FACTORS INFLUENCING TREE DIVERSIFICATION AT FARM LEVEL IN RUNYENJES DIVISION, EMBU DISTRICT, KENYA

BY

LUKE MAINA NJUGUNA
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DECLARATION

This thesis is my original work and has not been presented for award of a degree in any other university or any other award.

Luke M. Njuguna

DEPARTMENT OF ENVIRONMENTAL SCIENCES

Signature _____ Date _____

We confirm that the work reported in this thesis was carried out by the candidate under our supervision

Prof. James B. Kung'u

DEPARTMENT OF ENVIRONMENTAL SCIENCES

Signature _____ Date _____

Prof. Daniel N. Mugendi

DEPARTMENT OF ENVIRONMENTAL SCIENCES

Signature _____ Date _____

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ABBREVIATIONS AND ACRONYMES

CBD	-	Convention on Biological Diversity
CBS	-	Central Bureau of Statistics
EDDP	-	Embu District Development Plan
GZDSP	-	Green Zones Development Support Project
ICRAF	-	International Centre for Research in Agroforestry
IUCN	-	International Union for Conservation of Nature
KARI	-	Kenya Agriculture Research Institute
KEFRI	-	Kenya Forestry Research Institute
KFS	-	Kenya Forestry Service
MKEPP	-	Mount Kenya East Pilot Project
NEMA	-	National Environment Management Authority
NGO	-	Non-Governmental Organization
SPSS	-	Statistical Package for Social Sciences
AD B	-	African Development Bank

ABSTRACT

Mount Kenya Reserve is vital to the livelihood of the local populations who revere it. The forest reserve is of vital ecological, economic and environmental importance and is recognized as a world heritage site. The forest reserve serves as a water catchment reservoir for nearly a third of Kenya's population and feeds the country's largest River Tana, which in turn supports hydro electric plants that provide more than 50% of the country's electricity. The forest reserve is currently exposed to high degradation owing to illegal and unsustainable timber harvesting of high value indigenous trees such as *Vitex keniensis* and *Ocotea usambarensis*. Domestication of high value indigenous trees and their intensive planting on farmlands is one way of controlling degradation of Mt. Kenya forest. The study aimed at identifying factors that undermine indigenous tree planting on farmlands and the conservation mechanisms in place towards their conservation. The study was undertaken in Runyenjes Division in Embu District. A sample of 180 farmers was interviewed. It was drawn from three sub-locations randomly selected from three different purposively selected agro-ecological zones. Household members were interviewed using a farm-based interview schedule. Statistical Package for Social Sciences (SPSS) was used to analyze the data. The results obtained revealed that farmers in Embu plant trees for different reasons including timber production (67.8%), fuel wood (63.3%), poles and posts (31.1%), food (26.1%), among other uses or services. The most abundant tree species on farms was *Grevillea robusta* (100%), *Mangifera indica* (79.4%), *Eucalyptus* spp (43.3%) and *Bredellia micrantha* (70%). About 82% of farmers reported that there was value in planting indigenous trees. Constraints towards successful indigenous tree planting on farms were slow growth rate (60%), inadequate germplasm (55.7%), incompatibility with other crops (11%), low survival of planted seedlings (7.45%), and inadequate knowledge on economic returns (6.7%). The conservation measures in place included a concerted effort by various government agencies and non-government organizations in promotion of indigenous trees. It is highly recommended that a tree germplam policy be developed and implemented. Though some farmers (60%) perceive indigenous trees as slow growers, there were others who were willing to plant them (82%) and those concerned in conservation of the trees should take this advantage and scale up the indigenous tree planting. Further research is suggested that a tree domestication process for the preferred and appropriate indigenous trees be initiated in addition to developing appropriate propagation techniques for indigenous trees including the use of biotechnology.

CHAPTER ONE

INTRODUCTION

1.1 Background

Kenya's dependency on the natural environment is profound. Our environment supports key sectors of production such as agriculture, horticulture, tourism, wildlife

and energy. Our forest resources support many livelihoods. For instance, eighty percent of all energy comes from wood and rural dependency on wood is almost total. Kenya's closed canopy forests are estimated to cover 1.24 million hectares that translate to 2.1% of Kenya's land area (DRSRS, 2006).

Forests play a critical role in environmental protection and conservation. Their reduction and degradation is a concern for environmentalists in Kenya. Based on 1988-2003 forest losses, reduction has been reported to be 3% per annum (DRSRS, 2006).

To curb forest reduction and degradation, the Kenya government started an intensive promotion of farm forestry in the early 1970s with the establishment of Rural Afforestation and Extension Scheme. As a result, a substantial number of farmers have taken the challenge of tree planting on their farms throughout the country and have planted various exotic tree species including *Grevillea robusta A.Cunn, Cupressus lusitanica Carr* and *Eucalyptus* species in the high potential areas and *Senna siamea (lam) H.S Irwin & Barneby* in the arid and semi arid areas. Planting of indigenous trees has however not been popular with many people and the few indigenous trees on farms are mostly the remnants of the original vegetation and a few from natural regeneration.

There is great concern on the depletion of biodiversity through the introduction of exotic tree monocultures (Nchols *et.al* 2006) and efforts should be put in place to diversify tree species composition on farms so as to enhance biodiversity conservation and improve rural livelihoods.

1.2 Statement of the Problem

Kenya's closed canopy forest has been estimated to be 1.24 million hectares, which is about 2.1 percent of the country's land area (DRSRS, 2006). Mt. Kenya forest reserve is one of the blocks of closed canopy forests covering an area of 199,500 Hectares (Wass, 1995). Mt. Kenya Forest Reserve has vital ecological, economic and environmental importance and is recognized as a world heritage site. Mt. Kenya forest reserve has however been exposed to high degradation owing to illegal timber harvesting of high value indigenous tree species such *as Vitex keniensis Turrill, Ocotea usambarensis Engl.* and *Podocarpus* species. Degradation has also occurred in the past prior to the current ban of timber harvesting in government forests that was imposed in 1999 due to excessive removal of high value indigenous trees by licensed timber merchants.

Kenya government recognizes that one of the available options for increasing forest cover and the save the remaining indigenous vegetation is through intensive on farm tree planting because the available government land that can be put under forests is limited. Domestication of high value indigenous trees and their intensive planting on farmlands is one way of saving Mt. Kenya forest from further degradation. Tree planting trend taken up by farmers in Mt. Kenya region has been that of planting intensively *Grevillea robusta,* an exotic tree species and as a result most of the farmlands in the region are dominated by *Grevillea robusta* species. Illegal extraction of high value indigenous trees from Mt. Kenya Forest has however continued at an alarming rate in spite of the high abundance of exotic trees on farmlands in the region.

Tree mono-cultures contribute to reduction of biodiversity and are themselves an environmental disaster in waiting when one considers the prospects of a disease or pest epidemic. Dunn (1991) and Leaky and Newton (1994) reported that the value and

need to cultivate indigenous tree species for use in agroforestry systems was until recently overlooked by scientists.

There is need to diversify tree growing by incorporating indigenous trees in the farmer's tree planting programmes so as to reduce pressure on the remaining high value indigenous trees in the gazetted forests. Past government initiatives to promote diversification of indigenous tree planting on farm through social forestry have not yielded satisfactory results and there is therefore need to identify the underlying factors contributing to this scenario in order to propose strategies of enhancing indigenous tree planting on farmlands.

1.3 Research Questions

To achieve its objectives, this study was guided by the following research questions:

(a) Which tree species are being planted by farmers in Embu District and why?

(b) Where do the farmers obtain their tree germplasm?

(c) What are the major constraints associated with the planting of indigenous trees in the District.

(d) Are there mechanisms in place to enhance indigenous tree planting and conservation on farmlands in Embu District?

(e) Why are farmers not planting enough indigenous trees in Embu District?

1.4 Objectives of the Study

The broad objective of the study was to identify the underlying factors influencing tree diversification in farmlands in Embu District. Specifically the study tried to:

(a) Determine the reasons for on farm tree planting in Embu District.

(b) Find out types and sources of on farm tree planting germplasm in the District.

(c) Identify factors that constrain indigenous tree conservation at farm level in Embu District.

(d) Carry out a priority categorization of commonly used tree species at farm level in Embu District.

(e) Determine the methods that can enhance indigenous tree planting and conservation at farm level in Embu District.

1.5 Research Assumptions

(a) Farmers in Embu District plant trees for different reasons.

(b) There exist constraints towards on farm indigenous tree planting in Embu District.

(c) There exist opportunities towards enhanced on farm indigenous tree planting in Embu District.

1.6 Significance of the Study

The study was expected to generate solutions towards planting of high value indigenous trees which contribute to improved livelihoods. The high value indigenous trees are known to yield more cash to the farmers and are also environmentally friendly. The study was expected to benefit policy makers and act as a guide in formulating policies that are in harmony with people's expectations and promote conservation of indigenous trees.

1.7 Scope of the Study

The study entailed an attempt to understand the reasons behind the low adoption rate of indigenous trees on farmlands in Embu District. Constraints associated with indigenous trees growing were studied and tree conservation measures in place explored. The study was undertaken in Runyenjes Division and one hundred and eighty farms were sampled from three agro-ecological zones covering UM1 (tea/dairy zone) UM2 (coffee zone) and LM3 (cotton and tobacco zone). Tree nursery managers

and key informants from institutions dealing with tree resources in the district were interviewed. Sixty farms from one sub-location in each of the three agro ecological zones namely UM1, UM2, and LM3 in the division were sampled.

1.8 Operational Definition of Terms

Agro ecological zone - This refers to an area according to its agricultural potential. The potential is determined by parameters such as rainfall, temperatures, and soil type.

Diversification of tree planting - This refers to the number of different indigenous trees planted by farmers.

High value indigenous trees-These are the indigenous trees that produce timber that is highly sort and liked in the carpentry and joinery industry.

CHAPTER TWO

LITERATURE REVIEW

2.1 General overview

This section briefly describes the work that has been reported by researchers globally, East Africa region, nationally and in Embu district on issues concerning forest conservation. It covers areas such as policy and legislation, tree germplasm sources and availability, biodiversity conservation and indigenous tree planting. Obstacles and solutions as reported by researchers in forest conservation have been highlighted while gaps in research in conservation of Mount Kenya forest at farm level have been identified.

2.2 Forest Sector Policy and Legislation

Policy for forest sector development and management in Kenya dates back to the pre-independence period. Indeed the first forest policy for the country was written in 1957 with subsequent revisions and modifications in 1968 (MENR, 1994).

This policy and the consequent legislation laid very little attention to trust and privately owned forest lands. A lot of focus was laid on catchment protection and timber production with a strong government control and little emphasis on farm tree planting. This scenario could not effectively address the emerging and divergent needs of Kenyans for forest products. There was need to develop a comprehensive policy that would ensure systematic and sustainable development of the forest sector and a process towards this endeavour was initiated.

A key output of the process was the completion of twenty five year Kenya Forest Master Plan 1994 that provided an ideal framework and basis for the establishment of a revised legislation which has since been enacted (Moenga, 2005).

The Forest Act No 7 of 2005, and the Forest Policy Sessional Paper No 1 of 2007 (unpublished), have inbuilt mechanisms, that will ensure sustainable conservation and management of forest and allied resources. The act and policy paper provide for:-

- Broadening ways in which forests and their inherent products can be valued taking into account all direct and indirect factors.
- Support of sustainable agriculture by conserving soil and water resources through tree planting and appropriate tree resources management.
- Contributing to poverty alleviation and promotion of rural development through income based on forest and tree resources by providing employment, promoting equity and participation of local communities.
- Conserving the remaining natural habitats, their ecological services, rehabilitating them and conserving the existing biodiversity.
- Increasing forest and tree cover to ensure an increase in the supply of forest products and services for enhancing the role of forestry in socio-economic development.
- Respect of national obligations under international environmental conventions and principles.
- Developing a viable and efficient forest industry for national development through commercialization and private sector involvement.
- Promoting farm forestry to produce timber, wood fuel, and other forest products and services.
- Promoting dry land forestry to produce wood fuel and to supply non-wood forest products and services.
- Promoting forest extension to enable farmers and other forest stakeholders to benefit from forest management approaches and technologies.

2.3 Tree Planting and Biodiversity Conservation

The Convention on Biological Diversity Rio (CBD) (1992) defined biodiversity as variability among organisms from all sources including interalia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species between species and ecosystems. In short biodiversity is generally split according to genes, species and ecosystems including processes that form and sustain them all.

Biodiversity is an active phenomenon. It is ever changing over time and is not usually in equilibrium as all its components fluctuate in number. “It does not reflect any status quo, is not frozen and does not have a memory.” On one hand biodiversity is a buffer against environmental changes and disturbances and on the other hand it adapts to changes through selection.

The prevailing view in ecology is that diverse ecosystems consisting of various components are more resilient than ecosystems with few species (SGRP 2000).

(a) The more the species the greater the likelihood that some organisms exist that are tolerant towards changing conditions.

(b) The asychronicity of species responses to environmental conditions (the basis for diversity effect) increase resistance of ecosystems. Likewise Lovelock (1995) describes ecosystem as the survival mechanism of the entire earth. Although species diversity is often equated with species variability, it is a function of the number of species and the evenness in distribution of species abundance (Magurran, 2004 Purvis & Hector 2000).

Recent studies of tree densities and germplasm sources in agroforestry systems in western and Central Kenya, Central Uganda and in Cameroon showed that 75 percent

of all tree species observed on farms were represented at a density of one or less per hectare (Kindt, 2002). Atta-Krah (2004) further reported that there are three reasons for maintaining genetic diversity in agroforestry systems. The first and perhaps the most important is to guard against the instability that can result from its absence. Genetic diversity enables evolution and adaptation of species to take place within changing environments, both in natural ecosystems and farms. The second reason is that heterozygosis or high genetic variation within an individual species is positively related to fitness. Trees carry heavy genetic load of deleterious recessive alleles (Bushier 2000) and avoidance of inbreeding is therefore paramount. Atta-Krah (2004) also reported that it was crucial to maintain genetic diversity because its loss would mean the loss of the potential of any improvement to meet any changing needs and end-use requirements. The additive and interactive effects of inter and intraspecific genetic diversity determine both the resilience of agro ecosystems and the evolutionary potential of species (Sauchanka and Savchennko 1997). This is becoming more important as we live in an increasingly changing environment with agricultural developments, global warming, pollution and desertification (CBD, 2003). Shiva (1995) reported that the main thrust of conservation struggles was that forests and trees are life support systems and should be regenerated for their biospheric functions.

2.4 Tree Diversification and Germplasm

A successful approach to combat rural poverty is through increased involvement of the poor farmers in decision making about their natural resource management options (Izac and Sanchez, 2001). Part of such a decision making framework is the combination of natural resources management concerns with quality germplasm. The

use of health improved or genetically diverse germplasm can be expected to contribute to the ecological stability of an environment.

In Embu District, the natural ecosystem is diminishing and indigenous plant species are on decline and hence farmers are forced to grow plants they need for food, fodder, timber, firewood and other products or services on their farms. Such efforts are successful only if germplasm of these plants is available and is of high genetic quality (Simons, 1996; 1997). Farmers use and conserve species to obtain products such as food, wood, medicine and fodder and for numerous services. Trees also play a crucial role in the cultural life of people. The many products, services and roles these trees play can not be delivered by a few species only. As a result farmers need to have a wide variety of tree species on their farms. This conservation through use is increasingly becoming important as the natural tropical forests are disappearing fast (Simons *and Leaky 2004*). Kindt and Lengkeek (1999) argued that putting greater tree diversity into use is a method to increase farmer's benefits and conserve biological diversity on farm.

Farmers need biodiversity including intra-specific diversity for the productivity and sustainability of their agro forestry ecosystem. A broad genetic base provides the species with an adaptive capacity to respond to environmental fluctuations and changing farmer practices and markets. It ensures the vitality and long-term survival of the species in question and sustainability of the entire agro-forestry ecosystem (SCRP, 2000).

One peculiarity in agroforestry is that germplasm is typically viewed as relating to seed. Yet, few farmers plant seeds since few agroforestry species are directly sown. The few species that are directly sown are those that tend to provide services such as

fences, nutrient replenishment, shade, windbreakers and erosion control (Simons 2004). To a farmer, germplasm is more about seedlings rather than seed since a majority of agroforestry trees are planted from nursery- raised seedlings originating from either seeds or vegetative propagules. Germplasm supply is therefore as much about seedling supply as seed supply. Research in germplasm in agroforestry has mainly focused on quantity rather than quality of seedlings although it is recognized that quality encompasses both physiological and genetic components.

Tree genetic resources used in agriculture should ideally receive commensurate funding for conservation in tune with annual crop plants.

2.5 Tree Germplasm Availability

According to Oconnor (1997), the scarcity of seeds and seedlings is one of the major constraints in the expansion and perhaps even in the continuity of tree planting in central Kenya highlands. It was further noted that the demand for seedlings in Eastern and Southern African exceeds supply due to increasing culture of tree planting that arose from widespread and rapid adoption of agroforestry practices (ICRAF, 2000). Availability of seedlings however need not be looked at as simply the presence of large quantities of seedlings but more importantly the availability of high quality germplasm. The success of a tree planting programme according to Weightman (1999) lies in the availability of good plant quality that will serve as an incentive for farmers to maintain and tend trees on their farms. Nyabati et al. (2006) reported that most people in Nandi North District had no tree nurseries of their own and therefore depended on buying seedlings from elsewhere and that seedlings available were of poor quality and in small quantities.

It was further reported by Nyabati et al. (2006) that most farmers lacked technical know how on seed collection, handling and the capacity to produce seedlings.

Garrity (2004) reported that farmers in Meru were not in a position to enhance tree cultivation practices owing to certain tree farming challenges such as poor access to planting material, competing farm enterprise on limited land size and stated that there was need to support smallholder tree planting initiatives through provision of quality and quantity tree germplasm along relevant management knowledge tailored to emerging and future market opportunities.

2.6 Tree Diversification and Rural Livelihoods

With disappearing forests, farmers are increasingly dependent on growing their own trees. Farmers plant trees in pursuit of their livelihood goals of income generation, risk management, household food security while endeavouring to make optimum use of available land, labour and capital (Arnold and Dewees 1995). According to Kiage (1998) the choice of trees farmers plant and manage largely depends on their uses.

According to Shiva (1995) an important biomass output of trees that is never assessed by foresters who look for timber and wood is the yield of seed and fruits. Fruit trees such as mango and tamarind have been important components in agroforestry systems in the country for many years. Fruit trees yield annual harvests of edible biomass on a sustainable and renewable basis. Tamarind trees have yielded fruits for over centuries as reported by Shiva (1995) while trees such as *Azadrachita indicaa A.juss* which has been naturalized in Kenya, provide annual harvest of seeds which yield valuable oils. These diverse yields of biomass provide important sources of livelihood for millions of rural people. Since farm forestry programmes in their present form have been based on only the knowledge of foresters who have been trained only to look for the woody

biomass of the tree, the high yielding species of other forms of biomass have been ignored (Shiva, 1995).

Nair (1993) reported that agroforestry had been a way of life in India for thousands of years. Garrity (2004) further reported that agroforestry focuses on the trees on the farms and in agricultural landscapes to meet the triple bottom line of economic, social and ecological needs in the world. Recognition of the roles of trees in overcoming key economic, ecological and social problems from local to global level is growing. ICRAF (2004) has identified challenges related to the millennium development goals that agroforestry science and practice can materially address namely: Help eradicate hunger through basic pro-poor food production systems in disadvantaged areas based on agroforestry methods of soil fertility and land regeneration. Lift more rural poor from poverty through market driven locally led tree cultivation systems that generate income and build assets. Advance the health and nutrition of rural poor through agroforestry systems. Conserve biodiversity through integrated conservation development solutions based on agroforestry. Protect watershed services through agroforestry-based solutions that enable the poor to be rewarded for their services. Assist the rural poor to better adapt to climate change and to benefit from emerging carbon markets through cultivation of trees.

2.7 Multipurpose Trees and Tree Diversification

The need for selection and characterization of woody perennials that can provide multiple products and services in agroforestry systems has long been recognized (Puri, 2004). Although many traditional multipurpose trees have been recognized as valuable, efforts in selection and improvement of such species have generally been lacking.

Toky (2000) listed more than 250 indigenous multipurpose trees present in different eco-regions of India including many less known species that need domestication. In Kenya the number of higher plants was estimated at 6,000 of which about 2,000 are tree and shrub species (Wass, 1995).

2.8 Prospects for Cultivating and Domesticating Indigenous Tree Species

Degrande *et. al*. (2006) defined tree domestication as an accelerated and human-induced evolution to bring species into wider cultivation through a farmer-driven or market-led process, aimed at diversifying smallholder farming systems through the cultivation of indigenous trees. The concept also embraces the regeneration and sustainable management of species as reported by Leakey and Newton (1998).

Trees targeted for domestication are species whose products have been traditionally collected, gathered and utilized by man from the wild and are still of enormous importance to many people for food, nutritional security and welfare. In most cases they have not been planted or cultivated and have been overlooked by scientists (Leakey and Newton, 1994). Optimum and sustainable farm productivity requires quality germplasm for farmers such as species diversity, species choice and selected cultivars or provenances. In order to achieve this farmers and researchers domesticate trees.

In ICRAF tree domestication programmes, domesticating agro forestry trees involves an accelerated and human induced evolution to bring species into wide cultivation through farmer – driven and market-led process. This is a science - based and repetitive procedure involving the identification, production, management and adoption of high quality germplasm (Lengkeek, 1999).

High quality germplasm in agro forestry incorporates dimensions of productivity fitness of purpose, viability and diversity. Tree domestication is gaining importance since farmers are increasingly using and conserving many tree species. Lengkeek, (1999) reported in a study undertaken in Meru Central District that farmers listed benefits of tree domestication as follows:

- Food: fruits, nuts, vegetables, fat, soup and drinks as well food additives
- Medicines: wide range from human to veterinary
- Wood: for timber, firewood, charcoal, poles, construction, furniture, beehive, mortars and tools' handles.
- Cash: stimulants, fruits/nuts and wood
- Service: soil and water conservation, carbon sequestration, windbreaks, soil fertility improvement, boundary markers, shade, amenity and plant support
- Rituals: cultural and emotional well being.

Since 1991 ICRAF has endeavoured to develop a database embracing both exotic and indigenous trees and shrubs species for different agroforestry systems and practices. The concept of cultivating and domesticating high value indigenous tree species is a recent initiative and programme. This is now featuring prominently in the research and development agenda of most collaborating countries (ICRAF, 1997). In Kenya tree domestication by ICRAF has been going on with the *Prunus africana (Hoor.f.) kalkman* tree and on station trials have been established in Muguga and Kakamega (Simons, 2004).

Simons (2000) also reported that prioritization studies with farmers in Cameroon, Uganda and Kenya had confirmed the use and popularity of the species and on farm planting with *Prunus africana* had taken place in those three countries and in Madagascar.

2.9 Loss of Indigenous Tree Species

Indigenous tree species are rapidly disappearing (MENR, 2004). Many of these tree species are being lost before their uses are even discovered. There are more than 2000 indigenous tree species and shrubs documented in Kenya (Wass, 1995).The factors leading to indigenous tree species loss are habitat loss or destruction, overexploitation through excessive harvesting and the introduction of exotic tree species (Ombaba, 1998). The greatest impact of loss of the indigenous tree species is the disappearance of knowledge about the affected trees (Backers, 1995). Habitat loss and overexploitation of indigenous tree species is associated with deforestation. Deforestation has been responsible for elimination of vast temperate forests in both America and Europe and is associated with increasing demand for agricultural land and settlement (UNEP, 1992). Today the same motivations drive forest destruction in the tropical world.

While most Kenyan indigenous forests are shrinking, others such as Mt. Kenya and Kakamega are greatly threatened (MENR, 2004) impacting on the livelihood of the affected households and ecological systems. Deforestation is for instance associated with deterioration of water catchments, increased soil erosion, interference with nutrient cycles, alteration of microclimate and erosion of important genetic base. Indigenous trees on farms have been mostly cleared to pave way for agriculture. This is the case for Embu District where food and cash crops and exotic trees are a common landscape feature. The few remaining indigenous trees can be saved from extinction through on farm tree planting of indigenous tree species.

2.10 On Farm Tree Planting

Farmers plant trees in pursuit of their livelihood goals of income generation, household food security and risk management while endeavouring to make optimum use of available land, labour and capital (Arnold & Dawees, 1995).

In the tropics, Simons et. al. (2000) gave examples where the number of trees planted in farmers' fields now approaches or exceeds those established in formal plantations. Simons (2000) predicted a situation where human population in many areas rise to the extent that most natural sources of important tree products are exhausted followed by a lag phase before farmers compensate by increased cultivation of trees on farms. In order to exit this lag phase, suitable existing on-farm sources of germplasm are essential to implement the extended planting programme.

In Kenya, in the mid 1960s it was felt that the country's tree cover was inadequate and there was need to expand tree planting outside gazetted forests (KEFRI, 2004). Forest extension services came into being in 1971 with the creation of Rural Afforestation Extension Scheme (RAES). The scheme has undergone transition from the initial approach of massive seedling production to the current policy of farmer facilitation.

The gap between supply and demand of wood in Kenya remains wide which renders conservation of reserved forests unrealistic (MENR, 2004). On farm tree planting offers an opportunity of narrowing this gap as resources to address this problem also exist on the farmlands. KEFRI (2004), however, identifies the following problems that need to be addressed for a successful on farm tree planting programme.

- Limited species diversity for different ecological zones.
- Inadequate supply of high quality propagation material.

- Inadequate incentives for on farm tree development.
- Inadequate forestry and agroforestry techniques and management guidelines to guide Kenya forest service.
- Poor linkage between farmers, researchers, extentionists and processors.
- Inappropriate packaging and application of extension materials.

A key emerging issue concerning on farm tree planting is the diversification and intensification of on farm productivity to enhance impact by integrating appropriate innovations.

Evidence is emerging that on farm tree planting occurs when population pressure reaches a thresh hold level (Holmgren, 1994; Shepherd and Brown, 1998), although these pressures can have many components (Edwards and Schreckenberg, 1997). According to Arnold and Dewees (1997), tree planting can be explained as being one or more of four categories of response to dynamic change:

- To maintain supplies of tree products as wild sources decline due to deforestation or loss of access.
- To meet growing demands for tree products as population grow, new uses emerge or external markets develop.
- To help maintain agricultural productivity in the face of environmental degradation.
- To contribute to risk reduction and risk management in the face of need to secure right of land tenure and use.

Kenyan farmers have been planting trees on their farms and formerly deforested areas now have quite high tree stock though made up of relatively few species (Scherr, 1997).

These trees are planted or protected for their contribution to direct household use for consumption, amenity or social value or for farm inputs in response to increasing scarcity of these products/inputs relative to needs and available substitutes.

2.11 Indigenous Tree Planting Programs

Incorporation of indigenous tree species in tree planting programmes has become a crucial issue. Lumumba and Ouma, (2004) reported that the diminishing of forest cover and tree resources in the study area coupled with the ban on removal of forest products from government forests, have made farmers in Embu realize the essence of having high value indigenous trees on their farms. In Meru Central district Kenya, Lengkeek and Carsan (2004) also reported that indigenous tree species such as *Cordia africana Lam, Milicia excelsa (Welw) C.C. Berg, Newtonia buchananii (Backer)* and *Vitex keniensis Turill* were appreciated and planted for their soil improvement roles amongst other functions such as water catchment protection and certain cultural values.

In the past, indigenous tree species were neglected in both research activities and conservation. This was due to their perceived slow growth rate and low monetary returns (Ombaba, 1998). At the moment there is growing awareness that old-age practices of tree integration in farming land and local knowledge of indigenous trees are important attributes to include in tree growing projects. This is because the integration of indigenous trees in farming systems is a prime step to conserve the diversity of species. Integrating indigenous trees with crops is very important for improved farm management. Degrande et. al. (2006) further reported that the potential of indigenous trees on farms in Cameroon were not fully exploited because of a number of constraints that included:

a. Farmers facing problems in tree propagation.
b. Many indigenous trees have irregular and/or low seed production, or else seeds are characterized by low germination rates.
c. Indigenous fruit trees generally take a long time to start bearing, creating a considerable time gap between investment and income flows.
d. Farmers also lack knowledge on tree planting and management. Inappropriate tree densities and tree/crop combinations, in addition to poor tree management practices often lead to sub-optimal tree performance, hence low production.
e. Tree growers in rural areas face high marketing costs. This is so because of underdeveloped market and transport infrastructure, such as bad roads, abusive road-checks, etc.
f. Rural households also lack capacity to add value to their tree products, resulting to high post-harvest losses and inability to enter new markets.

2.12 Conservation through Tree Planting

One of the most important concepts underpinning this thesis is 'conservation.' Elliot (1996) explored how paradigms of forest conservation and utilization could have evolved over time. He concludes "conservation means different things to different people hence it is subject to a wide variety of interpretations. Allanby (1993), in his Macmillan Dictionary of Environment, defines conservation as 'the planning, production, management and sustainable use of natural resources to ensure their wide use within the natural ecosystem.

In this study conservation is viewed simply as the planning, cultivation, production, management and sustainable use of particularly indigenous trees and associated plants within natural ecosystems, agricultural landscapes and human settlements.

A poster by World Conservation Monitoring Centre (WCMC) global analysis of the conservation status shows the distribution of the protected areas of the tropical moist forests by region as: Africa 7.3%, Asia 10.5% and Latin America 15.1%. This suggests the need particularly in Africa to (i) understand the reasons for the poor status (ii) focus on sustainable land use management systems which are capable of diversifying and intensifying production activities at rural household level and (iii) strengthen the institutional capacities of the organizations and individuals responsible for planning, implementing and evaluating community oriented forest/tree conservation programmes (Sharma, 1992 and WCMC undated).

Deforestation is recognized as a major cause of the floral environment decline (Sanchez, 1996), particularly the high value indigenous tree species. There is increasing evidence that diversifying and intensifying land use system is making significant contributions to arresting soil erosion and gradually increasing the number of trees in the rural landscapes. The integration of indigenous plants within agroforestry systems provides the opportunity for conservation and sustainable use of the environment (Mukolwe, 1999). The value and need to cultivate indigenous tree species for use in agricultural systems had until 1998 been over looked by scientists (Dunn, 1991; Leakey and Mawman 1994; Maghembe and Simons 1998). Past initiatives have favoured the cultivation of fast growing high yielding commercial exotic tree species. Concerted efforts are needed to establish how to promote the use and integration of indigenous tree species into appropriate agroforestry systems (Scoh, 1996). Leaky (2004) argued that the emphasis should initially centre on ‘bring to human use’ and advance to the more intricate tree domestication activities.

Simply put, tree domestication refers to how humans select, manage and propagate trees where humans involved may be scientists, civic authorities, commercial companies, forest dwellers or farmers (Simons, 2004). Identifying farmers' preference of high value indigenous trees is the first step to developing a tree domestication strategy (Weber *et. al.*1997). In addition, Sanchez (1995) reported that the emphasis should be on a farmer approach while taking cognizance of the issues of competition, complexity, sustainability and profitability of the system.

2.13 Factors Influencing Tree Planting at Farm Level

Sometimes even where trees are scarce, rural people may be unwilling to grow them. It is unlikely that the reason for this is ignorance of the benefits of trees or the techniques for raising the trees. It is far more likely that there are other real constraints or considerations. It has been suggested (Burley, 1982) that the major conditions which must be satisfied before rural people plant trees are both economic and environmental.

Rural people recognize the role of trees in providing a number of locally important goods and services. Raintree (1986) reported that as nearby natural forests recede or are degraded, farmers have historically tried to protect, plant and manage trees on their land in order to maintain such sought-after outputs. As landholding size continues to decline, the farmers increasingly have to try to gain income from off-farm employment. At this stage, cultivation of annuals is reduced in order to allow more time for income-earning activities. Trees and other perennials requiring only low labour inputs become the main component of the garden (World Bank, 1986). Farmers may also plant trees for economic gains. In India for example there has been an upsurge in tree growing in response to expanding markets for poles and other wood

products (e.g. pulpwood), (Nair, 1984). Likewise in Kenya, farmers have been planting trees on farms since the establishment of a rural afforestation and extension branch in 1971 for provision of timber and fuel wood among other uses (KEFRI 2004).

The principal factors motivating farmers to move to cultivation of trees rather than other cash crops appear to be increased labour costs, shortage of labour, and declining returns from agricultural crops grown on rain-fed areas. The advantages of trees in these circumstances are usually perceived to be: low labour inputs, minimal annual operating costs in most years, greater resistance to drought, and hence reduced risk and uncertainty.

Available information about the rapid expansion of cash crop growing of trees in parts of Kenya has been assembled by Dewees in a study for the World Bank (World Bank, 1986). Two popularly cultivated species are eucalyptus, grown for poles, and black wattle, grown for poles, charcoal, and fuel wood. Markets for these wood products and sawn timber in some places are growing strongly, with farm level production accounting for a large part of the supply.

Tree growing tends to be practiced by poor farmers unable to meet their basic food needs and for whom it is a principal source of farm income. In Vihiga, Kakamega District, for example, the average farm size is about 0.6 ha, of which approximately 25 percent is under *Eucalyptus* woodlots (van Gelder and Kerkhof, 1984).

2.14 Knowledge Gap

Kenya government initiated an aggressive tree planting programme on farmlands in early 1970s having recognised the need to increase area under forest cover that is less than 2 percent.

The internationally recommended forest cover that a country requires to be environmentally stable is 10 percent. Farmers throughout the country have extensively planted exotic tree species with little or no effort in planting indigenous tree species. This has created exotic tree monocultures and thus greatly compromising biodiversity conservation. Earlier campaigns by the government and other relevant stakeholders to promote indigenous tree planting to enhance biological diversity at farm level have not yielded satisfactory results. This study was aimed at generating knowledge on the underlying causes of poor planting of indigenous trees at the farmlands.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter discusses the study area, research design, sampling design, sample size, nature and sources of data, methods of data collection and data analysis techniques.

3.2 Description of the Study Area

3.2.1 Location

The study was conducted in Embu District, which is one of the six districts bordering Mt. Kenya. The district lies approximately between latitude $0^0 8'$ and $0^0 35'$ South and longitude $37^0 19'$ and $37^0 42'$ East. Embu District occupies a total area of 729.4 square kilometres and its altitude ranges from 1,200 - 4,500 meters above sea level. The district is divided into six administrative divisions which are further divided into fifteen locations and fifty two sub locations. Runyenjes division where the study was undertaken has an area of 148.5 square kilometres with three locations and thirteen sub locations. The upper highland zone of the district constitutes a section of Mt. Kenya. According to the 1999 population census, the district had a total population of 278,196 comprising 136,316 males and 141,880 females (MP & ND, 2001). The locations making up Runyenjes Division are Runyenjes, Kaagari North and Kaagari South.

Kaagari North location lies in upper midlands agro ecological zone which is humid receiving an average annual rainfall of 2000 mm. Soils here are well drained extremely deep clay loams. It borders Mt. Kenya Forest Reserve. Runyenjes Location is in sub humid classified as upper midlands 2 agro ecological zone. Soils are well

drained Nitisols. Kaagari South location lies in a semi arid area classified as upper midlands 3 agro ecological zone. The area receives an average rainfall of 1200 mm per year. The soils are deep red loams and cracking clays in some areas (Ngoze *et. al,* 2008).

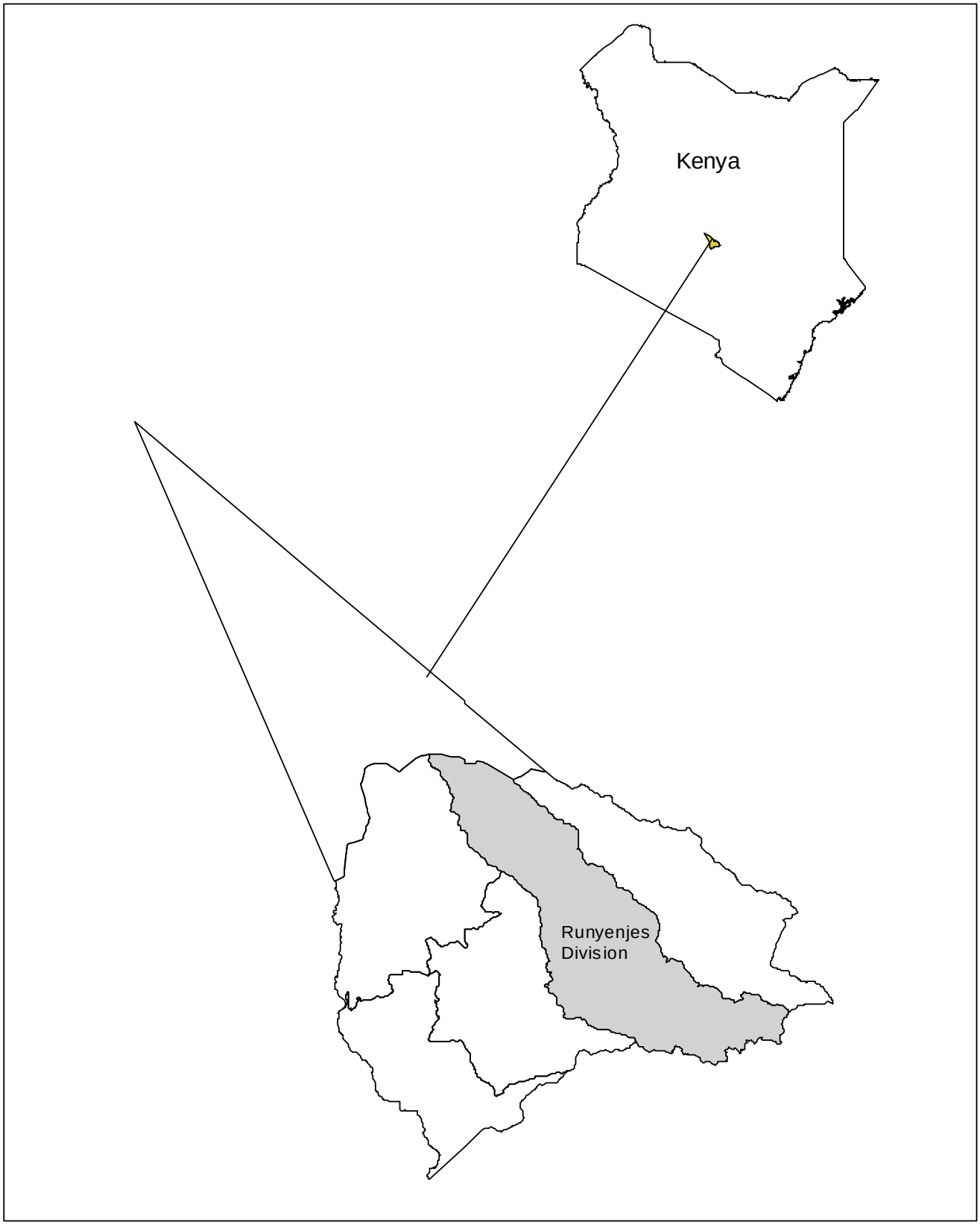

Figure 1: Map of Kenya showing the study area

3.2.2 Climate

Rainfall in Embu District is bimodal with two distinct rainfall seasons. The long rain falls between March and June while the short rains come in October to December. The amount received varies with altitude but averages 1,495 mm per year. However areas above 1,700 metres above sea level display a different pattern, at changes with altitude to a trimodal pattern which has a peak in July to August. The temperatures in the district range from a minimum of 12^0C in July to a maximum of 27.1^0 C in March (MP & ND, 2001).

3.2.3 Vegetation

The vegetation found in Embu at above 3000 metres above sea level is Afro-Alpine that occurs on Mount Kenya. This vegetation is sparse at the upper levels of above 3800 metres above sea level and below it is grassland and Erica Shrubland with stands of *Hagenia abyssinica var.viridifolia* in sheltered spots. The lower alpine occurs between 2800 and 3500 metres above sea level. In the lower slopes bamboo forest occurs followed by indigenous forest, natural grassland and cultivated region. Highland moist forest occurs between 1500 and 3000 metres above sea level and typical montane tree species include *Podocarpus, Olea, Juniperus* and *Newtonia*. (Dean and Trump 1983)

3.2.4 Land and Soils

The district has an agro ecological profile that is typical of the windward side of Mt. Kenya. The upper highlands are so wet that forestry is the best land use.

The forest reserve is characterized by humic Andosols which are well drained, very deep reddish brown clay loam to clay with thick acidic humic top soil. They then

gradually evolve into volcanic ridges which have soils developed on basic igneous rocks. The soils include humic Nitisols with humic Andosols found in parts of Manyatta, Nembure, Runyenjes and Kyeni Divisions. The central and lower parts of the district have Ferrasols that are equally well drained and generally very deep (MP & ND, 2001).

3.2.5 Crops

The physical features characterizing the district along with climatic conditions create a very favourable environment for growing high value crops such as coffee and tea. Other crops are cereals and horticultural crops including French beans, cabbages, kales, tomatoes, oranges, mangoes, avocadoes and numerous other fruits and vegetables.

3.3 Research Design

The multidisciplinary nature of agroforestry implies that no single method of data collection can be used to record perceptions, socio-economic, biophysical, ecological and institutional dimensions of agroforestry. For this reason a combination of qualitative and quantitative techniques was used to obtain empirical evidence to support the aim and objectives of the research study. In addition, literature review was done to complement information obtained using the two techniques (Bless and Higson – Smith, 1995; Slocum *et al.,* 1998; Neuman, 1997).

3.4 Nature and Sources of Data

The purpose of this study was to identify the underlying factors contributing to unsatisfactory planting of indigenous tree species on agricultural landscapes in Embu District. As a result, a comprehensive survey was carried out where primary and

secondary data were collected. Secondary data sources comprised a review of published information such as reports, textbooks, thesis, journals and abstracts obtained from libraries, government offices and the internet. Primary data was obtained from the study sites through interviews of owners of landholdings, key informants, tree nursery managers and observation walks. Issues covered with the questionnaires included types and reasons for planting trees, sources of planting materials, constraints in tree propagation and conservation. Other information included land sizes, age, gender, and literacy levels.

3.5 Sampling Design

Purposive sampling was used to select an administrative division where the study was carried out to ensure the division selected represented all the agro-ecological zones in the district. The district has five agro ecological zones (MP & ND, 2001). Data was collected from three agro-ecological zones that were purposively selected in Runyenjes division. One sub-location falling in each selected agro-ecological zone and sixty farmers from each sub-location were randomly selected using the Fisher formula (Le-Ann and Buzar, 1997; Fisher et. al., 1998). A list of farmers from which selection of farmers was made, was compiled with the assistance of provincial administration and Ministry of Agriculture at the village level. The Snowball sampling technique was used to identify individual farmers and farmers' groups with tree nurseries.

3.6 Sample Size

The sample size of the farms sampled at the sub-location level for administering the questionnaire was determined using the Fisher Formula with the total number of farms in the sub-location forming the sample frame (Fisher et. al., 1998). The number

of farms sampled was proportionately distributed among the villages and was based on the number of farms in each locality. Both female and male headed households were sampled. A total of one hundred and eighty farmers were interviewed besides key informants from relevant institutions. The respondents were composed of 92 males and 88 females.

3.7 Methods of Data Collection

Basic data on tree farming and tree seedling production was collected using Participatory Rural Appraisal (PRA); a technique used to gather information on community resources and needs for use in literacy and community development programmes (Wilde and Vainio-Mattila, 1995). The approach enabled the respondents to interact freely with the researcher and exchange views, ideas, experiences and knowledge on indigenous tree conservation, management and propagation. Information gathered using the technique also helped in determining whether farmers and institutions were aware of and responding to the need to diversify and optimize on farm tree production, contribute to conservation of indigenous trees through on farm tree planting and improve the quality of life of resource poor rural households. A questionnaire with closed and open ended questions requiring both short and detailed responses was used to gather information on the farms such as trees on farm, preferred species and reasons for preferences. The questionnaires targeted farmers and institutions involved in tree planting.

Target institutions included relevant government ministries; Ministry of Agriculture, Ministry of Livestock and Fisheries, Ministry of Environment and Natural Resources and others including tea factories and tobacco growing companies.

Semi-Structured Interview Schedule - The primary approach at the household level was based on face to face interviews which were complimented by visits to farms and tree nursery sites. To gather data from institutions, a set of self-administered questionnaire for interest groups such as Kenya Forest Service, Ministry of Agriculture, tea factories, Non-Governmental Organizations and community based organizations was used. Focused group discussions were held with key informants involved in development and promotion of tree planting. The approach to tree nurseries involved use of self administered questionnaires, complimented by visits to the tree nursery sites. Questionnaires comprising both closed and open ended questions (Bless and Higson-Smith, 1995; Slocum *et. al.,* 1997) were used. This enabled the respondents to give their views on the issues raised. The questionnaire was developed, pre-tested and amended to capture the objectives of the study.

3.8 Data Analysis

Descriptive method was used to analyze qualitative data. Tables and figures were used to display the data gathered in the study area. Quantitative data were analyzed and presented in form of frequencies, percentages, bar charts, pie charts as well as tables. The raw data collected from the field was prepared for analysis. The data first underwent the process of validation. This process included extracting from the raw data that was relevant to answer the specific research questions. This involved going through all the questions and the interview notes. The raw data was then coded. The coded data was then analyzed using SPSS a statistical package and presented as tables, bar charts, pie charts or as percentage.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 General overview

This chapter reports and discusses research findings on factors influencing tree diversification at farm level in Embu District, Kenya. It is organized so as to address the research questions raised in Chapter one. The research questions sort to identify the types of tree species being planted and reasons for planting them, including determining the source of tree germplasm. Constraints associated with propagation and planting of indigenous trees were investigated while mechanisms to enhance indigenous trees planting and conservation were also established. The results are also organized in manner to address the objectives of the study.

4.2 Social Economic Characteristics of the Respondents in Embu District

4.2.1 Population Profile of Respondents in Runyenjes Division, Embu District

Data collected from the study area depicted that 51.1% of the respondents were males while (48.9%) were females (Table 4.1). This compares favourably with the total population of Runyenjes division as the 1999 census results for Runyenjes indicated that 51.6% of the population were females and 48.9% were males (MP & ND, 2001). Franzel (1999) reported that female headed households are generally poorer, less educated, provide most of the household labour and have high time preference rate. Any new interventions likely to exert more labour demands on women and especially when the outputs are not immediate are therefore not likely to appeal to women farmers. Women have however advantage in tree diversification at farm level in that they have been observed to form spontaneous networks to exchange ideas among themselves (Jiggins, 1993).

The networking can facilitate access to extension information and thus improve on uptake of tree diversification technologies at farm level.

Table 4.1 Gender Characteristics of Respondents in Runyenjes Division Embu District

Gender	Number of farmers	Percentage
Male	92	51.1
Female	88	48.9
Total	**180**	**100.0**

4.2.2 Level of Education of Respondents in Runyenjes Division, Embu District

The level of education among the farming community was considered crucial in taking up tree planting initiatives.

Data collected suggested high literacy levels in the study area as 53.9% of the respondents reported having attained at least primary education while 32.2% of the respondents had attained secondary level as depicted with Table 4.2. It was only 11.1% of the respondents who had no formal education. The results showed that more males (28.9%) had attained primary education as opposed to 25 % of the females. There were however more females (17.8%) with secondary education than males (14.4%). The basic education that most farmers had attained is a useful background in inculcating new development ideas. The high literacy levels have a great impact on adoption of new technology including tree planting. Empirical evidence (Senkondo et.al. 1998; Kalineze *et.al.* 2000) suggested that farmers who are knowledgeable are expected to accept new technologies more readily compared with those who are not.

According to Lapar and Pandey (1999) adoption of soil conservation measures in Philippines could be hypothesized as positively correlated with farmers' education level. Farmers without formal education in the study area across gender could affect tree planting programmes aimed at increasing the number of tree species being planted. Individuals with no formal education may incur extra costs as they rely on external support to access basic information on development.

Table 4.2 Education level of respondents in Runyenjes division, Embu District

Education level	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
No formal education	11	6.1	10	5.6	21	11.7
Primary education	52	28.9	45	25.0	97	53.9
Secondary education	26	14.4	32	17.8	58	32.2
Tertiary education	3	1.7	1	0.55	4	2.2
Total	**92**	**51.1**	**88**	**48.9**	**180**	**100.0**

4.2.3 Land Ownership for Respondents in Runyenjes Division Embu District

The size of Land owned by farmers is considered very important in the establishment of perennials such as tree crops whose benefits are not always realized in the short term (Bondi, 1996). In the study area, 74.4 percent of the respondents reported having acquired their parcels of land through inheritance while 25.6 percent reported buying the land they own as shown in Table 4.3. The results agree with a study by Tanui (2002) who reported that in Embu the bulk of the land owned by farmers is acquired through inheritance. Where farmers have long term guarantee on the use or control of the land they farm, there are more incentives to make long term investments and improvements such as tree planting (Bondi, 1996).

Table 4.3 Land Acquisition by Respondents in Runyenjes Division Embu District

How land was acquired	Number of farmers	Percentage
Inheritance	134	74.4
Buying	46	25.6
Total	**180**	**100.0**

4.2.4 Land Size Ownership by Respondents in Runyenjes Division Embu District

Most farmers in the study area (51.7%) as depicted by the results in Table 4.4 had land sizes of four to six acres. The possible relationship between tree planting culture and population in a place is probably a function of farm size (World Commission on Forest and Sustainable Development, 1999). What this implies is that farmers with small land parcels mix agroforestry trees with other crops on same portion of land while those with large parcels are driven by commercial aspect of tree planting and set aside land purposely for tree growing.

Table 4.4 Size of Land Owned by Respondents in Runyenjes Division, Embu District

Size of land	Number of respondents	Percentage
1-3 acres	71	39.4
4-6 acres	93	51.7
7-9 acres	12	6.7
Over 10 acres	4	4.0
Total	**180**	**100.0**

The size of the farm held by individual farmers is critical when it comes to determining the tree species and tree planting technology a farmer adopts.

4.2.5 Age of the Respondents

The age of the farmer is considered crucial in the tree planting activities. The maturity time of tree crops is much longer than most other crops which a farmer has an option of planting or investing in. The data suggest that most farmers in the study area were over fifty years (46.7%) while 12.2% were below thirty years (Figure 1). While longer farming experience is expected to have a positive effect on acceptance of tree planting young farmers may have longer planning horizon and may be more likely to invest in conservation including tree planting. Shiferan and Holder (1998) point out that, young farmers are more likely to adopt conservation practices once they perceive the problem than old peasants.

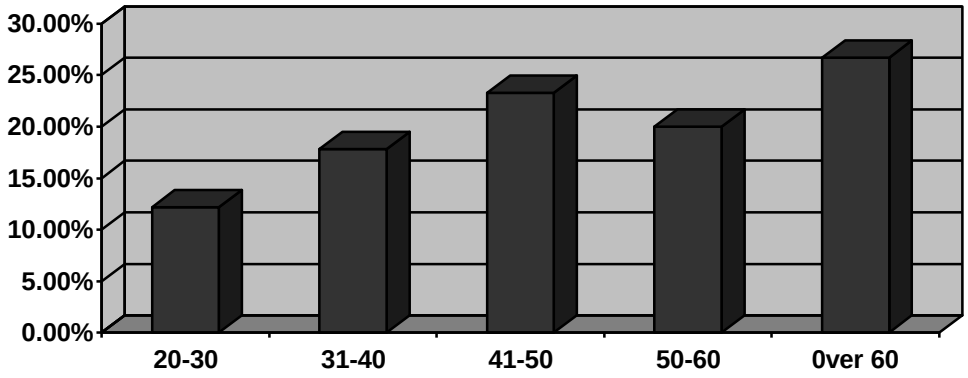

Figure 2 Different Age Groups of respondents in Runyenjes Division, Embu District

4.2.6 Household Tree Tenure Rights of Respondents in Runyenjes Division, Embu District

Secure tenure over trees or clear right to their use is of crucial importance as an incentive for household members to plant and manage trees. Tree tenure rights are secure as long as they are recognized by other members of the community and household (Romano, 2005).

Table 4.5 Household Tree Tenure Rights of respondents in Runyenjes Division Embu District (N=180)

Person holding tree tenure right	No of respondents	Percentage
Female adult	10	5.6
Male adult	26	14.4
Female and male adult	137	75.6
Male adult and children	4	2.2
All family members	3	1.7
Total	**180**	**100.0**

Generally, males in the study area had more secure rights to trees than females as depicted by the data in Table 4.5. The Table shows that 14.4% of males had tree tenure rights as opposed to 5.6 percent of females. In the study area female and male adults were reported to jointly hold tree tenure rights at a high level of 75.6 percent. The high level of both male and female adult holding jointly tree tenure rights is a possible reason for the successful tree planting programme in the study area as female adults participate in tree planting activities as beneficiaries and they feel motivated to plant trees because of the benefits they anticipate to get directly from the trees. This is unlike in other situations where only men have the tree rights making the females belief that tree planting is purely a male affair where their role and participation is limited (Wanjiku and Mugwe, 2004). Such a scenario may not be conducive for successful tree planting programmes.

4.3 Land Use Practices by respondents in Runyenjes Division

The data collected reveals that all farmers in the study area were involved in tree planting on their farms as shown in Figure 2. Almost eighty percent of the respondents practiced agrisilvipastoralism while those practicing agrisilvicultural system were nineteen percent. Only about two percent practiced silvopastoral system. It is possible that farmers in the study area practiced agrisilvicutural and

agrisilvipastoral to maximize on land usage of their parcels of land that are small as reported earlier in this thesis. Inter planting trees within crop fields was therefore evident in the study area and though crop yields may be affected by above and below ground competition for environmental resources. Smith and Scherr (2002) have argued that the incentive to plant trees on farms may be to diversify outputs, increase overall land productivity and reduce uncertainties associated with drought and increased cash income. This is not withstanding the fact that the returns from tree growing are not immediate and tree planting may altogether be a new activity.

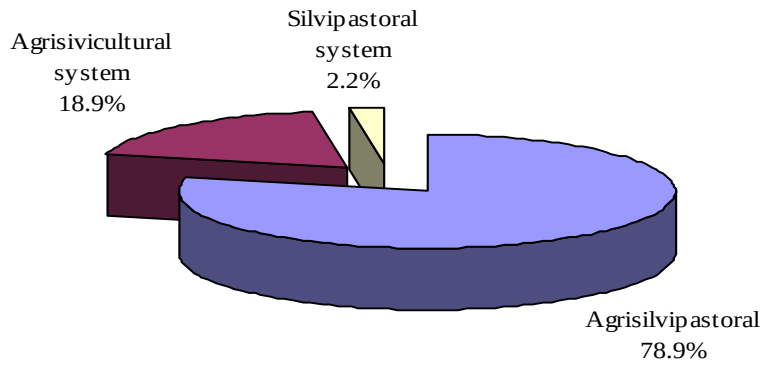

Figure 3 Land Use Practices by Respondents in Runyenjes Division, Embu District

4.4 Sources of Germplasm Planted for Respondents in Runyenjes Division, Embu District

As shown in Table 4.6 majority of the respondents (53.3 percent from Runyenjes location and 67 percent from Kagaari south location) were buying their seedlings from Kenya Forest Service tree nurseries while 40.0 %and 47% had their own tree household tree nurseries in Runyenjes and Kagaari North locations respectively. According to AFSICH (1993), Roothaert and Tuwei (1994), Kindt (1997), Koffa and Roshetko (1999), O'Connor (1997) and Holding and Omondi (1998),new planting

stock on farms in Meru central, another district bordering Mt. Kenya forest is also obtained from farmers own farms. The government through Kenya Forest Service responded to decreasing forest and tree resources in the country in the early 1970's by establishing many tree nurseries (KEFRI, 2004). It is from these nurseries that farmers reported to have gotten their tree seedlings to raise the current crop of mature trees. The results showed that 33.3% and 67 percent of the respondents in Runyenjes and Kagaari North location respective fully were relying on collection of wildings from farms and neighbouring forest. This agrees with what Wanjiku and Mugwe (2004) have documented that about 51 percent of farmers in Embu district who use seedlings as propagation materials buy them either from government or group nurseries. The willingness of a farmer to purchase seedlings is a good indication that if seedlings of higher genetic values were offered to the farmers at a reasonable cost, they would buy. Simons and Chagala (1996) postulated that farmers who have a tree planting culture are easier to target with improved materials since the only proof required is that the new germplasm is superior.

Table 4.6 Sources of Tree Planting Materials for respondents in Runyenjes Division, Embu District Showing Specific Locations (N = 60 in each case)

Source of germplasm	Runyenjes		Kagaari North		Kagaari South	
	F	%	F	%	F	%
Buying from Kenya Forest Service	32	53.3	12	20.0	40	67.0
Given from Kenya forest service	0	0.0	4	10.0	0	0.0
From household tree nursery	24	40.0	28	47.0	21	35.0
Collection of wildings	20	33.3	40	67.0	10	17.0
Given seedlings by NGOs/CBOs	4	6.7	10	17.0	17	28.3
Given seedlings by neighbours	0	0.0	12	20.0	20	0.0
Collecting seeds from forests/farms	2	3.3	6	10.0	10	0.0

Key: F - Frequency

The results also depicted that a higher percentage (67%) of farmers from Kaagari South location relied on Kenya Forest Service for provision of tree planting materials compared to 53.3% farmers from Runyenjes location and only 20% from Kaagari North location. The results in Table 4.6 further revealed that farmers in Kaagari North location had more (47%) household tree nurseries than farmers in Runyenjes location (40%) and those in Kaagari South locations where only 35% had household tree nurseries. The low abundance of household tree nurseries in Kaagari South location could be attributed to differing climatic conditions of the regions since as reported earlier in this thesis, Kaagari South location receives less rainfall compared to Runyenjes and far much less compared to Kaagari North location.

Results also revealed that a higher proportion (67%) of farmers in Kaagari North location were using wildings as their tree planting material as compared to 33.3% of farmers in Runyenjes Location. It was only 17% of farmers in Kaagari South location who reported to be using wildings. Kaagari North location borders Mount Kenya forest reserve and farmers could be getting wildings from the forest while the long distance to the forest for the farmers in Kaagari South and Runyenjes locations could be hindering them from accessing wildings from the natural forest of Mount Kenya.

As for seed sources for institutions with tree nurseries, it was reported that the main source of their seeds requirements was from KEFRI, seeds vendors, and collecting their own seeds locally. Respondents reported getting from KEFRI seeds of mainly exotic tree species such as *Pinus patula,Schiede &Deppe, Cupressus lusitanica Carr,* and *Eucalyptus s*pecies while seed vendors supplied indigenous seeds of various species including *Prunus africana (Hook.f.) Kalkm, Vitex keniensi Turill, Bredellia micrantha (Hochst)* and *Podocarpus* species. Seeds that were being collected locally by institutions and farmers included *Grevillea robusta* and also indigenous tree

species commonly growing in the region such as *Neutonia buchananii, Bredellia micrantha, Podocarpus* species and *Vitex kinesis* Kenya Forest Service reported to be raising various tree species in their tree nurseries as depicted in Table 4.7.

Table 4.7 Tree seedlings stocks at Kenya Forest Service tree nursery at Runyenjes Divisional Headquarters

Tree species	Number of tree seedlings raised				
	2001	**2002**	**2003**	**2004**	**2005**
Indigenous tree species					
Vitex Keniensis	70	50	210	19	
Cordia abyssinica	100	330	126	519	
Prunus africana	220	50		38	
Podocarpus spp	900	552	1479	62	
Markhamia lutea				462	
Syggium guinence					
Warbugia ugandensis					
Bridellia micrantha				29	
Ocotea usambarensis				20	
Exotic tree species					
Cupressus lusitanica	4860	2665	1090	2300	380
Grevillea robusta	5409	3270	104	18000	5860
Eucalyptus spp	200	200	360	5000	8330
Casuarina equisetifolia	117			1762	
Senna siamea	300	300	300	3800	
Terminalia species				343	80
Azadiracta indica				3000	800

4.5 Tree Species Preference at Farm Level among respondents

In order to capture knowledge on tree uses, farmers were asked to identify and rank tree species preferred. The results as depicted in Table 4.8 show that the most preferred tree species were exotic trees. The difference in preference rating may be attributed to previous extension strategies which promoted exotic trees such as *Grevillea robusta* and *Eucalptus* species. A similar observation was made by Ombaba (1998) in Kisii District. Other factors that have directly undermined preference in indigenous tree species are slow growth rate (Wass, 1995) and lack of tree seedlings (Holding and Omondi, 1998). Another factor that contributes to low preference of indigenous tree species according to Walker *et.al (*1995) is delayed economic returns.

The data collected also indicated that the most preferred tree species in the study area was *Grevillea robusta* (100%) followed by *Mangifera indica Blume* (80.8%). *Eucalyptus* species and *Macademia tetraphlla L.Johnson* were also popular trees species in the study area with 43.3 % and 45.5 % of the farmers preferring them respectively for planting. Indigenous tree species being planted by farmers included *Vitex keniensis* (15.5%), *Bridellia micrantha* (7.7%) and *Cordia abyssinca Lam* (14.4 %), (Table 4.8).

Table 4.8 Major Tree Species Planted by respondents in Runyenjes Division, Embu District (N=180)

Tree species	No. of farms with the tree species		No. of farms with the tree species planted		No. of farms with tree species naturally regenerated	
	Frequency	%	Frequency	%	Frequency	%
Mangifera indica	143	80.8	143	79.4	0	0
Persia americana	72	40.0	40	90	0	0
Grevillea robusta	180	100	180	100	0	0
Cordia abyssinica	86	47.0	26	14.4	60	33.3
Eucalyptus species	78	43.3	78	43.3	0	0
Macadamia tetraphylla	82	45.5	82	45.5	0	0
Bredellia micrantha	126	70.5	14	7.7	112	62.2
Cupressus lusitanica	16	8.8	16	8.8	0	0
Vitex keniensis	38	15.5	28	15.5	0	0
Combretum molle	19	0.0	0	0.0	19	10.5
Musaenda microdonta	29	16.1	0	0.0	29	16.1
Senna siamea	30	16.7	30	16.7	0	0
Senna spectabilis	27	15.0	27	15.0	0	0

In the study area farmers had also retained a substantial number of indigenous trees on their farms that included *Combretum molle G.Don (*murama) (10.5%) and *Mussaenda microdonta Weinh* (*mwanjati*) (16.1%), *Bredellia micrantha* (62.2 %) *Cordia abyssinca* (33.3%) as depicted in Table 4.8. In addition to retaining indigenous trees on farms, farmers in the semi arid zone of Kagaari South also preferred planting *Senna siamea (Lam) H.S Irwin&Barneby (*16.7%) and *Senna spectabilis (D.C) H.S Irwin&Barneby* (15%) tree species because of their resistance to

drought and termites. Apparently, *Mellia volkensii Gurke* which is popularized as a suitable tree species in semi arid zones of Kenya (Mulatya and Misenya, 2004) is not well known in this area.

4.6 Status of on Farm Trees in sampled farms in Runyenjes Division Embu District

To understand the situation concerning on farm tree resources in Embu District, farmers were asked to indicate status of the major trees on their farms during the last five years. The results are as indicated in Table 4.9

Table 4.9 Status of Trees on sampled Farms in Runyenjes division, Embu District (N=180)

Tree species	No of farms with the tree species		Status of the trees on the farm					
			Increasing		Decreasing		Same	
	F	%	F	%	F	%	F	%
Mangifera indica	143	80.0	68	37.7	12	6.6	63	35.3
Persea americana	72	40.0	46	25.5	17	8.8	90	5.0
Grevillea robusta	180	100	162	90.0	10	5.5	70	3.8
Cordia abyssinica	86	100	23	27.7	2	1.1	61	33.8
Eucalyptus species	78	43.0	44	24.4	4	2.2	30	16.7
Macadamia tetraphylla	82	45.5	62	34.4	0	0.0	20	11.1
Bredellia micrantha	126	13.3	85	47.2	24	13.3	17	9.4
Cupressus lusitanica	16	8.8	3	1.1	5	4.4	6	3.3
Vitex keniensis	38	21.1	20	52.6	0	0.0	18	47
Combretum molle	19	10.5	19	10.5	0	0.0	0	0.0
Senna siamea	27	16.1	12	6.6	0	0.0	17	9.4
Senna spectabilis	36	15.5	12	6.6	4	2.2	12	6.6
Mussaenda microdonta	29	16.1	12	6.6	0	0	17	9.4

Key: F - Frequency

Majority of the farmers indicated that the number of trees on their farms had been increasing. The highest increase as depicted in Table 4.9 was that of *Grevillea robusta* as reported by 90% of the respondents. This was followed by *Bredellia micrantha* an indigenous tree species with 47.2%. The tree was preferred because of its high quality

poles and firewood. It also provides fodder for animals as reported by Nyangaga (2004) but has shading effects on crops.

Respondents also reported that the density of *Vitex keniensis* had increased in 52.6% of the farms where it had been planted. Leaky (2004) stated that in Embu farmers who already had fast growing trees like *Eucalyptus, Grevillea robusta* and fruits trees on their farms had also started to integrate a few high quality indigenous trees like *Vitex keniensis* into niches in the farming systems.

The uptake of additional tree species for inclusion in the farmers' tree planting programme is an indicator that Embu farmers are willing to diversify tree planting. They need however to be supplied with the preferred indigenous trees species germplasm which is currently lacking. It is noted that high value indigenous tree such as *Ocotea usambarensis Engl* and *Podocarpus species* were not available on farms (Table 4.9), a situation which is worrying as these are the species mostly sort for timber in Embu district as reported by Wanjiku and Mugwe (2004).

4.7 Tree Planting Technologies in Runyenjes Division Embu District

As stated earlier (Table 4.4), most farmers (51.7%) in Embu District had four to six acres of land and hence not adequate to cater for all the farmer's needs. Farmers had therefore adopted different tree planting technologies on their farms in order to cope with the problem of inadequacy of land. The most common tree planting technology adopted by the farmers in Runyenjes division was planting trees scattered on cropland (Table 4.10). The tree species found scattered on farms in the study area included *Mangifera indica* (67%), *Grevillea robusta* (71%), *Macademia tetraphlla* (100%) and *Persia americana Mill* (63%). The presence of scattered trees on cropland can also be attributed to presence of retained indigenous trees such as *Bredellia micrantha* and

Cordia abyssinica that are left standing during land clearing. Farmers do not destroy naturally regenerated trees species especially when they are known to provide quality products and services. Other trees such as *Grevillea robusta* are planted by farmers purposely to increase tree density so as to meet the tree products requirements and other services

Table 4.10 Tree Planting Technologies on sampled farms in Runyenjes Division, Embu District N =180

Tree species	Woodlot		Scattered on cropland		Live fence		Fruit orchard		Boundary planting		Total number of farms
	F	%	F	%	F	%	F	%	F	%	
Mangifera indica	0	0	96	53.3			47	27.0			143
Percia americana			45	25			17	9.4.	10	5.50	72
Grevilia robusta	7	4.0	128	71.0					83	46.0	180
Cordia abyssinica			75	87.0					11	6.1	86
Eucalptus species	26	14.0	33	18.0					19	10.5	78
Macademia tetraphlla			83	46.0							83
Bredellia mirantha			103	57.2					23	12.7	126
Cupressus lusitanica					13	07			3	02	16
Vitex keniensis	9	05	15	08					14	7.7	38
Senna siamea	10	5.5	6	03					25	13.8	41
Senna spectabilis	5	2.7							23	13.0	28

Key: F – Frequency

Another tree planting technology adopted by farmers in the study area was planting along the farm boundaries as depicted in Table 4.10 and also shown by Plate No 1. Planting along farm boundary provide an extra niche for tree planting and also demarcate clearly a farmer's parcel of land thus reducing boundary disputes. *Grevillea robusta* was the most dominant tree planted on farm boundaries and this was in agreement with Kamweti (1996) and Thijssen et.al (1993) who documented the tree species to be the most common tree species planted along farm boundaries in Embu District. *Grevillea robusta* is preferred as a boundary tree because it grows fast, is easy to establish and provides economically viable products. In addition, its deep

rooting system makes it an associative ideotype in mixed farming systems because of reduced negative tree crop interactions and consequently reduction of land use conflict between neighbouring farmers.

Plate.1 Boundary Tree Planting with *Grevillea robusta* at Mr Peter Njiru's Farm at Runyenjes Division, Embu District

There were other indigenous and exotic trees that were also found on farm boundaries (Table 4.10). They included *Vitex keniensis* (7.7 %), *Bredellia micrantha* (12.7 %), *Eucalyptus* species (10.5 %), *Senna siamea* (13.8 %) and *Senna spectabilis* (13 %). The presence of many other tree species on farms is an indication that although farmers prefer planting *Grevillia robusta* they also have an interest in tree diversification for provision of other unique products such as medicine, food, fodder for livestock and bee forage.

Tree species that compete with agricultural crops such as *Eucalyptus* and are still crucial in meeting farmers' needs are planted in woodlots as shown in Table 4.10.

There were trees that are planted in fruit orchards and these included *Mangifera indica* (27%) and *Persea americana* (9.4%) to ease application of insecticides through spraying while farmers who use trees as live fence preferred mostly *Cupressus lusitanica* (7 %) especially in areas receiving high rainfall.

4.8 Factors Influencing Choice of Tree Species in Tree Planting Programmes

Farmers in the study area gave various reasons (Table 4.11) for planting trees on their farms. The major factor contributing to choice of tree species to plant was economic considerations. As Table 4.11, shows 92 % of farmers in the study area gave the reason for planting trees as provision of timber. Since 1999 when the government imposed a ban on timber harvesting from all government forests, the major source of timber consumed in the country has been the farmlands and this has benefited farmers economically thus making many realize the economic potential of tree growing on farms. FAO (2005) noted that, local communities controlled at least 25% of the developing world's forests and in forest-scarce countries local farmers were actively growing trees for commercial use. In Kenya, (with less than two percent forest cover) smallholder farmers growing trees were reported to have gained prominence owing to unsustainable plantation logging and subsequent government ban on the same. The results displayed in Table 4.11 also showed that 98 % of the respondents would prefer planting trees for fuel wood production while 60 % preferred planting trees for poles production. The results depicted in Table 4.11 also show that 29 % of the farmers preferred planting trees that provide fodder for their livestock while 56 % of the farmers preferred planting trees for production of food (fruits). The farmers who showed preference of trees for food production were farmers from the cotton/tobacco zone where fruit production was being undertaken as

a commercial enterprise. The various trees required for different products and services is one option available for farmers to diversify tree growing at the farm level.

Table 4.11 Farmers' Reasons for Planting Trees in Runyenjes Division, Embu District (N= 180)

Reason for tree planting	Number of farmers	Percentage
Timber production	167	92
Fuel wood production	178	98
Poles production	108	60
Fodder production	52	29
Medicine	56	31
Soil conservation	31	17
Food production	100	56
Amenity	23	13
Bee forage	9	05

Table 4.12 shows the tree species preferred by farmers for various uses. Most farmers (92%) preferred *Grevillea robusta* as a timber tree species. It is documented by Kamweti (1996) and also revealed by this study that the most widely planted tree species in Embu was *Grevillea robusta* (Table 4.12*). Grevillea robusta* was introduced from Australia to East Africa in 1910 (Hardwood, 1992). Initially the species was introduced as a shade tree in tea and coffee plantations but it has become a very popular agroforestry tree species and is used for timber/construction, firewood and as boundary marker as reported earlier in this study.

Other trees that farmers were willing to plant for timber were *Eucalyptus* species (56.7%), *Vitex keniensis* (43%), *Cordia abyssinica* (47.5%) and *Cupressus lusitanica* (8.9%). A study by Lumumba and Ouma (2004) indicated that *Grevillea robusta* is popular in the study area for timber production because it is readily available. It is also cheap and affordable compared to other species especially indigenous hardwoods

and it exhibits faster growth than most of the other tree species and it is easier to work with.

Table 4.12 Tree Species Preferred by Farmers for Various Uses in Runyenjes Division, Embu District N=180

	Uses													
	Timber		Fuel wood		Fodder		Poles/Post		Medicine		Aesthetic		Food	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Grevillea robusta	165	92.0	144	80.0	23	14.3	40	22.2	-	-	30	16.7	-	-
Eucalyptus species	102	56.7	90	50.0	-	-	171	95.0	-	-	-	-	-	-
Mangifera indica	-	-	-	-	-	-	-	-	-	-	-	-	143	79
Persea americana	-	-	-	-	-	-	-	-	-	-	--	-	72	40
Cordia abyssinica	86	47.5	10	5.5	-	-	6	3.3	-	-	-	-	-	-
Macadamia tetraphylla	-	-	-	-	-	-	-	-	-	-	-	-	83	46.
Vitex keniensis	78	43	-	-	-	-	-	-	-	-	17	21.8	5	2.7
Combretum molle	-	-	19	10.5	-	-	47	26.1	-	-	-	-	-	-
Senna siamea	-	-	45	25.0	-	-	59	32.7	-	-	25	13.8	-	-
Azadracta indica	-	-	-	-	-	-	-	-	85	47.2	-	-	-	-
Calliandra calothyrsus	-	-	-	-	75	41.7	-	-	-	-	-	-	-	-
Leucaena leucocephala	-	-	-	-	87	48.3	-	-	-	-	-	-	-	-
Terminalia species	-	-	-	-	-	-	-	-	-	-	142	78.9	-	-
Tecoma stans	-	-	-	-	-	-	-	-	-	-	117	65	-	-
Cupressus lusitanica	16	8.9	-	-	-	-	-	-	-	-	-	-	-	-
Mussaenda microdonta	-	-	49	27.3	-	-	-	-	-	-	-	-	-	-
Commiphora zimmermanii	-	-	-	-	39	21.0	-	-	4	2.2	-	-	-	-
Morus alba	-	-	-	-	32	17.7	-	-	23	15.6	-	-	-	-
Ficus natalensis	-	-	-	-	-	-	-	-	4	2.2	-	-	-	-
Erythrina abyyssinica	-	-	85	47.2	-	-	58	68.0	28	15.6	-	-	-	-
Prunus africana	-	-	-	-	-	-	-	-	86	48.0	34	19	-	-
Bredellia micrantha	-	-	126	70.0	26	14.4	87	48.0	-	-	-	-	-	-

Key: F – number of respondents preferring the tree species for respective use and the corresponding percentages.

Farmers in Embu rely on fuel wood as their source of energy and they were therefore growing trees for fuelwood as shown in Table 4.12. The main tree species preferred for fuelwood were *Eucalyptus* species (50.0%), *Grevillea robusta* (80.0%), *Senna siamea (25*%), *Bredellia micrantha* (70%) and *Mussaenda microdonta* (*mwanjati*) (27.3%). In Kisii, Ombaba (1998) reported that on farm trees were also an important source of fuelwood where a number of indigenous tree species including *Bridellia micrantha, Markhamia lutea, (Benth) K Schum* and *Croton microstachyus Hotchst* were being planted for fuelwood needs.

As stated earlier, farmers in Embu keep livestock on their farms in addition to tree farming. Farmers indicated their willingness to plant fodder trees for livestock. The

most preferred livestock fodder trees were *Calliandra calothyrsus Meissner* (41.7%) and *Leucaeana leucocephalla (Lam) De wit* (48.3%). Farmers also showed interest in planting *Sapium ellipticum (Krauss) Pax* (indigenous tree) for livestock fodder. The economic importance of on farm fodder trees was first to cut down on farmers' costs on animal feeds and secondly to increase livestock product yields. Patterson *et.al* (1996) reported that in Embu, a dairy industry with support of ICRAF had expanded with *Calliandra calothyrsus* being grown as a diet supplement with 3kg of *Calliandra calothyrsus* replacing 1 kg of conventional daily meal from animal feeds manufacturers.

Other tree species that farmers were using as fodder for livestock include *Bredellia micrantha* (21%) and *Grevillea robusta* (14.4%) (during harsh environment conditions), *Morus alba Y.B.Wu* (17.7%) and *Commiphora emnii Engl* (21%). Farmers in the study area also preferred planting trees for provision of food. The economic importance of on farm trees grown for food is two fold. First is to improve nutrition and food security and secondly is to generate income and provide employment. The tree species mostly preferred for food were *Mangifera indica* (79%), *Persea americana* (40%) and *Macadamia tetraphylla* (46%).

Herbal medicine could be gaining ground in the study area as some farmers indicated their willingness to plant medicinal trees. The tree species preferred for medicines were mainly indigenous tree species such as *Erythrina abyssinica Lam exD.C.* (15.6%), *Ficus natalensis Hoechst* (2.2%) and *Prunus africana* (48%).

Azadirachta indica A juss (neem tree), an exotic tree species was also popular with farmers for medicinal purposes and 47.2 percent of the farmers were reported to like it. Homestead tree planting was also common in the study area for provision of

shade. Trees planted in home compounds for amenity purposes were both exotic and indigenous. The most liked trees were *Terminalia* species (78.9%), *Tecoma stans angustata* (65%), *Vitex keniensis* (21.8 %) and *Prunus africana* (19%) (Table 4.12).

4.9 Tree Planting Extension Strategies

As shown in Table 4.13, most farmers (57.2%) get information on tree planting through seminars, workshops. and study tours that are organized by the Ministry of Agriculture and Kenya Forest Service as evidenced by Plate 2, which shows farmers in a training session under *Vitex keniensis* trees planted on a farm at Kagaari North.

Plate 2 Farmers in a Training Session under *Vitex keniensis* Trees on a Farm at Kagaari North Location, Embu District

Ministry of Agriculture was reported to be playing a greater role compared to Kenya Forest Service in disseminating information on tree planting since 54.4 percent of the farmers reported to have learnt about tree planting from this ministry while 29.4 reported learning from Kenya Forest Service (Table 4.13). This is through the field visits of the personnel from the two government agencies. Nyambati et al. (2006) reported that in Nandi District, Kenya Forest Service extension services were limited

due to lack of staff and that most farmers depended on the Ministry of Agriculture for these services. Other sources of information on tree planting are depicted in Table 4.13 included parents (20%), friends (8.9%), radio and television (11.7%), pamphlets and magazines (3.3%). Zubair and Garforth (2005) reported that farmers living in rural areas of Pakistan discuss matters of daily life with their friends and fellow farmers when they meet together and are highly influenced by the family in making decisions and pointed out the importance of social referents who play a persuasive role in a farmer's decision to grow or not to grow trees.

Table 4.13 Sources of information on tree planting in Runyenjes Division, Embu District (N=180)

Source of information	Frequency	Percent
Parent	36	20.0
Seminar/Workshop/Study tours	103	57.2
Reading magazines	6	3.3
Pamphlets	10	5.6
Radio and TV	21	11.7
Friends	16	8.9
Kenya Forest Service personnel	53	29.4
Ministry of Agriculture personnel	98	54.4
Others (school)	12	6.7

4.10 Farmers' Perceptions towards Indigenous Tree Planting

The results depicted in Table 4.14 shows that 82 % of the farmers in the study area were willing to plant indigenous tree species while only 18% of the farmers were not. This is in agreement with research results from Meru Central District by Lengkeek (1999) that showed that 84% of farmers wanted different tree species because of their need for different products, services and risk management.

Farmers reported their willingness to have a diversity of tree species stating that no timber from one tree is the same as timber from another and that different trees have different fire quality characteristics.

Table 4.14 Respondents Perceptions towards Indigenous Tree Planting in Runyenjes Division, Embu District

Number of farmers willing to plant indigenous tree species		Number of farmers not willing to plant indigenous tree species	
Frequency	**%**	**Frequency**	**%**
148	82	32	18

4.11 Indigenous Trees Planting in Runyenjes Division, Embu District

The indigenous trees that farmers were willing to plant are as shown in Table 4.15. All farmers reported that they wanted different tree species on their farms because of their needs for different products and services. The results as shown in Table 4.15 indicated that *Vitex keniensis* was the most preferred indigenous tree for planting since 77.7% of the farmers were reported to prefer it. Prodding farmers on reason for their preference of this tree other than its provision of high quality timber, farmers indicated that it grows fast and combines well with other crops on the farm. Some farmers indicated that its fruits are edible thus contributing to food security in the district. A similar observation was made in Meru Central District by Lengkeek et.al (2003) who listed *Vitex keniensis* as one of the species that farmers were willing to plant on their farms.

Table 4.15 Preferred indigenous trees by respondents in Runyenjes Division, Embu District (N=180)

Tree species	Uses	% of farmers who preferred the tree.
Prunus africana	Medicine, timber, firewood, posts	55.5
Vitex keniensis	Timber, firewood, food	77.7
Bredellia micrantha	Firewood, posts, charcoal	40.5
Cordia abyssinica	Timber, firewood, soil fertility	38.9
Podocarpus spp	Timber, firewood	11.1
Croton megalocarpus	Firewood, charcoal	10
Ocotea usambarensis	Timber, medicine	7
Ficus sycomorus	Firewood, timber	21.1
Sepium ellipticum	Livestock fodder	10
Myrianthus holstii	Fruits	16.6
Neutonia buchananii	Timber, firewood	6.7
Markhamia lutea	Timber, poles	25
Warbugia ugandensis	Timber, medicine	2.2
Azanza garckeana	Timber, medicine	15.6
Mussaenda microdonta	Firewood, posts	11.1
Combretum molle	Firewood, posts	7.2

Another indigenous tree preferred by majority of farmers as shown in Table 4.15 was *Prunus africana* (55.5%). *Prunus africana* was preferred for its superior quality timber until the realization of its great potential in the pharmaceutical industries made it more popular. Indeed farmers who stated their willingness to plant it indicated its medicinal value as the main reason for planting it. Results in Table 4.15 also showed that 38.9 % of the farmers planted *Cordia abyssinica* for provision of high value timber and soil fertility improvement. Results depicted in Table 4.15 also revealed that 40.5 percent of the farmers were willing to plant *Bredellia micrantha* as a source of firewood, poles/posts and charcoal. Prodding the farmers further revealed that the

tree is also used as fodder for animals. The other indigenous tree species that farmers were willing to plant for timber production included *Podocarpus* species (11.1%) *Neutonia buchananii* (6.7 %) and *Markhamia lutea* (25 %).

As depicted in Table 4.15, *Markhamia lutea* was also liked by 25 percent of the farmers to provide poles, posts and firewood in addition to timber. The tree was popular with farmers in Kagaari South location which receives less rainfall compared to Kagaari North location. Seven percent of the farmers were willing to plant *Ocotea Usambarensis Engl* because of its high value timber. The reasons for low preference in spite of its high timber demand and good prices for its timber as reported by Lumumba and Ouma (2004) could be due to the unavailability of its seedlings. Indeed there were very few seedlings of *Ocotea Usambareansis* at the Kenya Forest Service nursery in the study area (Table 4.7) and there were none in the individual tree nurseries. *Ocotea usambarensis* is one of the highly exploited tree species from Mt. Kenya forest both legally and illegally to an extent that its existence is threatened (Akobo, personal communication). The results also revealed that farmers were willing to diversify by planting indigenous fruit trees. Results in Table 4.15 showed that 16.6 percent of the respondents were willing to plant *Myrianthus holstii Engl.* Firewood is crucial in the livelihood of the respondents and they indicated their desire to source firewood from their farms by planting of indigenous trees. The indigenous trees that farmers were willing to plant to provide firewood included *Croton megalocarpus* (10%), *Ficus sycomorus L* (21.1%), *Neutomia buchananii* (6.7%), *Azanza garckeana* (F.Hoffin) Excell & Hillcoat (15.6%), *Mussaenda microdonta* (11.1%) and *Combretum molle* (7.2%). Some farmers were also willing to plant indigenous trees for provision of fodder for livestock and 10% of the respondents reported preferring *Sapium ellipticum. (Krauss)Pax*

4.12 Constraints to Indigenous Tree Planting

As shown in Table 4.16 farmers reported several obstacles that were hindering them from engaging in indigenous tree planting in their farms.

4.12.1 Slow Growth Rate

The results (Table 4.16) revealed that a significant number of farmers (60%) had not engaged themselves in indigenous tree planting as they perceived them to have a slow growth rate. In general one major reason why people may not engage in tree growing is the long rotation period trees take to mature in comparison with other crops on farm. The problem of growing indigenous trees is thus compounded further when their growth rate is compared to growth rates of popular exotic trees such as the *Eucalyptus* species *Grevillea robusta* and *Calliandra colothyrsus*.

Table 4.16 Constraints to indigenous tree planting reported by the respondents in Runyenjes Division, Embu District (N = 180)

Constraints	Frequency	Percentage
Slow growth rate	108	60.0
Seeds and seedlings not readily available	105	55.7
Small land units	12	6.7
Not compatible with crop	20	11.0
Inadequate water	16	9.0
Poor survival rate	17	7.4
Browsing by animals	3	1.7
Government policy and legislation	15	8.3
Inadequate knowledge on economic value	12	6.7
Inadequate knowledge on propagation	2	1.1
Don' t have straight boles	7	3.7
Require more care	13	12.0
Destroyed insects	10	5.6
Poor seeds germination	9	5.0

A similar observation was made in Kisii by Ombaba (1998) who reported that one of the draw backs of indigenous trees conservation was their slow grow rate. Similarly, in the Philippines, Alexander (2003) reported that where farmers grow timber for both

household use and market, the ability of a tree to grow fast and be harvested early was the most important characteristic to consider in choosing the tree species to plant.

4.12.2 Seeds and Seedlings Availability

In the study area, 55.7 percent of the respondents indicated that seedlings of indigenous trees were not readily available (Table 4.16). As reported earlier, the indigenous tree seedlings availability from Kenya Forest Service tree nurseries was extremely low (Table 4.7) and as shown in. Figure 4.3, farmers from Kagaari South, the cotton /tobacco agro ecological were the hardest hit by seedling shortage. In Tanzania, Mnzava (2001) reported that neither the government nor the village nurseries were raising enough seedlings at the right time and the main reason seemed to be inadequate resources combined with the fact that utilization of locally available materials was neglected.

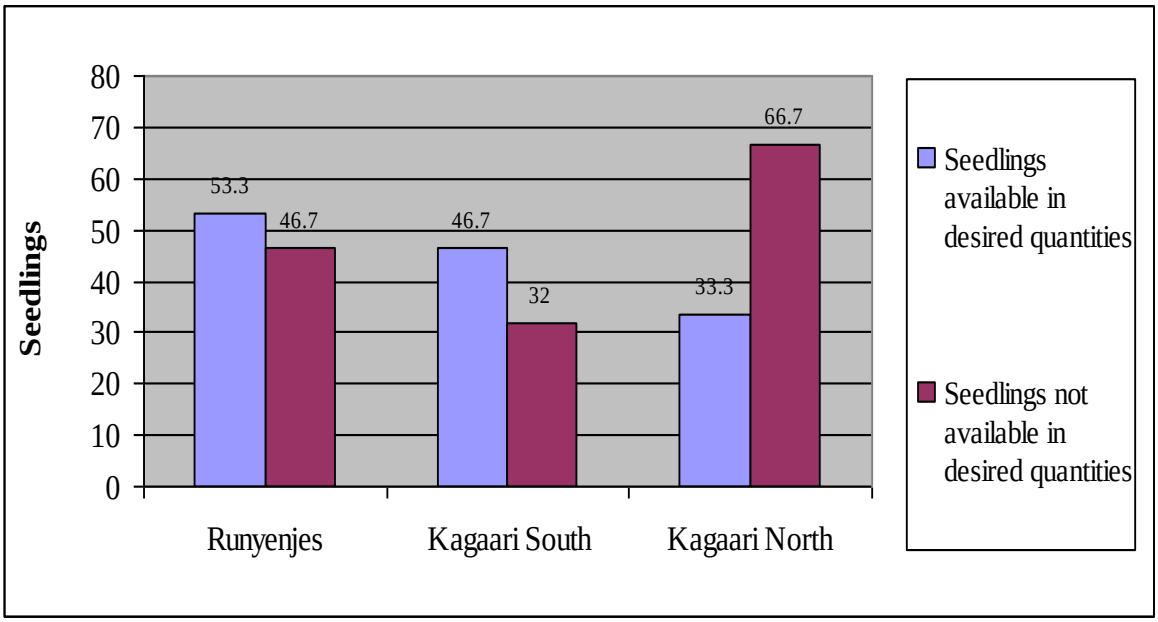

Figure 4 Availability of tree seeds and seedlings in Runyenjes Division, Embu District

4.12.3 Compatibility with Other Crops

About eleven percent of the respondents indicated that some indigenous trees are incompatible with crops (Table 4.16). As reported earlier, the most common planting technology in the study area was intercropping of trees and other crops on the same land unit. For a farmer to reap maximum benefits from the trees and other crop components, the trees should not act as a hindrance to higher farm output but should rather improve farmer's output from the parcel of land. In this regard *Bredellia micrantha* though preferred by farmers has heavy shading as reported by the farmers. Simbaya (2004) stated that in Zambia the major characteristics of fodder trees grown on arable land included their compatibility potential with food crops, growth rates and promotion of soil fertility. Lengkeek *et. al*. (2005) also reported the choice of tree planted by farmers in Meru Central District, Kenya depended on factors such as species compatibility with crops, duration to harvesting and the value of end products. Carsan and Holding (2006) argued that although it is true that trees compete with other crops as all crops do anyway planting of crops including tree crops in any farming system involves a trade off and concluded that farmers weigh the benefits of species and pick the species that is conceived to be more beneficial.

4.12.4 Small Land Units

Some respondents (6.7%) indicated small land sizes as the main reason for not planting indigenous trees. As reported earlier in Table 4.3, 39.4 percent of the respondents had a land size of between one and three acres and some respondents therefore believed that this size of land was not adequate for both crop production and tree growing. Similar observations were made by Wanjiku et al. (2004) in Ndeiya, Kiambu District where some farmers were not expanding tree planting quoting small

land units as the cause. Simons *et al.* (2000) and Lengkeek *et al. (*2005) reported that the choice of tree species to plant usually varies with individual farmer tree knowledge, interest and land size. The availability of land was reported by Zubair and Garforth (2005) as a major encouraging factor contributing toward the performance of on farm tree growing in Pakistan. They indicated that farmers considered trees as crops of marginal or barren land due to a number of discouraging factors (market unavailability, lack of nurseries and the long-term nature of farm forestry as an enterprise) in the performance of farm forestry. The competition between farm forestry and agriculture was reported to assume importance if both compete for the same land: if good agricultural land was put under farm forestry, then obviously crop production would be adversely affected (Sharma et al. 1995). This suggests a need to concentrate more on short-rotation multipurpose tree species rather than long-rotation tree species especially when availability of productive land is a constraint and farming is more directed toward subsistence level. Similarly Simons et al. (2000) reported that "devising more systematic tree designs and careful species selection could therefore reduce the perception of tree growing as long term business by taking farmland for tree planting as utilized for the agricultural purposes."

4.12.5 Survival Rate of Planted Seedlings

The results depicted in Table 4.16 show that 9.4 percent of the respondents indicated poor survival counts of planted seedlings as a constraint towards successful indigenous tree planting. It can be deduced that the poor survival rate is as a result of low quality germplasm used since when seedlings are unavailable as already shown farmers will have no choice of quality seedlings but to accept and plant whatever is available in the tree nurseries. Moenga (2005) reported that low survival rate of planted seedlings was one of the obstacles of on farm tree planting in Hombe area in

Nyeri District and also stated that the success of a tree planting programme was determined not only by the number of tree seedlings planted but also by the number planted and surviving.

4.12.6 Seed Germination Rates

Poor seed germination was reported by 5% of the respondents as a constraint to indigenous tree planting (Table 4.16). High quality seeds determine to a large extent the success of any tree planting programme especially in cases where no other means of tree propagation are known or have been developed. Respondents from the institutions engaged in raising tree seedlings also reported to be constrained in their efforts in raising indigenous trees by poor germination rates.

4.12.7 Knowledge on Economic Value of Indigenous Trees

Results displayed in Table 4.16 indicated that in the study area, the economic potential of indigenous trees is yet to be realized as perceived by some farmers (6.7%). This could be due to the current restriction by government on indigenous tree harvesting on farms and the general shortage of indigenous trees at farm level.

Generally, one may not perceive the economic value of a tree unless one gets monetary benefits from its sale. Results from this study reveal that 46.7 percent of the farmers had not sold trees from their farms (Table 4.17). Indeed Carsan and Holding, (2006) reported that where tree benefits are perceived, little effort is required to get farmers to invest in tree planting for the steadily growing timber market that resulted after the ban on timber harvesting from government forests. For those who had sold trees from their farms, 95% reported selling *Grevillea robusta* while only 3.3 % of respondents reported having sold indigenous trees (Table 4.18).

Indigenous trees species that farmers reported to have sold included *Vitex keniensis, Cordia abyssinica, Neutonia buchananii, Bredellia micrantha* and *Ficus sycomorus.*

Table 4.17 Farmers Who Had Sold Trees from Farms in Runyenjes Division, Embu District

Number of farmers	**Number of farmers**	**%**
Number that have sold trees	96	53.3
Number that have not sold trees	84	46.7
Total	**180**	**100.0**

Table 4.18 Tree Species Sold by sampled Farmers in Runyenjes Division, Embu District

Trees sold	**Number of farmers**	**%**
Grevillea robusta	91	95.0
Indigenous trees	3	3.3
Exotic and indigenous	2	1.7
Total	**96**	**100.0**

4.12.8 Weather

Survival and growth rate of planted trees to maturity depends to a large extent on the weather conditions especially the amount of rainfall where irrigation facilities are not available. Nine percent of the respondents in the study area indicated unfavourable weather conditions as a constraint towards indigenous tree planting. This was mostly experienced in Kagaari South location where rainfall received is lower compared to other parts of the district. Wanjiku et al. (2004) reported that the low survival of planted tree seedlings in Karai location, Kiambu District was attributed to drought

experienced in the area and recommended planting of drought tolerant tree species as well as promotion of water harvesting techniques to improve on farm tree growing.

4.12.9 Tree Characteristics

The data in Table 4.9 indicates that most farmers in the study area plant trees to produce timber. A tree with good timber production characteristics is of crucial importance when considering choice of trees to plant. Some farmers (3.9%) reported inappropriate boles of some indigenous trees as a hindrance towards their planting on farms (Table 4.16). Alexander (2003) stated that in the Philippines the major characteristics of timber tree species preferred by the smallholder farming communities included good wood quality, tall, straight stem, wide market and resistance to diseases. Other characteristics mentioned were ability of a tree to have a variety of uses such as timber, medicine, firewood, soil erosion control, landscape beautification, high price of wood in the market and adaptability in the locality. Lengkeek *et.al* (2004) also argued that tree species characteristics: such as agro ecological requirements (soil, climate), seasonal productivity, efficient use of farm niches as well as ability to create micro environments on the farm, duration to harvest time, and diversity between and within species characteristics so that not all species need services or provide produce at the same time were crucial in determining the type of trees a farmer planted.

4.12.10 Livestock Damage

As indicated in Table 4.16, some of the respondents (1.7%) reported browsing by livestock as a hindrance towards indigenous trees planting. Mwai (2000) reported that, in Trans-Nzoia District, livestock damage to planted trees was a major cause of low tree survival rates at farmlands. In Chepareria Division of West Pokot District,

Kenya, it was reported by Kiage (1998) that the major hindrance to tree establishment and growth on farmlands was livestock damage. It was also reported by Carle (2007) that the factors that significantly predicted farm level tree planting were availability of barren land, lack of markets, lack of nurseries, and damage caused by animals and humans.

4.12.11 Damage by Pests and Diseases

Some farmers (5.6%) reported that planting of indigenous trees was constrained by pest damage (Table 4.16). The damage ranges from seeds to planted seedlings. Termites' damage to planted seedlings in the fields was most common in cotton/tobacco ecological zone. Carle (2007) concluded that many smallholder tree growers in developing countries were uniquely vulnerable to technical difficulties in tree growing including weak technical knowledge and information on protection against diseases and pests. Zubair and Garforth (2006) indicated that farmers in Pakistan saw hindrance in agricultural operations and the harbouring of insects pests and diseases as negative impacts of tree planting.

4.12.12 Government Policy and Legislation

Table 4.19 Level of Awareness for the Need for a Cut/ Harvesting Permit for Trees on Farms in Runyenjes Division, Embu

Condition	Number of farmers	%
Aware	47	26.1
Not aware	133	73.9
Total	**180**	**100.0**

Data gathered (Table 4.19) indicates that one is required to have a permit before cutting trees at the farm with a lot of emphasis on indigenous trees. A permit is also

required to transport the wood products from farms to the markets. Indeed 26.1 percent of the respondents indicated their awareness of this requirement as shown in Table 4.19. The regulation being first a disincentive is worsened by the fact that, it is not implemented by the lead agency on forestry issues with 74.9 percent of those aware of this requirement indicating that they get the permits to cut trees on their farms from the provincial administration while 25.1% indicated that they get them from the forester (Table 4.20 The role of government should be essentially to promote sustainable environmental management and development. Promotion of indigenous tree planting at farm level has been a government's endeavour to increase indigenous tree cover on farm and forest land (MENR, 2004). The current restriction of harvesting indigenous trees by farmers on their farms could act as a disincentive towards indigenous tree planting since farmers do not feel motivated to plant trees which they have no control over its use. (Nawir et al. (2007) reported that in Indonesia, a clear policy framework and supportive local regulations in line with local community initiatives have been key to successful smallholder farm forestry.

Table 4.20 Government offices issuing tree harvesting permits at farm level in Runyenjes Division, Embu District

Government office	Number of farmers	%
Chief	35	74.9
Forester	12	25.1
Total	**47**	**100.0**

4.13 Conservation Measures

The data collected shows that there are a number of stakeholders in the study area that are involved in conservation activities through tree seedling production (Table 4.21).

The stakeholders doing conservation include: Kenya Forest Service, tea companies, tobacco companies, churches, various institutions, groups and individuals. The results in Table 4.21 show that the bulk of seedlings produced by Kenya Forest Service are exotic tree species (67.7%).

The seedlings raised by Kenya Forest Service are planted in government forests and public land while some are sold to farmers for on farm tree planting. Data gathered as shown in Table 4.21 indicated that organized groups were raising indigenous tree seedlings in large quantities (68%) and these seedlings are planted on farm lands. The results also show that there are institutions that are involved in tree seedling production and raising mostly exotic tree species. These institutions included the Kenya Agricultural Research Institute, Ministry of Agriculture, tea and tobacco companies.

Table 4.21 Number of Seedlings Produced and Distributed by Various Stakeholders in Embu District

Name of institution	Number of exotic tree seedlings	% of exotic tree seedlings	Number of indigenous tree seedlings	% of indigenous tree seedlings	Total number of seedlings
KFS	178015	67.7	84885	32.3	272900
Groups	224,230	32	476483	68	700683
Institutions	70,215	100	0	0.0	70215
Churches	300	100	0	0.0	300
Large farms	33950	96.7	1145	3.3	35095
Companies	218395	99	2002	1.0	220397
Individuals	214071	83.0	43531	17	257602
Total					

Information gathered in the study area indicated that there were various measures that were being undertaken by different institutions to conserve indigenous tree species (Table 4.22). Kenya Forestry Service (KFS) for example whose mandate is to contribute to the growth of the natural resources sector by enhancing development conservation and management of forests in Kenya has established a farm forestry and extension branch. The branch core functions are promotion of the tree planting outside gazetted forests and provision of extension services. KFS advocates for planting of indigenous trees on farm lands and conservation of the existing natural vegetation outside government forest. Indeed during launching of tree planting season which is done every year and highly publicized only indigenous trees are planted (MENR, 2006).In Pakistan,Zubair and Garforth (2005) reported that farm forestry was identified as a feasible solution to the problem of low proportion of forested land and continuing degradation of existing forest cover.

In the study area, KFS through support of African Development Bank (ADB) has put in measures to promote indigenous trees planting. The Green Zone Development Support Project that is funded by ADB has one of her output as promotion of tree planting among the resource poor farmers in Embu (Republic of Kenya, 2005).

This is expected to be achieved through on farm tree planting, wood lots establishment on farms, watershed protection and hill top rehabilitation with a lot of emphasis on use of indigenous tree species. The programme has also training component whose output is sensitizing the communities on the need of conserving the existing natural vegetation and this is done through an intensive participation approach with the farmers and is commonly referred to as farmers' field school, (ADB, 2005).

Information gathered also revealed that Ministry of Agriculture undertakes natural vegetation conservation measures. Indeed one of the Ministry of Agriculture's strategic objectives is to promote conservation of the environment and natural resources through sustainable land use practices (Ministry of Agriculture, 2006). The ministry through her National Agriculture and Livestock Extension Project (NALEP) target an area commonly referred to as the focal area where farmers are trained and encouraged to practice on farm tree planting and establish tree nurseries as an income generating activity among the farmers' groups, youth and schools. Awards are usually given to best conserved area, outstanding groups and individuals. Indigenous trees are particularly emphasized (Table 4.22).

Table 4.22 Types of Tree Conservation Activities by different institutions in Runyenjes Division, Embu District

Institution	Tree Conservation Activities
Kenya Forest Service	Raising indigenous tree seedlings Control of harvesting of trees on farms Offering technical advise on tree management
Ministry of Agriculture Service	Soil conservation measures through tree planting Giving incentives to best practices in environmental conservation
Kenya Agricultural Research Institute	Research in natural resource management
Kenya Forestry Research Institute	Development of improved tree species. Designing improved tree management strategies. Promoting sustainable tree germplasm production and distribution strategies.
Green Belt Movement	Awareness creation on indigenous tree conservation Support to tree planting activities on communal and public land

Kenya Forestry Research Institute (KEFRI) undertakes research activities in the district that are related to natural resource conservation. Forestry research activities reported in the study area included the following: developing improved tree species, increasing the range of priority species, designing improved management strategies that will increase overall tree productivity and associated crop components and

promoting sustainable tree germplasm production and distribution systems (KEFRI, 2005). Research findings from the research institution are used in the district to enhance crop production and conservation of natural resources including soil, water and trees on farmlands.

It was also reported that the Green Belt Movement, a Non-Governmental Organization (NGO) was actively involved in the promotion of indigenous tree planting and conservation in the district (Table 4.22).

The Green Belt Movement (GBM) is a civil society organization for women, advocating for human rights and supporting good governance and peaceful democratic change through the protection of the environment. The organization addresses the challenges of deforestation, soil erosion and lack of water by advocating for and training women to plant trees. According to Green Belt Movement, this activity empowers women by making them environmental champions and by providing them with income-generating activities. The tree planting activities are also supported by civic education and networking. Green Belt Movement was started in 1977 by Dr. Wangari Maathai, the first African woman and the first environmentalist to receive the Nobel Peace Prize in 2004. The NGO supports youth and women groups and encourage them to engage in seedling production as an income generating activity. The NGO also contribute to indigenous tree conservation through support of tree planting on communal lands, schools in addition to advocacy campaigns detailing importance of protecting and conserving Mt. Kenya forest reserve.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study revealed that farmers in Embu have adopted tree planting culture in significantly high proportions as over 80% of farmers interviewed showed that they had planted trees. Farmers have engaged in tree planting activities in pursuit of their livelihood goals for income generation, household food security, energy generation and environmental conservation. Economic consideration is a major driving force in determining the kinds of trees farmers are planting.

The choice of trees planted by farmers depended to a large extent on the expected product or service from the planted trees For instance, most farmers planted trees for livelihood support. The study revealed that most farmers' expectation is to be supplied with tree seedling species that could provide them with timber, fuel wood, posts and fruits as first, second, third and fourth priority in this order. However a significantly high percentage of farmers in the southern part of the district prefer fruit trees for commercial enterprise.

The study revealed that though the dominant tree species on farm lands was *Grevillea robusta*, there was a changing scenario and farmers were embracing tree diversification by incorporating high value indigenous species in their planting programmes. A significant high percentage (82%) of farmers was willing to plant indigenous trees on their farms. The indigenous trees preferred included *Vitex keniensis* (77.7%), *Cordia abyssinica* (57.5%) for provision of high value timber, *Bredellia micrantha* (40%), *Combretum molle* (7.2%), *Mussaenda microdonta*

(11.1%) for fuel wood and durable posts while *Prunus africana* was preferred by 55.5% of the farmers for provision of medicine.

The study revealed no adverse change on the status of tree resources on farmlands. Indeed the results indicated that the status of the major trees on the land had improved in the last five years despite the increased rate of harvesting of trees on farm upon slapping of ban on harvesting timber from all government forests in 1999. The situation was the same for indigenous tree species commonly found on farmlands such as the *Vitex keniensis, Cordia abyssinica and Bredellia micrantha*. Owing to unavailability of tree seedlings, farmers were heavily relying on wildings from their farms, neighbours' farms and forest as source of germplasm. While this may serve to reduce the tree seedlings shortage in short term, the quality of the planted trees may not be guaranteed and possibility of genetic erosion is quite high.

The tree planting technology adopted by farmers is determined by the size and use of land by a particular farmer so as to make optimum use of the same. The small land units have made farmers mix trees with other crops on the same piece of land without any definite pattern in most cases. Boundary tree planting was however the most common tree planting technology in the study area and this provided an extra tree planting niche and also acted as a boundary marker thus reducing farm boundary disputes amongst farmers.

Farmers in the district have realized the essence of high value indigenous trees and have therefore embraced tree diversification and indeed 82% of them were willing to plant high value indigenous trees.

Factors that were perceived to be influencing tree diversification at the farm level in the study area were numerous and included inadequate supply of appropriate and

quality germplasm (55.7%), the perception that indigenous trees are slow in growth (60%) and that they are not compatible with other crops (11.1%). Other factors influencing tree diversification at farm level in the study area were poor survival of indigenous trees planted (7.4%) and inadequate knowledge on the economic value of indigenous trees (6.7%). Further to this, tree diversification in the area was also perceived to be influenced by unfavourable weather conditions (9%), poor germination rates of sown seeds (5%), heavy branching of trees making them not ideal for timber production (3.7%), pests and diseases damage (5.6%) and animal damage (7%)

The main objective of government regulations and legislations on conservation is to enhance the conservation and sustainable use of forests and trees. However regulations introduced without adequate consultations and experimentation may sometimes become counter productive. The issuing of tree cutting permits on private farms was acting as a disincentive towards increased tree planting especially of the indigenous tree species. Indeed 8.3% of the respondents indicated government policy and legislation as factor that was hindering planting of indigenous trees as farmers feel constrained to plant trees that they will not have right over their harvesting. The study revealed that the Ministry of agriculture was doing better in sensitizing farmers in tree planting when compared with other government agencies. The study also revealed that there were a number of players involved in tree conservation activities including Kenya Forest Service, Ministry of Agriculture, Kenya Forestry Research Institute, Kenya Agricultural Research Institute and Green Belt Movement could therefore be relied on to carry out forest extension measures.

5.2 Recommendations

- The government should consider developing and implementing a tree germplasm policy in addition to improving supply chains for all tree seeds including those of indigenous tree species.

- Individual farmers and groups should be encouraged to establish tree nurseries as income generating enterprises and raise the preferred indigenous trees with the government playing a key role in the supply of seeds and offering of technical information on tree propagation and management.

- While many farmers perceived indigenous trees to be slow in growth there were a few who did not ascribe to this notion and appropriate government agencies including Kenya Forest Service should consider undertaking intensive campaigns to sensitize farmers on indigenous tree planting by giving appropriate and up to date information on growth rates and other qualities.

- The government may consider the relevance of issuing permits to farmers to cut trees on their farms.

- Since seminars, workshops, use of radio and television and pamphlets were revealed as the most appropriate tools of communicating with farmers on tree planting issues, those involved in on farm tree planting campaigns in the area are encouraged to use them.

- Farmers who are willing to plant indigenous trees should be supplied with appropriate germplasm of acceptable qualities and sufficient quantities.

- A tree domestication process for the preferred and appropriate indigenous tree should be initiated.

- Research institutions should initiate and develop improved tree propagation techniques for indigenous trees including use of biotechology

5.3 Area for further research

- A study on the impact of loss of indigenous trees at various ecological zones should be undertaken.
- There is need for research to enhance sustainable management and development of indigenous trees at farm level.
- Study on the propagation and supply of indigenous trees germplasm could be undertaken.

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APPENDIX I

FARMERS INTERVIEW QUESTIONNAIRE

Statement of Confidentiality

My name is Luke Maina Njuguna. I am a Kenyatta University student carrying out research for my Master of Environmental Studies degree. The information given through this questionnaire is confidential and purely for research purposes.

1. Date of interview …….....
2. Interview No. …….....
3. Name of enumerator …….....
4. Name of location …….....
5. Name of sub-location …….....
6. Name of the Respondent …….....

PART ONE: BACKGROUND INFORMATION

7. Relation in the family Father [ ] Mother [ ]
   Son [ ] Daughter [ ]
8. Gender of respondent Male [ ] Female [ ]
9. Marital status
   Single [ ] Married [ ]
   Divorced [ ] Widowed [ ]
   Other (**specify**) …….
10. Age (i) 20-30 [ ] (ii) 31-40 [ ] (iii) 41-50 [ ]
    (iv) 51-60 [ ] (v) Over 60 [ ]
11. Level of education
    No formal education [ ] Primary education [ ]
    Secondary education [ ] Tertiary level [ ]
12. Occupation ……..

Part Two: Land and Its Use

13. (a) Do you own any piece of land: Yes [ ] No [ ]
    (b) If yes, how much land do you own (in acres)?
14. How did you acquire your land?
    Inherited [ ] Rented [ ] Bought [ ]
    Others (**specify**) …….

15. What do you use your land for? Percentage of land use

Crop production	[ ]	[ ]
Tree planting	[ ]	[ ]
Animal production	[ ]	[ ]
Renting out	[ ]	[ ]

Other (**specify**) …….

16. What is the area under various crops

Name of the crop	**Percentage of land**

Part Three: Agro-Forestry Practices

17. Do you have trees on your farm? Yes/No. Please list them and their purpose as follows.

Name of tree species	**P/NR**	**Number**	**Uses**	**Status I /D / S**	**Where Planted**	**Rank 1/ 2 / 3**	**When planted**

Key **P-**Planted **NR**-Natural Regeneration

I-Increasing **D**-Decreasing **S-**Same as five years ago

1-Most important **2-**Important **3-**Least important

18 Where have you planted trees on the farm?

Where trees are planted	**Tree species (Names)**
Scattered trees in cropland	
Live fence	
Woody strips and hedge	
Woodlots/ block planting	
Wind break	
Boundary planting	

19. Which tree species do you prefer for the following uses in order of priority?

(a) Timber ----------

……

……

(b) Fuel-wood

……

……

(c) Fodder

……

……

(d) Poles/Posts

……

……

Medicine

……

……

(f) Food

……

……

(g) Beauty

……

……

(h) Bees forage.....

(i) Others (**specify**).....

20. If you were to plant trees today in your farm state in order of priority the trees you will plant based on product use**. For example (1) fodder (2) poles**

(1)..... (2)..... (3)..... (4)..... (5).....

21. In tree management activities who does the following

Activity	**Husband**	**Wife**	**Sons**	**Daughters**	**Hired labour**
Tree planting Tree pruning Thinning Tree sale					

21. Where do you obtain tree planting materials?

Buying tree seedlings from forest department [ ]

Given tree seedlings from forest department tree nursery [ ]

From household tree nursery [ ]

Collection of wildings [ ]

Given seeds /seedlings freely by an organization (NGOs, CBOs) [ ]

Given seeds / seedlings freely by neighbours [ ]

Collecting seeds myself from (1) forest [ ] (2) neighbours [ ] (3) my farm [ ]

22. Do you see any value in planting high value indigenous trees?

Yes [ ] No [ ]

22. Which indigenous tree species are you willing to plant and why?

Name of the indigenous tree	**Reason for planting**

23. From the following list tick the one that shows your source of information on tree planting?

Parents [ ] Radio and TV [ ]

Seminars/workshops/study tour [ ] Friends and relatives [ ]

Reading magazines [ ] Forest department [ ]

Pamphlets on tree planting [ ] Ministry of agriculture [ ]

Others (**specify**).....

24. Are the seeds and seedlings for the above mentioned species available in desired quantities? Yes [ ] No [ ]

25. What kind of tree species are not of your preference and why?

……

……

……

26. (a) Do you have these species in your farm? Yes [ ] No [ ]

(b) Why?

……

……

……

27. (a) Have you ever sold trees from your farm? Yes [ ] No [ ]

(b) If yes which species ……

……

……

28. (a) Do you need permit to harvest/cut trees planted/retained in your farm?

Yes [ ] No [ ]

(b) If yes who gives the permit? .....

29. Who in the household has tree tenure right?

Female adults	[ ]	Male adults	[ ]
Female and male adults	[ ]	Male adults and male children	[ ]
All family members	[ ]		

30. Which species are preferred by women/men and why?

Tree species			Reasons
Vernacular name	Scientific name	Gender prevalence male/female	

31. What do you consider as the main constraints to indigenous tree planting in your farm?

……

……...……

…….....

32. Rank them according to their relative importance

.....

.....

.....

33. What should be done in your opinion to overcome these constraints?

APPENDIX II

FIELD SURVEY QUESTIONNAIRE

Statement of Confidentiality

My name is Luke Maina Njuguna. I am a Kenyatta University student carrying out research for my Master of Environmental Studies degree. The information given through this questionnaire is confidential and purely for research purposes.

General Information

1. Date of interview ……..……
2. Interview No. ……..……
3. Organization/Department ……..……
4. Position ……..……..
5. Gender ……..……
6. Name of Respondent ……..……
7. What tree planting activities is your organization involved in?

   ……

   ……

   ……

8. (a) Does your organization have an outreach program/ project or study area to demonstrate the development activities in tree planting?

   Yes [ ] No [ ]

   (b) If the answer is yes, please state where and when started

   ……

   ……

   ……

   (a) Are there any NGOs or Community Based Organization (CBOS) you are aware of that are involved in any of the following activities? Promoting tree planting, energy conservation, soil and water conservation, etc)? Yes [ ] No [ ]

(b) If yes, please list (since 2001) as follows: (attach any useful references)

Organization	**Activities**	**Location**	**Year**	**Comments**
……..	……..	……	…….	……..
……..	……..	……	…….	……..
……..	……..	……	…….	……..

10. Does your organization see any value in using agro-forestry practices to promote planting, management, conservation and sustainable use of high value indigenous trees around homestead and in the rural areas?

Please state why

……

……

……

11. Are there any factors you are aware of that are constraining farmers particularly in the rural areas from planting indigenous trees? Yes [ ] No [ ]

Please state them in order of importance

……

……

……

12. Please suggest how you are addressing or would like to see the stated constraints addressed.

……

……

……

13. (a) Does your organization conduct intensive in-service courses, workshops, seminars or promotional events in tree planting for staff or other relevant, groups (teachers, farmers etc) at professional, technical and grassroots level?

Yes [ ] No [ ]

(b) Please state which important aspect of tree planting are covered or you would like them to be exposed to you

……

……

……

14. (a) are there any policy reforms in place or proposed by your organization that will ensure strong performance of tree planting among resource-poor farmers in the rural areas in Embu District? Yes [ ] No [ ]

(b) Please specify

……

……

……

15. In your opinion what do you consider as the major constraint towards indigenous trees planting and conservation:?

……

……

……

16. Suggest how the stated constraints can be addressed.

……

……

……

THANK YOU FOR YOUR CO-OPERATION