating locally known *Markhamia* species to test tree planting in lines and alleys (Scherr, 1995). They also reduced risks by experimenting with new practices in small numbers and in a small area and diversified by planting several species even for the same use to occupy different niches/sites conditions. Farmers preferred multi purpose tree species such as L*eucaena* planted, as an opportunity to take advantage of changing household needs and to offset their vulnerability to changing market prices. By trying out these species, these farmers gain multiple products such as leaves that could be used as green manure or fodder and prunings as firewood. Multipurpose tree species also offered components with early cash returns incorporated into the delayed returns from longer rotation tree production, where, for example, thinnings could be obtained earlier and used as fuelwood and poles for sale. Some farmers in western Kenya were also observed to plant fruit trees such as passion fruit to obtain an early return from sale of fruits, while others utilised badly degraded areas for trees, leaving the arable land for food production (Scherr, 1995).

Increased use of technological inputs and capital implies that risk and uncertainty over food production to the farmer and the entire nation would be reduced. Although off-farm activities can substitute for environmentally damaging farming activities on fragile land, there is need to integrate risk reducing and resource conserving traditional farming systems with applicable improved technologies such as agroforestry. Such integration can be achieved by involving stakeholders that include farmers, extensionists as sources of information and policy makers. This will in the end help achieve poverty alleviation, sustainability and growth objective.

4.4. Availability of Forest Extension Services and its Influence on Farmer Participation in Agroforestry

Forestry extension is any situation in which local people are directly and willingly involved in forestry activities and from which they will derive some recognisable benefit within a reasonable period of time. It is a two way educational process where local people and extension workers learn from each other based on perceived needs and/or opportunities by people for the betterment of their livelihoods, environmental maintenance and wood products (FAO, 1982; 1987).

Extension in the past has been regarded as a means of passing down to farmers, techniques that were believed to be beneficial to them without taking into account sufficiently the particular social or environmental conditions of the area. Now, extension is regarded as a much wider task of integrating indigenous and new skills and techniques, derived from study or research, into overall framework of discussion and co-operation between the people and the extension organisation (Juo and Freed, 1995). Recent views on extension suggest that it is a systematic process of the exchange of ideas, knowledge and techniques leading to mutual changes in attitudes, practices, knowledge, values and behaviour aimed at improving forest and tree management (Anderson and Farrington, 1996).

Within the study area, it was found that availability and accessibility of forestry extension services to the farmers was generally lacking despite the Government's efforts in the provision of these services. The majority of the respondents mentioned that forest extension agents had never visited them, while a key informant said that agricultural extension officers visited them more frequently during the early days of independence. Agricultural officers were more frequent, presumably because of the emphasis on agriculture as the main export-earning sector. This observation is in keeping with those of Anderson and Farrington (1996) who assert that governments have in most cases heavily invested on agricultural extension and therefore forest extension is relatively new and under funded or not well established. The farmers in the survey area said that agricultural extension officers informed them about ways of improving livestock production, improving crop yields and occasionally to plant trees as shade for livestock among other information. The contribution of agricultural extension agents to agroforestry practices in the study area is minimal owing to the type of training the extension agents receive.

It was also found that even among those farmers who practised agroforestry, the majority were partly constrained lack of forestry extension services in their efforts to participate and adopt agroforestry innovations. The majority of the farmers in the study area obtained information from the radio and the chief compared to a small fraction that obtained information through the forestry and agricultural extension agents, schools and neighbours. Although channels such as the radio and public gatherings are perceived to stimulate mass farmer awareness on new technologies and to improve the adoption and ease implementation of these innovations, these techniques were insufficient.

Most of the respondents said that information from the radio lacked details necessary for their decision-making processes because it only emphasised the usefulness of trees, and provided a one-way interaction. Information presented within a short period of time and therefore highly summarised is shallow in content. Information such as site and actual incorporation of trees with crops and the depth at which seedlings should be planted in the pit was needed. In addition, programmes were sometimes aired when farmers were busy with other farm activities and therefore even if there were important messages on agroforestry, they would miss them. Farmers saw extension as not being reliable because of lack of resources.

Despite forest extension officers' assertion that they used PRA to reach farmers, most of these techniques such as Training and Visit (T & V), field demonstrations, contact farmers and agricultural shows were found to be limited to a few farmers. As a result their impact was not as great as expected since the much needed agroforestry practices such as hedgerow intercropping and use of multipurpose tree species that have less negative and more positive interaction with annual crops had not been adopted by recipients. This is in keeping with Juo and Freed's (1995) findings that most agricultural and for that matter forestry education and extension is 'top-down' in that the methods used such as workshop and field tours depicts extension agents as the ones who know and the farmers are assumed not to know.

The findings from this research that extensionists do not visit farmers, the admission by the extension agents that they are constrained by lack of resources and the view by extension staff that farmers should be seen to be interested in agroforestry highlights a problem between the stakeholders. It may be that the current extension methods are too expensive for the Government, inappropriate because farmers' priorities are different or that frontline staffs are de-motivated. It is difficult to pinpoint one particular problem as the causal agent. This is in keeping with Evan's (1996) observation that extension methods fail because both the extension agent and the farmer are not playing their roles. Farmers have roles such as giving attention to the seedlings for the first few weeks while extensionists have roles that include adequately involving local farmers in development activities, facilitating them with and/or delivering seedlings the farmers at the critical time and above all provide follow up visits as well as devoting sufficient time for proper training and advice to the farmers.

The female farmers in this study mentioned that their husbands dealt with agricultural officers and they were unaware of the subjects discussed. This depicts a situation where extension agents probably ignored women in the course of their duties yet it is women who carry out most of the farm activities. Such gender biased extensionists indicate that the extension agents need re-training so that they can conform to the current belief that women are as capable as men of taking in a message and discussing it fruitfully with the household although it could be that culture does not allow talking to women in presence of their husbands. This problem is not unique. Almost 20 years ago women in Kisii, Kenya also affirmed that agricultural extension agents were ignoring them (Fortmann and Rocheleau, 1984).

By blaming farmers for their inactive role in agroforestry, the extension agents in this survey could have failed to understand the social issues prevailing in the study area as exemplified in a survey carried out to examine afforestation programmes in Kenya that revealed that four fifths of all interventions had failed. Among the cited reasons were extension agents' possession of packages of technological practices but very little skills in the art of communicating ideas to farmers (Mbithi, 1971 cited in Evans, 1996). In 1982 Mbithi identified the Kenyan educational system which produces graduates who are not trained to fit into rural communities often produce change agents with little empathy for the small farmers and their problems or needs as the major problem. An assessment of agricultural curricula in tertiary education systems would show whether this situation has changed over the past 20 years however.

In this study, farmers mentioned that seedlings are a constraint in their endeavours to engage in agroforestry. However, this sounds more of an excuse than a fact. In the study area, seedlings are distributed without charge during district and divisional tree planting days, sold cheaply by the Forest Department and in addition there are private nurseries that sell seedlings within the study area. As observed, seedlings were available but the menu could have been the limiting factor. Farmers claim in this study that they lacked capital to purchase seedlings, indicated that they would like seedlings for free and if possible the seedlings be carried up to their homesteads. This points at lack of interest. During the survey, a farmer in one of the households, mistaking the research team for forest extension officers, was quick to say "*we do not have money for buying seedlings if you are selling them*" just because the respondent heard the word tree during the introduction. With such attitudes, better extension techniques have to be sought so as to change farmer perception.

The best approach in extension is to first gather and document information on farmer characteristics such as decision-making procedure, family structure, attitudes and land tenure among others (FAO, 1987). More often, the indigenous skills and detailed local knowledge, beliefs, feelings, taboos, values and social relationships of the people have been ignored in trying to transfer new skills or techniques to them. By understanding these factors, an extension technique and innovation suitable to the area residents can be disseminated (Wang'ombe, 1984). For greater success in information dissemination, well-trained extension agents as well as cheaper methods such as use of influential leaders, 'best farm' competitions and incentives like "ICRAF" T-shirts are necessary in awareness creation (Kwesiga *et al*., 1997).

Decentralising administration and upgrading the skills of staff through training men and women equally can also improve forestry extension services. This offers an excellent opportunity for sensitising staff at all levels to gender issues in resource management and for developing gender attuned to extension services and participatory approaches (Jackson and Pearson, 1998). In an endeavour to promote afforestation, a forester should visit schools, talk to villagers and village elders and should generally advertise seedling availability, later making a follow up to assess the success. Today's foresters must possess skills far beyond those of knowing just how to grow and care for trees. They must help care for peoples needs and provide good technologies that have a range of tree-based options.

Some successful extension techniques include those used by the CARE-Kenya afforestation project in Siaya and South Nyanza Districts in Kenya. They employed simple and appropriate technologies such Diagnose and Design (D & D) to strengthen local knowledge of indigenous agroforestry system and within a year it is reported that there were more than two hundred applicants from an initial fifty groups. These methods established farmer priorities, problems, assessed current uses of indigenous trees and identified potential contribution of agroforestry (Cook and Grut, 1989). Other successful extension techniques include National tree planting days that have been shown to be useful for creating awareness. Presidential decrees have also been successfully used in countries such as Philippines. For example Presidential Decree no. 1157 (June, 1977) required every Philipino older than 10 years to plant one tree per month for five years. Such laws are largely directed at public education, environmental improvement and meeting widespread needs for firewood, fodder, shelter etc. These are better than pompous nationwide programmes that have been found not to lead to effective afforestation (Evans, 1996).

In Kenya, the presidential 'decree' or rather the slogan used is that for every one tree cut, two should be planted and that every year, there is a national tree-planting day that is often followed by tree planting at district and divisional levels. These methods could partially explain information derived from the radio and the chief by the farmers in the study area. One weakness however is the shallow information it gives to the recipients and that national tree planting and district tree planting dates do not coincide with the onset of the rainy season. Therefore, when farmers are issued with seedlings, once planted, their survival percentage is normally low because the dry season often starts before the seedlings take root and that the extension agents rarely monitoring in order to determine the survival percentage of seedlings planted out. Respondents in this study mentioned lack of water as one of the constraining factors in their endeavour to incorporate trees on crop fields. In areas such as Moiben Division where the 'murram' soils dry out, it is essential that farmers have access to seedlings (if they are available) early enough so that they can take root before the end of the rainy season. Timing is therefore crucial considering that at the same time farmers are also planting crops using the same labour force.

This study found that most of the respondents were not aware of the benefits of agroforestry and that six of those who were aware mentioned that they had no interest in tree planting. The disinterested farmers seem to be negatively inclined to trees in general and as such better approaches could be used to pass on the relevance of agroforestry to such farmers. Extension failures and negative attitude from the by treating as prototype to be adapted by farmers based on land conditions and economic needs. As Chavangi and Zimmermann (1987) point out, extension combines psychological, technical, social, institutional and political tasks. A well-established and well-informed extension service with adequate financial resources therefore, is a precondition to passing on of information relevant to the farmers who are largely rural.

4.5. Utilisation of the Forest Resources by Communities in the Study Area and its Effects on the Environment.

In this study, most of the farmers relied on bought or collected wood products, many of them from the government forests (objective 6). Farmers also graze their livestock freely in the forest, obtain medicinal herbs, keep beehives within the forest and house initiates during male initiation ceremonies. But a crosscheck with the forest officer in the forest station revealed that very few farmers buy wood products such as firewood and poles and very few pay the monthly grazing fee. Lack of policing due to insufficient resources in the forest department exacerbates the problem.

The continuous unabated use of these resources creates a false impression to the farmers that they are inexhaustible and therefore the need to incorporate trees on farms is given the least priority by them. The human population is increasing exponentially, farms are shrinking in size and therefore the population density is increasing. This is likely to increase dependence on forests and create acute shortages of resources, among other adverse environmental impacts, (Warner, 2000) particularly for commercialised products. Commodities such as poles from gazetted forests have been known to reach markets hundreds of kilometres away from their source (Koech[5], pers. comm.). It has been estimated that two in five people worldwide rely on fuelwood or charcoal for heating or cooking, and approximately 100 million people are already facing "fuelwood famine". A decreased fuelwood supply impacts negatively on food preparation that can lower nutritional values and increase chance of food related diseases (FAO, 1989 cited in Lipper, 2000).

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[5] J. Koech, forest officer, Ainabkoi forest station. January 2001

negatively on food preparation that can lower nutritional values and increase chance of food related diseases (FAO, 1989 cited in Lipper, 2000).

Apart from other wood products, farmers living adjacent to the forest in the study area also benefit from the *shamba* system of cultivation (Plate 4.1). The *shamba* system of cultivation found in the study is an old system of agroforestry, which was suspended by the Government in 1985 as a result of perceived abuse (Mogaka *et al*., 2001). Initially, Forest Department employees were allocated 'shambas' in the clear-felled areas and in the natural forest earmarked for plantation establishment as part of their pay package. When this was abolished, the 'shambas' were rented out, attracting outsiders. This caused huge allocations of land for cultivation even if the tree planting for the previous year had not been very successful (Kiriinya, 1994).

Plate 4.1. 'Shamba' system of plantation establishment as used by forest department in the study area. The fence is the boundary between state forests and the villages. Photo: B. Rotich. 2001.

Other problems associated with this development were that there was a reduction in the total forest area by squatters, forest labourers and their extended families, retired forest workers and licensed cultivators. Together with this was overstocking of cattle and sheep that accelerated soil erosion and degradation of steep slopes where trees these led to decreased reforestation and accelerated erosion forcing the Government to move everybody out of the forests (Kiriinya, 1994).

The *shamba* system is beneficial to the farmers in that it provides food and surplus sold in the markets, earns households income that can be used to bridge financial obligations within households (Koech, pers. comm). It was hoped that farmers would learn about the importance of trees by virtue of their constant contact with seedling tending in the forest and therefore be encouraged to plant their own. Unfortunately, this is not the case. To the farmers wood materials are obtained at minimal costs from the forest and therefore they do not perceive the need to carry out agroforestry and soil conservation measures on their farms. The negative impact of the system also is that most farmers spend their time and labour cultivating in the forest because of relatively higher yields from fertile forest soils, and have little incentive to plant trees at home. Therefore the system is a disincentive to on-farm technologies that include agroforestry.

The local community were concerned over the increasing scarcity from the adjacent forest of some indigenous tree species and that these species were rare on farms. The resource survey revealed that the farmers concern was genuine. Most of the size class diameters found were small showing that the communities' use of the larger tree diameters is likely to have a negative impact on the future survival of these species. A species such as *Juniperus procera* was most liked by farmers for purposes such as fencing because its heartwood is resistant to termite attack. Such slow growing species require many years to reach that stage although in the open, they can grow faster (Teel, 1984; Noad and Birnie, 1992). *Podocarpus gracilior* was least common within the sampled plots probably due to over exploitation for its highly valued timber. Large diameters are needed for a product such as timber and therefore the small diameters found in this study indicate that the communities have harvested most of the economically utilisable sizes. ICRAF (1992) assert that the species is becoming rare due to overexploitation.

There is need for sustained-use management of such uneven-aged mixed forests so as to provide for the needs of future generations for resources from these forests. It was found in this study that the regeneration of the three species is decreasing largely as

There is need for sustained-use management of such uneven-aged mixed forests so as to provide for the needs of future generations for resources from these forests. It was found in this study that the regeneration of the three species is decreasing largely as result of low densities of both large and small diameter classes. There is therefore a danger of losing these species in the near future due to a probable loss of the seed source, particularly now that pressure on the natural resources is increasing with increasing demand for products.

Since most indigenous species are known to grow slowly (Teel, 1984), there is a danger of biodiversity being lost as well as the general decrease in availability of wood products. *Olea africana* roots, leaves and roots were used for medicinal purposes traditionally and therefore extensive re-planting should be encouraged (Noad and Birnie, 1992; ICRAF, 1992). The observation that *Olea africana* regenerates well along forest margins (ICRAF, 1992) means that it can establish easily on farmlands since there is more open space and therefore farmers in Moiben and Ainabkoi should be encouraged plant the species both as a future seed source and for products. This can be achieved through facilitation by the Department of Forest. Wildings from the same forest can be transplanted on farms as already done for other species by some farmers in this study.

Although farmers were concerned about the three species, they are obtaining them illegally. The community is selectively removing certain species or products yet the Department of Forests has no resources for carrying out enrichment planting (Koech, pers. comm.). Despite knowing that it is illegal to harvest indigenous tree species, the local people continue to do so, because there was no incentive for them to stop. Charcoal production and marketing has become an illicit operation, being transported at night or very late in the evening (pers. obs.).

Several obstacles need to be overcome if social forestry programmes are to improve rural livelihoods and curb deforestation. These obstacles include absence of sufficient alternative productive employment opportunities for the rural poor, lack of secure access to adequate land, and exclusion from real participation in making the decisions and executing the programmes most affecting their lives (Barraclough and Ghimire, 1995). These observations are not new, and are relevant to all developing countries. In Zimbabwe, Grundy *et al.* (1993) found that rights of access to resources influence communities' management of these resources. They also observed that cultural taboos influence harvesting of particular tree species, indicating that incorporating indigenous practices into management plans may be a way to sustainably utilise resources.

Apart from loss of biodiversity, another environmental impact of community utilisation of the state forests is the increased erosion in harvested areas. Pilfering of indigenous tree species slowly and steadily is contributing to erosion of the fertile forest soils and increase in shortage of wood products that is worsened by planting backlog by the Department of Forests as mentioned by a key informant from the Department of Forests. Gregersen *et al.* (1989) maintain that forests in Kenya are being over exploited at about four times their sustainable growth rate for fuelwood among other wood products, and this deforestation can only be overcome by reforestation and tree planting at five times the present rate.

Involving local communities in the management of these forest resources could be a viable strategy in bringing trees closer to the communities so that they can develop a sense of responsibility, as this will ensure future survival of the species. The newly introduced Kenya Forests Bill (2000) that aims to create a semi autonomous body called the Kenya Forest Service to manage gazetted forests (Wily and Mbaya, 2001) will hopefully give provision for community participation in management of these forests. It is also hoped that it will curb unnecessary future excision of forests by the state, as has happened on several occasions where forests have been transformed into agricultural and residential lands.

Communities actively involved in management of forest resources will be able to learn more about trees and their usefulness and therefore it should be easier for them to adopt technologies such as agroforestry. Traditional knowledge and control of resources by communities has been shown to assist in conservation of these resources. Among the Turkana people of Kenya, Ellis (1984 cited in Mogaka *et al.*, 2001) found no evidence of deforestation or other undesirable environmental impacts due to routine activities of these people. The Turkana adapted to ecosystem changes by raising livestock that took advantage of the existing woody forage; they maintained itinerant and dispersed exploitation patterns and used trees selectively although at that time the population was low and land was readily available.

In situations where local communities have no decision-making processes related to the use of resources, agroforestry might be a better option. By capitalising on the indigenous knowledge of the communities in the study area, some of these highly utilised tree species can be domesticated. Through PRA techniques of disseminating information coupled with some form of incentives to the communities (such as assured markets), improved varieties of these trees can be supplied to farmers either as seeds or seedlings. The improved varieties should be fast growers because farmers need to see immediate benefits. Benefits such as marketable products that include fruits will generate cash for the resource-poor people in the rural areas. This agroforestry approach is at the same time linked to one in which perennial, biologically diverse and complex agro-ecosystems are developed as sustainable alternatives.

Domestication can balance food security with natural resource utilisation and is a means to reduce soil fertility depletion in sub-Saharan Africa (Leakey and Simons, 1998). The use of the forest for medicinal herbs as mentioned by some respondents may provide incentives for them to become involved in domestication programmes if such species can be planted within farms. This will reduce farmers' medical expenses in the long term and provide an income from sale of surplus products.

The need to intensify agroforestry in the study area is strengthened by the fact that it is a watershed area for Lake Victoria and that the existing forests resources are being decimated. As a land-use option for small-scale farmers living within the watershed, agroforestry can help achieve goals of both conservation and productivity (Hauf, 1999). When there is not sufficient absorption of precipitation, run off occurs and hence there is need to control water quality, quantity and regime. Sediments generated by ploughing, forest clearing, burning and cultivation as well as grazing from upstream lowers usability of water downstream (Colman, 1953).

they had no idea as to the effects of the run off that contained traces of fertiliser and herbicides on the water bodies further downstream. It is crucial therefore that farmers in the study area are introduced into the need to protect their croplands by engaging in agroforestry since those farms are part of the watershed. Tree species such as *Leucaena leucocephala*, *Sesbania sesban* that fix nitrogen and provide other benefits should be encouraged. Some farmers have already planted *Grevillea robusta* and those can act as a demonstration to the rest. Agroforestry practices such as homegardens could also be used to protect watersheds although their adoption depends largely on the social, economic and cultural environment. This implies that vegetation type, structure, and density can be manipulated according to the prevailing hydrological processes to suit the soil conservation purposes.

A range of management options is necessary to address the diverse mix of people and resources found within this watershed. Poor watershed management and planning is attributed to factors such as lack of awareness or action from administrators and inhabitants regarding the interrelationships of land user within the watershed and lack of mechanisms to involve both upstream and downstream communities and governmental agencies. In this study area, watershed planning should take into account the upstream and downstream management systems for drawing up effective catchment management programmes. In a nutshell, all stakeholders should together map out the best strategies of tackling problems afflicting them that are related to the land-use practices. A mismanaged upland may lead to negative effects in lowland and therefore strategic tree planting integrated with other land uses should be concentrated in high-risk areas such as upper slopes among other places (Evans, 1996; Gregersen *et al.*, 1989).

5.0. Conclusions and Recommendations

5.1. Conclusions

From the discussions in chapter 4, it is apparent that agroforestry in the study area has not been practised by farmers to any significant extent. Most farmers said that they faced some environmental problems that included soil erosion, decreased food yields and shortages of fuelwood among others. The low participation of farmers in agroforestry has resulted in over reliance on the natural resources from the state owned forests for wood products as depicted by the high percentage of farmers who either bought or collected these products free of charge from the forests. However, farmers have not been able to adopt and practise sustainable land management options such as agroforestry as a result of hindrances by some socio-economic factors. With its potential, agroforestry, if practised, could alleviate most of these farmer problems.

All farmers in the study area ranked annual crops and livestock rearing as the major agricultural activity and therefore a chief income earner in the area. The income from these sources is used to meet basic household needs. Therefore farmers' priorities are determined to a large extent by immediate household needs. This study established socio-economic factors that include gender, land tenure, farmer level of education, farmer perception of tree costs and benefits and farm labour as contributing to the low farmer participation in agroforestry activities in the area.

As the first objective of this study, most respondents in the study area relied on farming as the source of livelihood with a few deriving income from off-farm sources. The majority cultivated crops such as maize and wheat meaning that most farm operations are mechanised. Although a source of food and cash, the farming methods in the study area were found to have negative effects on the environment both within the survey area and further down stream as attested by perceived farmer problems in the second objective. The majority of the farmers knew soil erosion as the major problem afflicting them. Most farmers had not taken up soil conservation measures as advised by the Department of Agriculture. Reasons such as lack of labour for maintenance of earth bunds, refusal by tractor owners to plough contoured crop fields and bunds as consuming scarce land among others were cited by farmers. Of interest was the finding that some farmers did not believe that the conventional soil conservation structures such as terraces were alleviating soil erosion problems.

The extension agents, although acknowledging lack of resources on their part, blamed farmers laxity on lack of interest. The extensionists mentioned that even farmers with personal tractors did not like working on contoured crop fields claiming that tractors consumed more fuel. Agroforestry has a potential in the study area since the conventional soil conservation structures have not had much success. The few farmers, who had incorporated trees with crops, found potential benefits of trees in controlling erosion as well as providing the much-needed wood products. However, in as much as agroforestry is a potential land management option in increasing soil fertility and erosion control, much work has to be done in the study area to change the farmer perception of trees.

The third objective of this study was to determine farmer awareness of agroforestry, their engagement as well as needs and ways of fulfilling them. The majority of the farmers were aware of agroforestry although a few actually engaged in it. The communities within the study area need more information that can enable them to make decisions and how to manage their land parcels. Most farmers in the area knew of trees as competing with crops and as a result the majority of those who practised agroforestry planted trees away from crops. This could be attributed to the type of tree species in the area that were found not to be compatible with crops. As such farmers also need incentives such as seedlings with more options and at minimal costs if not for free.

The fourth objective of this study was to establish whether some perceived socio-economic factors that included land and tree tenure, gender, farmer level of education, farmer access to and availability of labour and farmer awareness on tree benefits, costs and risks, influenced farmers' participation in agroforestry activities. It can be concluded that all these factors were found to play a role in the ultimate farmer perception of agroforestry. Most farmers occupied land under private ownership, but despite this, most of them did not practice agroforestry. However, the few whose land was yet to be registered mentioned that they were not willing to carry out long-term investments such as agroforestry since they were not guaranteed of reaping benefits from the land. A number of these people were married sons who were temporarily allocated a small portion by their parents. Women in this community were also disadvantaged in that they had no rights to the land and property on it and therefore any potential from women could not be exploited. Given these views it is clear that private land ownership plays a role in the farmer decision-making process on investments although it does not on its own determine farmer participation and adoption of technologies.

From the discussions on gender, it was found that activities within the study area were highly gendered. Because of the patrilineal and patrilocal nature of the community in Moiben and Ainabkoi Divisions, most of the landholdings were registered under males. This was a sure way of ensuring that men control the major resource, the land, so that women, who are known to be the chief household labour force and providers for the family, were not able to utilise it flexibly. Men dominated decision-making on all farm activities. Women are the main resource users and therefore more knowledgeable on environmental matters such as the need to plant trees, especially for fuelwood. Women's capabilities could be seen through group activities. The majority of the groups found in the study area were largely female in composition. Within these groups women derived monetary benefits that sustained household needs. Without male interference, women are able to perform more tasks. Since men prioritise what they perceive to be of importance to themselves, women's needs are not addressed, and this negatively impacts on technological advances. Women in the study area were only accorded usufruct rights to access land that could be lost in the event of the marriage breaking. However, single women could buy land. In conclusion, this study found gender biases to negatively influence the introduction of new farm activities that include agroforestry.

Most farmers said that there was labour shortage during peak farming period. This is so considering that family labour was found to be used most. Although tree planting does not seem to be labour demanding, farmers who rely on annual crops for livelihood give priority to food production and therefore the little labour available is redirected to crop production at that critical time. Even if farmers were to hire labour, most of the capital will have been used in purchasing farm inputs and therefore farmers would not be able to pay for such services. Rainfall can be erratic and therefore farmers have to maximise the first rains by ensuring early planting. Availability of labour during peak agricultural period, therefore influences other farm activities such as agroforestry. It impacts negatively in the event that there is a labour shortage or when a farmer cannot afford to use paid labour to carry out extra activities during that critical period.

With regard to farmer perception of tree benefits, costs and risks, most farmers in the study area were aware about benefits of trees. Some had planted them while others bought wood. However, due to the perceived negative effects of trees, incorporating them into crop fields seems not to be favourable to farmers in this area. Farmers mentioned that trees competed with crops and that was why they planted them along boundaries and some as woodlots. Most farmers also mentioned that trees took too long to mature, while others did not wish to plant them again after losing them to pests, diseases and fire. Such risks deter farmers from engaging in agroforestry more so if the species is new to them. Most of the tree species found in the study are exotic including *Acacia mearnsii*, *Eucalyptus saligna* and *Cupressus lusitanica*.

Acacia mearnsii owes its existence to pre-colonial policies that encouraged the species in woodlots for tannin production; *Eucalyptus saligna* species owes its existence to plantations for fuelling railway engines while *Cupressus lusitanica* is easily available to the farmers from forest department since it is the dominant plantation species. The three species also regenerate easily through seeds for *Acacia mearnsii* and *Cupressus lusitanica* while *Eucalyptus saligna* coppices with ease. Unfortunately, these species exhibit high competition with annual crops. Therefore initial policies are partly to blame for farmers' perception of negative tree effects. The market for *Acacia mearnsii* bark is decreasing (Dewees and Saxena, 1995) making farmers wary of planting it. Without an assured outlet for a product, a farmer might not be ready to take a risk in planting what might not be sold. An aphid attack on *Cupressus lusitanica* a decade ago in Kenya forced farmers to pre-maturely harvest trees. Loss to disease cannot be afforded by small-scale farmers who have no finances to buy pesticides and who have no labour at their disposal. In conclusion, most farmers in the study area were aware of the benefits, costs and risks associated with tree growing, but are not willing to take risks and therefore they would rather use alternative methods of avoiding risks such as buying wood products or collecting them.

Levels of education and training amongst farmers were also examined as part of the socio-economic factors. Apparently, most farmers had been to a formal school although only to primary level. Some farmers who planted trees had never been to a school while some in the category of those who did not practice agroforestry had received primary education. However among those who planted or retained trees on their farms, the majority attributed their awareness about trees to the education received. They claimed that they have been able to follow radio programmes, read pamphlets whenever they could get them among others. No farmer had been trained on agroforestry matters though. The level of education could influence farmer awareness on agroforestry but its' positive contribution could be minimal considering that, at primary school level, understanding certain technologies might be difficult.

The fifth objective was to assess the impact of Forest Extension Services Division (FESD) in the past on farmer engagement in agroforestry in the study area. It can be concluded that the services have had minimal impact so far. The majority of the farmers indicated that they had never received such services. Most of those aware of agroforestry, obtained information mainly from the radio and the chief. In as much as this technique of disseminating information cover a wider area, the radio and the chief were inefficient probably because programmes were being aired at a time when farmers were not listening or the language used may not be understood or comprehended by the farmers. Some farmers have no radio and therefore the messages do not reach such respondents. Some, especially women, do not attend chiefs meetings, and the information being passed to the men might not be a priority to them.

This study found that most farmers needed more information about suitable agroforestry species, and the correct planting location within the farm, among other necessary information. Most of the farmers did not know of tree species that could be intercropped with annual crops without negative interactive effects, indicating that the right information was generally lacking. It is mostly the extension agents who could give technical advice on such matters but due to their minimal contact with their clients, farmers are left gambling with incorrect tree species.

The extension agents, although admitting that they are constrained by resources, were of the view that farmers partly contributed to the impasse. Their field experience indicated that farmers generally had a negative attitude towards trees and that was why they could rarely visit the extension officers for information. This study concludes that both the extension officers and the farmer have a role to play in ensuring the adoption and practising of technologies. A farmer has to have interest and the extension agents should take up the expressed interest rapidly so that the client is not discouraged. This is in line with the advocated bottom-up approach that emphasise the priorities, knowledge and full participation of local people (Rocheleau *et al*., 1989).

The sixth objective of this study was to identify users and uses of the adjacent forest resources as well as its influence on the environment. It was found that both males and females members of the communities living next to the forest within the study area used these resources for various purposes. Some communities further away benefited also. Benefits derived by these communities included firewood, poles, medicinal herbs, timber, grazing, forest cultivation and seedlings that were collected as wildlings. These communities also obtained non-timber products such as honey from the forests. From chapter 4, it is apparent that the majority of the farmers still rely on the forests due to insufficient supply of wood products even among those farmers who were engaged in agroforestry.

The intensive utilisation of forest resources arising from increasing population and therefore demand is stretching these resources beyond the limit. As found in the assessed resources, some species are already facing extinction due to selective nature of harvesting. Although the community benefited also from *shamba* system within the forest estate, it was found that the practice impacted negatively on farmers activities on their own farms since they spend more time tending crops within the forest area and less on their own farms. Even if there were problems such as erosion, they would not easily notice and even if they did, they had no time and labour at their disposal. The availability of wood products from the forest at affordable costs, the observation that they can be collected for free through pilferage or otherwise, impacts negatively on farmer participation in adoption of agroforestry practices in the study area since they have no incentive to do so. But the potential exists through encouraging agroforestry practices so that in the near future, farmers may attain self-sufficiency and even have surplus to be sold.

5.2. Recommendations

In order that agroforestry is accepted and made part of the sustainable land management practices in the study area, the following actions are suggested:

- As a cheap and therefore affordable source of seedlings, the Department of Forests should strive to incorporate multipurpose, nitrogen fixing, fast growing and culturally acceptable tree species in their annual program. Since most farmers in the area obtain seedlings from the department, it could be easier to access the right species that will in the end motivate farmers to incorporate trees in their crop fields after seeing the initial benefits.
- As part of Forest Department strategy, fruit trees can be made part of the annual seedling production program. Since farmers will reap benefits rapidly, this could encourage acceptance of other tree species.
- Domestication of useful indigenous species can be encouraged by harnessing farmers' traditional knowledge thereby easing acceptance of these and other tree species.
- Community groups can also be given credit facilities specifically for setting up tree nurseries. With these nurseries highly localised, there are greater chances that neighbouring households might experiment with a few of these species.
- Agroforestry awareness can be increased by incorporating it in the curriculum of the adult literacy classes, and in local school curricula.
- Agroforestry methods such as alley cropping and improved fallows that promote tree-crop combination are generally not practised in the area. The current methods are more or less farm forestry. Therefore the Forestry Extension Services Division (FESD) should aggressively promote technical skills and motivate farmers through educating them. By taking farmers for tours in regions such as central, eastern and western provinces where

agroforestry has taken root, farmers could be able to learn better by seeing what their fellow farmers have done elsewhere instead of just listening through the radio only.

- Extension agents should be retrained so that they may be able to move away from being managers and 'policemen' to social workers. The extension agents should be able to understand the farmer social setting, they should be partners with farmers and they should listen to the farmers. This way, the farmers might be motivated to plant trees.
- Extension services should be encouraged to employ more female extension officers who can reach fellow women since the current male-dominated services has been found to ignore women.
- Information on agroforestry can be spread through women's community groups. Fortunately in the area there were a number of women self-help groups that were involved in non-agroforestry activities and these group members could be encouraged to diversify their sources of income. This information can reach a greater number of women who are closely associated either by being neighbours or sharing common goals and aspirations. If such groups can incorporate agroforestry as part of their activities, then more people will be reached.
- In the study area, ceremonies such as weddings are common especially at the end of the year. Part of the ceremony involves planting of two or three trees within the homestead. Such occasions can be used to disseminate agroforestry information through coordination of the local social workers or the administration.
- Since resources limit extension services, the government should put in place mechanisms that ease NGO involvement in the field. NGOs could be more efficient and more accountable so that the role of the government will be more to do with coordination.
- The government should hasten subdivision of lands in areas that have not been subdivided so that each farmer should be assured of rightfully owning the land parcel therefore enabling him or her to engage in long-term investments.
- The government should look at ways of integrating customary landownership under private ownership in the sense that patrilineal societies vest property on males particularly fathers denying or restricting women and married sons

rights of access. Women play an active role in the family as shown by Chavangi (1986) and Williams (1985) while the young sons are a vibrant and knowledgeable group who can introduce new development technologies into the farm. It is envisaged that greater access to land will enhance their involvement in agroforestry issues.

- The government, through the better-equipped Department of Agriculture, should encourage people to diversify sources of income. By solely relying on crops and livestock, these farmers are subjecting themselves to high risks considering that selling prices of commodities such as maize are already dropping. Therefore they should spread and reduce risks by adopting agroforestry practices.
- The government should aggressively encourage family planning methods in order to curb the rapid population rise. This will reduce land fragmentation thus averting further degradation of these land areas as well as decreasing pressure on the use of the natural resources.
- The government, through NGOs such has Kenya Energy Non-Governmental Organisation (KENGO), should strategically intensify institutional energy conservation packages. This could be done through provision of credit facilities to households so that they may procure energy saving facilities. These include subsidising electricity tariffs, subsidising its supply costs so that more households can afford. Other alternative energy supply methods include solar power as well as biogas.
- Agroforestry needs a multidisciplinary approach since it encompasses several stakeholders. Various government departments should work together. For example the department of social services can coordinate programs that teach farmers social issues such as those that are gender-related so as to reduce men/women differences, the department of lands can ensure that land around water bodies or next to streams or very steep should not be allocated to individuals, department of agriculture and forestry can train extension agents jointly so as to reduce on expenses and to have officers knowledgeable in both fields. This will avoid sending of incorrect or conflicting messages to farmers.

5.2.1. Recommendation for further research

Further research should focus on:

- Appropriate and sustainable agroforestry practices that are suitable to the prevailing ecological conditions as well as cultural values of the inhabitants in the study area.
- Investigation of farmer attitude toward trees would create necessary information as to the right approach to the type of information to be disseminated to the local people.
- Effective channels of communicating information based on the above-mentioned research on attitude. This should include evaluation of the current extension methods. Strengths and weaknesses could be useful in such an exercise.
- Appropriate incentive schemes aimed at encouraging greater farmer participation in agroforestry so that they may be able to meet household needs.

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Appendices

Appendix 1: Survey Questionnaire

General Information on the farmer

Date of Interview: Respondent number:

1. Sex of the respondent: Male [ ] Female [ ]

2. Year of birth____Age (years) (i) < 18 years (ii) 18-25 (iii) 26-35 (iv) 36-45 (v) > 45

3. Area of residence

(a) Division_____(b) Location______(c) Sub-location______(d) Village/farm____

4. **Marital status**

(a) Married [ ] (b) Single [ ] (c) Divorced [ ] (d) Widowed [ ]

(e) Other (specify)____

5. (i) Number of people residing in the household_____(ii) Who is the head of this household____

6. Level of education

(a) Primary [ ] (b) Secondary [ ] (c) College[ ] (d) University [ ]

(e) Never went to school [ ] other (specify)________________________________

7. Occupation

(a) Farmer [ ] (b) Housewife [ ] (c) Civil servant [ ] (d) Self-employed [ ] (e) Private sector employee [ ] (f) Teacher [ ] (g) Other (specify)____________________

8. Land and land use practices

Size of farm (acres). (a) (i) < 1 [ ] (ii) 1-5 [ ] (iii) 5.1-10 [ ] (iv) 10.1-20 [ ]

(v) 20.1-30 [ ] (vi) 30.1-50 [ ] (vii) 50.1-100 [ ] (viii) > 100 [ ]

(b) Is your land registered (title deed)? Yes [ ] No [ ] (i) If yes, when (year)________

(ii) If no why ____

(c) Under whose name (i) Wife[ ] (ii) Husband [ ] (iii) Family [ ] (iv) Community [ ]

(v) Other (specify)____

(d) Farm origin (i) inherited [ ] (ii) bought [ ] (iii) other [ ]________________________

9. Who makes decisions on how to use the farm for various activities?

a) Community [ ] (b) Wife [ ] (c) Husband [ ] (d) Family [ ] (e) Extension officer (s) forestry/ agriculture [ ] (f) Chief [ ] (g) Sub Chief [ ]

(h) Other (Specify)____

10. Are women allowed to own land in this community? Yes [ ] No [ ]

If no, what are the reasons____

11. What activities do you carry out on your farm?

(i) Agriculture:

(a) Cash crops [ ] (b) Subsistence crops [ ]

(c) Crops grown for food and cash income [ ] (d) Bees [ ]

(e) Livestock (Cows, Goats, Sheep) [ ] (f) Rabbits [ ] (g) Agroforestry [ ]

(h) Other (specify)____

(ii) Ways of improving/retaining soil fertility

(a) Inter-cropping (crop combinations on the farm) [ ] (b) Crop rotation [ ]

(c) Monocropping [ ] (d) Use of animal manure [ ] (e) Use of crop residues/green manure [ ] (f) Use of inorganic fertiliser [ ] (g) Other (specify)_______________

(iii) Availability of farm labour

How available is labour during crop planting/weeding season?

(a) Not scarce (available) [ ] (b) Slightly scarce [ ] (c) Very scarce (not available) [ ]

(iv) Source of farm labour

(a) Family [ ] (b) Hired [ ] (c) Group [ ] (d) Other (specify)____________________

12. Awareness and adoption of farm forestry practices

Have you ever heard of the concept of agroforestry? Yes [ ] No [ ]

If yes, what was the source of information?

(i) Village headman [ ] (ii) Chief's barazas [ ] (iii) Neighbour [ ] (iv) Extension officer(s) forestry/agriculture[ ] (v)Radio/television/newspapers [ ]

(vi) Other (specify)____

13. Have you practised agroforestry forestry? Yes [ ] No [ ]

(i) If yes, what type of agroforestry practice (a) Boundary planting [ ] (b) Scattered trees on cultivated land [ ] (c) Home gardens [ ] (d) Live fencing [ ]

(e) Alley cropping [ ] (f) Woodlots [ ] (g) Windbreaks [ ]

(h) Other (specify)____

If no, go to 13 part (iv)

(ii) What are the Benefits of the planted trees?

Tree species	**Benefits/use**	**Preference**

(iii) Has your education helped you in agroforestry awareness? Yes [ ] No [ ]

If yes, how? ____

If no, why? ____

(iv) If no, what are the constraints to practising agroforestry/further-practising agroforestry?

(a) Lack of capital to purchase seeds/seedlings [ ] (b) Lack of interest [ ] (c) Lack of information [ ] (d) Long maturity period of trees [ ] (e) Lack of time and labour to plant or tend seedlings [ ] (f) Lack of security of land tenure [ ]

(g) Difficulty in obtaining permits for harvesting of trees and its related products [ ]

(h) Lack of seeds/seedlings [ ] (i) Lack of extension services [ ]

(j) Lack of water [ ] (k) Lack of land [ ] (l) pests and diseases [ ]

(m) Eaten by animals [ ]

(n) Tree interference with growth of crops and movement of farm machinery [ ]

(o) Other (specify)____

(v) Are forest extension services available/constraint Yes [ ] No [ ]

(vi) Is long gestation of trees a constraint Yes [ ] No [ ]

15. Ranking priority enterprises (what takes up more time, costs more, takes up more land etc). Fruit trees [ ] Trees [ ] Cash crops [ ] Food production [ ] Livestock [ ] Other (specify) [ ]_____________________________________

(i) How do you get your desired tree products?

	Source of wood/ non wood products				
Product	**Farm (own)**	**Collected free of charge**	**Purchased**	**Time**	**Cost**
Poles					
Timber					
Fruits					
Medicinal (herbs)					
Fodder					
Fuel wood					
Charcoal					
Other					

(ii) Who collects the above-mentioned products____________________________

17. Alternative sources of cooking Energy if shortage of fuelwood

(i) Solar Energy [ ] (ii) Electricity [ ] (iii) Crop residues [ ] (iv) Liquefied petroleum gas (LPG) [ ] (v) Paraffin [ ] (vi) Cow dung [ ] (vii) Others (specify)___________

18. Sources of (i) seeds (a) Bought from other Nurseries [ ] (b) Bought from Forest Department nurseries [ ] (c) From own nursery [ ] (d) Collected wildlings [ ]

Other (specify)____

Sources of (ii) seedlings (a) Bought from other Nursery [ ] (b) Bought from Forest Department nursery [ ] (c) From own nursery [ ] (d) Collected wildlings [ ]

(e) Other (specify)____

19. Who tends the seedlings once planted?

(a) Children [ ] (b) Wife [ ] (c) Employees [ ] (d) Husband [ ]

(f) Other (specify)____

20. Who decides on harvesting trees and tree products once ready?

(a) Children [ ] (b) Workers [ ] (c) Husband [ ] (d) Wife [ ]

(e) Other (specify)____

21. Ranking sources of income (relative generation of income)

(a) On -farm

Food crops [ ] Livestock [ ] Fruit trees [ ] Cash crops [ ] Tree/tree products [ ]

Other (specify)____

(b) Net annual on-farm income in Kenya shillings (Kshs.)

(i) < 5 000 [ ] (ii) 5 001-10 000 [ ] (iii) 10 001-20 000 [ ] (iv) 20 001-50 000

(v) > 50 000 [ ] (vi) I don't know [ ]

(c) Net income from Trees/tree products (specify period).

(i) < 5 000 [ ] (ii) 5 001-10 000 [ ] (iii) 10 001-20 000 [ ] (iv) 20 001-50 000

(v) > 50 000 [ ] (vi) I don't know [ ]

(d) Do you have other sources of income Yes [ ] No [ ]

If yes how much per year (i) <1 000 [ ] (ii) 1 001-5 000 [ ] (iii) 5 001-10 000 [ ]

(iv) >10 000 [ ] (v) I don't know [ ]

(e) Distribution of income (relative expenditure) on: Food [ ] Dressing [ ]

School fees [ ] Housing [ ] Health [ ] Investment on the farm (Farm inputs, labour, animal feeds, tree seeds/seedlings etc) [ ] Other (specify)_____________

22. Are you an active member of any community self-help group participating in agroforestry/other activities?

(i) (a) Very active [ ] (b) active [ ] (c) not active [ ] (d) not a member [ ]

(ii) History of the group: Name of group____________ When was it started______

- Membership Male[ ] Female [ ] Mixed [ ]
- Purpose of group____
- Routine activities of the group: Agroforestry/non-agroforestry___________

(iii) Has the group been helpful to you? Yes [ ] No [ ]

(iv) If yes, how____

(v) If no Why____

23. Do you experience any environmental problems on your farm? Yes [ ] No [ ]

If yes, what kind of problems? (i) Scarcity of land [ ] (ii) Soil erosion [ ]

(iii) Low crop yield [ ] (iv) Soil infertility [ ] (v) Food shortage [ ]

(vi) Shortage of fuel wood [ ] (vii) other (specify)____________________________

24. What agroforestry practices have you adopted to curb the environmental problems if any?

(i) Mixed/multiple cropping [ ] (ii) Use of multipurpose tree species [ ] (ii) Alley cropping [ ]

(iii) Windbreaks/shelter belts [ ] (iv) Boundary planting [ ] (v) Live fencing [ ]

(vi) Woodlots [ ] (vii) Scattered trees on the farm [ ]

(viii) Other (specify)____

25. How many animals do you have on your farm?

(a) Cattle___ (b)___ (c) Goats___ (c) Chicken___(d) pigs___ (e) Sheep___

(f) Other (specify)_____

Appendix 2: List of Tables

Appendix 2.1: Occupation of respondents in the study area (n=300)

Occupation	Frequency	Percent
Farmer	147	49.0
Housewife	96	32.0
Farmer and house wife	18	6.0
Student	14	4.7
Civil servant and farmer	8	2.7
Teacher and farmer	6	2.0
Self-employed	4	1.3
Private sector employee and farmer	4	1.3
Civil servant	2	.7
Teacher	1	.3
Total	300	100.0

Appendix 2.2: Marital status of respondents in the study area (n=300)

Status	Frequency	Percent
Married	251	83.7
Single	26	8.7
Widow	16	5.3
Divorced	5	1.7
Widower	2	.7
Total	300	100.0

Appendix 2.3: Female inheritance of land in the study area (n=300)

Responses	Frequency	Percent
Yes	161	53.7
No	126	42.0
No comment	13	4.3
Total	300	100

Appendix 2.4: Land uses in the study area (n=300)

Agricultural activities	Frequency	Percent
Mixed & cash crop farming	154	51.3
Mixed farming	81	27.0
Mixed farming and bees	34	11.3
Mixed farming and horticulture	20	6.7
Crops for food and cash	4	1.3
Subsistence farming	3	1.0
Mixed & subsistence farming	3	1.0
Livestock farming	1	.3
Total	300	100.0

Appendix 2.5a: Distribution of domestic animals among respondents in the study area (n=300)

No. of cattle	Frequency	Percent
1-5	154	51.3
6-11	79	26.3
12-17	28	9.3
None	13	4.3
18-23	12	4.0
24-50	11	3.7
>50	3	1.0
Total	300	100.0
No. of goats	**Frequency**	**Percent**
None	185	61.7
1-5	72	24.0
6-11	26	8.7
12-17	12	4.0
18-23	4	1.3
24-50	1	.3
Total	300	100.0
No. of sheep	**Frequency**	**Percent**
1-5	95	31.7
6-11	58	19.3
12-17	25	8.3
18-23	11	3.7
24-50	10	3.3
None	101	33.7
Total	300	100.0

Appendix 2.5b: Distribution of domestic animals among respondents in the study area (n=300)

No. of chicken	Frequency	Percent
6-11	93	31.0
1-5	80	26.7
None	57	19.0
12-17	25	8.3
18-23	25	8.3
24-50	20	6.7
Total	300	100.0
No. of beehives	**Frequency**	**Valid Percent**
None	249	83.0
2-5	33	11.0
1	7	2.3
Did not know	8	2.7
6-10	3	1.0
Total	300	100
No. of rabbits	**Frequency**	**Percent**
None	288	96.0
3-5	5	1.7
1-2	2	.7
6-10	2	.7
Total	300	100.0

Appendix 2.6: Ranked sources of income by respondents in the study area in decreasing order of importance (n=300)

Sources of income	Frequency	Percent
Cash crops, livestock, food & cash crops	79	26.3
Food& cash crops, livestock, cash crops	63	21.0
Livestock, food & cash crops	37	12.3
Livestock, food & cash crops, cash crops	27	9.0
Not able to rank	18	6.0
Livestock & food crops	15	5.0
Cash crops, food crops, livestock & trees	13	4.3
Cash crops, livestock, food & cash crops, trees	11	3.7
Livestock, food & cash crops, cash crops, trees	10	3.3
Food & cash crops, livestock, cash crops, fruit trees, trees	8	2.7
Vegetables, food crops, livestock	7	2.3
Food crops	4	1.3
Cash & food crops	3	1.0
Fruit trees, food & cash crops & livestock	3	1.0
Tree seedlings & food crops	1	.3
Livestock only	1	.3
Total	300	100.0

Appendix 2.7: Ranking of expenses in decreasing order of importance by households in the study area (n=300)

Ranking in decreasing order	Frequency	Percent
Food, school fees, farm input, animal feed, dress, health	77	25.7
Food, school fees, farm inputs, animal feed, dress, health, housing	70	23.3
School fees, food, farm inputs, animal feed	48	16.0
Not able to rank	37	12.3
Food, farm input, school fees, dressing, health, housing	35	11.7
Farm input, food, dressing, school fees, animal feed, health, housing	28	9.3
Health, dressing, animal feed, farm input, labour, housing, school fees	5	1.7
Total	300	100

Appendix 2.8: Farm practices that are used by respondents to sustain soil fertility in the study area (n=300)

Fertility enhancement methods	Frequency	Percent
Inter cropping, crop rotation, inorganic fertiliser	88	29.3
Intercropping, animal manure & inorganic fertiliser	86	28.7
Intercropping & inorganic fertiliser use	45	15.0
Inorganic fertiliser, intercropping, crop residues & animal manure	15	5.0
Intercropping & monocropping & inorganic fertiliser	13	4.3
Inter & monocropping, crop rotation & inorganic fertiliser	12	4.0
Crop rotation, monocropping & inorganic fertiliser	10	3.3
Inorganic fertiliser application	10	3.3
Monocropping & inorganic fertiliser use	6	2.0
Crop rotation & inorganic fertiliser use	5	1.7
Animal manure & inorganic fertiliser	4	1.3
Intercropping & animal manure	2	.7
Animal manure	1	.3
Crop residues & inorganic fertiliser	1	.3
None of the above	1	.3
Inter cropping, crop residues & inorganic fertiliser	1	.3
Total	300	100.0

Appendix 2.9: Prevalence of burning crop fields by landowners in the study area before cultivating (n=300)

Responses	Frequency	Valid Percent
Yes	284	94.7
No	15	5.0
Not sure	1	.3
Total	300	100

Appendix 2.10: Common tree species preferred by respondents in the study area (n=128)

Tree species	Frequency	Percent
Acacia mearnsii, Cupressus lusitanica & Eucalypts saligna	67	52.4
Acacia mearnsii, Cupressus lusitanica,Olea africana,Croton megalocarpus & Dombeya goetzenii	17	13.3
Acacia mearnsii Eucalypts & Cupressus lusitanica & Grevillea robusta	9	7.1
Acacia mearnsii& grevillea	8	6.3
Acacia mearnsii,Hakea saligna & Eucalypts	7	5.5
Eucalypts & Cupressus lusitanica, Olea africana,Croton megalocarpus & Dombeya goetzenii and Syzygium guineenses	6	4.7
Eucalypts saligna, Pinus patula & Cupressus lusitanica	5	4.0
Grevillea robusta	5	3.9
Eucalypts & Cupressus lusitanica & Grevillea robusta	2	1.6
Eucalypts, Syzygium guineensis & Sesbania sesban	1	.8
Sesbania sesban, Grevillea robusta & Terminalia mentalis	1	.8
Total	128	100.0

Appendix 2.11: Sources of obtaining wood products for free by farmers in the study area (n=103)

Sources	Frequency	Percent
Forest reserve	92	89.3
Neighbour	3	2.9
Forest reserve and other farmers	3	2.9
EATEC[1]	3	2.9
Other farmers	1	.97
Forest reserve and neighbour	1	.97
Total	103	100*.0

1:East Africa Tannin Extract Company (EATEC). A defunct private company that specialised in *Acacia mearnsii* plantations for tannin production and by-products such has poles and charcoal as well as firewood

*: Rounded off to the nearest Figure

Appendix 2.12: Sources of purchasing poles by farmers in the study area (n=266)

Sources	Frequency	Percent
Forest reserve.	158	59.4
Dealers	45	16.9
Other farmers	36	13.5
Trading center	8	3.0
EATEC	13	4.9
Forest reserve and dealers	5	1.9
Forest reserve and other farmers	1	.37
Total	266	100*.0

*: Rounded off to the nearest figure

Appendix 2.13: Alternative sources of cooking energy in the study area (n=300)

Alternatives	Frequency	Percent
Crop residues	70	23.3
Crop residues and paraffin	60	20.0
No shortage (from forest reserve)	62	20.7
Crop residues and cow dung	52	17.3
Crop residues, paraffin and cow dung	29	9.7
Electrical energy, crop residues and paraffin	6	2.0
Liquefied petroleum gas (LPG)	5	1.7
Paraffin	5	1.7
Crop residues and liquefied petroleum gas	4	1.3
No shortage (from own farm)	4	1.3
Electrical energy and paraffin	2	.7
Electrical energy and crop residues.	1	.3
Total	300	100.0

Appendix 2.14: Average cost of firewood in the study area (n=203)

Cost (Kshs.) per head load	Frequency	Percent
<5	88	43.3
5-10	78	38.4.0
11-16	28	13.8
>23	6	3.0
17-23	3	1.5
Total	203	100.0

Appendix 2.15: Average cost of construction and fencing poles in the study area (n=264)

Cost (Kshs.) per piece	Frequency	Percent
<5	131	49.6
5-10	75	28.4
11-15	45	17.0
16-25	8	3.0
26-50	3	1.1
>50	1	.4
Did not know	1	.4
Total	264	100*

*: Rounded to the nearest figure

Appendix 2.16: Availability of farm labour during peak farming period in the study area (n=300)

Responses	Frequency	Percent
Slightly scarce	156	52.0
Not scarce (available)	110	36.7
Very scarce (not available)	34	11.3
Total	300	100.0

Appendix 2. 17: Prevalence of group membership in the study area (n=300)

Group membership	Frequency	Percent
Not a member & no agroforestry group	266	88.7
Member of other group(s)	34	11.3
Total	300	100.0

Appendix 2.18: Group composition in the study area (n=34)

Responses	Frequency	Percent
Females only	27	79.4
Mixed	7	20.6
Total	34	100.0

Appendix 2.19: Benefits derived by members from their groups (n=34)

Benefits	Frequency	Percent
Owning a maize milling machine	10	29.4
Get 'loans'	9	26.5
Buy household items	6	17.6
Yet to generate income	4	11.8
Agricultural activities. (Bee keeping, livestock, chicken)	4	11.8
Making water tanks	1	2.9
Total	34	100.0

Appendix 2.20: Income earned from tree/tree products sales by respondents with trees in the study area (n=128)

Tree income (Kshs.)	Frequency	Percent
Trees immature	42	32.8
Did not know amount	33	25.8
Trees not for sale	20	15.6
<5000	20	15.6
5000-10000	12	9.4
10001-20000	1	.78
Total	128	100*

* Rounded off to the nearest figure

Appendix 2.21: Observed densities of the three species (n=10); df = 10

Species	Diameter classes (cm)					
	<10 (I)	10-15 (II)	15.1-20 (III)	20.1-25 (IV)	25.1-30 (V)	>30 (VI)
J. procera	40	56.67	106.67	41.11	24.44	2.22
O. africana	114.44	72.22	80	16.67	6.67	5.56
P. gracilior	16.67	1.11	37.78	30	4.44	0

Appendix 2.22: Observed densities within the plots (n=10). df = 10

J. procera	Diameter classes (cm)					
Plot no.	<10 (I)	10-15 (II)	15.1-20 (III)	20.1-25 (IV)	25.1-30 (V)	>30 (VI)
1-4	22.22	50	113.89	13.89	0	0
5-7	77.78	29.63	66.67	70.37	14.81	0
8-10	25.93	92.59	137.04	48.15	66.67	7.47

Appendix 2.23: Observed densities within the plots (n=10); df = 10

O. africana	Diameter classes (cm)					
Plot no.	<10 (I)	10-15 (II)	15.1-20 (III)	20.1-25 (IV)	25.1-30 (V)	>30 (VI)
1-4	94.44	63.89	47.22	13.89	2.78	2.78
5-7	144.44	133.33	81.48	0	7.47	3.74
8-10	111.11	22.22	122.22	37.04	11.11	11.11

Appendix 2.24: Observed densities in various plots (n=10); df = 8

P. gracilior	Diameter classes (cm)				
Plot no.	<10 (I)	10-15 (II)	15.1-20 (III)	20.1-25 (IV)	>25 (V)
1-4	5.56	2.78	0	0	2.78
5-7	22.22	0	18.52	25.93	3.74
8-10	25.93	0	107.44	74.07	7.47