ABUNDANCE AND POTENTIAL USE OF *GREVILLEA ROBUSTA* IN THE WOOD CARVING INDUSTRY. A CASE OF EMBU DISTRICT, KENYA.

BY

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DECLARATION

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

_____ Date 10th April, 2003

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

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DEDICATION

To my Parents (Mr. & Mrs. Simeon Gathogo), husband and friend Humphrey Kisioh and daughters Maureen and Faith.

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DEFINITION OF TERMS

Wood carving:	Art of shaping statues, ornaments, furniture, and utensils out of wood by means of cutting tools, drills and abrasives.
Policy	Principles that govern actions directed towards given ends.
Nature forest:	A forest not subjected to significant anthropogenic disturbances resulting in severe alteration of the forest structure, composition, and physiognomy for the past 250 years
Natural forests:	Are God-made as opposed to man-made forests (plantations)
Forest	A forest is an ecological system dominated by trees and other woody vegetation, which are at least 10 meters tall and their crowns interlock.

Good woods	Woods that are good to carve and produce fine carvings; come from farmland or plantations, not from forests; are fast growing; are introduced in Kenya; have multiple uses; resprout easily and are common.
Deforestation	The conversion of forests to other land uses (both permanent and periodic) as well as the serious deterioration of the quantity and productivity of existing forests.
Agroforestry	Landuse system which enables the production of trees, crops and livestock on a given unit of land either in spatial arrangement or over time to maximize productivity and sustainability of the land.
Firewood:	Includes all parts of trees made up into bundles or loads, or cut up in a manner in which it is usual to cut wood for burning, and refuse wood

generally, but does not include sound straight timber logs or poles of any kind.

Agro-ecological zone (AEZ) A land resource mapping unit, defined in terms of climate, landform and soils, and/or land cover, and having a specific range of potentials and constraints for landuse.

ABSTRACT

Closed canopy forests cover about 2% of Kenya's total land area (Crafter, Awimbo and Broekhoven, 1997) with an annual deforestation rate of 54km^2 between 1980 and 1990, but rank high as one of the country's most important national assets. Presently, there is intense pressure on forests due to increased demand for land for alternative uses like farming and high demand for tree products in the growing economy. Today, the wood resource is in a critical state of overexploitation, particularly with respect to targeted tree species in the wood carving industry (Choge, 2000).

This study was carried out between September, 2000 and January 2002 to determine the abundance and potential use of *Grevillea robusta* in the wood carving industry. The main aim of the study was to investigate the potential contribution of *Grevillea robusta* towards alleviating the pressure on indigenous species in the wood carving industry. The specific objectives were to determine the volume, density and distribution of *G. robusta* in Embu district; to find out current and potential uses of *G. robusta* by farmers in Embu and to determine customer and consumer preference of wood used in carvings and the volume of *G. robusta* required by the carvers annually. Seven Agroecological zones (AEZ): Upper Midland 1 (UM1), Upper Midland 2 (UM2), Upper Midland 3 (UM3), Upper Midland 4 (UM4), Lower Highlands

(LH), Lower Midland (LM3), Lower Midland 4 (LM4) of Embu District, where, both indigenous and exotic tree species are grown were used for this study.

Both primary and secondary sources of data were used. A sample of two hundred and ten households in seven agroecological zones was drawn using random sampling technique. Data was collected by means of questionnaires, checklists and observation schedules. Tree heights and diameters were taken using a suunto hypsometer and a diameter tape respectively. Data was analyzed using descriptive and inferential statistics. Carvers and traders in the wood carving industry were also interviewed using checklists.

The results show that the highest number of Grevillea trees are found in UM3 this being 22% of the total number of Grevillea in the seven agroecological zones. The results further indicated that the forest department nurseries supplied the respondents with 24.3% of Grevillea seedlings. It was further found that 19% of farmers are not willing to sell their trees since they are used for soil conservation and household needs such as firewood, timber, construction and fodder. The farmers also have alternative sources of income such as the livestock. The study findings revealed a problem of lack of awareness of the option of using *Grevillea robusta* as a wood carving species

among most farmers and carvers. The rate of cutting of the trees per month varied among the respondents. Those who cut between 1-5 trees were 67%. This may have been as a result the ban on logging in the national forests and therefore middlemen were buying Grevillea for the timber industry. It is clear from the study that Grevillea has a medium potential as an alternative wood carving species and that carving of Grevillea wood is currently minimal. From the study not even one trader sold carvings made from this tree species.

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The study recommends moving the carving sites close to the farmers as this may encourage carvers to use Grevillea and also reduce on the transportation cost of the logs. This may be applicable when the carvers have a specific order on carvings made from Grevillea. There is need to create awareness among buyers on the need to buy carvings made from 'good wood' species such as Grevillea so as to conserve forests for the sake of biodiversity for future generations. Such interventions will enable the government to develop workable farm forestry policies and hence achieve the goal of protecting and conserving the natural indigenous hard woods.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Natural and plantation Forests cover a very small proportion of Kenya's total land area but they rank high as one of the country's most important national assets.

The thrust of Kenya's forest policy is to reserve land for forests, protect and conserve forest resources, and promote tree planting for private forestry (Republic of Kenya, 1997). The high and medium potential areas of Kenya are faced with the problem of rapid population increase that the natural resource base, particularly land, cannot sustain (Sayer and Whitemore, 1992).

There is an increased demand for land for settlement, and crop and livestock production (FAO 1991). Forests are therefore being cleared to provide land for such competing uses resulting in adverse effects on the environment.

Agroforestry is a probable solution to the problems in high and medium potential areas vis-à-vis the management of natural resources, particularly the reduced soil productivity, fuel wood and timber productivity on farmland thus reducing the need to clear natural forests for agricultural expansion and provide an alternative source of income to farmers. Therefore farmers in these areas have integrated tree

crops particularly *Grevillea robusta* into their farming systems, which is generally used for subsistence (Tyndall, 1996). This is seen with most farmers of Embu District.

Wood carving, a rural forest-based industry, relies on a limited range of indigenous hardwood tree species (Choge, 2000). These indigenous species have become scarce forcing carvers to harvest young trees. Concern over the depletion of hardwoods from natural forests and woodlands has brought about an alliance of carvers, community development organizations, concerned citizens, conservation groups, the forestry sector and traders in the carving industry. Jointly they aim at ensuring that wood for carving comes from sustainable supplies (UNESCO *et al.*, 2000).

The use of fast growing soft wood tree species is being encouraged as an alternative source of wood carving. One of the targeted fast growing exotic tree species is *G. robusta* whose abundance has not been quantified. The study will try to bridge this gap by using Embu District as the study area.

1.2 Statement of the Problem

Population growth is often regarded as the main driving force behind deforestation, but it is certainly not the only factor. It needs to be seen in relationship to past patterns of tree and resource exploitation (FAO, 1987). In

Kenya, many tourists visit souvenir shops and stalls that sell beautiful hardwood carvings made from muhugu 'mahogany' (*Bracylaena hulliensis)* or 'mpingo' ebony (*Dalbergia melanoxylon)*. These are the preferred wood carving species in Kenya (Emerton, 2000). Hardly anyone leaves these shops without either a carving of a spectacular African animal, which one saw on safari or a beautifully crafted article, such as salad spoons. Little do they know the history behind these carvings and the impact their purchase has on the last remaining forests of Kenya.

Kenya's export earnings from the wood carving industry are as high as Ksh.264 million per year (UNESCO *et al.*, 1999a). The Kenyan woodcarving industry has been expanding at a high rate both in volume and trade, number of people involved and the wood requirements. Today, the wood resource is in a critical state of overexploitation, particularly with respect to the targeted hard wood species in Kenya's indigenous forests.

About eighty thousand carvers are active in Kenya today (Choge, 2000). The wood carving industry utilizes 7,000 m^3 of wood every year with 50,000 trees felled every year to supply to carvers, this being equivalent to ten trees per hectare of natural closed canopy forest (Ombuga, 1995). The felling of these trees for carving alone poses a major conservation problem – degradation of forest habitat leading to loss of nesting sites and shelter for rare, forest-dependant animals. Selective harvesting of the preferred species has a severe impact on forest

structure and species composition and renders the populations of these species vulnerable as increasingly smaller immature trees are being cut.

The challenge Kenya now faces is that current demand for indigenous hardwoods far outstrips supply (UNESCO *et al.*, 1999b). In order to satisfy the current and future demand, efforts must therefore be made to manage and utilize forests on a sustainable basis. To reverse this trend of progressing forest degradation, there is need to promote the use of agroforestry species such as *G. robusta* as an alternative species to *Dalbergia melanoxylon* and Embu farmers have adopted Grevillea for inclusion in the farming system. It is accepted due to its qualities as a fast growing tree giving multiple benefits to the farmers. Farmers have not adopted it for qualities needed for wood carving yet it is not used for carving. This is what the study tries to address. The availability, volume and distribution of G. robusta have however not been determined. The study therefore sought to determine the availability of *G robusta* in terms of volume and distribution and the potential for its adoption as an alternative species in the carving industry.

1.3 Research Questions

1. Which are the tree species found in Embu District and which is preferred.
2. What is the abundance and size distribution of Grevillea in Embu District.
3. What are the current uses of Grevillea by the farmers in Embu
4. What is the consumer preference in terms of wood carvings.

1.4 Objectives of the Study

The aim of this study was to investigate the potential contribution of *G. robusta* towards alleviating the pressure on indigenous species in the wood carving industry in Kenya, with the ultimate aim of conserving natural forests.

Considering this broad objective, the study examined the following specific objectives:

1. To determine the volume, density and distribution of *Grevillea robusta* in Embu District.
2. To find out current and potential uses of *Grevillea robusta* by farmers in Embu District
3. To determine consumer preference of wood used in carvings
4. To determine the volume of *G. robusta* required by the carvers annually.

1.5. Assumptions

1. *Grevillea robusta* as an alternative in the wood carving industry will reduce the current problem of wood scarcity for carving.

1.6 Justification of the Study

In the study area, Embu District of Kenya many households practice agroforestry, which holds considerable potential as a major land management alternative for conserving forests and maintaining soil fertility.

The Kenyan wood carving industry is expanding at a high rate in terms of volume of trade, number of people involved and carving wood requirements. This has led to over exploitation of preferred indigenous tree species. The slow growth rates of indigenous wood carving species offers limited incentives to wood carvers who are increasingly faced with a resource shortage. The carvers are however aware of this threat to their livelihoods (UNESCO *et al.,* 1999a). *Grevillea* can be harvested with minimal ecological impact and its increased use will generate extra income to the farmers. The species has been well adopted by farmers in Embu District, where it is present on 96 percent of the farms within the Coffee and Tea zones (Tyndall, 1996) and therefore offers important opportunities for improving and sustaining productivity while maintaining environmental stability.

The wood structure of *Grevillea robusta* has 75% similarity with that of *Dalbergia melanoxylon* which is indigenous and a preferred species for carving (KEFRI, 1999). *G. robusta* may therefore substitute *Dalbergia melanoxylon* in the wood carving industry. If *G. robusta* is accepted in the carving industry, then this can relieve the pressure from the declining and already over-exploited indigenous carving species. Further more carvers are willing to use alternative wood carving species as has been demonstrated in the use of *Azadiratcha indica* (neem) in Malindi Kenya.

The study aims to demonstrate the viability of cultivation as an alternative to harvesting from the wild, with emphasis on the possibility of sourcing carving wood from on-farm plantations to alleviate resource shortage. Past studies have not addressed abundance and potential uses of *G. robusta* in the carving industry. Careful planning and action now has the potential to yield a bountiful harvest in future, inaction may lead to disaster.

1.7 Significance of the Study

The research findings will be important to carvers who are faced with wood shortage as it might offer an alternative to the most sought wood carving species. Farmers in the area of study will also benefit as they may generate extra income from the sale of trees to wood carvers. The environment will also be conserved. This is because the findings will encourage use of alternative species in the carving industry by inclusion in farm forestry, as opposed to the depletion of the natural indigenous forest resource while searching for a few species.

Wider adoption and use of *G. robusta* in the carving industry may create additional employment in terms of labour on farms where *G. robusta* is grown and in transportation. Middlemen may also be interested in the trade. This will contribute to poverty alleviation as people may find additional income generating activity.

Policy makers and resource managers could also benefit from this study in that the right policies aimed at promoting wood carving in the tourist industry would be made. Resource managers would know how best to conserve the existing Grevillea among other trees for sustainability.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The most important source of indigenous timber in Kenya is Mount Kenya because of its central location. Timber from Mount Kenya ends up in markets in Nanyuki, Meru, Embu and Nairobi, which has the largest market (Choge, 2000). Recent research by Choge (2000) and Mugo (1997) points to an increasing scarcity of indigenous hardwoods in Kenya. The supply of good wood (quality timber) has generally not been a major problem for timber users but most have realized that stocks are becoming depleted and that in future availability of certain species will be insufficient (Marshal, 1995). Removal or felling of marketable trees, which are generally large emergents causes considerable damage to other layers of the forest - an emergent tree of more than 2.5 m girth will destroy around 0.02 hectares on falling (Johns, 1992). According to Kaudia (1990), the use of trees in farming systems has been considered a viable intervention for realizing not only increased yield but diversified sustainable production of wood products. Agroforestry has been opted by many farmers.

According to USAID (2002), tomorrow's forests will be everywhere- in farmer's fields, fallows, on roadsides, in compounds and on hill sides and

degraded lands, these will be dynamic forests which target these areas. Agroforestry forms an integral part of the livelihood strategies of Embu farmers. The incentives for tree planting are derived from household needs. The basic needs consist of building materials, fodder, fruits and fuelwood whereas farmers' interest for cash income is secondary (Tyndall, 1996). This should however, not obscure the vital importance of other tree products to rural people. Agricultural implements, bullock carts and boats are often crafted out of wood. Certain varieties of wood with qualities for tool-making are highly valued. The other use of trees include that of water storage using hollow trunks (Owino, 1992), and camel bells (FAO, 1987). The combination of inter-related – high population density, small land holdings, scarcity of tree products and land demarcation means households are forced to produce more tree products on farms. As a result, trees are planted and wildlings are transplanted or protected such that farmlands contain a complex diversity of tree species for different purposes. These trees on farms can substitute for the indigenous hardwoods currently used in the wood carving industry.

2.2 Deforestation

The World Watch Institute (2002) reported that the world's natural forests continued to be converted to other land uses at a very high rate. An estimated 4.2% of the forest cover that stood in 1990 had disappeared by the end of the

decade. The report further estimates that 161 million hectares of natural forest were lost during the decade of which 152 million hectares were in the tropics. According to UNCED (1992), deforestation is a result of many causes; some natural, but a majority due to human development, such as inappropriate land tenure systems, lack of incentives, expansion of agricultural land, increasing forest product demand and lack of information and understanding on the value of forests. Matiru, (2000) and Wass, (1995) indicated that forest loss proceeds from obvious immediate causes such as uncontrolled clearing for settlement, farming to meet the needs of rapidly growing populations to the demand for tradable products, excessive timber extraction and increasing charcoal production. Not all loss is illegal or unregulated. Even demarcated forests (reserves) may be subject to revocation. The latter has been marked in Kenya where 400,000 hectares of prime forest estate had been degazetted for private farming and other interests (Mbaya and Wily, 2001). However, according to Sayer and Whitmore (1992), mankind has been destroying forests for millenia, ever since the discovery of agriculture.

Kenya has meager forest resources. The total area of forest reserve land is 16,910 Km^2 constituting only two percent of the nation's total area. Closed forests comprise 56% of the forest reserve land (Emerton, 2000). In Kenya, the forestry sector contributes significantly to national development. According to

Emerton (2000), indigenous forests in Kenya have a total of 200,000,000 m^3 standing timber volume, which if harvested sustainably, would yield wood products worth US$75 million every year. That is enough to supply all the domestic energy needs of 1.5 million households, build 100,000 houses and fill 80,000 trucks with logs. Kenya's forests generate more than $35million a year in tourist earnings, and environmental services estimated to be worth more than $50 million. Recent studies (Emerton, 2000), estimated that the presence of Mount Kenya forest alone saved the country's economy more than $20million a year through natural protection of the catchment of the Tana and Ewaso Ngiro rivers. It is therefore clear that forests play a key role in environmental amelioration and hence influence most aspects of human life. Some major sectors of the economy are also fostered by forestry. The industrial sector for instance utilizes forest products as raw materials. Presently, there is intense pressure on forest resources as a result of the increasing demand for land for alternative use and, a high demand for the products in the growing economy (Akotsi, *et. al*, 1997).

One of the non-timber forest products with an increasing demand is the wood for carvings. Today, the wood resource is in a critical state of over-exploitation, particularly with respect to the targeted wood species (Barraclough and Ghimire, 1995).

2.3 Carving in Kenya

According to Bentham (1978), trees are found almost everywhere in the world. Where they are scarce, they are considered precious. It is therefore not surprising that the shaping and carving of wood is one of the oldest human activities.

In Kenya, there are an estimated 80,000 active carvers. Their work feeds nearly half a million people in this country. The carvers depend on wood from natural forests, farms and bush land. Both wood supplies and number of buyers have decreased in recent years thus creating hardships for the Kenyan carvers and their families (UNESCO *et al.*, 1999a).

According to Choge (2000), Kenyan wood carvers are using more than fifty different tree species and consume some 17,500 m^3 of wood each year. In 1998, almost 85 % of the wood volume came from only three indigenous species: *Brachyleana hulliensis* (*muhuhu*/mahogany), *Dalbergia melanoxylon (mpingo*/African ebony), and *Olea europea* ssp. *Africana* (*mutamaiyo*/African olive). Slow growth but good quality wood characterizes these indigenous species. A study carried out by Obuga in 1995, revealed a general concern of the increasing scarcity of the prime carving timber. Several factors contribute

to this scarcity, including forest clearing for shambas, commercial woodcarving and selective harvesting. The preference for and selective harvesting of the species mentioned above has contributed to a serious decline of their populations in forests and woodlands throughout Kenya (Kigomo *et al.,* 1990, 1991; Kariuki and Mathooko 2000; Kirubi *et al.,* 2000). While the total wood volume used for woodcarving is smaller than that used for construction, charcoal making and firewood collection, the impact of woodcarving is great because of the species selective harvesting, suitability of a large variety of sizes suitable for carving and growth forms for this purpose. Ebony (*Dalbergia melanoxylon*), locally known as the mpingo, is a valuable African Blackwood. Fifty thousand ebony trees are cut down in Kenya every year mostly for carving (Saoshiro, 2001). There are only a few pockets of ebony forests left in Kenya, with slow and inadequate action in replanting of the tree. The situation is such that Kenya has to import ebony from Tanzania to meet the growing demand for the wood carving industry. The lack of infrastructure in Tanzania makes many of the trees in remote areas hard to access. Table 2.1 on the economic data on wood carving in Kenya and Tanzania below supports this information.

Table 2.1: Economic data on wood carving in Kenya and Tanzania

ITEM	KENYA	TANZANIA
Industry output (earnings)	The wood carving	The wood for

	industry generates $20 million a year.	the instrument industry generates $1.5 million a year.
Trade in forest products	$30 million in exports and is 4 % of the nation's total exports.	$6 million in exports and is 40 % of the nation's total exports.
Employment	60,000-80,000 people are employed in the wood carving industry.	Data not available
Extraction rate	50,000 mpingo trees are felled each year.	Estimated 20,000-30,000 are felled each year.

Source: Saoshiro, 2001.

The slow growth rates of these species offer limited incentives to wood carvers who are increasingly faced with a resource shortage. One of the ways to solve this problem is the cultivation of a range of wood carving species (or multiple-use tree species) in mixed planting (agroforestry) (UNESCO *et al.*, 1999b). Cultivation of these species may be promoted using the good wood campaign. This is where large importers increasingly demand for carvings produced from a sustainable source. Only good woods can qualify as they originate from managed farms.

Good wood campaign aims at developing sustainable supplies of wood outside the natural forests. Good woods are wood species found on farmlands, are fast

growing, multipurpose and can be harvested sustainably. Species such as neem (Mwarobaini or *Azadirachta indica*), jacaranda (*Jacaranda mimosifolia*), grevillea (*G. robusta*) and mango (*Mangifera indica*) provide excellent alternatives to over-harvested indigenous species. By providing creative designs originating from environmentally friendly production, forests will be conserved and a future ensured to the carving industry (UNESCO *et al.*, 1999a).

Currently, about 40 % of the carvers in Kenya are organized in six co-operative societies located in Wamuyu and Makindu in Ukambani, Gikomba in Nairobi, Mombasa and Malindi on the Coast, and Nanyuki near Mount Kenya. Sixty percent of the carvers are not in any organized groups. They carve individually (UNESCO *et al.*, 1999b).

2.4 The Tree Grevillea

There are about 250 species in the genus grevillea (family proteacea), most of which are endemic to Australia. *G. robusta* , the largest in the genus. The specific epithet is derived from the Latin robustus- hard, strong, robust, in reference to the size of this species in a genus where many species are shrubs. It has no recognized subspecies or varieties, and no hybrids with other species have been recorded (McGillivray and Makinson, 1993).

G. robusta is commonly known as "grevillea" or "silky oak" and is conspicuous in landscapes of many countries in all the continents where it is grown as an exotic. This species is native to subtropical eastern Australia where it currently exists in scattered small stands in southern Queensland and New South Wales.

Grevillea is the farmers first choice for agroforestry in Embu District of Kenya (Harwood, 1992; Tyndall, 1996). It is grown from around 850 to 2500 m above sea level in the 900 to 1500 mm annual rainfall range. When grown under sub-optimal conditions, it suffers from termite damage and drought stress (Ling, 1993). The tree grows on a variety of soils except clay soil and tolerates heavy pruning of its roots and branches. It can grow well in low-rainfall areas as well as montane zones. Grevillea is preferred for inclusion in agroforestry systems because of its quick growth rate, production of timber, poles, leaf mulch, firewood and fodder and also because of its positive effects on the growth of crops. Furthermore it is grown as an ornamental tree on the farms and in urban areas (Sagwal, 1984; Harwood, 1992; Van Duij, 1998).

According to Ling (1993), planting of *G. robusta* has been found to be a good investment for the farmer, as it produces good returns from timber and fuel wood after twenty years. For example the crop yield loss margin is low.

When planted in woodlots and line plantings, thinning of inferior trees is often carried out at the age of around four to five years to yield poles and firewood for local use or sale. Farmers in the Kenyan highlands commonly harvest branches by high pruning and pollarding every three to four years from age four to six years onwards (Poulsen,1983; Spiers and Stewart, 1992). Intercropping agricultural crops with *G. robusta* gives a significant soil conservation effect. On farm fuel wood production improves the working conditions for women, as it makes fuel collection easier. Time is saved which could have otherwise been used in search of firewood and placed into more economical activities.

G. robusta is a popular agroforestry tree in Kenya where it grows well in many parts of the country, from the drylands of Kitui to the highlands of Nandi and Embu (ICRAF, 1992; Tyndal, 1996). It also does well in the Lake Basin area (Tyndal, 1996). On the farm, *Grevillea* is placed along boundaries on soil conservation structures, while in cropland it is grown together with food crops or coffee. *Grevillea* is also grown in wood lots, but is then susceptible to diseases; a sign that *Grevillea* is a tree suited for integration with crops rather than in pure forest tree stands (Ministry of Agriculture, 1991; Mwangi and Paterson, 1996).

The supply of the two main products of Grevillea, namely timber and firewood can be sustainably produced, although farmers are not fully aware of the commercial possibilities of this species and need to be informed about it (Ling, 1993). Other products of this tree include veneer (plywood), tool handles, fodder (leaves), bee forage, ornamental, tannery, and paper pulp (Sagwal, 1984). It is possible to obtain knot free pieces of wood that make good furniture from this species (Aloo, 1995). According to Raju (1992), *G. robusta's* wood is hard, light (0.5 – 0.7 tonners per cubic meter), reddish brown, elastic and durable. On seasoning, it can be used for ornamental panelling, parquet floors, toys, bobbins, and veneering. *G. robusta* has attributes that make it suitable in the carving industry. These include moderately coarse texture, moderately heavy wood density of 0.61 g/cm^3 density, moderately strong with a modulus of structure (MOR) of 60 Mega Pascals (Mpa), crushing strength of 36 Mpa, moderately durable but prone to weevil attack, easy to saw and season, colour is light golden brown and heartwood is pinkish and Janka hardness is 3.7 Kilo Newtons (KN) (KEFRI, 1999).

2.4.1 Comparison between Grevillea robusta and Dalbergia melanoxylon

Dalbergia melanoxylon (African Blackwood) which is the most preferred hardwood carving species, is a small tree found in semi-arid Africa and India. In Kenya, it is found in low altitude savannah or woodland, 0 to 1300 m above

sea level, around Kitui down to the coast (Marshal, 1995). It is used for wood carving (Kamba, Makonde), cabinets, musical instruments, walking sticks, construction, fuel, medicine (bark, roots, leaves), fodder, mulch, green manure and for improving soil fertility through nitrogen fixation. The wood is very hard, durable, termite resistant and has a purple-black heartwood which is very valuable and used for carvings (ICRAF, 1992).

Dalbergia melanoxylon's comparable wood characteristics with *Grevillea robusta* include easy to saw, tans and polishes very well, usually seasoned as logs, sapwood is yellow, white and narrow; heartwood is brownish yellow and not uniform in colour; gross grains and fine structure; heavy texture 1.3 g/cm^3 and Janka hardness of 18 KN (KEFRI, 1999).

Good woods that have been used for carvings are those that are good to carve and produce fine carvings, come from farmland or plantations, not from forests, fast growing, introduced to Kenya, have multiple uses, resprout easily, and are common. (UNESCO *et al.* 1999a). *G. robusta* is therefore classified as a good wood and is economically important in many countries, particularly in Africa and South Asia. Grevillea was first introduced as a shade tree for tea and coffee plantations. This use has declined over the last few decades but still remains significant in many countries. Meanwhile, farmers in Embu have

developed a new role for the species as a multi-purpose tree for small mixed farms (Booth and Harwood, 1992).

Grevillea robusta became popular in East Africa from around 1910. Since 1970s, forestry policies and practices worldwide have shifted attention from supplying wood to meet industrial demand to that of meeting peoples' needs. From the 1970s, Kenya's Forest Policy has been re-directed to address the issues of tree planting at the farm level to meet the demand for wood and tree products for local use (Ongugo, 1992).

Little has been done on the potential use of *G. robusta* as a wood carving species (Choge, 2000; UNESCO *et al.*1999a). Tyndal (1996) cites woodfuel as the major use of *G. robusta*. Other uses indicated by Harwood (1992) include timber, fuelwood, poles, windbreak, fodder and soil erosion control. Wood carving has not been cited as a use. Although KEFRI (1999) looks at the characteristics of *G. robusta* in relation to wood carving, its adoption by carvers has not been studied. The amount or abundance of Grevillea that could be used in the wood carving industry at present has received relatively less attention. The study aims to fill these gaps.

2.5 Policy Implications on Wood Utilization

Kenyan policies and legislation have weaknesses, which have led to uncontrolled access to the indigenous forest in search of wood for carving. This has resulted into irreparable degradation of the natural environment and ultimately represents a significant threat to the people who depend on natural resources for their survival (Choge, 2000). Regulation of forest legislation is hampered by mistrust between communities living near the forest and the forest guards of who collect bribes. The Forest Department lacks funds to run efficiently and implement such legislation.

Land in Kenya is subject to various state laws and policies, which may have a direct impact on the use and conservation of forests. The forestry legislation in Kenya is fairly comprehensive but is spread over various acts, which are administered without co-ordination by a wide range of public bodies and individuals due to the numerous pieces of legislation. These Acts include Forest Act, Timber Act, Wildlife Act, Chief's Authority Act, Land Acts, Agriculture Act, Water Act and the Environmental Management and Coordination Act.

2.5.1 National Forest Policy

The first forest policy was written in 1957. It was revised after independence in 1968. It has since been revised to address new issues related to the management of indigenous forests. The 1968 policy focused on catchment protection and timber production with government control of the sector. The new forest policy is broader and maintains the important functions of environmental protection and supply of forest products on a sustainable basis. There is generally less emphasis on government control of the forestry sector.

2.5.2 The Forests Act

The Forest Act cap. 385 of 1962 (Revised 1982 and 1992), was originally drafted to support the 1957 forest policy. It allows for the gazettement of forest areas on state land, control and regulation of their use. It covers:

- Alteration, de-gazettement and gazettement of Forest Reserve boundaries;
- Issuing of licenses for various forms of forest use, and setting royalties and fees under the Forests (General) rules;
- Gazettement of and regulations for Nature Reserves;
- Prohibition of various activities in forest areas;
- Procedures for enforcing the Act and Penalties for breaches; and
- Rules for regulating the sale and disposal of forest produce; other use, and occupation of forests; licensing and entry to forests

The Forests Act has proved deficient in various ways: It covers only gazetted forest reserves; there are inadequate consultative procedures during the process of excision; and it often does not adequately cover the needs of local communities leading to conflicts which may result in forest degradation or loss of forest area. The Act does not recognise the importance of forests for environmental protection (Wass, 1995).

In practice it is evident that Kenya is losing its best natural forest at a rapid rate, and woodcarving has partly contributed to this. Public sensitivity to encroachment of forests has greatly increased and this has adversely affected the wood supply to the carvers (Choge, 2000).

2.5.3 The Timber Act

The Timber Act , Cap.386 of 1972 provides for control of the sale and export of timber by means of grading, inspection and marking, and provides for the control of timber in transit. In practice the procedures required by the Act are often not followed. The export of unprocessed indigenous timber is currently banned by a Presidential Decree (Wass, 1995). During the 2001 Budget, import of timber was zero-rated (no importation tax charged) in order to protect the forest (reduce deforestation). This was a good move but it has been

seen as belated because the forests have already been cleared and the preferred wood for carving is depleted.

2.5.4 The Wildlife (Conservation and Management) Act.

The Wildlife Act, Cap. 376 of 1976 (1989 and 2000 Amendment), closely interacts with the Forest Act. It includes the conservation of forests within National parks, National Reserves and Sanctuaries. More recently (2000), the custody of indigenous forests have been transferred to the Kenya Wildlife Service. This was due to poor management of these forests by the Forest Department. This implies that less wood will be available to carvers due to close protection of these forests (Choge, 2000), hence use of on farm trees like *G. robusta* will be necessary.

2.5.5 Chiefs' Authority Act.

The Chief's Authority Act, Cap. 128 of 1970 (Revised 1988) empowers Chiefs to enforce various environmental conservation provisions within the local limits of their jurisdictions, including controlling use of tree resources on private land. Of relevance to forests are powers for prohibition of vegetation destruction, regulating the cutting of timber and prohibiting the wasteful destruction of trees, control of grass fires, and prohibiting/restricting grazing. Others include ordering the execution of work or services for the conservation

of natural resources and empowering the Minister to remove member(s) of a tribe or community who have land reserved for them, if they unlawfully occupy or cultivate any land other than the reserved land (Wass, 1995)

This is probably the most widely applicable Act that farmers and carving resource owners know. Each time a tree is to be removed (usually more than three or four trees), permission has to be sought from the local Chief. However, due to the low penalties, violation of this Act is very common (Choge, 2000).

2.5.6 Trust Land Act, Land Adjudication Act and Land (Group Representatives) Act

The Trust Land Act, Cap.288 of 1962 (revised 1970), The Land Adjudication Act, Cap.284 of 1968 (revised 1977) and The land (Group Representatives) Act, Cap. 287 of 1968 (revised 1988) are inter-connected. The Trust Land Act makes provision for rights in Trust Land and controls the unauthorized occupation of land. Of particular relevance to forestry is that it also provides legislation covering general conservation, and protection or controlled utilization of trees and other forest produce on land other than the forest areas under the Forest Act. The Land Adjudication Act and Land (Group Representatives) Act deal with the ascertainment and recording of rights and

interests on Trust Land. They are implemented by the Minister for Local Government and stipulates that the minister can make rules for the protection, felling and removal of trees or forest produce or minerals from Trust Lands.

The Government therefore has a right to change forest landuse to other uses that might not favour conservation. This would mean that forests and biodiversity would be affected in cases where the government would wish to clear the trees for development of industries.

2.5.7 The Agriculture Act

The Agriculture Act, Cap.318 of 1980 (revised 1986), has special relevance to indigenous forest conservation such as the provisions within the Agriculture Act for soil conservation by preventing the destruction of vegetation. It gives authority to Provincial Agricultural Boards and District Agricultural Committees and Sub-committees to enforce land preservation rules which can control the clearing of land for cultivation and other destruction of vegetation, or require the afforestation or re-afforestation of land, in order to protect the soil. It covers, for example, the harvesting of *G. robusta* from private farms if this is deemed destructive. However, this Act is generally unclear and rarely put into practice. Agriculture Act infers that unproductive land is regarded as idle land regardless of any unique quality natural vegetation. This view is

rather outdated and no longer compatible with the current principles of sustainable use of natural resources.

2.5.8 The Water Act

The Water Act, Cap. 372 of 1962 (revised in 1972) stipulates that the minister, after consultation with the water Resources Authority, may declare an area to be a protected catchment area and may, by order, require, regulate or prohibit the doing by any person in such protected area of any act which he considers necessary for the protection of such area.

2.5.9 The Environmental Management and Coordination Act

The Environmental Management and Coordination Act of 1999, takes care of the protection and conservation of the environment. In relation to forestry, through the District Environmental committees reaforestation and afforestation of hill tops, hill slopes and mountainous areas is given emphasis. This Act protects the forest in that it stipulates that no action shall be taken in respect of any forest or mountain areas, which is prejudicial to the traditional interests of the local communities customarily resident within or around such forest or mountain area. The act further promotes the use of renewable sources of energy by taking measures to encourage the planting of trees and woodlots by individual land users, institutions and by community groups. (Republic of Kenya, 2000).

Despite the consistency with which all these policies and Acts focus on forest conservation, there is very little to show on the ground. Forest lands and biodiversity are disappearing rapidly largely as a result of government actions such as forest excisions and it is becoming clear that a lot needs to be done to meet the objectives of the existing policies. Growing of agroforestry species on private land would be the best alternative to the Government's action and therefore help in meeting the growing demand for wood products.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Size

Embu District is one of the thirteen districts that make up Eastern Province. The other districts include Isiolo, Kitui, Makueni, Machakos, Marsabit, Mbeere, Meru Central, Moyale, Mwingi, Meru North, Tharaka and Nithi. Embu District borders it to the east and southeast, Kirinyaga District to the west, and Tharaka Nithi to the north (Figure 3.1). It lies approximately between latitudes $0^0 8$ and $0^0 35$ South and longitudes $37^0 19$ and $37^0 42$ East. The District occupies a total area of 708 square kilometers, which is sub-divided into five administrative divisions as shown in the table below.

Table 3.1 Area of the district by division

Division	Area in Km^2
Manyatta	208
Runyenjes	186
Nembure	111
Kyeni	139
Central	64
TOTAL	**708**

Source: Republic of Kenya, 1996

Manyatta Division is the largest with an area of about 208 Km^2, followed by Runyenjes, Kyeni and Nembure. Central Division is the smallest of all. Forests occupy about 30 % of the district's area. This is attributed to the fact that a section of Mt. Kenya forest falls within Embu.

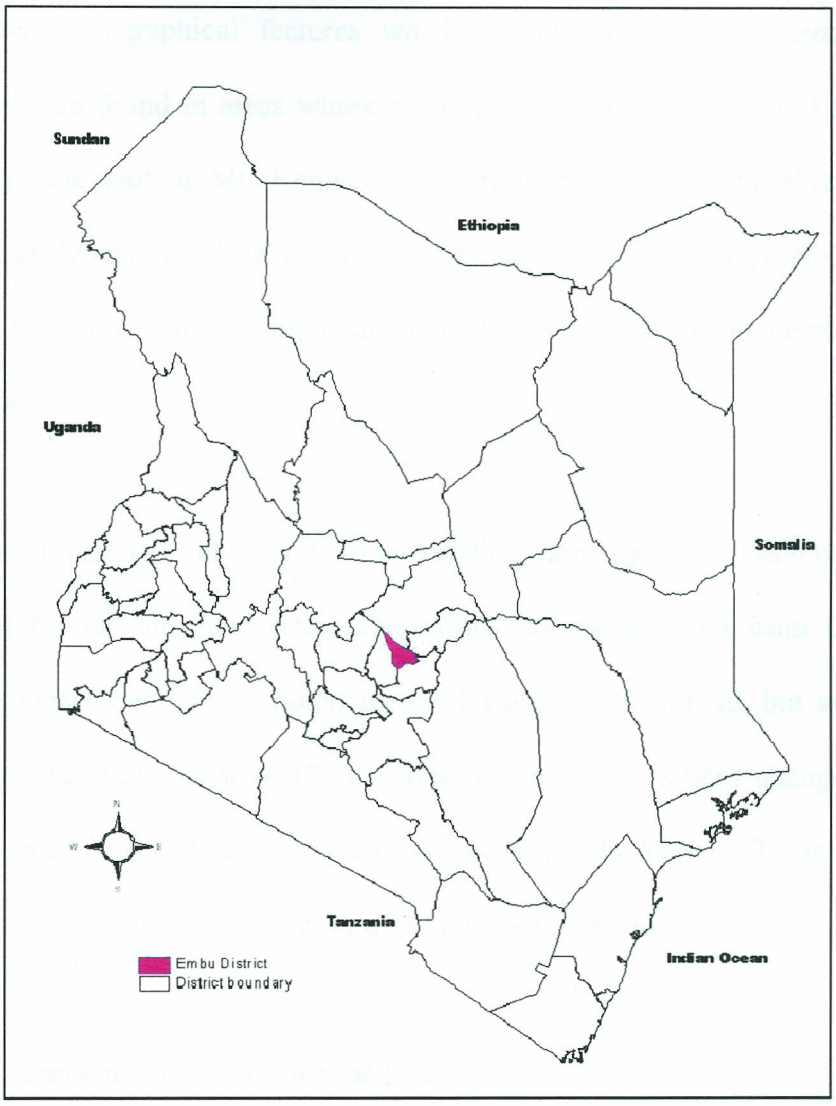

Figure 3.1: Map of Kenya showing location of Embu District. (Source:Republic of Kenya, 1996).

3.1.2 Topography and Climate

Being one of the districts that form part of Kenya's eastern highlands, the landscape of Embu District is characterized by typical highlands and midlands and other topographical features which include hills and valleys. The highlands are found in areas whose altitudes range from about 1500 to 4500 metres at the foot of Mt. Kenya and cover parts of Manyatta, Kyeni, and Runyenjes Divisions. The midlands dominate most areas of Nembure and Central Divisions with an altitudinal range of 1200 to about 1500 metres above sea level.

The rainfall pattern is bimodal with two distinct rainy seasons. Long rains fall between March and June while short rains are experienced from October through December. The amount received varies with altitude, but averages 1495 mm per year. Above 1700 metres however, the pattern changes with altitude to a tri- modal pattern which has a peak in July/August. Temperatures in the district range from a minimum of 12^0C to a maximum of 27.1^0C.

3.1.3 Administrative and Political Units

The District is divided into 5 divisions, 14 location and 52 sub-locations as shown in Table 3.2 and Figure 3.2.

Table 3.2:Administrative Units by Divisions.

Division	No. of Locations	No. of Sub-Locations
Manyatta	3	12
Runyenjes	3	13
Nembure	3	10
Kyeni	3	10
Central	2	7
Total	14	52

Source: Republic of Kenya, 1996.

The administrative boundaries of Embu District are shown in Figure 3.2

3.1.4 Population Size and Distribution

According to the 1999 population census, the district had a total population of 277,000 of which 136,000 were males and 141,000 were females (CBS, 2000). Table 3.3 shows population density of the small farm sector by division.

Table 3.3:Population density of the small farm sector by division.

Division	Area (sq. Km)	Farm Area (sq. Km)	Rural House-hold	House hold Per sq. Km
Manyatta	208	90	8,401	93
Runyenjes	186	140	10,534	75
Nembure	111	105	8,167	78
Kyeni	139	97	7,238	75
Central	64	64	9,415	147
Total	**708**	**496**	**10,534**	**468**

Source: Republic of Kenya, 1996.

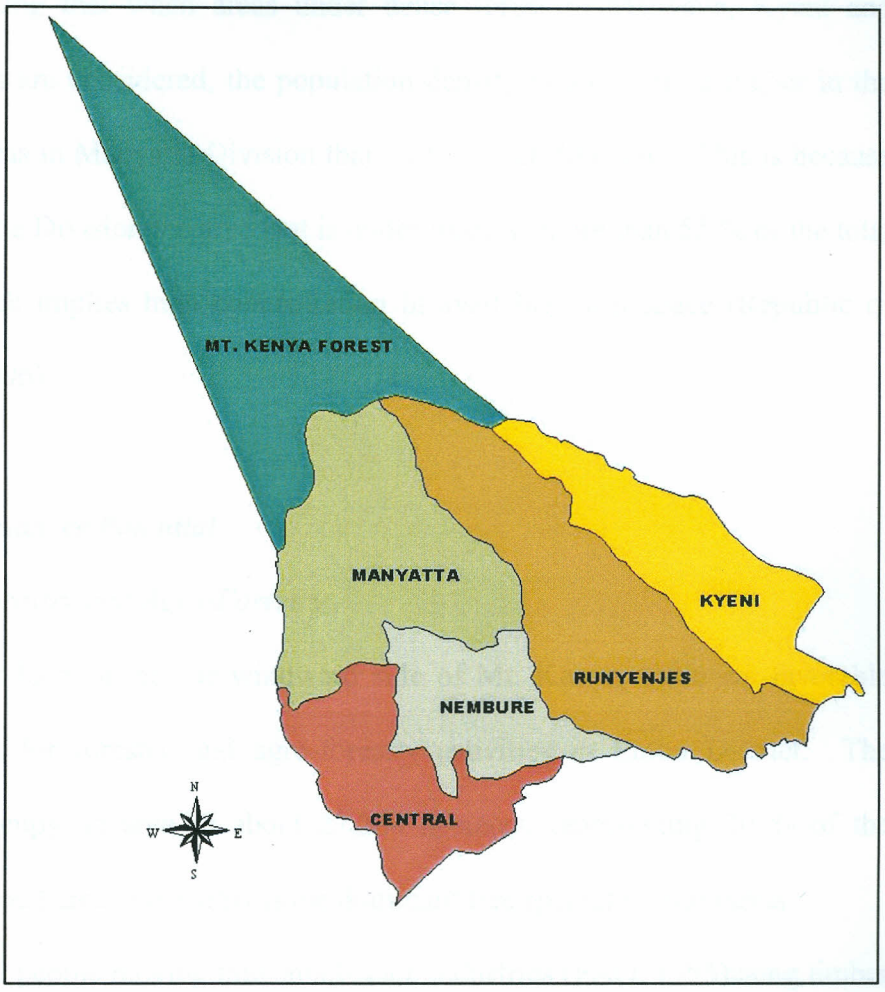

Figure 3.2: Map showing Embu District Administrative Boundaries (Source: Republic of Kenya, 1996.)

The population density is higher in Central Division than in all the other divisions, largely due to its small size and status as the provincial and district headquarters. Manyatta Division has the least population density, but it is worth noting that when areas under dense forest in Manyatta, Kyeni and Runyenjes are considered, the population density might well be higher in the settled areas in Manyatta Division than in the other divisions. This is because in Manyatta Division the area that is under forest is more than 55 % of the total area, which implies high concentration in available farm space (Republic of Kenya, 1996).

3.1.5 Resource Potential

3.1.5.1 Forestry and Agro-Forestry

Due to its location on the windward side of Mt. Kenya, there are favorable conditions for forestry and agro-forestry activities in Embu District. The forests occupy an area of about 22,264 hectares, representing 30 % of the district's total area. *Grevillea* is the dominant tree species on the farms.

With more people moving into small-scale industries (FAO, 1995)using timber as raw material, there is an increasing demand for forest resources; and since there is a ban on indigenous hard woods, there has also been an increasing demand for exotic tree species.

3.1.5.2 Land and Soils

As shown in Table 3.4 and Figure 3.3, the District has an agro-ecological profile that is typical of the windward side of Mt. Kenya. It has eight agro-ecological zones. These exclude the Tropical Alpine (TA) at the top of Mt. Kenya, which has no economic activities, and the upper highland zone, where forestry is the main land use. The zones include Lower Highlands (LH), Lower Highland 1 (LH1), Upper Midlands (UM), Upper Midlands II (UM2), Upper Midlands III (UM3), Upper Midlands IV (UM4), Lower Midlands III (LM3) and Lower Midlands IV (LM4).

Table 3.4: Agro-Ecological Zones and Soil Types

Zone	**Soil Type**	**Divisions Covered**	**Altitude (m)**
LH, LH1	Home Andosols and	Part of Manyatta	1770 –
UM, UM2	Citric Nitosols	Nembure and Runyenjes	1590
UM3, UM4	Nitochodic and	Kyeni, Nembure	1280 -
LM3, LM4	Orthic Ferrasols	And Central	1220

Source: Republic of Kenya, 1996.

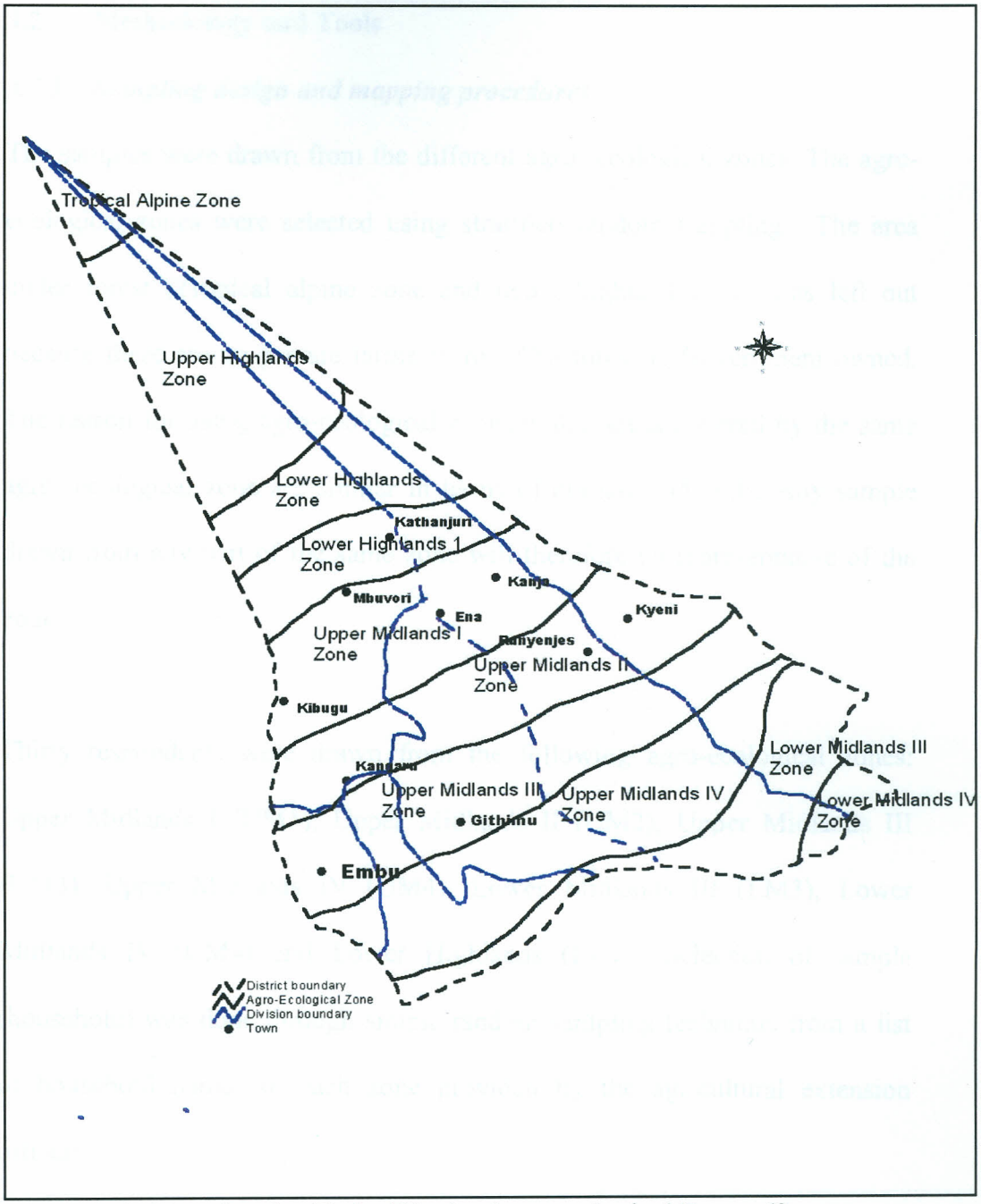

Figure 3.3: Map showing Embu District Agro-ecological Zones. (Source: Jaetzold and Schmidt, 1983)

3.2 Methodology and Tools

3.2.1 Sampling design and mapping procedures

The samples were drawn from the different agro- ecological zones. The agro-ecological zones were selected using stratified random sampling. The area under forest (Tropical alpine zone and upper highland zone) was left out because there are no private farms there. The forest is Government owned. The reason for using agro-ecological zones is that areas covered by the same agro- ecological zone are similar in terms of climate and soils. Any sample drawn from any part of the same zone will therefore be representative of the zone.

Thirty respondents were drawn from the following agro-ecological zones: Upper Midlands I (UM1), Upper Midlands II (UM2), Upper Midlands III (UM3), Upper Midlands IV (UM4), Lower Midlands III (LM3), Lower Midlands IV (UM4) and Lower Highlands (LH). Selection of sample (household) was done through simple random sampling technique from a list of household names in each zone provided by the agricultural extension officers.

Data was collected from farmers as shown in table 3.5

Table 3.5: Data Collection Areas

AEZ	Division	Location	Sub-location	Farmers
UM1	Nembure	Makengi	Kevote	30
UM2	Runyenjes	Township	Gichiche	30
UM3	Kyeni	Kyeni (S)	Lower Kathanjuri	15
	Central	Mbeti (S)	Karurina	15
UM4	Runyenjes	Kagaari (S)	Gicera	30
LM3	Nembure	Kithimu	Kithegi	30
LM4	Kyeni	Karurumo	Kasafari	30
LH	Manyatta	Nginda	Kibugu	30

NB: S=South

The total number of farmers interviewed was two hundred and ten. Validity of the list was confirmed by site visits.

A set of fifteen extra names was generated by simple random sampling from the target agro-ecological zones. These names served as replacements in case the chosen farmer had no *Grevillea* on the farm or was not present for interviews even after giving two call back cards (Appendix 1)

3.2.2 Methods of Data Collection

Both primary and secondary sources of data were used. Before any survey work began, permission to carry out the survey was sought from the Ministry of Education, Science and Technology at the District as well as the local community level.

3.2.3 Instruments of Primary Data

Main survey instruments for primary data collection included Structured questionnaires, observation schedules, checklists, key Informant interviews (Babbie, 1992).

3.2.3.1 Questionnaires

Structured questionnaires were used for individual farmers. These had both open and closed ended questions (Appendix 3). They were used to collect information from farmers regarding the use and sale of *G. robusta*. The farmers' perceptions on potential uses of this species were also sought. Socio-economic information such as age, land size and ownership, head of household was also collected. The questionnaires were administered by the researcher and three assistants.

The questionnaire was pre-tested on ten farmers to make sure that all the topics were adequately covered, relevant and phrased correctly. Necessary changes were made before the research work began. The questions were asked in the local dialect and therefore, the assistants were trained before administering the questionnaires so that the questions were correctly interpreted. In case a farmer was not found in the homestead, a call back card was issued. If not

found a second time then the farmer was replaced by a different one in the reserve list.

3.2.3.2 Observation schedules

Observation schedules were guided by a prepared checklist of things to observe and points which needed to be noted. Information sought by this method included tree spacing and evident tree management practices (Appendix 2). The observation schedule was expected to yield information which when combined with measurement could be compared to verify the truth that would supplement information from households and resource persons. The spacing, for example, together with the tree basal area, was expected to give the density of the trees on the farms.

3.2.3.3 Interviews

The interviews were semi-structured and comprised a checklist which outlined the topics which were to be discussed. Interviews eliminated bias of the respondents due to other peoples' views and expectations. These interviews were conducted among carvers and consumers or customers in the wood carving industry. Key informants who carve *Grevillea* wood were drawn using the snowball sample \ effect (Babbie, 1992). In this case a Grevillea carver

identifies another carver who uses Grevillea whom the researcher then interviews.

It was expected that through use of interviews, valid information on the current use, market and potential use of *G. robusta* would be determined. Checklists were used to find out the preference of farmers in terms of selling *G. robusta* to carvers and timber agents. In addition, checklists were used to find out the ranking order in terms of wood carving species among traders.

3.2.3.4 Tree measurements.

Ten percent of Grevillea trees per sampling unit (household) were sampled. A diameter tape was used for diameter measurements. The Suunto hypsometer was used to determine the merchantable height of the individual trees. A linear tape was also used to determine the distance between the observer and the object (tree). These measurements gave the basal area and hence volume of trees. The numbers of trees present were counted and their age recorded. Age of the trees was captured by use of the questionnaire. The number of trees was used to calculate the abundance or density of *G. robusta* in Embu. This was used in determining total volume of wood that may be available to the wood carving industry.

Basal area was used to calculate volume. This was chosen as the test statistic as Kenya lacks comprehensive volume tables. Precision in terms of basal area is effective in giving accurate volume (Alder, 1992).

The volume of Grevillea was estimated from the calculation of individual Grevillea trees that were sampled. The volume of each standing tree was calculated using the following formula:

$V = ghf$ Where:

V= volume (m^3) , g= basal area $\frac{(22.7\pi d^2)}{4}$ m^3 , h= height (metres) , f= form factor (0.44) (Philip, 1994).

3.3 Sources of secondary Data

Sources of secondary data were mainly from relevant books, and articles published in journals and magazines.

3.4 Data Analysis

Data collected from the field was coded and analyzed using the Statistical Package for Social Sciences (SPSS) for Windows Version 6.1.4. Both descriptive and inferential statistics were used to analyze data collected as described below. Results are represented in form of tables, graphs, maps and plates.

3.4.1 Descriptive analysis

Data collected from interviews (Appendix 4, 5 and 6) were analyzed using descriptive statistics. In addition descriptive statistics were undertaken in order to determine variation within and between agro-ecological zones for volume, density and dominant species.

3.4.2 Inferential statistics

The techniques used include Chi-square and Analysis of Variance (ANOVA). Chi-squared test cross tabulation was used to examine the stem count and volume of Grevillea in Embu. It was also used to examine responses on the use and pricing of Grevillea trees. The results were used to determine if there was a significant difference in the number of stems occurring in the different agro-ecological zones, prices expected from carving wood and timber, and in the sale and use by gender.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the study findings. The specific objectives of the study were to determine the volume, density and distribution of Grevillea in Embu District; to find out the potential and current uses of Grevillea by farmers of Embu and to determine customer and consumer preference of wood used for carvings and the volume required by the carvers annually. This chapter is divided into three sections. The first section discusses the presence and distribution of *Grevillea robusta* in Embu District. The second part deals with the farmers' use and marketing of Grevillea. The third part deals with utilization of Grevillea in the wood carving industry.

4.1.1 Household Characteristics

Household heads interviewed were between 21 and 60 years old. Those above 41 years were 69 %. Of this category, household heads above 60 years were the majority comprising 26 %. Majority of household heads were males who constituted 73 % while female heads formed 27 % only. In cases where females headed the household, the husbands had either died or had left for formal employment in the urban areas. Half of the respondents completed primary level of education while quarter had not received any formal education. Secondary level education and above constituted 25 %. From group discussions, it was

established that most educated people migrated to urban areas in pursuit of formal employment opportunities. The household socio-economic characteristics are summarized in Table 4.1 below.

Table 4.1: Household and land ownership characteristics

Variable	Number of households (n)	Percentage (%)
Age of household head		
< 20	1	1
21-30	34	16
31-40	29	14
41-50	46	22
51-60	44	21
> 60	56	26
Sex of household head		
Male	154	73
Female	56	27
Education level of household head		
None	51	25
Primary level	104	50
Secondary level	38	18
Certificate level	11	5
Diploma	3	1
University	3	1
Land ownership		
Private	205	98
Communal	5	2

4.1.2 Land Tenure

Land in Embu district is privately owned and the owners have title deeds. Almost all farmers (98%) got own land privately either through buying or inheritance while 2% were in communal land. Land leasing was not cited during discussions.

This makes adoption of tree planting easy because tree tenure is clear right from planting to harvesting of trees.

4.2 Presence and Distribution of *G. robusta* in Embu District.

4.2.1 Existing Agroforestry Species

Farmers in the study area have planted various agroforestry tree species on their farms as indicated in Figure 4.1 below.

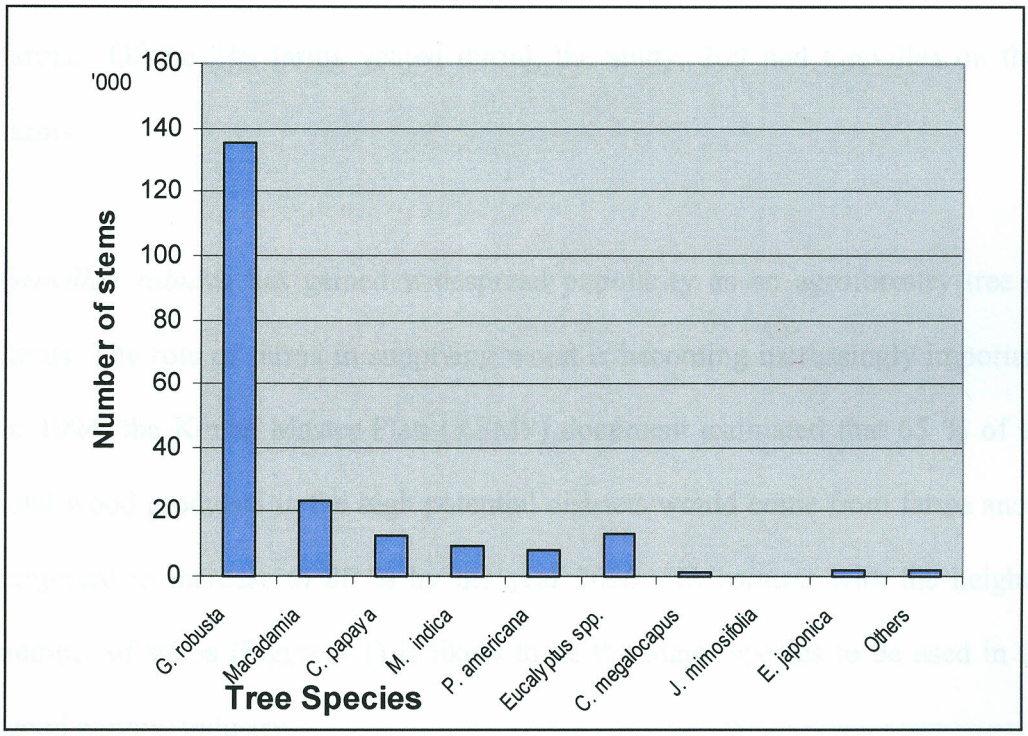

Figure 4.1: Total number of tree species found in sampled area.

During data collection, the presence of various agroforestry trees was noted through observation. Figure 4.1 shows that Grevillea has the highest number of stems (13,546). Macadamia trees were 2341 and *Carica papaya* stems were 1245. Jacaranda trees were only 13. Timber trees include Grevillea, Eucalyptus and Jacaranda. The rest of the trees (*Carica papaya, Mangifera indica, Persea americana* and *Eriobothrya japonica*) are fruit trees. Macadamia is grown for its nuts and Croton is used as a shade tree. A list of common tree species is found in Appendix 7. This qualifies *G. robusta* to be the dominant species grown on most farms. Of the 210 farms visited during the study, 209 had Grevillea on their farms.

Grevillea robusta has gained widespread popularity as an agroforestry tree on farms. The role of farms in supplying wood is becoming increasingly important. In 1994, the Kenya Master Plan (KFMP) document estimated that 65 % of the total wood produced in the high potential districts would come from farms and is projected to increase to 80 % by the year 2020. *G. robusta* with the heighest number of stems (Figure 4.1) is likely to be the major species to be used in the wood carving industry.

Ongugo (1992), had other reasons which tend to favour the growth of Grevillea on farms. The first is that the rapid increase in both humans and livestock requires more wood and fodder. The second reason is the reduction of good land for

agriculture due to the population increase and sub division of farms. This requires that available land is used more intensively and that only those tree species, which are more compatible with various agricultural crops and management systems, can be planted. The third factor is that since forest land can not be expanded, the planting will be carried out on farms to meet demand for fuelwood and timber.

From the study, respondents gave various reasons for tree growing including fuelwood, timber, and for sale. This is because there is demand for these products due to the growing population.

The lower (arid) areas tend to have more timber trees compared to the upper (wetter) areas that have more fruit trees. Fruit trees are more rewarding in terms of fruits for sale and home consumption. All the agro-ecological zones of Embu district have grevillea trees as shown in figure 4.2.

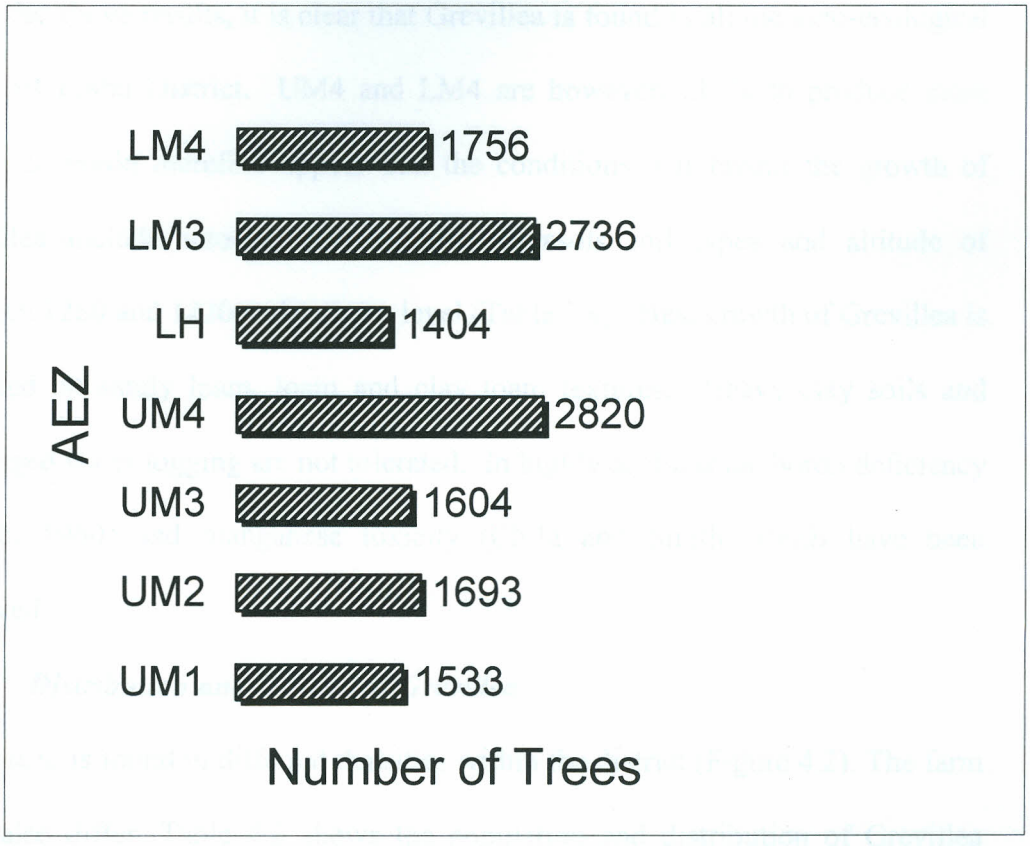

Figure 4.2: Distribution of Grevillea trees according to agroeclological zones in Embu District.

Figures 4.2 shows that the highest numbers of *Grevillea* trees (2820 or 22 %) are found in UM4. This is closely followed by LM3 with 2736 trees, which is equivalent to 20 % of the total trees counted. The least number of trees was 1404 (10 %) found in LH, the driest part of Embu District.

From the above results, it is clear that Grevillea is found in all the agro-ecological zones of Embu District. UM4 and LM4 are however, likely to produce more trees. It would therefore appear that the conditions that favour the growth of Grevillea include nitochodic and orthic ferrasols soil types and altitude of between 1280 and 1220m above sea level (Table 3.4). Best growth of Grevillea is obtained on sandy loam, loam and clay loam textures. Heavy clay soils and prolonged water logging are not tolerated. In highly acidic soils, boron deficiency (Smith, 1960) and manganese toxicity (Child and Smith, 1960) have been observed.

4.2.2 Distribution and Density of Grevillea

G. robusta is found in different densities within the district (Figure 4.2). The farm sizes also differ. Table 4.2 shows the population and distribution of Grevillea trees in the areas sampled.

Table 4.2 Density of *G. robusta*

AEZ	Area (Ha)	No. Of Trees in The Farms Visited	Density (Trees/Ha.)
UM1	79.9	1756	22
UM2	38.5	1693	44
UM3	41.2	1604	39
UM4	46.1	2820	61
LH	22.7	1404	62
LM3	40.6	2736	67
LM4	32.2	1533	48

The table above gives an average density of 49 trees per hectare. The heighest density was in LM3 with 67 trees per hectare. This was followed by LH and UM4 with 62 and 61 stems per hectare respectively. Thijssen *et al.*, (1993) found an average 40 grevillea trees per hectare in the Embu coffee and tea zones (UM4). This makes *Grevillea robusta* a very important tree in the coffee and tea land use system in Embu District..

4.2.3 Estimated Tree Volume.

Tree volume was estimated from the DBH (diameter at breast height) and height of the trees. These trees were sampled from the farms that were visited in all the agro-ecological zones. UM2 had the highest tree volume while LM4 had the lowest tree volume (Table 4.3)

Table 4.3: Estimated Volume Distribution of *Grevillea robusta* by agroecological zones

AEZ	No. of trees sampled	Volume (m^3)	Volume (m^3)/tree
UM1	61	71	1.16
UM2	169	177	1.05
UM3	144	52	0.36
UM4	160	70	0.44
LH	50	43	0.86
LM3	153	65	0.42
LM4	179	35	0.20

The total number of trees sampled was 916 out of 13,546 counted. The sample gave a total volume of 513 m^3. This gives an average of 0.56 m^3 per tree. For the total trees counted, the volume was 7,585.76m^3. The mean volume per tree was calculated at 95 % confidence interval. This showed a significant difference in volume in the different agro-ecological zones (p=0.004). LM4 has the most number of trees yet the volume per tree is least. This difference stems from the DBH of the trees. The DBH classes are summarized in figure 4.3 and 4.4 below.

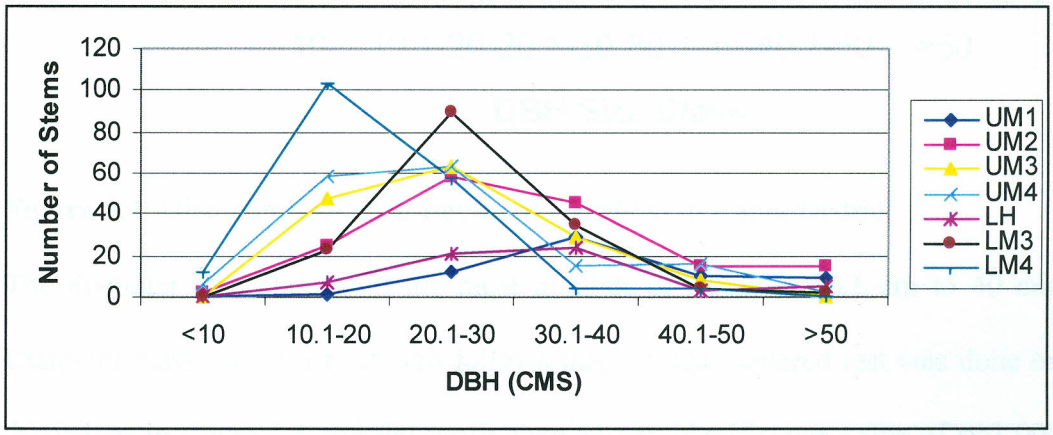

Figure 4.3: Comparison of DBH Distribution

From the above figure, UM2 has more stems between 20.1 and 40 DBH compared to LM4 with more stems between 10.1 and 20 DBH.

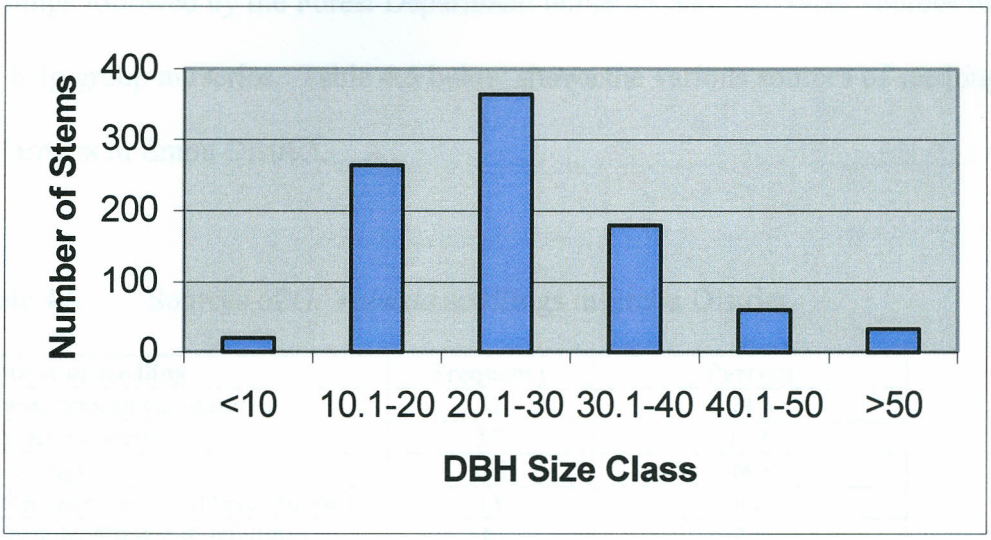

Figure 4.4: Diameter Size Distribution of *Grevillea* in Embu District

The diameter size class with the most number of stems is 20.1 cm to 40 cm. Diameter class 10.1 cm to 20 cm follows this. A chi- squared test was done on the values in figure 4.4 and the result showed non-significance value of p=1.000 in the variation of the same size classes in the agro-ecological zones. It is noted therefore that the performance of *Grevillea robusta* in Embu district in terms of growth does not vary greatly in respect to agroecological zones.

4.2.4 Reafforestation Efforts

Reafforestation is tree planting to increase the tree stock or to replace harvested trees outside the gazetted forests(FAO, 1991). Throughout Embu, it was observed that there was more *Grevillea robusta* compared to the other species. *G. robusta*

is readily established, through seed or wildlings and was grown in all but one nursery surveyed. The main source of seedlings planted by farmers was from wildlings followed by the Forest Department nurseries and then other sources like self help group nurseries. Table 4.5 below shows the various sources of seedlings for farmers in Embu District.

Table 4.5 Sources of *G. robusta* seedlings in Embu District.

Source of seedling	Frequency	Percent
Forest department nurseries	51	24.3
Private nurseries	37	17.6
Wildlings	101	48.1
Other nurseries (self help groups)	13	6.2
Forest department & wildlings	6	2.9
Total	208	100

The percentages were calculated on the basis of the total respondents. Forty eight percent of respondents get their seedlings from wildlings. These wildlings are either protected where they are found naturally growing or may be transplanted to desired sites such as on boundaries or woodlots. Forest Department nurseries supply respondents with 24.3 % seedlings. Private commercial nurseries supply 17.6 % of seedlings. The Forest Department is encouraging private nurseries since it has reduced the number of its own nurseries. Table 4.5 results indicate a good potential for the farmers to go on with the afforestation efforts because the wildlings are found free growing in the farms. The possible disadvantage with the wildlings is that the genetic base is very narrow (Harwood, 1992). The solution to this is for the farmers to identify plus trees (trees with superior qualities) from

where they can collect the seeds for raising in their own private nurseries. This would be a sure way of maintaining the sustainability of the grevillea stock for the wood carving industry.

Only two of the farmers visited had on-farm nurseries. The reason for most farmers not having nurseries was lack of water. In an effort to address the issue of water the farmers have organized self help groups that supply 6.2% of the seedlings. Farmers who are far from the urban centers will certainly benefit from such an arrangement. This arrangement would also ensure that all the farmers have an easy access to the planting stock. Table 4.6 shows the seedlings return (seedling report) for October 2000 for Embu District. These results were compiled from seedling returns found at the District Forest Office.

From the table below, it is evident that there are more exotic seedlings (311,109) in the nurseries compared to the indigenous ones (27,059). The reason was that exotic species are easier to propagate and are fast growing. This encourages farmers to grow the exotics because the returns are made within a short period. Table 4.6 shows that farmers in Embu have introduced exotic species that now out number the indigenous ones. This is a positive gesture to the wood carving industry because the farmers are already willing to continue growing Grevillea on their farms.

Table 4.6: Embu District seedling return for October 2000.

Exotic species

Division	Departmental	NGOs	Private	Institutions	Total
Manyatta	21,499	15,265	7,088	14,500	58,352
Runyenges	23,736	88,994	6,031	7,700	126,461
Kyeni	6,076	-	-	-	6,076
Nembure	5,738	57,240	27,780	-	90,758
Central	18,614	5,854	2,910	2,083	29,461
Sub Total	75,663	167,353	43,809	24,283	311,108

Indigenous Species

Manyatta	858	13	504	-	1,375
Runyenges	643	16,000	-	-	16,643
Kyeni	700	-	-	500	1,000
Nembure	99	270	70	172	611
Central	6,382	77	499	472	7430
Sub Total	8,682	16,360	1,073	944	27,059

The willingness to continue growing *Grevillea*, which is an exotic species, is shown in table 4.7 below.

Table 4.7: *G. robusta* seedling return for the month of October, 2000.

Division	**Forest Department**	**NGOs**	**Private**	**Institutions**	**Total**
Manyatta	8,707	-	100	85	8,892
Runyenges	6,061	62,000	1,500	1,200	70,761
Kyeni	3,300	-	-	3,410	6,710
Nembure	2,600	5,720	980	-	9,300
Central	2,990	400	840	-	4,230
Sub Total	23,658	68,120	3,420	4,695	99,893

The total number of *G. robusta* is 99,893. This is an equivalent of 29.5 % of the total seedling production and 32.1% of the exotic seedlings in the district. Non governmental nurseries produce the highest number of tree seedlings. The reason given for this is that resources are available to raise the seedlings unlike farmers who use the locally available resources to raise the seedlings (Plate 4.1). These organizations give the seedlings free of charge to the local communities. This is a sure gesture of intensification of tree planting in Embu district that may increase the available wood volume for use in the carving thereby taking off pressure from indigenous forests. However, for tree planting to be sustainable, the farmers should not be given the seedlings entirely free. A small fee can be charge in order to encourage sense of ownership and also to encourage farmer nurseries as a business venture.

Plate 4.1: Individual farmer nursery

Seedling production has to go hand in hand with the rate of cutting. This is very important for planning especially if the trees are cut at a frequent rate. The study found out that the farmers introduced Grevillea at different times and that the rate of cutting per month also differed. This is shown in Figure 4.5

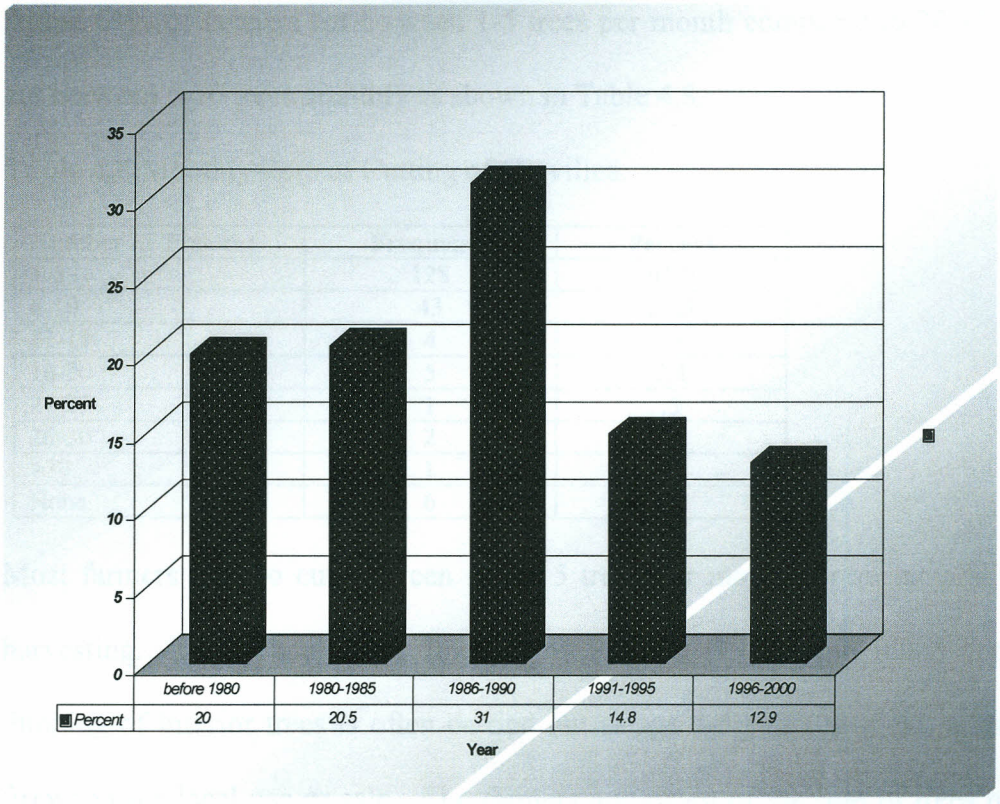

Figure 4.5: Year when farmers first planted Grevillea.

Majority of the respondents (31%) planted trees between 1986 and 1990. In the years between 1980 and 1985, 20.5% of respondents planted their first Grevillea seedlings. The above scenario does not represent what has grown as wildlings and Grevillea trees that were found on the farm by members of households. There was a decline in tree planting after 1990. After 1990, most of the farmers had already planted the trees. There was little to add to the farms. Between 1980 and 1990, there was vigorous tree planting campaign by the Forest Department extension staff (Tyndall, 1996).

About 61% of farmers cut between 1-5 trees per month compared to 20.5% who cut between 6-10 trees monthly as shown in Table 4.8.

Table 4.8: Monthly Rate of Cutting of Grevillea.

Number of Tree cut	Frequency	Percent
1-5	128	61.0
6-10	43	20.5
11-15	4	1.9
16-20	5	2.4
21-25	1	.5
26-30	2	1.0
>30	1	.5
None	6	2.9

Most farmers tend to cut between 1 and 5 trees per month for sustainability of harvesting. This concurs with findings by Poulsen (1983) who found out that thinning of inferior trees is often carried out at age 4-5 years to yield poles and firewood for local use or sale. The farmers are aware of the role of trees hence not ready to cut many at a go. This would mean that with a new alternative use like wood carving, the farmers may harvest more trees and therefore need to plant more.

During the study, mobile saw mills (power saws) were seen. The saws were used to fell the trees and to further cut them into required timber sizes. This was attributed to the fact that there was no sourcing of timber from the natural forest because of the presidential ban on tree harvesting from the forest. Many people therefore meet their demand for the timber from tree species on the farms. Plate 4.2 shows stumps of Grevillea along farm boundaries.

Plate 4.2: Stumps of Grevillea along a farm boundary.

4.3 Farmers use and Marketing of *G. robusta*

4.3.1 Current Uses.

Respondents gave various uses of *Grevillea robusta*. The uses include timber, sale, shade, firewood, charcoal, mulching, windbreak, withies, soil fertility, fodder and animal bedding (Table 4.9).

Table 4.9:Uses of Grevillea

Use	Response %
Timber	27
Sale	21
Firewood	14
Fodder	6
Withies	5
Animal Bedding	5
Shade	4
Charcoal	2
Mulching	2
Windbreak	1
Soil Fertility	1
Wood carving	0

It is apparent that timber (27 % respondents) is the major use of Grevillea mainly for construction (Plate 4.3) and furniture making. Income earning potential of Grevillea is second with 21% response. Firewood was placed third (14%). The quality of the fuelwood is said to be good, one of its frequently mentioned attributes is its usability only three days after cutting. Woodcarving was not mentioned as a current use of Grevillea (Table 4.9). This shows that there is need to sensitize the farmers on the use of Grevillea for woodcarving.

The study finding concur with the findings of Booth and Harwood (1992), to the effect that Grevillea provides a range of useful, economically valuable products, which include timber, poles, firewood and leaf mulch. It is important to note that only 6 % use Grevillea as fodder. According to Spiers and Stewart (1992), Embu farmers use Grevillea as fodder only during the dry season. This study was

carried out during the dry season and the cows were being fed on whatever palatable material available-Grevillea being one of them. The cows are fed on the pruned tender branches and leaves. This kind of practice does not affect the wood volume as only the pruned material is used. A study carried out by Omoro and Nair (1993) concur with the use of Grevillea leaves for mulching which can eventually reduce soil loss on sloping land.

Plate 4.3: A homestead showing the use of *Grevillea robusta* for construction.

4.3.2 Gender Priorities in Tree Growing and Usage

During the study, the gender factor was taken into account. This mainly covers the role played by both men and women in tree growing, tending, harvesting and marketing. Table 4.10 below shows different responses as to why the respondents plant *Grevillea* by gender.

Table 4.10: Reason for planting *Grevillea* Trees by Gender.

Reason for Planting	Male (%)	Female (%)
Firewood	39	43
Timber	39	40
Windbreak	6	7
Shade	6	3.4
Sale	3	2.3
Marking boundaries	3	2.3
Beauty	2	1
Cowshed bedding	1	1
Withies	1	

The head of the households' gender can affect adoption of tree growing because different uses fall under different gender's jurisdiction. Both men and women benefit from *Grevillea* on farm. *Grevillea* on farm saves women effort and time not only by eliminating the time necessary to collect distant firewood but also by making the fuelwood activity the man's pruning responsibility.

The table above shows that the reasons for planting *Grevillea robusta* as a multipurpose tree do not vary greatly between sexes. These results clearly indicate that gender does not affect reasons for planting trees.

It is also clear that the farmers meet their basic needs first before selling the trees. The implication of the reasons for planting trees for the wood carving industry is

that the farmers would be willing to sell the extra trees for whatever use the customer intends.

In the Tobacco growing areas (LH), the rising fuelwood market has contributed to extensive tree planting of fast growing species like Grevillea. One female respondent reported that:

"I am planning to plant more trees to sell to tobacco growers. When I am in need of money, I prefer to sell a standing tree instead of taking fruit and food crops to the market for several days'.

This shows that the sale of *Grevillea* trees fetches more money than fruits from the fruit trees and food crops. If the *Grevillea* trees fetch more money than other on-farm products, the farmers would therefore make sure that they have enough tree stock resulting in conservation of the environment. The ready market (tobacco and carving industries) may act as incentive for planting of exotics.

4.3.3 Trade and Marketing Channels

There has been buying and selling of *G. robusta* trees among farmers in the study area. Of the 210 respondents interviewed, 89 bought and sold *Grevillea* products, 99 bought but did not sell Grevillea products, 8 sold but did not buy, while 7 did not buy nor sell Grevillea products. There is a relationship between those respondents who sell their products and also those who use the products for their own consumption (Table 4.11).

The following table shows the relationship between selling and direct use of *Grevillea robusta* by the respondents.

Table 4.11: Comparison of those who sell and those who use Grevillea directly.

		DIRECT USE OF *GREVILLEA*		
		YES	NO	TOTAL
SALE OF *GREVILLEA* BY FARMERS	YES	89	8	97 47.8%
	NO	99	7	106 52.2%
		188 92.6%	15 7.4%	203 100%

Chi-square	value	DF	Significance
Pearson	.19996	1	0.65475

There was no significant difference (P>0.005) between those who sell and those who use the Grevillea products directly (Table 4.11). As Grevillea generates additional income, it is at the same time used directly by the households.

The respondents were asked about the amount of money they receive from selling a Grevillea tree for timber and how much they would expect from the same if they were to sell to the wood carving industry. The respondents gave various figures as shown in Figure 4.6 below.

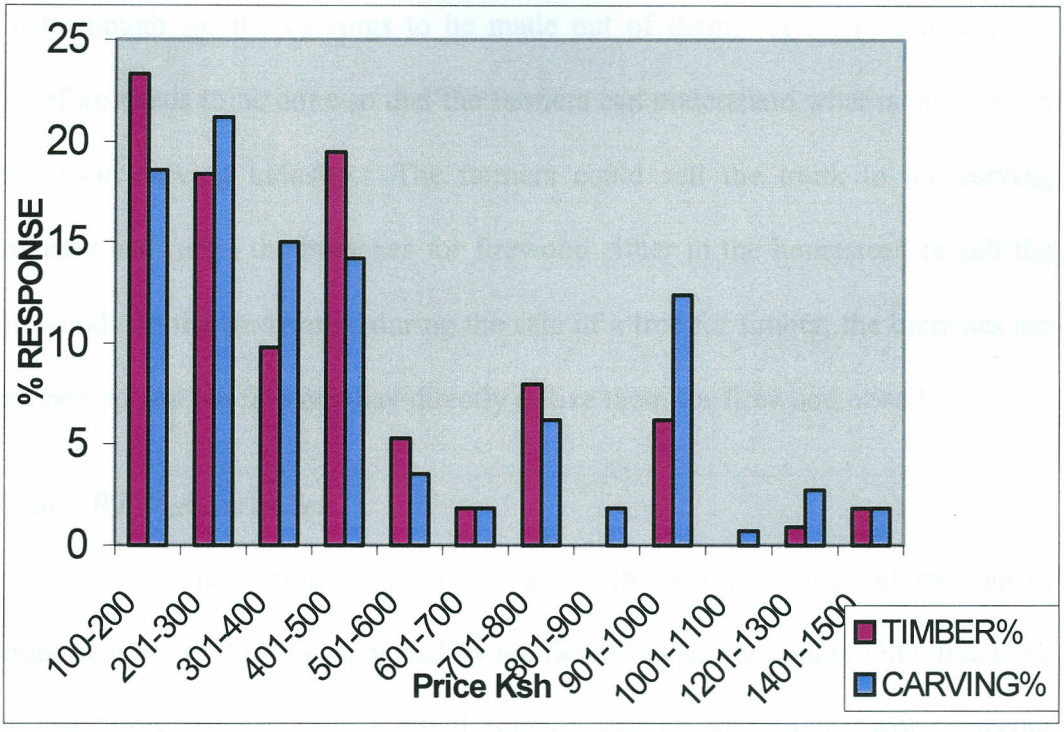

Figure 4.6:Comparison between Timber Prices and Expected Income from Carving Industry

The results above show that farmers expect a high income from the sale of Grevillea for carving compared to what they are already fetching from the sale of timber . T-test results p=0.000 indicate that there is a significant difference in the amount of money expected from the wood carving industry and that received from the sale of timber. The farmers expect to receive more money from the wood carving industry.

One respondent said "I would sell my tree at a higher price to the wood carver compared to a timber end user because a carver will utilize all the parts of the tree including branches".

To this farmer, the wood carvers would utilize all the parts of the tree which is not the case because price is a function of demand and supply and not necessarily the usage of all parts. Only the stem is used in carving because the branches are not

thick enough for the carvings to be made out of them. A lot of sensitization therefore needs to be done so that the farmers can understand what is involved in the wood carving industry. The farmers could sell the trunk to the carving industry and retain the branches for firewood either in the homestead or sell the firewood. In the study area, during the sale of a tree for timber, the branches are left behind and the farmers may directly utilize them for firewood or sell.

4.3.4 Willingness to Sell

Most farmers are willing to sell their trees to the wood carving industry but in small quantities. This is supported by the fact that there are many Grevillea trees on the farms and yet only a small fraction can be sold to the wood carving industry. The farmers perhaps had alternative source of income. Out of 209 respondents, 40% of the respondents are willing to sell 1-5 trees for carving, 15.2% are willing to sell 2-10 trees and 19% are not willing to sell at all. One respondent among those willing to sell said:

"I value my trees, I can not sell any of them. What would happen if my land was left bare without any trees. That would take me back many years, so I would rather use them for basic household needs like firewood".

This statement is a true testimony of the extension services' failure to reach the farmers. The farmer should be aware of the benefits he can reap from planting the trees other than fuelwood and how he can obtain seedlings. He should also be equipped with the best methods to use in planting to foster fast growth rate. On the other hand, the farmer does not want to leave his land bare which is a positive

contribution to soil conservation through the planting of wind breaks (Table 4.10). Since farmers are willing to sell to wood carvers, the latter also need to be sensitized on the need to use the exotic species.

4.3.5 Marketing

There is no organized marketing channel for the sale of Grevillea. A total of 29.3 % respondents sold their trees directly to the consumers, who were mainly farmers from the locality for use in construction and fuelwood. Respondents who sold the trees through middlemen comprised 5.1 %. The rest of the respondents either use the tree products directly or exchange the tree products with other assets such as land. One respondent who was interviewed had exchanged one acre of land with 100 mature Grevillea trees. The buyer used the trees in construction of three houses for his sons and sold the rest. This means that the farmers would be better off forming a cooperative for ease of marketing their wood to the carving industry. This would also ensure that the farmers fetch good price for their trees. For this to happen, a lot of campaign is needed to sensitize the farmers of their bargaining potential once in a group. A study carried out by Tyndall (1996) showed that on-farm forestry will be the major supplier of tree products in the near future. This therefore calls for urgent organized market and market information system.

4.4 Utilization of Wood Carving Species by Wood Carvers

A wide range of species are utilized for carving as shown in Table 4.12. According to Chikamai *et al.,* (1998), the raw materials for wood carving in their order of preference are *Dalbergia melanoxylon, Olea europaea, Combretum shumanii, Terminalia spinosa, Brachylaena hulliensis* and *Terminalia browni.* The above authors further state that *G. robusta* has 63% similarity with *Dalbergia melanoxylon* which is ranked first as a preferred wood carving species. *Grevillea* has therefore a medium potential use as an alternative wood carving species. This could be the reason why it is used sparingly. Grevillea makes beautiful carvings. Some of these carvings are shown in Plates 4.4 and 4.5

Plate 4.4: Elephant candle stand made from Grevillea by Mr. D. Mutuku of Equator Handicraft.

Plates 4.4 and 4.5 shows that *Grevillea* can be carved just like the other preferred wood carving species. These carvings are not common and therefore they are less known by traders. This is an area that requires a lot of promotion so that the traders do not stick to the now scarce hardwood carving species.

Plate 4.5: Cut out bowl made from Grevillea

Different carving sites utilize many tree species as indicated in Table 4.12 below.

Table 4.12: Wood species used by carvers at different sites.

Site	Carving wood species
Handicraft Industrial Cooperative Society, Gikomba	*Mangifera indica, Azadirachta indica, Jacaranda mimosifolia, Grevillea robusta, Dalbergia melanoxylon, Brachyleana huilensis, Olea africana.*
Kuona Trust (National Museums)	*Terminalia brownii, Dalbergia melanoxylon, Brachyleana huilensis, Olea africana, Grevillea robusta.*
Wamunyu Handicraft Factory	*Mangifera indica, Azadirachta indica, Jacaranda mimosifolia.*

The carving of Grevillea wood is not wide spread. At the Handicraft Industrial Cooperative Society (Gikomba), the carvers did not find it necessary to carve

from Grevillea because other preferred woods were available. The only Grevillea carvings found at the site were those which had been entered into a competition to promote the utilization of good wood. The carvers had been given the Grevillea wood and told to carve so as to win a prize. Only five carvers had agreed to join the competition. The others thought that it was a waste of time since most customers would go for carvings from hard wood.

Kuona Trust often used the good woods. Reasons given for use of Grevillea are that the wood is very light, portable, easy to obtain and dries quite fast. Problems experienced included splitting during use of Grevillea and attack by wood borers that necessitated pretreatment. The carvings made from this wood are small, mostly picture frames.

Gikomba sources wood from Karura, Ngong and Ololua forests. Other wood supplies come from Mount Kenya forest. The volume of wood utilized for carving between 1998 and 2000 is given table 4.13

Table 4.13: Quantities of wood utilized in Gikomba and Wamunyu sites.

Year	Volume (M^3)	
	Wamunyu	**Gikomba**
1998	1980.7	1201.9
1999	1145.2	819.8
2000	1218.2	492.6
Total	4344.1	2509.3
Mean	1448	836.4

The wood supplies for Gikomba have been declining over the years (Table 4.13). The reason given for this was the anticipated excision and allocation of forests to private developers (Ngong and Karura forests). This increased illegal harvesting from these forests leaving less stock. Another reason given was that wood supplies from Mount Kenya destined for Gikomba often go through various police roadblocks on the highways at which heavy bribes are demanded. The suppliers sometimes risk being jailed for handling the banned indigenous hardwoods. It is also apparent that the number of tourists coming to Kenya has decreased and therefore carvers may not be willing to tie their money on carving woods or carvings which will take a long time to be sold.

At Wamunyu the wood supplies have also been declining. The reasons given were that the wood carving species are becoming difficult to source. Wood carvers have increasingly tended to overexploit the already slow growing species. They should therefore be encouraged to use fast growing species if they are to continue with their work.

4.4.1 Consumer Preference in Wood Carving Species.

Survey on consumer preference was carried out at the Masaai and City Markets in Nairobi. Masaai Market is operational only on Tuesdays. At the Maasai market observation schedule was used and in places where the trader was not busy, an

informal interview was conducted. A total of thirty seven traders were visited at random, and observations made. Only 21.6% of traders had carvings made from softwood. None however was from Grevillea. The rest of traders (78.4%) specialized in hardwood carvings. During this field data collection, the consumers were observed as they bought the carvings. None of them asked for carvings from good wood. One customer who was of Japanese origin was overheard as saying,

"I hope that you are not lying to me that this carving is made from Ebony because other carvings tend to crack after some time".

At the city market, thirteen stalls were visited. None sold carvings made from Grevillea. The traders gave the reason of customer preference. Only carvings that sell fast are stocked. These are carvings made from hardwood.

There is need to sensitize consumers/buyers who are mainly tourists, on the need to buy 'good wood' products in order to conserve the indigenous forests which are habitats for animals they come to see together with the water catchment areas. They should also know that their insistence on hardwoods will create more problems and therefore may not enjoy the biodiversity in tourist sites in future. There is no need to kill the goose that lays the golden eggs in this case the indigenous tree species.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

This study looked at the abundance and potential use of *Grevillea robusta* in the wood carving industry in Kenya. Specifically, the following aspects were examined in this study: a) Presence and distribution of Grevillea trees in the various agro-eclological areas in Embu, b) Farmers' use and marketing of Grevillea and, c) Utilization of *G. robusta* in the wood carving industry

The first objective of the study was to determine the volume, density and distribution of *Grevillea* in Embu district. From the findings of this study, it was found that *G. robusta* has gained a lot of popularity with the farmers. UM4 has the highest number of Grevillea (22 %) followed closely by LM3 (20 %) with LH having the lowest number (10 %). The density of the trees in Embu was calculated to be 49 trees per hectare. This is further supported by Thijssen *et al.* (1993) that the density of trees in the Kenyan highlands is 40 per hectare. The total volume calculated from the 13,546 counted trees was 7,585.76 m^3 with an average volume of 0.56 m^3 per tree. The total volume required by the wood carvers per year is 7000m^3. This is equivalent to felling

50,000 trees (Choge, 2000). This means that they require 0.14 m^3 of wood from every tree felled. *Grevillea* in Embu would be able to supply these quantities. It is important to note at this point that the researcher does not intend to promote *Grevillea* wood to replace all the other wood carving species but to supplement the scarcity. Sustainability of Grevillea is assured as is the number of institutions involved in seedling management in the nurseries. Demand for wood products has been a strong incentive to tree planting in farms. This is supported by the amount of money received from the sale of trees for timber. The farmers' expectations in selling the trees to the wood carving industry may raise their replanting efforts.

The second objective was to find out the current and potential uses of *Grevillea* by farmers in the study area. The uses of Grevillea are many (Table 4.9). They include timber (27%), sale of whole tree (21%), and firewood (14%) in that order. These uses do not include woodcarving. This is an area that requires a lot of sensitization to the farmers and the carvers. The rate of cutting of the trees show that 61% of the respondents cut between 1 to 5 trees every month (Table 4.8). There was no significant difference $P>0.005$ between those who sold and those who used the *Grevillea* tree products for home consumption.

The third objective was to determine the customer preference of wood used in carving. Customers were not keen on buying the good wood carvings (Section 4.4.1). This may be attributed to the fact that the people are already used to certain woodcarvings and therefore are unaware of alternative wood carving species.

The fourth objective was to determine the volume of *Grevillea* required by the carvers. Three sites were visited during the study to determine the usage of *Grevillea*. On two of the sites *Grevillea* was used for wood carving. These were the Handicraft Industrial Cooperative Society, Gikomba and the Kuona Trust (Table 4.12). During an exhibition of good woodcarvings, a member of Equator Handicraft displayed two carvings made from *Grevillea* (Plate 4.4 and Plate 4.5). The results show that the use of *Grevillea* as a wood carving species is not widespread. Carvers were not willing to carve using Grevillea because they said that there was no market for these carvings. Carvers are familiar with the indigenous hardwoods and at present they have few incentives to switch to 'good woods'. Indigenous hardwoods are expected to cost more than good woods. Carving hardwoods is also more convenient, because there is no need for first curing (pretreating) the timber. The key is to give carvers an incentive to switch to good woods. Kenyan carvers as in any business, are very responsive to falling demand and there is a good chance that

market led demand for good woods would change their practice. Relying on farm-grown resources to satisfy the wood demand of the carving industry would help to reduce the pressure on natural forests. Fragmentation of natural habitats, logging and conversion of forests, large scale monocultures and traditional hunting habits are putting pressure on the populations of various taxa such as plants (Beentje 1988), birds (Bennun and Njoroge 2000) and mammals many of which are endemic or have narrow distributions. As the consequences of deforestation on populations tend to become apparent only years or decades later (Brooks *et al.* 1999), the currently observed loss of species and ecological instability is likely to continue. This makes it even more urgent to protect forest resources from destructive harvesting through using wood from managed farms.

5.2 Conclusion

Grevillea robusta is abundant in all the agroecological zones of Embu. It could be used in the wood carving industry in order to reduce the pressure exerted on the already scarce preferred indigenous hard wood carving species. Carvers will only use this species if there is a ready market for it. It therefore means that the customers have also to be sensitized on the need to conserve our forests by using carvings made from the good woods that are abundant on the farms.

Once hardwoods are exhausted, carvers will naturally resort to good wood species for carving.

5.3 Recommendations

Based on the findings of this study, the following recommendations have been made:

I. *Grevillea robusta* is plentiful in Kenya. Awareness about its qualities is needed, which will only come about through concerted efforts involving education and production. Efforts should be made to demonstrate Grevillea's quality in carving by holding a trade show to exhibit its potential to farmers, carvers and traders in the wood carving industry. The forest department, in collaboration with other agencies such as Kenya Wildlife services (KWS) should review alternative strategies to achieve forest conservation (including leases), and in particular should explore the possibility of involving the local communities. Carvers could lease forest land if the Forest Bill 2001 is enacted by parliament in order to plant tree species which they could use later in wood carving. Carvers with land should plant Grevillea to ensure easy access.

II. Carvings from 'good woods' can make excellent art objects with innovative designs. Substantial awareness and training in design and

treatment (wood curing) is required to help carvers shift successfully from the traditional woods to 'good woods'.

III. For the farmers to realize full benefits from agroforestry practices based on *Grevillea robusta*, they should be backed by the removal of legal constraints such as land tenure, low cost technologies for seed/ seedling acquisition and distribution. Decentralized seedling production will enable easy access to the seedlings in good time. There should also be a properly developed market and marketing systems for the products

IV. Certification could provide incentive for the carvers to adhere to a transparent and legal system of wood acquisition and production of quality carvings. Its introduction, however, will depend on an improvement of the managerial and business skills within the wood carving cooperatives. The cooperatives should spearhead the certification process so that the good wood carvings can fetch good returns.

V. It would be desirable to identify other tree species which can perform a similar role in agroforestry. While *Grevillea robusta* has not experienced severe pest and pathogen problems, there is always a risk that such problems may develop, as happened with *Leucaena leucocephala.* Easy access to a broad genetic base within the species is

one defense against pest and pathogen problems, but availability and widespread use of other species would reduce their initial impact. Other good wood species could be used together with Grevillea.

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5.4 Areas for Further Research

1. The wood carving industry merits further attention to determine the number of active carvers , quantities of specific woods used and their origins, and the impact of harvest on populations of the tree species involved. Other species may be in danger of overexploitation and therefore need to be protected.

2. A study of the possibility of relocating carving sites close to the farmers (source of carving wood) could be carried out so that the carvers reduce on the transportation costs. This would also speed up the certification process. This would be feasible when there is a ready market for Grevillea carvings.

3. Quantity of Grevillea in other areas of Kenya should be determined.

REFERENCES

Akotsi, N., Gang, P.O. and Shimba, M. (1997). *The Role of Remote Sensing in Forest Cover Mapping and Monitoring*. DRSRS, Nairobi

Alder, D. (1992). *Computer Processing of Forest Inventory Data*. KIFCON, Nairobi.

Aloo, T.C. (1995). *`Hardwood Users'*. Swara. 15. Nairobi. p 5

Babbie E. (1992). *The Practice of Social Research*. Wadsworth Publishing Company, Califonia.Pp. 260-270,292.

Barraclough, S. L. and Ghimire , K. B. (1995). *Forests and Livelihoods. The Social Dynamics of Deforestation in Developing Countries*. UNRISD. p.11

Beentje, H. J. (1988). *Atlas of the rare trees of Kenya*. Utafiti. 3. Pp.71-123

Bennum, L and Njoroge, P. (2000). *Important Bird areas in Kenya*. Ostrich71 (1-2) Pp 164-167.

Bentham, G. (1978) *Creative Wood Sculpture.* Blandford Press, Great Britain. P.4

Booth, T.H. and Harwood, C.E. (1992). *Status of Grevillea robusta in Forestry and Agroforestry . Grevillea robusta* in Agroforestry and Forestry.ICRAF.
Nairobi P.9

Brooks, T. M., Oyugi, J. O. and Pimm, S. L. (1999). *Time lag between Deforestation and Bird Extinction in Tropical Forest Fragments.* Conservation Biology 13(5). Pp. 1140-1150.

Central Bureau of Statistics. (2000). *Preliminary Census Results: Population Size by Province, District, and Sex.* Ministry of Planning and National Development, Nairobi.

Chikamai, B.N., Githiomi,J.K., and Muga, M.O. (1998). *Anatomical and Related Properties of Wood carving Species in Kenya*. KEFRI. Nairobi Pp.15-16

Child, R. and Smith, A.N. (1960). *Manganese Toxicity in Grevillea robusta.* Nature, London. 186 (4730) P. 1067

Choge, S.K. (2000). *Study of Economic Aspects of the Wood carving Industry in Kenya*: Implications for policy Development to make the Industry more Sustainable. M.Sc. Thesis. University of Natal, Durban.P.21,206.

Crafter, S.A., Awimbo, J. and Broekhoven A.J. (1997). *Non-timber Forest Products. Value, use and management issues in Africa, including examples from Latin America.* IUCN. European Union.

Emerton, L. (2000) *Squandered wealth 'Poverty!' we cry, perched on a gold mine.* Ecoforum 24.4 Environment liaison center International Office for Africa Nairobi. P. 15.

FAO. (1995). *Non-wood Forest Products for Rural Income and Sustainable Forestry.* Non-Wood Forest products. Paper No. 7. FAO, Rome.

FAO, (1991). *Trees and Forests in Rural Land Use.* FAO Forestry Department. UK.

FAO. (1987). *Tree Growing by Rural People.* FAO Forestry Paper. 64. Rome. Pp 72, 73.

Harwood, C.E ed. (1992). *Grevillea robusta in Agroforestry and Forestry*: proceedings of an international workshop. ICRAF, Nairobi, Kenya.

ICRAF (1992) *A Selection of Useful Trees and Shrubs for Kenya.* ICRAF, Nairobi.P.94.

Jaetzold, R. and Schmidt, H. (1983). *Farm Management Handbook of Kenya,* Vol.II. East Africa. Ministry of Agriculture, Kenya.

Johns A.D (1992). *Species Conservation in Managed Tropical Forests. Tropical Deforestation and Species Extinction.* Chapman & Hall, London. P. 23.

Kaudia, A. (1990). *Extension Strategies for Tree Species Introduction in Agricultural Farming Systems:* lessons from Grevillea robusta adoption in less Developed countries. KEFRI, Muguga.

Kariuki. S. T. and Mathooko, J.M. (2000). *Disturbances and Species Distribution of the Riparian Vegetation of a Rift Valley Stream.* African Journal of Ecology 38 (2) Pp123-129

KEFRI. (1999). *The Catalogue of Kenyan Commercial Timber.* Forest Products Resource Centre, KEFRI. Nairobi. (Unpublished).

Kenya Forestry Master Plan (1994). *Development programmes.* Ministry of Environment and Natural Resources. Nairobi, Kenya.

Kigomo, B.N., Savill, P.S and Woodell, S.J.R. (1991). *The Pattern and Distribution of Brachyleana hulliensis in a semi-deciduous dry Forests of Kenya.* African Journal of Ecology .29(4): Pp275-288.

Kigomo, B.N., Savill, P.S and Woodell, S.J.R.(1990). *Forest composition and its Regeneration dynamics-a case study of semi-deciduous tropical forests of Kenya.* African Journal of Ecology .28(1): Pp 174-188

Kirubi,C., Wamicha, W.N., Laichena, J.K. (2000). *The effects of Woodfuel Consumption in the ASAL areas of Kenya: the case of Marsabit forest.* African Journal of Ecology .38 (1): Pp 47-52.

Ling, E. (1993). *Socio-economic Evaluation of Intercropped Grevillea robusta on small scale farms in Kerugoya District, Kenya.* IRDC. p 9.

Marshal, N.T. (1995). *'The Timber Trade. Threat to Kenya's Forest Conservation?'* Swara. 15. P 24.

Matiru, V. (2000). *Forest Cover and forest Reserves in Kenya; Policy and Practice.* Nairobi IUCN-EARO

Mbaya, S. and Wily, L.A (2001). *Land, People and Forests in eastern and southern Africa at the beginning of the 21st Century.* IUCN, Nairobi, Kenya.

McGillivray, D.M and Mackinson, R.O. (1993). *Grevillea , Proteacea, a taxanomic revision.* Melbourne, Australia. Melbourne University Press.

Ministry of Agriculture. (1991). *Grevillea. Establishment and Management of Grevillea on Farms.* SWCB, Nairobi. pp 1,2,3.

Mugo, F. W. (1997). *Factors contributing to woodfuel scarcity and the consequent use of crop residues for domestic energy in rural Kenya.* MSc. Thesis. Cornell University.

Mwangi, L.M. and Paterson, R.T. (1996). *Honey fungus in Agroforestry.* KARI, Embu. P 12.

Obuga, R. (1995). *Sustainable Development of Wood Carving Industry in Kenya.* N.M.K. Nairobi. p 13.

Omoro, L.M.A., Nair, P.K.R. (1993). *Effects of mulching with multi-purpose tree prunings on soil and water run-off under semi-arid conditions in Kenya.* ICRAF, Nairobi.

Ongugo,P.O (1992) *National Wood Production Policies. Grevillea robusta* in Agroforestry and Forestry.ICRAF Nairobi. P.29.

Owino, F. (1992). *'Trends in Growing and Utilization of Grevillea robusta as an Exotic'. Grevillea robusta in Agroforestry and Forestry.* ICRAF. Kenya. P 17.

Philip, M. S. (1994*). Measuring Trees and Forests.* 2nd Edition. CAB International. P.18

Poulsen, G.(1983). *Using Farm Trees for fuelwood.* Unasylva.35(141) Pp 26-29

Raju, K.R.T. (1992). *'Silver Oak (Grevillea robusta) a multipurpose tree for Arid and Semi-arid regions'. Grevillea robusta* in Agroforestry and Forestry. ICRAF. Nairobi. p 55.

Republic of Kenya. (1997) *Forest Development Policy.* MENR, Nairobi.

Republic of Kenya (2000*). Environmental Management and Coordination Act.* Nairobi, Kenya.

Republic of Kenya (1996). *Embu District Development Plan 1997-2001.* Government Printer, Nairobi.

Sagwal, S.S. (1984). *Silver Oak. A tree of many uses.* Palampur, India. P 26.

Saoshiro, U. (2001). TED Case Studies. No. 636

Sayer, J.A. and Whitemore, T.C. (1992). *`Deforestatation and Species Extinction in tropical moist forests'.* Tropical Deforestation and Species Extinction. IUCN, London. P 2.

Smith A. N. (1960). *Boron Deficiency in Grevillea robusta.* Nature, London. 186 (4729) Pp. 987.

Spiers, N. and Stewart, M.(1992). *Use of Grevillea robusta in Embu and Meru Districts of Kenya. Grevillea robusta in Agroforestry and forestry Proceedings of an international Workshop* .ICRAF. Nairobi, Kenya. Pp 37-48

Thijssen, H. J. C., Murithi F. M., Nyaata D. A., Mwangi J. N., Aiyalaagve, I. O. O., and Mugendi, D. N. (1993*). Report on an Ethnobotanical survey of woody perennials in the coffee zone of Embu district, Kenya.* KARI/KEFRI/ICRAF. Nairobi, Kenya. AFRENA. 62

Tyndall Brad. (1996) *The Socio-economics of Grevillea robusta within the Coffee Land use System of Kenya.* AFRENA Report .109.

UNESCO, WWF, Royal Botanical Gardens. (2000*). Chonga. Good wood News.*2 .P1

UNESCO, WWF, Royal Botanical Gardens. (1999a). *Chonga. Good Wood News.* 1. Pp 1,2,3.

UNESCO, WWF, Royal Botanical Gardens. (1999b). *Wood Carving, Certification and `Good Wood' labelling. Searching for Practical Systems.* Nairobi. pp 2,3.

UNCED (1992) *A Guide to Agenda 21, A Global Partnership.* Geneva. P.58.

USAID (2002). *Investing in Tomorrow's Forests: Towards an Action Agenda for Revitalizing Forestry in West Africa.* USA, Washington DC. P.3

Van Duij. (1998). *Monitoring Women's Tree Planting in Kabale District, Uganda; A Study on farmers' Preferences for tree species and planting niches.* ICRAF, Nairobi. p 48.

Wass, P. ed. (1995). *Kenya's Indigenous Forests. Status, Management and Conservation.* IUCN and ODA (UK) Nairobi.

World Watch Institute (2002). *Vital Signs 2002. The Trends that are Shaping our Future.* UNEP. Haddon Craftsmen, Inc. USA.

APPENDICES

APPENDIX 1

CALL BACK CARD.

AEZ ----------
Location ----------

Sub-location ----------

Village ----------

To Farmer ----------

This is to inform you that a student of Kenyatta University is carrying out research in your area and you are one of the farmers the student would like to interview. We came to interview you but did not find a person who could furnish us with the required information. We shall come back to conduct the interview on ;

Day: ----------; Date----------\ 2000 Approximate time:----------
---
Please wait for us.

Name:----------

Sign. ---------- Date ----------\2000 Time.----------

APPENDIX 2

OBSERVATION SCHEDULE

1. Different tree species on the farm

Spp.	Number observed

2. Arrangement and spacing of *Grevillea robusta* on the farm.

3. Evident tree management practices.

4. Resprouts \ wildlings of *Grevillea robusta* seen.

Tree Number	No. of resprouts\ wildlings

5. Tree nursery on the farm \ homestead

6. Tree seedlings on the farm nursery

APPENDIX 3

QUESTIONNAIRE TO THE FARMER ON THE CURRENT AND POTENTIAL USE OF *GREVILLEA ROBUSTA* IN THE WOOD CARVING INDUSTRY.

DISTRICT: EMBU

Agro-ecological zone _____
Division _____
Location _____
Sub-location _____

1. Name of farmer _____
2. Size of farm _____
3. Household type: male headed _____
   Female headed _____
4. Farmer interview:- Respondent
   Male _____
   Female _____
   Both _____
5. Age Years
   16 – 20 _____
   21 – 30 _____
   31 – 40 _____
   41 – 50 _____
   51 – 60 _____
   61 and above _____
6. Education Level
   Nil _____
   Primary _____
   Secondary _____
   Post-secondary training _____
   Diploma _____
   University _____
7. Land Ownership
   Private bought land _____

Communal _____
Leased _____
Family/Ancestral _____

8. How many *Grevillea robusta* trees do you have on your farm?

9. Where do you obtain grevillea seedlings?
   Forest Department Nursery _____
   Other nursery (specify) _____
   Wildlings _____
   Other source (specify) _____

10. Where do you plant grevillea?
    Boundary _____
    Block _____
    With crops _____
    Other (specify) _____

11. When did you plant the grevillea?

12. What purposes did you plant it for? (Ranking in brackets)

13. Do you sell products from grevillea?
    Yes _____
    No _____

14. Do you use the products yourself?
    Yes _____
    No _____

15. How much do you receive for the following in a month (give units of sale)?
    Timber _____
    Fuel wood _____
    Poles _____
    Others (specify) _____

16. How many trees do you cut in a month?

17. For what reason?

18. How do you market your grevillea?

Direct	_____
Middlemen	_____
Co-operative	_____
Other (specify)	_____

19. What other uses do you think grevillea can be used for?

20. If you were to sell grevillea to the carving industry, how much money would you expect to receive from the sales?

21. How many trees would you sell to the wood carving industry if they offered a ready market?

Some (specify)	_____
All	_____
None (give reasons)	----------

APPENDIX 4

QUESTIONNAIRE FOR NURSERY SURVEY

1. Location

a. Division ---------- b. Location ----------
c. Sub-location ---------- d. AEZ ----------

2. Institution

a. Name _____
b. Government _____ Church _____
Private _____ Womens' group _____
School _____ NGO _____
Farmers' group _____ Other (specify) _____

c. Name of nursery headman _____ M \ F

d. When was the nursery established ? _____

e. What are the objectives of the nursery ?
To sell seedlings 1
To produce seedlings for own use 2
Other (specify)_____

3. Size

a. Size of the area occupied by the nursery?

$< 10m^2$ 1 $10 - 100m^2$ 2 $100 - 1000m^2$ 3 $>1000m^2$ 4

b. Number of seedlings present : _____

c. Seedlings production per year (number) _____

4. Species

a. Do you have *Grevillea robusta* (Mukima) seedlings in your nursery?_____

b. If yes how many ?_____

c. What is the age of the seedlings (months) ? _____

d. What is the condition of the seedlings ?
Good 1

Medium 2
Poor

e. What are the seedlings raised from ?
Seed 1
Cutting 2
Wildling 3
Grafting 4

f. If seed, is supply enough ? Yes / No

g. Is seed supply regular / predictable ? Yes / No

h. What is the seed source ?
Commercial 1
Governmental 2
Non – Governmental 3
Research Institution 4
Project 5
Other (specify) _____

i. Is seed quality Good 1
Normal 2
Bad 3
Unknown 4

j. What is the price per seedling of Grevillea ?

k. How does it compare with prices of other seedlings ?

Species	Price

5. Market

a. Who are the buyers of Grevillea ?
Men 1
Women 2
Farmers' Groups 3
Women's Groups 4
Other (specify) 5

b. How many *Grevillea robusta* seedlings do you sell per month ?

c. How does this compare to the sell of other seedlings ?

Species	Quantity Sold

6. Constraints

What are the main problems that you face in the nursery ?

APPENDIX 5

CHECKLIST FOR CARVERS

Location _____ **Sub-location**_____

Name of carver _____

1. Is *Grevillea robusta* carved ?
2. If so why ?
3. Carvings made out of Grevillea.
4. Money (Ksh.) got from sales of Grevillea carvings in a month.
5. Comparison with the sale of other carvings

Carving wood	Ksh. Per month

6. Source of Grevillea logs.
7. Distance covered during transportation.
8. Transportation cost.
9. Possibility of carving Grevillea on site where it is bought.
10. Future of carving using Grevillea robusta.

APPENDIX 6

CHECKLIST FOR TRADERS IN THE WOOD CARVING INDUSTRY

Trader _____ **Location** _____

1. Carvings traded in.

2. Wood used for the carvings?

Carving	Type of wood used

2. Preference(Number of carvings sold per month)

Wood used for carving	Local customers	Foreign customers

3. Quantity of Grevillea sold.

4. Future of trade in Grevillea carving

APPENDIX 7 LIST OF COMMON TREE SPECIES

BOTANICAL/COMMON NAME	LOCAL NAME
Acacia mearnsi/black wattle	muthanduku
Acacia mellifera	muthigira
Acacia nilotica	muemba, mucemeri,mucemei
Acrocarpus fraxinifolia	no local name
Adansonia digitata	muramba
Albizia corriara	mukorwe
Annona muricata	mumotomoko
Azadirachta indica	muarubaine
Balanities egyptiaca	mububua
Berchemia discolor	muthwana
Bridelia micrantha	murera, mukwego
Calliandra calothyrsus	no local name
Callistemon phoeniscus	no local name
Callistris robusta	no local name
Carica papaya/ pawpaw	mubabai
Cassia siamea	muebeci
Cassia spectabilis	muebeci
Casuarina equsetifolia	no local name
Catha edulis	muraa, murungi
Citrus spp.	mutima, mucungwa
Combretum collinum	mugereki
Commiphora spp.	mura, mukuu
Cordia africana	muringa
Croton macrostachys	mutundu
Croton megalocarpus	mukinduri
Cupressus lusitanica	mutarakwe/muthithinda
Cyphomandra/tree tomatoe	matunda ma thakame
Dalbergia melanoxylon	mubingo, muvingo
Eriobthrya japonica/loquat	mucuca
Erythrina abyssinica	mubuti, muvuti, muhuti
Eucalyptus camadulensis	munyua maji
Eucalptus maculata	munyua maji
Eucalptus saligna	munyua maji
Euphobia tirucalli	mukariaria, muasi
Fagara macrophylla	mugucwa
Ficus benjamina	mugumo

Ficus syscomorus	mukuyu
Grevillea robusta	mubariti, mukima
Grewia trichocarpa	murenda
Jacaranda mimosifolia	mujakaranda
Kigelia africana	muratina, muringi
Lantana camara	mucimoro, mukenia
Leuceana leucocephala	muburi
Mangifera indica/ mango	mugembe
Markhamia lutea	muu
Melia azederatch	muarubaine
Melia volkensii	mukau
Persea americana/ avocado	mukondobia
Psidium guajava/guava	mubera
Ricinus communis/castor oil plant	muariki
Schinus molle/pepper tree	mugaita
Sesbana sesban	mukarura
Spathodea nilotica/nandi flame	mucabaviduki
Sterculia africana	mujuria, muuria
Tamarindus indica	muthithi
Tecoma stans	no local name
Terminalia brownii	mururuku
Terminalia mentalis	muaburi
Trema orientalis	muvevu
Vitex doniana	muki, mukumuu
Vitex keniensis	muuru, muburu, muhuru
Zzizyphus pubescens	mugaa, munjuki