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LOCAL KNOWLEDGE AND TREE SPECIES PREFERENCE FOR LAND REHABILITATION IN KENYA

Edinam K. Glover[1]

Abstract

Kenya's natural resources are under considerable threat and are already severely degraded in many areas due to overgrazing, clearance of forests and woodlands cover for agriculture, as well as fuelwood collection. According to available records, about 75% of the landmass in Kenya is dryland, exposed to the vicissitudes of an irregular rainfall pattern. This study identifies local people's priority tree species most apt to halt land degradation in Karai Location. Data was gathered through questionnaire-based interviews with households. Descriptive statistics suggest farmers' preferences for tree species and the reasons behind their preferences. Results also show the great potential and challenge of agroforestry in the area. Farmers in Karai are interested in cultivating exotic species, namely, Grevillea robusta, Eucalyptus saligna, Casuarina equisitifolia, Leucaena leucocephala, Calliandra calothyrsus and Sesbania sesban on their farms. This study concludes that the agroforestry approach of incorporating "scientifically approved" multipurpose trees of farmers' own preference into the existing landuse systems would simultaneously restore the environment, conserve the forests, generate income for resource-poor farmers, catalyse more sustainable land-use practices and enhance increased and sustained food production.

Keywords: *agroforestry, climate change, land degradation, overgrazing, preferred tree species, Kenya*

1. Introduction

In the last few decades, land degradation remains a challenge for many developing countries across the globe (Gadzirayi 2006). Land use change in Africa has been characterized by a significant amount of land degradation and conversion (Barbier 2000). Land degradation refers to a reduction of resource potential (Dregne et al. 1991, Valentin 1995, Glover and Elsiddig 2012), or diminution of the biological potential (Darkoh 1998), or economic

[1] *Faculty of Law ,University of Helsinki, Finland. P.O. Box 4, FI-00014. Corresponding e-mail address: eddie.glover@helsinki.fi*

productivity and complexity of the land (UNCCD 1994) by a single process or a combination of processes acting on the land ((Dregne et al. 1991, Valentin 1995, Darkoh 1998). These processes include water erosion, wind erosion and sedimentation by these agents, long-term destruction of vegetation and diminution of many plants and animal populations, or decreases of crop yields where relevant, and salinization and alkalinization (Dregne et al. 1991, Valentin 1995, Darkoh 1998), crusting and hardsetting of soils, and long-term reduction in the amount or diversity of natural vegetation (Dregne et al. 1991, Valentin 1995). The United Nations considers land degradation as one of the "most important global change issues facing mankind" (INCD 1994, UNCCD 1994) owing to its impacts on human populations (food security, economics, sustainability etc.) and environment quality (dust storms, trace gas emissions to the atmosphere, soil erosion, etc.) (Vitousek et al. 1997).

Many countries of sub-Saharan Africa (SSA) are faced with a serious food crisis and with environmental degradation. Much of SSA has seen a fall in per capita food production in the last 30 years. They are unable to produce enough food to feed the growing population and to generate sufficient income to meet basic needs (Hudson and Cheatle 1993), moreover being under pressure of conflict (Oneka 1996). A major reason for this is declining soil fertility, caused in large part by soil erosion (Glover and Elsiddig 2012) and "nutrient mining" (ICRAF 1997, Adams et al. 1978). It is reported that every year between 7.6 million and 10 million hectares of forests are eliminated outright. Though it is climatic changes that have partly contributed to deforestation, anthropogenic pressures remain the principal cause (FAO 1995, The People 1997, Vitousek et al. 1997, Glover 2005).

Kenya, like its neighbours (Ethiopia, Somalia, Sudan, Tanzania and Uganda), has not been spared the ravages of food shortage, wide-spread malnutrition and famine, environmental degradation, with recession of forests and pastures and the loss to wind erosion of huge quantities of soil. An estimated 2.9 million people (and rapidly increasing) live along forest boundaries and exert considerable pressures on forest resources through such activities as agriculture, settlement, livestock grazing (Mwangi and Ongugo, 1997), logging and burning (Mwendi 1997), resulting in permanent loss of forest lands through excisions and encroachment. When the loss is through fire (Fig. 1), there are added problems besides the immense loss to the vital vegetation cover. The bad side of fire, ecologically, is that vegetation and habitat are both destroyed, along with the bio-resources of both plants and animals. Unlike grassland fires which enhance the regeneration of certain grass (Mgendi 1997) and legume (Munyanziza 1994) species, forest fires are particularly damaging because they retard the regeneration of the most forest plant species (Mgendi 1997).

Figure 1. Accidental Bushfire

(Photo: Edinam K. Glover).

Data on Kenya's forest coverage indicate a steady decline at an average rate of 2% between 1972 and 1980, and more recently an average loss of 3,700 ha to 5,000ha per year (Mwangi and Ongugo 1997). Deforestation is one of the major causes of land degradation in these areas. About 80 per cent of the country comprising arid and semi-arid lands, increasing human settlement, deforestation and overgrazing, among other factors, are aggravating the problems of soil fertility depletion. These regions are now faced with land degradation due to depleted soil fertility, recognised as the major biophysical constraint responsible for the decline of agricultural production (Pier 1989, Bryan 1994); this is the main backbone of economic growth in Africa, particularly in Kenya into the next 21st century (Gruduah 1997). Some twenty four thousand hectares of tropical forest around Mount Kenya which experts describe as a botanical garden of immeasurable scientific and economic value to mankind is threatened with extinction unless the government swiftly puts an end to its present destruction by illegal logging and clearing (Mwai 1997). Gone are the mighty indigenous trees that took centuries to mature, either felled for timber and charcoal or wantonly hacked down to make room for cultivation. As the fire laid waste, huge expanses and the undergrowth gave way to cultivated patches, and the animals could not endure the heat and exposure. They had to flee. This included elephants estimated at more than 400 that, during dry spells, trooped to the forest from semiarid Meru National Park and Samburu national reserve in pursuit of water and food. Also gone

are the beautiful bush bucks, water bucks and baboons, Columbus monkeys, gazelles, snakes and myriad species of birds that colonised the forest for generations.

In the forested region lie the sources of many rivers and streams flowing south to join the Tana. They formed a sure reservoir of water while it lasted. The reservoir is already drying out, as the nightmare becomes reality of not only the animals but the huge human population that relied on the rivers for their livelihood (Ombuour 1997).

For years Baringo district, which lies in the northern part of Rift Valley Province in Kenya, has been regarded as one of the most severely degraded areas in Kenya, being variously described as the "agricultural slums of Kenya" (Maher 1937), "one of the saddest sights in Kenya" (Huxley 1951), "an overgrazing endpoint where most of the grass and topsoil has already gone" (Brown 1963) and "an embarrassment to Kenya" (Kenya 1966). Such views focused national and international attention on Baringo, in an attempt to halt the apparently drastic environmental decline associated with agriculture and livestock. In most areas in Kenya, e.g. Machakos, Baringo and Kitui districts, deforestation has mainly been due to any one of the following factors: clearing of forests for charcoal production; poor grazeland management and overgrazing by livestock (see Fig. 2), which alone or together prevent tree regeneration; as well as collection of firewood for home and commerce. Some of the consequences of the above activities include declining soil fertility leading to low crop yields; lack and/or shortage of fodder during the dry season; fuelwood problems; shortage of construction poles and timber; and increased soil erosion problems. Environmental problems, it is said, do not stay within political boundaries but the repercussions of environmental degradation affect many people and linger for a long time (The People 1997). With the country's population close to 25 million and an annual increase of 4 per cent (Cooper et al. 1992; Bryan, 1994), Kenyans today are increasingly aware of the problems they face in order to feed themselves, to produce sufficient fuelwood for domestic needs, together with the need to sustain biological diversity in combination with the continuing provision of fodder (Mengich 1994), fruits, dyes, tannins, gums, resins, and medicines (Cooper et al. 1992). With an increasing population, their difficulties escalate and they are forced to farm marginal land which is vulnerable to degradation. At best, the overall results are static crop yields and widespread poverty (Barbier 1999, Glover and Elsiddig 2012).

Famine, refugee problems and abandoned lands are common symptoms of our failure to practice good land husbandry, and impede efforts to manage our affairs to ensure a decent livelihood for the majority of rural people (Hudson and Cheatle 1993). This situation worsens, unless measures are taken to improve the use of land and allow farmers to produce food, fodder,

fuelwood and building material on the farm without continuously opening up new lands, the latter causing deforestation and with all its consequences. These consequences of failing to take the situation in hand will be disastrous both to the people of the hills and to the people of the adjoining plains and the cities fed by rural areas. Damage to the national economy will be enormous. Several case studies highlight the need for land degradation assessment in sub-regions and individual countries including Kenya (FAO/UNEP 1984, Dregne et al. 1991). Against this backdrop, there is a need to develop appropriate strategies to stimulate tree growing by farmers. In the absence of clear management practices local people's involvement in the natural resource management, existing forests are continuously subjected to heavy pressure from the forest-dependent and forest-adjacent local people. This paper provides a scientific analysis of the effect of community-based participation in the rehabilitation, establishment, management, protection and sustainable development of forest resources with particular reference to Karai Location in Kenya.

Figure 2. Easy to Degrade, Difficult to Restore

Note: The young man is one of the victims of tomorrow. (Photo: Edinam K. Glover).

2. Materials and methods

2.1. Description of the study area

Karai Location is situated in Kikuyu Division (Fig. 8), one of the seven divisions of Kiambu District (Fig. 7) in Kenya (Fig. 6). Kikuyu Division, the second smallest division of the Kiambu District, has a total area of 232 sq. km., almost 9.5% of the total area of the Kiambu district, which measures 2,451 sq. km. This Division is the second most densely populated division in Kiambu District. The division has a population of 171,000 people and a density of 737 persons per sq. km. Karai Location records a population of 24,173 persons (Kenya Government, 1994). The division shares common boundaries with a number of divisions both within and outside the district. For instance, to the North, it borders Kiambaa and Limuru Divisions; to the East it borders Nairobi while to the South-west it borders Kajiado District (Fig. 8). Karai Location has an area of 97.22 sq.km. (Kenya Government, 1994), with five sublocations, viz.: Karai, Lusegetti, Nechu settlement scheme, Gikambura and Renguti. The Lower Midland zone is found partly in Karai Location. It lies between 1200 -1500m above sea level.

The area is dry with rainfall being very low and unreliable. The area has a bimodal rainfall pattern with the long rains falling between April and May followed by a cool season in July and August. The short rains are experienced in October and November. The average annual rainfall recorded is 954 mm (Kenya Government, 1994). The rainfall influences agricultural activities in Kikuyu division to a great extent. However, due to the sparse and erratic rainfall regime, the environment is rather conducive to livestock production. Temperatures are also closely linked with elevation; for instance, temperatures range from 20.4^{o}C in March and April to 12.5^{o}C in July and August in the highland zone. Soils are developed on dissected erosional plains, on undifferentiated basement system rocks, ashes, pumice from recent volcanoes, and sediments mainly from crystalline basement system rocks. The soils vary from well drained, shallow, dark red to yellowish red, stony loamy sand to imperfectly drained, very deep, dark brown, firm, strongly calcareous, moderately saline and strongly sodic clay, with a topsoil of clay loam (Kenya Government, 1994). Drought resistant crops such as katumani maize are grown. Owing to the low rainfall in the area, the environment is conducive for the rearing of livestock.

Figure 3 & 4. Political Africa and East Africa Political Maps

Fig. 3. Political Africa (Primary School Atlas, 1988).

East Africa Political

Fig. 4. East Africa Political (Primary School Atlas, 1988).

Figure 5, 6, 7 & 8. Administrative 1988 Kenya, Kenya Central Province, Kiambu District Administrative Boundaries, and Kikuyu Divisions

Fig. 5. Administrative 1988 Kenya (Primary School Atlas, 1988).

Fig. 6. Kenya Central Province (Primary School Atlas, 1988).

Fig. 7. Kiambu District Administrative Boundaries.

Fig. 8. Kikuyu Division.

2.2. Methodology: Sampling, Data Collection and Analysis

For the purpose of this study, the cross sectional study was employed. In line with this, information was gathered from a sample of study area residents having access to land**.** A survey of 39 households was carried out at Karai Location. Data were gathered from both primary and secondary sources. Primary data were obtained by using a pre-tested semi-structured questionnaire (Bryman, A. 2004). The questionnaire was pre-tested with ten heads of households at Muguga, a nearby town to Karai Location to explore its relevance to the respondents, and modifications based on pre-testing were incorporated into the final questionnaire forms to improve their clarity (ibid.). All the interviews were conducted in Swahili and English with the help of trained field assistants. Data was collected on household and land-use characteristics, management of forest resources and participation of farmers in tree planting activities. The household questionnaire survey was conducted face-to-face in people's homes or during farm visits (Curasi 2001). Questions were presented directly to each respondent by the interviewer. The interviewer read each of the questions as instructed on the survey form and recorded the interviewee's responses. To every interviewee, the purpose of the research and its importance was explained by the interviewer in order to build confidence in the participants to respond to all questions. Names of respondents were not requested (Cohen and Manion 1994, Ary et al. 2002). The respondents were informed that their contribution was on a voluntary basis and that it was to support participatory approaches to tree planting.

Sources of secondary data used in the study included grey literature and peer-reviewed academic documents. These included previous institutional reports, inventories, records and papers which provided base-line information for the study. The institutions from which the secondary data were collected were directly involved in natural resource management in Kenya, and included the Kenya Forestry Research Institute (KEFRI), Ministry of Agriculture (MOA) in Nairobi, Kenya Agricultural Research Institute (KARI), the Food and Agricultural Organization of the United Nations (FAO), and the universities. Information was also obtained from reports and files maintained by the Karai Local Council.

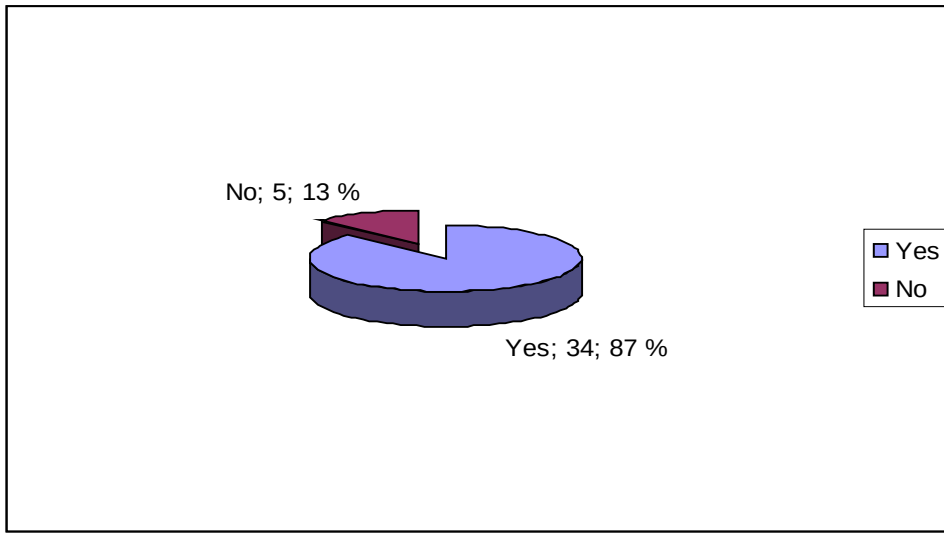
Data gathered from the questionnaire were coded, computerized and analyzed using the Statistical Package for Social Sciences (SPSS) software. Descriptive statistics were used to find out the distributions of respondents in the different categories and combinations of land use types, willingness, preferences, perceptions and attitudes towards tree production systems in order to conceptualize and build empirical reasons of farmer level participation in forest management. For this study, the frequencies for all the different demographic segments were computed together with their percentages.

3. Results

3.1. Willingness to Plant Trees

The outcome of the interviews indicated the willigness of 87% of farmers to adopt agroforestry technologies aimed at establishing individual and community pastures for supplementay fodder, fuelwood, timber etc. Of the 39 farmers surveyed, 87 % expressed interest in future tree planting, while the remaining 13 % were unwilling (Fig. 9).

Figure 9. Willingness to Plant trees as Indicated by Respondents.



The fulfillment of short and long-term needs was an aspect mentioned in connection with tree planting by many farmers in the study area. Short-term needs included fruits, fodder and fuelwood (Fig. 10), whereas long-term needs included timber and a safeguard against future problems such as urgent cash needs. It was also found that it was the emphasis on short–term needs that made fuelwood tree cultivation more attractive for farmers in comparison to timber tree growing. Farmers' willingness regarding tree growing was also stimulated by expanding markets in the nearby Nairobi city. The trees that farmers were willing to plant in the future were intended for the market, as they mentioned a fuelwood tree such as *Eucalyptus saligna* and a timber tree such as *Grevillea robusta*. Tree species mentioned by farmers were largely those which would provide produce for sale (such as timber or fuelwood). Despite various "constraints" the Karai Location farmers had a fairly high (87 %) willingness to plant trees for specific purposes.

Figure 10**. O**ff-Farm Fuelwood Collection

Note: Provision of fuelwood is a woman's task; Women spend considerable time and effort in off-farm fuelwood collection. (Photo: Edinam K. Glover).

3.2. Reasons for Unwillingness to Plant Trees

A total of 5 farmers (13 % of all respondents) indicated reasons for not planting trees, identifying insufficient land/land tenure (10%) and poor seedling growth (3%) (Table 1) as constraints to farm forestry development in Karai Location. An inadequate extension service/support was also an influencing factor reported by study area residents during group discussions.

Table 1. Reasons for Not Willing to Plant Trees as Indicated by Respondents

Reasons	**Total No. of respondents**	**%**
Have enough trees	-	-
Insufficient land/lack of land tenure	4	10
Poor seedling growth	1	3
Insufficient time	-	-
No tree cutting rights	-	-

N= 39

3.3. Intensity of Tree Problem and Land Use (Constraints Associated with On-Farm Tree Management)

Farmers in Karai location cited various constraints that are associated with on-farm tree management (Table 2). Twenty-six percent (26%) of farmers confirmed that a large number of seedlings die before maturity. Responses received from group discussions show that the average survival rate of seedlings was 30%. The farmers attributed the cause of seedlings' death to water stress (51%), lack of technical know-how about seedling handling (26%), and destruction by pests (38%). The most serious problem is water stress followed by pests and diseases, most notable, termite attack during the dry season. Other associating factors to tree planting mentioned by the farmers included scarcity of land, seeds/seedling and problems with drought. Among the farmers interviewed, 10% indicated scarcity of land as their major constraint to tree growing; and few others indicated lack of seeds as the major constraint.

Table 2. Constraints Associated with on-Farm Tree Management as Indicated by Respondents

Constraints	**Total number of Informants**	**Percentage of informants (%)**
Water stress	20	51
Diseases /Pests	15	38
Unavailability of seeds	6	15
Marketing	2	5
Survival rate	10	26
Cash	4	10
Lack of awareness	10	26
Browsing	2	5

N=39

3.4. Extent and the Nature of Existing Traditional Tree Planting Practices

Table 3 is an inventory of all the species that are being used by the clients. This inventory represents the extent and nature of existing traditional tree planting practices. It also forms the universe from which the priority species would be selected.

All farmers interviewed had at least one tree on their farms. Most species planted on the farms are exotics. In term of number of tree species planted on the farms, *Grevillea robusta* was the most common tree planted by 79% households, followed by *Eucalyptus saligna* (64%) and *Leucocephala leucocephala* (41%) in descending order of frequency. The other species found on farms were: C*roton megalocarpus, Casuarina equisitifolia, Acacia mearnsii* and *Dovyralis caffra.* There is a tendency that the larger the land owned, the greater the

number of species planted. For those owning less than 1 ha, 11 species were found; owning 1 to 2 ha, 15 species, and for those owning more than 2 ha of land, 26 species were found.

Table 3. Tree Species Planted as Indicated by Respondents.

Botanical name	Family	English name	Kikuyu/Swahili Name	* A	** B	*** C	No. of Resp.	%
Acacia mearnsi De Wild.	Leguminosae	Wattle; De wild	Muthanduku (kik)	1	3	5	9	23
Acacia seyal Del.	Leguminosae	White thorn	Mugaa(Kik)	-	-	1	1	3
Albizia gummifera (J. Gmelin) C.A. Smith	Leguminosae		Mukurwe(kik)	-	-	1	1	3
Azadirachta indica L.	Meliacae	Neem	Mwarumbaine (Swa)	-	-	2	2	5
Calliandra calothyrsus Meissn.	Leguminosae	Calliandra	-	-	-	2	2	5
Casuarina equisitifolia L.	Casuarinaceae	Whistling pine	Mvinje (Swa)	2	3	7	12	31
Citrus sinensis Pers.	Rutaceae	Orange	Macungwa(Kik)	1	1	1	3	8
Commiphora zimmermannii Engl.	Burseraceae	C. missionis	Mukungugu (kik)	-	-	1	1	3
Croton megalocarpus Hutch.	Euphorbiaceae	Mukinduri	Mukinduri (kik)	-	6	6	12	31
Cupressus spp. Tourn. ex Linn.	Cupressaceae	Cypress	Mutarakwa(Kik)	4	2	10	16	41
Dodonaea viscosa Jacq.	Sapindaceae	Hopbush	Murema muthua (Kik)	-	-	1	1	3
Dovyralis caffra Warb.	Bixaceae	Kei apple	Kaiyabak(Kik)	-	2	5	7	17
Elvetia cymosa		-	Murembu (Kik)	1	-	-	1	3

Auct.								
Eriobotrya japonica L.	Rosaceae	Loquat	Rungati (kik)	-	1	4	5	13
Eucalyptus saligna Sm.	Myrtaceae	Sidney blue gum	Muringamu (Kik)	3	8	14	25	64
Fagara usambarensis Engl.	Rutacaeae	-	Mugucua (Kik)	-	-	2	2	5
Grevillea robusta A. Cunn.	Proteaceae	Silky oak	Mukima (Kik)	5	9	17	31	79
Jacaranda mimosaefolia D. Don	Bignoni-aceae	Jacaran da	Mucakaranda (Kik)	1	1	-	2	5
Leucaena leucocephala (Lamk.) De Wit	Legumi-nosae	Leuca-ena	Lusina (Swa)	1	5	10	16	41
Mangifera indica Wal.	Anacar-diaceae	Mango	Maembe (Kik))	-	1	1	2	5
Markhamia lutea K. Schum.	Bignonni-aceae		Muu (kik)	-	-	2	2	5
Olea africana Mill.	Oleaceae	Wild olive	Mutero mutamaiyu(Kik)	-	1	1	2	5
Persea americana Mill.	Lauraceae	Avoca do	Mukurobea(Kik)	1	1	4	6	15
Podocarpus milanjianas Rendle.	Podocar-paceae	Podo	Muthengera(kik)	-	-	3	3	8
Sesbania sesban Merril	Lgumino-sae	-	Mwethia (Kik)	-	-	2	2	5
Teclea nobilis Del.	Rutaceae	-	Munderendu (Kik)	-	-	2	2	5
Vitex keniensis Turril	Vebana-ceae	Meru oak	Muhuru (kik)	-	-	1	1	3
Warburgia ugandensis Sprague	Canella-ceae	Green-heart	Muthiga (kik)	1	1	1	3	8

*A = land owned <1 ha; **B = land owned 1- 2 ha; ***C = land owned > 2 ha.

3.5. Preferred Tree Growing Species (Priority Tree Species in the System)

Out of the 28 tree species found on farmers' fields (Table 3), seven (viz. *Grevillea robusta, Eucalyptus saligna, Casuarina equisitifolia, Leucaena leucocephala, Calliandra callothyrsus* and *Sesbania sesban*) have been selected by farmers (Table 4) as the most preferred species for this research. The tree species that farmers were most willing to grow on their land are shown in Table 4. These species were mentioned by 25% or more of the farmers. Species mentioned by fewer respondents were not included in this list. Farmers usually expressed their willingness to plant a tree for more than one reason. This attitude shows the fact that the farmers were aware of the multipurpose potentials of trees species in their land-use systems. Thus, the percentages shown in Table 4 add up to more than 100%.

Table 4 indicates that *Grevillea robusta* has gained widespread popularity in Karai Location (87%), originally as a shade tree for tea and coffee and more recently as an agroforestry tree for small farms. It is preferred by most people because it provides economically valuable products including timber and firewood. It also a priority tree species in the area because because farmers are aware that it does not compete strongly with adjacent crops. Table 4 shows that, of the total of 39 respondents, *Eucalyptus saligna* was known to be useful for furniture, veneer/plywood, posts and poles in construction and as fuel. The species is very common in towns, where it provides both shade and decoration (72%). Table 4 shows that, of the 16 farmers willing to plant trees, most valued the planting of *Cauarina equisitifolia* for firewood and charcoal. It is also widely preferred for amenity purposes and timber. Table 4 shows that the main reason for integration of *Leucaena leucocephala* into future land use systems was fuelwood use and, additionally, use for gum production, fodder and building material. Survey analysis indicated that 18% of the total numbers of respondents interviewed were willing to plant *Calliandra calothyrsus* (Table 4) because of its multipurpose nature in providing forage as a supplement to low quality roughages for ruminant livestock. It is also preferred because it provides shade for coffee and tea; an excellent fuelwood for cooking. Results also revealed that *Calliandra calothyrsus* wood dries very quickly (overnight for small stems) and burns well with a smokeless fire. *Sesbania sesban* was preferred by 10 % of respondents (Table 4) because of its usefulness in agroforestry since it is a good coffee shade tree and soil improver. It stabilizes soil and grows well in swampy sites and the wood provides firewood. Results show that 87% of the farmers interviewed were interested in planting *Grevillea robusta* while 72% were interested in planting *Eucalyptus saligna.* Other species mentioned were *Casuarina equisitifolia, Leucaena leucocephala, calliandra calothyrsus* and *Sesbania sesban.* Some of the farmers did not specify the kind of species preferred but only mentioned that

they wanted species that would provide them with fuelwood, timber, fodder and poles.

Table 4. Preferred Tree Species as Indicated by Respondents.

Species' names	Total	Percentage
Grevillea robusta A. Cunn.	34	87
Eucalyptus saligna Sm.	28	72
Casuarina equisitifolia L.	16	41
Leucaena leucocephala (Lamk.) De Wit	11	28
Calliandra calothyrsus Meissn.	7	18
Sesbania sesban Merril	4	10

N=39

4. Discussion

4.1. Strategies to Increase Forest Coverage

As a response to widespread malnutrition and famine, degradation of the eco-systems, with recession of forests and pastures and the loss to wind erosion of vast quantities of soil, a majority of study area residents interviewed were of the opinion that the strategy to increase the forest cover in Karai Location area should focus on reforestation and afforestation, especially in marginal lands. An obvious reason was that the local people wanted to focus on productive forests in order to secure their essential needs. In this respect, several important considerations were suggested by the different categories of land users for reforestation and afforestation programmes in the study area. Although land-use practices vary greatly across the world, their ultimate outcome is generally the same: the acquisition of natural resources for immediate human needs, often at the expense of degrading environmental conditions (Foley et al. 2005). Suggestions related to reforestation and afforestation programmes included: enrichment planting, participation of local people in the management of tree resources, use of human resources to better manage degraded and marginal lands, and increase of the overall production of wood or other tree products to counter growing deficits. Baumer (in Maharaj et al. 1991), recommends, in order to arrive at a successful implementation of afforestation and tree planting, projects should be preceded by detailed diagnosis, be sensitive to local people's priorities and capacities, ensure freedom of species selection and provide adequate advisory services to the rural people on their technology, be based on community consensus and participation.

4.2. Land-Use Preferences in the Future

It is quite obvious from the survey results discussed earlier, that local people have developed positive attitude towards natural resources in general and forest resource in particular. Responses received from farmers showed that they were conversant with the important role of trees in a land–use system which combines trees and crops and/or livestock to provide multiple products and management options for them. Group discussions indicated that farmers tended to adopt these technologies as a means of increasing the profitability and for risk-buffering. Some farmers also admitted that they were willing to incorporate trees in their land-use system because they no longer could rely on commercial feeds or fodder from the government forest alone in meeting the demands for their livestock. Ayuk (1997) pointed out perceived benefits as one of the principal determinants of agroforestry practices.

4.3. Willingness to Plant Trees

The fulfillment of short and long-term needs was an aspect mentioned in connection with tree planting by many farmers in the study area. Short-term needs included fodder and fuelwood, whereas long-term needs included timber and a safeguard against future problems such as urgent cash needs. It was also found that it was the emphasis on short–term needs that made fuelwood tree cultivation more attractive for farmers in comparison to timber tree growing. Farmers' willingness regarding tree growing was also stimulated by expanding markets in the nearby Nairobi city. The trees that farmers were willing to plant in the future were intended for the market, as they mentioned a fuelwood tree such as Eucalyptus *saligna*. Tree species mentioned by farmers were largely those which would provide produce for sale (such as fuelwood). The majority of study area residents did prefer the more commercial trees with high cash value. Several authors agree that the willingness to plant trees and the selection criteria for farmers' priority tree species depend on a number of physical, environmental and socio-economic pre-conditions. Burley (1982), Raintree (1983), Luukkanen (1996), Wiersum (1996) and Glover (2005) all note that there are major pre-conditions which must be satisfied prior to tree planting by rural people.

4.4. Reasons for Unwillingness to Plant Trees

An inadequate extension service/support was also an influencing factor reported by respondents during group discussions. For many farmers the absence of extension personnel to advice on the farming systems was indicative of a lack of interest of officialdom in the contributions their farms provide both for the economy and the environment. Extension when it is available is not unified; instead, separate agencies have responsibilities for

food crops and trees. Thus for the farmer it is not easy to understand why two or more officials would visit the farm to give advice but no one can deal with the holistic questions that the farmer has.

4.4.1. Land Tenure

A concern expressed by many farmers in the study area was the land tenure system. It was found that farmers were unwilling to invest their time and money establishing and nurturing trees on land they do not own, unless they are certain they will be able to harvest and use or sell the products in the future. Current et al. (1995) and Glover (2005) reported that the farmers' interest in tree planting may be defined by their land ownership position or by their access to technical advice.

4.4.2. Constraints

The inadequate supply of wood and tree products such as firewood, poles, fruits and nuts to meet household energy, food, construction and medicinal needs is due to farmers not planting enough trees. Farmers also lack knowledge of tree species and alternative niches where trees can be planted with minimum competition and possible complementarity with existing crop/livestock. In general, trees are given the lowest priority in terms of resource allocation and management inputs. The obstacles to tree growing depend on the precise local circumstances. But it is only when they have been clearly identified that measures can be designed to remove or circumvent them. And if there are fundamental barriers to tree growing which cannot be altered within the context of the programme, this must be recognised. Otherwise programmes are likely to be a waste of effort and resources for all concerned (Foley and Barnard 1985).

4.5. Tree Species Planted

The survey gave strong corroborating evidence of what sort of trees people like (Table 4) and why they plant them. Popular trees are those that supply: (i) Timber - e.g. *Grevillea robusta;* (ii) Fuelwood -e.g. *Eucalyptus saligna;* (iii) Fodder - e.g. *Leucaena leucocephala.* Trees are planted explicitly for timber, medicines, enclosures (fences), fuelwood and others such as windbreaks, ornamentals, and cash. On-farm tree products mentioned by a number of farmers are: timber, fuelwood, poles and fodder. The significance of the on-farm tree products seemed to vary between men and women. Materials for construction are often insufficient and have to be purchased within the area or imported from outside the area. This indicates a definite need for tree species that can provide these materials. Women farmers, when interviewed, often mentioned fuelwood as their priority on-farm tree product while on the other hand, men mentioned poles and fodder.

We can thus understand that local people see trees as sources of timber (construction), fodder, fuelwood rather than as providers of service functions e.g. provision of soil conservation, water management, just to mention a few. In selecting species to be promoted, care should be taken to include multipurpose trees which would meet at least one of the high priority needs (timber, etc.), but which would also provide protective functions. This would be a more effective strategy than trying to persuade people to grow trees solely for service functions.

4.6. Farmers' Preferences in Tree Cultivation

These were identified on the basis of the main problems farmers face and the opportunities that agroforestry offers towards solving these problems and to improving domestic welfare. In terms of cultivation, farmers' general preferences were related to the fulfilment of short-and long-term demands, the multi-purpose aspects, and the risk minimization involving tree cultivation.

The fulfilment of short-and long-term needs was an aspect mentioned by many farmers. Short-term needs include fruits, fodder and fuelwood; whereas long-term needs include timber, construction wood, fuelwood and a safeguard against future occasions as urgent cash needs, land ownership security and as a dominant means of boundary demarcation. Farmers preferences regarding tree growing are also stimulated by expanding markets. Those trees preferred are intended for the market as well. Large-scale farmers do prefer the more commercial trees with a high cash and timber value (e.g. *Grevillea*). Small-scale farmers prefer fast-growing species or prime species that yield quickly and have cash return.

Grevillea robusta is highly preferred by farmers owing to the following reasons:

– Its multiple uses, as leaves are used for fodder during the dry season, and are good for firewood and timber
– Its rate growth is very fast and, therefore, farmers can get returns within a very short period of time.
– Its coppicing ability. It resprouts once pollarded.
– Does not interfere with crops when grown together

The only problem that a few farmers raised is the unavailability of *Grevillea* seed. Farmers who have mature *Grevillea* trees are not able to harvest the seed.

Eucalyptus which the farmers refer to as "blue gum" or "*munywa mae*" which literally translates to 'water drinker" is liked by farmers because of several reasons:

– Growth rate is high and, therefore, farmers can only wait for a short time before they see its benefits.

– Good for poles and timber which farmers can readily sell
– Has good coppicing ability which makes it easier for regeneration. Once planted, it can be cut several times without having to replace.

It is essential that the local population is directly involved, especially if new forms of agroforestry are introduced. Not only extension is needed, but also the active involvement of the farmers in planning, organization and execution of the project (Wiersum 1988). Introducing trees into land use systems involves indigenous cultural practices; this is not a cause for concern. What is, however, is the persuasion needed for farms to accept and implement innovation. Indeed the objective characteristics of a system are less important than the way the target group perceives them. Foremost are the criteria required to implement innovation. These frequently are expressed in terms of changes in management, knowledge and skills, but can also reverberate socially and culturally. Conversely farmers will be looking at the short and long term effects and how this is expressed in production, production cost, labour input and disposable income.

Secondly, the need for improvement must be felt in order for it to be accepted. The inclination to try out a new system, even on a small scale, is more readily adopted after observation of its relative ease of implementation. Agroforestry technique does meet these criteria and can be applied in most situations where the need does arise. Making the process self-sustaining requires development of the appropriate skills and implementing capacity and the presence of institutions at the local, regional and national levels to ensure the effective use of existing resources and to foster the mobilization of additional financial and human resources for continued development of the subsistence sector. Self sustenance thus means involving, as distinct from simply reaching, the subsistence populations through development programmes (Lele 1975). The most important aspect in the promotion of agroforestry practices is flexibility of a planned intervention being able to respond to what is needed by the people, particularly through offering them a range of techniques that they can choose from and experiment with in order to develop the system that suits their situation.

4.7. Conditions for the Successful Promotion of Agroforestry in Karai Location

The selection criteria for farmers' priority tree species depend on a number of physical (environmental) as well as socio-economic pre-conditions that are related to successful cultivation of perennial crops and in particular trees (Eppink and Palte 1980, Teel 1984, Palte 1989, Oldeman 1997, Glover et al. 2013:179, 181). In the following paragraph, the above will be discussed in relation to Karai, the study area: In the first place, the climatic conditions that go with elevation are just enough for trees to grow (see Palte 1989). The

bimodal rainfall in the Kikuyu division creates a favourable climate for tree planting. The average annual rainfall recorded is 954 mm which is just enough for trees to grow: temperatures range from 13°C to 21°C; the altitude lies between 1200 - 1500 m above sea level.

Secondly, the soil types, especially the deep ones, offer great potential for tree growing. The soils in this area are developed on recent lava and sediments. They vary from well drained, shallow, dark red to yellowish red, stony loamy sand to imperfectly drained, very deep, dark brown, firm, strongly calcareous, moderately saline and strong in sodic clay, with a topsoil of clay loam (Kenya Government, 1994). These preconditions have determined the natural vegetation for most common tree species in Karai. While the above environmental preconditions determine the promotion of agroforestry, there are also a number of social economic and geographical factors that determine the actual occurrence of agroforestry. Among these factors is sufficient size of land. The size of land holdings refers to the preference of the farmers to grow as much food for their household and the market and for sale as possible. The size of the land holdings is large enough to allow for a sufficient production of food in a more or less dense interculture with trees. In most areas they are usually more than 1 ha in extent but may exceed 5 ha occasionally. A family often farms two or more plots in different parts of the village land; probably it seems, with the idea that even if crops are lost due to drought, disease or theft in one area, there is a possibility of harvest in another. Similarly, more land is cultivated than would be necessary if good harvests were assured.

In a recent paper by Glover et al. (2013:181) several socio-economic factors influencing agroforestry practices have been discussed: 'The security of tenure is a very important socioeconomic condition. Fruit trees are usually not harvestable before the age of four or five years and may be productive for decades. Timber trees are only full grown after ten to eighty years. Consequently the cultivation of perennials offer a long-term investment which will only take place if the farmer can be certain of his rights on the yields. In practice this will only happen on owned land. Tenants do not care much about soil management, how bad the deterioration of soil fertility or the run-off erosion of the land they operate may be. So agroforestry practices are not found on leased land.' In this context, Karai counts few landless households and in the study area, there are many farms under freehold title deeds (69%). Most of these farms were demarcated and registered under freehold title. The majority of farmers therefore have their ultimate say on the use of land; be it for the cultivation or planting of perennial crops.

Another precondition for successful agroforestry is accessibility of markets (*ibid*., 180). In terms of market accessibility, Karai stands at a great advantage, owing to the fact that the area is closely situated to Nairobi, the

urban consuming area. There is substantial rate in population growth in these areas. The demand for agricultural products is therefore buoyant. Marketing of local products is extremely diverse, ranging from interhousehold exchange, through local markets, to town markets, and even to Nairobi.

With respect to prices, the local situation is less comfortable, as these are entirely determined by the market. In Kenya there is no Government organization active in buying perennial products, such as coffee or tea, against guaranteed market prices. Local scarcities of timber, fuelwood, poles, fruits etc. which differ from province to province within the country, are critical to the economics and adoption of agroforestry. The higher the prices that often accompany scarcity and correspondingly higher profits, the more incentive for farmers to turn to agroforestry. Including trees in agricultural systems, therefore, makes tree, crop and livestock systems less sensitive to changes in yield and prices and improves overall profitabilities.

5. Conclusion and Recommendations

5.1. Conclusions

It is clear from the introductory part of this paper that Kenyan agriculture including that in Karai, suffers from land degradation; i.e. degradation of the ecosystem. This paper views problem identification and priority setting by consensus of the community as crucial. It is the role of indigenous knowledge to help design technologies that are cost effective, relevant and easily adoptable. Without participation by local people unhealthy ecosystems can not be made healthy. Farming systems survey and analysis clearly show the great potential and challenge of agroforestry in the area. Farmers in Karai are interested in cultivating exotic species on their farms. The most preferred species in the area were *Grevillea robusta, Eucalyptus saligna, Casuarina equisitifolia, Leucaena leucocephala, Calliandra calothyrsus* and *Sesbania sesban*. Hence these species should be the ones to focus research on.

Willingness of a majority of farmers in planting more on farm boundaries and on degraded lands on an individual basis is the great potential; drought, pests and diseases are some of the major obstacles that have to be overcome. The agroforestry approach of incorporating "scientifically approved" multipurpose trees of the farmers' own preferences into the existing landuse systems producing vital farmer needs (fuelwood, timber, soil fertility maintenance etc.) is appropriate for the area. Shortages of fodder in the dry season were expressed by some farmers in the area. Shortages are due to bushfires, lack of storage facilities and lack of knowhow on pasture and establishment and management. It was felt that any intervention to increase fodder production and conservation without introducing significant competition for land and/-or with food crops for humans should be a viable option.

An inadequate extension service/support was an influencing factor reported by few farmers. An effective forestry extension could also bring people onto common ground with respect to incorporating trees into their land use systems. Farmer education on management and conservation techniques will enhance adoption of proposed technologies. In order to arrive at a successful implementation of afforestation and tree planting, forest-related development programmes should be preceded by detailed analysis and be responsive to local people's priorities (Fanzel et al. 1996, Wiersum 1996) and capacities. They should also ensure freedom of tree species selection and, as a whole, be based on community consensus and participation. In selecting tree species, care should be taken to include multipurpose trees that would meet at least one of the high-priority needs (e.g. fuelwood) but that would also provide protective functions. This would be a more effective strategy than trying to persuade people to grow trees solely for service functions (Wiersum 1996). It is therefore a matter of extreme urgency to design appropriate technologies and to grow the appropriate trees that will simultaneously restore the environment, conserve the forests, generate income for resource-poor farmers, catalyse more sustainable land-use practices and enhance increased and sustained food production. The consequences of failing to do so will be disastrous both to the people of Karai and to the people of the adjoining plains and/or hills. Damage to the national economy will be enormous.

5.2. Recommendations

1. Adopt priority species: it is important for the agroforestry institutions to thoroughly screen the multipurpose tree species most adaptable to the area;
2. The agroforestry interventions must be tried out with a few farmers before involving the whole community and that farmers develop a monitoring system within their means that is effective in assessing the performance of these technologies;
3. By operating cooperatives, better market prices may be bargained and access to government services may be easier;
4. More water projects are needed in the division; hence, the government of Kenya must assist to foster the move to introduce water projects in the area.

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