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MEDICINAL TREES IN SMALLHOLDER AGROFORESTRY SYSTEMS: ASSESSING SOME FACTORS INFLUENCING CULTIVATION BY FARMERS EAST OF MT KENYA

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Dedication

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Abstract (English)

Low health standards in the developing world call for multifaceted health management approaches which include traditional medicine. Traditional medicine in Africa, often self administered but mostly relying on consulting traditional healers (herbalists), derives *materia medica* mainly from medicinal plants. Trees constitute about 75% of these plants but many useful species are threatened in natural forests due to rising demand and competing land uses. Farm lands present the new frontiers to conserve these species as part of tropical agroforestry systems. Rising trade in medicinal plant products can also provide an extra source of income when farmers are linked to markets. However smallholder farmers are faced with multiple production constraints, especially diminishing farm sizes and success of medicinal tree conservation on farms will depend on several factors. The main objective of this study, therefore, was to investigate the influence of farmers„ knowledge of species„ medicinal value, access to herbal medicinal product markets, availability of tree planting materials and knowledge of cultivation ecology on medicinal tree cultivation.

The study was conducted in the Mt. Kenya East area of Kenya and used survey method to generate data. First, 200 farmers, 60 herbalists, 60 tree nursery operators and 55 urban herbal medicine traders were interviewed on their perspectives on medicinal tree cultivation. An ecological survey was later conducted to determine the abundance of priority medicinal tree species in natural forests, farms and herbalist gardens. Data was analyzed through SPSS for interview responses and BiodiversityR for species abundance details. ANOVA was used to interpret differences in perspectives of respondents in socio-demographic categories (gender, age and level of education attained) and the districts where they came from.

Results showed that farmers and herbalists had established many medicinal species in their farms but less than thirty were highly preferred and present in many farms. Farmers were mostly influenced by knowledge of medicinal value of a species and availabilty of markets for medicinal tree products when planting or saving species in their farms. Herbalists considered species that treated many diseases and were getting scarce as the highest priority for cultivation. Farmers' knowledge of medicinal species increased with age of respondent and decreased with level of education attained. Farmers from Mbeere district knew more medicinal tree species than those from Embu and Meru central districts. The knowledge was passed on from older relatives and only a quarter of farmers had learned about use of medicinal trees from herbalists. Knowledge of medicinal species associated strongly with the number of medicinal tree species present in farms but less strongly with the number of species that farmers had deliberately planted.

Interviews with traders portrayed a rising trade in medicinal tree products, with many indigenous species sourced from the wild. The preference of forest to farm sourced herbal

material was not associated with the ecological conditions of the source and there was likelihood for many traders, especially those involved in production of retailable herbal products, to use more of farm grown plants in future. Availing more medicinal tree species„ seedlings in tree nurseries would not raise the cultivation levels of medicinal trees, especially when farmers had poor access to product markets and the seedlings were offered at a price. Highly preferred species were found to be more abundant in herbalist gardens than forests and other farms. The trees had also been recently planted showing a trend of increased planting of priority medicinal plant species by herbalists as the species became increasingly scarce in forests.

Through matrix ranking, the study recommended at least twenty species for which domestication efforts and/or levels of cultivation need to be enhanced. The following actions were also recommended in order to increase farmer's cultivation of medicinal tree species. (i) Engaging herbalists and nursery operators in sharing information on priority species medicinal value with farmers. (ii) Medicinal plant product market development and linking farmers to markets. (iii) Pursuit of policies that promote cultivation and discourage wild collection of herbal medicine material from the forests. (iv) Participatory germplasm conservation and production involving herbalists, tree nursery operators and farming communities. And (v) Pursuit of policies that develop arid areas as future sources of medicinal trees.

Key words: Smallholder farms, medicinal trees, traditional medicine, herbalists, markets, tree nurseries, species abundance

Abstract (German)

Niedrige Gesundheitsstandards in Entwicklungsländern erfordern mannigfaltige Gesundheits-Management-Methoden, die auch die traditionelle Medizin einschließen. Traditionelle Medizin wird in Afrika oft in Selbstmedikation oder durch traditionelle Heiler verabreicht. Als Rohstoffe (*materia medica*) dienen meist Medizinalpflanzen, von denen etwa 75 % zu den holzigen Arten gehören. Viele dieser Nutzbaumarten sind allerdings in ihrem natürlichen Habitat, dem Wald, wegen steigender Nachfrage und konkurrierender Flächennutzung bedroht. Der Anbau von Medizinalbäumen in Agroforstsystemen erschließt eine neue Möglichkeit, zum Erhalt dieser Arten beizutragen. Der zunehmende Handel mit Heilpflanzen-Produkten bietet den Landwirten bei gutem Marktzugang auch eine zusätzliche Einnahmequelle. Allerdings sind Kleinbauern mit vielfältigen Problemen bei der Heilpflanzen-Produktion konfrontiert. Vor allem schränkt die abnehmende Größe der Wirtschaftsflächen den Anbau von Medizinalbäumen ein. Der Erfolg der Arterhaltung von medizinisch nutzbaren Baumarten in landwirtschaftlichen Systemen hängt von mehreren Faktoren ab. Die vorliegende Studie hatte zum Hauptziel, den Einfluss der folgenden Faktoren auf den Anbau von Medizinalbäumen zu untersuchen: Umfang des traditionellen Wissens von Bauern zum medizinischen Wert der Baumarten, Zugang zu Märkten für pflanzliche Arzneimittel, Verfügbarkeit von Setzlingen und Anbaukenntnisse.

Die Studie wurde im Osten des Mt. Kenia durchgeführt. In Umfragen wurden zunächst 200 Bauern, 60 traditionelle Heiler, 60 Baumschulenbesitzer und 55 städtische Kräutermedizin-Händler zu ihrer Meinung über den Anbau von Medizinalbäumen befragt. Später wurde eine Arteninventur der wichtigsten Medizinalbäume und ihrer Abundanz in natürlichen Wäldern, auf landwirtschaftlichen Nutzflächen und in den Gärten traditioneller Heiler durchgeführt. Interview-Daten wurden mittels SPSS, Arteninventur-Daten mit Hilfe von BiodiversityR ausgewertet. Mittels ANOVA wurden die Interviewergebnisse auf signifikante Unterschiede in Bezug auf sozio-demografische Charakteristika der Befragten wie Geschlecht, Alter, Bildungsgrad und Herkunftsbezirk analysiert.

Die Ergebnisse zeigten, dass die Landwirte und traditionelle Heiler zwar viele Medizinalarten in ihren Gärten und landwirtschaftlichen Nutzflächen kultivieren, jedoch waren weniger als dreißig Arten stark bevorzugt und in vielen Betrieben angebaut. Die befragten Bauern gaben an, dass sie hauptsächlich solche Arten kultivierten, von denen sie den medizinischen Wert genau kannten oder die einen hohen Marktwert hatten. Traditionelle Heiler bauten dagegen hauptsächlich solche Arten an, mit denen viele Krankheiten behandelt werden konnten oder die immer schwieriger in den natürlichen Habitaten zu finden waren. Das Wissen der Bauern über Heilpflanzen war positiv mit dem Alter der Befragten und negativ mit ihrem Bildungsgrad korreliert. Bauern aus dem Mbeere-Bezirk verfügten über ein größeres

Medizinalartenwissen als Bauern aus den anderen Bezirken. Das Wissen wurde zumeist von älteren Verwandten weitergegeben. Lediglich ein Viertel der Bauern hatte Wissen über die Verwendung von Medizinalbäumen von traditionellen Heilern erworben. Der Umfang der Medizinalarten-Kenntnisse war deutlich korreliert mit der Anzahl der Medizinalbaumarten auf dem jeweiligen landwirtschaftlichen Betrieb, aber weniger stark mit der Anzahl der Arten, die der jeweilige Bauern bewusst angepflanzt hatten.

Die befragten Händler erwähnten einen steigenden Umsatz von Medizinalbaum-Produkten. Material von einheimischen Arten wurde zumeist in den natürlichen Habitaten gesammelt. Diese Bevorzugung von Wildsammlungen wurde allerdings nicht mit den möglicherweise vorteilhaften ökologischen Bedingungen der natürlichen Habitate begründet. Viele Händler, vor allem die Einzelhändler, erwähnten, dass sie in Zukunft häufiger Material von angebauten statt wildwachsenden Medizinalbäumen verwenden werden. Ein besseres Angebot von Setzlingen verschiedener Medizinalbaumarten in Baumschulen würde die Anbaufrequenz dieser Arten laut Aussage der Befragten nicht erhöhen, vor allem nicht, wenn der Marktzugang für Produzenten schlecht ist und die Sämlinge verkauft statt verschenkt werden. Die am meisten bevorzugten Arten wurden häufiger in den Gärten der traditionellen Heiler als in den natürlichen Habitaten oder auf landwirtschaftlichen Nutzflächen gefunden. Die Tatsache, dass viele der Medizinalbäume von den Heilern erst vor kurzem gepflanzt worden waren, deutet auf einen Trend zum verstärkten Anbau dieser Arten in Zukunft hin, besonders in Bezug auf solche Arten, die in den natürlichen Habitaten immer seltener werden.

Mittels Matrix-Ranking wurden in dieser Studie zwanzig Arten ausgewählt, die für eine Domestikation sowie den verstärkten Anbau empfohlen werden können. Außerdem sollten die folgenden Maßnahmen ergriffen werden, um den Anbau von Medizinalbaumarten generell zu steigern: (i) Förderung des Wissenstransfers in Bezug auf die wichtigsten Medizinalbaumarten von traditionellen Heilern und Baumschul-Betreibern zu den Bauern. (ii) Weiterentwicklung des Marktes für Heilpflanzenprodukte und der Verbindungen zwischen Landwirten und Märkten. (iii) Stärkung von politischen Vorgehensweisen zur Förderung des Medizinalbaum-Anbaus auf landwirtschaftlichen Betrieben und zur Reduzierung der Wildsammlungen. (iv) Förderung von partizipativen Arterhaltungsmassnahmen und der Produktion von Sämlingen unter Einbindung von traditionellen Heilern, Baumschul-Betreibern und bäuerlichen Gemeinschaften. Und (v) Stärkung von politischen Vorgehensweisen zur Entwicklung von ariden Gebieten als zukünftige Quelle für Medizinalbaumprodukte.

Schlüsselwörter: kleinbäuerliche Betriebe, Medizinalbäume, traditionelle Medizin, traditionelle Heiler, Märkte, Baumschulen, Arten-Abundanz

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1 Introduction

1.1 The problem of health in Africa

Despite impressive economic growth observed globally in the last few decades about 21 per cent of the world population remains poor, subsisting on less than one dollar per day, until recently, the internationally recognized absolute poverty threshold (Wolz, 2005). The majority of the poor are in the tropics with Africa being the poorest continent, where at least 46% of the population subsists on less than one dollar per day (Magrath, 2006). Poverty and health have a vicious cycle kind of a relationship. Poor people are unable to adequately access modern methods of both preventive and curative measures of disease control while ill health results in low labour productivity and high rates of mortality implying that people do not live according to their physical and intellectual potential (Wolz, 2005). Research shows that households are being forced into deeper poverty when faced with substantial medical expenses and loss of household income due to ill-health (Russell, 2004 and McIntyre *et al*., 2006). Mango *et al.,* (2009) found that 40% of households in 71 Kenyan communities had become poorer between 1990 and 2005 due to health and medical expense related issues. A further 26% had become poor due to the death of the major bread winner also a health related factor. It is possibly due to this kind of relationship that health has featured prominently among the millennium development goals (MDGs) with goals 4, 5 and 6 directly relating to health (United Nations, 2008).

A big proportion of the population in Africa is unable to afford modern medicine either due to the high costs of drugs or poor infrastructure (Patwardhan, 2005; Ruxin *et al.,* 2005). For instance in a study done in Kenya (MoH, 2003), 23% of people reported to have been ill but did not seek health care service. Many of the respondents who were sick but did not seek health services were hindered by either the cost of medicine (44%) or the long distance to a health facility (18%). Derriennic and Mensah (2003), reported that only 32-53% of malaria patients in Uganda could pay for modern drugs despite the low or moderate pricing of malaria remedies. In the same country (Uganda), thirty percent of communities did not have access to roads that were passable in the dry season while two thirds of the communities lacked any bus or taxi connections by 2005 (Salami *et al*., 2010).

Developing countries have performed dismally in meeting health related MDGs with Africa predicted to have fallen far behind by the target year 2015 (United Nations, 2008). A child born in the developing world is over 13 times more likely to die within the first five years of life than one born in an industrialized country. Sub-Saharan Africa accounts for more than half of these deaths (United Nations, 2008). Health insurance is also out of reach for majority of the rural population with only 7% rural area coverage compared to 18% in the urban population

of Kenya. Yet Kenya has among the best health related socio-economic indicators in the Eastern Africa region (Table 1). A high shortage of medical staff in public health facilities in many Sub-Saharan Africa countries (Smith and Henderson-Andrade, 2006; Chankova *et al*., 2009; Kober and Van Damme, 2006) also serves to make the situation worse such that even those who visit the health facilities are not assured of adequate service. Kulindwa et al (2006) estimated that 23,000 health-care professional emigrate annually from Africa.

Table 1: Selected health and economic indicators for selected Eastern Africa countries in comparison with Austria

Indicator	Austria	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Population (est. 2010) million	8.4	79.5	38.6	15.6	10.4	43.2	31.8	13.3
GDP (US$) billions (2009)	384,908	28,537	30,200	4,975	5,064	21,623	15,736	12,748
GDP per capita US$ (2009)	38,748	936	1,572	859	1,071	1,358	1,219	1,431
Infant mortality rate (IMR) per 1000 births (2009)	4.4	86.9	64.4	89.4	112.4	72.6	76.9	92.7
Under five mortality rate (U5MR) per 1000 births (2009)	5.4	145.3	104.1	131.8	187.8	118.4	127.4	157.0
Maternal mortality rate (MMR) per 100,000 live births (1999)	NA	870	590	1100	1100	530	510	650
Total fertility rate (2005 - 2010)	1.42	5.29	4.96	5.59	5.92	5.16	6.46	5.18
Literacy rate (2007/8)	99.0	35.9	73.6	71.8	64.9	72.3	73.6	70.6
Life expectancy - years (2005-2010)	79.8	52.9	54.1	48.3	46.2	52.5	51.5	42.4
Contraceptive use (%) (1999)	NA	8	39	31	13	25	23	25

Sources: 1. CIA World Factbook; 2. Wikipedia; 3. MoH Kenya, 2003*; 4.* www.nationmaster.com

NA. Not available

Apart from failure to access already available medicine, a category of diseases with minimum investment in modern drug development due to low profit prospects also exists among poor rural communities in the developing countries. Appropriately named neglected diseases, this disease category lacks modern treatment and continues to either maim or lower the productivity potential of a big section of the developing world population especially in Africa (Hotez and Kamath, 2009) and alternative (non-conventional) methods of treatment ought to be promoted (Adolfo, 2005). In addition, new strains of diseases and rising cases of pathogen resistance to conventional drugs as is the case for malaria call for new ways of treatment (Simons *et al*., 2006).

1.2 Traditional medicine and medicinal plants

To address the above challenges, there is increased focus by leading health research and management organizations led by the World Health Organisation (WHO), on diversified

healthcare systems in management and treatment of many diseases/syndromes that have global economic importance such as HIV/AIDS, tuberculosis, cancers and malaria (NIAID, 2001; African Union, 2003; Ruxin *et al.,* 2005). The role of traditional medicine in maintaining good health in the developing world has been seen to be significant (Elujoba *et al*., 2005). The practice has maintained popularity in all developing regions and is increasingly being used in the developed countries (Wei, undated). The increased global interest in traditional medicine has led to calls for its protection with China and India leading in policy processes that will protect their indigenous medical knowledge (Abbott, 2009). Close to one hundred countries have also initiated policy processes for the regulation and development of traditional medicine within their populations. Unconfirmed estimates by the World Health Organization (WHO), indicate that across Africa, close to 80% of the population relies on traditional medicines (WHO, 2002). Empirical studies also report a close trend of consumption with 72% of black South Africans and 68% of Ethiopians found to use traditional medicine (Mander *et al.,* 2007). Estimates also show that ratios of traditional medicine practitioners to the local population are much higher than that of formal doctors in many African countries (Cunningham 1993; Conserve Africa, 2004).

Medicinal plants, a majority of which are perennial (trees and shrubs), are the biggest component of African traditional medicine (Barnett, 2000; Rukangira, 2000). Traditional remedies also represent „leads' that have contributed immensely to the discovery of many modern medicines from plants (Hostettmann *et al.,* 2000; Verpoorte *et al.,* 2006). However medicinal plants constitute an important component of natural biodiversity and have historically been wild harvested (Cunningham, 1993; Rao *et al.,* 2004). For instance 90% of the medicinal plants identified in Mana Angetu, Ethiopia, were only collected from the wild and only 6% were in cultivation with rest being in both the wild and cultivation (Lulekal *et al.,* 2008). The global transition of almost all cultures from subsistence towards cash based economies has however challenged traditional resource management strategies such as the ones listed by Cunningham (1993) and Kala (2010) and many ecosystems that appeared resilient in the past are now threatened with degradation. Widespread biodiversity loss poses a threat to, not only the survival of traditional medical practices but also upsets human health in general by affecting the natural equilibrium that exists between hosts, vectors and parasites in plants, animals and humans (Alves and Rosa, 2007). Diseases such as malaria and leishmaniasis are known to have increased infection rates due to upsetting of this equilibrium, especially through deforestation, in addition to loss of potential drug sources (Colfer *et al.,* 2006). Climate change is also contributing to worsening disease regimes in many regions of the world (Costello *et al.,* 2009) as well as altering patterns of distribution of plants, pathogens and vectors (Backlund, 2008).

While agriculture plays a major role in maintaining rural economies in developing countries (Wolz, 2005), crop cultivation has contributed enormously to deforestation and loss of biodiversity in general. Dixon *et al*. (2001), reported the area under cultivation as having been increasing in the Sub-Saharan Africa by 0.73% per annum from 1961 to 1997 and an increasing pastoral and grazing area in the developing world at 15% per annum in the same period. Forest and woodlands bore the cost of this increase with an estimated decline of about 2.3 billion ha over the same period in the developing world. FAO statistics indicate that forests have fallen below ten percent of the total land in most of Eastern Africa countries (Table 2) and with this, a significant portion of medicinal plant material sources has been lost.

Table 2: Proportion of forest and other wooded land in selected Eastern Africa countries in comparison with Austria (2005 status)

	Country area (x1000 hectares)							
FRA categories	Austria	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Forest*	3862	13000	3522	3402	480	35257	3627	42452
Forest and other wooded land	3980	57650	38442	3402	541	40013	4777	45613
Other land	4293	51981	18472	6006	1926	48346	14933	28726
Total land area	8273	109631	56914	9408	2467	88359	19710	74339
Inland water bodies	113	799	1123	2440	167	6150	4394	922
Total area of country	8386	110430	58037	11848	2634	94509	24104	75261
% forest of total land area	46.7	11.9	6.2	36.2	19.5	39.9	18.4	57.1
% forest of total area of country	46.1	11.8	6.1	28.7	18.2	37.3	15.0	56.4

* This is the area that is gazetted as forest land but may not necessarily be under forests e.g. in Kenya, more than 65% the forest land is already lost to other land uses and forests occupy less than 2.5% of the land. (Holding *et al.,* 2001)

Adapted from: FAO, Global Forest Resources Assessment, 2005

Most medicinal plants are perennial trees and shrubs with long rotations and often have other competing uses. They thus often suffer greater losses and less replacement in agricultural lands than herbaceous plants. Some of these tree species are endemic in African ecosystems as shown in Table 3 and need to be conserved (Cunningham, 1993). In many cases these plants only remain in patches of remaining natural vegetation created from clearing large tracts of land for agriculture (Barrance *et al.,* 2009; Scholes *et al.,* 2006; Maitima *et al.,* 2009). Medicinal plants in these islands then face over-exploitation and threats of extinction due to greater anthropogenic disturbance caused by intensified harvesting within these fragments to satisfy increasing demand (Cayuela *et al.,* 2006). Indeed, Schipmann *et al.* (2006), estimated about 15,000 medicinal and aromatic plants (MAPS) to be threatened, to some degree, globally.

Table 3: The biodiversity features of Eastern Africa region

Country	Area Km^2	Biodiversity opportunity						Threat % of land transformed	Response % of land protected
		Mammals		Birds		Plants			
		Endemic	Total	Endemic	Total	Endemic	Total		
Burundi	27 830	0	107	0	451	not known	2 500	37	5
Djibouti	23 200	0	61	1	126	6	826	1	1
Eritrea	117 600	0	112	0	319	not known	not known	19	4
Ethiopia	1 104 300	31	277	28	626	1 000	6 603	39	5
Kenya	580 370	23	359	9	844	265	6 506	13	6
Rwanda	26 340	0	151	0	513	26	2 288	52	8
Somalia	637 660	12	171	11	422	500	3 028	6	0
Uganda	241 040	6	345	3	830	not known	4 900	36	7
All countries	2 758 340	72		52		1 797		24	4

Source: Scholes *et al.,* 2006

In tandem with dwindling supply of plant materials is the fragile knowledge base associated with medicinal plants is getting eroded. Traditional herbal medicine relies on availability and access to resources as well as the knowledge to use it. This knowledge can be either self treatment therapies or treatment administered by a specialist (herbalist), but it is not as codified for the African and Latin American medicinal plants as compared to that for Asia (Rao *et al.,* 2004). It is also often underground due to repressive colonial associations with witchcraft, or undue social influence that hitherto remains somewhat hard to change (Cunningham, 1993). Traditional health practitioners (THPs or herbalists) continue to die with the knowledge and the scale of passing the knowledge remains low due to poor policy incentives by current governments. This knowledge is not only the basis for African traditional health systems but has also contributed immensely to the development of modern medicine through development of drugs from African plants (Hostettmann *et al.,* 2000). A great potential still remains to develop new drugs if sustainable utilization of these plants can be assured together with increased availability as the demand increases (ibid).

With increasing use of medicinal plants for both traditional medicine and industrial purposes, trade in the plants has been rising at both local and international markets causing increased demand and hence more pressure on natural resources (Kuipers, 1997; Rao *et al.,* 2004). From an estimated US$ 6 billion at the turn of the century (Schipmann *et al.,* 2006), the present global trade in medicinal plants is about US$ 14 billion per year. The trade is estimated to grow at annual rate of 25% and is likely to increase to more than US$ 5 trillion by 2050 (Kala, 2010). Tropical farmers can benefit from this trade through cultivation of both herbs and trees which have market value even when they do not use them in self-administered therapies. However, even though the medicinal plant markets especially in Europe report high volumes of raw material from cultivated plants, the number of species involved is very low and majority of them are lower plants (herbs and shrubs; Rao *et al.,* 2004; Schipmann *et al.,* 2006). Cultivation of majority of these herbs in European countries

such as Germany (Kathe *et al.,* 2002) is also denying Africa opportunities to benefit from this economic activity due to failure to domesticate endemic African species with proven medicinal potential.

Cultivating medicinal plants within farming landscapes or on community land is one way to protect and sustain traditional medicinal practices while conserving natural biodiversity. Medicinal plants also have potential to offer other socio-economic benefits especially in dry lands such as income generation and ecosystem stabilization (Lambert *et al*., 2005). The scale of cultivation has however been low especially for tree species, which constitute about two-thirds of all medicinal plants (Rukangira, 2000; Lengkeek, 2004). While natural resources continue to be depleted there seems to be preference by herbalists and other market players for wild collected materials as compared to cultivated material. Herbalists in Kenya and even other parts of the developing world have been observed to attempt cultivation of medicinal herbs but rarely higher plants although they have to travel long distances to access material for their practices (Kisangau and Kokwaro, 2004; Mander, 1998; Shanley and Luz, 2003). Efforts by traditional health practitioners (THPs) to raise tree nurseries and cultivate trees in highly diversified herbal gardens are increasing appreciably. This is however set back by poor organization among them which sometimes tends to counter productivity. In South Africa some THPs were reportedly mocked by counterparts for cultivating medicinal plants when they could harvest from the wild and they lost substantial social capital due to their failure to organize a joint project (Botha *et al.,* 2007[a])

1.3 Research focus

A lot of research on medicinal plants has tended to be divided either into the plant focus or the disease focus and few integrated research efforts exist. In plant focus research, ethno botanical efforts have been geared towards identifying the plants used by communities as medicinal plants in general and what diseases they treat (for example, Giday et al., 2003; Owuor *et al.,* 2006; and Bussmann, 2006; among others) without investigating the socio-economic importance of those diseases at the community level. Cunningham (2001), observed that ethno botanical studies are more about ecology with an economic motivation and ignore cultural and socio-economic issues that affect conservation. Recently, however, several studies have incorporated adoption potential (Pattanayak *et al.,* 2003) and marketing of medicinal tree products especially in Southern Africa, India and other regions.

The disease focused research looks at certain diseases that are perceived to be of great socioeconomic importance at the macro-level (national and continental) such as malaria, TB and HIV/AIDS and what methods are used to treat or manage them (for example, Willcox *et al.,* 2004). Local perceptions on the socioeconomic importance of the diseases and how this

influences conservation of local treatment resources have not been adequately studied. There is a disconnect therefore between the plants and disease research which fails to attach great importance to community conservation and possible cultivation of the trees. This is one of the gaps that this study aimed to fill.

Tree cultivation is enhanced by domestication of wild species which Simons and Leakey (2004), define as an "accelerated and human induced evolution to bring species into wider cultivation through a farmer-driven or market-led process involving the identification, production, management, and adoption of high quality germplasm in a science-based and iterative procedure". Rao *et al.* (2004), outlined some steps needed for research towards successful cultivation of medicinal and aromatic plants. The first step they recommended was to establish priority species based on participatory surveys and market analysis involving rural people, traditional healers, material collectors and drug industry. This implies that successful domestication must take into account the farmers' and market players' perspectives. As traditional medicine knowledge is not significantly shared by the practitioners with other stakeholders and markets are poorly defined, farmers lack methods to determine priority species to cultivate for socio-economic gains. Farmers thus do not know which germplasm (species or provenances) to grow, where or how to grow it.

This study aimed to test whether the scale of cultivation increases when farmers perceive the benefits of cultivation of medicinal trees by relating important species with local disease threats which could create local demand and market potential. The approach of this project was to investigate both perceived economic importance of diseases and cultivation of medicinal trees. Increased cultivation due to perceived economic importance of some diseases and limited access to alternative curative measures would imply need for high quality germplasm by farmers. Consequently identification of appropriate germplasm delivery pathways and ecology-based cultivation technologies for medicinal tree species on cultivation was also assessed. An anticipated output was an indication of priority medicinal species for cultivation at the local community level, the constraints to planting the preferred species and possible research and development interventions.

1.4 Study objectives

The main objective of the study was to explore the scope for accelerated medicinal species domestication through participatory methods by assessing factors that influence farmer adoption. The factors assessed include the effect of germplasm availability, perceived economic importance of disease, species ecological requirements and availability of markets for medicinal trees products on the efforts by farmers to cultivate medicinal trees species. To achieve this, the study pursued the specific objectives below.

1. To collate the perspectives of farmers and herbalists on the factors influencing their preference and cultivation of tree species with medicinal value
2. To assess the influence of local disease burden perception and knowledge of herbal treatment on the efforts by farmers and herbalists to cultivate medicinal trees
3. To explore the contribution of farm grown herbal material to medicinal tree product markets and its effect on medicinal tree cultivation
4. To explore how germplasm access by farmers and on-farm tree nurseries influence medicinal tree cultivation
5. To explore motivational drivers of cultivation and the scope for herbalists' and traders' utilization of farm produced medicinal tree products

1.5 Theoretical framework and hypothesis

Due to the intricate nature of traditional medicine, agroforestry systems and trade in non-timber forest products, this research did not attempt to hinge on a single theory but drew from a number of them, more so as applied by other authors. There was a general founding on the farming systems theory which is based on the systems theory, a tool that is applicable to any study subject (Ray, 2000). However analysis mainly dwelt on induced innovation theory with a bit of it based on the livelihood analysis theory. A discourse on these three theories is done briefly below followed by an explanation on the drawing of hypothesis for this study from the theories.

1.5.1 Systems theory

A farming system is defined as a decision-making and land-use unit, consisting of the farm household, cropping, and livestock systems that produces crop and animal products for consumption and sale (Ker, 1995). It is a complicated interwoven mesh of resources and factors (agronomic, economic, social, cultural, and physical, among others) which are managed to a greater or lesser extent by the farmer (Hansen, 1981). The system is defined by socioeconomic boundaries which determine the people who are involved in farming (the farm household), as well as all the resources and inputs, capital, and information managed

by the farm household and the farm physical boundaries. These boundaries can be difficult to define in shifting cultivation systems and where the farm household may consist of several units of the extended family. In many cases other neighbouring households may also be units of the same family, and may share resources, labour, and so on (Salami *et al.,* 2010). In system analysis, the structure and functions of the system are studied as well as the dynamic aspects which depict how the system is evolving, including its components and interactions (FAO, 2005).

Ker (1995) described a farm as an ecosystem managed by farmers in which case it is viewed as both an ecosystem and an independent unit of economic activity. It is an anthropological modification of the natural system which, untouched by man, would be a steady state climax with a "zonal" type of vegetation typical for the given natural conditions but relatively unproductive in terms of human objectives. Farming therefore is an attempt by man to produce a more productive but unstable "state", through application of farm inputs (tillage, fertilizers, weeding, etc.), guided by technological development as an effort to prevent the new state from declining towards an unproductive low-level steady state. The farmer„s unique understanding and interpretation of the immediate environment (both natural and socio-economic) is instrumental in creating the farming system (Hansen, 1981). Pressure from limited land access, due to population increase forces farmers towards intensification so as to raise productivity of smaller units of production (Netting, 1993; Stone, 2001). Agroforestry systems are ecologically beneficial forms of this intensification which involve growing woody herbaceous species and perennials in association with food crops and livestock on the same piece of land (Leakey, 2010). The systems are mainly practiced by smallholder farmers who have been observed to achieve higher productivity per unit area than large producers worldwide due to their use of intensification, intercropping and higher labour inputs (Hazell *et al.,* 2007; Cook, 2009).

Systems involve an arrangement of components and subsystems (structure) that interact in some process that transforms inputs into outputs (function). Essentially all relevant interactions and feedbacks should be included, so that all those components that are capable of reacting as a whole to external stimuli form a system, but boundaries can be difficult to define in complex systems (Ker, 1995). Thus in this research medicinal trees in the farm were taken as a sub-system within the farm (agroforestry) system that has been of little relative importance to the farmers but whose importance can change. The study focused on how the subsystem is likely to respond to external factors relevant to it.

The general hypothesis based on the systems theory therefore was that:-

> *The level of medicinal tree cultivation or conservation in farms (Mc), is a factor of local perception of disease burden and appropriate knowledge on use of medicinal trees (dk), germplasm availability (g), species ecology (e – climate, soil and competition), and availability of market for medicinal tree products (m) and other unaccounted factors (≺).* Fig 1.2 shows the conceptualization of these factors.

$$Mc = f(g, e, dk, m, \prec)$$

1.5.2 Livelihood analysis theory

A livelihood consists of the capabilities, assets (both material and social resources) and activities required to make a living (Carney, 1998). Even with markets and other external factors inducing changes in farmers' practices, not all farmers have profit objectives for every farm activity (Shiferaw *et al.,* 2009). Earlier concepts of smallholder farming actually referred to it interchangeably with subsistence farming (Morton, 2007). Barnett,1997 defined subsistence farming as "farming and associated activities which together form a livelihood strategy where the main output is consumed directly, where there are few, if any, purchased inputs and where only a minor proportion of output is marketed". Lately however the interaction of the smallholder farmers with market to generate income and access goods that they cannot produce in their fields is being appreciated (Netting, 1993; Morton, 2007). The livelihood analysis theory assumes a household to have multiple objectives which include security of food and essential subsistence goods and social security (secure access to subsistence goods and resources). The farmer or farm family attempts to increase or maximize the farm household utility (broad range of satisfactions) within a given context of accepted preferences, aspirations and socio-economic conditions (Hansen, 1981).

Agroforestry practices that provide returns to production factors in a way superior to the available alternatives or more cost-effectively are likely to be adopted by farmers (Scherr, 1995). Raintree (2005) drew the basic elements of a livelihood analysis approach explaining that households organize the means of production in order to meet the basic needs of a household economy. The basic needs of the households are supplied by the „basic needs supply systems," each of which is composed of a number of „production sub-systems' (Figure 1). Medicine is one household need that can be met by use of either medicinal trees or alternative healthcare which needs to be paid for. The farmer saves income by use of farm grown medicinal trees but consumes income when alternative healthcare is paid for. As the farming system is determined by the farmer's attempt to cope with the anticipated environment (Hansen, 1981), incorporating medicinal plants in rural smallholder farms is expected as a response to declining sources of these plants in the wild, if farmers choose to use the species for health management.

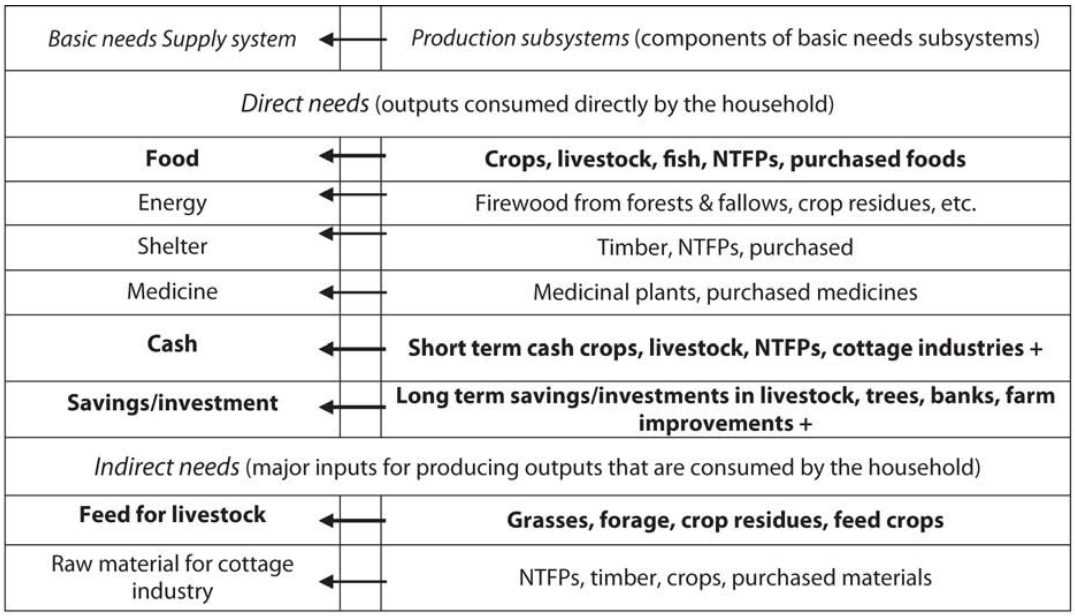


Figure 1: Household livelihood systems – diagnostic results from Lao PDR (*Source: Raintree, 2005)*

Under the livelihood strategies theory, the study hypothesized that:-

> *Unless a farmer perceives a medicinal tree species to be useful in the treatment of diseases that are of great socio-economic importance then there is no incentive to plant or conserve the species if no market demand exists for the products of the species*

1.5.3 Induced innovation theory

The theory of induced innovation posits that technological developments are applied in the goods production process as a response to price movements of the most expensive (limiting) factor of production (Koppel and Oasa, 1987). In natural resources management the induced innovation model projects the total supply of services and products from a given resource as a function of its quantity, quality and productivity of use (CGIAR, 1998). The model assumes that, with increasing population density or market demand, four distinct phases/time periods of management response can be identified; (i) dependence on naturally occurring resources, (ii) a period of resource degradation, (iii) onset of resource rehabilitation occurs with transition to intensive management because the benefits from the investment in resource rehabilitation outweigh the costs, and (iv) dependence on human managed resources (for example agro-forestry, forest plantations and managed reserves - ibid). Thus with limited resources the farmer applies more technological advancements to increase productivity per unit of land, labour and time and maximise on rising prices (Shiferaw *et al.,* 2009).

Smallholder agricultural production has historically been geared towards food security (Tinsley, 2004; Salami *et al.,* 2010) and provision of other household needs such as energy, medicine, and house construction among others, which in most cases was served by trees

(Raintree, 1986; Franzel and Scherr, 2002; Kumar, 2006). Historical developments in agriculture have seen access to land resources decreasing for households and this has been reflected in decreasing fallow periods for land replenishment in addition to decline in forest resources (Raintree, 1986; Marquette, 1997). Smallholders farmers at the last stage of the farming/fallow evolution (continuous cropping with no fallow) manage trees and crops in their fields to meet as many needs as possible through subsistence production and raise income for meeting other needs through the market. Due to the desire to maximise productivity from both trees and crops, there is evidence that trees maintained in farms have been domesticated through historical increases in species selection and management intensity (Maranz and Wiesman, 2003).

The theory of induced innovation points at more intensification efforts being applied by farmers in terms of technical and institutional innovation as a response to increasing land pressures (Scherr, 1995). The balance of management attention given to the different farm components is dynamic and commodity prices play a big role in determining the farmers' focus. Usually whatever component serves subsistence purpose but has a poor market price will be maintained in the farm but may not receive a lot of management attention. For instance, in the Amazonia, farmers were initially collecting forest products such as fruits, timber and medicine for subsistence while engaging in highly intensified production of annual crops for both household consumption and sale (Pinedo-Vasquez, 2000). When market prices for annuals plummeted as forest products were gaining value at the markets, an increase in the number of species and varieties of perennial woody plants was observed in farms. Farmers also changed production technologies in order to favour germination of valuable tree species and opted not to burn the trash while less intensive weeding was done for the crops. Farmers also engaged in other management practices such as transplanting seedlings of valuable species and broadcasting them in the fallows to increase the numbers of those species.

Similarly an evolution was observed on the use of fuelwood by farmers in Siaya and South Nyanza in Western Kenya (Scherr, 1995). From the early reliance on gathering fuelwood from naturally growing trees farmers started to manage naturally germinated trees in farms, then increased the number of trees they let to grow naturally in their farms. Farmers later increased the management intensity of the trees to increase yields and accommodate food and cash crops growing in the same fields. Other observed changes later were increased numbers of trees planted from seedlings procured from nurseries and changes in the farmers' choice of site and planting arrangement. A similar observation was reported by Ite (2005), in Southeast Nigeria, where the availability of markets for tree products, under circumstances of little access to natural forests, made farmers to intensify tree integration in homestead farms. CGIAR (1998) has reported other cases where land-users were observed

to respond to land degradation through other local land-use innovations apart from tree planting.

Under the induced innovation theory, this study hypothesized that:-

> *In an environment of decreasing farm sizes, farmers become more sensitive to tree crop interactions and desire high quality germplasm and a cultivation technology for medicinal trees that maximises benefits from these interactions in agroforestry systems.*

1.5.4 Application of the theories in this study

Smallholder farms constitute a big proportion of agricultural production in the developing world (Kumar, 2006; Cook, 2009; Salami *et al.,* 2010). Multipurpose tree species with medicinal value are found in many of these farms and are managed based on several factors as conceptualised in Figure 2. As a livelihood strategy, farmers save medicinal tree species in their farms for domestic health management. This is however dependent on three conditions; (i) the farmers knowledge of using the plants to treat various diseases, (ii) the herbal materials not being readily available from the wild, and (iii) other means of treating the malady being less effective or less readily available. The more the disease is taken as socio-economically important by the community the more the farmers would want to manage it and reduce the socio-economic costs accrued when the disease attacks. However if wild sources can supply all the herbal materials needed for domestic health management then farmers would not need to conserve medicinal trees in their farms. But if the wild resources are not accessible either due to long distance from villages or due to policies that prohibit access, the farmers plant or manage the useful trees in their farms (Ite, 2005). If medicines are perceived to be more superior to and/or cheaper than herbal treatment then farmers are not motivated to conserve medicinal trees in their farms for household health management.

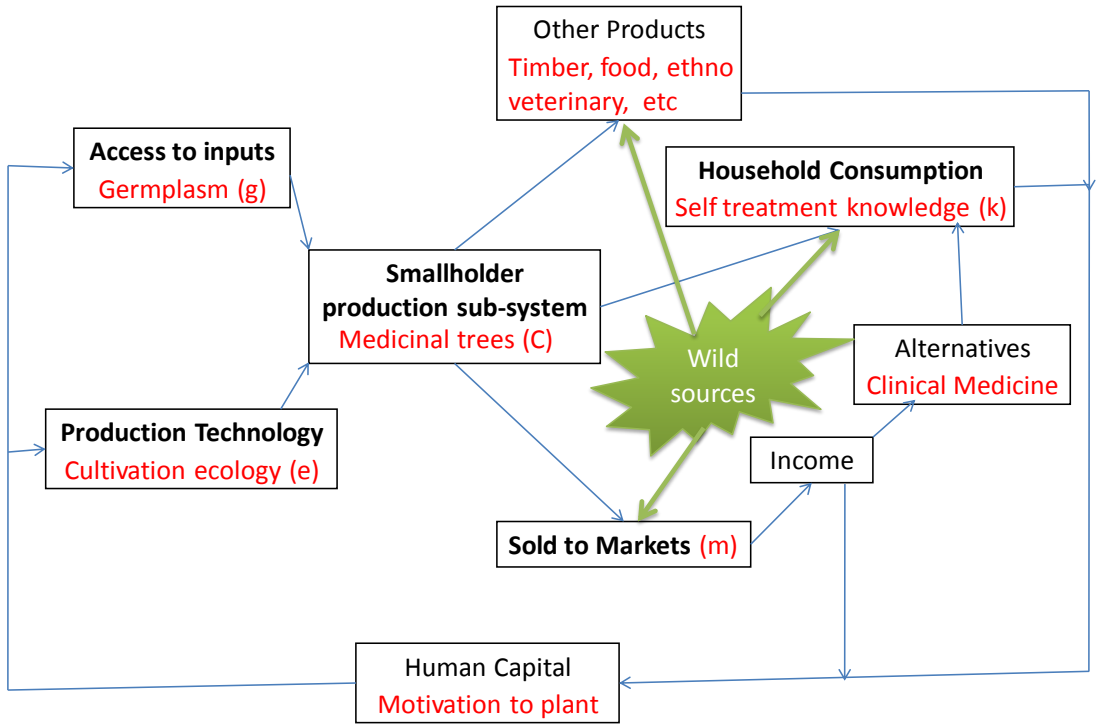


Figure 2: Conceptual framework on medicinal tree production system showing factors that are likely to motivate smallholder farmers to plant medicinal trees

As medicinal trees increase in their importance for community health management, scarcity of the most useful species get scarcer and trade channels are established. Farmers then can grow more trees for household health and for sale of herbal products in order to raise income. The income is then channelled into meeting other household needs or to access health management options that cannot be met by farm grown trees. In deed increased incomes from sale of medicinal trees can lead to reduced use of these species for household health management if conventional medicine is perceived to be of higher quality and financial constraint is the only reason why traditional medicine is used. Salami *et al*., (2000) observed that increased incomes lead to improved nutrition and living status and this can lead to use of purchased products if they are perceived to be better than goods produced in the farm. However if wild sources are easily accessible by traders and supply all market needs, then market availability does not give incentives for farm cultivation of medicinal tree species. Wild resources can however get easily depleted in the absence of controls which means loss of future health management based on medicinal trees as well as loss of genetic resources which would support farm growing in future.

Sustainable development theory posits that environmental damage, if unchecked, may undermine the achievements of development and even lead to collapse of ecosystems (Harris, 2000). Policies to check wild resource depletion incorporating traditional systems of control should thus make wild resources less accessible and stimulate farm conservation

with use of medicinal trees in farmlands. In an ideal world, rising population increases the demand for medicinal tree products both for household consumption and industrial use, which should raise cultivation levels as postulated in Figure 3. Technological advancements as well as increased access to knowledge on use of medicinal trees have raised the scope of use of medicinal trees from just traditional medicine to both pharmaceutical and cosmetic use (Verma and Singh, 2008). This creates markets and useful value chains which, in many cases, source materials from the wild resources and leave out smallholder farmers. But development of cultivation technologies and high quality germplasm should make cultivated material more accessible and appealing to markets leading to rise in the use of farm grown material (Schipmann *et al.,* 2006) and some decrease in material collected from the wild. For species whose industrial demand will rapidly rise to very high volumes, plantations can profitably supply the demand as has been observed with *Artemisia annua* for malaria control (Dalrymple, 2006). Highly diverse smallholder farms are however better suited for the current demand trend which consists of many species required in small too quantities each to stimulate plantation establishment.

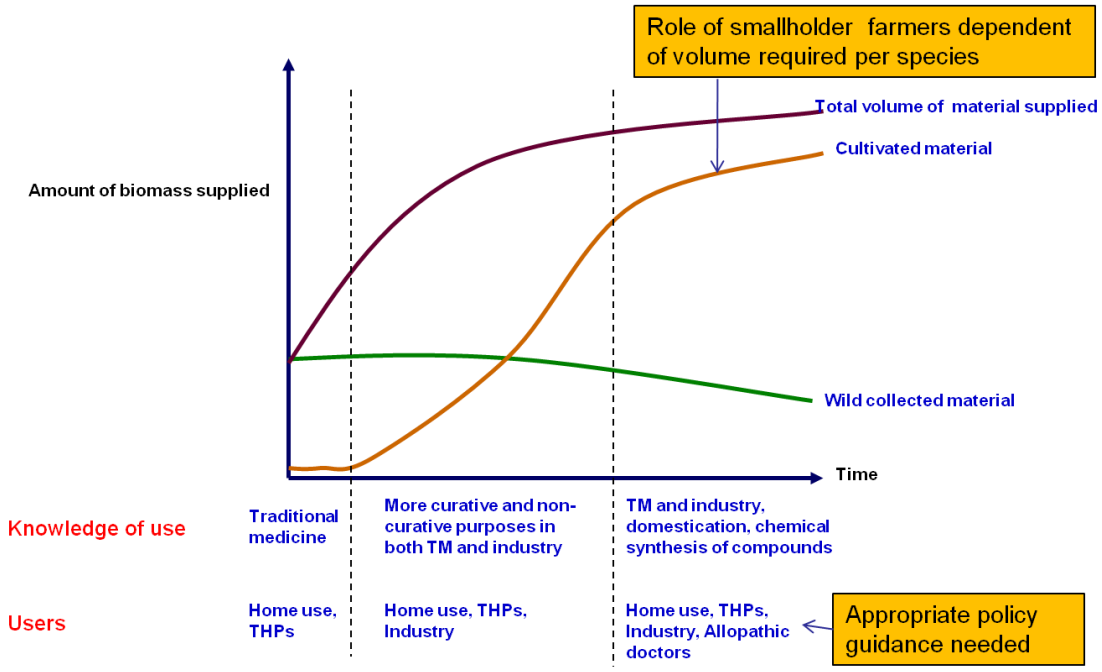


Figure 3: Hypothetical trend of sustainable supply of medicinal tree material with the level of growth in knowledge of use

When farmers are motivated to grow farm medicine either for household health management or for sale under intensified agroforestry systems then issues of medicinal tree quality and the agroforestry system component interactions come into play. These components include crops, livestock and other woody perennials. To maximize system productivity, farmers need

medicinal trees that are able to give maximum productivity of the herbal medicine material with minimum reduction of other system components„ productivity. Nursery systems supplying seedlings of high genetic and physical quality as well as cultivation methodologies (technologies) based on appropriate species„ ecological studies will be required. These constitute the basic induced innovation options by smallholder farmers in order to maximize outputs from his factors of production.

The change of the farming system to adopt technological improvements calls for participatory farming systems research. Quoting Gilbert, *et.* al., (1980), Hansen (1981) gave four general steps of a farming systems research program which include (i) diagnosis and description, (ii) design of alternative technologies, (iii) testing of the alternatives and (iv) extension. McCown (2003) outlined a similar cycle of farming systems research and expanded the first step as identifying target group farmers followed by a survey diagnosis of farmers„ priorities, resource and development opportunities. Identification and evaluation of materials and techniques with potential for problem solution and exploitation of opportunities was the next step he gave followed by experiments on apparently relevant materials and techniques under farmer conditions (Figure 4). This study thus sought to explore the factors that influence planting or saving of medicinal trees in smallholder farms and identify top priority medicinal tree species for which further research to develop appropriate propagation and germplasm delivery systems ought to be conducted.

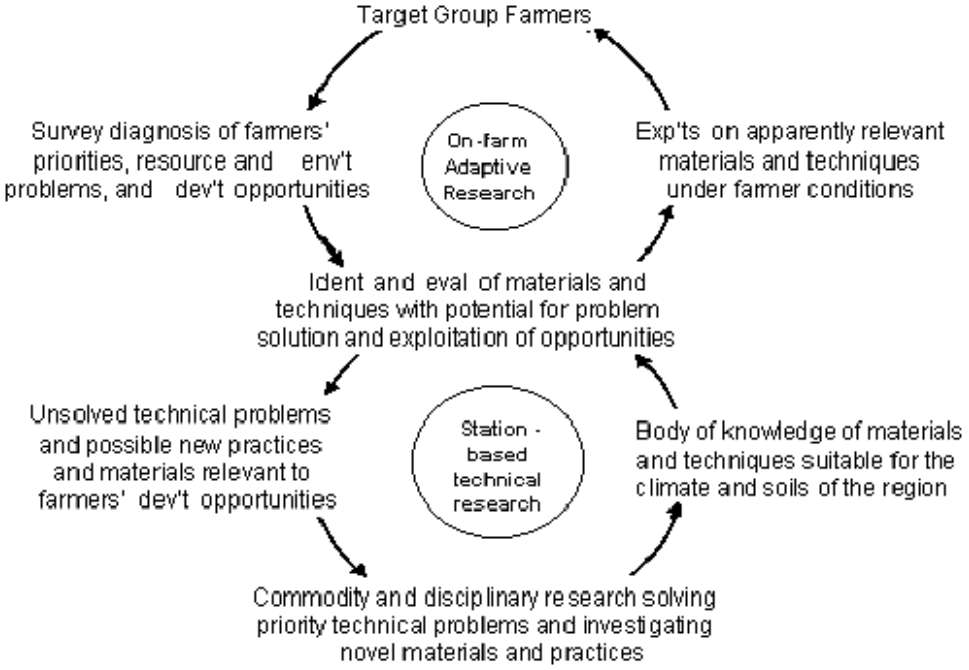


Figure 4: The classic Farming Systems Research (*Source: McCown, 2003)*

The thinking along the theories discussed in this section was implied in the simplest sense of the theories and did not attempt to analyze them deeply or separately in this study. The theories only guided the thinking on how cultivation of medicinal trees in smallholder farms is likely to develop and support the farmers in their attempts to assume a role in a dynamic global economy. That is why the study was limited at assessing the role of germplasm suppliers and desired cultivation technologies as the only technological innovations employed by the farmer. However cognizance was taken of the fact that some economic criticisms of these theories exist such as Nordhaus (1973) critique on induced innovation and Langlois (1983) on systems theory, among others. Farmer decision making is also influenced to a large extent by the evolving global, national and local policies and institutional changes (Shiferaw *et al.,* 2009) which could not be extensively captured in an exploratory study such as this.

General research methodology

The study was undertaken based on the five objectives presented in Chapter 1. The objectives are presented as essays in Chapters 3 to 7 where the literature review/background on which the objective was embedded, the methodology through which each objective was measured, the results of analysis as well as the discussion relevant to each objective is written. In this chapter, the general methodology describing the study area, sampling of the research units and the general approach to the data collection and analysis is given. Tables 5 to 9 also briefly summarize the hypothesis tested, specific analysis objectives measured, the data required and the specific questions in the various research instruments used for each of the five objectives.

1.6 Study area

Mount Kenya is the second highest mountain in Africa and is covered with approximately 213,000 ha of natural forest. Although modest in size, the forest block on Mt Kenya comprises 20% of Kenya's natural forest and is the largest continuous block of indigenous montane forest in the country. Furthermore it is the most ecologically significant and economically important natural forest area in Kenya. Due to its biodiversity value, Mt Kenya National Park and the surrounding belt of natural forests were inscribed as a World Heritage Site in 1997 (Bett, 2005).

Most of the area around the mountain has high agricultural potential with soils of good inherent fertility. Nine distinct agro ecological zones occur along the top sequence and these include tea-dairy zone (LH1), coffee-tea zone (UM1), main coffee zone (UM2), marginal coffee zone (UM3), sunflower-maize zone (UM4), cotton zone (LM3), marginal cotton zone (LM4), lower midland livestock-millet zone (LM5) and lowland livestock-millet zone (L5). The majority of the population are smallholder farmers growing mainly maize, beans, bananas, potatoes and horticultural crops. The farmers integrate tree cultivation and management in their farming systems, with a majority of them preferring a high diversity of tree species in their farms (Barr, 2004). Thus tree species such as *Grevillea robusta, Eucalyptus sp*. and a variety of fruit/nut trees dominate the landscape and supplement the cash crops (Shepherd, 1989; Oginosako *et al.,* 2006).

In many areas of the Mt. Kenya landscape, high population densities coupled with the diverse farm management systems exceed the carrying capacity of the land. Population densities range between 80-1300 people per km^2, with the coffee and tea zones being the highest. Migration is only a solution for the few that can find employment in the urban centres but the majority of the populace has to earn their livelihood on the small farms. This often

leads to unsustainable farming practices and high pressure on the remaining natural resources and forest areas in particular.

The area to the east of the mountain is occupied by the Meru and Embu tribes of Kenya. It comprises of six administrative districts (Embu, Mbeere, Meru South, Meru Central, Meru North and Tharaka) which are part of the Eastern Province of Kenya although the new constitution recently promulgated in the country has redefined administrative units to three counties. The area quickly falls in altitude from 5199m above sea level (top of Mt. Kenya) to about 300m and has a bimodal rainfall pattern whose annual amounts fall with the attitude. Mbeere and Tharaka districts fall in the arid and semi-arid lowlands while the other four districts are in the humid and sub-humid areas (Figure 5). Since household wealth has tended to be defined by the agricultural potential, poverty rates increase as altitude decreases and majority of farmers in the drier areas are extremely poor apart from the few with off-farm income (Onduru *et al.,* 2002).

Agriculture is the main economic activity and the community has a highly developed tree planting culture. Around the mountain, communities have always saved trees in their farms and in many cases plant additional trees (Castro, 1991; Barr 2004; Oginosako *et al.,* 2006). However, majority of the planted trees are exotic species especially in high altitude humid areas. A migratory pattern of people to the lowlands, due to high population densities in the highlands, tends to take along the exotic species that are suited to highlands to the lowlands albeit with low success. Natural and plantation forests occupy the area next to Mt. Kenya and Nyambene and other hills while natural woodlands are found in the drier lowlands of Mbeere and Tharaka (Fig. 6).

Traditional medicine has been practiced by the communities throughout history (Kareru *et al.,* 2007). The area has herbalist associations with officials at each district level which come together to form provincial and national herbalist associations. Formation of healer association at many levels is a trend in many countries in Africa due to changing socio-economic conditions to facilitate their integration in national health programmes (Wondwosen, 2005). Altogether, over one hundred traditional healers practice herbal medicine in the area east of Mt. Kenya and they mainly collect materials from the natural resources mentioned above (author's observation from lists provided by leaders of herbalists associations in the districts).

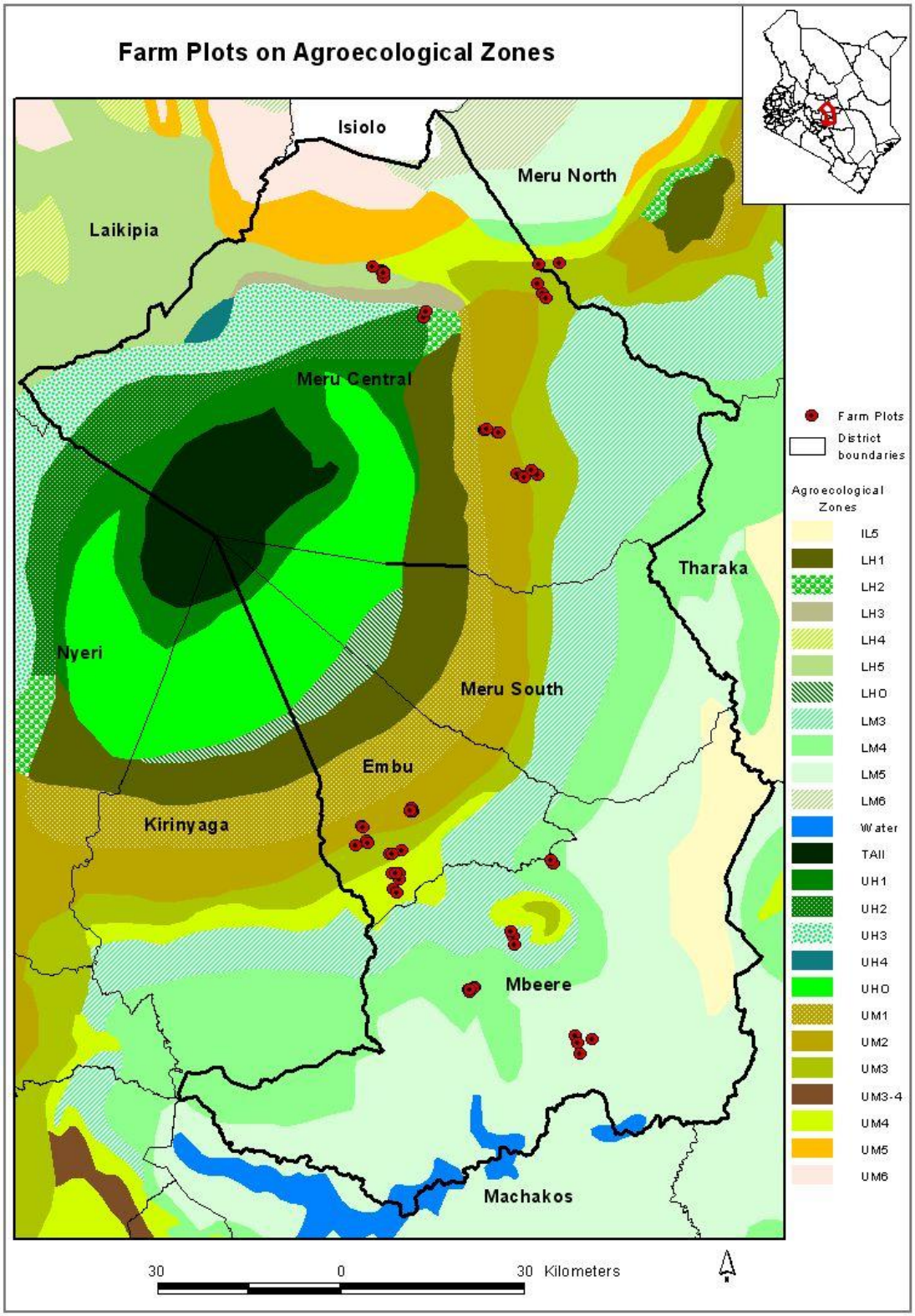


Figure 5: Agro-ecological map of the area East of Mt. Kenya showing the farms sampled for the survey on medicinal trees species abundance

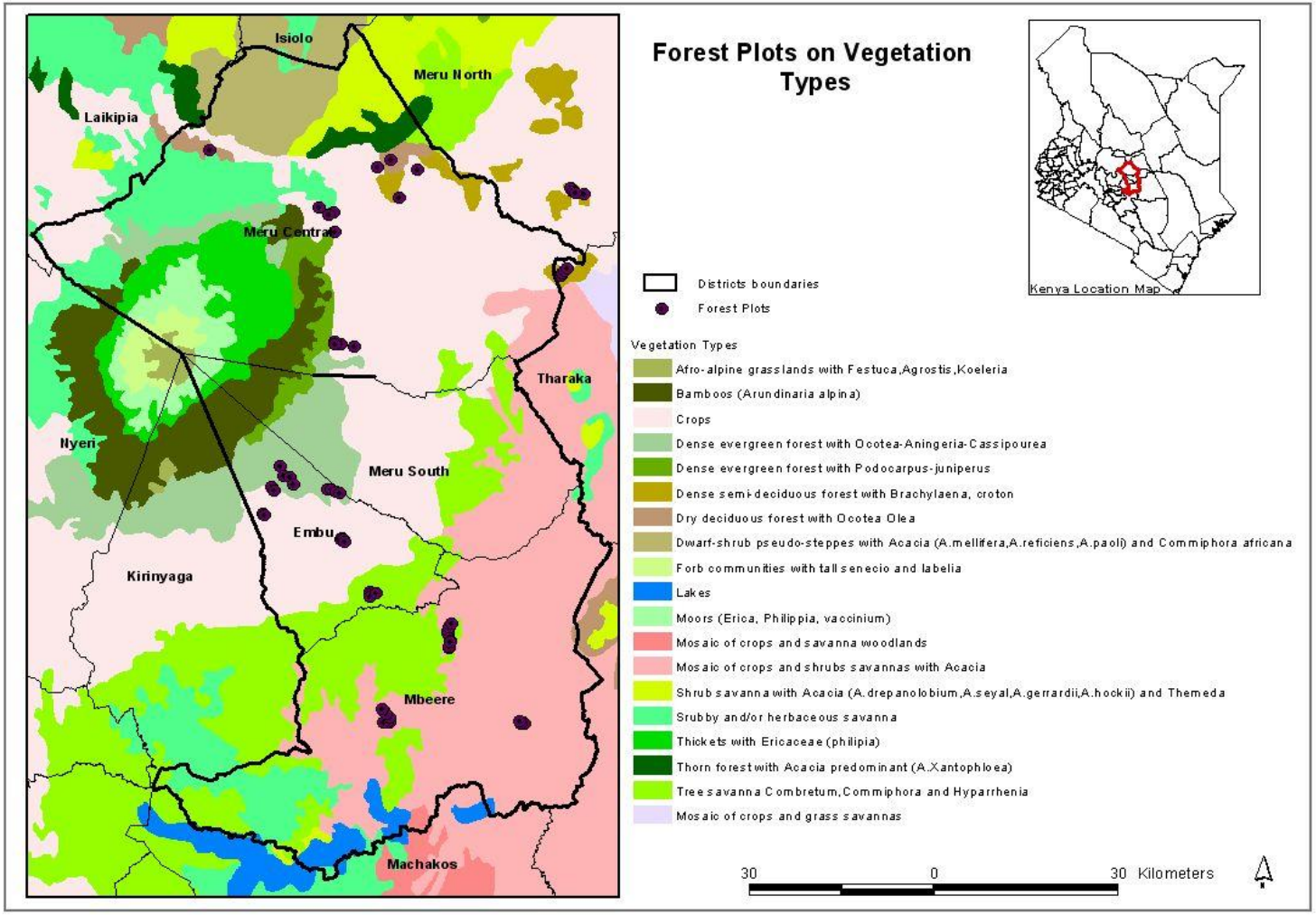


Figure 6: Vegetation map of the area East of Mt. Kenya showing the forests plots sampled for medicinal tree species abundance surveys

Out of the six districts, only three districts were purposively selected for this study; Mbeere, Embu and Meru Central. This stratification ensured representation of both humid and semi-arid areas in the study with focus on the humid area in Meru, sub-humid in Embu and semi-arid area in Mbeere (Figure. 5). A summary of the demographic, climatic and ecological characteristics of these three districts is presented in Table 4. The Kenyan Ministry of Agriculture has sub-divided the area into extension focal areas or water catchment areas which correspond to villages, some of which were sampled for this study. The study mainly consisted of three tier surveys; farmers', herbalists' and a nursery operator's survey, all of which were conducted in the three districts but respondent sampling was done differently as explained in section 2.2. The market surveys were conducted in the cities of Nairobi, Kisumu and Mombasa whose geographical descriptions are presented in Chapter 5.

Table 4: Agricultural, climatic and demographic features of the study area

Parameters	Unit	District		
		Embu	Mbeere	Meru Central
Size	Km^2	725.5	2,092.5	2,992.3
Population (2009)	Persons	296,992	219,220	580,319
Population structure (2009)	Households	80,138	51,545	157,706
Population density (2009)	Persons / Km^2	409	105	194
Arable land	Km^2	300	1695	1952
Altitude	Metres ASL	1,200 – 2,100	500 – 1,200	750 – 2,900
Mean temperature ranges	^{o} Centigrade	16 – 26	20 - 32	12 - 21
Rainfall	Mm per year	640 – 2,200	550 – 1,100	500 – 2,600
Soils		Nitisols to Ferrasols	Cambisols to Rhodic Ferralsols and Luvisols	Nitorhodic ferrasols
Main Agro-ecological zones		Upper midlands (UM) 1 - 3	Lower midlands (LM) 3 - 5	Upper highlands (UH) 1 – 2, Upper midlands (UM) 1 – 5, Lower midlands (LM) 2 - 5
Main farming system		Mixed crop livestock	Marginal crop livestock	Mixed crop livestock (marginal in some areas)
Main cash crops		Tea and coffee	Cotton (no longer planted)	Tea, coffee, horticultural crops
Important food crops		Maize, beans, potatoes	Maize, beans, cowpeas, pigeon peas	Maize, beans, potatoes
Monthly mean household income (1997)	Kshs (Kshs 1 = one euro cent)	7,505	2,025	6,248

Adapted from many sources: MKEPP, 2005; Gacheru *et al* (undated); Onduru *et al.,* 2002, GoK, 2010

1.7 Sampling

The study was based on a two stage data collection and analysis process. In the first stage ethno botanical surveys with farmers, herbalists, nursery operators and market players (mainly dealers in herbal products) were conducted.

Sampling for farmer respondents followed an hierarchical (multi-stage) approach (Stern *et al.,* 2004). This approach is useful in populations where there is no adequate list of the individuals and no way of getting to all the population directly, a common feature of

smallholder farming populations in the developing world. Fowler (1993) advised such sampling to follow a strategy that links population members to a kind of grouping that can be sampled. As such, in each district, a list of catchment areas (villages) was requested from the ministry of agriculture and the Kenya Forest Service (KFS). In the first stage, simple random sampling was done to give four catchment areas/villages per district from those listed at the district KFS offices. Five villages were selected in Meru Central district since it is bigger than the other two districts.

The district administrative boundaries were not the focus of the study and their (boundaries') only significance was to single out Mbeere which would give a good comparison between humid and arid areas in terms of medicinal tree species conservation. However district officers in the two government ministries helped to identify catchment units for sampling. Fifteen farmers were randomly sampled in each village/ catchment for farmer interviews giving a total of sixty per district (eighty in Meru Central) and two hundred (200) farmers in total. The approach followed in the interviews involved selecting seven or eight members of the contact catchment group randomly. During the interview time we would interview one of the selected group members as well as a neighbour who was not a member of the group before moving to the next group member selected in the list. This approach ensured that members of target groups comprised about half the interviewed farmers while the other half did not belong to the groups. Villages where there had been interventions that had potential to influence the results, such as where ICRAF had promoted cultivation of medicinal trees were left out of the sampling frame. This was done to avoid bias since the livelihood experiences and attitudes of such villages could have been altered by the project intervention making such respondents untypical (Stern *et al.,* 2004).

For nursery operator interviews, the forest department heads in the three districts were contacted to give a list of tree nurseries operating in or near the sampled villages. Additional nurseries were identified through chain sampling where the list was populated after inquiries from the interviewed farmers. The nurseries were randomly sampled to give a total of twenty study nurseries per district and sixty for the whole study. Respondent herbalists were randomly drawn from lists provided by officials of the herbalist associations in the districts. However additions were done after consultations with staff from the National Museums of Kenya (NMK) since rivalries were noted among herbalists in two district herbalist associations. Twenty herbalists were selected from each district to give a total of sixty herbalists interviewed for the study. Sampling for traders followed a rapid reconnaissance survey to determine the number of small scale herbal business in key Kenya cities and those listed in the Kenya Business Directory 2007/8. Fifty five business operators were interviewed from the list generated with only a few traders declining to grant interviews. The four surveys were conducted between May and July 2008.

The second phase of the study was conducted between October 2009 and January 2010 and focused on a short list of thirty species that were found to be the most preferred for cultivation by farmers and herbalists in the preliminary analysis. The preferences changed in later analysis as some other species were botanically identified and their frequency of preference went higher than those initially selected. In each district, twenty farms were systematically sampled from the list of the sixty farmers and ten herbalists from the thirty who were interviewed in the first stage. Sixty plots (each 50m x 50m) were also sampled along transects in the forests and woodlands that herbalists and indicated were the main sources of medicinal tree materials (Figure 6). The highly preferred medicinal species were counted and their heights and diameters measured in these farms and forest plots. More details on the sampling for the second phase are given in chapter 7.

1.8 Data collection methods

In order to set the research in the local cultural context farmer group meetings were held in April 2008 in each of the thirteen villages selected. The help of the KFS officials was solicited to help gather as many farmers as possible to the meetings. Where a herbalist or a nursery operator was based in or near the selected village, he would also be asked to be part of the group. Although the focus was on medicinal trees, discussions were based on all medicinal plants (including herbs) and their use in the village. The sequence of discussion in the group meetings was

1. Analyzing the disease situation – the diseases affecting people in the village and which were the most serious (always after the disease was mentioned the reason why it was serious was asked and recorded in the note book for developing the questionnaire)
2. Use of plants for medicinal purposes – which plants did farmers know that had medicinal use whether they used them or not
3. What factors influenced whether or not a species with medicinal value would be planted in the farm or left in the field when others are cleared for cultivation and why medicinal trees were not commonly cultivated.

Later the farmers, herbalists, markets and nursery surveys were conducted using questionnaires (Appendix 3). Tables 5 to 9 below show the data that was collected. A snapshot survey (Stern *et al.,* 2004) in the form of descriptive studies (Neuman, 2006) was preferred for this study since it was desirable to get some scope about the various aspects of the medicinal trees species sub-system in a smallholder agroforestry system as presented in the conceptual framework. The questionnaires had an introductory preamble to explain the

survey intent to all respondents due to the sensitive nature of interviews related to traditional medicine.

Stern *et al*., (2004) described a survey as a research process in which new information is collected from a sample drawn from a population with the purpose of making inferences about the population in an objective way. While many authors associate surveys with studies on people, surveys can be carried out on households, crops, soils, trees and others items of interest (Keogh, 2004). In this study two types of surveys were conducted. In the first stage of research we conducted household interviews with farm walks to gauge the influence of knowledge of herbal treatment, access to markets and tree seedlings and species ecology on the farmer's decision to plant medicinal trees. The individual respondent rather than the household was the unit of analysis as personal opinions were gauged (referred to as self reporting by Fowler, 1993). The individual respondent however had to have sufficient stake in decision making on allocation of factors of production in the farm enterprises to qualify for interviews. Only one individual respondent was interviewed per household to avoid influence in the responses. In the second stage land (per hectare) was the unit of analysis as measurements involved counts of trees in farms and forests.

Stern *et al*., (2004) enumerated a number of strengths and weaknesses of the survey research methodology. A great strength is that, when well organized, the method can achieve breadth of coverage with many units so that the wide range of characteristics in the population can contribute to the whole picture. A suitably structured survey can also take advantage of varying sizes of units (such as farms) and correct for under-enumeration and to some extent non response. However surveys require considerable time to plan and complete and in many cases the time and resources required may be under-estimated. Ill-phrased questions or those poorly linked to objectives can also lead to results that are neither digestible nor informative. As such careful planning is paramount in survey execution. High levels of non-response can also result in biased results especially when the segment that is not responding is distinctive relative to the subject of the survey (Fowler, 1993). In this study a personal interviews approach was used and a clear introduction of subject given to all respondents to minimize non-response. This was especially to control for any fear that the respondents (mainly traders and herbalists) would feel threatened by the research. Two of the identified traders however refused to grant us interviews even when the purpose was clearly stated in the telephone calls that were made to make appointments. They could have introduced some bias in the results as they are among the biggest players in the herbal industry in the country.

To increase reliability of the results triangulation was used. This is an approach used in many fields but in research (especially social research) refers to the use of more than one approach to the investigation of the research question in order to enhance confidence in the

findings (Guion, 2002; Olsen 2004; Bryman undated). The term however is derived from land surveys where it refers to the use of a series of triangles to map out an area. In research, four forms of triangulation are distinguished; data triangulation, investigator triangulation, theoretical triangulation and methodological triangulation. Methodological triangulation, which refers to the use of more than one method for gathering data was used in this study. The approach is important in that it not only validates research results when the methods used converge (agree) on the same result but also widens one's understanding and gives a chance for further investigation when different results are arrived at (Bryman undated; Olsen 2004).

Bryman (undated) gave two types of methodological triangulation; within-method triangulation and between-method triangulation, both of which were applied in this study. Within method triangulation involves use of varieties of the same method to investigate the research question. Under this approach, farmers were asked to rate the factors influencing their cultivation of medicinal trees and then other questions were included in the same questionnaires to empirically investigate whether the factors mentioned by the farmers had the same weight of influence as rated by the farmers. Between method triangulation was used in several cases. Group meetings were used to give a rough analysis of the rating of diseases and use of medicinal trees in the village and factors influencing medicinal tree cultivation and these were later verified with the farmer interviews. Herbalists were also interviewed on their preference of medicinal tree species for cultivation and later the presence of the species in herbalist gardens was verified through species abundance surveys. The influence of access to medicinal tree planting material on cultivation by farmers was also assessed through farmer's surveys, nursery operator's surveys and a qualitatively analysed experiment. Olsen (2004), drawing from Sayer (1992) said that a single piece of research, even when integrating methods, would always have to make a choice: either to be intensive (examining the topic in great depth) hence qualitative or extensive (examining a wide range of data) hence quantitative. This study followed the later (quantitative) choice and mainly used quantitative data analysis with some qualitative enrichment.

1.9 Data analysis

A Microsoft Excel database was created for survey data based on the format of the questionnaires for ease of data entry. Survey data was then summarized using the sorting and pivot-table functions of Microsoft Excel and extracted to SPSS (Statistical Packages for Social Studies) for further analysis while species abundance data was extracted to BiodiversityR. The units of analysis for farmers, nursery, market and herbalist surveys were the respondents and farms/plots for species abundance surveys.

Survey data was reported using descriptive statistics such as charts and tables showing frequencies for species cultivation, diseases and trade characteristics. The mean was the preferred measure of central tendency and T-tests and ANOVA were used to test mean differences for most of the parameters. Where the mean was unfairly skewed by extreme values and was found not to be representative enough, such as when showing the volumes of trade handled by traders for some species, a box-plot that uses the median and shows how data is scattered was used instead. Pearson Co-relation and Linear Regression were used to test associations such as between knowledge of herbal treatment of diseases with level of medicinal tree cultivation and tree nursery size with level of income of nursery operators among others.

Frequencies were used to interpret data on farmer, herbalist and market preferences on herbal sources as well as sources of information on treatments, tree planting and buyers of products. To analyse preferences by respondents, the study frequently used ranks and scores. Ranking involves asking the respondent to mention the order of preference of a set of options from the best case to the worst. Scoring on the other hand involves assigning values for the various points along the preference gradient (such as the Likert scale) and a respondent can give the same score point to more than one assessment unit. While ranking implies that the respondent has to make up his/her mind on the difference between every two units and therefore units (or options) can be fairly assessed the method is less informative than scoring. This is especially so when respondents have to choose between some nearly-equal alternatives and some very different ones (Stern *et al.,* 2004). Therefore scores were the more preferable mode of preference ranking in this study.

Recommendations from research are more utilisable if it is possible to target sub-groups of users who would be most receptive to changes and cluster analysis of responses offers a useful tool to do this (Norušis, 2010). Cluster analysis tries to find a natural grouping of units depending on measured parameters (Stern *et al.,* 2004) and differs with discriminant analysis which classifies units based on an already known group membership (Norušis, 2010). In this study a cluster analysis was used to determine whether users of medicinal tree products namely traders and herbalists would turn to farm grown trees as forest trees get scarcer. User preference of the ecological characteristics of the source of medicinal tree material as well as the desirable improvement traits for medicinal tree species were used to cluster traders and herbalists. Since there was a small sample of traders and herbalists and only nominal and score data was used, K-Means clustering was preferred and SPSS was allowed to do the sufficient iterations that would yield clearly identifiable clusters. The clusters are defined in Chapter 7.

Analysis of tree species diversity is based on the concepts of species richness and evenness (Kindt and Coe 2005). Species richness is the number of species that has been recorded in

a specific area (plot or study area) in a specific time period while evenness is the proportions (or relative abundances) of each of the species encountered in the area. Species diversity in the study area is high when both richness and evenness of species are high. Diversity is analyzed through various diversity indices (Khan, undated; Heip *et al.,* 1998) that combine species richness and evenness into a single statistic with Shannon-Wiener and Simpson Indices being among the most commonly used. However one diversity index is insufficient when it comes to comparing the diversity of different sites. Kindt and Coe (2005) recommended the use of Rank-Abundance curves which order the species in each site from the most abundant to the least abundant and display the information in a curve. The authors also recommended the use of a Rényi Profile which has an advantage over the Rank-abundance curve in that it orders the sites from the highest diversity to the lowest but has a disadvantage in that the species proportions are not shown. This study used both approaches to compare diversity of farms, herbalist gardens and forests for the species most preferred by herbalists. Also because herbalists had indicated that forests were preferable as sources of herbal material because many species could be accessible within a short travelling distance, we drew species accumulation curves to compare species richness in the three types of sites. These curves calculate the average species richness for combinations of sites and can show how many of the encountered species can be found in every number of sites„ combinations.

1.10 Methods matrices

Methods matrix for objective 1

Objective: To collate the perspectives of farmers and herbalists on the factors influencing their preference and cultivation of tree species with medicinal use value

Hypothesis: Socio-demographic differentiation determines the factors influencing medicinal tree cultivation by smallholder farmers

Table 5: Methods matrix for objective 1

Specific analysis objectives	Data required	Main method	Reference question number in questionnaire
1. To document the plant species with medicinal value in farms and herbalists gardens	• List of medicinal plant species in the farms and their life forms • Other known medicinal plant species but not in the farm • List of medicinal plant species used by herbalists	• Farmers' and herbalists' surveys (questionnaires)	• Farmers - 14, 16 • Herbalists – 23, 24
2. To document the factors influencing farmers and herbalists cultivation of medicinal trees	• Summarized list of factors influencing medicinal tree species cultivation from farmer groups and individual farmers	• Group meetings, farmers' survey (questionnaire)	• Farmers – 21
3. To present differences in the weighting of the factors influencing medicinal species cultivation by socio-demographic categories (age, gender and education)	• Socio-demographic characteristics (age, gender, education level) of farmers and herbalists • Scoring of the factors influencing medicinal tree cultivation by farmers in percentages – all % add up to 100 per farmer • Ranking of factors by herbalists from 1 (most important) to the highest number in the list (least important)	• Farmers' and herbalists' surveys (questionnaires)	• Farmers - 2-7, 21 • Herbalists – 2-4, 18
4. To compare farmers and herbalists ranking of medicinal plant species and list the most preferred species for cultivation in the area	• Farmers' scoring of species by how each factor is likely to influence of cultivation of the species (1 – least likely, 3 – most likely) • Herbalists ranking of ten most important species	• Farmers' and herbalists' surveys (questionnaires)	• Farmers - 22 • Herbalists - 19

Methods matrix for objective 2

Objective: To assess the influence of local disease burden perception and knowledge of herbal treatment on the efforts by farmers and herbalists to cultivate medicinal trees

Hypothesis: The number of medicinal tree species planted or maintained in farms is influenced by the farmers' knowledge of treatment and perception of the disease socio-economic importance

Table 6: Methods matrix for objective 2

Specific analysis objectives	Data required	Main method	Reference questionnaire number
1. To document the diseases perceived to be of high economic importance to the community by farmers and herbalists and compare with hospital statistics	• Farmers perception of disease importance • List of the most economically important diseases by herbalists and farmers • Records of disease cases and morbidity rates in year 2007 in district hospitals	• District hospital visits (disease case records) • Group meetings, Farmers' and herbalists surveys (questionnaires)	• Farmers - 10, 11 • Herbalists – 7, 8, 9, 10
2. To list the species used by farmers and herbalists in the treatment of the most economically important diseases	• List of species used to treat the diseases listed in 1 above • Sources of knowledge on use of medicinal plants for treatment	• Farmers' and herbalists surveys (questionnaires)	• Farmers - 13, 14, 15,16, 17 • Herbalists – 23, 24
3. To test if the level of cultivation of medicinal plant species by farmers is associated with the knowledge of species medicinal use and farmers' perception of disease economic importance	• Species under cultivation that treat most important diseases • Author indices decided apriori to relate important diseases to important plant species and other parameters affecting tree cultivation for correlation	• Farmers' and herbalists surveys (questionnaires) • Indices based on number of species whose medicinal value is known by farmers and the farmers' perception of the socio-economic importance of diseases	• Farmers - 19

Methods matrix for objective 3

Objective: To explore the contribution of farm grown herbal material to medicinal tree product markets and its effect on medicinal tree cultivation/ conservation

Hypothesis: Medicinal tree cultivation can be stimulated by increased formal trade in herbal medicine products in the country

Table 7: Methods matrix for objective 3

Specific analysis objectives	Data required	Main method	Reference questionnaire number
1. To list the species in trade by herbal clinics and other urban players in the medicinal plant markets	• List of businesses involved in medicinal plant products (apart from tree parts vendors) • List of species in trade in selected cities in the country	• Market surveys	• Market - 1 - 6, 16 - 17
2. To assess urban traders„ veiws on the role of farms compared to forest as sources of herbal medicine raw material	• Trends in the marketing of highly traded species • Proportion of cultivated material in trade compared to wild sourced • Open ended information on trade	• Market surveys	• Market - 5, 6, 12-15
3. To assess the level of marketing of products from medicinal trees and other tree categories by farmers east of Mt. Kenya	• Number of species for which products are sold by farmers	• Farmers' surveys	• Farmers – 33 - 35
4. To assess whether there was scope for increased sourcing of raw materials from farms by the formalising herbal medicine trade		• Recommendations derived from the analysis of the three objectives above	

Methods matrix for objective 4

Objective: To explore how germplasm access by farmers and on-farm tree nurseries influence medicinal tree cultivation

Hypothesis: Lack of appropriate germplasm in local supply systems limits the number of medicinal tree species smallholder farmers plant in their farms

Table 8: Methods matrix for objective 4

Specific analysis objectives	Data required	Main method	Reference questionnaire number
1. To characterize on-farm nurseries as income generating farm enterprises	• Description of small-scale nursery enterprises in the districts	• Nursery operators survey	• Nursery – 1-12
2. To assess the relative importance (availability and demand) of medicinal tree seedlings in on-farm tree nurseries as compared with other tree categories	• Data on seedling production, supply and demand for all categories of species produced in the districts • Details of species with medicinal use value in nurseries, seedling production volumes, demand trends and production constraints	• Nursery operators survey	• Nursery – 13 - 18
3. To explore any other role that tree nursery operators play in ensuring availability of medicinal tree seedlings and information	• Summary lists of efforts to promote medicinal tree cultivation • Open ended information on propagation constraints	• Nursery operators survey	• Nursery – 19 - 21
4. To assess the contribution of tree nurseries to medicinal tree germplasm planted by farmers and farmers' willingness to pay for seedlings	• Proportion of medicinal tree species in farms deliberately planted by farmers compared to that naturally regenerated • Sources of seedlings for planted trees • Nearest nurseries to farms • Farmers willingness to pay for medicinal tree seedlings	• Farmers survey • Informal experiment of medicinal tree seedlings supply (action research)	• Farmers – 14, 29 - 32

Methods matrix for objective 5

Objective: To explore motivational drivers of cultivation and the scope for herbalists' and traders' utilization of farm produced medicinal tree products

Hypothesis 1: As medicinal trees get scarce herbalists respond by planting the most important species in their farms and these species soon become more abundant in their farms than the forests

Hypothesis 2: With increased scarcity of medicinal trees in forests, herbalists and traders gradually change preference to farm grown trees if the trees are established in farm niches that mimicked those in the forest as close as possible

Table 9: Methods matrix for objective 5

Specific analysis objectives	Data required	Main method	Reference questionnaire number
1. To assess the abundance of high priority medicinal tree species in forests and natural woodlands compared to smallholder farms and herbalist gardens	• A list of the species most preferred by herbalists and farmers for cultivation based on criteria of use in traditional medicine • Counts of all trees in selected farms and forests	• Preliminary analysis of main objective 1 to generate priority species list • Ecological surveys – tree species abundance counts	• Farmers - 21 -22 • Herbalists - 18 - 19
2. To compare the preferred niches for medicinal tree cultivation by farmers and herbalists	• Listing the different niches where the selected species are planted in farms (and herbalist gardens)	• Researcher observations and inquiries from farmers and herbalists on reasons for niche preference	• Not in questionnaires
3. To compare age and size classes of highly preferred medicinal tree species in farms with those of forests and natural woodlands	• Age and diameter at breast height (DBH) of all individuals of the thirty selected tree species in farms and DBH in forests	• Ecological surveys – tree DBH measurements and age inquiries from farmers	• Not in questionnaires
4. To assess the scope of potential use of farm grown medicinal trees by herbalists and herbal medicine traders by defined ecological conditions	• Opinion by traders and herbalists on how ecological characteristics of source of herbal material may influence medicine quality • Opinion by traders, herbalists and farmers on preferred improvement characteristics for medicinal tree germplasm	• Farmers survey • Market survey • Herbalists survey	• Farmers – 28 • Market - 11 • Herbalists - 27

2 Perspectives of farmers and herbalists on factors influencing their preference and cultivation of medicinal tree species in the Mt Kenya East area

2.1 Introduction and literature review

Agroforestry, although an old practice, is relatively young as an organized scientific discipline and intensive research dates back to only about three decades ago (Gholz, 1987) and its adoption is yet to receive enthusiastic public policy support (Kumar, 2006). The discipline incorporates agricultural practices in the forests such as pastoralism, forest litter transfer to farms for soil fertility and others, but the bulk of studies have concentrated on tree growing in agricultural land in spatial or sequential interaction with crops and/or livestock. Early studies on agroforestry as a livelihood option in the African tropics such as Arnold and Dewess (1997), and Scherr (1995), did not feature medicinal trees as prominent among the household tree products needs. They mainly featured food, fuel and construction needs although their arguments on evolution of tree planting in private farms are very useful in promotion of medicinal tree cultivation. Cultivation of medicinal trees has however, been recommended in many studies as a panacea to the fast degradation of the herbal resources as their use in traditional medicine and the phytochemical industry increases (Wiersum, 2006; Schipmann *et al.,* 2002; Silori and Badola, 2000).

Medicinal plants in agroforestry systems usually include trees planted for other purposes such as timber fruits and fodder. For example, Iranbakhsh *et al*. (2009), found that 63% of households in Mwekera area of Zambia were using indigenous fruit trees for medicinal purposes. Fruit crops such as *Musa spp* (banana), *Ananas comosus (*pineapple), *Morus alba* (mulberry), *Passiflora edulis* (passion fruits) and *Carica papaya* (pawpaw) also provide food as well and medicine. Other food plants that are used for medicinal purposes include garlic *(Allium sativum),* onion *(Allium spp),* groundnut *(Arachis hypogaea),* pepper (*Capsicum* spp) and sesame (*Sesanum indicum*) among others (Lindsey and Hirt, 2001). The food plants with medicinal uses are usually domesticated and found in many farming systems but are mainly grown for their nutritional purposes and their medicinal properties are usually unknown by many farmers (Voeks, 2007). However other plants are known mainly for their medicinal qualities and these include both trees and herbs. Few tree species in this later group are domesticated, although tree species consist of more than 50% of plants in medicinal plant use (Lengkeek, 2004) and many are threatened with extinction due to rising trade served mainly by materials collected from wild populations (Kuipers, 1997).

Studies to identify factors influencing tree growing and/or agroforestry adoption are increasing and Pattanayak *et al*. (2003), reviewed many such studies. The authors

summarised the factors mentioned in the studies to five clusters namely; preferences, resources, market incentives, biophysical factors and uncertainty. The authors (Pattanayak *et al.,* 2003) also summarised the influence of the factor clusters as follows; “Preferences define the objectives and motivations of the economic agents choosing technologies. Resource endowments enable their technology choices. Market incentives and biophysical factors condition the extent, timing and nature of the technology choices. Finally, risk and uncertainty can seriously undermine investments that pay dividends only in the long run”. Sood and Mitchell (2009) studied factors that influenced tree growing in traditional agroforestry systems of Mandi district of Himachal Pradesh, India and concluded that both biophysical and social factors were in play together. The key factors identified in their study such as farm size, agro climatic zone and soil fertility had been summarised in the analysis by Pattanayak *et al.* (2003), but they (Sood and Mitchell, 2009) also identified the mobility of the farmers and the importance of trees for future generations as influential.

Smallholder agroforestry systems offer great opportunities for conservation of medicinal trees (Rao *et al.,* 2004), but as an integral part of a household livelihood system, their cultivation largely depends on the perspective of the farming population as well other resource users on the importance of these trees (Rocheleau, 1997). Barrance *et al*., (2009) writing on conservation of tree species through use by farming communities, observed that species circa situ conservation by farmers is largely motivated by their perceived use value. Analysis of gendered differences is especially important as women and men have been observed to have different perspectives in natural resource management (Sigot *et al.,* 1995).

Gendered analysis is critical as women constitute an average of 44 percent of agricultural labour in the developing regions with the proportion higher in Africa (Dixon *et al.,* 2001; Quisumbing, 1996). They play a vital role in farming systems including production, marketing and domestic responsibilities and their contribution to the systems’ evolution is very important (Dixon *et al.,* 2001). Women are responsible for the subsistence and nutrition of their families (Johnson-Welch *et al.,* 2005; Sigot *et al.,* 1995). They were reported to account for over 80% of indigenous fruits’ collectors in Mwekera area of Zambia (Iranbakhsh, 2009), and 67% of non-wood forest products collectors in Adiarbaetu, Ethiopia (Howard and Smith, 2006). They are also the first line of intervention in family health care and will often administer plants for childhood ailments and family health problems (Bodeker, 1997). It is therefore useful in ethno botanical studies to compare insights of different gender as well as other user groups of plant resources, within and between communities (Cunningham, 2001).

Rocheleau (1997) also advocated for a user perspective in agroforestry research and action programs while Cunningham (2001) observed that dialogue with resource users is crucial in developing resource conservation and management proposals. Resource users walk further or pay more for scarce resources hence they are more aware of scarcity (Sigot *et al.,* 1995).

Traditional healers are a major user group of medicinal plant species and have traditionally lead cultural conservation efforts for these resources (Cunningham, 1995). In South Africa, where herbal medicine is fairly developed and studied, the healers were observed to cultivate medicinal plant species for their own practice in Kwa Zulu Natal (Mander, 1998) and Eastern Cape Wild coast (Keirungi and Fabricius, 2005). In Eastern Cape, the healers reported that the most important medicinal tree species were unsuitable for cultivation in agricultural landscapes due to their physiological growth patterns; long taproots and wide shading crowns (Ibid). Additionally they were constrained by lack of viable germplasm and mainly planted climbers and herbs although trees were more threatened with extinction due to unsustainable harvesting methods.

Against the foregoing background, this study was conducted in the area east of Mt. Kenya to: (i) document the plant species with medicinal value in smallholder farms and herbalists gardens, (ii) document the factors influencing farmers' and herbalists' cultivation of medicinal trees, (iii) present differences in the weighting of the factors influencing medicinal species cultivation by socio-demographic categories (age, gender and education) of farmers and, (iv) compare farmers' and herbalists' most preferred medicinal plant species for cultivation in the area. This was based on the premise that local knowledge represents a practical and cost effective method for identification of possible key species for conservation and/domestication (Cunningham, 2001).

2.2 Research methods

Farmer group meetings were held in April 2008 in thirteen villages in order to introduce objectives of the research and set it in the community cultural context. Herbalists and nursery operators resident in the selected villages were also requested to attend the farmer group meetings. The discussions in the group meetings brainstormed on the species that farmers knew to have medicinal value in the village, the diseases treated and the factors that influenced whether they would cultivate a medicinal plant species in their farms. Cultivation was explained to the farmers to mean both deliberate planting and also leaving a species in the farm when clearing the field for crop production. The factors mentioned in the groups were not ranked at group level but were included in the farmer interview questionnaires for individual farmer ranking.

Farmers were interviewed using a semi-structured questionnaire (Appendix 3a) which had been drafted earlier and modified using factors generated from the group meetings. Only the household heads or their spouses (mainly wives) were interviewed except in four cases where sons and daughters-in-law (two cases each) were interviewed as they had sufficient input in decisions regarding running of the farms. Although a metric parameter, respondent

age was recorded in classes, where a respondent was not comfortable in giving his actual age, since no linear analysis was intended but a rather general view of whether attitudes towards medicinal plants differed with age categories.

After a tour of the farm to identify and listing all the species with medicinal value present and their uses, respondents were also asked to give details of the species they knew to have medicinal value but were not present in their farm and how the plants were accessed and used. Respondents were informed of the factors influencing medicinal tree cultivation as raised in the group meetings and asked to add any other factor they felt had been left out. Any factor raised in the group meeting but a respondent felt was not important to him (or her) at all was also dropped. Each respondent was asked to score how he felt each factor was important in influencing him or her to cultivate medicinal trees. Scoring was done by each respondent sharing ten scores between the factors that were important to him so that each of the factors could get a score between one and ten and the total for all factors for each respondent was ten. Using the factors they had just rated as criteria, farmers were asked to name up to ten medicinal tree species they preferred most for cultivation and score how important each factor they had mentioned was, in influencing that preference. This later scoring was done using scores of one to three, 3 for most important, 1 for the least important and 2 for medium importance.

Herbalists were also interviewed using a semi-structured questionnaire (Appendix 3b) and the species present in their gardens together with the treatment uses (of the species) recorded. Species that the herbalists were using but were not in the gardens were recorded together with the reasons why the plants were not cultivated and where the herbalists sourced them from. The factors that farmers had raised as influencing cultivation were presented to herbalists for ranking. Respondent herbalists were asked to add any factors that were important to them but had been left out by farmers and similarly to drop any factors included by farmers that was not important to them at all. In the herbalists' ranking, the most important factor was ranked five (5) and the least important factor ranked one (1). Only two herbalists (5%) ranked more than five factors but they both ranked the sixth factor as the least important.

2.3 Data analysis

Data was entered into a Microsoft Excel database and analyzed using a combination of Ms Excel and Statistical Package for Social Studies (SPSS). All factors mentioned by farmer groups were summarized according to how closely related they were and included in the questionnaire for farmer interviews. If a farmer gave an extra factor that was similar to one of the factors already included in the questionnaire in the individual interviews, he was allowed

to rate it separately. The rating of this extra factor was added up to that of the similar factor in the preliminary analysis to give the farmers' weighting of the factor. For example, issues related to knowledge on treatment included a species that treats many diseases, or that treats serious diseases and/or that safe dosage levels are known for the species.

The unit of analysis for this study was the household as represented by the respondents. Descriptive statistics were used to report socio-demographic information. The Pivot Table function of Microsoft Excel was used to summarize species preference scores and frequency of occurrence in the farms. Socio demographic differences in the ranking of factors influencing cultivation were analyzed using ANOVA and Student t-test for significant differences at an alpha level of 0.05 (unless where lower level is specified).

2.4 Results

3.4.1 Respondents' socio-demographic categories

The survey interviewed two hundred farmers of whom, 61% were women and 38% were men (Table 10). The middle age categories (between 25 and 55 years) were well represented by over thirty respondents each while ten respondents were below 25 years of age and 17 above 65 years. Two women farmers declined to state their ages. Majority of the practicing herbalists were men and constituted 87% of the survey respondents with women respondents being only 13%. No woman herbalist was interviewed in Meru Central district. With so few women herbalists, analysis of herbalists' responses was general and not done by gender in any parameter.

Table 10: Gender and age categories of respondent farmers and herbalists

Respondents	% farmers (n=200)							% herbalists (n=60)						
District	Embu		Mbeere		Meru Central		Total	Embu		Mbeere		Meru Central		Total
Age / Gender	F	M	F	M	F	M		F	M	F	M	F	M	
≤ 25	1	0	2	1	1	1	5	2	0	0	0	0	0	2
26 - 35	4	1	7	3	2	6	22	3	0	0	5	0	0	8
36- 45	8	2	8	1	3	5	25	3	3	3	10	0	7	27
46 - 55	4	1	4	0	6	6	21	0	5	0	8	0	10	23
56 - 65	4	3	3	1	3	6	18	2	7	0	7	0	5	20
≥ 66	2	3	2	1	1	1	9	0	8	0	0	0	12	20
Total	21	9	25	5	16	25	99	10	23	3	30	0	33	100

The majority of the farmers and herbalists had attained primary level of education (59% and 45% respectively; Table 11). One farmer and one herbalist declined to state their level of education. A big proportion comprising 25% of both farmers and herbalists had also attained

secondary school education. Respondents with qualifications beyond secondary school of education were a minority for farmers (2.5%) but a significant number of herbalists (20%). More than half of the herbalists had practiced for a period below ten years (28% for five to ten years and 23% for five years or less). Majority (83%) of them had learned the trade from their fathers or grandfathers and a further 13% from other (unrelated) herbalists. One had trained in an institution while another had started the trade after reading related books.

Table 11: Level of education attained by respondent farmers and herbalists

Respondents	% farmers (n=200)				% herbalists (n=60)			
District / Level of Education	Embu	Mbeere	Meru Central	Total	Embu	Mbeere	Meru Central	Total
Not schooled	3	3	7	13		2	5	7
Primary	15	22	22	59	12	20	13	45
Village Polytechnic	0	0	1	1	2	0	0	2
Secondary	11	5	9	25	12	7	7	25
Post secondary	1		2	3	8	3	8	20
Total	30	30	40	100	33	32	33	98

3.4.2 Cultivation of plant species used as medicine by farmers and herbalists

A total of 295 medicinal plant species consisting of trees (45%), shrubs (27%) and herbs (28%) were encountered in the surveyed farms (Appendix 2). A further 60 species (22 trees, 26 shrubs and 12 herbs) were mentioned by farmers as having medicinal uses but were not encountered in any farm. Herbalists' gardens had a total of 203 medicinal plant species (40% trees, 27% shrubs and 33%) herbs. The numbers of trees planted by farmers per species were few, less than ten per farm in most cases and various species were only encountered in few farms. Apart from *Aloe spp*, other species were encountered in less than half of the sampled farms (both farmers and herbalists). Most of the species were mentioned as medicinal (either in or not in farm) by less than half of the respondents except *Aloe spp* and *Azadirachta indica* by farmers and *Prunus africana, Warburgia ugandensis* and *Aloe spp* by herbalists (Table 12)

Majority of the species in farms were mostly naturally regenerated and in most cases planted trees consisted of about half of those naturally regenerated. Farmers reported that an average of one tree per tree species was sufficient for household herbal medicine needs and for lower plants, two shrubs were sufficient (for shrubby species) and three plants for herbaceous species. About half of the farmers who had medicinal trees in their farms reported sharing with neighbours and this was a major source of herbal material for all farmers who did not have the highly rated species in their farms but were using them. Other sources of the materials were forests and woodlands while some farmers bought from neighbouring markets. Half of the species used by farmers but not available in farms in the

humid areas were sourced from arid areas as farmers perceived the species not to do well in the humid areas (Annex 3.1).

Table 12: Sampled farmers' and herbalists' cultivation trends of the most preferred medicinal plant species

Species	% farms present (n =200)*	% farms not present	Average number of trees per farm	% herbalists planting (n=60)*	% herbalists not planting
Prunus africana	23	15	5	35	22
Warburgia ugandensis	4	6	1	15	42
Aloe spp∞	52	13	12	62	5
Azadirachta indica	27	45	2	23	20
Olea europaea ssp africana	17	20	4	18	5
Strychnos henningsii	4	8	12	5	22
Erythrina abyssinica	20	13	2	17	12
Myrsine melanophloeos	3	17	2	3	35
Caesalpinia volkensii	8	19	1	8	8
Zanthoxylum chalybeum	10	7	2	7	15
Moringa oleifera	4	4	15	13	3
Ocotea usambarensis	0	1	0	2	22
Croton megalocarpus	20	6	14	15	3
Dalbergia melanoxylon	3	2	7	7	12
Leonotis mollissima	5	6	5	7	12
Solanum incanum	13	4	16	20	7
Zanthoxylum usambarensis	0	1	0	10	8
Croton macrostachyus	24	3	6	8	3
Osyris lanceolata	5	4	14	5	0
Senna didymobotrya	21	11	9	23	8
Bridelia micrantha	5	1	5	7	2
Tithonia diversifolia	19	5	63	20	0
Cordia africana	6	0	5	8	2
Ficus sycomorus	5	4	1	7	5
Vepris nobilis	1	1	30	0	3
Albizia gummifera	1	1	2	0	2
Kigelia africana	1	1	2	3	8
Ricinus communis	9	2	8	8	8
Rhamnus prinoides	2	5	6	0	10
Ficus thonningi	2	1	3	7	2
Fagaropsis angolensis	4	6	2	0	8
Lantana trifolia	8	4	8	8	3
Carissa spinarum	4	14	6	8	17
Terminalia brownii	11	3	6	5	7
Acacia mellifera	4	1	9	7	3

* Percentages of the respondents who had planted added to those not planting do not add up to 100 because many respondents (the missing percentage) did not mention the species as medicinal.

∞There are many species in this genus used for medicinal purposes and it was difficult to decipher the particular one referred to by each respondent

Farmers who were not cultivating some species gave reasons for not doing so which (reasons) were closely related to where they sourced the herbal materials for domestic health use. The major reasons were that the species were accessible in other farmers' (neighbours or relatives) farms or in the wild and that climate or farm ecology was not suitable for the species establishment (Table 13). Other significant reasons were lack of planting materials, unknown propagation or cultivation technology and that some species affected farm productivity (either trees were too big and shaded crops or interfered with crops at below-ground level) which was closely related with competition for other land uses. Diminishing land sizes was given as a general reason while four farmers reported planting *Melia azedarach* instead of *Azadirachta indica* after being misled on species identity by seedling traders. There was a common confusion between the two species of the Meliaceae family due to their resemblance and seedlings of *Melia azedarach* were commonly sold as *Azadirachta indica* sometimes deliberately as demand for the later was high (author's personal observation).

Table 13: Reasons given by farmers for the absence of some medicinal plant species from their farms

Reason why species was not in farm	Number of species	Average number of respondents per species
Accessible from neighbour's farm	23	2
Affects farm productivity	13	1
Available in the wild	91	2
Area or farm ecology not suitable	18	2
Competition for other uses	4	1
Cultivation knowledge unknown	47	2
Farmer has no interest in planting	19	1
Farmer had planted but dried up	26	2
Intending to plant in future	9	1
Lack of planting materials	81	4
Land is small	18	1
Propagation method not known	8	2
Uprooted by other users without consent	2	2
Wrong species planted	1	6

The presence of medicinal trees in herbalists' farms was low even as many herbalists reported increasing scarcity of some species. At least 60% of the herbalists reported travelling long distances to source the species whose demand was high such as *Prunus africana, Warburgia ugandensis, Myrsine melanophloeos, Azadirachta indica*, *Zanthoxylum chalybeum* and *Ocotea usambarensis*. The average distances travelled to source these species ranged between 19 and 34 kilometres on average although some herbalists would travel up to 100 kilometres (Annex 3.2). All herbs and shrubs were sourced from places near herbalists' homes. The main reasons that herbalists gave for less availability of some

species included unfavourable climate (some important species could only grow in arid areas) and clearance of the species for crop cultivation (Table 14). Another major reason was depletion due to other competing uses for some species such as use of *Prunus africana* and *Ocotea usambarensis* for timber.

Table 14: Main reasons given by herbalists for decreasing availability of some medicinal species in their areas of practice

Reason for less accessibility to some species by herbalists	Number of species	Average number of respondents per species
Species cleared for cultivation	51	1
Area ecology unfavourable for species growth	60	1
Competition with other uses of the species	14	1
Farm ecology not favourable for species	2	1
Lack of planting materials	19	1
Lack of interest to cultivate	1	1
Over-exploitation of species for medicinal purposes	13	1

3.4.3 Factors influencing cultivation of plant species used as medicine by farmers and herbalists

Farmer groups listed 19 factors that influenced farmers' selection of medicinal plant species for cultivation. Many of the factors mentioned were however closely related and were summarized to more general ones as shown in Table 15. Factors related to knowledge of the medicinal value of the species and market availability were mentioned by almost all, while seven groups mentioned multiple uses of the species. Knowledge of appropriate cultivation technology and availability of planting materials (germplasm in form of seeds and/or seedlings) were mentioned by five groups each. Cultural acceptance for cultivating the species by the community was also mentioned in two group meetings.

Table 15: Raw listing of factors influencing farmers' selection of medicinal plant species for cultivation as mentioned in farmer group meetings

Factor	Summarized to	Number of groups (n=13)
Accepted by community	Community acceptance	2
Adapted to local climate	Cultivation technology known	4
Cheaper to treat than western medicine	Cheaper than medicine	1
Cultivation technology known	Cultivation technology known	1
Easy to extract medicine	Knowledge of treatment	1
Effective or works fast	Knowledge of treatment	1
Fast growing	Fast growth	2
Germplasm availability	Germplasm availability	1
Has other uses	Multiple uses	7
Knowledge of use	Knowledge of treatment	1
Known dosage	Knowledge of treatment	4
Known medicinal value	Knowledge of treatment	5
Market availability	Market availability	12
Not very big	Small tree size	1
Preservable	Preservability	1
Seeds available	Germplasm availability	3
Species threatened	Conservation	2
Treats many diseases	Knowledge of treatment	5
Treats most troublesome diseases	Knowledge of treatment	4

The issues mentioned by the farmer groups were summarized into market availability, knowledge of medicinal value of the species (herein referred to as knowledge of treatment), cultivation technology, germplasm availability and multiple use of a species (Fig 3.2). Issues like small size and fast growth, although related to cultivation technology, were not summarized under that category as they also implied germplasm improvement aspects. All summarized criteria mentioned by four or more groups were included in the farmers' questionnaire for ranking although farmers were allowed to include other criteria they felt were important to them individually.

Scoring by individual farmers also rated factors related to knowledge of treatment highly making this factor to rank significantly higher than all the others (P=0.01; Table 16). The factor (knowledge of treatment) was scored for by 97% of the farmers followed by availability of germplasm, access to medicinal product markets and knowledge of species cultivation technology all of which were scored closely by more than 80% of the farmers. Slightly more than half (54%) of the farmers scored for the need for conservation while less than a quarter (19%) rated multiple uses of the species as important in influencing their decision to plant or manage medicinal tree species in their farms.

Table 16: Farmers' scoring of factors influencing cultivation of medicinal trees

Category of respondents	Average rating by farmers on importance of factor					
	Knowledge of species medicinal use	Availability of species seeds or seedlings	Access to markets for species medicinal products	Knowledge of cultivation technology	Need to conserve the species	Species has multiple uses
Frequency % (n=200)	97	81	89	81	55	19
Average score	2.3	1.2	1.2	1.3	1.2	1.3
Analysis by district						
Embu	2.1a	1.1d	1.4	1.2	0.9	1.3
Mbeere	2.8b	1.8e	1.4	1.4	1.5	0.9
Meru	2.0a	1.0d	0.9	1.2	1.2	0.8
Analysis by gender						
Female	2.5*	1.3	1.3*	1.2	1.2	1.3
Male	2.1*	1.1	1.0*	1.3	1.3	1.1
Analysis by level of education attained						
Not schooled	2.6	0.9	1.3	1.5	0.9	1.9
Primary school level	2.3	1.3	1.2	1.2	1.2	1.2
Village polytechnic	2.2	0.7	0.8	1.2	2.6	
Secondary school	2.1	1.2	0.9	1.2	1.5	1.1
Post secondary school	2.5	0.6	0.6	0.9	0.7	
Analysis by age categories						
Below 25 years	2.9	2.0	1.2	1.1	2.3	
26 - 35 years	2.3	1.3	1.0	1.3	1.6	1.5
36 – 45 years	2.3	1.1	1.1	1.2	1.4	1.1
46 – 55 years	2.3	1.2	1.2	1.3	1.1	1.1
56 – 65 years	2.3	1.2	1.2	1.3	0.7	1.2
Above 65 years	2.2	1.4	1.5	1.6	1.3	1.9

Figures followed by * or different letters are significantly different (P=0.05)

There was no significant difference (P=0.05) in the rating of the factors by the different age classes or education level attained by farmers. Female farmers rated both knowledge of treatment and market access significantly higher than men (Table 3.5). A species having multiple uses was rated higher by women than men both in terms of average score (although the difference was not significant; P=0.05) and number of respondents (27 women against eleven men) implying that this factor was more important to women. Farmers in Mbeere district rated knowledge of treatment and germplasm availability significantly higher than those in other districts while farmers in Meru Central district rated market access significantly lower than the farmers in the other districts.

Herbalists considered a species that treated many diseases as the most favourable for cultivation and more so if the species was getting scarce (Table 17). Access to markets for

medicinal tree products and availability of planting materials (seeds/seedlings) were next in rank. Knowledge of cultivation technology was the least important criteria for herbalists while the three herbalists who gave a rank to multiple uses of the species ranked it last. Ranking by herbalists was not associated with respondents' socio-demographic categories apart from the knowledge of cultivation technology which was ranked significantly higher (P=0.05) by herbalists who had attained post-secondary level of education (3.9) than those with primary level of education (4.9).

Table 17: Herbalists' ranking of criteria for selection of priority species for cultivation

Species preference criteria	Lowest rank	Mean rank	Highest rank	Frequency % (n=60)	Std. Deviation
Treats many diseases	3	4.3a	5	98	0.69
Species is getting scarce	2	4.0a	5	98	1.00
Availability of seeds/seedlings	1	2.5b	5	98	0.94
Access to market for species medicinal products	1	2.9b	5	98	1.31
Cultivation technology known for species	1	1.4c	4	98	0.69
Species has multiple uses	1	1	1	3	0

Figures followed by different letters are significantly different (P=0.05)

3.4.4 Species most preferred for cultivation by farmers and herbalists

Farmers mentioned up to 137 trees and shrub species they preferred to cultivate in their farms and rated how important the factors presented above influenced that preference as shown in Table 18. Only nine species were presented as preferred by more than ten percent of the farmers and a further ten species were preferred by at least five percent (ten farmers). The species preference by farmers closely followed the number of farms where the species were present implying that almost as many farmers as wanted to plant a species had managed to get it present in their farm either by planting or saving those that naturally regenerated.

Table 18: Medicinal plant species most preferred for cultivation by farmers and factors influencing the preference

Species botanical name	Frequency of farmers interested in cultivation (%)	Average score for importance of factor's influence in species preference			
		Medicinal use known	Planting materials available	Market for species herbal products available	Cultivation technology known
Azadirachta indica	47	3	3	3	3
Aloe sp	45	3	3	3	3
Prunus africana	26	3	3	3	2
Olea europaea ssp africana	18	3	2	3	3
Caesalpinia volkensii	14	3	3	3	2
Myrsine melanophloeos	13	3	3	3	3
Croton megalocarpus	11	3	2	3	2
Erythrina abyssinica	10	3	2	3	2
Strychnos henningsii	9	3	3	3	3
Croton macrostachyus	10	3	2	3	2
Senna didymobotrya	9	3	2	3	2
Eucalyptus globulus	8	3	2	3	2
Warburgia ugandensis	7	3	3	3	3
Ajuga remota	6	3	2	3	3
Mangifera indica	6	3	2	3	2
Zanthoxylum chalybeum	6	3	3	3	2
Fagaropsis angolensis	5	3	3	3	3
Citrus limon	5	3	2	3	2
Psidium guajava	5	3	2	3	2
Lantana trifolia	4	3	3	3	2
Jatropha curcas	4	3	2	3	3
Rhamnus prinoides	4	3	3	3	3
Ocimum suave	4	3	2	2	2
Leonotis mollissima	4	3	2	3	2
Piliostigma thonningi	4	3	2	2	2
Carissa spinarum	4	3	3	3	2
Moringa oleifera	3	3	3	3	3
Tithonia diversifolia	4	3	1	2	2
Terminalia brownii	4	3	2	2	2

*No respondent gave a score for conservation of the species while multipurpose use of the species was given an average score of 1 for only four species (*Erythrina abyssinica, Mangifera indica, Ocimum suave* and *Tithonia diversifolia*). No respondent gave a score for multi-purpose use for other species

Herbalists mentioned several species as high priority for cultivation but only *Warburgia ugandensis* and *Azadirachta indica* were ranked highest (3) in terms of both being useful for treating many diseases and also being increasingly scarce (Table 19). For species such as *Croton macrostachyus*, *Myrsine melanophloeos, Solanum incanum, Juniperus procera, Leonotis mollissima* and a few others, the two parameters that most influenced preference by herbalists had been scored as of medium importance (2) in influencing preference. *Carissa spinarum* was not even viewed as getting scarce by those herbalists who presented it as a high priority for cultivation.

Table 19: Medicinal plant species that herbalists would most prefer to be cultivated

Species	Frequency (%) of herbalists preferring species	Average score for importance of factor influence in species preference	
		Species scarcity	Species treats many diseases
Warburgia ugandensis	56	3	3
Prunus africana	56	2	3
Olea europaea ssp africana	51	2	3
Aloe sp	49	2	3
Azadirachta indica	40	3	3
Erythrina abyssinica	35	3	2
Croton macrostachyus	28	2	2
Caesalpinia volkensii	26	3	2
Strychnos henningsii	26	2	2
Ficus thonningi	23	2	2
Myrsine melanophloeos	23	2	2
Solanum incanum	23	2	2
Juniperus procera	21	2	2
Ocotea usambarensis	19	3	2
Leonotis mollissima	19	2	2
Fagaropsis angolensis	16	3	2
Cordia africana	16	2	2
Senna didymobotrya	16	2	2
Dalbergia melanoxylon	14	2	3
Muchani	14	2	2
Zanthoxylum usambarensis	12	2	3
Zanthoxylum chalybeum	12	2	2
Croton megalocarpus	12	2	2
Ricinus communis	12	2	2
Carrissa spinarum	12	1	2

The species preferred by most herbalists were also preferred by most farmers especially *Prunus africana, Aloe spp., Azadirachta indica, Olea europaea ssp africana* and *Caesalpinia volkensii*. Notable differences observed between the species preference by farmers compared with herbalists included *Ocotea usambarensis, Solanum incanum,* and *Cordia africana* being preferred by many herbalists but not by many farmers. On the flipside few herbalists preferred *Ajuga remota, Citrus limon* and *Psidium guajava* even though the species were preferred by many farmers.

2.5 Discussion

The study encountered many medicinal tree species either planted or saved from clearing when fields were cultivated. Knowledge of species medicinal use was rated as the main factor that influenced cultivation possibly because the trees in farms supported domestic health needs. Access to functioning markets by farmers for medicinal products from these

species would raise their income levels but this did not come out as a major priority possibly due to lack of market knowledge. Barr (2004) observed that farmers in Meru planted trees first to meet their subsistence needs and sale of tree products was secondary. Sale of tree products by farmers largely happens by chance after persuasion by interested buyers except in situations where the family is in urgent need of money (ibid). This implies that unless herbalists or traders in herbal medicine approached farmers to purchase herbal material, market access is unlikely to be a key factor influencing cultivation of medicinal trees compared to knowledge of treatment for subsistence use. Farmers however scored availability of markets second in influencing preference of most species meaning the numbers planted for most species would increase if markets for their products were available.

The respondents' socio-demographic categories did not show any different trends in the rating of factors influencing cultivation of medicinal tree species apart from gender. This observation is useful as it implies that interventions related to medicinal tree cultivation may not have to consider education and age differences in the farming community. Many people with post primary education normally find off-farm employment and either move to urban areas or live in the rural areas in off-farm employment while spouses (usually wives) manage the family farms. Traditional medicine has however evolved to a business practice and herbalists presently have high levels of education practicing both in urban (Wondwosen, 2005) and rural areas. The elevated social status of herbalists due to respect of traditional medicine can be enhanced by evidence of herbalists attaining high formal education levels which can serve a good platform in promoting medicinal tree species conservation and domestication in farms if herbalists participated in the efforts.

Women rated knowledge of species medicinal use and market access higher than men possibly due to their (women) higher involvement in household support responsibilities. This observation can be related to the observation that women in Adiarbaetu, Ethiopia had deeper knowledge on medicinal plants than men and were relied on to treat common household illnesses (Howard and Smith, 2006). Women have also been observed to be more involved in informal markets and have played a major role in collection and marketing of non-timber forest products (Dahal *et al.,* 2000; Vanclay *et al.,* 2006). They tend to be left out in major cash crop systems and rarely benefit from the income from crops although they provide the bulk of required labour (Sigot *et al.,* 1995). Being able to use medicinal trees present in farm therefore presents women with an opportunity to save the meagre cash they control while markets offer opportunity to raise more income and social networking (Koczberski *et al.,* 2001).

Farmers in semi-arid Mbeere ranked access to germplasm (tree planting materials) second to knowledge of species medicinal value. Akinifesi *et al*. (2008), reported poorly functioning

germplasm supply systems as a major constraint to adoption agroforestry technologies. A survey by Muriuki *et al.,* (unpublished) showed that the semi arid zone in the study area had fewer tree nurseries than the humid zone. Semi-arid areas also have fewer opportunities to raise a lot of income in agricultural based economies and are often remote with poorly functioning health systems (IIRR, 2002). Famers in drier zones are however likely to possess a lot of knowledge on plant resources since, being poorer than the humid areas, they depend more on natural resources than products sourced from markets. Dahal *et al*., (2000) stated that knowledge of plant ecology, harvesting and semi-processing techniques may be present among poorer members in a society due to their long association with certain tasks and roles in the community, yet market and price trend knowledge is often absent in that population segment. This may explain the trend mentioned by farmers and herbalists in humid areas of sourcing many species from arid lands. The role of drier zone ecology on the potency of active components in medicinal plants however needs investigation.

Medicinal trees' use in traditional medicine can be classified into four categories; self administered herbs, marketable species (mainly herbal materials that are not easily degradable with drying and storage), regulated and restricted types (Simons and Muriuki, 2004). The last two categories are used by very experienced herbalists and should be subjected to licensing by authorities. Use of medicinal plants in these two categories is based on accumulated knowledge by herbalists and is also likely to yield more economic benefits to the herbalists. This might explain why herbalists rated a species that treated many diseases as the most important factor influencing cultivation while the species abundance status was critical to them too. The availability of the plant resource determines the evolution of the associated knowledge of use and loss of medicinal plant biodiversity can contribute to loss of traditional medicine knowledge. Plants in the restricted and regulated categories are in most cases subjected to overharvesting. Thus medicinal tree conservation status was a higher priority for herbalists than it was with farmers.

A species with multiple uses was not rated highly by herbalists as healers have specialized in the herbal medicine trade so other tree uses may not have high importance to them. The factor can however be important to herbalists if another use of an important medicinal plant species led to competition for highly rated species in the wild such as use of *Prunus africana* and *Ocotea usambarensis* as timber. Multiple use of a species was also not rated as important by farmers, especially men, since there appeared to be a tendency to identify a species through its most economically important purpose. Thus species that have high value for other purposes such as *Mangifera indica* as fruits were not highly ranked as medicinal but had been ranked highly by farmers in the same study area for other uses in a study by Betser *et al*. (1999). Since medicinal use for farm grown or conserved trees has not been given prominent importance, there has been a tendency to assign species only to lists that

are drawn based on the major use. Regmi *et al*. (2003), in their study of contribution of agroforestry to rural livelihoods in Nepal, listed medicinal value of species as minor contribution compared to fodder, fuel and timber. Additionally, farmers in the Regmi *et al*. (2003) study did not rank multiple use of fodder species highly, compared to factors directly associated with high quality fodder such as palatability, milk production, dry season fodder and biomass production.

In our study multiple uses of species was found to have more significance to women compared to men possibly be due to women having more responsibilities for household subsistence (Howard and Smith, 2006). A species that meets several household needs would go a long way in unburdening women when it is accessible within the farm. Citing five case studies of gender and natural resource management in Africa, Sigot *et al*. (1995), reported that women were involved in many household tasks that demanded more labour input than men. Some species that were rated highly by women but poorly by men could have been playing key roles in household health management or playing multiple roles in meeting household needs which needs further investigation. Conservation and domestication of these species could deliver high socio-economic benefits in the society. However women in many societies have less control on land use and production decisions (Sigot *et al.,* 1995; Quisumbing *et al.,* 2001) and their preferred species may not be cultivated if men or local institutions do not support them.

The number of individuals of a medicinal tree species in a farm was positively correlated to the number of farmers who preferred the species and was largely based on the species that farmers knew. Only eight species were preferred by more than ten percent of the farmers and none was preferred by up to a half of the respondent farmers. This implied that majority of farmers did not know the medicinal value of many plant species and therefore would not plant them for medicinal purposes. Farmers would most likely clear the species whose medicinal value is unknown when competition for land use became critical in their small holdings. One farmer actually stated in a group meeting that he was willing to cut one *Carissa spinarum* tree that was growing in his farm to create some space for cultivating more beans. The species that were preferred most by herbalists, but not by farmers, were not common in farms possibly due to this reason. This group of species is likely to be playing a critical role in regulated and restricted herbal consultative medicine but not in household self-treatment healthcare. Such species can suffer threatening pressures since cultivation by herbalists alone may not sustain viable breeding populations especially if the species suffer competition for other extractive uses. A good example of this was *Ocotea usambarensis*, also a high value timber species. Governments and projects should facilitate platforms where herbalists can share information on the medicinal value of such species to the general farming population if cultivation levels are to be raised.

Herbalists reported experiencing scarcity of some highly ranked species and were travelling long distances to source them. Majority of these species were sourced from the arid areas and the wild resources (forests and woodlands) in humid areas. In the absence of continuous monitoring of these wild resources, some of these species could have already been in a threatened state as the herbalists reported. Tree planting in arid areas is a major challenge owing to water scarcity and often open forage livestock management systems (Dixon *et al.,* 2001) while wild resources in many cases suffer degradation in the form of the tragedy of the commons (Hardin, 1968). Tradeoffs between travelling long distances and buying from nearby farms could stimulate local informal markets if herbalists did not view farm grown material as inferior to wild sourced as opined by Schipmann *et al.,* (2002).

The practice of allowing neighbours to access herbal materials from farmers' fields was commonly reported and herbalists must also have been benefiting greatly from this social benevolence. Since farmers felt that the few trees present in their farms or at their neighbours' farms were sufficient for household herbal health care, they would not plant more medicinal trees unless other incentives apart from knowledge of treatment were availed. The same practice was observed in Tigray, Ethiopia, where culture allowed people to collect medicinal herbs and wild fruits from any area whether private or not (Howard and Smith, 2006). Farming communities have used sharing as a livelihood supply system even for marketable products like palm oil (Koczberski *et al.,* 2001; Stone, 2001). Faced with diminishing land sizes, cultivation of medicinal trees beyond what is sufficient for subsistence has to be for some markets, either product markets or payments for environmental services. An alternative conservation approach is to facilitate communities to plant medicinal trees in public or communal lands with guaranteed access and use as suggested by Rao *et. al.,* (2004).

Knowledge of the appropriate cultivation technology of medicinal tree species was not ranked highly as a factor influencing cultivation decisions. Farmers however mentioned factors such as small farm sizes and species ecology as contributing to absence of some medicinal tree species from farms. This information shows that development of cultivation technology based on species ecology is important to aid smallholder intensification needs. There is need to identify niches that can accommodate some of these species in farm fields with the least opportunity costs borne by farmers in terms of forgone productivity of other farm enterprises. *Olea europaea* ssp *africana*, a species among the most highly rated by both farmers and herbalists in our study was reported by farmers in Ethiopia and Tanzania as among species incompatible with planting niches in farms and recommended as better planted in communal lands (German *et al.,* 2006). These farmers (in Ethiopia and Tanzania) however planted *Eucalyptus* species in high densities in their farms because the perceived

benefits from planting the species were more important to them than the negative ecological effects.

2.6 Conclusion

Knowledge of species medicinal value was the leading factor that influenced medicinal tree species cultivation by both farmers and herbalists. Availability of markets was the second most influential factor for farmers generally although farmers in the arid zone considered germplasm availability more critical. Herbalists considered conservation of important species more critical than germplasm availability (although the two are closely linked) and had a low rank for availability of markets since the traditional medicine practice was their source of income. Women farmers ranked knowledge of species medicinal value and market availability higher than men and had a higher rating for species that could serve other purposes apart from healthcare. Few farmers had wide knowledge of medicinal tree species with only eight species ranked by at least a tenth of the farmers. Species cultivation (both deliberate planting and leaving in the farm when clearing for crop production) was positively correlated to the species preference in terms of number of farmers or herbalists cultivating the trees. However farmers felt that one tree or two shrubs per species were sufficient for household herbal health management and were willing to share with neighbours.

Further research is needed to measure the interaction between the identified factors. Since the ranking was largely based on medicinal trees being part of household subsistence more than income generation, a model is needed that shows how the rating would change with change in the status quo. For example should one species become important for industrial medicine production thus highly marketable but not in traditional medicine use, farmers would be expected to increase its cultivation. Availability of germplasm as input support or sharing market knowledge with farmers could also change the scenario. The results also call for more sharing of information on species medicinal value between herbalists and farmers to act as a catalyst for more cultivation or conservation in farms. Governments and related projects should facilitate such exchange fora and encourage herbalists to share information since they are paying more costs in sourcing for high value species as they get scarce. Trade between the farmers and herbalists will then grow as farmers sell the herbal material to and buy treatment from herbalists. But this will work only if herbalists find it more attractive to acquire herbal material from farmers rather than collecting it from the wild. Assessment of species abundance in the neighbouring forests and woodlands is important to determine whether current harvesting is sustainable and what policy recommendations should be developed to discourage wild collection in favour of sourcing from farms.

Annex 3.1: Cultivation and use of highly ranked medicinal species by farmers

Species name	Growth habit	Farmers planting med species in their farms						Farmers not planting med species in their farms					% Farmers don't know species as medicinal (n = 200)
		Total farms	Av. No planted	Av. No Natural Rege-nerated	Av. Total number	Trees sufficient for household use?	No of farmers sharing with neighbours	Total farms present	Farms where used species at Home	Farmers getting enough	Sources	Why not in farm	
Acacia mearnsii	Tree	5	32.3	8.7	24.6	1	1	12	7	4	4(1), 5(7)	1(3), 2(1), 11(4), 17(1)	92
Albizia gummifera	Tree	1		2.0	2.0	1		1	1	1	6(1)	3(1)	99
Aloe sp	Herb	103	10.9	17.9	12.4	1	68	24	17	12	2(8), 4(1), 5(9)	3(2), 7(2), 8(2), 10(1), 14(2), 17(1)	36
Azadirachta indica	Tree	54	2.1	3.3	2.1	1	36	89	64	47	1(1), 3(1), 4(10), 5(52)	1(4), 8(9), 19(2), 11(56), 12(2), 13(7), 16(1), 17(1)	29
Bridelia micrantha	Tree	10	5.8	2.7	4.5	1	6	2	1	1	5(1)	7(1)	94
Caesalpinia volkensii	Shrub	16	1.2	2.0	1.4	1	12	37	27	18	1(1), 2(5), 4(3), 5(20)	1(2), 2(2) 3(1), 5(3), 7(4), 11(15), 12(2), 17(1)	74
Carissa spinarum	Shrub	8	1.0	5.6	5.8	1	3	26	21	20	1(2), 2(20), 5(1), 6(1)	3(11), 5(3), 7(1), 8(1), 9(2), 11(5), 12(1)	83
Cordia africana	Tree	12	3.4	10.5	4.6	1	4						94
Croton macrostachyus	Tree	48	6.6	4.9	6.2	1	23	5	4	4	2(1), 5(3)	3(1), 10(2), 16(1)	74
Croton megalocarpus	Tree	40	13.5	10.0	13.9	1	19	11	4	5	2(4), 5(4)	1(1), 2(3), 3(1), 8(1), 10(1), 11(2)	75
Dalbergia melanoxylon	Tree	6		6.5	6.5	2	2	4	3	3	2(2), 5(1)	3(3), 11(1)	95
Erythrina abyssinica	Tree	40	3.0	1.7	2.2	1	29	25	19	16	1(1), 2(3), 4(1), 5(14), 6(1)	1(3), 3(6), 6(1), 7(3), 8(1), 11(3), 12(2), 16(1)	68
Ficus sycomorus	Tree	10	1.0	1.6	1.4	1	3	8	7	7	2(4), 5(2), 6(20	3(3), 9(2), 11(1)	91
Ficus thonningi	Tree	3	5.0	1.5	2.7	1	3	1	1	1	2(1)	3(1)	98
Kigelia africana	Tree	1	2.0		2.0			2	2	1	1(1), 4(1)	3(1), 10(1)	99
Lantana trifolia	Shrub	15	14.6	5.0	7.9	1	8	7	6	6	2(2), 5(3),	1(1), 3(1), 5(1), 13(1)	89

Moringa oleifera	Tree	8	14.6		14.6	1	1	7	2	1	5(2)	10(1), 11(4)	93
Zanthoxylum usambarensis	Tree							1	1		3(1)	11(1)	99
Leonotis mollissima	Herb	10	1.5	7.0	4.8			14	11	8	2(4), 4(1), 5(2), 6(4)	3(3), 5(1), 7(2), 8(3), 9(1), 11(2)	89
Myrsine melanophloeos	Tree	5	1.0	2.8	2.4	1	4	34	28	19	2(23), 4(1), 5(1), 6(1)	5(3), 7(2), 9(1), 11(23), 12(3)	81
Olea europaea	Tree	34	3.8	3.3	3.6	1	28	39	32	26	2(20), 4(4), 5(8)	1(2), 3(8), 5(3), 7(2), 8(2), 10(1), 11(17), 16(1), 17(2)	64
Osyris lanceolata	Shrub	9		14.0	14.0	1	6	8	5	4	2(5)	3(5), 8(1), 14(1)	92
Prunus africana	Tree	46	4.8	2.5	4.7	1	25	30	22	16	2(13), 5(8)	1(2), 3(2), 8(2), 10(3), 11(16), 16(3)	62
Rhamnus priniodes	Shrub	4	3.5	7.5	5.5	1	3	10	9	9	2(9), 5(1)	3(1), 7(1), 11(6), 16(2)	93
Ricinus communis	Shrub	17	8.6	5.5	8.4	1	8	4	4	4	2(3), 5(1)	3(2), 11(1)	90
Senna didymobotrya	Shrub	42	5.1	10.7	9.1	2	16	21	19	17	2(10), 5(6), 6(3)	1(3), 3(11), 7(1), 8(1), 11(2)	89
Solanum incanum	Shrub	26	10.0	16.6	16.3	2	11	6	7	6	2(6)	3(2), 9(2)14(1)	84
Strychnos henningsii	Tree	7	1.0	13.8	12.0	1	7	16	14	12	1(1), 2(8), 5(3), 6(3)	1(1), 3(6), 5(2), 7(4), 8(1), 9(1)	89
Terminalia brownii	Tree	21	2.5	6.0	6.2	1	5	6	4	5	2(2), 5(3)	3(3), 6(1), 11(2)	87
Tithonia diversifolia	Shrub	37	62.8	61.7	62.5	2	16	10	8	8	2(1), 5(5), 6(2)	1(1), 3(4), 7(2), 8(2)	77
Vepris nobilis	Tree	1	30.0		30.0	1	1	2	2	1	2(1), 5(1)	11(1)	99
Warburgia ugandensis	Tree	7	1.4	1.0	1.3	1	7	12	10	5	1(1), 2(8), 4(1), 6(1)	3(2), 7(1), 11(8), 12(1)	91
Zanthoxylum chalybeum	Tree	20	1.0	2.4	2.1	1	9	13	11	6	1(1), 2(9), 5(1)	1(1), 3(2), 7(3), 11(4), 12(2)	84

Codes: (Numbers in parenthesis indicate the number of herbalists who gave the source or reason)

Sources - 1: Arid areas, 2: Forest/woodland, 3: Institutions (KARI, Ministry of agriculture etc), 4: Market, 5: Other farmers (neighbours or relatives), 6: river lines

Why not in farm – 1: Accessible at neighbour, 2: Affects farm productivity, 3: Available in the wild (forest/woodland), 4: Cleared for cultivation, 5: climate not favourable, 6: Competition for other uses, 7: Cultivation technology unknown, 8: Dried up after planting, 9: Farm ecology not suitable for species (does better on forest or river lines) , 10: Interested in planting, 11: No planting material, 12: Propagation method unknown, 13: Species confusion, 14: Poached, 15: Species are weeds in farms, 16: Farm plot small, 17: Not interested in planting species

Annex 3.2: Cultivation and assessment of the status of the most preferred medicinal plant species by herbalists

Species name	Number of herbalists			Average of species status as mentioned by herbalists			Number of herbalists travelling to search species	Estimate of distance to source (km)			Reasons given by herbalists Why species is not available
	cultivating	not cultivating	not mentioned species as medicinal	threatened?	Supply trends	easily cultivated?		Min	Ave	Max	
Prunus africana	21	13	26	1	1	1	8	1	24	100	6(3), 4(2)
Warburgia ugandensis	9	25	26	1	1	1	18	10	34	100	3(4), 6(1), 2(7), 1(5)
Aloe sp.	37	3	20	1	2	1	3	25	57	80	1(2), 2(1)
Azadirachta indica	14	12	34	1	2	1	6	5	28	50	1(2), 4(1), 2(2)
Olea europaea	11	3	46	1	1	2	10	2	33	100	6(4), 1(5)
Strychnos henningsii	3	13	44	1	1	2	4	10	35	100	3(1), 6(1), 1(2)
Erythrina abyssinica	10	7	43	1	2	1	2	30	55	80	6(1), 3(1)
Myrsine melanophloeos	2	21	37	2	1	1	12	5	26	100	6(2), 1(1), 4(1), 2(1)
Caesalpinia volkensii	5	5	50	1	2	1	4	10	32	50	6(2), 1(1)
Zanthoxylum chalybeum	4	9	47	1	1	1	6	2	19	50	6(1), 1(1)
Moringa oleifera	8	2	50	1	2	1					
Ocotea usambarensis	1	13	46	1	1	1	7	3	26	100	6(1), 4(2), 1(1), 5(1), 2(1)
Croton megalocarpus	9	2	49	2	2	1	1	100	100	100	1(1)
Dalbergia melanoxylon	4	7	49	1	1	2	3	5	62	100	6(1), 1(1), 2(1)
Leonotis mollissima	4	7	49	1	1	1	4	5	15	20	6(1), 1(1)
Solanum incanum	12	4	44	1	1	1	1	5	5	5	6(1)
Zanxthoxylum usambarense	6	5	49	1	2	1	5	3	11	20	6(1), 1(1), 4(1)
Croton macrostachyus	5	2	53	2	2	1	1	10	10	10	4(1)
Osyris lanceolata	3		57	1			3	5	45	100	4(1), 1(1), 3(1)
Senna didymobotrya	14	5	41	1	1	1	1	5	5	5	6(1)
Bridelia micrantha	4	1	55	1	1	1	1	25	25	25	4(1)
Tithonia diversifolia	12		48	2			1	1	1	1	6(1)
Cordia africana	5	1	54	2	2	1					
Ficus sycomorus	4	3	53	1	2	1					

Vepris nobilis		2	58		1	1					
Albizia gummifera		1	59	1	1	1					
Kigelia africana	2	5	53	1	1	1	3	20	48	100	6(1), 1(1)
Ricinus communis	5	5	50	1	1	1	1	40	40	40	1(1)
Rhamnus prinoides		6	54	1	1	2	4	5	15	30	6(1), 1(1)
Ficus thonningi	4	1	55	1	2	1	1	20	20	20	6(1)
Fagaropsis angolensis		5	55	1	1	1	3	5	12	20	2(1), 6(2)
Lantana trifolia	5	2	53	2	1	2					
Carissa spinarum	5	10	45	1	1	2	4	1	34	100	6(2), 1(2)

Codes: Threatened – **1**: Yes, **2**: No **Supply trends** – **1**: Decreasing, **2**: Constant, **3**: Increasing **Easy to cultivate** – **1**: Yes, **2**: No **3**: Not sure (Averages were taken for these three factors)

Reasons for species not available - 1: climate not favourable, **2**: Lack of germplasm, **3:** over-exploitation, **4:** competition for other species uses, **5**: grows in forest and **6**: Cleared for cultivation). Numbers in parenthesis indicate the number of herbalists who gave the reason

3 Influence of local disease burden perception and knowledge of herbal treatment on medicinal trees cultivation

3.1 Introduction and literature review

The world health organization defines traditional medicine as the sum total of all the knowledge and practice, whether explicable or not, used in the diagnosis, prevention and elimination of physical, mental or social imbalance and relying exclusively on practical experience and observation handed down from generation to generation, whether verbally or in writing (Conserve Africa, 2004). Mander (1998) posits that the practice is not just traditional but also dynamic and is also addressing new challenges such as AIDS and adopting new technologies and new medicines. In Africa the practice continues to attract a big section of the population and is little affected by changing levels of education, income, religious affiliation, occupation or wealth as Mander (1998) reports of Kwa Zulu Natal in South Africa. Medicinal plants form a bulk proportion of the raw materials used in the practices although other materials such as animal parts are used. However concerns abound about disappearance of supportive resources threatening the survival of the practice and provisions to provide *materia medica* (raw materials) for the practice ought then to be put in place in national and international health and development strategies (Rukangira, 2000).

Efforts to support conservation of medicinal plants started mainly by documentation of species and remedies through numerous ethno botanical studies conducted on general disease treatment by specific communities in Africa and beyond (such as Kareru *et al.,* 2007). These studies have helped identify species that need conservation due to the roles the species have been seen to play in traditional medicine. Many studies have focused on treatment of specific diseases which have been observed to inflict high socio-economic costs to African communities such as malaria (Njoroge and Bussmann, 2006; Ssegawa and Kasenene, 2007), cancers (Koduru *et al.,* 1997) and gastrointestinal diseases (Kisangau and Kokwaro, 2004) among others. Most of these studies involve interviews with traditional health practitioners and normally list species that were highly ranked by respondents as high priority for conservation.

The second level of studies involves review of ethno botanical information in terms of clinical treatment efficiency of traditional remedies such as for malaria (Willcox and Bodecker, 2004; Rukunga and Simons, 2006) and laboratory evaluations of remedies (Beha *et al.,* 2004). Conserve Africa (2004) observed that the fields of study have expanded to include pharmacology, phytochemistry, chemistry of natural products, organic synthesis and the usefulness of medicinal and aromatic plants. There is increasing literature evidence that a lot

of research deriving from ethno botany and traditional medicine practices is influenced by increased socio-economic importance of diseases such that more work is done for diseases such as malaria (Rukunga and Simons, 2006), HIV/AIDS (Homsy *et al.,* 2004; Cox, 2004), tuberculosis (Oeser *et al.,* 2005) and various cancers (De Wet *et al.,* 2009). Results from these studies have resulted in bio-prospecting for new pharmaceutical drugs from compounds isolated from plants for treatment of these diseases (Verma and Singh, 2008; Tyler, 1995; Kitua and Malebo, 2004). Drug extraction opportunities increase competition for the source plants as both companies and traditional healers extract from existing species populations. Hoareou and DaSilva (1999) gave a brief review that connected ethno botanical findings with possibility of increasing trade in medicinal plant products globally, pointing to a case of need for conservation. All this interest in medicinal plants leads to more pressure being exerted on already degraded natural resources.

As natural forests and woodlands get decimated in terms of area and species numbers, development of appropriate conservation strategies is urgently called for (Cunningham, 1993). Smallholder farms with diversified agroforestry enterprises offer new frontiers to cultivate the species playing important roles in traditional medicine. Hawkes and Ruel (2006), have explored relationships between agriculture and health. While ill health reduces agricultural productivity by removing labour contributions by sick people, agricultural practices can also predispose farmers to ill health and can also support health management. This is particularly significant for smallholder farmers in the developing world who basically subsist on agriculture. With food costs eating up over 70% of their output (Tinsley, 2004), smallholder farmers are left with little to spend on other household needs such as medicine and have relied, in many cases, on traditional medicine for health maintenance. Smallholder farmers respond to scarcity by having diversified farm production systems which are capable of providing as many as possible household needs (Netting, 1993; Stone, 2001). Thus they plant timber, fodder and medicinal species in addition to food producing (fruit and grain) species to support their livelihoods. Traditional home gardens and woodlots play a great role in this livelihood strategy (Uddin and Mukul, 2007; Tangjang and Arunachalam, 2009; Maroyi, 2009).

Studying local perception of populations' socio-economic situations has been applied in several situations to come up with useful recommendations for community development. Mango *et al*., (2009) studied local perception of poverty and the stages of escape in 71 Kenyan communities and recommended interventions useful for poverty alleviation. Tabuti (2007) studied local perceptions on tree species use and threats in Gadumire sub-county, Uganda and recommended species that needed urgent conservation strategies. In health related studies, Nyamongo (1998) reported that lay people responded to disease situations based on their perception on the effectiveness of the available treatment options. Quoting a

number of studies he reported the treatment options available to local communities as including the application of a home remedy, self-medication with pharmaceuticals bought over-the-counter on the open market, herbal therapies provided by traditional healers, and therapies obtained from health centers or hospitals. Some patients also choose not to seek any therapeutic intervention. Nuwaha (2002), studied people's perceptions of malaria in Mbarara, Uganda, and recommended collaboration between governments, traditional and private health care providers in promoting preventive measures such as insecticide treated nets. Deressa and Ali (2009) gave similar recommendations after studying malaria-related perceptions and practices of women in rural Ethiopia.

Using a similar approach of studying community perception, this study was designed to test whether farmers in the area east of Mt. Kenya were influenced by their perception of the economic importance of diseases and their knowledge of the species medicinal value when planting or conserving medicinal trees in their farms. The following objectives informed the analysis of community perspectives and medicinal species cultivation. (i) To document the diseases perceived to be of high economic importance to the community by farmers and herbalists and compare with hospital statistics. (ii) To study the role of traditional medicine and medicinal plants in the management of the economically important health conditions. (iii) To list and rank the species used by farmers and herbalists in the treatment of the most economically important diseases, and (iv) To test if the level of cultivation of medicinal plant species by farmers is associated with the knowledge of species medicinal use and farmers' perception of disease economic importance.

3.2 Research methodology

The study involved interviews with 200 farmers from thirteen villages (four from Embu, four from Mbeere and five from Meru Central districts), conducted with a structured questionnaire between May and July 2008. The villages were selected randomly from groups that the extension wing of Kenya Forest Service (KFS) was working with to promote tree planting in each district. Fifteen farmers were randomly sampled from each village (twenty from Kithoka in Meru) after conducting group meetings in each village where we introduced the study and had a discussion on the health situation in each village and the use and sources of medicinal plants in general. Further interviews were conducted with twenty traditional health practitioners (herein referred to as herbalists) in each district that were also randomly selected from the list of herbalists registered with the respective district's herbalists association. A leader of the association accompanied our research team in the interviews in order to gain trust of the respondent herbalists who had lately been complaining of intellectual property loss after responding to research surveys.

Farmer interviews involved assessing the most socio-economically important diseases, the farmers' response to disease problems as well as the medicinal tree species they knew were useful in treatment/management of these diseases including those species that were not present in their farms. We recorded the medicinal plants that were in the farm, either deliberately planted (herein referred to as planted) or naturally regenerated but managed in the farm (herein referred to as managed). Herbalists were asked to give details of the health situation in the villages around them judging from their observations as well as patients that came to consult them for treatment and the plant species that were useful in treating them. We did not seek details on the actual methods of disease treatment (remedy composition). Both farmers and herbalists were requested to score the diseases' frequency in the population and as a cause of mortality. A score of three (3) was given for the most serious case (high frequency or high mortality rate) and one (1) for the least serious. We also collected records from Embu and Mbeere district hospitals on the top ten serious diseases as causes of out-patient and in-patient morbidity and mortality for comparison with farmers and herbalists perceptions.

3.3 Data analysis

Survey data was entered into a Microsoft Excel database and part of the analysis done using the pivot-table function while the rest of the data was extracted to SPSS (Statistical Packages for Social Studies) for further analysis with the units of analysis being the respondent farmers or herbalists. We used matrix ranking to rank diseases' socio-economic importance for both farmers and herbalists by adding the average scores for frequency of disease incidence in the community to the average score for the disease as a cause of mortality. However the score for frequency was weighted by the number of respondents that had mentioned the disease since respondents scored for the diseases they were felt were important to them (we did not have a pre-selected list of diseases for respondents to rank). We converted the frequency of respondents into scores of one to three (by multiplying the percent frequency by 0.03) and the derived score was multiplied by the average score given for frequency of incidence of that disease. Species ranking was done by summing the weights of all diseases a species was reported to treat by either farmers or herbalists (Appendix 2). Kareru *et al*. (2007), used a similar approach to rank diseases only that they did not consider the perception of the importance of the disease by the respondents themselves but instead used the diseases that were found to be more common in hospitals in Embu district. To identify the species botanically from the local names given, we relied heavily on Maundu and Tengnas (2005) and Kibwece (1993) as reference materials.

We gauged the farmers' knowledge of traditional medicine by the number of the medicinal plant species they mentioned, both present and absent from their farms and the number of

diseases they mentioned that the species treated. ANOVA and student t-tests were used to test whether farmers' knowledge of traditional medicine varied with socio-demographic factors (gender, age and education) as well as the districts they came from. A significant analysis question to cluster respondents on their knowledge and use of medicinal plant species was on the first step taken by the respondent in response to a symptom of illness in the family. A knowledge index was also created as shown in the formula below and compared by linear regression with the number of species that were in each farmer's field whether planted or managed. We used the number of species in the farm but not the total number of trees per species since farmers had reported that one tree was sufficient for household medicinal use for most trees and shrub species. To test whether disease perception influenced the conservation and/or planting of medicinal trees by the farmer we assessed the knowledge of medicinal tree use with three indices:-

1. Knowledge index A - summation of all the plant species that the farmer mentioned as medicinal including all the diseases the respondent said that each species could treat. For example if a farmer mentioned two species as medicinal and said that he knew species X to treat two diseases and species Y to treat three diseases we would assign his knowledge index a as five (5) points.
2. Knowledge index B – same as index A but the mentioned species were weighted depending on whether the particular species was actually used in the household or not (weights: 2 if used; 1 if not used in the household)
3. Knowledge index C = same as index B but the diseases treated were weighted with the score the farmer gave as his/her perception of the economic importance of each disease treated

3.4 Results

4.4.1 Introduction of respondents

The socio-economic and demographic characteristics of respondent farmers and herbalists are as described in section 3.4.1. It was apparent from farmer group discussions that communities felt diseases were a major problem mainly because the health centers that were close did not have enough medicine for many serious diseases (Table 20). Though many farmers knew which medicinal tree species would be useful to treat some diseases, access to sources of naturally growing medicinal plants near them was getting restricted since the sources were either in forests or the remaining uncultivated lands that were disappearing with time. Access to these sources was not necessarily assured as land owners or forest managers' assent was required. One group (Ikongu) did not even have any source of medicinal trees close to them.

Table 20: Some aspects of community access to conventional and herbal medicine resources as reported by farmer groups east of Mt. Kenya

Village	Average land size (acres)	Nearest source of medicinal plants	Average distance to source (km)	Free access allowed at source*	Nearest medical centre	Average distance centre (km)	Drugs availability in centre
Ikongu	3	None	NA	NA	Gatunduri dispensary	2	Not enough
Kabuguri	6	Uncultivated land	2	1	Kabuguri dispensary	1	Not enough
Kambo mwienderi	1	Uncultivated land	5	1	Kithimu dispensary	4	Not enough
Kiigene	3	Kithino river banks	2	3	Consolata Hospital Nkubu	5	Enough
Kithoka Twajai	2	Kithoka forest	1	2	Rimauru dispensary	4	Not enough
Kwamacembe	6	Kianjiru hill	2	2	Mbita dispensary	4	Not enough
Mutethania	3	Uncultivated land	6	1	Siakago hospital	3	Not enough
Mwamko	2	Meru Forest	13	2	Nkando dispensary	3	Not enough
Mwembeni	5	Uncultivated land	1	1	Kamumu health centre	3	Not enough
Nduva Mwirutiri	3	Njukiri forest	8	2	Kithimu dispensary	3	Not enough
Nkuriga	1	Mucheene forest	1	2	Kiandugui health centre	6	Not enough
Ntugi	2	Uncultivated land	2	1	Kiirua health centre	4	Not enough
Thamari	1	Uncultivated land	1	1	Makengi dispensary	1	Not enough

* 1 - Depends on owner of land; 2 - Controlled by forest department officials; 3 - Yes in most cases

4.4.2 Ranking of ill health conditions based on the perception of disease economic importance by farmers and herbalists

Farmers and herbalists ranked 50 ill health conditions in common by their perception of the economic importance of the diseases in the community (Tables 21 and 22), but there were some diseases that were mentioned by only one category of respondents (either farmers or herbalists) and not the other (Annexes 4.1 and 4.2). However most health conditions in this later group were mentioned by few respondents and rated of low economic importance. Herbalists were found to be more knowledgeable about diseases than farmers with 27 diseases being ranked by more than 20% of the herbalists while only 18 diseases were ranked by more than 20% of the farmers. In total, farmers gave 69 health conditions compared to the eighty (80) mentioned by herbalists. The pattern of ranking the diseases was however very similar between the herbalists and the farmers with the total scores given for the 50 diseases ranked by both categories having a very strong Pearson Correlation coefficient (0.88 significant at P=0.01).

Table 21: Top thirty diseases ranked by farmers based on the disease frequency and rate as cause of human mortality in the local population

Disease	Response frequency % - f (n=142)	Response frequency weight – fw = f x 0.03	Score for disease frequency - fd	Weighted frequency – F = fw x fd∞	Score for Mortality – M	Total score – S = F + M
Malaria	100	3	3	9	2	11.2
Typhoid fever	80	2	3	6	2	8.5
Colds/coughs/flu	86	3	3	7	1	7.9
HIV/AIDS	54	2	2	4	3	6.7
Pneumonia	51	2	2	4	2	6.1
Hypertension	41	1	2	3	2	5.0
Tuberculosis	43	1	2	2	2	4.4
Diabetes	31	1	2	2	2	4.2
Back/bones/Joints pains	37	1	3	3	1	4.2
Cancers	20	1	2	1	3	4.0
Measles	38	1	2	2	2	3.9
Stomach disorders	34	1	2	2	2	3.9
Headaches	32	1	3	2	1	3.8
Diarrhoea	27	1	2	2	2	3.8
Rheumatism	26	1	2	2	2	3.8
Amoeba	24	1	3	2	2	3.7
Worms	23	1	2	2	2	3.2
Prostate cancer	12	0	2	1	2	3.2
Kwashiorkor*	1	0	1	0	3	3.0
Dental problems	22	1	2	1	1	2.8
Cholera	9	0	1	0	2	2.7
Fever*	7	0	3	1	2	2.6
Kidney diseases	3	0	2	0	3	2.6
Asthma	15	0	2	1	2	2.6
Vomiting*	2	0	2	0	2	2.5
Marasmus*	2	0	1	0	2	2.4
Chest problems	10	0	3	1	2	2.4
Epilepsy	7	0	2	0	2	2.4
Ulcers	7	0	3	1	2	2.3
Eye problems	17	1	2	1	1	2.2

∞ Disease frequency was weighted by the number of respondents who mentioned it based on the assumption that a disease mentioned by many respondents must have been more commonly occuring in the community than that mentioned by few respondents even if the few who mentioned the later could have given it a high score for frequency

* This condition was not mentioned by herbalists

Table 22: Top thirty diseases ranked by herbalists based on the disease frequency and rate as cause of human mortality in the local population

Disease	Response frequency % - f (n=43)	Response frequency weight – fw = f x 0.03	Score for disease frequency - fd	Weighted frequency – F = fw x fd∞	Score for Mortality – M	Total score – S = F + M
Malaria	98	3	3	8	3	10.7
HIV/AIDS	84	3	2	6	3	8.6
Colds/coughs/flu	84	3	3	7	2	8.3
Pneumonia	63	2	2	4	3	7.0
Diabetes	56	2	2	4	2	6.1
Tuberculosis	60	2	2	4	2	5.9
Typhoid fever	49	1	2	3	2	5.7
Dental disorders	60	2	2	4	1	5.3
Hypertension	40	1	2	3	2	5.2
Asthma	42	1	2	3	2	5.1
Cancers	47	1	2	3	2	5.0
Amoeba	44	1	3	3	1	4.8
Rheumatism	35	1	3	3	2	4.8
Diarrhoea	44	1	2	3	2	4.5
Stomach disorders	42	1	2	3	2	4.2
Back/bone/joints pains	35	1	2	2	2	3.6
Epilepsy	42	1	1	2	2	3.5
Measles	14	0	2	1	3	3.5
Arthritis	26	1	2	2	2	3.4
Uvula problems	5	0	3	0	3	3.4
Ulcers	23	1	2	1	2	3.4
Worms	26	1	3	2	1	3.2
Allergies	37	1	2	2	1	3.2
Leukaemia*	7	0	1	0	3	3.2
Stroke*	2	0	3	0	3	3.2
Prostate cancer*	14	0	2	1	3	3.2
Menstrual problems	2	0	2	0	3	3.1
Anaemia	2	0	1	0	3	3.1
Meningitis	2	0	1	0	3	3.1
Pancreatic disorders	2	0	1	0	3	3.1

∞ Disease frequency was weighted by the number of respondents who mentioned it based on the assumption that a disease mentioned by many respondents must have been more commonly occuring in the community than that mentioned by few respondents even if the few who mentioned the later could have given it a high score for frequency

* This condition was not mentioned by farmers

Most of the diseases that were ranked by farmers and herbalists highly were also found to be leading causes of out-patient and in-patient morbidity and mortality in Mbeere and Embu district hospital statistics (Annex 4.3). However some conditions that were not ranked highly by respondents were leading causes of outpatient morbidity such as accidents (including fractures and burns), skin diseases, eye infections and ear infections. Others that were either ranked as low importance or not mentioned by respondents but found to be leading causes of in-patient morbidity and mortality included dehydration, pelvic ulcer disease and congestive cardiac failure.

4.4.3 Role of traditional medicine and medicinal trees in the management of serious health conditions

Farmers reported various preventive and treatment measures they used to minimize socio-economic costs resulting from disease infection (Table 23). The most common disease prevention practices included maintaining high personal and household hygiene (57% of respondents), planting or conserving medicinal plants in their farms (51%), sleeping under mosquito nets to prevent malaria (31%), as well as taking good diets and clean drinking water (30% each). Use of herbal medicine was also mentioned as a measure for disease treatment (although it also could have been used in a preventive prophylactic way) by 25% of the farmers. However on the first response to a symptom of illness, 37% of the farmers reported finding a known medicinal plant and preparing a herbal treatment, 27% reported buying an over-the-counter drug while another 36% reported consulting a medical facility. Only one farmer reported consulting a herbalist as the first response to a symptom of illness. It is however good to note that these were reported as the most likely responses to common illnesses but cognizance is taken of the fact that the responses would differ with different illnesses.

Table 23: Preventive and treatment measures used by farmers to minimize socio-economic costs resulting from disease incidences

Health management measure	Percent (n =142)
Preventive	
Clean drinking water	30
Contribute to development of community health facilities	3
Good diets	30
Immunization through vaccination	3
Keep useful medicine in house	19
Keeping warm	4
Medicinal plant conservation	51
Other preventive methods	1
Other traditional health practices	3
Personal and household hygiene	57
Public health training and practices	1
Use of mosquito nets	31
Treatment	
Off the counter medicine	4
Seek conventional medicine assistance	3
Use of herbal medicine	25

*Percentages total to more than 100% because respondents were allowed to give multiple answers

Herbalists also indicated that there was generally an increase in the number of patients that were consulting them for treatment especially due to failure by members of the community to

get appropriate drugs in health centres. However consultation trends varied and while some of the herbalists were reporting increased consultation, others were reporting declining consultation for the same diseases (Figure 7). More herbalists reported increase in the number of patients consulting them for diseases like typhoid, tuberculosis, rheumatism, pneumonia, diarrhoea, diabetes and dental disorders than those who reported decrease. On the flipside more herbalists reported decrease in the number of patients consulting them for malaria, respiratory problems (coughs/colds/flu), back/bone/joint problems and stomach disorders, including worms and amoeba than those who reported increase. Less than forty percent of herbalists reported treating diseases such as HIV/AIDS, epilepsy and asthma.

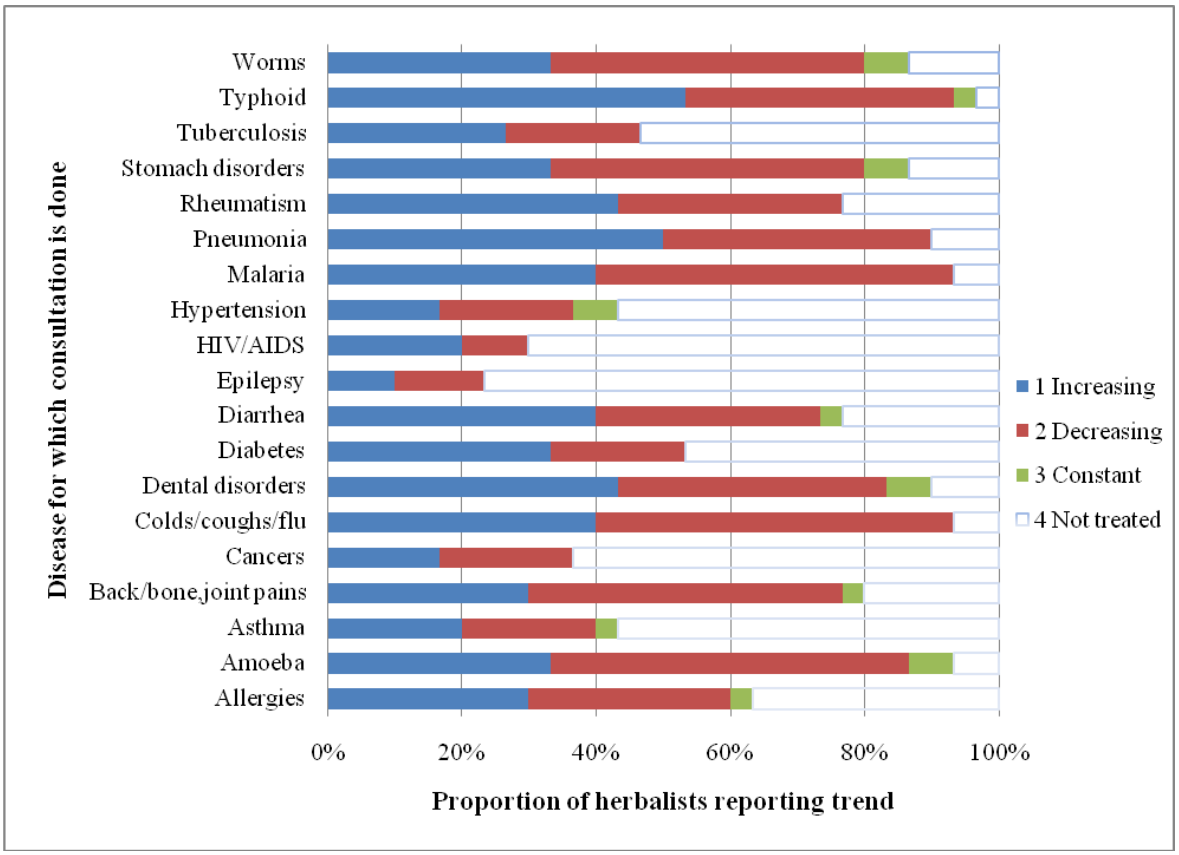


Figure 7: Proportion of herbalists who reported rise or decline in number of patients consulting them for diseases highly rated in socio-economic importance

4.4.4 Farmers' knowledge of medicinal plant species used for treating various diseases

Farmers reported getting information on the species with medicinal value from many sources but the most common source of information was older relatives who were reported by 57% of the respondents as the first and 21% as the second source of information (Table 24). Herbalists were reported by 25% of the farmers as the first source of information on species medicinal value but no farmer reported them as a second source. The other reported sources of information included media, tree nursery operators, neighbours and development agents

although their contribution was low. In terms of information on conservation of medicinal plants in farms, older relatives and herbalists played a minimal role (6% and 11% respectively) while development agents were the key primary source of information (16%). A number of farmers (11%) took personal initiatives to find information on cultivation of medicinal trees and 45% of the farmers did not respond to this question.

Table 24: Farmers' sources of knowledge on use and cultivation of medicinal plants

Information sources	Frequency (%) of category being mentioned as source of knowledge on:							
	Medicinal tree use in treatment of diseases (n=200)				Medicinal tree conservation in farms (n=200)			
	Primary source	Second source	Third source	Total	Primary source	Second source	Third source	Total
Herbalists	24.5	0	0	25	11	0	0	11
Tree nursery operators	2.5	0	0	3	6	1	0	7
Media (newspapers, radios)	5.5	4.5	0	10	2	1.5	0.5	4
Older relatives (parents, grandparents)	57	21	4	82	5.5	0.5	0	6
Neighbours	6.5	16	9	32	1.5	3.5	2.5	7.5
Development programmes by government and NGOs	2.5	6	2	11	15.5	6.5	1	23
Medicinal tree product buyers*					0.5	0.5	0	1
Own initiative*					14	2.5	1	17
No response	1.5	52.5	85		45	84	95	
Total	100	100	100	300	100	100	100	76

* These two sources were not included in the question on sources of information on treatment

The average number of medicinal plant species known by farmers in general was thirteen. There was no significant difference between the number of species known by women and men (P=0.05; Table 25) but older respondents (beyond 35 years) knew significantly more species than younger ones PANOVA=0.05). There was some correlation (albeit weak with Pearson Coefficient of 0.03 but significant; P = 0.01) between respondent age and the number of medicinal plant species mentioned. Mean values of the number of the species known decreased with rise in the level of education attained by the respondents. The farmers who had not attended school and those who had only been to primary school knew more species than those who had attained secondary and post-secondary school education. Farmers in Embu district also mentioned less species than those from the other two districts while those from Mbeere mentioned the highest number of species on average.

Table 25: Socio-economic differentiation in the number of medicinal plant species known (mentioned) by farmers

Socio-economic factor	1	2	3	4	5	6	Mean	F - value	P - value
Gender	13	13					13	0.357	0.551
Age	8	10	13	15	15	13	13	3.915	0.002
Education level	16	13	13	11	7		13	3.282	0.012
District	9	15	14				13	13.558	0.000
First response to symptom of illness by family member	15	11	12	9					

Key: Gender -1(Female), 2 (Male); **Age in years** – 1 (≤25), 2 (26-35), 3 (36-45), 4 (56-65), 5 (≥66); **Level of education attained** – 1 (not schooled), 2 (primary level), 3 (village polytechnic), 4 (secondary), 5 (post secondary); **District** – 1 (Embu), 2 (Mbeere), 3 (Meru Central); **First response to ailment** - 1 (find a medicinal plant), 2 (buy an over the counter drug), 3 (consult a medical clinic or hospital), 4 (consult a herbalist)

Many medicinal plant species were each reported to treat more than one condition by farmers (Appendix 2), but individual respondents gave only two to three diseases they knew to be treated by each species. Among the twenty diseases farmers ranked highest, no farmer reported knowing any species that could treat HIV/AIDS, tuberculosis and cancers (Table 26). Very few farmers knew species that were useful in treating high blood pressure, diabetes, measles and prostrate problems. Other diseases in the top twenty list had several tree species that were known by farmers to treat them. These species included *Senna didymobotrya, Aloe spp, Azadirachta indica, Croton megalocarpus* and *Prunus africana* which were ranked as the top five in that order.

Herbalists also mentioned several tree species as useful for treatment of many diseases. Just like farmers, they presented a few species that were involved in the treatment of many of the highly ranked diseases (Table 27). They mentioned species useful for treatment of all diseases they had ranked top-twenty in terms of economic importance except mental disorders. Very few herbalists mentioned species that were useful for treatment of diseases such as measles, epilepsy, high blood pressure, asthma and cancers. Their ranking of species however differed with farmers ranking in the diseases treated by the species although eleven of the species ranked top twenty by farmers were also included in top twenty ranks by herbalists albeit in different positions. The top five species in herbalists' ranking were *Prunus africana, Aloe spp., Erythrina abyssinica, Warburgia ugandensis* and *Carissa spinarum.*

Table 26: Medicinal plant species ranked top twenty by farmers by the number of diseases the species are known to treat

Species / disease	Number of diseases treated	Total points*	Species rank	Malaria	Typhoid	Cough/colds /flu	Pneumonia	High blood pressure	Diabetes	Back/ joint/ bone problems	Measles	Stomach disorders	Headaches	Diarrhoea	Rheumatism	Amoeba	Worms	Prostrate problems	Kwashiorkor	Dental problems
Senna didymobotrya	21	75.9	1	6	4	1	1			1	4	4		2	1	5	5			
Aloe sp	28	75.4	2	48	4	5	14			3		3	1		4	3	3			2
Azadirachta indica	21	73.5	3	63	13	6	5	1	1	8		3			8	1	1			1
Croton megalocarpus	21	68.6	4	6	7	1	1			2		2	1		3	4	4			2
Prunus africana	22	67.8	5	1		3	1		1	7		4		1	7	2	2	9		2
Erythrina abyssinica	17	66.2	6	3	2	2	3			3		4		7	4	3	3	1		6
Carica papaya	23	63.3	7	1	2	2				1		2			3	12	12	1		4
Olea europaea ssp africana	19	61.7	8	9	2	3	1			16		3	1		4	7	7			
Mangifera indica	14	56.4	9	1	1	13	1		1	1					1	1	1		1	
Eucalyptus globulus	18	54.8	10	3		12	1			1	2	1	1		2					
Plectranthus barbatus	12	53.7	11	1	1	3		1				3	1		1	6	6			1
Rhamnus priniodes	11	53	12	2	1	1	1			1		1			2	1	1			1
Psidium guajava	13	52.3	13	1	2				1	2		2		1	1	7	7			
Terminalia brownii	15	52.2	14	2		2	1			2		2			1	1	1			
Dalbergia melanoxylon	10	52.1	15	2	1	2	1			4				1	1					
Bidens pilosa	14	51.1	16	2	1	2				1		3			1	1	1			
Warburgia ugandensis	12	50.1	17	5	1	4				1					1	1	1			2
Juniperus procera	9	48.5	18	1	1	1						2		1	1	2	2			
Tithonia diversifolia	10	48.2	19	9	19	1	1					1	1			5	5			
Zanthoxylum chalybeum	11	48.2	20	7	1	6				2		2	1		1					
Disease rank	21	75.9	1	1	2	3	5	6	8	9	11	12	13	14	15	16	17	18	19	20

*The total ranking points indicate the summation of weights of the diseases (Appendix 2) that the species was reported to treat by farmers. The numbers from the fourth column onwards indicate the percentage of farmers who mentioned the species as useful for treatment of the respective disease; n = 200. Where blank, the species was not reported by any farmer to treat that disease. None of the farmers mentioned any of the twenty species as treating HIV/AIDS (ranked 4th), tuberculosis (ranked 7th) and cancers (ranked 10th) so the three diseases are not presented in the table.

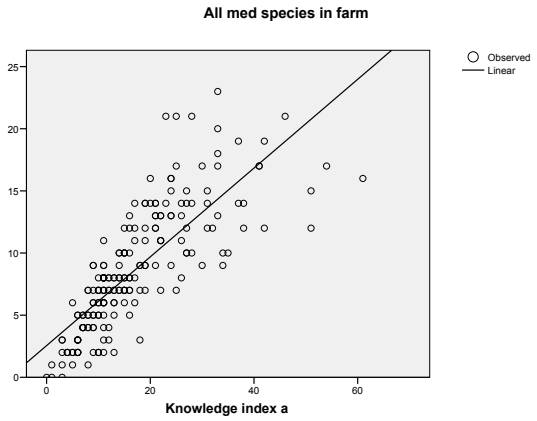
Table 27: Medicinal plant species ranked top twenty by herbalists by the number of diseases the species are used to treat

Species	Number of diseases treated	Total points*	Species rank	Malaria	HIV/AIDS	Cough/colds/ flu	Pneumonia	Diabetes	Tuberculosis	Typhoid	High blood pressure	Asthma	Cancers	Amoeba	Rheumatism	Diarrhea	Stomach disorders	Syphilis	Back/ bone/ joints problems	Measles	Arthritis
Prunus africana	30	96.4	1	3		2	5	5		3	2		5	3	5		2		3		2
Aloe sp.	25	91.6	2	50	2		30	2		13				3	5	2	3				2
Erythrina abyssinica	29	90.3	3	5		2	2			5	2		2	2	3	2	2		3	2	
Warburgia ugandensis	22	89.7	4	22		17	2	3	5	5	3	5		2	7				7		
Carissa spinarum	18	67.3	5	5		7	2		2		2		2	2			3		2		
Azadirachta indica	18	65.7	6	43		2	13			12				5	5				7		
Ocotea usambarensis	13	63.5	7	5		7	5			2	2	2	2					3	3		
Solanum incanum	16	61.9	8	3		5			2	2		2							2		
Moringa oleifera	17	58.4	9	7		2				2		2	2	2	3		2				
Zanthoxylum usambarense	13	56.6	10	8		2				7				2	3		2		3		2
Plectranthus barbatus	12	55.3	11	2	2	2				2				5			3				2
Ovariodendron anisatum	7	54.6	12		2	3		2		2				2	3						2
Zanthoxylum chalybeum	12	54.5	13	10		3	2		2									2			
Combretum collinum	9	49.8	14	2		2			2	3						2			3		
Croton megalocarpus	9	46.4	15	3		5	7			12							3				
Cyphostemma bambusati	9	46.3	16	2	2	2											2	2	8		
Lannea sp.	12	43.6	17			3	3	2											7		2
Senna didymobotrya	12	43.5	18	12		2				5				8						3	
Olea europaea ssp africana	14	42.8	19	7			2			2				7					40		
Dalbergia melanoxylon	9	42.5	20	2		3	3											2	17		
Disease rank	30	96.4	1	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	19	20

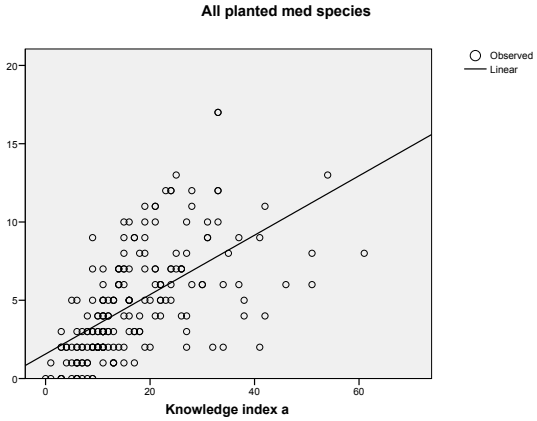
*The total ranking points indicate the summation of weights of the diseases (Appendix 2) that the species was reported to treat by herbalists. The numbers from the fourth column onwards indicate the percentage of herbalists who mentioned the species as useful for treatment of the respective disease; n = 60. Where blank, the species was not reported by any herbalist to treat that disease.No herbalist mentioned any of the twenty species as treating mental disorders (ranked 8th) and only one mentioned *Prunus africana* as treating Epilepsy (ranked 18th) so the two diseases are not presented in the table

4.4.5 Testing for association between knowledge of medicinal plants and cultivation in farms

Regression analysis showed that all the knowledge indices as explained earlier in the methods section associated positively with medicinal plant species cultivation (P=0.01; Figure 8). Knowledge index A which only considered the diseases that the farmers reported as treated by all the species mentioned without weighting diseases had a strong association with the presence of medicinal trees in farms (r = 0.79). Sixty three percent (63%) of the medicinal plant species in farms could be attributed to farmers having general knowledge that the species were useful for treating diseases (r^2 = 0.63; Figure 8a) but only 36% of the deliberate planting could be associated with the knowledge (r^2 = 0.36; Figure 8b). The association pattern was not changed in any significant way when we weighted the species known with whether the household was using them or not (knowledge index B; Figure 8c and 8d). We however saw a reduction in the strength of the relationship when the perception of the economic importance of the disease by the farmers was used to weight the knowledge of disease treatment with medicinal trees (knowledge index C; Figure 8e and 8d). Only 25% of the planted medicinal trees could be associated with the perceived economic importance of the disease they were known to treat.

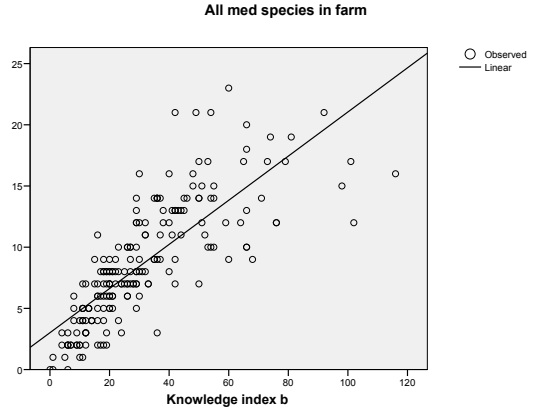


8a: All species in farm both planted and managed ($r = 0.79$; $r^2 = 0.63$)

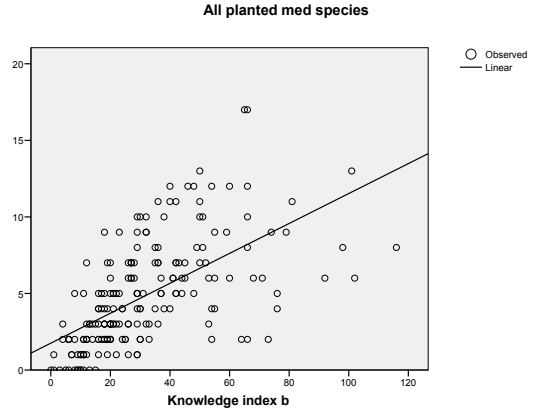


8b: All species directly planted by the farmer farm ($r = 0.60$; $r^2 = 0.36$)

Knowledge index a - the sum of diseases treated by all species known by the farmer

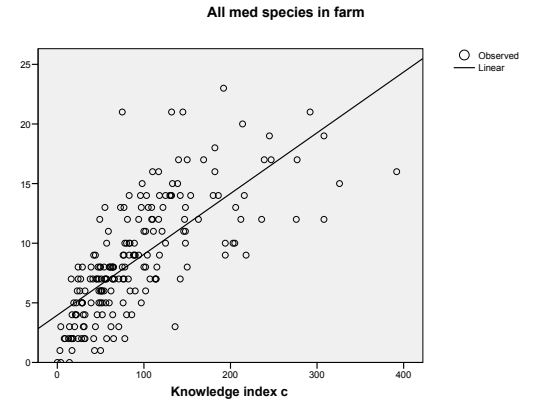


8c: All species in farm both planted and managed ($r = 0.79$; $r^2 = 0.62$)

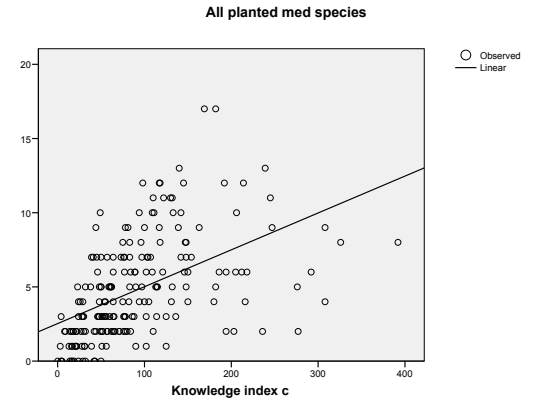


8d: All species directly planted by the farmer farm ($r = 0.61$; $r^2 = 0.37$)

Knowledge index b - sum of diseases treated by all species known by the farmer weighted by whether the household uses the species or not



8e: All species in farm both planted and managed ($r = 0.72$; $r^2 = 0.53$)



8f: All species directly planted by the farmer farm ($r = 0.50$; $r^2 = 0.25$)

Knowledge index c - the sum of all diseases treated (weighted by the farmer's rating of the socio-economic importance of each disease) by all species known by farmers weighted by household use

Figure 8: Linear regression of the knowledge that the farmer has on treating diseases with medicinal trees in three indices with the number of medicinal species in the farm

The knowledge indices were strongly influenced by the number of species that the farmer knew with a significant Person correlation coefficient (P = 0.01) of 0.936 for index A, 0.925 for index B and 0.852 for index C. Due to this association, the influence of the respondents' socio-demographic differentiation on the knowledge indices was similar to that on the number of species known by respondents (Table 28).The values of the knowledge indices increased with age and decreased with the level of education attained by the respondent categories and were on average lower for farmers from Embu district than their counterparts in Mbeere (highest) and Meru Central districts. Farmers who reported their first response to illness as preparing a herbal treatment had significantly higher knowledge index values than those who first bought a drug over-the-counter or those who visited a health centre.

Table 28: Socio-economic differentiation in the knowledge of disease treatment with medicinal trees weighted by farmers perception of the socio-economic importance of the diseases (knowledge index C)

Socio-economic factor	1	2	3	4	5	6	Mean	F - value	P - value
Gender	91.8	91.4					91.65	0.002	0.967
Age	43	73	93.2	111.1	109	77.5	91.34	2.952	0.014
Education level	115	96.6	49.5	75.37	45.6		91.97	2.314	0.059
District	57.4	114	101				91.65	12.05	0.000
First response to symptom of illness by family member	117	67.9	83.4	75			91.65	6.109	0,001

Key: Gender -1(Female), 2 (Male); **Age in years** – 1 (≤25), 2 (26-35), 3 (36-45), 4 (56-65), 5 (≥66); **Level of education attained** – 1 (not schooled), 2 (primary level), 3 (village polytechnic), 4 (secondary), 5 (post secondary); **District** – 1 (Embu), 2 (Mbeere), 3 (Meru Central); **First response to ailment** - 1 (find a medicinal plant), 2 (buy an over the counter drug), 3 (consult a medical clinic or hospital), 4 (consult a herbalist)

3.5 Discussion

This study showed that farmers had a good understanding of the health situation in their community and were actively involved in various efforts to minimize economic losses from diseases. The clear perception of the disease burden was shown by the closeness of the rating of the economic importance of diseases by farmers and herbalists and with formal health centres. Some of the diseases highly ranked such as malaria, HIV/AIDS and tuberculosis are also a cause of international concerns due to the rate of mortalities they cause especially in Africa (African Union, 2003; NIAID, 2001). Despite the complaint of high costs of drugs and even lack of essential drugs in nearby health centres, farmers had a good understanding of important public health measures to prevent diseases. This means that the community was able to appreciate information coming from health workers although the full scale of adoption of these measures was not assessed. Use of medicinal plants was highly appreciated as an insurance against diseases although only 37% of the sampled population

used it as a first response to common ailments. There is a likelihood that engagement in conservation of medicinal plants as a means of minimizing disease effects was over-reported since we had introduced our agenda as cultivation of medicinal trees to the groups and even to the individual respondents before the interviews began. However the results resonate well with the study by Snow *et al.,* (1992) where 31% of the respondents reported to respond to malaria in children by using homemade remedies.

Farmers reported many species that were useful in treating equally many diseases but their ranking of species based on the number and importance of diseases treated was different from that of herbalists. Only eleven species were common in the top twenty species lists of both farmers and herbalists. Farmers were observed to use more of agroforestry species grown in the farms for other household goals other than medicinal purposes. Such species include *Carica papaya* and *Mangifera indica* for fruits and *Eucalyptus globulus* for fuelwood. Herbalists did not rank this category of species highly but in contrast they highly ranked species found more in the wild resources than agroforestry systems such as *Ocotea usambarensis* and *Carissa spinarum*. It is important to note that farmers mentioned the species that treated various diseases as they had known from information passed to them from elders while herbalists gave the species they were mostly using in their practice. Farmers mentioned many species but reported known treatments for only a few diseases which, incidentally were mainly treated by the highest ranking medicinal trees. The trend was not very apparent with herbalists' reports. It can be assumed that farmers' knowledge of treatment is superficial and that is why many would first seek formal health services when they sensed some ailment in the household.

Unlike farmers, herbalists mentioned species involved in treatment of almost all diseases except mental disorders. However few herbalists reported treating serious diseases such as HIV/AIDS, epilepsy, hypertension and paediatric problems such as measles and kwashiorkor. This is encouraging since safety of remedies has not been proven in many cases and it would be a cause of concern if herbalists claim to know all treatments in absence of functional mechanisms to regulate traditional medicine in Africa compared to the developed countries. But traditional remedies have been scientifically proven to work in the treatment of many diseases (such as malaria; Rukunga and Simons, 2006; Kitua and Malebo, 2004) and the few claims by herbalists on treating serious diseases need evaluation on their credibility. Safety is a key issue in allowing practice of traditional medicine especially on children, so having less reported administration of herbal medicine on paediatric problems may be a sign that many herbalists are reliable and not irresponsibly driven by monetary interests.

The results showed an expected trend where knowledge on disease treatment with medicinal trees by farmers increases with age of respondents. The analysis question also showed that

those with higher knowledge of disease treatment with medicinal trees were more likely to respond to a symptom of ailment by preparing a herbal treatment from a known medicinal plant before buying a drug or going to a health centre. Knowledge of medicinal plants also correlated negatively with education and appeared to increase with aridity. Mbeere district is arid, Embu is humid and possibly the selection of some villages from the drier part of Meru central influenced the lack of significant difference between the knowledge index for Mbeere and Meru central farmers. These results are consistent with those from a rural Brazilian community where ethno botanical knowledge was negatively correlated with literacy and increasing access to formal education although not associated with relative prosperity (Voeks, 2007, quoting Voeks and Leony, 2004). Social economic marginality as observed in arid areas like Mbeere, was also seen to be correlated with ethno botanical importance values in the study by Voeks (2007). However our study did not show gendered differences in the level of knowledge on medicinal plant species in our study community in contrast to what has been observed in a number of studies (such as Tabuti, 2006 and Bodecker, 1997).

Lack of documentation of African traditional medicine has been suggested to contribute to the erosion of its knowledge (Conserve Africa, 2004). This is likely the reason why younger and more educated people knew less about medicinal plants apart from the prevalent association of traditional medicine with primitivity as was presented by western civilization. Since knowledge of medicinal plants influenced the efforts by the farmers to conserve the plants (mainly trees and shrubs) in their farms, there is need to share medicinal plant knowledge with the young and school going population possibly by including it in school curricula. This should include delinking the practice with negative aspects such as primitivity and witchcraft as has been the trend in the past. With more herbalists now being modernized and many highly educated (Chapter 3), there is an opportunity now to influence the young and more educated farmers to conserve medicinal trees. There was a concern observed in the results however. Herbalists were not reported to be doing a lot to share information about useful medicinal trees or even to encourage cultivation compared to older relatives and development projects. This observation is in line with the report by Castro (1991) that family elders in Kirinyaga district were significant repositories of knowledge on vegetation which they passed to the young. It is however possible that fear by herbalists of losing an edge in their trade contributed to this. But the fact that it is the number of species that were known by the farmers that seemed to influence the conservation of medicinal trees in farms more than whether the farmers used the species or not this fear does not seem applicable for this farming community.

The perception of the economic importance of the disease did not influence cultivation of medicinal trees in the farm. The number of species deliberately planted did not look significantly related to the rating of the disease by the farmer. This is possible due to the fact

that farmers seemed to associate some plants with the treatment of many diseases while some diseases had very few species that were known to treat them. This has positive implication on cultivation in that farmers will conserve almost all species they know to be medicinal. However it is not clear whether they can maintain viable breeding populations of those species for long as competition for limited land resources increases and more production concentration becomes desirable. There is need to relate medicinal trees with some economic parameters for example to compare with costs of conventional drug treatment of a serious disease in order for farmers to view medicinal trees as live pharmacies. Knowledge of treatment methods in this approach is thus very vital for farmers to be certain of the value of the species (see Chapter 3). Since most information on medicinal tree cultivation was coming from development workers it is important to investigate how herbalists can be roped in to collaborate in the sharing of this information without loss of their intellectual property.

3.6 Conclusion

Farmers' perception of their health situation as gauged by their perception of the economic importance of diseases was good viewed against herbalists' perception and hospital statistics. Traditional medicine based on medicinal trees played a key role in the management of diseases both by farmers and herbalists although conventional health management based on modern medicine was used more. Farmers had a high level of knowledge of medicinal tree species used for treating diseases that were rated to be of high economic importance. This knowledge increased with the age of the farmer and decreased with the level of education but was not associated with gender. The number of medicinal species known by the farmers was highly correlated to the number of medicinal species that the farmer had conserved in the farm (both planting and managing the naturally regenerated trees) but the correlation was lower when only the intentionally planted tree species were considered. The same trend was observed when the diseases treated by those species were considered in the analysis and the relationship was not affected by whether the farmer used the species in the household or not. However there was less evidence of influence by farmer's perception of the economic importance of the disease treated by a species in medicinal species cultivation.

Farmers acquired information on use of tree species in disease treatment from older relatives and herbalists but efforts to cultivate were mainly by own initiative or partly influenced by development workers from government and non-government organizations. Farmers' ranking of species was also different from herbalists as the farmers regarded trees in agroforestry systems highly and did not seem to know species mainly found in the wild. There is need to share information on species used in the treatment of diseases especially to the young and

school going population. Development workers also need to collaborate with herbalists in passing on of messages on species that are very useful in the treatment of highly rated diseases especially those in the wild and to encourage cultivation by farmers.

Annex 4.1: Other diseases mentioned and ranked by farmers

Disease	Response frequency % - f (n=142)	Response frequency weight – fw = f x 0.03	Score for disease frequency - fd	Weighted frequency – F = fw x fd	Score for Mortality – M	Total score – S = F + M
Mental disorders	2	0	3	0	2	2.2
Paralysis*	1	0	3	0	2	2.1
Skin diseases	15	0	2	1	1	2.1
Dysentery*	1	0	2	0	2	2.1
Growths	1	0	2	0	2	2.1
Meningitis	1	0	3	0	2	2.1
Brucellosis	6	0	2	0	2	2.0
Anaemia	1	0	2	0	2	2.0
Heart problems	1	0	2	0	2	2.0
Tapeworms	1	0	2	0	2	2.0
Tetanus	1	0	1	0	2	2.0
Syphilis	6	0	2	0	2	2.0
Elephantiasis	3	0	2	0	2	1.9
Ringworms	8	0	2	1	1	1.8
Gonorrhoea	6	0	2	0	2	1.8
Polio	6	0	1	0	2	1.7
STDS	3	0	1	0	2	1.6
Puscells	3	0	2	0	1	1.6
Jiggers*	1	0	2	0	2	1.6
Chicken pox	10	0	2	0	1	1.6
E.N.T.	10	0	2	1	1	1.6
Dizziness	3	0	3	0	1	1.5
Cardidiasis*	2	0	2	0	1	1.4
Scurvy*	6	0	1	0	1	1.4
Allergies	4	0	2	0	1	1.4
Muscle problems*	1	0	3	0	1	1.1
Arthritis	2	0	2	0	1	1.1
Roundworms*	1	0	2	0	1	1.1
Swellings*	1	0	2	0	1	1.1
Inflammations	1	0	2	0	1	1.1
Foot infections*	1	0	3	0	1	1.1
Heart burns*	1	0	3	0	1	1.1
Tonsils*	1	0	2	0	1	1.1
Athletes foot*	1	0	1	0	1	1.0
Cowpox*	1	0	1	0	1	1.0
Lack of appetite*	1	0	1	0	1	1.0
Sleeping sickness*	1	0	1	0	1	1.0
Fractures	1	0	1	0	1	1.0
Stress	1	0	1	0	1	1.0

*** This condition was not mentioned by herbalists**

Annex 4.2: Other diseases mentioned and ranked by herbalists

Disease	Response frequency % - f (n=142)	Response frequency weight – fw = f x 0.03	Score for disease frequency - fd	Weighted frequency – F = fw x fd∞	Score for Mortality – M	Total score – S = F + M
Injuries/cuts/wounds*	26	1	2	2	1	3.0
Headaches	16	0	2	1	2	3.0
Mental disorders	26	1	2	1	2	3.0
Chest problems	19	1	2	1	2	2.9
Eye problems	33	1	2	2	1	2.9
Growths	5	0	2	0	3	2.7
Chicken pox	5	0	1	0	3	2.6
Fibroids*	9	0	2	1	2	2.6
Puscells	14	0	3	1	2	2.6
STDs	23	1	1	1	2	2.6
Bites*	7	0	1	0	2	2.5
Gonorrhoea	21	1	2	1	2	2.5
Reproductive health problems*	19	1	2	1	1	2.2
Liver problems*	5	0	2	0	2	2.2
Depression*	2	0	2	0	2	2.1
Dizziness	2	0	2	0	2	2.1
Kidney problems	5	0	1	0	2	2.1
Poison*	2	0	2	0	2	2.1
Polio	5	0	1	0	2	2.1
Stress	2	0	2	0	2	2.1
E.N.T.	14	0	2	1	2	2.1
Syphilis	7	0	2	0	2	2.1
Cholera	2	0	1	0	2	2.1
Heart problems	2	0	1	0	2	2.1
Urinary tract infections*	2	0	1	0	2	2.1
Skin diseases	19	1	2	1	1	2.0
Ringworms	9	0	3	1	1	1.9
Boils*	5	0	3	0	2	1.9
Gouts*	9	0	2	0	2	1.9
Syphilis	7	0	1	0	2	1.9
Elephantiasis	7	0	2	0	1	1.8
Addictions*	5	0	2	0	2	1.7
Bones setting*	5	0	2	0	2	1.7
Goitre*	5	0	1	0	2	1.6
Low libido*	7	0	2	0	1	1.4
Brucellosis	5	0	2	0	1	1.3
Indigestion*	2	0	3	0	1	1.2
Inflammations	2	0	3	0	1	1.2
Enlarged testicles*	2	0	2	0	1	1.1
Fatigue*	2	0	2	0	1	1.1
Tapeworms	2	0	2	0	1	1.1
Varicose veins*	2	0	2	0	1	1.1

Weight control*	2	0	2	0	1	1.1
Leg tumour	2	0	2	0	1	1.1
Constipation*	2	0	1	0	1	1.1
Fractures	2	0	1	0	1	1.1
General body pains*	2	0	1	0	1	1.1
Hair loss*	2	0	1	0	1	1.1
Lupus *	2	0	1	0	1	1.1
Tetanus	2	0	1	0	1	1.1

*** This condition was not mentioned by farmers**

Annex 4.3: Leading causes of out-patient and in-patient morbidity and mortality in health centres of Embu and Mbeere districts in 2007

Disease parameter	Outpatient morbidity cases		Rank as cause of in-patient morbidity		Rank as cause of in-patient mortality	
District	Mbeere	Embu	Mbeere	District	Mbeere	Embu
Malaria	147,552	206433	1	1	1	3
Pneumonia	13,261	34446	2	2	2	1
HIV/AIDS	***	***	10	7	3	2
Pulmonary tuberculosis (PTB)	***	***	8	6	6	4
Diarrhoeal diseases	8,295	***	7	3	8	7
Diseases of the respiratory system	88,499	138072	3	***	***	***
Intestinal worms	26,931	52522	***	***	***	***
Disease of the skin	17,804	32641	***	***	***	***
Dehydration	***	***	9	5	4	***
Rheumatism (joint pains)	6,789	20246	***	***	***	***
Dental disorders	***	21158	***	***	***	***
Accidents (incl. fractures & burns)	5,551	13568	***	***	7	***
Eye infections	4,905	15129	***	***	***	***
Typhoid (suspected)	4,677	***	6	***	***	***
Ear infections	***	11200	***	***	***	***
Anaemia	***	***	4	8	***	6
Pelvic Ulcer disease	***	***	***	9	***	10
Diabetes mellitus	***	***	***	10	***	***
Congestive cardiac failure (CCF)	***	***	***	***	5	8
Birth Asphyxia	***	***	***	***	***	9

*** Data not available (the two district medical offices only gave data for the leading ten diseases in each of the three parameters: out-patient and in-patient morbidity and causes of mortality)

4 Influence of local herbal product markets on medicinal tree cultivation by smallholder farmers in Kenya

4.1 Introduction and literature review

Traditional medicine has been gaining acceptance as a viable way to maintain human health in the developing world (Rukangira, 2000). It is a dynamic practice that evolves with culture and is able to meet the needs of a developing as well as the developed world where (in the later) it is regarded as complementary and alternative medicine (Brown, 1992; IARC, 2002). The reasons for its prevalence in rural societies in the developing world are mainly poor access to modern medicine due to perceived high drug costs and poor infrastructure that hinders delivery of all necessary medicine in good time to many remote areas as well as patients reaching hospitals in time (Patwardhan, 2005). Prevalence of traditional medicine can also be attributed to the trust that communities have on the practice to manage some health and psycho-socio conditions that modern medicine is believed not to handle (Brown, 1992). Another reason is the continued prevalence of some health conditions referred to as neglected diseases for which investment in drug development has been poor as no profitable business can be created due to affecting low numbers of patients who often are among the poor (Adolfo, 2005).

The traditional healer is the dispenser of traditional medicine in many societies especially in the rural areas. Conserve Africa (2004) reported the ratio of traditional healers to the local populations as far higher than that of conventional health practitioners in many nations in Africa. With dwindling land resources against rising population, agrarian societies become more settled and involved in monetary economy to meet needs that household production cannot meet (Turchin and Nefedov 2009). Traditional healers thus charge some form of monetary compensation for their services in order to maintain their practice. Less abundance of wild resources where herbal material can be accessed also implies that healers spend long hours in search of raw materials for the practice. Alternatively healers have to pay other people to gather herbal material on their behalf (Mander *et al.,* 2007) or buy raw materials from markets thus creating a trade chain. The trade chain can also induce cultivation of medicinal trees in farms due to prospects for diversified income generation by farmers (Schipmann, 2002).

Changes in agrarian societies due to reduced land resources also leads to more rural people moving to settle in urban areas to seek employment in the industrial sector (Turchin and Nefedov, 2009). The immigrants into urban centres tend to maintain cultural practices in cities even with attainment of high education standards and often pay higher prices for

culture related services than those paid in rural areas. For instance, in their study on bride wealth in Kenya, Mburugu and Adams (2004) reported that the two figures reported as the highest bride wealth paid was by university educated life-long Nairobi dwellers. Thus demand for traditional medicine at higher prospective returns attracts many traditional healers to practice in cities and towns (Wondwosen, 2005; Cunningham, 1993). Higher competition in the herbal medicine industry in urban areas than rural areas, due to different market segments and easy availability of conventional medicine, demands value addition and formalization of the practice in terms of hygiene maintenance, product packaging and delivery methods (Makunga *et al.,* 2008). Cunningham (1993) reported of registered pharmacies and shops that dealt exclusively in manufacturing and/or retailing herbal remedies in India, Nepal and South Africa. Herbal medicine is currently found in various forms ranging from powders, liquid concoctions, creams and others forms of packaging (Shanley and Luz, 2003). This value addition creates more opportunities for trade in medicinal tree products with many actors in the value chain such as collectors, healers, manufacturers and even exporters. Traditional healers play a key role in these chains as both suppliers and customers as has been observed in Maputo, Mozambique (Krog *et al.,* 2006), Cameroon (Facheux *et al.,* 2003), Kwa Zulu Natal, South Africa (Mander, 1998) and Kenya (Kariuki and Kibet, 2007).

A developing urban trade in plant products is initially served by vendors who collect materials from the wild resources and supply to customers or distributors in cities. For instance, Franzel *et al*., (2006) reported of a budding trade of leaf meal from *Leucaena leucocephala* serving peri-urban dairy farmers from collectors through urban stockists in Tanga, Tanzania. Other non-timber forest products that have been observed to be collected from the wild to supply urban markets include indigenous fruits in southern Africa and the Amazonia (Karaan *et al.,* 2005; Pinedo-Vasquez *et al.,* 2000), gum arabic in many parts of Africa (Chikamai *et al.,* 1996; Mueller and Okoro, 2004), Shea butter from *Vitellaria paradoxa* in the Sahel (Boffa *et al.,* 1996) and others. Trade in medicinal plant products by vendors, including women, who collect plant parts from the wild and supply to urban centres has been reported extensively in southern Africa (Mander, 1998; Botha *et al.,* 2004; Krog *et al.,* 2006), western Africa (Facheux, 2003), Asia (Chandra *et al.,* 2006) and Latin America (van Andel and Havinga, 2008) among other regions.

Rising trade that mainly relies on wild collection however leads to deterioration in quality and quantities of highly demanded species as scarcity sets in (Rukangira, 2000; Schipmann *et al.,* 2006). In southern Africa, increased medicinal plant trade resulted in herbalists using smaller plant sizes and less bark thickness since trees could not regenerate sufficiently (Mander, 1998). Travel time for collection of equivalent quantities of plant parts also doubled and import of materials from neighbouring countries increased (Mander *et al.,* 2007). The

failure by traders to raise prices even as herbal materials got scarcer was a disincentive from collecting materials from far places especially by women vendors, leading to further exploitation and degradation of resources near villages. Opportunities for international trade in a species' products increases local prices leading to further degradation as Krog *et al*., (2006) observed in Mozambique. Regeneration of some species such as *Warburgia salutaris* was also hindered by extensive trade in their roots and bark other than leaves, bulbs and flowers (ibid).

Cultivation of medicinal trees in smallholder farms is thus a viable alternative source of medicinal tree products to serve rising trade in addition to wild collection. Arnold and Dewess (1997) observed that trees become attractive to farmers as their products become increasingly traded and cited *Acacia mearnsii* for tannin and charcoal and *Eucalyptus spp* in Kenya as cases where availability of product markets was an incentive for increased tree planting. Scherr *et al*., (2003) also linked expansion of agroforestry to increased local subsistence and market demand for forest products and services. Many market chains studied for medicinal tree products markets have mainly focused on wild collection but Wiersum *et al.,* (2006), observed that availability of markets for medicinal species' products appeared to stimulate cultivation in Amatola, South Africa. Some volumes of trade reported for medicinal tree products such as 4,300 tonnes of material in Kwa Zulu Natal generating an expenditure of US$13.3 million (approximately one third of the annual Kwa Zulu Natal maize harvest value; Mander, 1998) indicate that even local trade can sustain profitable cultivation of medicinal trees. Verma and Singh (2008) also reported estimates of 7,800 drug manufacturing enterprises consuming about 2,000 tonnes of herbs annually in India.

With so many species being used in traditional medicine however, species prioritization for cultivation technology development is necessary. Market surveys can give an indication of which species to domesticate. For instance Facheux *et al*., (2003) found that *Annickia chlorantha* was highly traded in Cameroon and added the species to a list of priority species for an ongoing domestication programme described by Tchoundjeu *et al*., (2006). There has however been more research conducted on informal trade by vendors and also on international trade in medicinal plants (Kuipers *et al.,* 1997) than on the formal industry that is developing in the urban centres of the source countries. In Sarawak, Malaysia, Lee (2004), reported that consumers did not have confidence in medicinal plants sold in open markets except those sold as herbal teas or for external application on wounds due to lack of clear instruction on preparation and application. With increasing calls for the inclusion of traditional medicines in formal health management systems, safety concerns abound (Verma and Singh, 2008) and hygienic preparation conditions with proper labelling is desirable. Formal industries dealing with medicinal plants in a country can also aid growth in the country's export volumes. For instance, due to increased formalisation of its herbal medicine products,

China's share in the world herbal market is US$ 6 billion (Verma and Singh, 2008). Thus this study assumed that increase in consumer awareness will lead to more growth and demand for medicinal products that are better packaged and labelled as compared to openly sold plant parts. We did not include vendors and collectors in the study but focused on businesses that were more formal than just open air. Kariuki and Kibet (2007) had also focussed on vendors and collectors in the same urban centres targeted by this study and their findings gave the perspective of sources of materials by this category of traders.

This study was conducted to establish whether medicinal plant markets were linked to smallholder farmers in Kenya and whether there was potential to raise cultivation levels of medicinal trees with rising formal trade. The specific objectives of the study were to: (i) list the species in trade by herbal clinics and other urban players in the medicinal plant markets, (ii) assess urban traders„ views on the role of farms compared to forest as sources of herbal medicine raw material, (iii) assess the level of marketing of products from medicinal trees and other tree categories by farmers east of Mt. Kenya and (iv) assess whether there was scope for increased sourcing of raw materials from farms if herbal medicine trade gets increasingly formalised.

4.2 Research methodology

The study was conducted between May and July 2008 in the three major cities of Kenya, Nairobi, Mombasa and Kisumu as well as Meru a town next to Mt. Kenya the area where farmers were interviewed. Nairobi is located 500 km from the Kenyan coast and is situated at an elevation of about 1670 m above sea level. The city covers an area of about 700 square kilometers with a population of about three million people having a density of about 3000 people per square kilometer. The total average annual rainfall is 800 to 1500 mm, which follows a bimodal pattern. The soils in the northern part of Nairobi are moderately well drained, shallow, yellowish red to dark brown friable clays (ironstone soils), while in the southern part, they are imperfectly drained, very deep, dark grey to black clays (Sombroek *et al.,* 1980).

Kisumu city is situated at latitude 00 0 06' South and longitude 34 0 45' East on the shores of Lake Victoria at an altitude of 1160m above sea level. The city covers an area of approximately 417 Km², 35.5% of which is under water, and has a population of about half a million people (Kisumu City Council, 2005). The rocks in the Kisumu area are of volcanic origin mainly granites making the major soil types to be red loams, black cotton soils and decomposed rocks. The mean annual rainfall is approximately 1300mm with a bimodal pattern. The mean annual temperature is 23^{o} centigrade. Mombasa lies between latitudes 3° 80' and 4° 10' S and longitudes 39° 60' and 39° 80' E, with a total land mass of 229.6 km^{2}

and inshore waters covering 65 km^2. The mean rainfall is about 1000 mm with a bimodal pattern. The district is situated in coastal lowland with extensive flat areas rising gently from eight to 100 meters above sea level. Soils vary from well-drained, shallow (less than 10 cm) to deep, loamy to sandy with variable colour, consistency, texture and salinity (Munga *et al.,* 2004).

Survey method was used to do a rapid reconnaissance of the species in the market and their sources. To generate a list of businesses to interview, we used the yellow pages of the Kenya telephone directory; herbal products category and the East African Business directory. We called many of the listed businesses to book interview appointments and to ask for additional names that they knew and may have been missing from the directories. We interviewed as many businesses as accepted to grant us appointments although a few major herbal clinics declined interviews, especially in Nairobi. We used a questionnaire to collect information on the herbal medicine market trend, species the traders dealt with, where they sourced them from as well as their preference for species source defined by ecological parameters (Appendix 3C). Fifty five traders were interviewed comprising 25 in Nairobi, 13 in Mombasa, twelve in Kisumu and five in Meru. Two hundred farmers in Embu, Mbeere and Meru were also asked about the medicinal products they sold during the survey on their preference for medicinal tree cultivation (Chapter 3).

Data were entered into a Microsoft Excel database and processed using the Pivot Table function as well as SPSS. Analysis was mainly in descriptive form with box plots used to present differences in the trends and volumes of trade in the different species encountered. ANOVA was used to analyze differences in business performance by the three categories analyzed (herbal clinics, final products processors and pre-processors). Pre-processors are those traders who mainly dealt with powders and liquids that were not packaged for long term storage or retailing. An enterprise's mean annual growth rate for a species (MAG_v) was calculated as the volume of the species material traded at the time of interview (V_t) minus the volume traded in the year the business started (V_o) divided by number of years the trader had traded in the species products (t) multiplied by 100 $\{MAG_v = (V_t - V_o)/t\}$.This formula was used just as an indication of business growth, modified from the calculation of mean annual increment in tree volume in forest mensuration, but taking cognizance of the fact that business growth is never linear.

4.3 Results

5.3.1 Categories of herbal medicine enterprises and nature of trade

Majority (40%), of the enterprises involved in herbal medicine trade in the cities were herbal clinics and those that processed herbs into packages for retail sales herein referred to as

final products (36%; Table 29). Traders that were doing partial processing into powders and liquids that could not circulate in retail outlets (herein referred to as pre-processing) comprised 24% of the businesses. The average trading period was 17 years for both herbal clinics and pre-processors while final products business were relatively recent ventures with an average trading period of eleven years. The differences in average trading period by business category were however not significant (P=0.05). The number of plant species dealt with by an enterprise ranged from one to 24 species with six being the average. The traded volumes per species per enterprise are presented under the species analysis in section 5.3.2 below.

Table 29: Categories and characteristics of enterprises interviewed in the medicinal tree product trade

Business categories	Frequency % (n=55)	Average Trade period (years)	Average percent annual growth	Average number of species traded	Average percent of raw materials purchased	Average percent of volume traded sourced from the wild
Final products	36	11 (7.5)	424 (621.6)	7 (5.0)	69 (31.5)	29 (30.9)
Herbal Clinic	40	17 (12.7)	158 (159.5)	6 (4.0)	45 (36.0)	59 (36.3)
Pre-processing	24	17 (10.8)	100 (87.6)	5 (2.4)	36 (43.5)	72 (31.5)
Grand Total	100	15 (10.7)	241 (409.3)	6 (4.1)	53 (37.9)	51 (37.1)

Numbers in parenthesis indicate the standard deviation of the values of the reported parameter. The average trade period implies the average period (years) that the traders had been in medicinal plant products business

Enterprises dealing with final products had the highest mean annual growth rate at an average of 424% growth in volumes per year (Table 29). Herbal clinics were growing at an average rate of 138% per year while pre-processors' trade volumes were growing at an average rate of 100%. These general differences in annual business growth rates between the business categories were significant (PANOVA = 0.05). Enterprises dealing with final products were purchasing most of the raw materials (average 69% volume purchased) and most of it was sourced from farms (average 71%). Operators of both herbal clinics and pre-processing enterprises were collecting most of their raw materials themselves (55% and 64% respectively) and they sourced mainly from the wild (59% and 72% respectively). The difference between final products enterprises and the other two categories was significant (P=0.01) for both the proportion of raw materials purchased and the volumes sourced from the farms. It was encouraging to note that in general 49% of the materials traded were reported to have been sourced from farms.

5.3.2 Medicinal plant species in the formal herbal market trade in Kenya

Over 150 plant species of all growth habits (trees, shrubs and herbs) were encountered in the herbal medicine enterprises (Table 30; Annex 5.1) but only 27 species were being traded

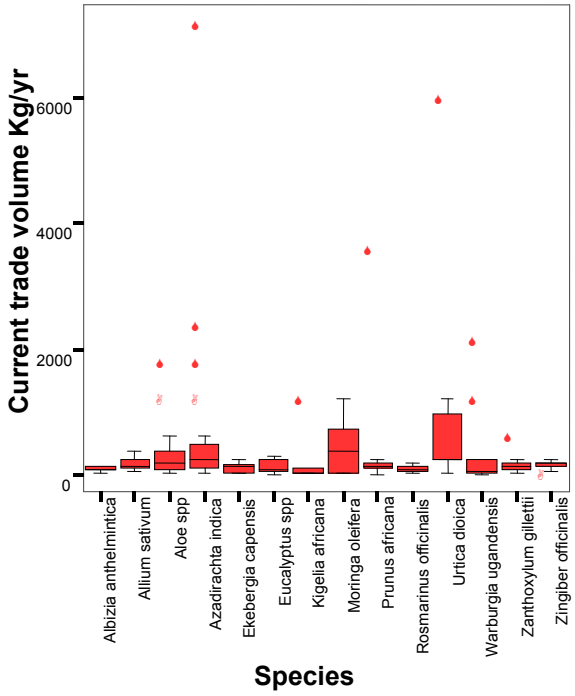
by at least 5% of the enterprises (Table 30). The annual trading volumes were less than one tonne (1000kg) on average for the species traded by at least 5% of the traders. The highest traded volume was for *Urtica dioica* (a herb) at an average of 943kg followed by *Azadirachta indica* at 693kg, *Moringa oleifera* at 463kg and *Prunus africana* at 408kg. All these species were mostly sourced from farms and their demands were seen to be rising apart from *Urtica dioica* which was mostly sourced from the wild and had an apparently constant demand. Other species traded by more than 5% of the traders had average annual volumes of less than half a tonne. However there were other species in one or two enterprises such as *Ocotea usambarensis, Ceasalpinia volkensii, Artemisia annua, Flacourtia indica* and *Hydrastis canadensis* that had over one tonne of annual business volume and whose demand was also seen to be rising (Annex 5.1).

Table 30: Medicinal plant species traded by 5% or more herbal medicine enterprises in Kenyan towns

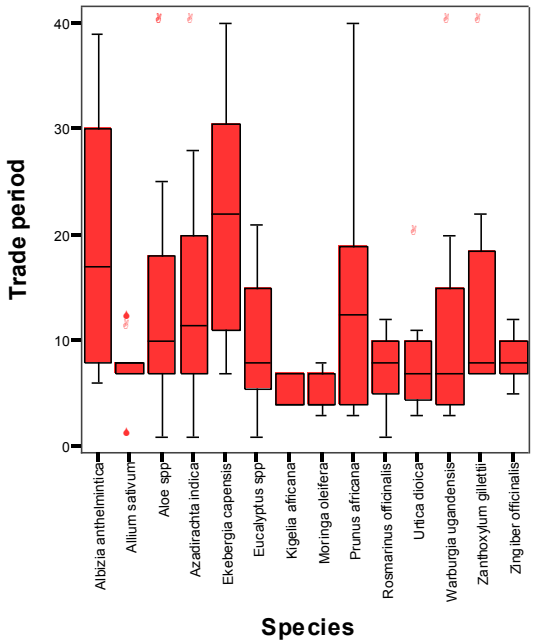
Species	Growth habit	Frequency % (n=55)	Average trade period	Current average annual trade (Kg)*	Mean annual trade growth %*	Average % sourced from farm*	Demand trend
Aloe spp	Shrub	51	14	286	333	55 (39.6)	Rising
Azadirachta indica	Tree	44	14	693	496	88 (30.6)	Rising
Rosmarinus officinalis	Herb	24	7	80	320	82 (37.6)	Rising
Warburgia ugandensis	Tree	24	11	333	231	44 (49.1)	Rising
Eucalyptus spp	Tree	22	10	117	600	98 (5.8)	Rising
Prunus africana	Tree	22	14	408	255	73 (31.1)	Rising
Urtica dioica	Herb	20	8	943	1122	30 (39.6)	Constant
Allium sativum	Herb	16	8	179	432	100 (0)	Rising
Zingiber officinale	Herb	16	8	147	244	100 (0)	Rising
Ekebergia capensis	Tree	13	22	105	32	5 (13.0)	Rising
Zanthoxylum gillettii	Tree	13	15	175	109	0 (0)	Rising
Albizia anthelmintica	Tree	9	20	77	75	0 (0)	Rising
Kigelia africana	Tree	9	5	269	214	30 (44.8)	Constant
Moringa oleifera	Tree	9	5	463	864	100 (0)	Rising
Acacia nilotica	Tree	7	11	105	100	0 (0)	Rising
Cinnamomum verum	Tree	7	6	132	1769	100 (0)	Rising
Croton megalocarpus	Tree	7	20	168	189	95 (10)	Rising
Petroselinum crispum	Shrub	7	10	75	302	100 (0)	Rising
Rumex crispus	Herb	7	9	330	130	0 (0)	Rising
Amaranthus spp	Herb	5	16	180	134	100 (0)	Rising
Curcuma longa	Shrub	5	9	72	200	100 (0)	Rising
Hydnora abyssinica	Shrub	5	29	80	22	0 (0)	Rising
Rhamnus prinoides	Tree	5	6	104	150	33 (57.7)	Rising
Senna didymobotrya	Shrub	5	12	80	199	33 (57.7)	Constant
Toddalia asiatica	Shrub	5	30	280	134	33 (57.7)	Rising
Zanthoxylum usambarense	Tree	5	12	36	-74	0 (0)	

* The values indicated in these three columns indicate average for only the respondents that deal with the tree products, not all respondents. Numbers in parenthesis indicate that standard deviation for proportions of materials sourced from farms

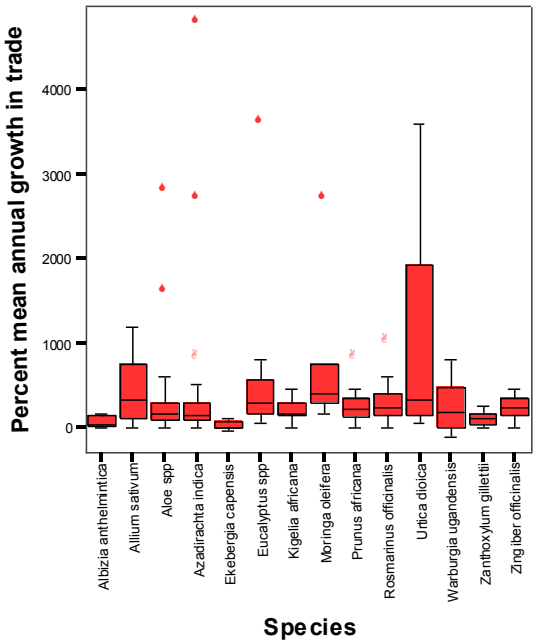
Most of the species had average annual volume of trade growth above 100% apart from *Ekebergia capensis, Albizia anthelmintica,* and *Hydnora abyssinica*. Trade in *Zanthoxylum usambarense* was low at an average volume of 36kg per year and was reducing at an average rate of 74% (Table 30). Trade in from tree species was generally low in volumes but some traders were individually having very high volumes (Figure 9a). One trader was dealing with about eight tonnes of *Azadirachta indica*, another with about four tonnes of *Prunus africana* and another with about two tonnes of *Warburgia ugandensis*. However most of the traders had only dealt with these species for less than two decades and there were wide spans between the first and third quartiles in trading periods (Figure 9b) and traders reported that the growth in the trade in these species was more than 100% per year in most cases (Figure 9c). Almost all traders were sourcing some materials of indigenous species from the wild and some from farms.



9a: Volumes in trade for leading species at survey time



9b: Time periods that leading species had been in trade



9c: Rates of annual growth in volumes traded for leading species -

Figure 9: Patterns of trade volumes and periods for leading species in the medicinal plant trade in four Kenyan towns (dots and circles show extreme values)

5.3.3 Tree parts dealt with in herbal medicine trade

Leaves were the most traded plant parts for most species found in the herbal medicine enterprises (Table 31). A number of traders were dealing with whole plants for herbaceous species such as *Rosmarinus officianalis* (29% of traders), *Urtica dioica* (10%) and *Aloe spp* (22%). For most of the woody species most common in trade, majority of the traders were dealing with roots and barks of the species apart from *Moringa oleifera* and *Senna didymobotrya* whose leaves were the major parts traded.

Table 31: Plant parts traded by herbal medicine enterprises for the most traded species

Species	Growth habit	Freq % of traders	Plant parts traded (percent of the traders trading in species)					
			Whole plant	Roots/ tubers	Bark	Pods/Fruits /flowers/ seeds	Leaves	Total*
Azadirachta indica	Tree	44	0	45	75	5	100	223
Aloe spp	Shrub	51	22	4	0	0	82	108
Warburgia ugandensis	Tree	24	0	46	100	0	46	188
Prunus africana	Tree	22	0	23	100	0	32	159
Eucalyptus spp	Tree	22	0	0	73	9	59	141
Zanthoxyllum gillettii	Tree	13	0	69	85	15	54	223
Urtica dioica	Herb	20	10	10	20	0	90	125
Rosmarinus officinalis	Herb	24	29	0	0	8	63	100
Ekebergia capensis	Tree	13	0	69	100	0	0	169
Kigelia africana	Tree	9	0	44	100	56	44	244
Moringa oleifera	Tree	9	0	22	22	122*	78	244
Croton megalocarpus	Tree	7	0	71	100	29	71	286
Allium sativum	Herb	16	0	100	0	0	0	100
Zingiber officinale	Shrub	16	0	100	0	0	0	100
Albizia anthelmintica	Tree	9	0	100	44	0	0	144
Acacia nilotica	Tree	7	0	56	56	0	0	122
Rumex crispus	Shrub	7	0	29	71	0	57	157
Senna didymobotrya	Shrub	5	0	40	0	80	80	180

* Numbers represent the frequency of the respondents who reported dealing with the plant part as a percentage of only the number that reported dealing with the species. Totals add to more than 100% because many traders were dealing with more than one part for several species

5.3.4 Traders' preference for source of medicinal plant materials

More than two thirds of the traders (69%), preferred herbal materials sourced from the wild resources (forests or woodlands) while about a third (27%), preferred materials from farms (Table 32). Two traders did not have a specific preference between the two types of sources. The main reason given for preferring materials from forests and natural woodlands was expectation of a high potency of the harvested herbal material due to the plants having grown to full maturity and in a rich soil substrate (36%). The other reasons were the presence of a huge diversity of plants, in high abundance, in these natural sources as compared to farms (16%) and the expectation that the plants would not have been polluted by human activities such as chemical application (15%). Seven percent of the traders

preferred wild sourced material because it was free. The reasons for preference of farm sourced materials were an expectation of high drug quality due to good crop husbandry (good cultivation practice, 11%), increasing scarcity of species in the wild (7%), and a deliberate choice to contribute to conservation of wild resources (5%).

Table 32: Preference for sources of medicinal plant materials by traders in herbal medicine

Preferred source	Reason for source preference	% of respondents giving reason (n=55)	Procurement approach
Farms (27% of the respondents)	• To contribute to conservation of natural resources	5	Own collection 39%; purchased 61%
	• Good crop husbandry in farms hence high quality	11	
	• Assurance of species authenticity	4	
	• Species getting scarce in the wild	7	
	• To create a market for future conservation	2	
	Total	29	
Forests (69% of the respondents)	• Customary practice for herbal medicine	2	Own collection 51%; purchased 49%
	• High potency of plants in the forest due to plant maturity and rich soil substrate	36	
	• Huge diversity and abundance of medicinal plants in the wild	16	
	• No chance of pollution or any human interference in the wild	15	
	• No cost involved when collecting from the wild	7	
	Total	76	
No preference (4% of the respondents)	• Determined by distance and cost of getting material from source	2	Own collection 100%;
	• No reason	2	
	Total	4	
Grand Total		109*	

* Percentages add to more than 100 because some respondents gave more than one reason for preferring source

Majority of the traders who preferred sourcing from the wild resources (51%) were collecting materials for themselves while majority of those who preferred farm sourced material (61%) mainly purchased their raw materials (Table 32). Two traders reported that they processed most of their products from plant material obtained from farms but would prefer material sourced from forests since the later was collected from more mature plants. The two traders acquired most of their raw material (one 60% and the other 90%) through purchasing.

5.3.5 Medicinal tree product marketing by farmers in Embu, Mbeere and Meru central districts

Only five farmers (3%), of the 200 interviewed in Embu, Mbeere and Meru Central districts had ever sold products from medicinal trees established in their farms. They had sold products (plant parts) from only five tree species in farms mainly to vendors and neighbours (herbalists) but two of them in Mbeere district had taken seeds of *Myrsine melanophloeos* to Siakago market to hawk to market customers (Table 33). The main reason why all the other farmers gave for not selling medicinal tree products was lack of market.

Table 33: Farmers who had sold medicinal tree products from their farms in three districts east of Mt. Kenya

Species	Number of farmers	Plant part sold	Where sold
Markhamia lutea	1	Roots	Herbalist/neighbours (1)*
Myrsine melanophloeos	3	Seeds	Vendors (1); Market (2); Neighbours (1)
Olea europaea	2	Cuttings	Vendors (2)
Osyris lanceolata	1	Whole plant	Vendors (1)
Warburgia ugandensis	1	Bark	Herbalist (1)

* numbers in parenthesis indicate the number of farmers who had sold medicinal products in the said market

Aside from medicinal trees, there was no tree category of farm trees for which all farmers were selling products (Table 34). However many farmers were selling fruits (64%) and timber (40%) from their farms. A further 21% (41 farmers) reported that they would be selling timber had their farm trees matured for sale. Farmers who had sold tree products had a significantly higher number of trees in their farms on average (P=0.05) for both fruit and fodder species than those who were not selling although the number of species was not different. The farmers who had ever sold timber had planted a significantly higher average number of species (P=0.05) than those who were not selling but the average number of trees per farm was not significantly different. This apparent similarity in the number of timber trees is possibly due to the high number of farmers who had planted trees which they intended to sell later as timber but the trees were yet to mature and as such no sales had been done yet. These farmers were included in the category that was not selling but had a high chance of making a significant difference in the number of trees planted by the two categories if they had been categorised as selling timber tree products. There was no significant difference in the average number of species or number of trees in farm between those who were selling and those who were not selling tree products in the medicinal tree category. The number of farmers selling medicinal tree products was too small to make any meaningful difference however.

Table 34: Comparison of marketing of medicinal tree products with those of other farm tree categories by farmers east of Mt. Kenya

Category of farm trees	Frequency (%) of respondents (n=200)		Average number of species in farm		Average number of trees in farm	
	selling	not selling	selling	not selling	selling	not selling
Fodder	2	37*	2	2	280_a	74_b
Fruits	64	34	5_c	4_d	112_e	44_f
Fuelwood	5	15	4	4	66	53
Medicinal	3	97	5	5	169	120
Timber	40	58	4_g	3_h	227	206
General average			4	4	154	119

* normally fuelwood is harvested from other category of species but we allowed those farmers who wanted to report it as a category to do so hence respondents add up to less than 100%. More than half of the farmers also did not report trees in the fodder category. Figures in the same category followed by different subscripts are significantly different (P = 0.05)

4.4 Discussion

The results revealed that trade in herbal medicine products was fairly young and was developing into formal enterprises that had a great potential for growth. The enterprises that were dealing with final products that could be retailed and also dispensed in herbal clinics (such as tablets and stable creams and powders), were the most recent in development but had higher mean annual growth rates. Most of the raw materials used by this category of traders were sourced from the farms and mainly purchased. This showed that as formal enterprises continue to establish and grow in trade, there will be greater opportunities for more players to participate in business as collectors, producer business groups, processors or other players in the trade chains. The traders in that category seemed to concentrate on the processing part of the business and preferred to purchase raw materials rather than go collecting for themselves. These purchases are most likely done from vendors and some from farms. As Kariuki and Kibet (2007) observed, vendors were collecting most of the materials for their trade from the forest so if the purchases are mainly done from vendors then the formalization of business would not stimulate cultivation by farmers. Formalization of trade will however lead to traders desiring more uniform raw materials which cultivation can provide more cost effectively than wild collection (Schipmann *et al.,* 2006). The traders who reported preference of raw materials from farms gave the expectation of high quality due to good crop husbandry and species authenticity as the main reason for that preference.

The trade volumes were found to be low at the time of the survey but with high growth rates. There is a risk of the current trade volumes being too low to stimulate cultivation but then the high growth rates lead to degradation of wild resources if cultivation rates do not increase. Tree species such as *Warburgia ugandensis, Zanthoxylum gillettii* and *Kigelia africana* were reported to have trade growth rates above 100% but were mainly sourced from the wild (66% for *W. ugandensis* and 100% for the other two species). Such species are high priority for domestication in order to increase the volumes sourced from the farm and conserve wild resources. Two herb species, *Urtica dioica* and *Rumex crispus,* also had high trade growth rates and were only sourced from the wild possibly because they were highly abundant in the wild. The most traded tree species also had a higher concentration of trade in the parts that support tree life most i.e. the roots and barks. In the absence of sustainable harvesting practices, as demand continues to rise, preference for roots and barks of woody species can threaten species survival. It has been observed that some of the most traded species such as *Prunus africana* and *Warburgia ugandensis* are becoming threatened in many regions (Cunningham, 1993). *Prunus africana* is already on the CITES Appendix 2 due to its high international trade volumes viewed against existing stocks.

The best approach to serve the market at the current state would be to link traders to farmers in form of grower groups for the most traded species. Growers can form medicinal tree producer groups that would start cultivation at present in order to supply projected future demand. The species in high demand by herbalists and the other traders such as *Prunus africana, Warburgia ugandensis, Azadirachta indica* and *Moringa oleifera*, would be a high priority for cultivation, especially the ones that have graduated to export business such as *Prunus africana*. The few trees of each of these species currently present in farms (Chapter 3) can supply to the present traders as more trees are planted to meet growing demand. Vegetative propagation technologies such as grafting techniques need to be tested on their compatibility for most of these species that are in high demand. Vegetative propagation can ensure more uniform germplasm (clonal material) is planted by farmers in producer groups whose source is known and produce trees which have high chemical concentrations at early maturity as traders desired when propagules are sourced from mature branches.

Farmers in Mt. Kenya east area were not engaged in any significant sales of medicinal tree products mainly due to lack of market access. From observations on other categories of tree species it was notable that the farmers who had made some sales had planted more trees per farm although not necessarily more species than the farmers who had not. Even in the case of medicinal trees, there were more trees planted by the few who had sold herbal products but the differences were not significant. This is possibly because for medicinal tree species category we included all the trees which had medicinal value in the farms as given to us earlier in the survey for analysis while we asked the respondents to only give the number of trees they had planted specifically for other categories of trees. The number we used for medicinal trees included many tree species in the other categories since most of the species had also been given as having medicinal value due to their multi-purpose nature. This coupled with the low number of farmers who had sold any medicinal tree products made it difficult to test whether marketing of herbal products had any association with the number of medicinal trees in the farms.

From the analysis of all tree product categories it was clear that access to market stimulated increased cultivation and this is possible for medicinal trees. An interesting case was timber species where the number planted by those who were selling timber was almost the same as those who had not yet sold. Timber had not been taken as a source of income for farmers until the state forests were closed from logging in Kenya, a decade earlier, making timber dealers to focus on smallholder farmers as sources of logs (Carsan, 2007; Holding *et al.,* 2001). This demand then led to many more farmers planting timber trees. Any policy that would cause markets to focus on farm grown medicinal trees as source of raw materials for both formal and informal herbal products businesses is likely to stimulate cultivation by farmers.

4.5 Conclusion

The results of this study showed that trade in herbal medicine products was rising in the urban areas of Kenya and formalisation in terms of packaging of the products in trade was likely to increase. The traders who dealt with final products portrayed a higher preference for raw materials that were sourced from farms compared to herbal clinics and pre-processors. However they (final product traders) preferred to purchase most of the raw material they used in processing of products. As such it was not clear how they ascertained the source of the raw materials they purchased and having an assured source from farmers' producer groups could attract them to collect directly from farms. Farmers in Mt. Kenya area were however not aware that market demand existed and were not selling medicinal tree products. The few medicinal trees in their farms could only have been conserved for household health use or other purposes but not for sale of products. Access to markets due to raised demand appeared to raise cultivation levels for other tree product categories, a high possibility for medicinal trees too. We can therefore conclude that increased formalisation of herbal medicine products trade has potential to raise demand for farm grown raw material which can raise the level of cultivation of medicinal tree species in smallholder farms.

Annex 5.1: Other species traded by less than 5% of the respondent traders

Species	Growth habit	Frequency % (n=55)	Average Trade period	Current average annual trade (Kg)	Mean annual trade growth %	Average % sourced from farm
Albizia coriaria	Tree	4	26	48	80	0
Chenopodium oppulifolia	Herb	4	26	90	296	100
Erythrina abyssinica	Tree	4	3	1092	900	25
Euphorbia candelabrum	Tree	4	23	108	74	0
Harrisonia abyssinica	Shrub	4	32	210	8	17
Leonurus cardiaca	Shrub	4	8	21	161	83
Ocotea usambarensis	Tree	4	4	1836	450	20
Solanum incanum	Shrub	4	5	54	222	0
Terminalia brownii	Tree	4	17	13	20	25
Trichilia emetica	Tree	4	17	13	220	25
Acacia mellifera	Tree	2	5	120	240	0
Ajuga remota	Herb	2	10	60	80	0
Allophylus rubifolius	Tree	2	16	132	17	0
Aloe lateria	Shrub	2	10	360	600	67
Artemisia annua	Shrub	2	4	4800	700	100
Bersama abyssinica	Tree	2	1	9	1200	50
Beta vulgaris	Shrub	2	11	1080	218	100
Bridelia micrantha	Tree	2	4	3600	450	0
Cactus spp	Shrub	2	14	600	129	20
Caesalpinia volkensii	Shrub	2	4	2400	300	10
Carica papaya	Tree	2	17	36	0	100
Carissa edulis	Shrub	2	22	120	55	0
Carissa spinarum	Shrub	2	4	72	300	0
Catha edulis	Tree	2	4	1080	600	100
Clerodendum myricoides	Shrub	2	30	24	40	0
Combretum constrictum	Shrub	2	16	132	17	0
Commifora africana	Tree	2	27	120	844	0
Conyza canadensis	Herb	2	4	96	300	100
Cordia africana	Tree	2	2	36	300	50
Cordia moniaca	Tree	2	3	6	1600	50
Dichrostachys cinerea	Tree	2	10	120	280	0
Drypetes spp	Tree	2	48	60	-13	0
Euclea divinorum	Shrub	2	40	48	30	0
Ficus sycomorus	Tree	2	3	4	800	50
Flacourtia indica	Tree	2	4	2400	900	50
Glycine max	Herb	2	10	600	480	60
Haplocoelum inoploeum	Tree	2	48	60	-13	0
Hydrastis canadensis	Herb	2	11	3600	109	0
Jatropha curcas	Tree	2	3	6	1600	100
Kalanchoe pinnata	Shrub	2	14	600	343	80
Lannea schweinfurthii	Tree	2	14	360	429	0
Lawsonia inermis	Herb	2	30	24	40	0
Lippia javanica	Shrub	2	28	240	243	0
Maerua decumbens	Herb	2	30	24	40	0
Mangifera indica	Tree	2	3	18	200	100
Medicago sativa	Shrub	2	11	7200	109	50
Microglossa pyrifolia	Tree	2	40	60	-15	0
Mondia whytei	Liana	2	4	3600	450	10
Mucuna gigantea	Herb	2	22	60	0	0
Myrsine africana	Tree	2	30	24	40	0
Olea europaea	Tree	2	2	12	0	20
Ormocarpum kirkii	Shrub	2	10	60	30	0
Osyris lanceolata	Shrub	2	3	24	0	0
Panax quinquefolium	Herb	2	8	18	300	67
Persia americana	Tree	2	3	18	200	100
Polyathia stuhlmannii	Shrub	2	39	120	8	0
Premna chrysoclada	Tree	2	16	132	17	0
Rauvolfia caffra	Tree	2	2	24	600	0
Salvadora persica	Tree	2	8	36	75	0
Sawparl metal	Tree	2	4	24	300	100
Securidaca	Shrub	2	48	96	-5	0

longipendunculata						
Solanecio angulatus	Shrub	2	48	120	-13	0
Solanecio manni	Shrub	2	3	2	400	0
Solanum nigram	Shrub	2	8	36	300	0
Stellaria sp	Herb	2	4	96	300	100
Strychnos henningsii	Tree	2	4	60	450	0
Taraxacum officinalis	Herb	2	5	420	180	0
Teclea nobilis	Tree	2	7	48	514	0
Vernonia zanzibarensis	Tree	2	39	60	8	0
Withania somnifera	Shrub	2	36	360	67	100
Zanthoxylum chalybeum	Tree	2	7	360	86	0
Syzygium aromaticum	Herb	2	4	24	300	100
Acacia tortilis	Tree	2	0	36		0

- Due to the many dialects encountered in the survey some species mentioned by one or two respondents were not identified botanically and there is a possibility that different local names recorded could be referring to the same species and those species could be among the ones listed above

5 The role of on-farm tree nurseries in the supply of medicinal tree seedlings and information to farmers

5.1 Introduction and literature review

Forest lands are rapidly decreasing in both size and species diversity in the tropics. This trend has led to increased focus on the importance of trees outside forests and the latest studies indicate that trees in agricultural land cover a huge part of the global land resources (Zomer *et al.,* 2009). Much of this spread has been maintained not only by saving trees from cutting during field clearing but also by increased tree planting efforts by millions of smallholder farmers in the tropics (FAO, 2000). Unlike many other farm crops tree germplasm is acquired by farmers mainly as seedlings rather than seeds due to the care needed to nurture tree seedlings from seeds and also because annual per capita tree planting plans by smallholder farmers rarely go beyond tens of trees (Simons, 1997; Simons and Leakey, 2004). In most cases the annual tree planting programme by a smallholder farmer requires just a few individuals of each of a number of species that are to be planted at the same season. These seedlings are often acquired as naturally growing wildlings but in most cases raised in tree nurseries. Roshetko *et al*., (2010) described various tree nursery categories from which farmers can access seedlings.

Tree nurseries, especially the group operated ones, are major entry points for organizations intending to introduce tree planting, new agroforestry technologies or promising species identified through research in farming communities (Kerkhof, 1989). Some projects that reported the central role of nurseries in adoption of tree planting success were in Kenya (Nieuwenhuis and O'Connor, 2000; Shisanya *et al.,* 2007); Philippines (Gregorio *et al.,* 2004; Garcia, *undated*), Ghana (Heist, 2001) and Southern Africa (Böhringer *et al.,* 2003) among others. Project interventions at the nursery level also aim at improving local capacity to produce high quality tree seedlings since farmers rely on these nurseries to access seedlings at the local level on a continued basis. High quality seedling production is critical for success of agroforestry practices and poorly produced seedlings from a local tree nursery lead to poor performance of the trees (Jaenicke, 1999; Wightman, 1999). Tree nurseries also offer great opportunities to influence the tree species mix in a landscape as often it is the species available at the nurseries that will appear in farms. The other trees in the landscapes will most likely be naturally regenerated. The study done by Oginosako *et al*., (2006) showed a clear similarity between the species in farms and those in nurseries. It is not clear whether the nurseries actually influence the type of trees in the landscape or farmers' demand based on limited knowledge on available tree species diversity influences the species that nursery operators stock.

Past interventions to promote cultivation of new or underutilized tree species involved projects establishing central nurseries where farmers could access both seedlings and technical information on tree species. But as early as 1994, Shanks and Carter, reporting on several project case studies, gave several disadvantages of these central nurseries, the major one being long distances to community planting sites which posed problems of seedling transportation. Other disadvantages included cases where nurseries fell victims of project budget shortfalls and were neglected even when communities were relying on them to source seedlings. Group nurseries were the next intervention approach where projects supported farmer groups to establish nurseries and then share the seedlings produced between group members in order to plant in their farms (Kerkhof, 1989). Group nurseries however usually fall victim of poor group management and are short lived in most cases (Garcia, undated). Individually ran nurseries are the other alternative source of seedlings where enterprising farmers establish nurseries in order to sell tree seedlings in addition to meeting their own tree planting needs. Such nursery operators were observed to be very instrumental in distribution of underutilized fruit species germplasm in Sri Lanka (Boris *et al.,* 2006).

Tchoundjeu *et al*., (2006) described the central role of nurseries in participatory tree domestication activities in the Africa Humid tropics region. Tree nurseries developed from an initial stage of total dependency on ICRAF for support with inputs to an almost autonomous stage by nursery operators. The success of the nurseries depends on a rising demand of tree seedlings by the community which raises sufficient income for the nursery operator to maintain the nursery and invest in high quality germplasm and good nursery practices. Several species that have been promoted by projects have ended up being successful enterprises for nursery operators as farmers demand increased. Examples include fodder tree species in central Kenya (Wambugu *et al.,* 2002), and indigenous fruit trees in southern Africa (Akinifesi *et al.,* 2008_b). Research and development projects working with these nursery operators can ensure that cultivars improved through science are disseminated through these nurseries in order to give the desired results by users (Roshetko and Verbist, 2000).

The main objective of this study was to assess the role that local tree nurseries play in influencing cultivation of medicinal trees. The specific objectives pursued were to (i) characterize on-farm tree nurseries as income generating farm enterprises, (ii) assess the relative importance (availability and demand) of medicinal tree seedlings in on-farm tree nurseries compared to other tree categories, (iii) explore any other role that tree nursery operators could play in ensuring availability of information and seedlings of medicinal tree

species, and (iv) assess the contribution of tree nurseries to medicinal tree germplasm planted by farmers and farmers willingness to pay for the seedlings.

5.2 Research methodology

This chapter reports some results from the farmers' and herbalists' surveys that were conducted between May and June 2008 and whose sampling procedure has been described in Chapter 3. The body of the chapter is however based on the nursery survey which was conducted with a questionnaire (Appendix 3D). We collected lists of on farm tree nurseries from offices of the Kenya Forest Service (KFS) in Embu, Mbeere and Meru central districts and purposively sampled nurseries that were as close as possible to the villages where we had conducted the farmers' surveys. After selecting nurseries near research villages, we did a further random sampling to ensure that we had a total of twenty respondent nursery operators in each district. Although group nurseries were included in the survey, especially in Mbeere district, we ensured to interview only the groups that had an active nursery, more so where only one individual ran the nursery and the group used the nursery only as a meeting place. We however did not include nurseries operated by the groups where the farmers' survey had been conducted even if any of them fitted the other criteria. The interview focused on the general seedling demand (numbers demanded, produced and supplied – these terms are explained in the results as they were used in this study), general observation on the trend of demand for medicinal species and whether the nursery operator was involved in promoting medicinal trees species cultivation.

As a form of triangulation we engaged in an informal experiment to test whether farmers were willing to buy medicinal trees seedlings if the seedlings were accessible to them. After the initial farmers' surveys, we responded to farmers' reported lack of knowledge of medicinal uses of various tree species by organizing seminars for farmer groups where an herbalist presented the medicinal uses of about ten selected tree species. We invited all farmers who had been interviewed in the surveys and informed them to extend the invitations to all neighbours who could find time to attend the seminar. The herbalist interacted at length with the farmers and responded to all the group members' questions as far as was technically possible. Farmers' lack of access to the seedlings of the most valuable seedlings was discussed and where possible a nursery operator from a nearby nursery who had been interviewed would join the group and present the situation on the availability of seedlings.

In an ICRAF nursery within the study area, we already had raised seedlings for a number of these species namely *Prunus africana, Warburgia ugandensis, Azadirachta indica, Olea europaea ssp africana, Cordia africana, Artemisia annua* (an annual herb from China playing a key role in the production of Artemisinin-based Combination Therapies for malaria) and

Ocimum suave (a shrub highly valued in the treatment of various diseases – Appendix 2A). We distributed the seedlings to the villages we were working in each of the three districts just before the rainy seasons of March/April and October/November 2009, in different approaches as follows:-

Village 1 – we distributed the seedlings at no cost to the farmer groups and asked group members to share among themselves and plant the species they each desired. No nursery operator was engaged in this village and the group nursery served as the seedling collection point.

Village 2 – we gave the seedlings to a nursery operator close to the village and requested him to give the seedlings freely to whoever asked for them and record the numbers that had been distributed for each species.

Village 3 – we gave the seedlings to a nursery operator close to the village and requested him to sell the seedlings at a subsidized price to whoever asked for them and record the numbers that had been distributed for each species.

Village 4 – we gave the seedlings to a nursery operator close to the village and requested him to sell the seedlings at the prevailing market prices to whoever asked for them and record the numbers that had been distributed for each species.

In villages 2-4 we informed the group leaders in the villages that the seedlings were available in the nurseries although the seedlings were not necessarily restricted to the group members but any farmer that expressed a desire to plant/buy them. We also gave reading materials with information on medicinal uses of these and other species to nursery operators to familiarize themselves and share the knowledge with clients. From the beginning we had selected the villages in a way that ensured that the different villages would be as far as possible from each other to avoid spill over effects and conflicts when groups became aware that they were under different seedling distribution scenarios by the research team.

Data analysis was basic through tabulation of parameters with ANOVA and independent samples T-test used to test mean variations for interview data. We used box-plots to show variation in parameters that did not favour means as the comparable measure of central tendency such as the number of species in nurseries and the prices that farmers were willing to pay for seedlings of the medicinal tree species they desired to plant. Qualitative analysis and reporting was used for the experiment in order to further explore the willingness by farmers to buy seedlings. This approach was similar to that of Barrance *et al*. (2009), who also used a combination of quantitative and qualitative methods to assess the success of conservation-through-use projects in the Mesoamerican dry forest, drawing on recommendations by Hollard and Campell (2005).

5.3 Results

6.3.1 Characterizing the nursery operators and their enterprises

The socio-demographic characteristics of farmers and herbalists have been presented in chapter 3 and Table 35 shows the characteristics of the nursery operators. Overall women constituted 45% of the respondent nursery operators comprising 50% in Embu, 55% in Mbeere and 30% in Meru Central districts. Most of the operators (64%), were more than 45 years old and the rest between 25 and 45 years old apart from two nursery operators who were younger. Two respondents declined to state their age. Majority of the respondents (75%), had attained secondary school education while 13% had only attained the primary level of education. A number of them (17%), had however not attained any level of education. These were mainly women who were over 50 years old. All but four nurseries (7%), were individually operated and even the four group nurseries were basically ran by one group member and only remained group nurseries for the sake of hosting group activities.

Table 35: Social-demographic characteristics of nursery operators

Parameters / percent of respondents (n = 60)	1	2	3	4	5	6
Gender	45	55				
Age	3	12	17	28	28	8
Education	17	13	37	33		
Nursery category	7	93				

Key: **Gender** 1 – Female, 2 – Male; **Age** - 1 - ≤25, 2 - 26-35, 3 - 36-45, 4 - 46-55, 5 - 56-65, 6 - ≥66 (two nursery operators did not state their age; **Education** 1 – Not schooled, 2 – Primary, 3 – Secondary, 4 - Post Secondary; **Nursery category** 1 – Group, 2 - Individual.

Nursery operators were also smallholder farmers and earned income for their households from the nursery, farm crops (surplus sales), livestock and tree sales while some (or their spouses) were also employed or ran businesses. The annual income (total from all sources in the household) for the nursery operators was Ksh 137,494 (about 1,375 Euro; Table 36) on average. The total annual income did not differ by gender of respondent (women respondents earned Ksh 137,768 and men Ksh 137,270) but varied significantly with the district where they operated the nurseries. Nursery operators from Embu district earned the lowest income (Ksh 72,842), while those in Meru central had the highest (Ksh 221,505).

Table 36: Annual incomes of nursery operator households and proportion of contribution by the various sources

District	Average annual income (Ksh)	Disaggregated income proportions per source (%)					
		nursery	livestock	crops	trees	employment	business
Embu	72,842 (60,770.7)	19_a	22	31	16	5	7
Mbeere	118,135 (109,634.6)	10_b	17	36	11	17	9
Meru Central	221,505 (200,092.9)	38_c	12	25	8	7	10
Average	137,494 (147,952.1)	22_d	17_{de}	31_{de}	$12d_{ef}$	10_d	9_{df}

- Figures followed by the same subscript letter are not significantly different and numbers in parenthesis indicate standard deviations

Nurseries contributed an average of 22% of the operators' household income but this proportion differed significantly with the districts and the operators from Mbeere were earning the least income from nurseries. They earned only 10% while those from Embu and Meru central earned 19% and 38% of their total income respectively from the tree nurseries. The income from nurseries was not associated with either the age or the level of education attained by the nursery operator and had no relationship with the number of years that the nursery had operated (regression r = 0.003; r^2 = 0.000) that would signify growth in income as the nursery grew. But the size of the nursery had a relationship, though weak (r = 0.453; r^2 = 0.205), with the annual income from the nursery. The nurseries were generally small (average size 231m^2) with those in Meru central district being the biggest (544m^2) while those in Mbeere were the smallest (47m^2; Table 37). There were other enterprises in the nurseries such as flowers, vegetable seedlings and manure for sale but tree seedlings occupied most of the space (average 89%) implying that trees comprised the main nursery business.

Table 37: Tree nursery sizes and occupancy of the nursery space by different enterprises

District	Number of nurseries	Average nursery size (m^2)	Average % nursery space occupied by			
			trees	flowers	manure	vegetables
Embu	20	103 (185.9)	93	6	1	1
Mbeere	20	47 (63.3)	94	4	2	0
Meru Central	20	544 (758.8)	79	9	3	3
Pooled average	60	231 (498.1)	89	6	2	1

* numbers in parenthesis indicate standard deviations

6.3.2 Comparison of demand for medicinal tree species seedlings with other tree species categories in nurseries

Most tree nurseries did not have a very high diversity of species. The average number of tree species was one for fodder species, two for medicinal species, and three for flowers, fruits and timber species. Apart from fodder and fruit categories, the number of species in the

nurseries differed by the districts. Meru Central had an average of four timber species and three medicinal species per nursery while Mbeere had an average of two ornamental species (herein referred to as flowers). Mbeere and Embu districts had an average of one medicinal species per nursery each. These differences in the number of species in nurseries by the district were only significant in a few cases such as timber and medicinal species between Mbeere and Meru Central and also medicinal species between Mbeere and Embu districts. Within the species categories some nurseries had up to ten species in a category such as timber in Meru (Figure 10). There were only a few nurseries in Embu and none in Mbeere with more than two medicinal species while the median number of medicinal tree species in nurseries in Meru was three with some nurseries having up to six species.

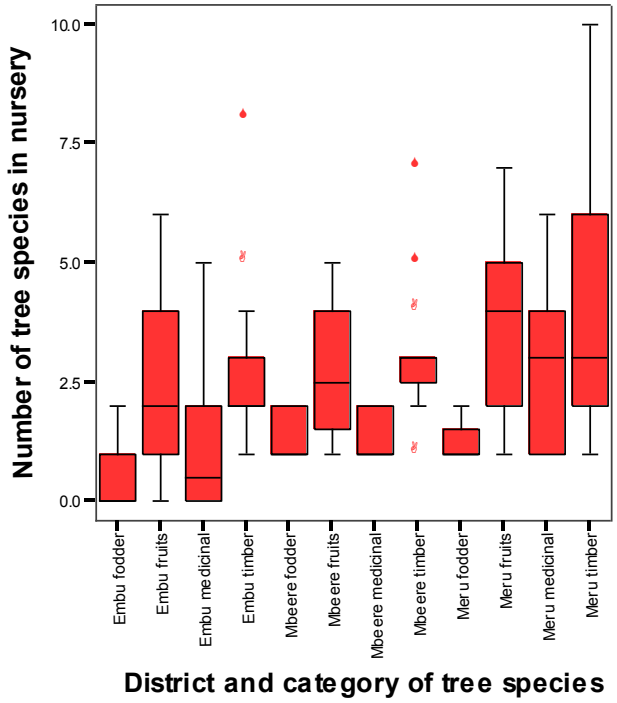


Figure 10: Comparison of number of tree species of four categories in tree nurseries in three districts East of Mt. Kenya

We asked tree nursery operators to give the closest estimates of the seedling business in the year 2007 since there were no records of sales and we expected them to roughly remember the number of seedlings produced and sold in the previous year. Also judging from their orders they could tell estimates of the number of seedlings of various species their clients had asked for (whether they could supply them or not) herein referred to as seedlings demanded. In general medicinal tree seedlings were second to timber tree species seedlings (Figure 11d) in terms of the number of seedlings produced (average 2,231 seedlings) and supplied (either sold or given away for free; average 2,218 seedlings). In terms of the

number of seedlings demanded (3,425), medicinal species came third after timber (33,999) and flower seedlings (11,875 seedlings). Demand for medicinal tree seedlings was significantly lower than flowers and timber species but not different from the demand for fruits and fodder tree seedlings (P=0.05). The supply for medicinal tree seedlings (2,218) was lower (P=0.05) than that of timber species (9495) but not different from the supply of flowers (1,794), fodder (509) and fruit tree seedlings (1,275).

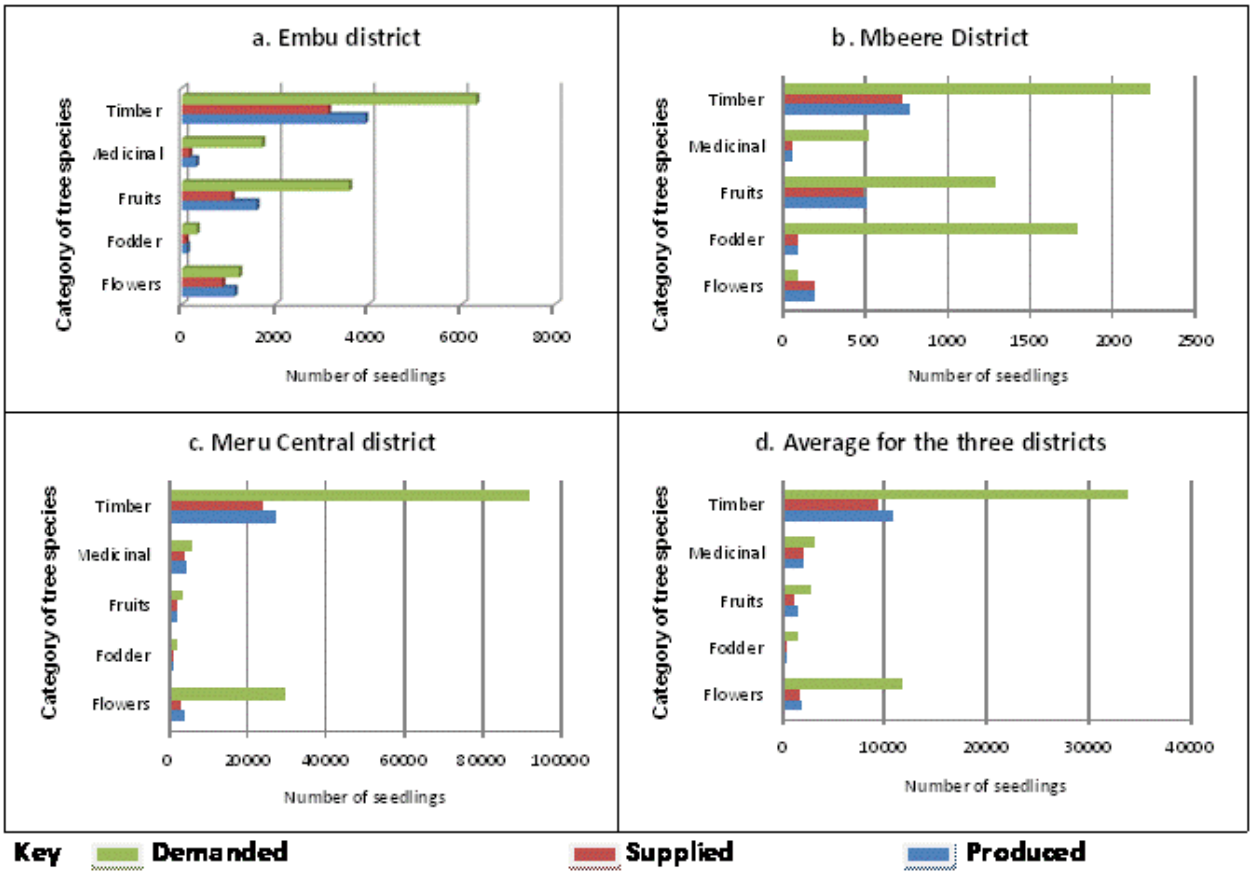


Figure 11: Numbers of seedlings produced, supplied and demanded for various tree species categories in tree nurseries in three districts East of Mt. Kenya in 2007

District wise analysis revealed demand for all tree seedlings as higher than supply in all districts albeit very high for timber species in Meru central district. The average seedling production and supply was 27,685 and 24,307 respectively for timber species and between 1,500 and 5,000 for the other categories in Meru central. Mbeere district had the smallest nursery business with average production and supply below 1,000 seedlings and reported demand below 2,500 seedlings. It is worth noting that we considered total tree seedlings production and supply and not species specific business. However the demand for tree seedlings differed between species in that, while some species were under supplied and in high demand, other species were over-stocked in nurseries. That is why the number of seedlings produced was higher than that supplied in most of the cases. Demand for medicinal trees was lower than timber species in all districts and significantly lower (P=0.05)

than fruits and fodder in Mbeere district. In Meru central district medicinal tree species demand was lower than timber and flowers but not significantly different from fruits and fodder species. Demand for medicinal trees seedlings was higher than production in Embu and Mbeere districts but not in Meru Central.

Majority of the nursery operators (88%) indicated that they perceived the demand for medicinal tree species to be lower than that of other species categories while 8% saw 8% saw it as higher. However most of them (63%) saw the medicinal tree seedling demand as rising with time (Table 38). The main reasons given for a rising medicinal tree seedling demand was increasing awareness of the importance of medicinal tree species by the local community (35%) and the prominence that herbal medicine was seen to be gaining by the day (20%). On the flipside some respondents stated that the demand of medicinal tree seedlings was constant (20%) or decreasing (17%) due to lack of awareness on the value of medicinal tree species.

Table 38: Nursery operators' perception of demand for medicinal tree seedlings and possible reasons for the trend

Demand trends	Trends reason	Frequency (n = 60)
Constant (20%)	Apathy towards herbal medicine	2
	Clients have fixed orders	2
	Lack of awareness on the value of medicinal tree species	15
	Presence of medicinal trees species in the wild	7
Rising (63%)	Awareness campaigns on conservation bearing fruits	7
	Conventional medicine seen as expensive	18
	Herbal medicine gaining prominence	20
	Increasing awareness of the importance of medicinal species	35
	Medicinal trees are multipurpose	7
	More availability of medicinal tree seedlings in the nursery	2
Decreasing (17%)	Apathy towards herbal medicine	7
	Lack of awareness of medicinal tree species	8
	No market information for products	3

* Percentages add to more than 100 because some respondents were giving more than one reason

6.3.3 Availability of medicinal tree species seedlings in nurseries

We encountered many medicinal tree species seedlings in the nurseries but only *Prunus africana*, *Azadirachta indica* and *Olea europaea ssp africana* were found in more than 10% of the nurseries (Table 39). *Prunus africana* was the most common medicinal tree species in Meru central district followed by *Olea europaea ssp africana* (20% and 10% of the nurseries respectively) while *Azadirachta indica* was the most common in Mbeere district nurseries (7%). Nurseries in Embu and Mbeere districts had very few medicinal species compared to

those in Meru Central and no species was found in more than three nurseries in Embu district.

There were relatively few seedlings per species in the nurseries at the time of the survey because nursery operators had just supplied seedlings to farmers for planting in the long rain season that was on-going. The average number of seedlings for each species supplied from nurseries in 2007 was generally low for all species apart from *Prunus africana, Olea europaea ssp africana* and *Myrsinne melanophloeos*. The other medicinal species whose seedlings were supplied in high numbers were those also highly valued for other non-medicinal purposes especially timber (*Juniperus procera, Eucalyptus spp* and *Cordia africana*).

Table 39: Seedlings of medicinal tree species found in on-farm tree nurseries East of Mt. Kenya in June 2008

Species	Growth habit[a]	Indigenous /exotic[b]	Frequency nurseries % (n = 60)				Average number of seedlings in nursery	Average number of seedlings supplied previous season	Reported demand trend[c]
			Embu	Mbeere	Meru	Pooled average			
Prunus africana	T	I	15	0	60	25	211	1111	H
Azadirachta indica	T	E	10	20	10	13	37	43	H
Olea europaea ssp africana	T	I	0	5	30	12	292	1477	H
Aloe spp.	H	I	5	10	10	8	101	61	H
Croton megalocarpus	T	I	5	0	20	8	7	46	C
Juniperus procera	T	I	0	0	25	8	406	2223	H
Hagenia abyssinica	T	I	0	0	20	7	4	108	H
Croton macrostachyus	T	I	10	5	0	5	0	87	C
Markhamia lutea	T	I	10	0	5	5	305	93	C
Myrsinne melanophloeos	T	I	0	0	15	5	668	3438	H
Acacia xanthophloea	T	I	0	0	10	3	5	33	C
Bridelia micrantha	T	I	10	0	0	3	0	25	H
Rosmarinus officinalis	S	E	0	0	10	3	50	260	H
Eucalyptus spp.	T	E	0	0	10	3	1508	2005	H
Leonotis mollissima	S	I	0	5	5	3	1	9	H
Artemisia annua	H	E	0	0	5	2	0	500	H
Boscia coriacea	S	I	0	0	5	2	2	10	H
Cordia africana	T	I	0	0	5	2	10	2000	H
Ficus sycomorus	T	I	0	0	5	2	0	250	H
Melia volkensii	T	I	0	5	0	2	2	25	H
Ocotea usambarensis	T	I	0	0	5	2	20	100	H
Strychnos henningsii	T	I	5	0	0	2	0		H
Vitex keniensis	T	I	5	0	0	2	0		H
Mugugutu	S	I	0	0	5	2	1	22	H
Zingiber officinalis	H	E	0	0	5	2	many*	many	H
Jatropha curcas	T	E	0	5	0	2	5	50	H
Moringa oleifera	T	E	0	0	5	2	0	2	H
Foeniculum vulgare	H	E	0	0	5	2	Many*	many	H
Petroselinum crispum	H	E	0	0	5	2	Many*	many	H
Warburgia ugandensis	T	I	0	0	5	2	5	0	H

* nursery operator could not estimate number a:– T – tree, S – shrub, H – herb; b:– I – indigenous, E – exotic c:– H – high, C – constant

Apart from *Croton macrostachyus, Croton megalocarpus, Markhamia lutea* and *Acacia xanthophloea* whose demand was seen as constant, all the other species found in nurseries were reported to have a rising demand trend. There were however many nurseries that did not have the species despite the high demand (Annex 6.1). This was mainly due to lack of seeds but for some species nursery operators did not necessarily make any efforts to raise them since they perceived the species to be plenty in the wild and therefore in low demand.

Most of the nurseries also reported problems in deciphering the best propagation technology for many of the species (Annex 6.1).

6.3.4 Possible role of nursery operators in influencing cultivation of medicinal trees by farmers

On their personal views on what needed to be done to stimulate cultivation of medicinal trees by farmers, many nursery operators (28%) indicated that growth in herbal medicine product markets would push cultivation rates. Others (27%), believed that there was need for awareness creation on the importance of medicinal trees among both farmers and nursery operators. Support for nursery oprators in terms of seed provision for rare species and capacity building on appropriate propagation technology was indicated as important by 26% of the respondents. Others however indicated need for investment in germplasm improvement for medicinal trees to produce more evidence on the medicinal use of the species (22%), produce species or provenances that are compatible with farm conditions (12%) and those that can grow fast (3%).

Every nursery operator reported that he or she had engaged in some efforts to improve the sales and hence cultivation rates of medicinal species (Table 40). Most of the operators (73%) conducted some awareness campaigns to their clients on the importance of medicinal trees while others (23%) gave out free samples of medicinal tree species to farmers who bought other seedlings. A third of the nursery operators (35%) reported that stocking the nursery with medicinal tree species was their only way of encouraging cultivation while 7% would initially subsidize the seedlings of medicinal trees to encourage more purchases. Four nursery operators in Embu district encouraged neighbours to establish their own individual nurseries for medicinal tree species seedlings possibly because they did not see any threat of competition for seedlings.

Table 40: Efforts engaged in by nursery operators to encourage farmers to plant medicinal trees East of Mt Kenya

Promotion effort	% of nursery operators reporting efforts in district				% of nursery operators giving effort as		
	Embu	Mbeere	Meru Central	Total	First	Second	Third
Educating farmers about the importance of medicinal trees	70	70	80	73	50	18	5
Encourages neighbours to establish individual nurseries	20	0	0	7	2	5	0
Subsidize seedling prices to the farmers	0	10	10	7	3	2	2
Free seedling samples given to farmers when buying seedlings	20	10	40	23	15	7	2
Stocking the nursery with various medicinal trees	25	35	45	35	22	12	2
Encourage conservation of medicinal trees	0	5	5	3	3	0	0
Encourage planting of all types of tree species	20	10	15	15	5	10	0

6.3.5 Sources of medicinal tree species found in farms

In our farmers' survey, we found that most of the trees on farms did not emanate from tree nurseries (Table 41). Most of the species, especially the indigenous ones, had regenerated naturally in farmers' fields and farmers had saved them where they had germinated. In many other cases, farmers had uprooted wildlings from their farms or neighbours farms and planted them where they felt was appropriate for the species in to grow. The only species had been procured from tree nurseries by more than 20% of the farmers were; *Azadirachta indica* (59%), *Psidium guajava* (also a fruit species; 48%), *Croton megalocarpus* (48%), *Persea americana* (also a fruit species; 71%), *Cordia africana* (also a timber species; 50%), and *Prunus Africana* (22%).

Table 41: Sources of germplasm for medicinal tree species found in farms East of Mt. Kenya

Species	Percent of farms present	Growth habit	Natural regeneration	Sources of seedlings where trees planted (expressed as percent of farms present)			
				Neighbours	Tree nurseries	Wildlings	Unknown
Aloe spp	52	Shrub	17	6	5	64	8
Azadirachta indica	27	Tree	9	4	59	6	22
Croton macrostachyus	24	Tree	48	2	17	29	4
Prunus africana	23	Tree	24	2	22	50	2
Senna didymobotrya	21	Shrub	67	2	2	21	8
Croton megalocarpus	20	Tree	3	3	48	35	11
Erythrina abyssinica	20	Tree	68	3	3	25	1
Tithonia diversifolia	19	Shrub	24	8	0	62	6
Olea europaea ssp africana	17	Tree	41	3	12	35	9
Psidium guajava	16	Tree	10	3	48	23	16
Plectranthus barbatus	14	Shrub	32	0	0	61	7
Ajuga remota	13	Herb	62	0	0	38	0
Solanum incanum	13	Shrub	96	0	0	4	0
Cissampelos pareira	11	Herb	100	0	0	0	0
Terminalia brownii	11	Tree	81	0	5	14	0
Ocimum suave	10	Shrub	80	5	0	10	5
Zanthoxylum chalybeum	10	Tree	90	0	0	10	0
Lantana camara	9	Shrub	76	0	0	18	6
Ricinus communis	9	Shrub	18	12	6	29	35
Amaranthus sp	8	Herb	50	0	0	6	44
Caesalpinia volkensii	8	Shrub	25	6	6	44	19
Acacia nilotica	8	Tree	93	0	0	7	0
Jatropha curcas	8	Tree	7	0	13	60	20
Lantana trifolia	8	Shrub	67	0	0	33	0
Piliostigma thonningi	8	Tree	93	0	0	7	0
Leonotis mollissima	7	Shrub	71	0	0	29	0
Persia americana	7	Tree	7	0	71	14	8
Vernonia lasiopus	7	Shrub	85	8	0	8	0
Combretum collinum	6	Tree	92	0	0	8	0
Cordia africana	6	Tree	17	0	50	33	0
Tamarindus indica	6	Tree	42	0	17	33	8
Combretum molle	6	Tree	82	0	0	18	0
Euphorbia tirucalli	6	Shrub	36	0	9	55	0

When we asked the farmers which nurseries were closest to them, they mainly indicated group nurseries that were affiliated to the village contact groups. They were very close to the farmers with most of the interviewed farmers reporting distances of less than two kilometres from their homes to the nurseries and the median distance for all villages was about one kilometre (Figure 12). Opinion was divided among farmer respondents in every village as to whether the nurseries they mentioned were functioning or not. Some farmers in the same

village reported that the nursery was functional and had seedlings while others indicated that the same nursery was no longer functional. On our visits to the group nursery sites we rarely found seedlings and the group leaders indicated the nurseries were seasonal and whatever seedlings were raised would mainly be shared out among group members. Individually operated nurseries were few and rarely reported by farmers. Only eight farmers gave individually operated nurseries as the ones closest to them.

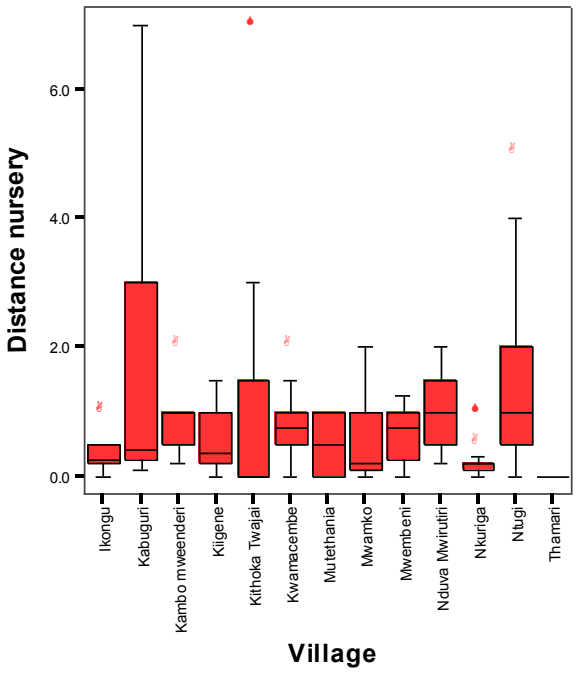


Figure 12: Distance between farms and the nearest tree nurseries in thirteen villages East of Mt. Kenya (dots indicate extreme values)

There were other tree nurseries with medicinal tree seedlings that were operated by the herbalists. Two in every five herbalists interviewed (40%), indicated that they had medicinal tree seedling nurseries most of them being in Meru central district (23%), while only three herbalists had nurseries in Mbeere (Table 42). The herbalists raised seedlings for planting in their own herbal gardens (15%), to give away seedlings for others to plant (8%) or for sale (8%). Some herbalists (8%) would give away seedlings for free but also sell if a client was willing to buy (8%). Herbalists' nurseries were also not mentioned by farmers as being close to them.

Table 42: Herbalists with tree nurseries and fate of medicinal tree seedlings raised in three districts East of Mt. Kenya

District	Fate of raised seedlings (percent of herbalists)				
	Exclusively planted in herbal garden	Given away for free	Either sold or given free	Exclusively sold	Grand Total
Embu	7	7	5	5	23
Mbeere	3	0	2	0	5
Meru Central	5	2	2	3	12
Total	15	8	8	8	40*

* Numbers represent the percentage of herbalists reporting the mode of seedling supply (n=60) adding up to 40% since only 40% of the herbalists had medicinal tree nurseries

6.3.6 Willingness by farmers to pay for medicinal tree seedlings

Majority of the farmers indicated that they were willing to pay for seedlings of the medicinal tree species they wished to plant although only seven species were desired by more than 10% of the farmers (*Azadirachta indica, Prunus africana, Aloe vera, Moringa oleifera, Olea africana, Caesalpinia volkensii, Warburgia ugandensis* and *Strychnos henningsii*). They would pay between Kshs 5 and 100[1] (average Ksh 30), for most of the species highly preferred for planting and the prices tended to drop with the frequency of farmers that preferred the species. For most of the desired species they were willing to pay higher prices if the seedlings had gained some form of improvement such as faster growth rate or increased concentration of the active ingredient.

The average seedling price was influenced by a few farmers who gave much exaggerated prices of seedlings and the median prices were lower than the means. The upper quartiles for the prices that farmers would pay for seedlings reached Ksh 50 for only *Aloe spp, Azadirachta indica, Ceasalpinia volkensii, Moringa oleifera* and *Warburgia ugandensis* (Figure 13). For other species desired for planting by more than 10% of the respondents the median price was less than Ksh 20. The number of those who would pay more if the seedlings were improved correlated strongly (R=0.998) with the total number of farmers that said they would pay for the seedlings. Only a few farmers said they would not pay extra if the seedlings of the species available in nurseries were improved.

[1] Exchange rates at the time of data collection were Ksh 62 and 96 to the US dollar and Euro respectively

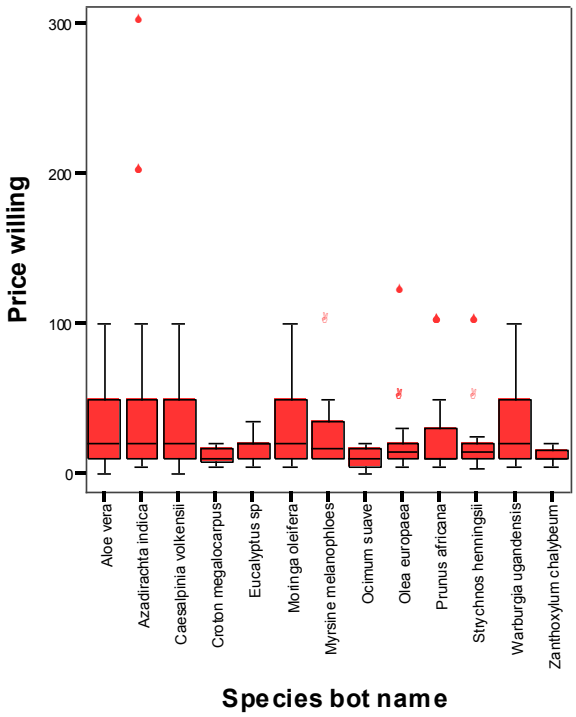


Figure 13: Prices (Ksh) farmers were willing to offer for the seedlings of the most preferred medicinal tree species (dots indicate extreme values)

Farmers did not show any enthusiasm to buy the seedlings we supplied to the nurseries however, whether the prices were subsidised or not. For the three groups where we gave seedlings for free, farmers collected the seedlings but the pattern of planting was different among the three. All the farmers in the group in Mbeere planted the seedlings for the two seasons we supplied while those in Embu were not very enthusistic to plant in the second season citing limitations in the expected rainfall amount. The farmers in the Meru group collected the seedlings and planted in the first season but claimed the tree species were not economical to them in the second season. Many group members in Meru therefore did not collect the trees and claimed fast growing trees would be more preferable. Most of the group members had very small farms however and were apprehensive of having to plant so many trees and lose crop productivity.

In the villages where the nursery operator was to give seedlings for free to whoever desired any of the distributed species, seedlings had been collected and planted by farmers. *Ocimum suave* was rarely collected as farmers claimed it was abundant in the wild. Where nursery operators were to sell at subsidized prices, seedlings were only bought in one nursery (Meru) but not by members of the group that was working with us. The offtake of the seedlings was

low in the nursery and the only species that sold were *Olea europaea ssp africana, Prunus africana*, *Azadirachta indica* and *Moringa oleifera*. In Embu, the nursery operator let the seedlings to dry in the first season and did not accept others in the second season because she did not want to invest time in seedlings that had no demand. The nursery operator in Mbeere planted all the seedlings given in the first season because farmers did not buy them while at the last visit she was yet to sell any of the seedlings from the second distribution.

Where nursery operators were to sell seedlings at the prevailing market price, there were low seedling sales in Embu and Meru but the purchases were not by farmers who had attended our seminars. In Meru the nursery operator had sold some *Olea europaea* and *Warburgia ugandensis* mainly to private developers for home beautification purposes while the same species had sold in low numbers in Embu. In Mbeere the farmers did not buy the seedlings at all but when they deciphered that the seedlings in the nursery had been supplied by us, those in our contact group demanded to be given the seedlings at no cost. The same thing happened in Embu with farmers claiming that the seedlings were being sold at a very high price yet the prices were lower than they had indicated they would pay. In Meru some seedlings especially *Olea europaea, Warburgia ugandensis, Prunus africana* and *Cordia africana* that had been planted by farmers along fences that boarder roads were uprooted (stolen) by strangers in two villages indicating that these species had some demand.

5.4 Discussion

Income gain has been reported in many studies as a variable most likely to influence agroforestry adoption (Pattanayak *et al.,* 2003). Therefore we included a focus on the income generating potential of tree nursery enterprises in our study. Rational nursery enterpreneurs are expected to invest in a variety of species that are in high demand to generate income sustaionably. When the nursery is generating significant income then the operator is motivated to, not only diversify enterprises, but also engage in some level of risky ventures where he supplies species whose seedlings are not in high demand currently but is likely to rise. In our study, the tree nursery business was found to be more prominent in Meru central than the other two districts. Nurseries contributed upto 35% of the nursery operators' household income in the district (Meru central) and yet the average annual household income was double the average of the other two districts. The farmers with nurseries in Meru had also set aside bigger portions of their land (average 0.05 ha out of about 1 ha) for the nurseries implying they had forgone productivity of crops in favour of the nurseries. Demand for seedlings was reported to be higher in this district and the nurseries had stocked more species than in the other two districts. This can support our proposition that higher incomes from nurseries could lead to more investment by the nursery operator in nursery management at the expense of other farm enterprises.

In addition to the high demand for seedlings in all species categories, Meru central was the only district where demand for medicinal species was not lower than fruits and fodder species. The number of medicinal trees species in nurseries was also higher in the district than the other two districts and matched the number of fruit species in nurseries in Mbeere and Embu districts. Although we report these statistics with caution bearing in mind that they were not based on nursery records but on what the nursery operators could recall for the previous year, they can give some general association. Meru central district had a higher seedling demand than the other districts which implies that farmers in the district were more willing to buy seedlings. This was confirmed by the fact that it was only in Meru district that the seedlings we supplied to nursery operators for sale (at either subsidised or market price), that more sales were reported. Some sales were also reported in Embu but none in Mbeere which had the lowest seedling demand. The factors that contributed to these disparities in seedling demand need investigation.

It appears that where there was more tendency by farmers to buy seedlings, nursery operators diversified their enterprises and engaged in selling more species which included a diversity of medicinal species. Although only a few medicinal tree species were in nurseries and these were the ones that farmers had reported high preference for (chapter 3), it was apparent that demand for medicinal species was rising as farmers appreciated species' medicinal value. Supporting the nursery operators in terms of access to sources of high quality seeds or setting up community-based seed sources and training on propagation methodologies for highly demanded medicinal tree species will boost these enterprises. The present state of farmers planting more wildlings or just saving natural regeneration could then change.

Nursery size corelated positively with the proportion of income that the nursery contributed to the household. Whereas the amount of variation that could be associated with the association was only 20% (r^2 = 0.2), there is a likelihood that the nursery operators would forgo productivity of other farm enterprises as the nursery income grew. This allocation of land resources is a pointer that the nursery operators invested in improving their production technologies and marketing approaches to raise their income. An awareness by the nursery operators of rising demand of medicinal tree species seedlings which they also linked to the increasing awareness of the importance of medicinal plants by farmers would call for investment in that direction. The nursery operators reported engaging in awareness creation campaigns on the importance of medicinal trees. It was not clear how much information they had themselves but a quick probe showed that their information on the medicinal use of various species was also scanty. Facilitating efforts where traditional healers and nursery operators can share information on medicinal tree species that are useful and threatened is necessary. It is important to test tailor-made communication materials that nursery operators

can use to enhance their knowledge on species medicinal value and then pass on to their clients. Supporting projects can then subsidise the costs of raising the seedlings initially when market demand is still too low to sustain seedling production but exit early as market demand rises.

Our farmers' survey was initiated with farmers' groups that had been selected through the Kenya Forest Service (KFS) extension wing. Organising group tree nurseries was a major support that KFS was giving to these groups. At least half of the respondents were members of a group and were associated with the group nursery. The other half consisted of neighbours to these group members who could have had a remote relationship with the group nursery. This association could be the reason most farmers indicated that only group nurseries were close to them. Few farmers mentioned being close to an individually operated nursery or a herbalist's nursery and some farmers from Kabuguri and Kithoka Twanjai villages said that the nearest (group) nurseries were about seven kilometres away. This distant was unusual as many rural farmers have been reported not to want to transport tree seedlings for more than two kilometres especially when the rains come and other farm enterprises need attention. This desire by farmers to be associated with group nurseries and less with private nurseries could be due to the observation that many projects have been supporting group nurseries (Kerkhof, 1989). The nursery may be serving as as a way for farmers to associate with projects and get other support more than a genune desire to raise seedlings (Garcia, undated). This was indicated by the fact that groups that knew we had supplied seedlings to the nursery operators shunned those nursery operators and in one case it led to conflicts between the nursery operator and the farmers. Members of the group felt that they had associated with us longer than the nursery operator and therefore deserved to get the seedlings and sell, if need be, instead of him.

Association with projects has been observed to give a false impression on agrofrestry adoption. Kiptot *et al.,* (2007) in their study of the adoption of improved fallows in western Kenya referred to a category of farmers as pseudo-adopters because they planted improved fallows to access benefits associated with projects. These benefits included free inputs as well as chances to attend seminars and tours, and the prestige of being visited by prominent people among others. In our study it is very likely that many farmers reported willingness to buy medicinal tree seedlings so as to enhance association with us by appearing to have interest in planting medicinal trees. That could also be the reason why all the members of the groups in villages where we distributed seedlings planted all the seedlings. We asked one member of the group in Embu where we distributed seedlings why they had planted seedlings in the two seasons and he said it is because they expected that we would provide a market for the tree products, an offer we had not made. This report is in agreement with the observation by Kiptot *et al.,* (2007) that farmers had many expectations from projects even

where the projects had explicitly explained their scope. As such it was not feasible to assume that the seeding prices farmers indicated they were willing to pay for the medicinal species were carefully thought out as an indication of the value attached to the species and that is why we tested it through the action experiment.

It is clear that linkage to markets for medicinal tree products has more potential to stimulate seedling demand than just provision of information on the medicinal value of trees. Our results also concurred with Kiptot *et al.,* (2007) observation that a long association of a farmers' group with development projects can confound the purposes of use of agroforestry packages by the members. Although many studies have shown a positive correlation between group membership and agroforestry adoption (Pattanayak *et al.,* 2003), it is difficult to expect that farmer groups that have got used to receiving free seedlings from projects can associate with and even buy seedlings from private nursery operators. The difference between the report by the farmers on how much they would buy seedlings and the actual uptake when the seedlings were availed in nurseries also shows the importance of using different research approaches, both asking farmers what they would do and observing their actions, in order to understand farmers' reality before implementing recomendations.

It is important to note that nurseries were few and small in Mbeere district and medicinal tree species were found in small numbers in the few nurseries. The district had the lowest number of herbalists who operated nurseries. Farmers in this district had also reported access to planting material as a limiting factor to planting of medicinal tree species (chapter 3). This could have contributed to the more frequent use of natural regeneration and planting wildlings as the means of medicinal tree regeneration in the districts. Being a water dependent enterprise, tree nurseries tend to be limited in areas of low precipitation especially where irrigation infrastructure is not in place (Frost and Muriuki, 2006). Central nurseries and group nurseries (temporary ones sited near reliable water sources) tend to be the main mode of germplasm supply in arid areas (Kerkhof, 1989). Low demand from farmers who wish to avoid risk of buying highly priced seedlings then lose them to rain failure could be a disincentive to individual nursery enterpreneurs. This was confirmed by the observation that tree nurseries contributed only 10% of the nursery operators' household income in the district. The nursery operators in this district had higher average annual incomes than their counterparts from Embu impying that they could have been relying on their other income sources and the nurseries were more of passionate than profitable ventures. Provision of high quality germplasm in such arid areas may continue to draw from project nurseries but when developments such as irrigation infrastructure are in place, private nursery enterprises should be developed instead. It might be better still to support the nursery operators in the area who have a passion for the work and reliable water sources with minimal subsidies to cover for the lost farm productivity.

5.5 Conclusion

Our results did not show a strong association between lack of tree planting material and low levels of planting of medicinal tree species in the smallholder farms. Where demand for tree seedlings was high, tree nursery operators invested in production of medicinal tree seedlings. Therefore the association between availability of medicinal tree germplasm with the number of trees planted by farmers was confounded by other factors. One of those factors was a tendency by some of the farming population to buy tree seedlings thus stimulating demand. It appears that farmers who were keen on planting trees of all categories of species were also willing to try other species and that included medicinal trees. The raised demand prompted nursery operators to invest more resources (land) in nursery production and to diversify in the portfolio of species present in the nursery. Aridity raised the risk of survival failure for trees planted in farms especially in Mbeere district which lowered the propensity by farmers to buy seedlings. Farmers in the district preferred to save naturally germinated wildlings or transfer the wildlings to niches that were more appropriate for the species. This lowered seedling demand and as a result was a disincentive to nursery operators. Being a member of a group that had continually received subsidies from development projects also appeared to have raised an expectation of free farm inputs including free seedlings and this in return made group members to be poor seedling customers. These factors were not measured empirically in this study and need investigation.

Annex 6.1. Species not found in nurseries but known by nursery operators as medicinal

Species	Nurseries frequency % (n=60)	Indige-nous / exotic	Demand outlook	Why not in nursery?		Propa-gation problem*
				Lack of seeds	Other reasons	
Azadirachta indica	70	E	H	39	3(1), 5(1)	29
Aloe spp.	40	I	H	20	3(2), 4(1), 5(1)	12
Prunus africana	20	I	C	7	3(2), 4(1), 5(2)	5
Olea europaea ssp africana	17	I	H	9	7(1)	3
Caesalpinia volkensii	15	I	H	9		6
Moringa oleifera	15	E	H	9		4
Warburgia ugandensis	13	I	H	8		7
Myrsinne melanophloeos	10	I	H	6		3
Dalbergia melanoxylon	7	I	H	4		4
Erythrina abyssinica	7	I	H	2	3(1), 7(1)	3
Osyris lanceolata	7	I	H	4		2
Senna didymobotrya	7	I	H	1	4(3)	2
Acacia nilotica	5	I	H	3		3
Carissa spinarum	5	I	H	2	4(1)	2
Ocimum suave	5	I	H	1	4(2)	1
Other species desired by less than 5% of the nursery operators						
Acacia drepanolobium	2	I	H	1		1
Acacia mearnsii	2	E	H	1		1
Acacia mellifera	2	I	H	1		0
Albizia anthelmintica	2	I	H	1		1
Antidesma venosum	3	I	H	2		2
Artemisia annua	3	E	H	2		2
Bridelia micrantha	3	I	C		3(1), 7(1)	2
China small	2	I	H	1		1
Cordia africana	3	I	H	1		1
Croton macrostachyus	2	I	H		2(1)	1
Croton megalocarpus	3	I	C	1	5(1)	1
Cupressus lusitanica	2	E	H	1		0
Eucalyptus globulus	2	E	H	1		0
Euclea divinorum	2	I	H	1		1
Fagaropsis angolensis	2	I	H	1		1
Ficus sp	2	I	H	1		1
Gitunduku	2	I	L		3(1)	0
Hagenia abyssinica	3	I	H	2		2
Hoslundia opposita	2	I	H		4(1)	0
Jatropha curcas	3	I	H	2		2
Juniperus procera	2	I	H	1		0
Karuma	2	I	H	1		0
Kibaki	2	E	H	1		0
Lannea sp	3	I	H	2		2
Leonotis mollissima	3	I	H	2		2
Melia volkensii	2	I	H	1		1
Mubota	3	I	H	2		1
Mububao	2	I	H	1		1
Mucuka	2	I	H	1		0
Mukururiti	2	I	H	1		1
Murogorogo	2	I	H	1		1
Mutachiuna	2	I	H	1		1
Muthuguya	2	I	H	1		0

Muukurwa	2	I	H	1		1
Mwompo	2	I	H	1		1
Ndago	3	I	C	1	3(1)	1
Ocimum basilicum	2	I	H		4(1)	0
Ocotea usambarensis	2	I	H	1		0
Pappea capensis	2	I	H	1		1
Piliostigma thonningii	2	I	H		4(1)	0
Psidium guajava	2	E	H	1		0
*Quinine***	2	I	H	1		1
Rai	2	I	H	1		1
Rhamnus priniodes	2	I	H	1		1
Rosmarinus officinalis	2	E	L		3(1)	0
Strychnos henningsii	2	I	H	1		0
Tamarindus indica	3	I	H	1	6(1)	1
Terminalia brownii	2	I	H	1		1
Thespesia garckeana	3	I	H	1	4(1)	1
Tithonia diversifolia	2	I	H		7(1)	0
Urtica massaica	2	I	L	1		1
Vitex keniensis	3	I	H	2		1
Withania somnifera	2	I	H	1		0
Ximenia americana	2	I	H		4(1)	0
Zanthoxylum chalybeum	3	I	H	1	4(1)	1

Reasons key: 2 – Seeds failed to germinate, 3 – low seedling demand, 4 – plenty of species in the wild, 5 – usually present in the nursery but not currently; 6 – unfavourable climate for cultivation, 7 – seedlings dried up

* numbers represent the number of nursery operator who reported having difficulties in propagating the species

** this is species locally called quinine for its role in treating malaria but is not related to *Cinchona spp*

6 Comparison of abundance of preferred medicinal tree species in forests and farms and users' preference of sources of herbal raw material based on ecology

6.1 Introduction and literature review

The increasing use of medicinal plants in traditional medicine in the tropics and global trade in the plants' products, in tandem with declining forest resources is well documented (Cunningham, 1993). Use of already degraded resources to serve the increased demand for medicinal plant species not only poses a threat to the targeted species, but also sets in motion processes that affect forest ecosystems in general (Feeley *et al.,* 2007). In several case studies reviewed by Ticktin (2004), harvesting of non timber forest products was shown to have ecological effects (in many cases negative) ranging from species to ecosystem levels (also Marshall *et al.,* 2006). Taxon specific effects may differ with localities and this calls for closer monitoring of the species populations in all regions and countries. For instance harvesting of *Warburgia salutaris* in South Africa for commercial purposes was observed to threaten the species survival, with the number of stems and stem basal diameter as well as populations of younger plants seen to be decreasing (Botha *et al.,* 2004). In contrast, the sister species *Warburgia ugandensis* and two other species, *Hallea rubrostipulata* and *Syzygium guineense* were found to have viable regeneration populations in Uganda although they were highly valued by the community for malaria treatment (Ssegawa and Kasenene, 2007).

Traditional medicine practitioners (herein called herbalists) occupy a central place in the medicinal tree sub-sector. They are custodians of the knowledge on which the practice is hinged as well as the main initiators of trade based on the practice (Cunningham, 1993). Medicinal tree species involved in preparing remedies for more than one disease of high socio-economic importance are the most preferable to the healers (see chapter 3). This preference tends to concentrate the intensity of harvest and use on a few species which has a potential knock-on effect on the health of the forests or woodlands where the species grow (Omeja *et al*., 2004). The population structures of the targeted species are affected and concerns abound on their regeneration status under varying levels of natural and anthropogenic disturbances. This has been the reasoning behind conducting various studies to establish population structures of species found to have high socio-economic value in various communities (Omeja *et al.,* 2004; Tabuti, 2007). Focusing on size class distributions of such species is potentially informative of the population dynamics within local forests (Feeley *et al.,* 2007).

Resource users respond to scarcity by seeking alternatives and cultivation of medicinal plants in agricultural landscapes has been recommended as a viable alternative for sustainable sourcing of herbal material (Canter *et al.,* 2005; Vines, 2004). As the main users of medicinal tree products, herbalists experience scarcity of medicinal tree species more than other community members. Rural based herbalists can plant the medicinal trees in their gardens while urban based traders in herbal medicine can buy the tree products from farmers as forest resources decline. But herbalists and traders in medicinal plants have shown reluctance to use farm grown material and continue to harvest in already decimated forests, leading to resource degradation (Schipmann *et al.,* 2002). This in return has made conservationists to recommend sustainable harvesting methods (Geldenhuys, 2007) and enrichment planting or forest farming of some medicinal species to conserve wild resources (Cech, 1998). However, these recommendations rarely take root, calling for further research on the viability of cultivation in agricultural landscapes as an alternative to wild sourced herbal material.

There is paucity of scientific evidence connecting the quality of the medicinal components in plants with ecological conditions that would explain why herbalists would prefer forest sourced to farm grown material. However, it is known that plants develop curative components (secondary metabolites) as a defence mechanism against the many enemies facing them since they (plants), are permanently static organisms (Thomas, 2000). Change of growing conditions or environment has potential to cause genetic transformations of these secondary metabolites (Terryn *et al*., 2006). Cultivation can therefore lead to more luxurious growth conditions for a medicinal plant and possibly lower the concentration of the active ingredients. This could be a reason why herbalists and traders in medicinal plant products would hesitate to use cultivated material. There is no concrete data to show that cultivated material would consistently be of inferior quality however. Other reasons, such as being able to access forest material cheaply (Kuipers, 1997) and spiritual beliefs that view farm grown herbal material as inferior (Wiersum *et al.,* 2006) could also be the basis for that preference.

Leakey (2010) outlined the scope for agroforestry to deliver multifunctional agriculture, a deficiency in the current intensive agricultural production systems, also decried by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) reports. Agroforestry production systems in the tropics are diverse with trees planted in farms in varying niches from single trees scattered in croplands through trees planted along farm hedges to multi-strata home gardens that mimic forests (Arnold *et al.,* 1997). Medicinal trees planted in these different niches can provide varying levels of active components that could serve local and market demand for herbal medicine while improving farmers' livelihoods (Rao *et al.,* 2004).

Geldenhuys, (2007) reported on studies in South Africa where cultivated material was compared with wild material and the later found to have more concentrations of the secondary metabolites. However, cultivation was only studied for home garden planted material but not other agroforestry niches. The same study also observed inconsistent responses by some medicinal herb and shrub species to different forms of soil treatment implying that responses to ecological variation may be species specific. The process of drying as well as different temperature conditions during the plant growth period have also been observed to significantly alter the concentration of the medicinal compounds (Cech, 1998).

Herbalists are concerned with the conservation of plant species that are most useful in herbal remedies and which are getting scarcer (Cunningham 1993; Chapter 3, this thesis). Our study was based on the assumption that herbalists would plant more medicinal trees in their farms and use more of farm grown trees as the most preferred species get scarcer in the forests and woodlands. The aim was to test two underlying hypothesis; (i) as medicinal trees get scarcer, herbalists respond by planting the most important species in their gardens and these species soon become more abundant in their gardens than forests, and (ii) with increased scarcity of medicinal trees in forests, herbalists and traders gradually change preference to farm grown trees if the trees are established in farm niches that mimic forest conditions. We herein refer to herbalists' farms as "gardens" to differentiate them from other smallholder farms (herein referred to as "farms").

The study focussed on thirty species of trees and shrubs that herbalists and farmers had indicated to be of high preference in the exploratory survey (Chapter 3). The specific objectives were to (i) assess the abundance of high priority medicinal tree species in forests and natural woodlands compared to smallholder farms and herbalist gardens, (ii) compare the preferred niches for medicinal tree cultivation by farmers and herbalists, (iii) compare age and size classes of highly preferred medicinal tree species in farms with those of forests and natural woodlands, and (iv) assess the scope of potential use of farm grown medicinal trees by herbalists and herbal medicine traders as defined by various ecological conditions.

6.2 Methodology

We obtained data from the questionnaire surveys described in Chapters 3 and 5 and ecological surveys (species abundance) in farms and natural stands. The selection of the respondent farmers, herbalists and traders is explained in Chapters 2 and 5. During the surveys we sought the opinion of farmers on what niches they preferred to plant medicinal trees. We also investigated the germplasm improvement traits that farmers, traders and herbalists desired for tree species with medicinal value. We further asked herbalists and

traders to give their preference for sources of herbal medicine raw material (forests or farms) and specifically preferable farm conditions for sourcing medicinal tree material.

The species abundance surveys were conducted between October 2009 and February 2010. Twenty farms were systematically sampled from the list of sixty whose farmers had been interviewed in each of Embu, and Mbeere districts and 25 in Meru Central. Likewise we systematically selected ten out of the twenty herbalists interviewed in each district by randomly choosing between the first and the second name in the list and picking every second name after that. We engaged one herbalist as a member of the study team in order to help with the identification of the targeted tree species. In each farm and herbalist garden, we counted all the woody perennials and recorded them in botanical names for the known species and local names for those not identified. Then we measured the diameter at breast height (dbh) for any individual tree of the thirty targeted species encountered in the farm. We interviewed the farmer on the most important purpose the trees of interest served the household, when each tree was planted and whether there was any specific reason why it was planted or allowed to grow where it was growing.

For the forests and woodland sampling and measurements, we first inquired in a meeting with herbalists on which forests or woodlands they sourced most of the targeted medicinal species. About four sources of medicinal plants (forests and hills; Table 43) were identified in each district and their maps sourced (where available) from the Kenya Forest Service (KFS). With help from KFS staff, extensive forest areas (those part of the Mt Kenya forest block) were described by size and known patterns of vegetation variations and possible transects determined. For small hill forests, a transect walk to the top through the most feasible path was done and four quadrats laid from the top to the nearest village (or across the hill) depending on the observed variation of vegetation. Each quadrat was a quarter hectare square plot (50m x 50m) laid out with bright coloured nylon ropes held at corners with wooden pegs. In bigger hills, we laid two transects from the nearest villages to the hilltop, one from the southeast direction and the other from the northwest direction. A member of the local KFS security staff was engaged to provide security and also help navigate through the forest.

Table 43: Forests and woodlands surveyed as natural sources of preferred medicinal trees by herbalists

District	Forest/ woodland	Size (Ha)	No. of transects	No. of quadrats
Mbeere	Kiambeere	643	1	4
	Kianjiru	1004	2	3, 4
	Kiang'ombe	2104	2	4, 5
Embu	Kirimiri	101	1	4
	Maranga	219	1	4
	Irangi	1700*	1	4
	Rotune	1700*	1	4
	Kiye	1700*	1	4
Meru	Thuuri	734	1	4
	Kiagu	931	1	4
	Mucheene	4571	1	4
	Ngare ndare	5534	1	4
	Ruthumbi	6557	1	4
	Meru station	14836 (including plantations)	1	4
	Total		16	64

Irangi, Rotune and Kiye are parts of Mt Kenya forest managed from Embu district but their exact acreages were not available. The figures presented are the forester's approximations from the map. Meru station, Mucheene and Ruthumbi are also parts of Mt Kenya forest but managed from Meru central district.

The measurements largely followed the ecological survey method recommended by Martin (1995). We noted descriptors that would be important for every quadrat such as past land use, vegetation storeys, general geology and specifically how close the plots were to the nearest inhabited village. All the trees and shrubs in each quadrat were counted to give the number of individuals of each species in the plot. Grass and annual herbaceous species were generally ignored unless they occupied a big proportion of the quadrat, in which case the percent cover was recorded but the herbaceous species were not specifically recorded. For the targeted medicinal species that had been rated highly by farmers and herbalists, the diameter at breast height (dbh) was measured. Any visible sign of damage that could have been caused by harvesting of medicinal products from the tree was also recorded.

6.3 Data analysis

Data was entered into a Microsoft Excel spreadsheet and sorted to generate age and diameter classes as well as create data files for further analysis using SPSS (SPSS 16.0; SPSS Inc., Chicago, USA) and BiodiversityR (Kindt and Coe, 2005). BiodiversityR was used to analyse species diversity. The software works in an R environment (R Development Core

Team, 2005), under the Vegan ecology analysis package (Oksanen, 2005), with data recorded as community and environmental files (Kindt and Coe, 2005). The PivotTable function of Ms Excel was used to cross-tabulate species with farms/ forest quadrats in order to create the community data files for analysis using BiodiversityR while the farm/quadrat description sheet was used as the environmental file.

The richness and abundance of all trees and shrub species in each district was calculated, and species accumulation curves plotted to show the abundance profiles. Rényi profiles were plotted to compare the diversity of the targeted species in farms, forests and herbalists gardens and species accumulation curves (exact method) plotted specifically for these thirty species. These curves would give an indication of how many sites a herbalist needed to visit before he could access all the species in each district and each category of sites. The proportions of each of the targeted species, in farms or quadrats where they were encountered, as well as the total sample area was also calculated. Maundu and Tengnas (2005), and Kibwece (1993), provided very helpful references to identify species for which only the local name was given. For the species which were mentioned by many respondents but could not be botanically identified we used the local names as morphospecies to place in the lists for species abundance comparisons (as Kindt and Coe, 2005 advised). However we dropped species which were only mentioned by one respondent each and could not be botanically identified as there was a possibility that the stated name was a local dialect pseudonym for a species that could have already been included in the analysis.

We used Pivot-Tables (Ms Excel) to analyse parameters that gauged traders' and herbalists' preferences for forest or farm sourced herbal material and to summarise the reasons given for the preferences. A cluster analysis was done with SPSS to search for any common patterns of preference by respondents.

6.4 Results

7.4.1 General tree diversity in farms, herbalist gardens and forests

High tree species diversity was encountered in both farms (including herbalists' gardens) and forests with the sampled farms having a total of 211 tree species while the natural forests and woodlands had 240 tree species (Table 44). Estimates of the total species richness in the forests and woodlands using various indices gave a range of 265 (Chao and Boostrap) to 290 (second-order Jacknife; Annex 7.1). Herbalist gardens had more tree species (230) than other farms (211) despite the herbalist sample size being smaller (30 herbalists against 65 farmers). Estimates of the total number of species in farms ranged from 245 (bootstrap) to 343 (second-order Jacknife) and from 266 (Boostrap) to 367 (second-order Jacknife) in herbalist gardens. Mbeere district had a higher number of species in both forests and farms

(herbalists and farmers) while Embu had the least number of species in both forests and farms. Herbalists' gardens in Embu however had a higher number of species (135) than farmers in the same district (82) and their counterparts in Mbeere (130) and Meru central (111; Table 44).

Table 44: Tree diversity parameters for farms, herbalist's gardens and forests

District / Category	Farms/quadrats		Species richness			Tree abundance (per ha)		Simpson index		
	No	Av size (ha)	Total	Mean	sd	Mean	sd	Total	Mean	sd
Farmers										
Embu	20	1.1 (22)	82	16.5	6.84	265	274	0.91	0.78	0.11
Mbeere	20	2.9 (58)	138	26.9	8.57	289	382	0.93	0.78	0.15
Meru	25	1.0 (25)	110	19.2	7.11	382	516	0.84	0.73	0.15
Total	65	1.6 (106)	211	20.8	8.56	309	462	0.95	0.76	0.14
Herbalists										
Embu	10	0.8 (8)	135	36.8	18.02	876	1024	0.90	0.84	0.15
Mbeere	10	2.8 (28)	130	39.7	8.12	719	471	0.90	0.74	0.12
Meru	10	1.1 (11)	111	26.5	15.06	683	795	0.89	0.67	0.21
Total	30	1.6 (48)	230	34.3	15	722	731	0.94	0.75	0.17
Forests										
Embu	20	0.25 (5)	123	21.8	4.54	3388	2812	0.93	0.79	0.10
Mbeere	20	0.25 (5)	147	26.5	12.07	1572	888	0.97	0.80	0.17
Meru	24	0.25 (6)	138	18.4	4.67	2244	1692	0.96	0.78	0.14
Total	64	0.25 (16)	240	22	8.33	2392	2052	0.97	0.79	0.14

Numbers in parenthesis indicate the total area sampled for each site category in the three districts

Total tree abundance assessments showed that forests in Embu district had more tree abundance (average 3388 trees per hectare) than Mbeere (1572) and Meru central (2244). Herbalist gardens had more tree abundance in general (722 trees per hectare) than other farms (309). Herbalists in Embu district had the highest tree abundance in their gardens (876) compared to their counterparts in Mbeere (719) and Meru central (683). In contrast farms in Meru central district had the highest tree abundance (382) compared to those in Mbeere (289) and Embu (265).

The trees encountered in farms and forests were dominated by only a few species (Table 45). In farms *Eucalyptus spp, Grevillea robusta* and *Catha edulis* were the most dominant species consisting of 11, 10 and 9 percent proportions respectively. Species accumulation curves for trees in farms (Figure 14a), showed species increasing faster with sites in Mbeere district than Meru and Embu districts. This implied that many tree species would be present in the landscape but encountered in fewer farms in each of Embu and Meru central districts.

Table 45: The most abundant tree species in farms, forests and herbalist gardens East of Mt. Kenya

Species	rank	abundance	proportion	Log abundance
Farms				
Eucalyptus spp	1	3649	11.3	3.6
Grevillea robusta	2	3223	10.0	3.5
Catha edulis	3	3031	9.4	3.5
*Solanum incanum**	4	2921	9.1	3.5
Acacia tortilis	5	1939	6.0	3.3
Acacia spp	6	1031	3.2	3.0
Acacia brevispica	7	1023	3.2	3.0
Lantana camara	8	938	2.9	3.0
*Tithonia diversifolia **	9	929	2.9	3.0
*Aloe spp **	10	852	2.6	2.9
Herbalists„ gardens				
Lantana camara	1	5672	16.4	3.8
Catha edulis	2	3186	9.2	3.5
*Solanum incanum**	3	3145	9.1	3.5
*Erythrina abyssinica**	4	2349	6.8	3.4
Leucaena spp	5	2213	6.4	3.3
Grevillea robusta	6	1092	3.2	3.0
Indigofera lupatana	7	1061	3.1	3.0
Acacia nilotica	8	991	2.9	3.0
Acacia tortilis	9	915	2.6	3.0
Maytenus senegalensis	10	899	2.6	3.0
Forests				
Sizygium guinense	1	3330	8.7	3.5
Mugiru	2	2978	7.8	3.5
Mwenyuka	3	2438	6.4	3.4
Mukwethe	4	1118	2.9	3.0
Mutengerethe	5	1098	2.9	3.0
Aspilia africana	6	1051	2.7	3.0
Gnidia subcordata	7	1007	2.6	3.0
Lantana camara	8	922	2.4	3.0
Murieni	9	866	2.3	2.9
*Ocimum suave**	10	705	1.8	2.8

Species marked with * are among the targeted medicinal species

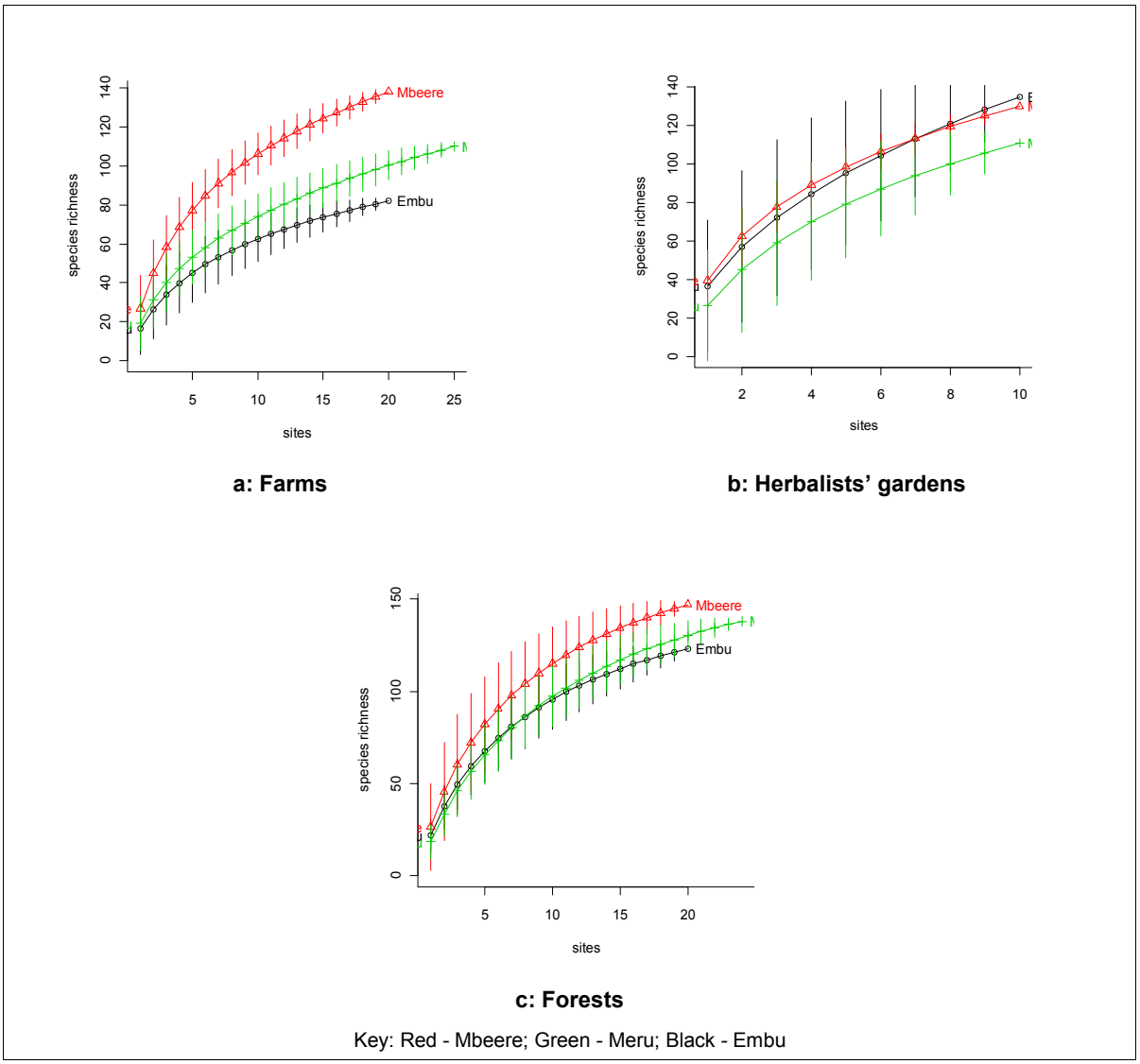


Figure 14: Species accumulation curves for all tree species encountered in farms, herbalist's gardens and forests in Embu, Mbeere and Meru Central districts

The evenness of species in herbalist gardens was almost as low as in farms but with different species proportions. *Lantana camara, Catha edulis* and *Solanum incanum* constituted 16%, 9% and 9% of the tree numbers respectively (Table 45). *Eucalyptus spp* and *Grevillea robusta* which occupied the first and second position in other farmers' fields ranked 12 and 6 respectively in the rank abundance profile and constituted 3% each, of the trees in herbalists' gardens. Species accumulation curves for herbalists' gardens were almost similar for Embu and Mbeere districts and showed more evenness of tree species in the two districts than Meru central district (Figure 14b).

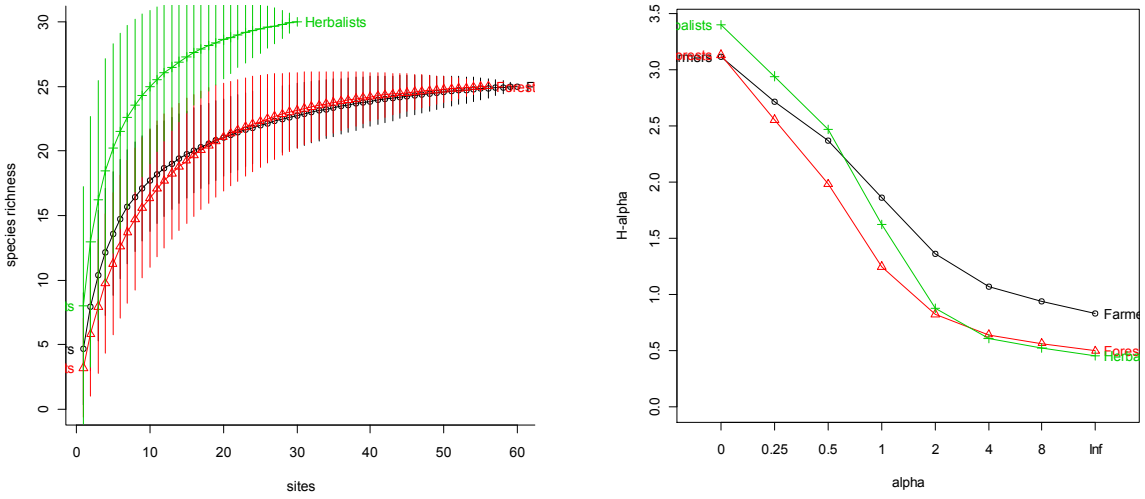
The diversity of tree species in forests and woodlands was dominated by a few species too. *Sizygium guineense* and two species not yet botanically identified (Mugiru and Mwenyuka) were the most abundant species with proportions of 9%, 8% and 6% of the total tree numbers respectively (Table 45). Species composition differed in the three districts due to

different agro ecological conditions but the hills in the semi-arid Mbeere showed more diversity that forests in Embu and Meru central districts as shown by the species accumulation curve (Figure 14c).

7.4.2 Abundance and evenness of highly preferred medicinal tree species in farms, forests and herbalist gardens

The thirty highly preferred medicinal tree species targeted in the study were not very abundant in farms and forests. Among the ten most abundant tree species, only *Solanum incanum, Tithonia diversifolia* and *Aloe spp* were encountered in farms, *Solanum incanum,* and *Erythrina abyssinica* in herbalist gardens and *Ocimum suave* in forests (Table 45). All thirty species were encountered in herbalist gardens but not all in forests and other farms. *Azadrachta indica* and *Moringa oleifera* were missing from forests as they are exotic to Kenya and had never been introduced in natural forests. Other species missing from forests were *Ricinus communis, Leonotis mollissima* and *Tithonia diversifolia*. *Ocotea usambarensis, Leonotis mollissima, Zanthoxylum usambarense, Kigelia africana* and *Vepris nobilis* were not encountered in farms.

Since most traditional medicine remedies are prepared from combinations of plant parts drawn from different species, herbalists need to access many medicinal tree species in one source or in several sources that are close. Species accumulation curves focusing only on the presence and evenness of the thirty species were used to show how many sites a herbalist would need to visit to access as many trees as possible with minimum travel. Herbalist gardens had the steepest slope of the species accumulation curves despite having the fewest sites where species counts were done (Figure 15a). The Rényi profile for the thirty species in herbalists' gardens was also the steepest showing the least evenness in species individuals compared to the farms and forests' profiles (Figure 15b). This is possibly because they had purposively planted higher numbers of the species needed more frequently in remedy preparations. Such trees included *Warburgia ugandensis, Strychnos henningsii* and *Leonitis mollissima* which were encountered in higher numbers in herbalist gardens than forests and other farms. Farms had more evenness of the thirty species than the forests possibly because farmers had planted just a few trees of each of the targeted species while species meant to serve other purposes such as timber, fruits and fodder dominated the farms.

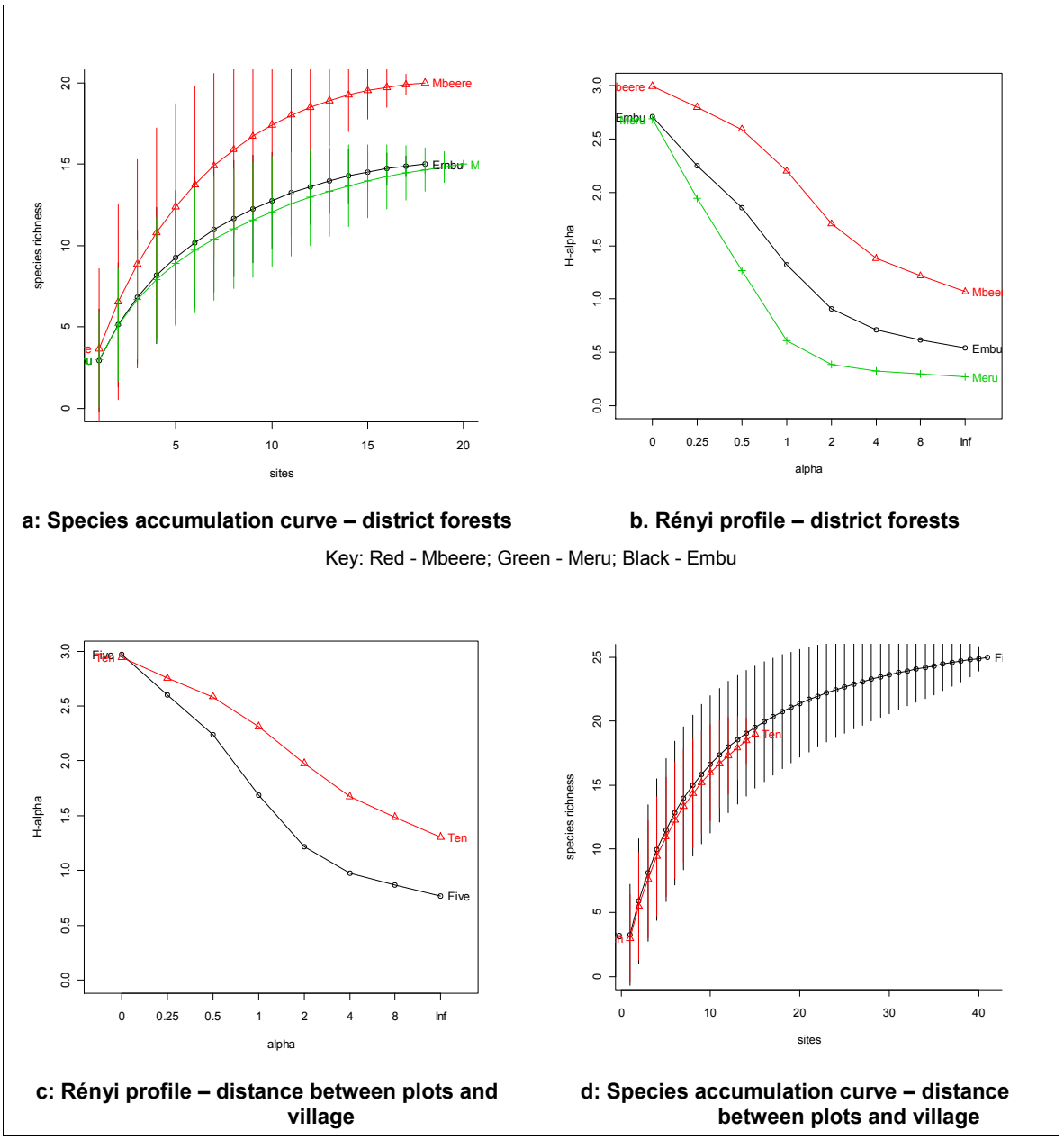


a: Species accumulation curve **b. Rényi profile**

Key: Green – Herbalists gardens; Red – Forests; Black - Farms

Figure 15: Comparison of abundance of highly preferred medicinal tree species in farms, herbalist gardens and forests using a species accumulation curve and a Rényi profile

Analysis by site category and districts showed that forests in Mbeere had a higher level of diversity (both abundance and evenness) of the thirty preferred species than those in Embu and Meru (Figure 16a and b). The species accumulation curves for forests and woodlands in Embu and Meru (Figure 16a) did not show much difference in terms of species abundance but the Rényi profile revealed more evenness in Embu than in Meru (Figure 16b). An interesting observation was that the evenness of the species numbers increased in the forests as plots got further away from the nearest inhabited village (Figure 16c) although the species abundance trend did not change (Figure 16d). We however report this observation conservatively as we did species counts in too few plots to reach this conclusion in a concrete manner.



a: Species accumulation curve – district forests

b. Rényi profile – district forests

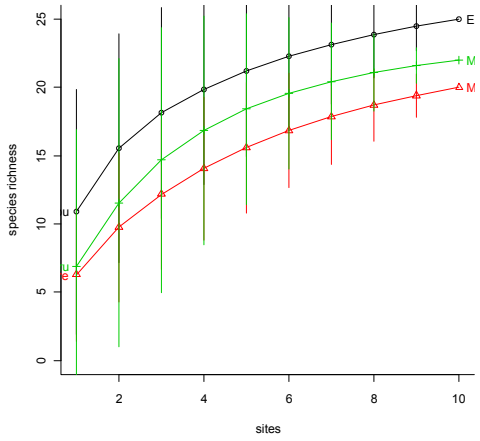
Key: Red - Mbeere; Green - Meru; Black - Embu

c: Rényi profile – distance between plots and village

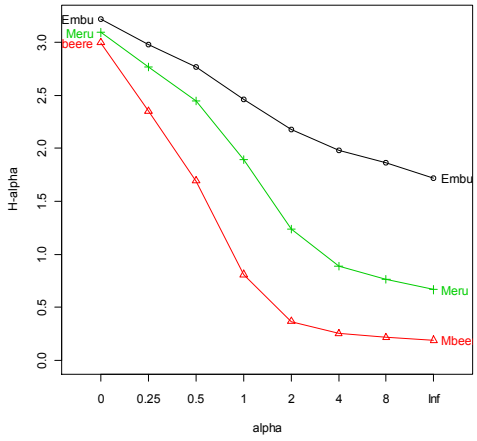
d: Species accumulation curve – distance between plots and village

Figure 16: Rényi profiles and species accumulation curves showing the ease of accessibility of highly preferred medicinal tree species in forests and woodlands

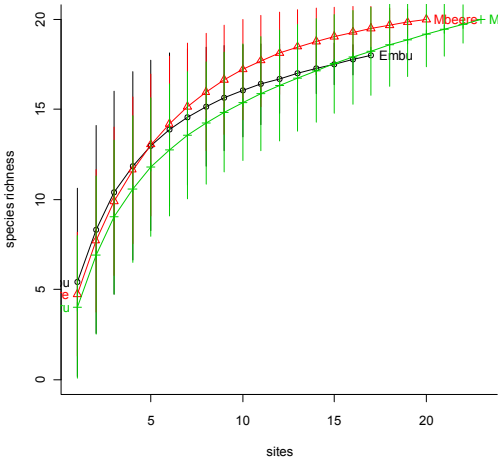
There was a marked difference in abundance and evenness of the thirty species in the herbalist gardens in the three districts (Figure 17a and b). Herbalists in Embu had more diversity in their farms, having up to 25 of the thirty species and a very low gradient Rényi profile, which portrayed a high level of evenness (Figure 17b). Herbalists in Mbeere had the least diverse farms compared to their counterparts in the other two districts. The species' abundance in farms was low in all the three districts with the species accumulation curves going up to 20 species in both Mbeere and Meru central districts and around 17 species in Embu districts (Figure 17c). Species evenness in farms was highest in Meru followed by Embu and lowest in Mbeere district (Figure 17d).



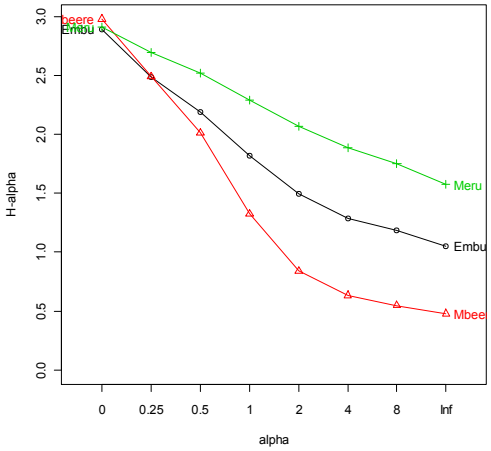
a: Herbalists gardens' species accumulation curve



b. Herbalists gardens' Rényi profile



c: Farms species accumulation curve



d: Farms' Rényi profile

Key: Red - Mbeere; Green - Meru; Black - Embu

Figure 17: Rényi profiles and species accumulation curves showing the ease of accessibility of highly preferred medicinal tree species in herbalist's gardens and farms

7.4.3 Specific establishment conditions for the highly preferred medicinal species in farms and forests

The specific sites where the species were encountered either in farms or forests were further analysed in order to assess whether herbalists were deliberately planting more than the ordinary farmers and whether there was an indication that the species would in future be more abundant in the herbalist farms than forests. This assessment included analysing (i) the frequency of appearance of a species in farms or forest plots, (ii) the relative abundance of the species in each farm or plot, (iii) the main purpose for which the species was planted or managed in the farm, (iv) the agroforestry niche in the farm where the tree was growing and any reasons for the niche preference by the farmer and (v) the age and diameter classes of the tree species in farms and forests. Of the thirty target species it was only *Moringa oleifera*

and *Croton macrostachyus* that were encountered more in farms than herbalists' gardens (Table 46). All the species were encountered more frequently in herbalist gardens than in forest plots while twenty species were encountered more in farms than forests. While herbalists' gardens showed more frequency of occurrence of the thirty tree species than forest plots and farms, there was no clear difference in the relative abundance of the species in the three categories of species.

Farmers, unlike herbalists, did not necessarily plant or manage the targeted species to primarily serve medicinal purpose in the household. Only five of the thirty species were reported to primarily serve medicinal purpose by all the farmers who had the species in their farms as opposed to twenty of the thirty species by herbalists (Table 46). At least 50% of the herbalists also gave medicine as the primary household purpose for the other ten species. The species primarily planted for medicinal use by farmers included *Azadirachta indica, Myrsine melanophloeos, Osyris lanceolata, Strychnos henningsii* and *Warburgia ugandensis.* For at least nine of the remaining species, medicine was reported as the primary household purpose by less than 50% of the farmers. These species mainly provided fodder, fuelwood and timber to the farmers' households.

There was no outright preferential niche for planting of medicinal trees by both herbalists and farmers (Table 46). The species were mainly scattered in cropland or in the home compound and others planted along the external hedges or in woodlots just like other trees in the farms. The reasons given for preference of the niches where the species had been planted by the farmers and herbalists were scarcely associated with the anticipated medicinal component quality. Only the farmers who had planted the trees in river-line strips (64%) gave minimal interference of the tree as the reason for selecting the niche. Respondents mentioned ease of management of the tree as the reason for preference of establishing the trees in cropland (20% farmers, 14% herbalists), home compound (14% farmers, 44% herbalists) and woodlots (60% farmers, 11% herbalists). When planted along external hedges, the trees served as boundary markers (40% farmers, 24% herbalists), while soil fertility improvement was another reason behind planting them in cropland (40% farmers, 5% herbalists).

Table 46: The establishment purpose and farm conditions for high value medicinal tree species in farms and herbalists' gardens East of Mt. Kenya

Species	Growth habit	Frequency %		% of respondents giving medicine as most important use to household[b]		Average relative abundance (%)[c]		Most frequent niche planted[d]		Most frequent medicinal use stated by herbalists	
		F[a]	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**Main diseases treated[e]**	**Plant part(s) used**
Albizia gummifera	Tree	5	10	0	100	0.2	3.6	WL (50)	WL (75)	Stomachache, worms	Bark
Aloe sp	Shrub	37	71	96	100	4.8	2	HC (58)	CL(52)	Malaria, pneumonia, wounds	Leaf sap, roots
Azadirachta indica	Tree	9	19	100	100	0.4	0.3	HC, CL (50)	CL (60)	Malaria	Bark, leaves
Brideria micrantha	Tree	28	42	20	58	2.8	2.9	CL (37)	CL (46)	Typhoid	Bark, leaves
Ceasalpinia volkensii	Shrub	3	10	100	100	0.7	0.1	HC (67)	RL, WL (50)	Malaria	Leaves, seeds
Cordia africana	Tree	17	48	0	58	1.6	1.3	CL (38)	CL (46)	Rheumatism, joint pains	Bark, roots
Croton macrostachyus	Tree	49	45	56	100	5.2	3.1	CL (54)	CL (72)	Wounds, diabetes, typhoid	Bark, leaves
Croton megalocarpus	Tree	38	45	36	93	3.1	1.9	CL (31)	EH (51)	Amoeba, typhoid, wounds	Bark, roots, leaves
Dalbergia melanoxylon	Tree	3	10	0	100	1.9	0.4	CL (67)	WL (60)	Cough	Stem
Erythrina abyssinica	Tree	23	52	60	100	1.2	6.5	WL, CL (33)	CL (81)	Diarrhoea, pneumonia, toothaches	Bark
Ficus sycomorus	Tree	14	42	27	83	0.7	0.4	CL (47)	CL (35)	Diarrhoea, abdominal pains, toothaches	Bark, sap
Ficus thonningii	Tree	14	32	0	50	0.6	0.3	CL (36)	CL (33)	Diarrhoea, fibroids, rheumatism	Bark
Kigelia africana	Tree	3	13	50	100	0.7	0.8	EH (100)	EH, CL (50)	Rheumatism, toothache, typhoid	Bark
Leonotis mollissima	Shrub	0	16		100	0	0.4		CL, RL, WL (33)	Amoeba, malaria	Whole plant, sap
Moringa oleifera	Tree	8	6	60	100	1.7	0.4	CL (56)	CL (50)	Blood purification, rheumatism	Leaves
Myrsine melanophloeos	Tree	2	10	100	100	2.1	0.2	WL (100)	CL (50)	Worms	Seeds
Ocotea usambarensis	Tree	0	6		100	0	0.2		EH (100)	Colds	Bark
Olea europaea ssp africana	Tree	20	23	70	71	2.6	1.8	WL (43)	HC (69)	Amoeba, joint pains, rheumatism	Bark, leaves
Osyris lanceolata	Shrub	5	3	100	100	0.8	0.7	WL (83)	WL 100	Coughs	Roots
Prunus africana	Tree	26	35	56	100	2.1	2.6	EH (38)	WL 61	Prostrate problems, typhoid, diabetes	Bark, leaves
Rhamnus priniodes	Shrub	0	6		100	0	0.2		EH, HC (50)	Colds, joint pains	Roots
Ricinus communis	Shrub	2	48	47	79	5.6	2.5	CL (68)	CL, HC (45)	Digestion problems, allergies, toothaches	Roots, seeds
Senna didymobotrya	Shrub	14	35	67	100	4.3	2	HC (55)	CL (57)	Amoeba, malaria, puscells	Bark, leaves
Solanum incanum	Shrub	49	61	90	94	15.1	7.6	EH (51)	CL (44)	Coughs, malaria, abdominal pains, toothaches	Roots, fruits
Strychnos henningsii	Tree	3	13	100	100	0.4	0.4	WL (100)	WL (67)	Malaria	Stem, leaves
Tithonia diversifolia	Shrub	18	90	67	81	17.3	7.7	EH (38)	EH (43)	Typhoid, malaria	Leaves
Vepris nobilis	Tree	0	16		50	0	0.8		CL (50)	Worms, malaria, allergies	Leaves, roots
Warburgia ugandensis	Tree	2	19	100	100	0.4	0.4	CL (73)	HC (100)	Malaria, pneumonia, tuberculosis	Bark, leaves
Zanthoxylum chalybeum	Tree	22	26	77	100	0.6	0.2	WL (50)	WL (50)	Malaria, coughs, abdominal pains	Bark, leaves
Zanthoxylum usambarense	Tree	0	3		100	0	1		CL (80)	Joint pains	Bark

Key: *a; - F – farmers; H – herbalists;*

b: - Numbers indicate the respondents who mentioned medicinal use as the primary purpose of the species in the household expressed as percentage of all the farmers who had the species in their farms

c:- Species relative abundance was calculated as the number of individual stems of a species in a farm expressed as the percentage of all the trees in the farm

d: - WC- woodlot, HC – home compound, CL – cropland, RL – river line, EH – external hedge (Numbers in parenthesis represent the farms where the species was encountered in that niche expressed as percentage of all the farms where the species was encountered)

e: - This column shows a few of the diseases that herbalists with the species in the gardens said were treated with the species. A comprehensive list of all diseases mentioned by herbalists and farmers as treated by various medicinal plant species is given in Appendix 2

The age structure was only analysed for farm trees, comparing trees in herbalist gardens with those in farms while the diameter size structure analysis also included the forest trees. The objective was to assess whether there were more young/small trees in herbalist gardens than farms and forests, so broad classes for both parameters (age and diameter) were used. We also broadened the classes as they progressed because fewer trees were expected in the higher classes, an approach used by Tabuti *et al*., (2007) although our classes were generally broader than theirs. Species that were non woody (*Aloe spp*) or multi-stemmed shrubs with small dbh generally (*Caesalpinia volkensii, Solanum incanum, Senna didymobotrya* and *Tithonia diversifolia*) were included in the age class but not diameter class analysis.

Natural regeneration accounted for 71% of the individuals of the targeted species encountered in farms and only 15% in herbalist gardens (Table 47). The youngest of the planted trees (below five years in age) constituted over half (56%) of the individuals in herbalist gardens compared to 19% in other farms. Those trees in the age class between six and twenty years old constituted 24% and 8% of the individuals in the herbalist and farms respectively.

Table 47: Age and diameter class distributions of medicinal tree species in farms and forests

Age class (years)	Mean proportion of tree numbers planted by					
	Farmers	Herbalists	Forests*	Average	F	Sig
0.0-0.5	19	56		36	104.8	0.00
6.0-20.0	8	24		15	34.3	0.00
>20	2	5		4	4.0	0.04
NR	71	15		45	259,6051	0.00
Size class	Mean proportion found in					
(Dbh in cm)	Farms	herbalists	Forests	Average	F	sig
0.5 – 4.9	19	22	8	17	7.10	0.00
5.0-9.9	57	53	45	52	3.51	0.03
10.0-19.9	13	12	13	13	0.21	0.81
20.0-39.9	7	9	15	10	5.91	0.00
>40	3	5	19	8	22.28	0.00

** numbers represent the average of the proportion of the trees in the age/dbh category to all the trees of each of the study species in the farm/plot. Ages of forest trees could not be ascertained. NR – Natural regeneration*

Diameter size classes were compared for all saplings and trees with diameter at breast height (dbh) greater than 0.5 cm. Seedlings that were smaller than 0.5cm in diameter (root collar diameter) were left out of the analysis since most of them were wildlings that farmers could weed out later or forest regeneration whose survival was not certain. The proportion of trees in the various size classes did not differ significantly between farms and herbalist gardens but differed between trees in farms and those in forests for most size classes

(P=0.05). Forests had higher proportions of trees with larger diameters (15% for dbh 20 – 39.9 cm compared to 8% in farms and 19% for trees with 40 cm and above compared to 4% in farms). Farms and herbalist gardens on the other hand, had higher proportions of trees with small diameters (75% trees had between 0.5 - 9.9cm compared to 53% in forests).

7.4.4 Preferences of herbalists and herbal medicine product traders on sources of medicinal raw materials

Majority of the respondents (85% herbalists and 93% traders) reported that the ecological conditions (referred to as climate in the interviews) of the source of herbal material influenced the medicinal quality of trees (Annex 7.1). By influencing the level of stress the plant would experience, and the rate of plant growth, ecology would influence the composition and concentration of the active component of the plants. Similarly majority of the users (78% herbalists and 89% traders) believed that the condition of the soil where a plant grows influences the medicinal quality of the plant (Annex 7.1). Many herbalists (63% herbalists against 31% traders) stated that nutrient availability influences chemical composition of the active component while many traders perceived soil influence as determining the growth rate of the plant and hence the amount of biomass produced (38% traders against 2% herbalists). A few herbalists (12%) said they had not experienced any differences in medicinal plant quality that could be attributed to substrate quality. Two traders said that plants could modify soil conditions to suit their requirements while one said that plants had a selective mechanism to take up whatever nutrients are required for medicinal components' build up and therefore the soil quality had little effect.

Most respondents (65% herbalists and 69% traders) preferred forests to farms as sources of herbal medicine raw material (Annex 7.2). Many respondents (50% herbalists; 18% traders) believed that the plants in the forest are more natural because of less interference by chemical and other anthropogenic factors. Others believed that forest trees are more potent (12% herbalists; 16% traders) and some, mainly traders, saw the forests as having a high tree species diversity making collection easy (2% herbalists; 16% traders). The respondents who preferred farm sources were mainly traders (27% against 10% herbalists) and their main reason was that farmers were expected to offer good husbandry to plants which would improve the quality of medicine (11% traders).

More than 70% of the respondents preferred arid, semi-arid and warm areas to humid and cold areas as sources of medicinal plant parts (Annex 7.3). The main reason given for that preference was that moisture stress caused build up of a high chemical concentration in a plant (70% herbalists and 31% traders) and that low moisture content in the collected material made processing of the medicine easier (7% herbalists and 22% traders). The main

reason given by those who preferred humid areas as sources of herbal medicine raw materials was that the plants had higher survival and growth rates resulting in higher plant biomass and better medicine (5% herbalists and 15% traders). Preference for a cool source was mainly because plants had higher survival and recovery rates after harvesting (9% traders). Some herbalists (5%) reported no preference for either arid, humid, warm or cool areas saying they preferred to collect from all sources and dispense medicine to match where patients come from. In a further discussion, the herbalist who was accompanying us in the ecological surveys informed us that the ecology of the area where they source the trees determined the parts to be collected. They preferred to collect bark and roots from species in dry lands and leaves and fruits from species in humid areas since cambial transport processes were more constrained in the former than the later thus dry land species had more sap in the roots and the bark close to the base of the stem.

If herbal materials could only be sourced from farms, majority of herbalists (45%), would prefer to harvest scattered trees in farms to many trees growing together (27%; Annex 7.3). Majority of the traders (60%) preferred to harvest from many trees growing together to single trees scattered in farms (31%). The main reasons given for isolated trees preference was the expectation that the trees would have less competition or interference (pollen) from other tress (45% herbalists and 20% traders). In contrast, the main reason given for preference of many trees growing together was that competition would yield more concentration of the active ingredients in plants and that shading from neighbouring trees would enhance faster recovery of harvested plants (2% herbalists and 35% traders).

A tree growing on a fertile site would be more preferable to one established in an infertile one to 42% herbalists and 75% traders mainly because it would result in high plant growth rates and a high chemical concentration. However, 38% of the herbalists and 16% of the traders would prefer an infertile site since fertile sites would most likely be polluted by farm chemicals (15% herbalists and 4% traders). Two herbalists and 13% of the traders also believed that low soil fertility would result in slow growth rates which would raise the potency of the medicinal component. Many respondents (62% herbalists and 56% traders) preferred a tree whose canopy was exposed to a shaded one as a source of herbal medicine since exposure to a lot of sunlight would ensure better plant development and chemical composition. Those who preferred to source materials from shaded trees (13% herbalists and 38% traders) said that the plants were better protected from any extreme conditions that could affect the chemical composition and that plants recovered faster after harvests of sensitive parts such as bark and roots when shaded.

As farmers are also users of medicinal trees in self treatment, we included the question on the desired improvement traits for medicinal tree species in their interview in order to compare with responses from traders and herbalists. We asked all users to rank four traits that we deduced would be relevant to medicinal trees germplasm development namely high chemical composition, high biomass production, plant resilience with continued harvesting of plant parts and fast growth. Fast growth was found to be significantly more preferable to farmers and traders than to herbalists (P = 0.05; Figure 18). Resilience of the plant with constant harvesting was ranked equally by all user categories but traders ranked high biomass production significantly higher than both farmers and herbalists. However, the traders ranked high chemical composition significantly lower than herbalists and farmers (P=0.05).

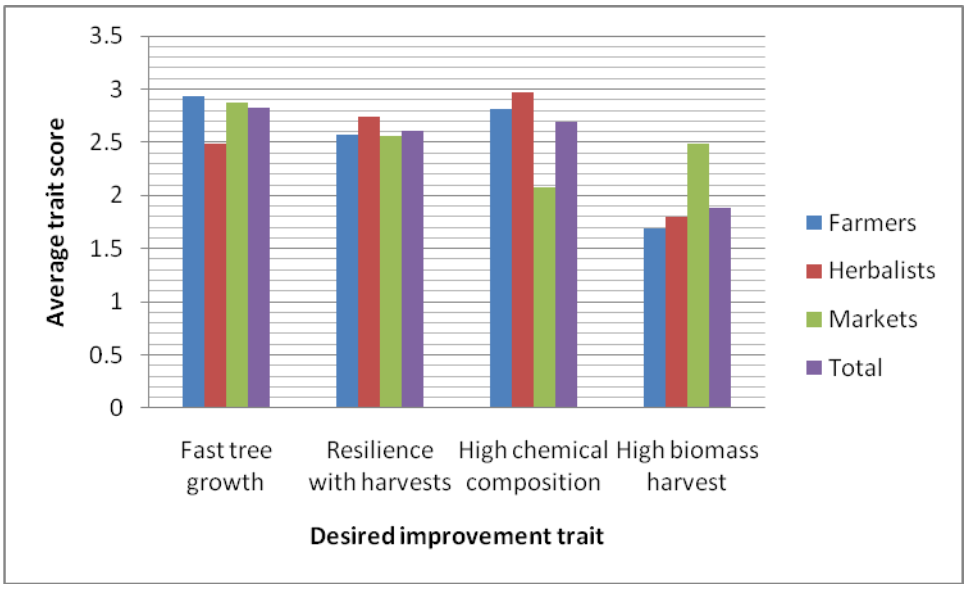


Figure 18: Patterns of preference for medicinal tree germplasm improvement traits by market traders, herbalists and farmers

7.4.5 Segmenting users of herbal medicine by ecological preferences

Using cluster analysis we segmented the traders and herbalists based on their similarity in preference for different ecological conditions for sources of herbal material. We attempted clustering the respondents into three, four or five clusters with multiple iterations and settled at four clusters which displayed clearly identifiable user respondent patterns with significantly distinct cluster centres (Table 48). The first cluster consisted of half of the traders and a quarter of the herbalists. They preferred to collect herbal materials from forests especially in drier and warmer areas but would collect from single trees scattered in fertile farmlands with minimum shade, if farms would be the only available sources. They placed a premium on

trees that grew fast especially if the trees produced high biomass, but not necessarily with high chemical composition or high resilience with continued harvesting.

Table 48: Clusters segmentation of medicinal tree product users based on their preference for ecological conditions of herbal material sources

Item	Parameter	Cluster centres			
		1	2	3	4
General ecological perception	Believes ecology affects medicine quality	2	2	2	2
	Prefers farm (1) or forest (2) source	2	1	1	2
	Prefers humid (1) or dry (2) source	2	2	0	2
	Prefers cool (1) or warm (2) source	2	2	0	2
Perception of farm as only source	Prefers isolated (1) or many (2) trees	1	1	0	1
	Prefers fertile (1) or infertile (2) site	1	1	0	1
	Prefers open (1) or shaded (2) sites	1	1	0	1
Preference for improved medicinal tree ideotype*	Mean score for fast growth rate	3	4	3	2
	Mean score for resilience with constant harvesting	2	3	3	3
	Mean score for high chemical composition	2	2	3	4
	Mean score for high biomass production	4	1	2	1
Percent of respondents in clusters	Herbalists (n=60[α])	15	22	17	43
	Traders (n=55)	51	25	2	22
	Total	32	23	10	33

- *Options for ideotype improvement preference:- 1. Least important; 2. A bit important; 3. Important; 4. Most important*

[α] *Percentages do not add up to 100 because two herbalists expressed that they would not process medicine from farm sourced trees under any circumstances as the medicine would not be effective and therefore declined to give preferences for farm tree conditions. Their responses were thus not included in the cluster analysis.*

The second cluster consisted of a quarter of the traders and 22% of the herbalists. They preferred to collect herbal materials from farm sources in drier and warmer areas especially from trees scattered in fertile farmlands under minimum shade. They placed a high premium on trees that grew fast and with high chemical composition but not necessarily high biomass production or resilience with continued harvesting. The third cluster consisted mainly of herbalists (17% and 2% traders). They preferred sourcing herbal materials from farms but were indifferent on the status of humidity or temperature of the source or the farm niche where the tree was growing. They placed a premium on trees that grew fast, with high chemical composition and a high resilience with constant harvesting but did not regard high biomass production as very important. The fourth cluster consisted of 22% of the traders and 43% of the herbalists. They preferred forest sources especially in drier and warmer areas. If trees were only available in farms, they would prefer single trees scattered in fertile farmlands with minimum shade. They placed low premium on trees that grew fast and produced high biomass but regarded high chemical composition very highly and were also mindful of the resilience of the tree with continued harvesting.

6.5 Discussion

Species abundance surveys showed that herbalist gardens had potential to be the future sources of medicinal tree species. Many of the herbalists and traders who preferred forests to farms as sources of medicinal tree material gave species diversity as the main reason for that preference. Ability to collect many species in the same place as well as fulfil the needed quantities was a great driving force to continued harvesting of medicinal trees from forests and woodlands. The abundance of the species that were assessed in forests appeared to increase with distance from the nearest place of human inhabitation, an indication of more pressure on the species near the villages. Herbal collectors would have to travel further into the forest to achieve high biomass harvest from many medicinal tree species at once until the long distances become a hindrance to further travel. The result would be further degradation of the species near the villages or seeking alternatives such as establishing the trees in the herbalists' fields.

We concentrated our study on the thirty most preferred medicinal tree species since many of the tree species in the forests were reported to be medicinal (see chapter 3), but the most preferred tree species were each involved in preparing remedies for several diseases (chapter 4). From our survey we observed that herbalists were deliberately planting most of the species that were important to their practice and whose scarcity they were already experiencing. Increased planting by herbalists was observed as herbalists' gardens were portrayed by various indices to have higher abundance of the study species than farms in the same locality despite equivalent farm sizes.

Hesitance by herbalists and traders to collect herbal materials from farms keeps farmers disconnected from the trade chain and acts as a disincentive to cultivation of medicinal trees. This was shown by the fact that natural regeneration accounted for 70% of the highly preferred medicinal trees in farms and medicinal use was not the primary reason for planting or leaving most of the species in the farms. Herbalists however had planted most of the trees planted in their farms with natural regeneration accounting for only 15% of all the trees in their gardens and medicinal use was their primary tree establishment purpose. The fact that the proportion of younger trees was higher in herbalist gardens than farms was evidence of recent reaction to scarcity to save on the cost of travelling by the herbalists in search of materials. The smaller sized trees (expectedly younger) were also more abundant in farms (with herbalists having planted most of them) than forests. This implies that future populations of these species might have higher diversity in herbalist farms due to preferential planting, better management and reduced competition with other trees compared to forests. Herbalists are then likely to reduce use of wild sourced materials in future which can contribute to conservation and even increased abundance of the trees in the forests and

woodlands. With the current population numbers of the species being very low in the forests however, constant monitoring and possibly enrichment planting may be required for some high value species.

Mbeere district was selected in the study to represent differences in abundance and evenness of the highly preferred medicinal tree species in arid areas compared to humid areas. The district had a high abundance of the species most preferred for medicinal purposes consistent with the observation that herbalists ranked arid and warm areas as better sources of medicinal trees. Castro (1991) reported that people living around Mt. Kenya utilized trees from a range of local zones for various purposes, so herbalists in the area collect medicinal tree species' parts from the whole range of agro-climatic zones they can easily access. The tree species in Mbeere district were therefore utilised not just by local herbalists but also most likely by those from the nearby Embu district which had low abundance of medicinal trees in the woodlands.

Arid areas are characterised by low populations and nomadic lifestyles and where inhabitants are sedentary as represented by Mbeere district, there are many uncultivated tracts of land especially on hills. These areas remain as sources of medicinal trees where local community members and even foreigners can access these materials without cost. However as population increases, the uncultivated tracts of land get inhabited and placed under continuous cultivation. Two areas, a hill and some extended tract of uncultivated river line land, that had been recommended to us as areas where herbalists were accessing medicinal trees in Mbeere district were already under cultivation and some level of human habitation when we went for surveys. The implication of this observation is that the current practice of harvesting medicinal trees by many traders and herbalists in the arid areas is not sustainable and may lead to degradation of the existing wild resources. A greater concern was the revelation by our herbalist guide that bark and roots were the most preferable parts collected for medicinal use in arid areas. Related to the current abundance, it was observed that herbalists' farms in Mbeere were less diversified than their counterparts in Embu and Meru central districts meaning herbalists from Mbeere were planting less than others. There is need to encourage herbalists in the arid areas to increase cultivation of some of these high value dry land species in farms as the natural sources get decimated.

Particular preference by herbalists to plant trees in niches that mimicked forest situations was not observed in their gardens. If growth conditions that mimicked forest situations were desirable for appropriate development of the secondary metabolites, then herbalists would have planted most of the species in woodlots with high levels of tree species mixtures. Most of the species were established in homesteads and croplands by herbalists and farmers equally and ease of management and access to the trees was given as the main reason for

preferring those niches. Medicinal plant quality was not given as a major reason for growing a tree species on any particular niche. Only farmers next to rivers gave the reason for planting medicinal trees in river line strips as less interference with the trees by agro-chemicals used on crops.

The reasons for planting medicinal trees on external boundaries were more informed by a cultural practice that marks boundaries with trees rather other than medicinal quality. Species such as *Cordia africana, Ficus spp,* and *Bridelia micrantha* were used traditionally by communities living around Mt Kenya to mark boundaries and wildlings that were not conveniently located would be transplanted to the boundary (Castro, 1991). Niches such as woodlots are not feasible options for smallholder farmers with land holdings below one hectare and multi-strata multispecies fences remain among the only available niches to maximise species composition (Fig 7.8). These results support the observation by Shepherd (1989) that farmers in Meru and Embu (during their study Mbeere was taken as part of Embu), planted most of the trees in the home compounds, cropland and boundaries and a few trees in blocks.

Farmers also mentioned improvement of soil fertility as among the reasons why they preferred scattering the trees in farms. Due to the various niches occupied by different components of the farm system, agroforestry practices have been viewed as stages in the development of an agro-ecological succession akin to the dynamics of natural ecosystems (Ong and Leakey, 1999; Kumar, 2006). Component interactions can be competitive, complementary or neutral. As the number of trees in agroforestry systems increase and farms tend towards multi-species and multi-canopy vegetation as found in home-gardens (Soini, 2005) even scattered trees in croplands appear to mimic forests. This trend was observed in the assessment of general tree diversity in the humid districts of Embu and Meru where a high abundance of trees was observed in small farms although only a few tree species were dominant. Crops in such systems may benefit from some added fertility but suffer from shading by trees. Tree management practices such as pollarding geared towards reducing the shading effect in addition to below-ground competition could yield the stress needed to maintain high levels of medicinal components in trees.

The objective of the farmer in agroforestry systems is to maximise positive effects from component interactions. That is why *Olea europaea ssp africana*, one of our study species, was not a favourite intercrop with farmers in Ethiopia and niches such as external hedges and woodlots were more preferable for the species (German *et al.,* 2006). Increased market demand for a tree species' products can change the preference and farmers increasingly favour the trees species in more farm niches since the lost crop productivity can be compensated by the income derived from market sales. Medicinal trees are of more value to

herbalists than other farmers and this can explain why the herbalists were planting more of the trees and were not limited by the need for agroforestry niches that minimised negative interactions between the trees and other farm components. Management practices such tree root pruning (Wajja-Musukwe *et al.,* 2008) could also be favourable for some species especially those whose roots are the desirable parts for medicinal use when the trees are intercropped in smallholder farms.

User preference for the niche where medicinal trees were growing was mainly in favour of open growing conditions (scattered trees in farm with minimum shade) and with adequate soil fertility. This implied that all farm niches and, better still, scattered trees in farmlands and parkland systems had potential to yield sufficiently potent medicinal trees in agroforestry systems. Some users of medicinal tree products (herbalists and traders) had reservations about farm grown trees due to use of agro-chemicals for crop husbandry. Trees grown on hedges or woodlots may be least affected by such chemicals where carefully applied. Low external input sustainable agricultural practices such as organic farming could also offer the best medicinal tree cultivation practices in agroforestry systems. The critical role that trees play in supporting organic farming practices has been advocated for by Freyer (2007), and Bett (2010). Appropriate policies and incentives to encourage such farming approaches need to be put in place however, given that less than one percent of smallholder farmers in Kenya for instance, have been reported to practice organic farming (Ngetich Kibet personal communication). The reservations about chemical interference by the traders and herbalists could however be out of favour with minimum tillage systems that encourage some use of herbicides for weed control.

Two herbalists did not respond to questions that assumed agroforestry trees as the only sources of herbal material as he believed the medicine would not be effective. A trader gave his reason for preferring forests to farms as the fact that forests have been culturally known as sources of medicinal trees while one fifth of the herbalists had the same preference but gave no supporting reasons. This suggested that there may be no ecological basis related to medicinal component quality for preference of herbal material being sourced from forests instead of farms by herbalists and traders. With increasing scarcity of highly valued species in the forests, traders who had high turnovers would suffer more losses and their preferences could change in favour of farm grown material if the species become more abundant in farms. This was shown by the higher ranking of high biomass production compared to high concentration of the active component as the desirable improvement trait for medicinal plant germplasm by traders. On the contrary, farmers and herbalists placed a premium on high medicinal component concentration since less biomass would be needed to prepare herbal medicine for local consumption or sale.

Cluster analysis showed that 27% of the traders and 39% of herbalists (in the second and third cluster) already prefer farm grown trees to forest sourced medicinal trees. The third cluster consisting mainly of herbalists was indifferent in ecology based preferences of medicinal trees. This cluster most likely consists of herbalists that were mainly sourcing from their own farms and could plant as many tree species as possible in whatever niches that optimised farm productivity in their farms. They were probably engaged in other farm enterprises also and lacked time to go sourcing trees from far and therefore could purchase herbal materials from other farms. The second cluster consisting of herbalists and traders, had some ecology based preferences but regarded high biomass production less highly than early maturing trees (fast growth). There is a high chance that these respondents procured materials from other farms too. This cluster would be the best entry for projects aiming at promoting on-farm conservation of medicinal trees. Projects need to identify such herbalists and traders and link them with farmers who have medicinal trees to purchase the required plant parts. The income generated by farmers will motivate the farmers to plant more trees of the species whose demand will rise.

The first cluster preferred trees from the forest and highly regarded fast growing trees with high biomass production. Half of the traders were in this cluster. It is likely that they preferred forest material because they could purchase high volumes of herbal materials at low prices from collectors and make high profit margins. This cluster can be influenced to purchase materials from farmers which would contribute to conservation of wild resources. Organising farmers into producer groups and linking them to such traders would play a great role in achieving this feat. The alternative is to take advantage of current trends that allow more community involvement in forest management where these traders can buy forest materials from community groups as long as appropriate monitoring processes are in place to ensure sustainable production. The fourth cluster would be difficult to influence towards use of farm grown herbal medicine material unless access to forest trees becomes extremely difficult for them. The cluster consisted mainly of herbalists and traders who seemed to believe that forest grown material was more potent and therefore placed a high premium on high chemical composition and plant resilience with constant harvesting. Traditional conservation approaches and participatory monitoring of resources with local institutions should be encouraged with such users in order to ensure sustainable harvests from the wild.

6.6 Conclusion

Our results are consistent with the hypothesis that with increased scarcity of medicinal trees, herbalists would be most affected and would establish the most preferred medicinal tree species in their farms. There was more species abundance and evenness in the herbalist farms than in farms and forests. Herbalists had also deliberately planted most of the

medicinal trees in their gardens while natural regeneration accounted for 70% of the same species present in other farms. There was a higher proportion of lower age and size classes in herbalist gardens than forests implying that these species are more likely to be abundant in the herbalist farms than in forests in future. However if continued planting of these species would contribute to reduced use of wild sourced material by herbalists then regeneration in forests could raise the wild abundance to levels higher than current ones. This however would depend on other ecological factors such as competition and presence or absence of invasive species and reduced forest degradation processes among others.

Preference by herbalists and traders for forest rather than farm sourced herbal medicine material was observed but it was not necessarily based on the perception of medicinal quality being better in forest sourced material. While many herbalists mentioned this as the reason for the preference they did not try to mimic forest conditions when they planted medicinal trees in their farms. There was no observed difference in the niches preferred for planting medicinal trees by herbalists compared to other farmers. The reasons given for niche preference were also not associated with the medicinal component in the plant but rather with ease of access and management of the trees. Traders and herbalists did not also show more preference for conditions that mimicked forests if medicinal trees could only be accessed from farms. Therefore with continued scarcity of medicinal trees in the forest, use of farm grown trees should increase. At least 65% of users (traders and herbalists) have potential to use farm grown trees as predicted through cluster analysis. Policies that make access to forest material difficult such as through some form of valuation and pricing have potential to increase abundance of useful medicinal species in farms and, in tandem, conserve the remaining wild resources.

Annex 7.1: Opinions of traders and herbalists on influence of ecological conditions of the area where a tree grows on the quality of herbal products from the species

Ecological parameter	Option	Reasons for option	Respondent percent		
			H (n=60)	T (n=55)	Total
Opinion on whether climate influences medicinal tree quality	No	No	15	7	11
	Yes	Active component concentration varies with seasons even in same plant	0	2	1
		Affects processing of drugs with drier plant parts easier	0	2	1
		Active component increases with altitude	0	2	1
		Determines stress levels which can affect active component either way	3	2	3
		Influences active component concentration of different provenances	63	33	49
		Influences plant growth rate hence active component concentration	2	29	15
		Reason not given	17	24	20
		Total	85	93	89
Opinion on whether soil properties where the tree is growing influences medicinal tree quality	No	As long as no agrochemicals are in the soil	2	0	1
		Reason not given	10	4	8
		Plants can modify the soil to suit their growth requirements	0	4	2
		Selective mechanism of plants to take up what they need to make medicine	0	2	1
		Not experienced differences	12	4	6
		Total	24	16	18
	Yes	Alkaline soils are not good for medicinal trees	2	0	1
		Deep soils give opportunity for more root harvests	0	5	3
		Different soil types have different minerals.	0	4	2
		Influences pest and disease regimes	2	0	1
		Influences plant growth rate hence active component	2	38	19
		More stressful soils produce better medicine	7	5	6
		Nutrients availability determines chemical composition in a species	63	31	48
		Exotic species are affected by soil properties	2	0	1
		Plants are adapted to specific soil types	2	2	2
		Soil adaptation is important for trees to grow well	0	2	1
		Soil type influences the processing needed eg moldy soils are not good	0	2	0
		Total	78	89	83

Annex 7.2: Preference of traders and herbalists on source of herbal materials

Ecological parameter	Option	Reasons for option	Respondent percent		
			H (n=60)	T (n=55)	Total
Preference for forests or farms as sources of herbal material	No preference	No reason	22	2	12
		Depends on distance and cost	0	2	1
		Total	22	4	14
	Farms preferred	Clear species authenticity in farms	2	7	4
		Conservation of forest resources	0	4	2
		Good husbandry in farms	3	11	7
		Reliability and accessibility	5	4	4
		To create market awareness	0	2	1
		Total	10	27	18
	Forests preferred	Free access to forest material	0	5	3
		Higher potency in forest plants	12	16	14
		Known to be source of herbs for generations	0	2	1
		Less interference or contamination	50	18	35
		Mature plant material from forests	3	9	6
		More species diversity/abundance in forests	2	16	9
		Rich soils in forests	0	2	1
		Total	65	69	67
Preference for arid/semi-arid or humid area as source of herbal material	No preference	No reason	10	2	6
		Depends on disease	3	2	3
		Depends on where patient comes from	5	0	3
		Total	18	4	11
	Arid or semi-arid area source	Known to produce high potent medicine	0	24	11
		Less moisture content good for drug processing	7	22	14
		More moisture stress better medicine	70	31	51
		Total	77	76	77
	Humid area source	Better survival and growth rate with moisture	5	15	10
		Ease of collection especially for roots	0	2	1
		Fresh material can be harvested	0	4	2
		Total	5	20	12
Preference for cold or warm area as source of herbal material	No preference	No reason given	22	4	13
		Depends on disease	5	0	3
		Depends on patients	3	0	2
		Depends on species	0	2	1
		Total	30	5	18
	Prefers cold area	Conducive collection environment	2	2	2
		Higher plant survival and recovery rates after harvest	0	9	4
		No reason given	0	4	2
		Slow growth rates result in good medicine development	0	5	3
		Total	2	20	10
	Prefers warm area	Easier to dry, extract and process medicine	5	35	19
		Known to have good medicine	0	9	4
		More chemical composition and/or concentration	63	31	48

		Total	68	75	71

Annex 7.3: Preference of traders and herbalists on medicinal tree niche if farms were the only sources of herbal materials

Ecological parameter	Option	Reasons for option	Respondent percent		
			H (n=60)	T (n=55)	Total
Preference for single (isolated) trees or many trees growing together for herbal material	No preference	No reason given	28	7	18
	Isolated (single trees) in farms	Collection is easier	0	9	4
		Higher biomass production per tree	0	2	1
		Less competition or influence of other plants	45	20	33
		Total	45	31	38
	Many trees together	Easier for sustainable harvest	0	2	1
		Enough biomass in the same place	0	2	1
		A lot of material can be harvested	7	4	5
		Many plants produce rich nutrients	0	9	4
		More diversity and support for species survival	2	35	27
		To mimic forest situation	0	9	4
		Total	27	60	43
Preference for tree in fertile or infertile site as source of herbal material	No preference	No reasons given	20	7	14
		Plants can modify any situation to suit them	0	2	1
		Total	20	9	15
	Fertile site	Better plant growth rates and resilience	0	18	9
		Good growth better potency because of more nutrients	40	47	43
		More biomass produced	2	9	5
		Total	42	75	57
	Infertile site	Less contamination	15	4	10
		Slow growth rate results in improved medicinal value	23	13	18
		Total	38	16	28
Preference for shaded tree or tree in open site as source of herbal material	No preference	No reasons given	25	7	17
	Open tree	Easier identification during harvesting	0	9	4
		More biomass	0	5	3
		Sunlight ensures better plant development and chemical composition	62	42	52
		Total	62	56	59
	Shaded tree	Better resilience after harvesting	0	2	1
		Conducive harvesting atmosphere	0	9	4
		Mimics forest situation	5	0	3
		Not much sun benefit noticed	0	2	1
		Plant better protected from extreme conditions	7	18	12
		Slow growth rates result in good medicine	2	6	4
		Total	13	38	25

7 Summary discussion, priority species and recommendations

7.1 Introduction

The discussions and conclusions based on the five objectives have been presented in Chapter 3 to 7. The summary discussion below will be based on the general study hypothesis that drawn from the theoretical framework. The other aim of the study was to recommend some species that need further development in terms of conservation and domestication in the study area and the Eastern Africa region. Some of these species are presented below based on the factors that were assessed in the study objectives. Some recommendations on what governments and development projects can do to promote increased cultivation of medicinal tree species as a conservation measure are also presented.

7.2 Summary discussion drawn from the theoretical framework

The general hypothesis based on the systems theory in our study was that:-

> *The level of medicinal tree cultivation or conservation in farms (Mc), is a factor of local perception of disease burden and appropriate knowledge on use of medicinal trees (dk), germplasm availability (g), species ecology (e – climate, soil and competition), and availability of market for medicinal tree products (m) and other unaccounted factors (≺).*

$$Mc = f(g, e, dk, m, \prec)$$

All these factors were observed to be at play in influencing the decision by farmers to plant or save medicinal trees in their farms. Farmers gave the knowledge of use of medicinal trees to treat diseases as the most important factor. However, access to markets for medicinal tree products appeared to limit the number of trees of any given species a farmer could maintain in the farm. Farmers favoured species which they saw as useful in the management of many diseases but not necessarily those useful for treatment of the diseases considered to be of high socio-economic importance to the community. Germplasm availability was mentioned as important but availing more tree seedlings in tree nurseries did not seem to have the potential to improve levels of cultivation of medicinal trees especially if there was a price to the seedlings. Even with free seedlings, farmers would not plant many trees at the expense of crop productivity as was observed when a group with relatively smaller farms was given seedlings and planted in the first season but declined to plant in the second.

Under the livelihood strategies theory, the study hypothesized that:-

> *Unless a farmer perceives a medicinal tree species to be useful in the treatment of diseases that are of great socio-economic importance then there is no incentive to plant or conserve the species if no market demand exists for the products of the species.*

The results of our study showed that farmers were maintaining trees whose medicinal value they knew in their farms. Since there were few sales of medicinal tree products (only five farmers reported any sales) farmers were either not aware of or not accessing markets. They therefore maintained medicinal trees of various species in the least numbers possible as an insurance strategy against disease attack. Conservation of medicinal trees in farms was also mentioned as some of the ways farmers hoped to minimise socio-economic losses from disease attacks. However one tree per species was more than enough for a family and farmers freely shared the tree products with neighbours. This implied that in a village, farmers could each save or plant one tree each of a few medicinal species in their farms and could ask to obtain materials of other species from neighbours when need arose.

A few tree species such as *Azadirachta indica, Prunus africana, Aloe spp* and *Senna didymobotrya* were encountered to play a role in the management of several diseases. These species were encountered in more farms than those which played relatively minor roles in disease management. However if any of these important species was seen to be abundant in the wild, for example *Senna didymobotrya,* the species was not necessary managed in the farm unless saved as wild regenerates in niches that were not useful for crop productivity such as fences. This was in agreement with our hypothesis that only market availability can raise the level of cultivation of medicinal species beyond levels that farmers deemed important for community insurance against shocks from diseases. Trade between farmers and local herbalists as a result of increasing scarcity of herbal materials in the wild may not be feasible because herbalists responded to scarcity by planting the most useful trees in their farms and chose to trade off crop productivity with the expected returns from their traditional medicine practice.

Under the induced innovation theory, this study hypothesized that:-

> *In an environment of decreasing farm sizes farmers become more sensitive to tree crop interactions and desire high quality germplasm and a cultivation technology for medicinal trees that maximises benefits from these interactions in agroforestry systems.*

Our results showed that formal markets for medicinal tree products exist and are growing but farmers in our case study area had minimal access to them. As such, medicinal trees present

in farms were not contributing to the household income in any significant way. Under such conditions, farmers lacked the economic rationale to invest in technological innovations for increasing productivity of medicinal trees in farms. They did not invest in purchase of medicinal tree seedlings but preferred to save or transplant wildlings of the medicinal species that sprouted naturally in the farms. Woodlots were also not preferred as niches for medicinal trees in farms compared to home compounds or scattering them in croplands. The niches for establishment of medicinal trees were clearly designed to favour productivity of other farm crops and maintain medicinal trees as an insurance against diseases. Thus medicinal trees were established in the boundaries where they could serve other purposes such as boundary marking while not competing with farm crops for growth resources. When left to grow in farms, the anticipated contribution to increased crop productivity in form of soil fertility improvement by the medicinal tree was an important factor considered.

Some evidence of increased investment that could be linked to induced innovation was in herbalist gardens. Growing acceptance for traditional medicine has raised the well-being of traditional healers due to prices that are paid for their trade hence raising their income. There was evidence of more numbers of highly preferred medicinal tree species present in their gardens compared to the other farms and natural forests. Majority of these trees were in their younger stages implying that they had been planted recently. The cost of travelling long distances and spending a lot of time trying to get raw materials in the natural forests was leading to healers trading off productivity of their farm crops as well as other categories of farm trees. While *Grevillea robusta* and *Eucalyptus spp* (highly favoured timber species in the study area) had the highest proportions in other farms, herbalist gardens had *Solanum incanum* (a leading medicinal shrub species) and *Lantana camara* as the highest ranking tree species in farms. *Erythrina abyssinica,* a leading medicinal species was also found to be high in abundance. These results are in agreement with the observation by Scherr 1995 about evolution of tree management in farms in Western Kenya as response to fuelwood scarcity. The evolution was observed to be in early stages in our study where more medicinal trees were being deliberately planted in herbalists farms than other species but no particular management technology was observed to improve quality of the medicinal tree products from farms.

7.3 Priority species

Several species came up as the most frequently used or preferred in the whole sub-system of medicinal plants use in the study area and in the urban centres where the market survey was done. A matrix ranking was done to identify the species which would be of the highest conservation priority from all the species that were topping the lists of farmers, traders and herbalist preferences. A total of 54 species were considered and subjected to a scoring

system with criteria drawn from the five objectives (Table 49). In the criteria we summed all the factors that had the potential to raise demand of the species (farmer preference and ranking, herbalist preference and ranking and market demand) and deducted all factors that contributed to abundance of the species in the community (abundance in tree nurseries, farms, herbalist gardens and forests) to come up with a priority score as explained below. All factors were transformed into scores of between zero and three.

Demand factors (all these were added)

1. Farmers' and herbalists' species preference – frequency (%) of respondents interested in planting the species divided by highest frequency in the respective respondent category and multiplied by three.
2. Farmers' and herbalists' ranking – The rank given by farmers/herbalists for the species in Chapter 4 by summing the diseases treated by the species weighted by the farmers/herbalists' rank of the diseases. The species ranks were divided by the highest rank score in the respective respondent category and multiplied by three.
3. Market demand – frequency (%) of traders dealing with a species multiplied by the average annual trade volume, the mean annual trade growth rate of the species and the perception on the trend of the demand of the species (3 – rising, 2 – constant and 1 – declining). The derived figures were divided by the highest score and multiplied by three.

Abundance factors (these factors were deducted from the sum of demand scores)

4. Abundance in nurseries – The frequency (%) of the species in nurseries multiplied by the average number of seedlings produced (sum of seedlings in the nursery and those supplied in the previous season). The derived figures were divided by the highest score and multiplied by three.
5. Abundance in farms, herbalist gardens and forests – The proportions of the species as part of total trees abundance was used in these three scores. For each of the three scores the highest proportion among the fifty-four species was used as the base value (denominator) to convert the abundances into scores between zero and three.

The results are as shown in Table 49. The narrative on botanic descriptions, ecological requirements and images as well as some scientific work done on the medicinal value of the first twenty species is given in Appendix 1.

Table 49: Score matrix to show priority of conservation of medicinal trees leading in traditional medicine and herbal products trade

(the sign after the score description shows the direction that the particular score contributes in the priority score summation)

Species / score	Growth habit	Farmers preference (+)	Herbalists preference (+)	Farmers rank (+)	Herbalist rank (+)	Market demand (+)	Abundance Nurseries (-)	Abundance Farms (-)	Abundance Herbalists gardens (-)	Abundance Forests (-)	Priority score	Priority rank
Azadirachta indica	*Tree*	2.8	2.0	3.0	2.9	2.7	0.1	0.0	0.0	0.0	13.3	*1*
Aloe sp	*Shrub*	2.7	2.2	3.0	3.0	2.1	0.1	0.7	0.3	0.3	11.6	*2*
Warburgia ugandensis	*Tree*	0.4	2.2	2.8	2.9	0.5	0.0	0.0	0.0	0.0	8.9	*3*
Caesalpinia volkensii	*Shrub*	0.8	1.1	2.7	2.2	0.0	0.0	0.0	0.0	0.0	6.9	*4*
Prunus africana	*Tree*	1.5	2.7	2.9	3.0	0.7	2.8	0.2	0.1	0.9	6.9	*5*
Zanthoxylum chalybeum	*Tree*	0.3	0.9	2.8	2.9	0.0	0.0	0.0	0.0	0.0	6.8	*6*
Strychnos henningsii	*Tree*	0.5	1.3	2.7	2.6	0.0	0.0	0.0	0.0	0.3	6.7	*7*
Senna didymobotrya	*Shrub*	0.5	0.7	3.0	2.8	0.1	0.0	0.1	0.2	0.2	6.6	*8*
Moringa oleifera	*Tree*	0.2	0.7	2.3	2.9	0.3	0.0	0.0	0.0	0.0	6.4	*9*
Dalbergia melanoxylon	*Tree*	0.0	0.7	2.8	2.8	0.0	0.0	0.0	0.0	0.0	6.3	*10*
Leonotis mollissima	*Shrub*	0.2	0.7	2.8	2.6	0.0	0.0	0.0	0.0	0.0	6.2	*11*
Croton macrostachyus	*Tree*	0.6	0.8	2.7	2.7	0.0	0.0	0.3	0.2	0.2	6.1	*12*
Croton megalocarpus	*Tree*	0.7	0.9	3.0	2.8	0.2	0.0	0.2	0.2	1.2	6.1	*13*
Olea europaea ssp africana	*Tree*	1.1	1.8	2.9	2.8	0.0	1.8	0.2	0.0	0.6	6.0	*14*
Psidium guajava	*Tree*	0.3	0.2	2.9	2.8	0.0	0.0	0.1	0.1	0.0	5.9	*15*
Osyris lanceolata	*Shrub*	0.1	0.5	2.7	2.8	0.0	0.0	0.0	0.0	0.2	5.9	*16*
Plectranthus barbatus	*Shrub*	0.1	0.1	2.9	2.9	0.0	0.0	0.0	0.1	0.0	5.9	*17*
Erythrina abyssinica	*Tree*	0.6	1.3	2.9	3.0	0.1	0.0	0.1	2.0	0.0	5.7	*18*
Rhamnus prinoides	*Tree*	0.2	0.3	2.9	2.7	0.0	0.0	0.0	0.0	0.5	5.7	*19*
Fagaropsis angolensis	*Tree*	0.3	0.3	2.8	2.4	0.0	0.0	0.0	0.0	0.2	5.7	*20*
Carissa spinarum	*Shrub*	0.2	0.5	2.7	2.9	0.0	0.0	0.0	0.0	0.8	5.6	*21*
Bridelia micrantha	*Tree*	0.1	0.5	2.7	2.6	0.0	0.0	0.1	0.2	0.2	5.6	*22*
Terminalia brownii	*Tree*	0.2	0.3	2.9	2.6	0.0	0.0	0.4	0.2	0.0	5.4	*23*
Vernonia lasiopus	*Shrub*	0.1	0.4	2.5	2.7	0.0	0.0	0.1	0.0	0.2	5.4	*24*
Carica papaya	*Tree*	0.2	0.0	2.9	2.7	0.0	0.0	0.4	0.0	0.0	5.4	*25*
Ficus sycomorus	*Tree*	0.1	0.5	2.4	2.6	0.0	0.0	0.0	0.0	0.2	5.4	*26*
Muchani	*Tree*	0.1	0.2	2.4	2.7	0.0	0.0	0.0	0.0	0.0	5.4	*27*

Table 49 (cont): Score matrix to show priority of conservation of medicinal trees leading in traditional medicine and herbal products trade

(the sign after the score description shows the direction that the particular score contributes in the priority score summation)

Species / score	Growth habit	Farmers preference (+)	Herbalists preference (+)	Farmers rank (+)	Herbalist rank (+)	Market demand (+)	Abundance Nurseries (-)	Abundance Farms (-)	Abundance Herbalists gardens (-)	Abundance Forests (-)	Priority score	Priority rank
Myrsine melanophloeos	*Tree*	0.8	1.2	2.5	2.8	0.0	1.8	0.0	0.0	0.2	5.4	*28*
Milicia excelsa	*Tree*	0.0	0.3	2.5	2.7	0.0	0.0	0.0	0.0	0.3	5.3	*29*
Citrus limon	*Tree*	0.3	0.1	2.6	2.1	0.0	0.0	0.1	0.0	0.0	5.0	*30*
Tithonia diversifolia	*Shrub*	0.2	0.3	2.8	2.4	0.0	0.0	0.8	0.0	0.0	5.0	*31*
Zanthoxylum usambarense	*Tree*	0.0	0.7	1.4	2.9	0.2	0.0	0.0	0.0	0.3	4.9	*32*
Cordia africana	*Tree*	0.2	0.5	2.2	2.4	0.0	0.3	0.0	0.1	0.0	4.8	*33*
Ricinus communis	*Shrub*	0.1	0.5	2.4	2.1	0.0	0.0	0.2	0.1	0.0	4.8	*34*
Combretum collinum	*Tree*	0.2	0.2	2.6	2.8	0.0	0.0	0.2	0.1	0.9	4.6	*35*
Albizia anthelmintica	*Tree*	0.1	0.4	2.5	1.5	0.1	0.0	0.0	0.0	0.0	4.5	*36*
Markhamia lutea	*Tree*	0.0	0.2	2.6	2.4	0.0	0.2	0.1	0.0	0.5	4.4	*37*
Hagenia abyssinica	*Tree*	0.0	0.3	2.2	2.0	0.0	0.1	0.0	0.0	0.2	4.4	*38*
Lantana trifolia	*Shrub*	0.2	0.4	2.5	1.3	0.0	0.0	0.1	0.0	0.0	4.3	*39*
Ocotea usambarensis	*Tree*	0.1	0.8	0.6	2.9	0.1	0.0	0.0	0.0	0.2	4.3	*40*
Vitex keniensis	*Tree*	0.0	0.3	2.2	1.9	0.0	0.0	0.0	0.0	0.2	4.2	*41*
Acacia nilotica	*Tree*	0.1	0.2	2.6	2.5	0.1	0.0	0.0	0.9	0.5	4.1	*42*
Piliostigma thonningi	*Tree*	0.2	0.1	2.5	1.2	0.0	0.0	0.1	0.1	0.0	3.9	*43*
Mangifera indica	*Tree*	0.4	0.0	2.9	2.3	0.0	1.5	0.5	0.3	0.0	3.3	*44*
Ficus thonningi	*Tree*	0.0	0.3	1.0	2.0	0.0	0.0	0.0	0.0	0.2	3.2	*45*
Vepris nobilis	*Tree*	0.0	0.3	1.8	1.9	0.0	0.0	0.0	0.0	1.1	3.1	*46*
Kigelia africana	*Tree*	0.1	0.4	0.3	2.2	0.1	0.0	0.0	0.0	0.0	3.1	*47*
Juniperus procera	*Tree*	0.2	0.3	2.8	1.0	0.0	1.8	0.0	0.0	0.0	2.4	*48*
Ocimum suave	*Shrub*	0.2	0.3	2.6	1.9	0.0	0.0	0.3	0.0	2.7	2.0	*49*
Eucalyptus spp	*Tree*	0.3	0.1	2.3	2.0	1.2	0.9	2.9	0.6	0.2	1.2	*50*
Jatropha curcas	*Tree*	0.2	0.0	0.7	0.0	0.1	0.0	0.0	0.1	0.0	1.0	*51*
Ekebergia capensis	*Tree*	0.0	0.1	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.7	*52*
Acacia xanthophloea	*Tree*	0.0	0.0	1.1	0.6	0.0	0.0	0.0	0.1	0.9	0.6	*53*
Solanum incanum	*Shrub*	0.1	0.7	2.8	2.9	0.0	0.0	2.4	2.7	1.2	0.1	*54*

7.4 Recommendations to enhance cultivation of medicinal trees

1. **Engage herbalists and nursery operators in extension for increased cultivation of medicinal trees.**

   Development projects should engage more with herbalists in promoting cultivation of medicinal trees especially because the current initiatives by herbalists to conserve the species in their farms are very positive. Herbalists can help to identify threatened species and with good support plant high quality germplasm in their farms. Herbalists also need to share the medicinal value of some of the scarce species in the forests that farmers do not seem to know such as *Ocotea usambarensis* since this basic knowledge would be useful to help farmers save the trees in farms. Therefore herbalists and nursery operators can be involved in extension seminars while ways to enthuse the participation of young and educated farmers are sought. Key information that ought to be included in these extension fora include

   - Tree species useful in traditional medicine and the diseases they treat
   - The species growing in industrial use volumes and thus market demand
   - High quality germplasm sources
   - Appropriate cultivation technologies for high priority medicinal species

2. **Market development and linking farmers to markets.**

   Markets development offers the best opportunity to raise levels of cultivation of medicinal trees by farmers. Our study showed that formalisation of medicinal product markets held the highest potential to use materials that are produced in uniform conditions of husbandry in agricultural fields. Traders who invest in manufacturing capacity in a market segment that is growing would be better off if assured of continued production when they are connected to ascertained sources. There is need to identify species which have high potential for business growth such as *Aloe sp, Azadirachta indica, Warburgia ugandensis* and a few others then organise farmers into village business groups which can market products of these species directly to traders, who are also organised in associations. Minot and Hill (2007) listed enabling cooperative behaviour, providing market information and contract farming as some approaches that can connect smallholder farmers to markets.

3. **Policies that promote cultivation and discourage wild collection in the forests.**

   Examples here include allowing community forest management groups to monitor trends in abundance of medicinal tree species in forests and raise some income by charging traders for collecting in the forests. Other policies include putting premiums

that favour medicinal tree species in carbon markets and other modes of payment for environmental services when the appropriate national and international legal foundations are in place. These policies should be in tandem with any other government policies that are directed at farm trees such as the requirement that 10% of all Kenyan farms should be under trees and on riparian strips conservation.

4. **Germplasm conservation and production.**

   It is important to involve rural players such as herbalists and nursery operators in identifying, developing and managing highly diversified seed production stands in the community especially for highly demanded species due to the role these species play in managing many diseases. This is highly critical for species that do not have good circa-situ storage behaviour (for example recalcitrant species like *Prunus africana*). The stands can be established in herbalist farms or community land where nursery operators can source high quality seed. Seeds dispersed to other farms in the community from these sources will also germinate to high quality wildlings that can be saved by farmers where demand for seedlings is yet to rise. Such dispersal would be very beneficial for arid areas where currently farm plots are bigger and medicinal trees in farms are mainly naturally regenerated. Medicinal trees in the dry areas are perceived to be of better quality and are preferred by traders and herbalists even from the humid areas and thus risk degradation as demand increases. Support for group nurseries in such places may also be needed for a while as modalities to develop private nursery enterprises are sought.

5. **Pursue policies that develop arid areas as future sources of medicinal trees.** Salami *et al*., (2010) recommended increased land under productivity as one way smallholder productivity can be raised in Eastern Africa. Dry areas have land that can be put into more productive use due to relatively low population. Farmers in these areas however have limited farming enterprises they can engage in as a result of low precipitation in absence of irrigation infrastructure. With climate change predicted to lower yields with as much as 50% in many areas in Africa where rain fed agricultural production is prevalent (Cook, 2009), alternative dry land farming enterprises are needed. The current preference for medicinal species naturally growing in the dry lands by herbalists and traders can stimulate income generation for farmers in arid areas if harnessed. As already said, linking farmers to markets for herbal medicine products and to sources of high quality germplasm is critical to motivate the farmers in these areas.

6. **Further research.** This study did not fully support the claim that herbalists are hesitant to harvest medicinal trees from farms if there is scarcity in forests. However a

significant portion of users (traders and herbalists) showed a high inclination to continue harvesting from forests even when degradation is apparent. There is need to further study whether there are significant variations in the concentration of the active components in a species when planted in different niches in farms and share results with users. In line with studies like the ones conducted by Geldenhuys (2007), comparison of high value medicinal species when planted in farms and as forest enrichment will be very useful. There is need to compare the species along the different agro-climatic zones within species agro-ecological limits and test the concentration of the medicinal component in the different plant parts to give recommendations on appropriate approaches to conserve medicinal tree species with use.

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11 Appendix

11.1 Appendix 1: Species narratives for the twenty high priority species

(The source of this information is Orwa *et al.,* 2009 and the images are the author's unless where otherwise specified)

Azadirachta indica A. Juss. Neem - Meliaceae

Azadirachta indica is a small to medium-sized tree, usually evergreen, upto 15 m tall, with a round, large crown up to 10 m in diameter. The branches are spreading and the branchless bole is up to 7.5 m height growing upto 90 cm in diameter and is sometimes fluted at base. The species may start flowering and fruiting at the age of 4-5 years, but economic quantities of seed are produced only after 10-12 years. Pollination is by insects such as honeybees and certain isolated trees do not set fruit, suggesting the occurrence of self-incompatibility.

The species grows in attitudes from 0-1500m, mean annual temperatures upto 40^{o}C and mean annual rainfall from 400 to 1200m. It is native to India, Indonesia, Malaysia, Myanmar, Pakistan, Senegal, Sri Lanka and Thailand but said to grow „almost anywhere' in the lowland tropics. The species does not grow gregariously under natural conditions. In India, it is present in mixed forest with *Acacia spp.* and *Dalbergia sissoo* and in Indonesia it is naturalized in lowland monsoon forest. In Africa, it is found in both evergreen and dry deciduous forests. It requires large amounts of light but tolerates fairly heavy shade during the first few years. It grows on a wide variety of neutral to alkaline soils growing best on soils with a pH of 6.2-7 but quickly dies in waterlogged soils. It performs better than most species on shallow, stony, sandy soils, or in places where there is a hard calcareous or clay pan not far below the surface.

Neem has proved effective against certain fungi that infect humans. In a laboratory study, neem preparations showed toxicity to cultures of 14 common fungi. The tree has suppressed several species of pathogenic bacteria, including *Salmonella typhosa* and *Staphylococus aureus*. Various parts of *A. indica* have anthelmintic, antiperiodic, antiseptic, diuretic and purgative actions, and are also used to treat boils, pimples, eye diseases, hepatitis, leprosy, rheumatism, scrofula, ringworm and ulcers. Leaf teas are used to treat malaria. People use the twigs as toothbrushes and dentists find twigs effective in preventing periodontal disease. Neem oil is a powerful spermicide and can be used as an inexpensive birth control method. A neem oil-based product, Sensal, is being marketed in India as an intravaginal contraceptive. Neem oil has been used traditionally as a topical treatment for skin symptoms in both humans and livestock, but it should not be ingested orally. As a pesticide, tests of neem extracts have shown results on about 300 insect species.

Azadirachta indica

Aloe sp

***Aloe spp.* (*Aloe vera L* . Burm.f.) - Asphodelaceae,**

Many Aloe species are medicinal and were encountered in farmers' and herbalists' fields. The most popular, as well as most preferred by farmers and herbalists, is *Aloe vera* and most of this description is about this particular species. It is a succulent perennial herb up to 160cm tall, without stem or with a short stem up to 30cm long. It has 16 -20 leaves in a dense rosette, erect or slightly spreading without stipules or petiole. The inflorescence is a terminal dense raceme 30 - 40cm x 5-6cm with bisexual, regular flowers.

Aloe vera grows well in sandy soil that is mostly found in tropical and subtropical plains. It is often cultivated as a garden plant and is only known as a cultivated or naturalized plant. It is generally presumed to originate from Arabia, Somalia or Sudan.

The gel obtained from the inner part of the aloe leaf, referred to as Aloe gel, is used to treat burns, skin rashes, insect bites, healing wounds by drawing out infection, and preventing infection from starting and chafed nipples from breast-feeding. This gel can also be used internally to keep the bowels functioning smooth. It is also used in menorrhea, asthma, inflamed or diseased breasts, burns, bursitis, colds, colic, conjunctivitis, constipation, coughs, dys-menorrhea, dysentery with bloody stools, ear infections, eye problems, fat and sugar metabolism, fever, gonorrhea, heart pain, hemorrhoids, hepatitis, herpes, infant pneumonia, insomnia, Intestinal worms, jaundice, kidney disorders, enlarged liver, menopause, rheumatism, skin inflammations, skin rashes, sores, sore throat, spleen enlarged, toothache, TB and other lung diseases, tumors, ulcers, chronic vaginitis and venereal diseases.

Warburgia ugandensis Sprague - Canellaceae

Warburgia ugandensis is a spreading evergreen tree 4.5-30 m tall and 70 cm in diameter with a smooth or scaly, pale green or brown bark a short bole clear of branches for about 3 m and a rounded crown. The leaves are alternate and simple, dotted with glands, glossy dark green above but paler green and dull below with midrib frequently slightly off-centre. The flowers are solitary or in small 3-4 flowered cymes and the fruits are berries 3-5 cm in diameter, at first green and ellipsoidal but later sub-spherical and turning purplish with two or more seeds about 1-1.5 cm long each. The species is hermaphroditic, flowering at the beginning of the rainy season.

Warburgia ugandensis occurs in lowland rainforest, upland dry evergreen forest and its relicts in secondary bushland and grassland and on termitaria in swamp forest. The biophysical limits include an altitude range 100 -2 200 m, mean annual rainfall 1 000 -1 500 mm and can withstand swamp forest soils. It is native to the Democratic Republic of Congo, Ethiopia, Kenya, Malawi, South Africa, Swaziland, Tanzania and Uganda.

The dried bark of *Warburgia ugandensis* is commonly chewed and the juice swallowed as a remedy for stomach-ache, constipation, toothache, cough, fever, muscle pains, weak joints and general body pains. It is also effective in powdered form for treating the same diseases. Fresh roots are boiled and mixed with soup for the prevention of diarrhoea. Leaf decoction baths are used as a cure for several skin diseases. The inner bark is reddish, bitter and peppery and has a variety of applications. It provides treatment for the common cold; dried and ground to a snuff it is used to clear sinuses; and it is chewed, or smoke from the burning bark inhaled, as a remedy for chest complaints. The bark, roots or leaves can be boiled in water and the decoction drunk to treat malaria, but this causes violent vomiting.

The species contains compounds that exhibit antifeedant activity against armyworm (*Spodoptera littoralis* and *S. exepta*), widely occurring African crop pests. In addition the compounds exhibit very potent antifungal, antiyeast and plant-growth regulating activity.

Warburgia ugandensis

Caesalpinia volkensii

Caesalpinia volkensii Harms - Caesalpiniaceae (Leguminosae)

Caesalpinia volkensii is a shrub with climbing or straggling stems armed with recurved and straight prickles 2–4 mm long. Leaves alternate, bipinnately compound, with 3–6 pairs of pinnae; small, 2–3-pointed stipules, c. 3 mm long; 15–50 cm long rachis with recurved prickles, especially at base of pinnae; opposite leaflets, 3–7 pairs per pinna, ovate to ovate-elliptical. Inflorescence is an unbranched or few-branched, hairy, axillary raceme, up to 20 cm long and densely flowered. Flowers are bisexual, zygomorphic, 5-merous; pedicel 4–14 mm long; with free, unequal sepals, the lower one hood-shaped and embracing the others; free, unequal, yellow petals, 1–1.5 cm × c. 4 mm, the upper different in shape and size. Fruit a broadly oblong or obovoid-ellipsoid, flattened pod up to 13 cm × 6.5 cm, covered with prickles. Seeds globose, c. 2 cm in diameter and hard.

Caesalpinia volkensii is native to Ethiopia, Kenya, Uganda and Tanzania. In Kenya and Tanzania the species is mostly used to treat malaria. In the area around Nairobi (Kenya) over 60% of the herbalists prescribe a decoction of the leaves of *Caesalpinia volkensii* to cure malaria, sometimes alone, but more often mixed with other plants. The leaf decoction is also taken to fight pains during pregnancy. Pregnant women take powdered pods dissolved in water to relieve stomach-ache. Roots are eaten cooked, raw or as an addition to palm wine for their aphrodisiac properties. They are also used to treat gonorrhea and bilharzia. Seeds are used to cure stomach ulcers. Flower buds are crushed and applied to the eye to treat eye problems. Unspecified plant parts are used in Kenya to treat retinoblastoma. The roots are used in Tanzania as a source of red dye.

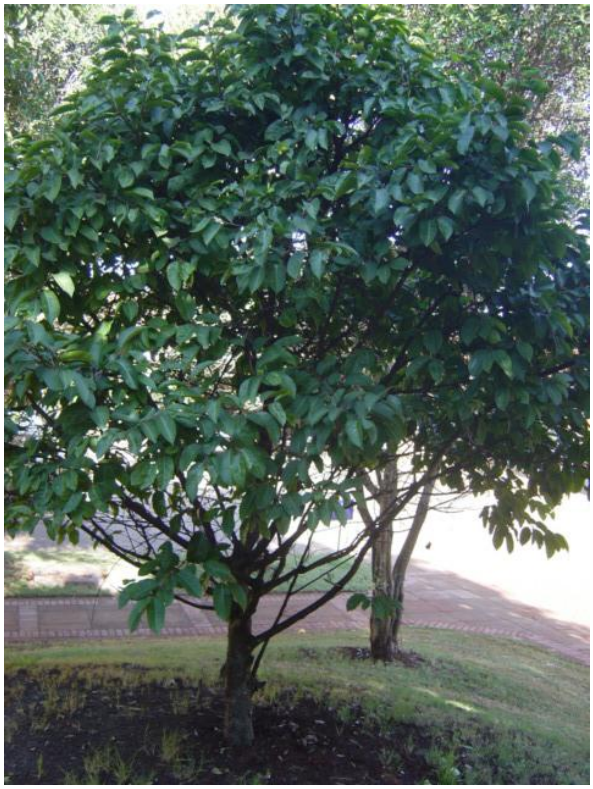
Prunus africana Hook. f. Kalkman - Rosaceae

Prunus africana is an evergreen tree, 10-24 m in height, with a stem diameter of up to 1m. The bark is blackish-brown and rugged with brown and corky branchlets dotted with breathing spots and knobbly twigs. The foliage is heavy and shining composed of alternate, simple leaves that are oval or lance shaped, 5-15 x 2-6 cm; shiny deep green on the top side but duller and lighter underside with conspicuous veins and a distinct midrib prominent on the underside. Crushed leaves have a bitter almond smell. The species produces flowers with male and female parts. The flowers are small, white or greenish, hairy, fragrant, borne abundantly in bunches 5-7.6 cm long in the axils of leaves or on the side of shoots. Fruits are spherical and bitter, 7 mm long, 1.3 cm broad, pinkish-brown, bilobed, with a thin, dark red to reddish-brown pulp when ripe, with 1 or 2 small, delicate, oval seeds inside.

Prunus africana is a highland forest tree and grows in the humid and semi-humid highlands and humid midlands mainly in sub-Saharan Africa. It is native to Angola, Benin, Botswana, Burkina Faso, Cameroon, Chad, Comoros, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Sao Tome et Principe, Senegal, Sierra Leone, South Africa,

Swaziland, Tanzania, Togo and Uganda. The species has a high light requirement and grows best in forest gaps. The biophysical limits include an altitude of 900-3 400 m, mean annual rainfall of 890-2 600 mm and mean annual temperature of 18-26^{o}C.

Liquid extracts from *Prunus africana* bark are used in the treatment of benign prostatic hyperplasia and prostate gland hypertrophy. Leaves are used as an inhalant for fever or are drunk as an infusion to improve appetite. Water is added to pounded bark, and the red liquid is used as a remedy for stomach-ache. The bark extract may be used as a purgative for cattle. The tree grows at a moderate rate and responds well to cultivation. It is able to withstand severe bark removal to exhibit complete bark regrowth, but poor harvesting of bark may lead to tree death. Bark is collected only from quarters on opposite sides of trees, from about 35 cm above the ground level to the height of the 1st branch. In this way it is thought that the bark can be harvested sustainably every 4-5 years. Bark removal induces early flowering.



Prunus africana (young tree)

Zanthoxylum chalybeum (stem)

Zanthoxylum chalybeum **Engl. – Rutaceae**

Zanthoxylum chalybeum is a deciduous spiny shrub or tree growing up to 12 m height with a rounded but open crown. The bark is pale grey, smooth and dark with scales and prickles. The bole has characteristic large, conical, woody knobs with sharp prickles. The branches also bear scattered thorns with conspicuous dark scales. The leaves are compound, usually 3-5 pairs of shiny leaflets plus a terminal leaflet. The leaflets are oblong to elliptic or lanceolate, 2.5 - 7 x 1-2.5 cm, sparsely dotted with pellucid glands and with a strong citrus smell when crushed. Flowers are sweet scented, inconspicuous, yellowish-green, in short sprays (racemes or panicles) 5-10 cm long, produced immediately below the leaves at the base of the new branchlets. The male and female flowers are on different trees. The fruits are spherical, about 5 mm in diameter, reddish-brown, splitting to allow the shiny black seeds to partly protrude.

Z. chalybeum is a tree of medium to low altitudes in dry woodland or grassland, often on termite mounds. The biophysical limits include an altitude of 0-1 600 m and mean annual rainfall: 750-1 500 mm. It is native to Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, Somalia, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

Bark extracts are said to cure malaria. The seeds are used in the treatment of measles in children. The roots and bark are used to treat pain in fallopian tubes, asthma and pneumonia. When dried, the leaves can be brewed to make a kind of tea for beverage while the twigs are used as toothbrushes. The leaves and fruit are eaten by goats throughout the year. The branches are sometimes lopped for feed. The species is also a good firewood tree as it burns easily. The timber is very hard, heavy,

elastic and highly durable. It works well, although it is difficult to nail; finishes and polishes well and has been used for carving, turnery and walking sticks.

Strychnos henningsii Gilg - Loganiaceae

Strychnos henningsii is a small erect, much-branched tree, 2-12 m tall with a clean green-reddish stem. The tree has a peeling, crown compact bark and dark green, glossy foliage. The twigs have pale ashy or straw coloured waxy skin that splits lengthwise. The leaves are opposite, sub-sessile, ovate, 2.5-6.5 cm long and 0.8-4.5 cm wide, with entire margins and acuminate leaf tips. They (leaves) are strongly 3-5 nerved from base, cuneate or rarely subcordate at base. Floral cymes are borne on flat clusters in the leaf axils, 2-2.5 mm long, 4 mm wide when open, scented, yellowish-green in colour but turning orange with age. The fruits are up to 1.9 cm long and 6-11 mm broad, oblong or roundish, 1-2 seeded (coffee-like); red, brown or orange when ripe. The species is hermaphroditic but reproduces cleistogamously in some localities.

Strychnos henningsii commonly occurs in dry or moist forests, wooded hillsides, evergreen thickets on rocky hills, coastal forests and stream banks. It is often associated with *Olea* and *Podocarpus* spp. It grows in altitude ranges between 340 and 2 000 m. It is native to Angola, Kenya, Mozambique, South Africa, Swaziland, Tanzania and Uganda.

The bark contains a poisonous bitter alkaloid that causes paralysis but the species has significant medicinal uses. It is used in African traditional medicine to treat various ailments including rheumatism, syphilis, gastrointestinal disorders (purgative) and snake bites. The ground bark is a mouth antiseptic and applied onto wounds in cattle and horses to hasten healing. Some of the applications can be explained partially by the presence of retulinelike alkaloids. *Strychnos henningsii* has potential in the development of new antinociceptive and antispasmodic drugs.

Strychnos henningsii

Senna didymobotrya

***Senna didymobotrya* Fresenius Irwin & Barneby - Fabaceae - Caesalpinioideae**

Senna didymobotrya is usually a several-stemmed shrub or small tree, 0.5-5(-9) m tall. Branches are terete, striate, pubescent to villous and rarely subglabrous. The leaves are simply paripinnate, narrowly oblong-elliptical in outline, 10-50 cm long with broadly ovate-cordate stipules, 6-17 mm x 8-10 mm with distinct marginal vein. Inflorescence are erect, axillary, 20-30 flowered, spike-like racemes, 10-50cm long, with broadly ovate black green bracts, 8-27 mm x 5-15 mm, at first imbricate and enclosing the flower buds. The fruit are flat, 9-16 seeded pods, linear-oblong, 7-12 cm x 1.5-2.5 cm, glabrescent, short beaked, dehiscent or indehiscent when dry, depressed between the seeds and raised, blackish-brown sutures. The seeds are flattened, oblongoid, apiculate, 8-9 mm x 4-5 mm x 2.5 mm, smooth and pale brown. The species flowers profusely twice a year; in temperate regions it flowers throughout the summer.

In its natural habitat *Senna didymobotrya* is often ruderal in riparian montane wooded grassland or evergreen bushland. It tolerates light frost. It is native to Angola, Ethiopia, Kenya, Mozambique, Sudan and Uganda and grows at altitude ranges of 900-2400 m.

Senna didymobotrya is widely used as a purgative and an anti-malaria medicine. A decoction of the leaves is used against stomach complaints. Leaves and roots contain a number of anthraquinones, choline, and the trisaccharide raffinose. In Africa, it is commonly used as a stupefacient poison for fishing.

Moringa oleifera Lam. - Moringaceae

Moringa oleifera is a small, graceful, deciduous tree with sparse foliage, often resembling a leguminous species at a distance, especially when in flower, but immediately recognized when in fruit. The tree grows to 8 m high and 60 cm dbh. The species is usually a single stem with a crooked bole that is often forked from near the base and with soft wood. The bark is smooth, dark grey; slash thin, yellowish with shortly but densely hairy twigs and shoots. The leaves are alternate and large (up to about 90 cm long), with opposite pinnae, spaced about 5 cm apart up the central stalk, bearing leaflets in opposite pairs, with a slightly larger terminal leaflet. Leaflets are dark green above and pale on the under surface; variable in size and shape, but often rounded-elliptic, seldom as much as 2.5 cm long. Flowers are very sweet smelling, produced throughout the year, in loose axillary panicles up to 15 cm long. Fruits are large and distinctive, up to 90 cm long and 12 mm broad, slightly constricted at intervals. It splits along each angle to expose the rows of rounded blackish oily seeds, each with three papery wings. The bisexual, oblique, stalked, axillary and heteromorphic flowers are highly cross-pollinated due to heteromorphism.

The species readily colonizes stream banks and savannah areas where the soils are well drained and the water table remains fairly high all the year round. It is quite drought tolerant but yields much less foliage where it is continuously under water stress. It is not harmed by frost, but can be killed back to ground level by a freeze. Its biophysical limits include an altitude of 0-1 000 m, mean annual temperature: 12.6 to 40 deg. C and at least 500 mm mean annual rainfall. It is adapted to a wide range of soil types but does well in well drained clay or clay loam without prolonged waterlogging and prefers a neutral to slightly acidic soil reaction. Its native to India, Malaysia, Oman, Qatar, Saudi Arabia, United Arab Emirates and Republic of Yemen but has also been introduced in Afghanistan, Bangladesh, Benin, Burkina Faso, Cameroon, Chad, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Haiti, Indonesia, Iran, Kenya, Kiribati, Liberia, Mali, Marshall Islands, Mauritania, Myanmar, Nepal, Niger, Nigeria, Northern Mariana Islands, Pakistan, Philippines, Senegal, Sierra Leone, Sudan, Tanzania, Thailand, Togo, Uganda, Vietnam and Zanzibar.

Moringa seeds are effective against skin-infecting bacteria *Staphylococcus aureus* and *Pseudomonas aeruginosa*. They contain the potent antibiotic and fungicide terygospermin. The alkaloid spirachin (a nerve paralysant) has been found in the roots. Even when free of bark, the condiment in excess may be harmful. A decoction of the flowers is used as a cold remedy. The gum is diuretic, astringent and abortifacient and is used against asthma. Oil of Ben is used for hysteria, scurvy, prostate problems and bladder troubles. The roots and bark are used for cardiac and circulatory problems, as a tonic and for inflammation. The bark is an appetizer and digestive. The iron content of the leaves is high, and they are reportedly prescribed for anaemia in the Philippines. A good source of protein, vitamins A, B and C and minerals such as calcium and iron, the leaves are used as a spinach equivalent. They are an excellent source of the sulphur-containing amino acids methionine and cystine, which are often in short supply. Suspension of the ground seed of *Moringa oleifera* is used as a primary coagulant. It can clarify water of any degree of visible turbidity.

Moringa oleifera

Dalbergia melanoxylon

***Dalbergia melanoxylon* Guill. et Perrott. - Fabaceae (Papilionoideae)**

Dalbergia melanoxylon is a small, heavily branched tree, typically 4.5-7.5m tall but occasionally reaching 15 m. The bole occasionally reaches 3.6m but normally ranges within 0.2-1.8 m in length and is fluted with high narrow ribs separated by deep indentations. The average dbh at maturity is less than 38 cm, although trees have been found with a dbh of more than 60cm. The stems are often crooked and the bark is pale grey to greyish-brown, papery, fairly smooth, and flaking in long, narrow strips.. Branchlets are clustered at the nodes, some growing out, others short and spine tipped; covered at first with short crisp hairs, usually glabrous. Leaves have a slender, common stalk 5-10 cm long with; 8-13 leaflets sometimes nearly opposite, increasing in size upwards but all much the same shape. The flowers are white, fragrant 6-9 cm long, occurring in dense clusters. The pods are elliptic oblong or irregularly oblong, bluntly pointed, flat and thin, 3-7cm long and 0.5-1.5 cm wide. They tend to be papery, glabrous, laxly and rather diffusely veined, with 1-2 seeds. The flowers are closed with a tripping mechanism that requires specialized manipulation, excluding all but bees as pollinators making the species self-incompatible.

Dalbergia melanoxylon grows under a wide range of conditions including semi-arid, subhumid and tropical lowland areas. It is often found on dry, rocky sites but is most frequent in the mixed deciduous forests and savannahs of the coastal region. This species demands water and light and is therefore common near water and will not regenerate under heavy cover. Mature trees are fire tolerant. Its biophysical limits include an altitude of 0 -1200 m, mean annual temperature of 18-35 deg. C and mean annual rainfall of 700-1200 mm. Soils vary from loamy sands to clayey vertisols (black cotton

soils). It is native to Angola, Botswana, Eritrea, Ethiopia, India, Kenya, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Uganda, Zambia and Zimbabwe

The roots are used in traditional medicines to treat abdominal pain, diarrhoea and syphilis; the wood smoke is inhaled to treat headaches and bronchitis. Other products made from the timber include carvings, turnery and marquetry to produce sculptures, musical instruments, ornaments, inlays, chess pieces, walking sticks, bearings and many other products. The main industrial use, long supporting an export trade from East Africa and Mozambique, is the manufacture of musical instruments, especially woodwinds. With its high density and fine texture, the wood produces a beautiful musical tone. It is stable, stands up to metalwork processes, and takes an excellent finish.

Leonotis mollissima - Labiatae

Leonotis mollissima is an erect woody herb or shrub growing 1-3m with all parts possessing a strong smell. The leaves are woolly, ovate with pointed apices and wavy margins. The flowers are orange, spherical and grouped in 1 – 3 terminal massess.

The species is very common along roadsides, in disturbed grasslands, on forest margins and in montane forests, as well as on hills and mountains at attitudes of 1,200 to 2,600 m. The species prefers full sun and is not picky about soil, although rich soil produces much finer bushes.

Infusions of the roots of *Leonotis* species are taken to treat dysentery, intestinal worms and digestive disorders. The fresh leaves are used as a remedy for stomach cramps. The young leaves are used to treat conjunctivitis. Leave and root decoctions are used to treat wounds, boils, eczema, itching and muscular pains. Leonotis species contain both essential oils and several diterpenoid lactrones.

(Source of information: Dharani and Yenesew, 2010; image not available)

Croton macrostachyus Hochst. ex Ferret et Galinier - Euphorbiaceae

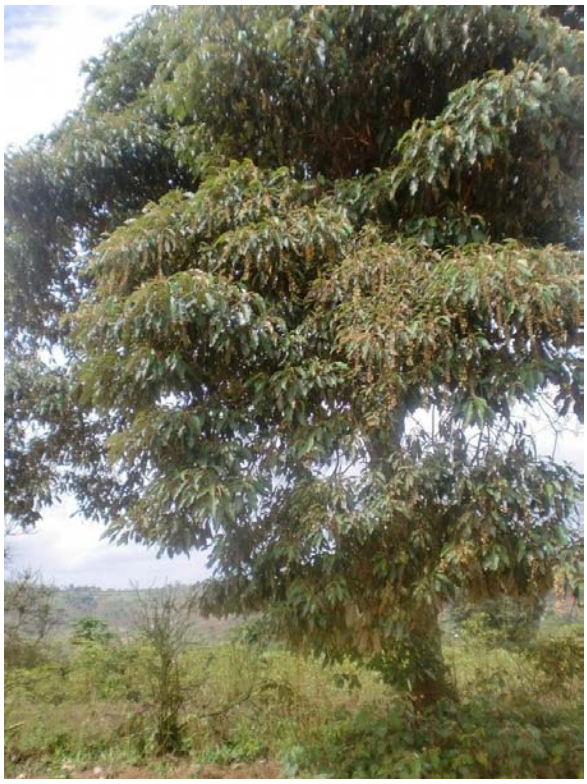
Croton macrostachyus is a deciduous tree 3-25 m high, although more commonly 6-12 m with a rounded open crown and large spreading branches. The bark is pale gray or gray-brown, finely reticulate, fairly smooth, finely fissured with age with reddish slash and densely and shortly hairy shoots. The leaves are large, green but turning to orange before falling, ovate, with subcordate or rounded base with acuminate apex, crenulate-serrulate or subentire margin, 5-19 x 3.5-15 cm, stellate hairy but more densely so beneath on long stems crowded at the ends of branchlets. The flowers are creamy to yellow-white, sweetly scented, to 3 mm long, dioecious or at least on separate shoots, in erect spikes, all over the tree. Sometimes a few female flowers accompany the males, appearing only briefly with the flower spike turning down as fruits mature. Male inflorescence is up to 25 cm long with pedicellate flowers. Female inflorescence is usually less than 10 cm long and subsessile. Fruits are green when young, turning grey at maturity, on drooping spikes to 30 cm long, 3-lobed, 8-9 x 8-10 mm, stellate-pubescent covered at one end by a soft, creamy envelope. Fruits mature when still on the

tree, splitting open with a sharp noise to release seeds. Each pea-sized capsule contains 3 shiny grey seeds with a soft, cream aril.

Croton macrostachyus is common in secondary forests, on forest edges along rivers, around lakes, in moist or dry evergreen upland forests, woodlands, wooded grasslands or clump bushland and along roadsides. It is associated with *Juniperus-Podocarpus* habitats and also occurs in the warmer parts of the montane rain forests and semi-tropical rain forests. Outside the forests, in wetter areas, the species is widely distributed. It is frequent in Uganda and common in the impenetrable Bwindi and in Kibale Forests. Its biophysical limits include an altitude of 200-2000 m and mean annual rainfall between 150 and1200 mm. It is native to Eritrea, Ethiopia, Kenya, Nigeria, Tanzania and Uganda.

Boiled leaf decoction is drunk or ashes taken orally as treatment for cough and juice from fresh leaves is applied on wounds to hasten clotting. Root decoction is used as an anthelmintic for tapeworm, as a purgative, and for malaria and venereal diseases. Bark from the stems and roots is boiled in water and newly born babies are bathed in the mixture as a remedy for skin rash.

Croton macrostachyus



Croton megalocarpus

Croton megalocarpus **Hutch. musine - Euphorbiaceae**

Croton megalocarpus grows to 15-35 m with a distinctive layering of branches and a rather flat crown. It is a hardy and fast growing tree. The bark is dark grey, rough, and crackling. Leaves are variable, long, oval and pointed to about 12 cm. The dull green upper surface contrasts with the pale, silvery underside. Flowers are conspicuous but very short-lived; yellow white, inserted in many flowered, silver-budded racemes, up to 30 cm long. The tree has a few female flowers towards the base while

the remainder are male. The fruit turns from green to greyish-brown as it matures. The endocarp is hard and woody. Each fruit contains 3 ellipsoid-ovoid or oblong-ellipsoid seeds, 2.2- 2.4 cm long and 1.2-1.4 cm wide. Seeds are white when immature but turn grey-brown when mature, with a minute caruncle.

C. megalocarpus is a pioneer species and it is found growing in cleared parts of natural forests, forest margins or as a canopy tree. Its biophysical limits include: altitude: 1 200-2 450 m, mean annual temperature: 11-26 deg. C and mean annual rainfall: 800-1 900 mm. Its native range includes Burundi, Democratic Republic of Congo, Kenya, Malawi, Mozambique, Rwanda, Tanzania and Uganda

Seed contains up to 32% oils, which have been used favourably as medicine. Bark decoction is used as a remedy for worms and whooping cough. The seed is incorporated in poultry feeds, as its protein content is high (50%).

Olea europaea ssp. africana (Mill.) P. Green. – Oleaceae

Olea europaea ssp. africana is a shrub or a small to medium sized tree 5-10 m in height, occasionally reaching 18 m. The bark is grey to brownish-blackish, smooth to rough when old. The leaves are narrowly oblong-elliptic, 2-10 cm x 7-17 mm, grey-green to shiny dark green above but greyish or yellowish with a dense covering of silvery, golden or brown scales on the under surface. The flowers are greenish-white or cream, 6-10 mm long, sweetly scented, in loose auxiliary or occasionally terminal heads, 5-6 cm long. The fruits are ovoid, thinly fleshy, about 10 x 8 mm tapering to a sharp tip, dark brown or black when mature.

O. europaea ssp africana is widely distributed in its native range of southern Africa occurring in a variety of habitats, usually near water, on stream banks, in riverine fringes, but also in open woodland, among rocks and in mountain ravines. It is resistant to both frost and drought. It is found in dry upland evergreen forest (edges, remnants) often associated with *Juniperus*; may be co-dominant and also in woodland on lava flows. It tolerates acid soils and grows at altitudes between 800 and-2 500 m. It is native to China, Eritrea, Ethiopia, France, India, Italy, Kenya, Mozambique, South Africa, Spain, Swaziland, Tanzania, Uganda and Zimbabwe.

The Wandorobo and Kipsigis of Kenya use a root or bark decoction as a remedy for malaria. A tea can be made from the leaves and powdered leaf is used as styptic. Traditional remedies prepared from this plant serve as eye lotions and tonics, lower blood pressure, improve kidney function and deal with sore throats. The plant is also taken internally as a remedy for colic or urinary tract infections The early Cape settlers used the fruits to treat diarrhoea (www.plantzafrica.com/plantnop/oleaeurop.htm)

Olea europaea ssp. africana

Psidium guajava (Source: en.wikivisual.com/index.php/Strawberry_guava)

***Psidium guajava* L. - Myrtaceae**

Psidium guajava is a large dicotyledonous shrub, or small evergreen tree, generally 3-10 m high with many branches. The stem is crooked with light to reddish brown, thin, smooth bark that is continuously flaking. The leaves are opposite, simple with no stipules having short petiole 3-10 mm long, dull grey to yellow-green above and slightly downy below. Inflorescence is axillary, 1- to 3-flowered having pedicles about 2 cm long with two linear bracts. Fruits are ovoid or pear-shaped berries, 4-12 cm long, weighing up to 500 g; with yellow skin when ripe and sometimes flushed with red. The exterior of the fruit is fleshy and the centre consists of a seedy pulp.

P. guajava appears to have evolved in relatively open areas, such as savannah/shrub transitional zones, or in frequently disturbed areas where it is a strong competitor in early secondary growth. The guava is a hardy tree that adapts to a wide range of growing conditions. It can stand a wide range of temperatures; the highest yields are recorded at mean temperatures of 23-28 deg. C. In the subtropics, quiescent trees withstand light frost and 3.5 - 6 months (depending on the cultivar) of mean temperatures above 16 deg. C. It fruits at altitudes up to 1 500 m and survives up to 2 000 m. It grows well on poor soils with reasonably good drainage but growth and production are better on rich clay loams and mean annual rainfall between 1 000 and 2 000 mm. Its native range includes Colombia, Mexico, Peru, United States of America but has been introduced to Australia, Bangladesh, Brunei, Cambodia, Cameroon, China, Costa Rica, Cote d'Ivoire, Cuba, Dominican Republic, Ecuador, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Greece, Guyana, Haiti, India, Indonesia, Israel, Kenya, Laos, Malawi, Malaysia, Myanmar, Nigeria, Pakistan, Panama, Philippines, Puerto Rico, Samoa, Senegal, South Africa, Sri Lanka, Sudan, Tanzania, Thailand, Togo, Uganda, Venezuela and Vietnam.

All parts of the young fruit are astringent. Guava exhibits antibacterial action against intestinal pathogens such as Staphyloccocus. The dried ripe fruits are recommended as a remedy for dysentery, while the leaves and fruits are used as a cure for diarrhoea. Oil contains bisabolene and flavinoides that exhibit anti-inflammatory properties. A decoction of the leaves or bark is taken externally as a lotion for skin complaints, ringworm, wounds, and ulcers. Water from soaking the fruit is good to treat diabetes. Some suggested treatments are as follows:- digestive tract ailments, cold, and high blood pressure: leaf decoction or fruit juice with salt or sugar taken orally. Trauma, pain, headache, and rheumatism: hot leaf decoction compress. Sore throat, hoarse throat: gargle leaf decoction. Varix, ulcer: leaf decoction, treated with warm water, bath. Hepatitis, gonorrhoea, and diarrhoea: clear fruit juice. The species has insecticidal properties and contains an essential oil. The volatile oil with methylchavicol, persein and d-pinene (a paraffin) is found in the leaf.

Osyris lanceolata Hochst. & Steud. ex A. DC. - Santalaceae

Osyris lanceolata is a large, slender hardy shrub or a small tree 7-10 m tall. This multi-stemmed, evergreen hemi-parasitic plant has a round to irregular canopy and a grey smooth bark (later thick and rough). Leaves are sparse, blue-green, simple, alternate, lanceolate, sometimes eggshaped, slightly glaucous, thick in texture, smooth with a waxy bloom, crowded along the stems; the apex is broadly tapering to rounded with a fine, sharp tip. The twigs and leaves point upwards. Flowers are small, unisexual, yellow-green, becoming red when ripe; borne in leaf axils in short panicles or clusters of 2-3 flowers. Fruits are small, edible, 1-seeded drupes, about 1 cm long, fleshy, egg-shaped, and green at first, turning yellow and becoming bright red to purple-black when ripe; crowned with a persistent calyx.

The species is normally found in mountain slopes, rocky ridges where the original vegetation has been cleared. It is also found in Brachystegia woodlands, lowlands and lower slopes; strandveld, gorges, dry forest margins, evergreen bushland, grasslands, thickets and sometimes riverine. It occurs as isolated individuals, in close association with other woody species, and does not occur communally in large numbers. It is frost and drought-tolerant. The species is probably a partial root parasite, growing on the roots of other plants and utilizing the root systems of these hosts, but it does produce its own chlorophyll. As a result this shrub is usually intimately associated with shrubs of other woody species. It is native to Kenya, South Africa and Tanzania and prefers well drained soils exhibiting humic friable clays or deep loams. Other biophysical limits include:- altitude: 900-2550 m, temperature: 14-22ºC and rainfall: 600-1600 mm.

A root decoction is used to treat diarrhoea in Kenya while a decoction of the bark and heartwood is used to treat sexually transmitted diseases and anaemia in Tanzania. Extracts from the plant can cure certain diseases, including the killer Hepatitis B. The roots and wood are scented and used to make cosmetics and perfume; and has a lucrative market in Germany, India, Indonesia and South Africa. The roots and bark are used for tea and as a tonic in soup. Fruits are edible. Ripe fruits are eaten raw,

with the seed discarded; only as an emergency food, especially by children or herdsmen. The bark was used for tanning leather by the voortrekkers while the root gives a strong red dye.

Osyris lanceolata

Plectranthus barbatus (Source: http://www.anniesannuals.com/signs/p%20-%20r/plectranthus_barbatus.htm)

Plectranthus barbatus Andrews - Lamiaceae

Plectranthus barbatus (sometimes referred to as *Plectranthus grandis*), is a sub-shrub or woody herb growing 0.2 - 2m tall. The leaves are petiolate rather densely pubescent with grayish hairs, ovate to broadly ovate blade, 40-100 x 15-50 mm, acute to rounded apex, cuneate-attenuate base and crenate margin. The inflorescence is rather lax; bracts narrowly or broadly ovate, early deciduous; cymes 3-5 flowered, sub sessile; pedicels 4 – 9 mm long in the fruiting stage. The fruiting calyx is 6 – 9 mm long, densely villous inside the throat; upper lip suborbicular or broadly ovate, concave, decurrent; lower lobes 3-4mm long, slightly longer than the lateral lobes. The nutlets are about 1.5 x 1.2mm, black, glossy and produce mucilage when wet (http://plants.jstor.org/flora/flos003361)

The native range of the species includes Eriteria, Ethiopia, East Africa, Arabia, India to Sri Lanka, South China and Thailand. The attitude range is 1000 – 2070m.

In the Caribbean, the leaves of the species are boiled to make an infusion, which is blended with honey to make a tonic for coughs and colds. It is said to be an excellent expectorant. The fumes from the crushed leaves are reported to clear stuffy noses. Traditionally, the juice of the leaves is used to treat asthma, chronic coughs, bronchitis, colic, flatulence and rheumatism. It has also been reported to treat earaches, boils, sprains, painful swellings, and sore throats. The decoction of leaves is also given

after childbirth (Main source: http://www.thairetreats.info/Asian-Herbs-Plectranthus-barbatus.html).

Erythrina abyssinica Lam. ex DC - Fabaceae - Papilionoideae

Erythrina abyssinica is a medium-sized tree, usually 5-15 m in height, deciduous, thickset, with a well-branched, rounded and spreading crown. The trunk is short with a yellow-buff bark when fresh, otherwise grey-brown to creamy brown, deeply grooved, thickly corky and often spiny. The leaves are compound, trifoliolate and alternate with leaflets almost as broad as long, 5.5-15 x 6-14 cm, with the terminal leaflet being the largest. Flowers are spectacular, in strong, sturdy racemes on the ends of branchlets, orange-red, up to 5 cm long with calyx joined to form a tube, split along the under surface almost to the base and separating away into long, slender, distinctive lobes at the apex. Fruits are cylindrical, woody pods, 4-16 cm long, deeply constricted between the seeds, densely furry, light brown in colour, opening to set free one to ten shiny, red seeds with a grey-black patch.

E. abyssinica is the most widespread species in Africa, found in savannahs throughout eastern and southern Africa. As with many trees in areas with frequent fires, the young trees establish a deep root system before stem growth. *E. abyssinica* grows well in most climates but not in dry or high areas. It does not grow in forests. It is native to Botswana, Burundi, Central African Republic, Congo, Democratic Republic of Congo, Eritrea, Ethiopia, Gabon, Kenya, Lesotho, Mozambique, Namibia, Rwanda, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. Its biophysical limits include an altitude range between 1 250 and 2 400 m, mean annual temperature: 10 - 26 deg. C and mean annual rainfall: 800 - 2 000 mm. The species grows best in well-drained soils of pH 3.5 - 5.4.

Pounded parts are used in a steam form in Kenya to treat diseases such as anthrax, and the bark is boiled with goat meat for treating gonorrhoea. The bark of the green stem may also be pounded and then tied into a fine piece of cloth and the liquid from it squeezed into the eyes to cure inflammation of the lids. The bark may be roasted until black, powdered, and applied to burns and general body swellings. A decoction is taken orally as an anthelmintic and to relive abdominal pains. The roots are used to treat syphilis, and the leaves to cure skin diseases in cattle. Seeds of *E. abyssinica* contain a curare-like poison that, if injected into the bloodstream, acts as an anaesthetic that may cause paralysis and even death by respiratory failure.

Erythrina abyssinica

Rhamnus prinoides (Source: www.plantzafrica.com/plantqrs/rhamnusprinoid.htm)

***Rhamnus prinoides* L'Hérit. - Rhamnaceae**

Rhamnus prinoides is a shrub sometimes with the tendency to scramble, or a small, dense, thick, bushy evergreen tree that may reach 9 m in height; usually spineless, with no buttresses. The branchlets are pubescent when young and glabrous when mature; bark grey to brown, smooth, with conspicuous lenticels, becoming dark brown with age. The leaves are alternate, simple, not deciduous, elliptic to oblong elliptic and 2.5 -10 x1.5 - 5 cm in size. Young leaves are light green while mature leaves are very glossy dark green on the topside, dull green on the underside and without hairs. Flowers are greenish-yellow, small, pentamerous, inconspicuous, on slender stalks, in sparse axillary groups or lusters of 2-10, in the axils of the leaves with greenish petals. Fruits are berrylike (drupe), ovoid to almost circular, about 5 mm in diameter, shiny red becoming dark red when mature, sometimes almost black, usually clearly divided into 3 compartments, with a small saucer-shaped calyx, 3-seeded and a thin stalk.

R. prinoides is widespread and locally common at medium to high altitudes, along water courses, in riverine forests and at the margins of evergreen forests. It grows in afro-montane rainforests, undifferentiated afro-montane forests (mixed *Podocarpus* forest, *Juniperus-Podocarpus* forest), and dry, single-dominant afro-montane forest (*Juniperus* and *Juniperus-Olea* forest), especially in clearings and along edges; also in secondary, montane evergreen forests and mountain slopes, frequently among rocks.On grassy hillsides the tree often appears quite black, or at times it glitters in the sun so conspicuously that it can be distinguished at a distance by this aspect alone. It shares this character with 2 other trees, *Olea africana* and *Bequaertiodendron magalismontanum*. The tree casts

so deep a shade that it often prevents other growth around it. It can withstand a fair amount of frost and grows well in light shade under trees and equally well in full sun. It is native to Botswana, Eritrea, Ethiopia, Lesotho, Namibia, South Africa, Swaziland and Uganda but has been introduced to Kenya. It grows at altitude ranges from 0 - 2 100 m and in most soils, but thrives in moist, humus-rich soils.

A decoction of the root is taken as a blood purifier, to treat pneumonia, gonorrhoea rheumatism and stomachache and as a gargle. The leaves are applied as a liniment to simple sprains. Leaf decoction may be mixed with the bark of *Erythrina abyssinica* to alleviate colic. In southern Africa, the chief use of the tree is for magic being widely used as a protective charm to ward off lightning and evil influences from homes and crops, and to bring luck in hunting.

Fagaropsis angolensis Engl. Dale – Rutaceae

Fagaropsis angolensis is a deciduous small to medium-sized tree up to 25 m tall with the bole branchless up to 18 m, usually straight and cylindrical, up to 100 cm in diameter, sometimes with buttresses at base. The bark surface is pale grey to greyish brown, slightly rough and the inner bark is bright orange with a white layer. The crown is spreading with short-hairy, purplish brown twigs. Leaves are opposite, compound with 2 – 4 pairs of leaflets without stipules and with petiole up to 7 cm long; petiolules 1–2 mm long, but in terminal leaflet up to 2 cm. The inflorescence is a terminal panicle up to 12 cm long, with opposite branches. Flowers are unisexual, regular, 4-merous; pedicel 4 – 10 mm long with sepals fused at base, ovate, about 1 mm long, densely hairy, oblanceolate, 3.5–6 mm long, yellowish white to greenish yellow. Male flowers have 4–8 stamens, 2.5 – 4 mm long and rudimentary ovary while female flowers have superior, slightly 4-lobed ovary, 4-celled, with short style and 4-lobed stigma and rudimentary stamens. Fruit are globose drupes 6–8 mm in diameter, pitted with numerous glands, indehiscent with two to four seeds. Seeds are triangular-ovoid, about 5 mm in diameter, grey to black, reticulately furrowed.

Fagaropsis angolensis occurs from eastern DR Congo, southern Sudan and Ethiopia south to northern Angola, Zimbabwe and Mozambique. It occurs in evergreen rainforest and dry evergreen forest or woodland, at 1000–2600 m altitude. It is often found in rocky localities on slopes of mountains, but also on termite mounds. In Ethiopia it is often associated with *Podocarpus*

In Kenya the stem bark of *Fagaropsis angolensis* is used in traditional medicine to treat malaria, and the root is chewed as an expectorant. In Malawi and Zimbabwe root powder is taken in drinks or gruel to treat male sterility. Several alkaloids and limonoids have been isolated from the stem bark, including the anti-malarial benzophenanthridine alkaloid nitidine. Methanol and aqueous extracts of the stem bark showed considerable in-vitro activity against both chloroquine-resistant and chloroquine-sensitive *Plasmodium falciparum* strains. Methanol extracts showed significant toxicity in the brine shrimp test, but water extracts showed only mild toxicity. Canthin-6-one and 5-methoxycanthin-6-one showed fungicidal activity (Source: http://database.prota.org/ - Image not available).

11.2 Appendix 2a: All medicinal plant species mentioned by respondent farmers and herbalists and the diseases treated

In medicinal uses column (6), the conditions in bold were only mentioned by herbalists (traditional healers), the ones in italics were only mentioned by farmers while those in normal script were mentioned by both farmers and herbalists

(1)	**Botanical name** *(2)*	**Local name** *(3)*	**Growth habit** *(4)*	**No of farms mentioned** *(5)*	**Medicinal uses as mentioned by respondents** *(6)*	**No of diseases mentioned by**			**Rank by**	
						Farmers *(7)*	**Herbalists** *(8)*	**Total** *(9)*	**Farmers** *(10)*	**Herbalists** *(11)*
1	*Acacia brevispica*		T	0	**Back/bone joints problems (1h), Ringworms (1h)**	0	2	2	-	249
2	*Acacia drenanolobium*	Muga mbuu (Meru)	T	*3*	*Back/joint/bone problems (1f),* **Cough/colds/flu (1h)** *Diarrhoea (1f), Rheumatism (1f)*	3	1	4	135	167
3	*Acacia geradii*	Mwombombwe (Mbeere)	T	*1*	*Prostrate problems (1f)*	1	0	1	260	-
4	*Acacia mearnsii*	Muthanduku (Embu)	T	5	Chicken pox (9f), Dental problems (2f), Measles (1f, **2h**), Skin diseases (1f), Small pox (3f), Typhoid (1f), **Toothaches (1h)**	6	2	7	97	158
5	*Acacia mellifera*	Mathigira/ muthigira (Mbeere)	T	8	**Asthma (1h),** Back/joint/bone problems (2f, **2h**), Chest problems (3f), Cough/colds/flu (6f, **2h**), General body pains (1f), Malaria (2f)	5	3	6	64	84
6	*Acacia nilotica*	Mucamacama (mbeere), Mucemeri (Embu)	T	15	Amoebiasis (1f), Arthritis (1f), Back/joint/bone problems (2f, **1h**), Cough/colds/flu (8f, **4h**), Energy boost (1f), Heartburns (1f, **1h**), Lack of appetite (2f, **1h**), Leg burns (1f), Malaria (7f), **Neutralises effect of other medicinals (1h),** Stomach disorders (1f, **1h**), Worms (1f, **1h**), **Wounds (1h)**	11	8	13	36	51
7	*Acacia seyal*		T	0	**Amoebiasis (1h)**	0	1	1	-	221
8	*Acacia tortilis*	Mugaa (Mbeere)	T	3	Back/joint/bone problems (1f, **5h**), Cough/colds/flu (1f, **3h**), *Malaria (1f), Pancreatic diseases (1f)***, Pain reliever (2h),** *Pneumonia (1f),* **Puscells (1h), STDs (1h)**	5	5	8	57	83
9	*Acacia xanthophloea*	Murera (Meru)	T	*1*	*Diarrhoea (2f),* Stomach disorders (1f, **2h**)	2	1	2	197	243
10	*Achyranthes aspera*	Gichegene (Meru)	H	*1*	*STDs (1f), Back/joint/bone problems (1f)*	2	0	2	209	-
11	*Acokanthera sp*	Mururu (Meru, Mbeere)	T	1	Malaria (2f), **Livestock (1h)**	1	1	2	142	280
12	*Agave sisalana*	Makonge (Embu, Mbeere), Nkonko (meru)	S	*1*	*Eye problems (1f), Injuries/cuts/wounds (2f),*	2	0	2	277	-
13	*Ajuga remota*	Njeri rurii (Embu), Kirurite (Meru)	H	*26*	*Amoebiasis (1f), Back/joint/bone problems (1f), Bites (1f), Cough/colds/flu (2f), Headaches (1f), Livestock diseases (1f),* Malaria (29f, **5h**), *Rheumatism (1f), Stomach disorders (1f), Typhoid (2f)*	10	1	10	21	128
14	*Albizia amara*	Mukame (Mbeere)	T	**2**	**Back/bone joints problems (3h),** *Cough/colds/flu (2f),* **Chest problems (1h), Cough/colds/flu (2h), Joints (2h),** *Malaria (2f)*	2	4	6	91	98

15	*Albizia anthelmintica*	Mubarwa/ Muvarwa (Mbeere, Embu)	T	*8*	*Allergies (2f),* Amoebiasis (4f, **2h**), *Back/joint/bone problems (1f), General body pains (1f),* **Meat appetizer (1h)**, *Puscells (1f), Malaria (2f),* Stomach disorders (4f, **2h**), Worms (3f, **3h**)	8	4	9	55	150
16	*Albizia gummifera*	Mukorwe / Mukurwe (Embu, Mbeere), Mukuru (Meru)	T	**3**	**Amoebiasis (1h),** *Back/joint/bone problems (3f), Chest problems (1f),* **Malaria (1h),** *Pneumonia (1f),* STDs (1f, **1h**), Stomach disorders (2f, **1h**), *Rheumatism (1f),* **T.B. (1h), Tapeworms (1h), Worms (1h),** *Typhoid (1f)*	7	7	12	111	37
17	*Allium cepa*	Kitunguu	H	*2*	*Cough/colds/flu (1f), Headaches (1f)*	2	0	2	136	-
18	*Aloe sp*	Kibiricha / Kirunja / Murucha / Sukurui (Meru)	H	103	**Allergies (1h),** Amoebiasis (6f, **2h**), *Athletee's foot (1f),* **Arthritis (1h),** *Back/joint/bone problems (6f*), **Blood purifier (1h),** Chest problems (1f, **1h**), *Cough/colds/flu (10f),* Dental problems (3f, **3h**), **Detoxifier (1h), Diabetes (1h), Diarrhoea (1h),** *E.N.T. (1f),* Eye problems (1f, **1h**), **Fatigue (1h),** *Fever (1f), General body pains (2f),* **Goitre (1h),** *Hard stool (1f), Headaches (2f), Heartburns (1f),* **HIV/AIDS (1h),** Injuries/cuts/wounds (37f, **6h**), *Livestock diseases (1f),* Malaria (95f, **30h**), *Mumps (1f), Muscle crumps (1f*), Pneumonia (27f, **18h**), *Poultry diseases (5f),* **Prostrate cancer (1h),** Rheumatism (8f, **1h**), Sceptic wounds (1f), Skin diseases (2f, **4h**), *Stomach disorders (5f),* **Swellings (4h),** Typhoid (8f, **6h**), **Ulcers (2h),**Worms (3f, **1h**), **Wounds (5h)**	26	23	39	2	2
19	*Amaranthus graecizans*	Terere/ Muterere (Embu, Mbeere, Meru)	H		*AIDS (1f), Amoebiasis (1f), Cough/colds/flu (1f), Diabetes (2f), Energy boost (2f), General health (1f), High blood pressure (1f),* Immunity booster (5f, **1h**)*, Increase blood (1f*), Poor digestion (1f, **1h**), *Rheumatism (2f),* **Worms (1h)**	11	3	12	28	242
20	*Anthocleista glandiflora*	Murigarigu (Meru)	S	16	**Amoebiasis (3h), Intestinal worms (1h), Leprosy (1h),** *Livestock diseases (1f), Rheumatism (1f),* **Skin diseases (1h), STDs (1h), Typhoid (1h)**	2	6	8	224	77
21	*Antidesma venosum*	Muthithia / Mwithethuko (Embu)	S	7	Amoebiasis (1f, **2h***), Back/joint/bone problems (1f),* **Blood purifier (1h), Cough/colds/flu (1h), Diabetes (1h), Immune booster (1h), Low libido (1h),** *Malaria (2f),* **Pneumonia (1h), Rheumatism (1h),** *Stomach disorders (1f),* Tonsolitis (1f, **5h**)	5	9	12	74	32
22	*Artemisia annua*	Artemisia	H	1	Malaria (1f, **2h**)	1	1	1	143	129
23	*Arundinaria alpina*	Murangi (Meru)	T	1	**Cough/colds/flu (1h), Mental ailments (1h),** Pneumonia (1f, **1h**), *Rheumatism (1f*), **STDs (1h)**	2	4	5	163	65
24	*Asarum canadense*	Forest ginger	H		**Cough/colds/flu (1h), Mental ailments (1h), Pneumonia (1h), STDs (1h)**	0	4	4	-	52
25	*Azadirachta indica*	Mwarobaini / Mwarubaini (Mbeere, Embu, Meru), Mukwinini (some Mbeere)	T	54	Amoebiasis (2f, **3h**), Back/joint/bone problems (15f, **1h**), **Blood purifier (1h), Brucellosis (1h),** Chest problems (3f, **1h**), Cough/colds/flu (12f, **1h**), Dental problems (2f, **1h**), *Diabetes (2f), Fever (1f), General body pains (3f),* High blood pressure (1f, **1h***), Injuries/cuts/wounds (1f),* **Joints (3h),** *Lack of appetite (1f),* Malaria (126f, **26h**), **Numbness (1h),** *Pimples (1f),* Pneumonia (10f, **8h**), Rheumatism (15f, **3h**), Skin diseases (3f, **1h**), **Puscells (1h), STDs (1h),**Stomach disorders (5f, **1h**), Typhoid (25f, **7h**), *Worms (1f)*	19	18	25	3	6
26	*Balanites aegyptica*	Mubugua (Mbeere,	T		**Cough/colds/flu (1h)**	0	1	1	-	152

		Embu)								
27	*Bauhinia taitensis*	Muiria njara (Mbeere, Embu)	S		**Joints (1h), Malaria (1h), Pneumonia (2h), Rheumatism (1h)**	0	4	4	-	47
28	*Beta vulgaris*	Beet root)	H		**Cancer (1h)**	0	1	1	-	217
29	*Bidens pilosa*	Mucege / Muchege (Embu, Mbeere) Munyugunyugu / Runyugunyugu / Muratha ngii (Meru)	H	*24*	*Amoebiasis (2f), Back/joint/bone problems (2f),* Cough/colds/flu (4f, **1h**), *Dizziness (1f), E.N.T. (1f),* Eye problems (3f, **3h**), *Heartburns (1f), Injuries/cuts/wounds (4f),* Malaria (3f, **1h**), **Pneumonia (1h),** *Rheumatism (2f),* STDs (2f, **2h**), *Stomach disorders (5f), Typhoid (1f)*	13	5	14	16	41
30	*Boscia coriacea*	Kiare (Mbeere), Muthangira (Meru)	H	*4*	*Dental problems (1f), Detoxifier (1f), Eye problems (1f),* **Meat appetite (1h), Pneumonia (1h), Prostrate cancer (1h),** Tonsolitis (6f, **1h**)	4	4	7	205	115
31	*Brassica oleracea*	Cabbage	H	*3*	*Heartburns (4f)*	1	0	1	287	-
32	*Bridelia micrantha*	Mukwego (Embu, Mbeere, Meru), Mukoigo (Embu)	T	10	Back/joint/bone problems (1f, **1h**), **Blood purifier (1h), Brucellosis (1h), Cancer (1h),** *Chest problems (1f),* Cough/colds/flu (3f, **1h**), **Cleans uterus (1h),** *Diarrhoea (1f),* Dizziness (1f, **1h**), **High blood pressure (1h), Increase blood (1h),** Malaria (1f), Pneumonia (2f), Rheumatism (2f), **Skin diseases (1h),** Stomach disorders (2f), **Typhoid (2h)**	9	11	17	27	36
33	*Bridelia taitensis*	Mucee (Mbeere)	S	*2*	*Cough/colds/flu (1f),* **Diarrhoea (1h),** *Livestock diseases (1f)*	2	1	3	178	235
34	*Caesalpinia volkensii*	Mucuthi / Muvuthi (Embu), Mujuthi (Meru)	S	16	Back/joint/bone problems (5f, **2h**), *Cough/colds/flu (1f),* Malaria (49f, **1h**), *Pneumonia (1f), Rheumatism (1f), Rubai (1f),* **STDs (1h),** *Typhoid (2f), Worms (1f)*	8	3	9	25	76
35	*Cajanus cajan*	Njugu (Embu, Mbeere), Gicugu (Mbeere), Ncugu (Meru)	S	*4*	*Amoebiasis (1f), Bites (1f), Malaria (2f), Snake bites (1f), Stomach disorders (1f)*	5	0	5	98	-
36	*Camelia sinensis*	Tea leaves	T	*1*	*Stomach disorders (1f)*	1	0	1	225	-
37	*Capparis tomentosa*	Mukarakara (Mbeere, Meru)	S	2	Cough/colds/flu (3f), **Back/bone joints problems (1h), Prostrate cancer (1h)**	1	2	3	177	197
38	*Capsicum sp*	Kanyenje (Mbeere), Pilipili (Meru)	H	*2*	*Constipation (1f), Poultry diseases (1f)*	2	0	2	285	-
39	*Carica papaya*	Mubabai (Embu, Mbeere, Meru)	T	*52*	*After-birth pains (1f),* **Allergies (1h),** Amoebiasis (23f, **1h**), Asthma (1f, **1h**), *Back/joint/bone problems (1f), Body weakness (1f), Chest problems (1f), Constipation (1f), Cough/colds/flu (4f),* Dental problems (8f, **1h**), **Diarrhea (1h),** *Heartburns (1f), Injuries/cuts/wounds (1f), Livestock Chicken diseases (1f), Malaria (2f),* **Placenta removal (1h),** *Prostrate problems (2f), Remove after birth (1f),* Rheumatism (5f, **1h**), Skin diseases (1f, **1h**), *STDs (12f), Stomach disorders (3f), Typhoid (3f),* Worms (2f, **1h**)	20	9	23	7	29
40	*Carissa spinarum*	Mukamuria (Meru), Mukawa (Embu, Mbeere)	S	*8*	*After-birth pains (1f,* **1h***),* **Amoebiasis (1h),** Back/joint/bone problems (4f, **1h**), **Cancer (1h),** *Chest problems (1f),* **Cleans stomach (1h),** Cough/colds/flu (5f, **4h**), *Diarrhoea (1f),* **Drug preservative (1h),** *Energy boost (1f),* **General body health (1h), High blood pressure (1h), Low libido (1h),** Malaria (19f, **3h**), **Meat appetizer (1h),**	13	17	24	26	5

					Painkiller (1f), Pneumonia (3f, **1h**), *Puscells (2f),* Reduces side effects of other medicines (1f, **1h**), *Rheumatism (4f),* **STDs (1h),** Stomach disorders (1f, **2h**), **T.B. (1h), Worms (1h)**					
41	*Cassipourea malosana*	Muthaguta (Mbeere)	S		**Cancer (1h), Fibroids (1h), Wounds (1h),**	0	3	3	293	145
42	*Catha edulis*	Miraa (Embu, Mbeere, Meru	T	*5*	*Cough/colds/flu (1f), Dental problems (1f), Diarrhoea (3f), Livestock flu (1f), Rheumatism (1f),*	5	0	5	101	-
43	*Cissampelos pareira*	Karigi kanononngwe (Mbeere)	H	22	Amoebiasis (9f, **2h**), **Asthma (1h),** *Diarrhoea (1f),* Stomach disorders (18f, **2h**), **Typhoid (1h),** *Vomiting (1f), Worms (1f)*	5	4	7	108	69
44	*Citrullus lanatus*	Melon	H	*1*	*Blood cleanser (1f)*	1	0	1	294	-
45	*Citrus limon*	Mutimu (Embu, Mbeere) Ndimu, Murimu (Embu)	T	38	**Asthma (1h), Back/joint/bone problems (1h),** *Blood cleanser (1f), Chest congestions (1f),* Cough/colds/flu (43f, **3h**), *E.N.T (1f), Lack of appetite (1f), Malaria (2f), Rheumatism (2f), Typhoid (1f)*	8	3	10	41	85
46	*Citrus reticulata*	Sandara (Mbeere)	T	*1*	*Cough/colds/flu (2f)*	1	0	1	179	-
47	*Citrus sinensis*	Muchunkwa (Meru), Mucungwa (Embu, Mbeere)	T	8	**Arthritis (1h),** *Cough/colds/flu (6f),* **Cancer (1h), Low libido (1h), Nose bleeding (1h),** *Rheumatism (1f)*	2	4	6	137	151
48	*Commelina benghlensis*	Mukengeria (Mbeere)	H		**Dislocations (1h), Injuries/cuts/wounds (1h)**	0	2	2	-	233
49	*Clerodendrum myricoides*	Munjuga-iria (Embu), Muthuguni (Mbeere)	S	*2*	*Back/joint/bone problems (1f),* **Burns (1h), Cough/colds/flu (3h), Puscells (1h), Malaria (1h),** *Stomach disorders (1f),* **Tonsolitis (1h)**	2	5	7	50	55
50	*Coffea arabica*	Kaua (Embu, Meru)	S	4	**Allergies (1h),** *Lack of appetite (1f),* **Low libido (1h), Pneumonia (2h),** *Pregnancy problems (1f), Rheumatism (1f),* **Sleeping sickness (1h)**	3	4	7	213	119
51	*Combretum collinum*	Muraba / Murava (Mbeere)	T	*12*	*Amoebiasis (3f),* **Back/bone joints problems (2h), Cough/colds/flu (1h),** Diarrhoea (1f, **1h**), Malaria (2f, **1h**), *Pneumonia (1f),* **Puscells (1h),** Stomach disorders (10f, **4h**), **T.B. (1h),** Typhoid (1f, **2h**)	6	b	10	39	14
52	*Combretum molle*	Murama (Mbeere)	T	*11*	*Back/joint/bone problems (3f), Cough/colds/flu (1f),* Diarrhoea (7f, **2h**), *General body pains (1f), Malaria (2f), Reduces side effects of other medicines (1f), Stomach disorders (4f),* Typhoid (2f, **2h**)	8	2	8	30	148
53	*Combretum zeyheri*	Mugereki (Mbeere)	T	*1*	*Stomach disorders (1f)*	1	0	1	226	-
54	*Commiphora eminii*	Muthithio / Mutunguu (Meru)	T	*7*	*After-birth pains (1f), Constipation (1f), Hard stool (1f), Rheumatism (1f), STDs (1f), Stomach disorders (4f),*	6	0	6	141	-
55	*Cordia africana*	Muringa Embu, Mbeere, Meru)	T	12	**Amoebiasis (1h),** Back/joint/bone problems (1f, **2h**), *Cancer (1f),* **Eye problems (1h), Family planning (1h),** *Heartburns (1f), Injuries/cuts/wounds (1f),* Livestock diseases (3f, **1h**), **Pneumonia (1h), Puscells (1h), Reduces labour pains (1h),** *Stomach disorders (3f), Typhoid (1f)*	7	8	13	82	57
56	*Crotalaria spp*	Mucugucugu (Embu)	S	2	**Dental problems (1h),** *E.N.T. (1f), Malaria (1f),* Skin diseases (1f, **1h**)	3	2	4	123	188
57	*Croton macrostachyus*	Mutundu (Embu,	T	*48*	*Acaricide (1f),* **Asthma (1h),** *Bites (1f),* Cough/colds/flu (1f, **1h**)), *Dental problems*	16	11	23	29	25

		Mbeere), Mutuntu (Meru)			*(3f), Diarrhoea (1f), General body pains (1f)*, **Heart problems (1h), Increase body temperatures (1h),** Injuries/cuts/wounds (43f, **1h**), *Livestock (pregnancy test in cows, 3f), Malaria (1f), Measles (2f), Mumps (1f),* **Pneumonia (2h), Puscells (1h),**Rheumatism (4f, **2h**), *Skin diseases (1f),* STDs (1f, **1h**), **Straightens muscles (1h),** *Thorn pricks (3f), Worms (5f),* **Wounds (1h)**					
58	*Croton megalocarpus*	Mui/ Muui (Meru), Mukinduri (Embu, Mbeere), Mutundu (some Meru)	T	*40*	*Amoebiasis (7f), Back/joint/bone problems (3f), Body weakness (1f), Chest congestions (1f), Chest problems (2f),* Cough/colds/flu (1f, **3h**), *Dental problems (3f), General body pains (1f), Headaches (1f),* Injuries/cuts/wounds (5f, **1h**), *Livestock diseases (4f),* **Low libido (1h),** Malaria (11f, **2h**), Pneumonia (1f, **4h**), **Puscells (1h),** Rheumatism (6f, **2h**), *STDs (3f), Stomach acid (1f), Stomach disorders (3f), Swellings (1f),* Typhoid (12f, **6h**), **Ulcers (1h),** Worms (1f, **2h**)	21	10	24	4	15
59	*Curcubita maxima*	Marenge (Embu, Mbeere, Meru), Kirenge (some Mbeere)	H	*17*	*AIDS (3f), Amoebiasis (3f), Bites (2f), Cancer (1f), General health (2f), Hard stool (1f), Immunity booster (1f), Low libido (2f), Operated mother (1f), Prostrate problems (1f), Skin diseases (1f), Snake bites (9f), Stomach disorders (1f), Worms (1f)*	14	0	14	34	-
60	*Cupressus lusitanica*	Muthithinda (Mbeere)	T		**Cancer (1h), Epilepsy (1h), Grey hair (1h), Rheumatism (1h), Skin diseases (1h),** *Typhoid (1f)*	1	5	6	-	88
61	*Cussonia holstii*	Mwenjera (Meru)	T	3	**Back/bones/joints problems (1h),** *Cough/colds/flu (2f),* **Kwashiakor (2h),** Malaria (1f, **1h**), *Rheumatism (1f)*	3	3	5	78	100
62	*Cyathula polycephala*	Mutegenye (Embu)	H		Dental problems (2f, **1h**)	1	1	1	266	208
63	*Cymbopogon afronardus*	Ciakimora, gakimora, kimora (Mbeere)	H	*6*	*Cough/colds/flu (3f), Fever (1f), Malaria (4f), Stomach disorders (2f)*	4	0	4	69	-
64	*Cymbopogon sp*	Gicaki, Gichaki, Gicaki gia cai (Embu, Mbeere)	S	8	Cough/colds/flu (7f, **2h**), *Malaria (2f),* **Nervousness (1h)**	2	2	3	95	68
65	*Cynoglossum coeruleum*	Kagwata ng'ondu (Mbeere)	H		*Back/joint/bone problems (1f)*	1	0	1	214	-
66	*Cyperus laevigatus*	Ndago / kirago (Embu, Mbeere)	H	*1*	*Chicken pox (1f), Malaria (1f), Stomach disorders (1f)*	3	0	3	210	-
67	*Cyphostemma bambusati*	Mu-ututu	S	2	Back/joint/bone problems (1f, **5h**), **Cough/colds/flu (1h), HIV/AIDS (1h), Low libido (2h), Malaria (1h), Rheumatism (1h), Sore throat (1h), STDs (1h), Stomach disorders (1h)**	1	9	9	215	16
68	*Dalbergia melanoxylon*	Mubingo / Muvingo (Mbeere)	T	6	**Artery problems (1h),** Back/joint/bone problems (6f, **6h**), Chest problems (2f, **1h**), Cough/colds/flu (3f, **3h**), **Dental problems (1h),** Malaria (2f, **1h**), Pneumonia (1f, **2h**), **Rheumatism (1h),** *Typhoid (1f)*	6	8	9	15	20
69	*Daucus carota*	Carrots	H	2	**Heartburns (1f), Stomach disorders (1f)**	0	2	2	212	-
70	*Dioscorea sp*	Gikwa (Embu)	S	1	**Fibroids (1h), Uterus cleaning (1h),** *Worms (1f)*	1	2	3	261	220
71	*Dioscorea minutifolia*	Rukwa rwa ngoma / mbiti (Embu)	H	*1*	*Blood cleanser (1f), Viral diseases (1f), Rheumatism (1f)*	3	0	3	227	-

72	*Dodonaea viscosa*	Muremamuthua (Mbeere, Meru)	T		**Back/bone joints problems (1h),** *Diarrhoea (1f),* **Stomach disorders (1h)**	1	2	3	-	183
73	*Dombeya rotundifolia*	Mutootoo (Mbeere)	T		*Back/joint/bone problems (1f), Cough/colds/flu (1f),* **Malaria (1h)**	2	1	3	133	130
74	*Dombeya torrida*	Mukeu	S		**Joints (1h), Rheumatism (1h)**	0	2	2	-	164
75	*Dovyalis abyssinica*	Muro / Muroo (Meru), Mukambura (Embu)	T	*3*	*Back/joint/bone problems (1f), Cough/colds/flu (1f), Lack of appetite (1f), Malaria (1f),* Rheumatism (2f**, 1h), Stomachache (1h),** *Worms (2f)*	8	2	7	206	157
76	*Dovyalis caffra*	Kei apple (Meru), Muroo (Mbeere, Embu)	T	*1*	*Lack of appetite (1f), Malaria (1f), Rheumatism (1f),*	3	0	3	114	-
77	*Dracaena steudneri*	Kithare (Embu)	T	1	**Cancer (1h), Toothaches (1h),** *Rheumatism (1f),* **Worms (1h)**	1	3	4	228	106
78	*Echinacea sp*	Echinacea	H		**Painkiller (1h)**	0	1	1	-	282
79	*Ehretia cymosa*	Murembu (Meru)	T	*5*	*Livestock diseases (1f), Malaria (1f), Rheumatism (3f),*	3	0	3	122	-
80	*Ekebergia capensis*	Muchogomo (Meru)	T	*2*	*Fever (1f),* **Swellings (1h)**	1	1	2	272	283
81	*Eleusine coracana*	Ugimbi (Mbeere)	H	*1*	*Cough/colds/flu (1f)*	1	0	1	183	-
82	*Elytrigia repens*	Thangari	H)	1	**STDs (1h),** Back/bone joints problems (1f, **1h),** *Chest problems (1f),* Cough/colds/flu (1f, **2h**), **Gouts (1h),** *Malaria (1f)*	4	4	6	216	126
83	*Engleromyces goetzei*	Kibia kia murangi (Embu, Mbeere)	S		**Stomachaches (1h)**	0	1	1	-	244
84	*Ensete ventricosum*	Gikobo (Meru)	S	*1*	*Dental problems (3f),* **Dislocations (1h),** Injuries/cuts/wounds (4f, **1h**), **STDs (1h),** Worms (1f, **1h**)	3	4	5	208	146
85	*Entada leptostachya*	Mucaritha (Mbeere)	T	1	**Amoebiasis (1h), Eye problems (1h), Knee problems (1h), STDs (1h)**	0	5	5	-	114
86	*Erigeron canadensis*	Horse weed	H		**Toothaches (1h)**	0	1	1	-	209
87	*Erythrchlamis spectabilis*	Mucibibi	S		**Asthma (1h),** Cough/colds/flu (*1f***, 1h)**	1	2	2	168	109
88	*Eriobotrya japonica*	Mucuca (Embu)	T	*2*	*Kwashiakor (1f), Marasmus (1f), Stomach disorders (1f)*	3	0	3	165	-
89	*Erythrina abyssinica*	Mubuti / muvuti / muhuti (Embu, Mbeere), Muuti (Meru)	T	*40*	*Allergies (1f),* Amoebiasis (1f, **1h**), **Antidote (1h),** Back/joint/bone problems (1f, **2h**), **Bilharzia (1h), Cancer (1h), Cholera (1h),** Cough/colds/flu (3f, **1h**), Dental problems (12f, **6h**), Diarrhoea (14f, **1h**), **E.N.T. (1h),** *General body pains (1f),* **High blood pressure (1h), Increase blood (1h),** Injuries/cuts/wounds (2f, **1h**), **Livestock (1h),** Malaria (5f, **3h**), **Male paralysis (1h), Measles (1h), Meat appetizer (1h), Neutralises other medicinals (1h),** Pneumonia (6f, **1h**), *Prostrate problems (1f),* Rheumatism (7f, **2h**), **Rift valley fever (1h),** STDs (1f, **1h**), Stomach disorders (8f, **1h**), Typhoid (4f, **1h**), **Ulcers (2h), Uterus problems (1h), Vomiting (1h), Whooping cough (1h),** Worms (2f)	16	30	33	6	3
90	*Eucalyptus saligna*	Munyua maai (Embu)	T	1	Cough/colds/flu (1f), Injuries/cuts/wounds (1f), Malaria (1f), Skin diseases (1f)	4	0	4	84	-
91	*Eucalyptus globulus*	Gikobo / Gitoi / Mpau mauta (Meru), Munyua mai (Embu)	T	*38*	*Allergies (3f), Back/joint/bone problems (2f), Chest problems (1f), Chicken pox (2f), Cough/colds/flu (23f), Fever (6f), Headaches (1f),* Injuries/cuts/wounds (2f,	17	1	17	10	259

					1h), *Livestock diseases (1f), Malaria (5f), Measles (4f), Pneumonia (2f), Rheumatism (4f), Skin diseases (4f), Slow urine passing (1f), Small pox (1f), Stomach disorders (1f)*					
92	*Eucalyptus sp*	Munyua maai (Mbere)	T		*Back/joint/bone problems (2f),* Cough/colds/flu (2f, 4h), *General body pains (1f),* **Lung problems (1h),** *Malaria (2f*), **Measles (1h), Skin diseases (1h**), Small pox (1f)	5	3	8	73	96
93	*Euclea divinorum*	Mukinyi (Embu, Mbeere), Murikinyei (Meru)	S	*2*	*Dental problems (9f), Diarrhoea (1f),* **Dislocation (1h), Indigestions (1h),** *Livestock diseases (1f)*	3	2	5	202	266
94	*Euphobia candelabrum*	Githuri (Mbeere)	T	*3*	*Eye problems (1f), Malaria (2f)*	2	0	2	127	-
95	*Euphorbia tirucalli*	Gikega / mukega (Mbeere), kariaria (Embu), Kathuri / Muthuri (Meru)	S	*11*	*Cancer (1f), Eye problems (2f), Injuries/cuts/wounds (5f), Livestock diseases (2f), Malaria (3f), STDs (1f), Stomach disorders (2f), Typhoid (1f)*	8	0	8	54	284
96	*Fagaropsis angolensis*	Mukuria mbungu (Mbeere), Murumu (Meru), Muvindivindi (Embu)	T	9	Amoebiasis (3f, **1h**), *Back/joint/bone problems (3f), Cough/colds/flu (1f),* **Diarrhoea (1h), Dysentry (1h),** *Livestock diseases (1f),* Malaria (14f, **1h**), *Rheumatism (7f), Stomach disorders (3f), Typhoid (1f),* Worms (1f, **1h**)				23	56
97	*Fagaropsis hildebrandtii*	Kivia (Mbeere)	S		**Arthritis (1h), Cough/colds/flu (1h)**	0	2	2	-	117
98	*Faurea saligna*	Mwanjati (Mbeere)	T	1	**Asthma (1h),** *Back/joint/bone problems (2f), Chest problems (1f), Cough/colds/flu (1f), Energy boost (1f), General body pains (1f)*	5	1	6	116	214
99	*Ficus benjamina*	Mugumo (embu)	T		*Chest problems (1f), Diarrhoea (2f), Headaches (1f), Livestock diseases (1f), Stomach disorders (1f)*	5	0	5	126	-
100	*Ficus sur*	Mugumo (Meru), Mukuu (Embu)	T	*3*	*Back/joint/bone problems (1f), Cough/colds/flu (1f), Dental problems (2f), Diarrhoea (1f), Pneumonia (1f), Stomach disorders (3f)*	6	0	6	58	-
101	*Ficus sycomorus*	Mugumo (Meru), Mukuu/mukuyu (Embu, mbeere)	T	10	**Allergies (1h),** *Amoebiasis (1f),* Dental problems (12f, **2h**), Diarrhoea (2f, **2h**), **Kidney cleaner (1h),** *Malaria (1f), Meat allergy (2f),* **Menstrual inconsistency (1h), Pneumonia (1h), Puscells (1h),** *Stomach disorders (1f),* Swellings (1f, **1h**), **Typhoid (1h)**	7	9	13	60	34
102	*Ficus thonningi*	Mugumo (Embu), Mukuu (Meru)	T	*3*	*Dental problems (2f),* Diarrhoea (1f, **2h**), **STDs (1h), Typhoid (1h), Uterus problems (1h)**	2	4	5	203	97
103	*Flacourtia indica*	Muraga (Meru), Muroo (Mbeere),	T	*1*	*Back/joint/bone problems (1f),* Malaria (2f, **2h**), *Worms (1f),* **Pneumonia (2h)**	3	2	4	100	79
104	*Fluegga virosa*	Mukururu (Embu, Mbeere)	T	*5*	*Amoebiasis (1f),* **Bilharzia (1h),** *Dental problems (2f), Malaria (1f),* **Meat allergy (1h), Prostrate cancer (1h),** *Typhoid (1f)*	4	3	7	67	200
105	*Foeniculum vulgare*	Fennel	H		**Colic (1h), Vit A supplement (1h)**	0	2	2	-	285
106	*Fragaria sp*	Strawberry	H		**Alertness (1h)**	0	1	1	-	273
107	*Gardenia volkensii*	Mukumuti (Mbeere)	T	*2*	*Back/joint/bone problems (1f),* **Burns (1h),** *Malaria (1f), STDs (1f)*	3	1	4	109	286
108	*Grevillea robusta*	Mukima (Embu, Meru),	T		*Back/joint/bone problems (1f),* **Cough/colds/flu (1h),** *Worms (1f)*	2	1	3	201	169

		Muthanduku (some Meru)								
109	*Grewia bicolor*	Kigucu (Mbeere), Murenda (Embu)	T	*3*	*Cough/colds/flu (1f), Diarrhoea (1f)*	2	0	2	138	-
110	*Grewia tembensis*	Muruba (Mbeere)	S	*2*	*Injuries/cuts/wounds (1f),* **Malaria (1h)**	1	1	2	295	131
111	*Grewia villosa*	Mubuu	T		**Malaria (1h)**	0	1	1	-	132
112	*Hagenia abyssinica*	Mujoga (Meru)	T	3	Amoebiasis (1f, **1h**), *Cough/colds/flu (1f), Headaches (1f*), Rheumatism (1f, **1h**), *Stomach disorders (2f),* **Typhoid (1h)**	5	3	6	77	94
113	*Harrisonia abyssinica*	Mutagataga (Embu)	S	1	**Blood purifier (1h),** Malaria (1f, **1h**)	1	1	2	144	133
114	*Hibiscus fuscus*	Mukumaa (Mbeere)	S	*1*	*Cough/colds/flu (1f)*	1	0	1	182	-
115	*Hoslundia opposita*	Mucobi (Mbeere), Muchibibi (Embu)	S	*1*	*Cough/colds/flu (1f), Typhoid (1f)*	2	0	2	183	-
116	*Hydrastis canadensis*	Golden seal	H		**Painkiller (1h)**	0	1	1	-	287
117	*Indigofera lupatana*	Mugiti (Embu, Mbeere)	S	1	Cough/colds/flu (1f, **1h**), **Epiglotis hair (1h)**	1	2	2	184	118
118	*Ipomoea kituiensis*	Ikothokotho (Mbeere)	S	*1*	*Typhoid (1f)*	1	0	1	169	-
119	*Jacaranda mimosifolia*	Jacaranda	T		**STDs (1h)**	0	1	1	-	270
120	*Jatropha curcas*	Mucariki (Embu, Mbeere), Kiariki (Meru)	T	*15*	*Burns (1f), Injuries/cuts/wounds (16f), Snake bites (2f), Stomach disorders (1f)*	4	0	4	233	-
121	*Juniperus procera*	Murana (Embu)	T	*3*	*Amoebiasis (4f), Cough/colds/flu (1f),* Diarrhoea (2f, **1h**), **Gall bladder (1h),** *Kidney problems (1f),* **Knock swells (1h),** *Malaria (1f),* **Placenta removal (1h),** *Rheumatism (2f), Stomach disorders (4f), Typhoid (1f), Worms (2f)*	9	4	12	18	198
122	*Kigelia africana*	Kiratina / Muratina (Embu, Mbeere), murantina (Meru)	T		**Arthritis (1h),** *Asthma (1f),* **Cleans digestive systems (1h),** *Depression (1f),* **Low libido (2h), Rheumatism (1h), STDs (3h), Typhoid (1h)**	2	7	8	273	78
123	*Lannea fluccosa*	Kitharara (Mbeere)	T	*3*	*E.N.T (1f)*	1	0	1	283	-
124	*Lannea schimperi*	Mukomothi (mbeere)			**Low libido (1h)**	0	1	1	-	-
125	*Lannea sp.*	Mubindabindi (Mbeere)			**Allergies (1h), Arthritis (1h), Back/bone joints problems (2h), Blood purifier (1h), Cough/colds/flu (2h), Diabetes (1h), Dislocation (1h), Gouts (1h), Joints (2h), Liver (1h), Pneumonia (2h), Prostrate cancer (1h), Toothaches (2h)**	0	13	13	-	17
126	*Lannea stulmannii*	Muraci (Mbeere)		**1**	**Cough/colds/flu (1h),** *Malaria (1f),* **STDs (1h), Urinary system infections (1h)**	6	7	11	93	111
127	*Lantana camara*	Macimoro / Mucimoro / Mucirigu / Mukenia / Muthirigu (Embu, Mbeere)	S	*17*	*Amoebiasis (1f),* **Back/joint/bone problems (1h)** *Cough/colds/flu (3f), Dental problems (2f),* Headaches (12f, **1h**), Injuries/cuts/wounds (4f, **1h**), *Malaria (1f)*	3	6	7	56	154

128	*Lantana trifolia*	Muthiriti (Embu)	S	*15*	*Back/joint/bone problems (1f),* Cough/colds/flu (23f, **7h**), *Fever (2f), Malaria (1f), Pneumonia (1f)*	5	1	5	53	172
129	*Larrea tridentata*	Chaparral	H		**Arthritis (1h), Cancer (1h)**	0	2	2	-	161
130	*Launea cornuta*	Muthunga (Embu)	H	3	Amoebiasis (2f, **2h**), **Diabetes (1h), Lack of appetite (1h),** *Low libido (1f),* Stomach disorders (1f, **2h**), Typhoid (1f, **1h**), Worms (1f)				88	63
131	*Leonotis mollissima*	Kabobo / Kavovo / Murungwa / Mwirungwa (Mbeere)	S	14	Amoebiasis (8f, **7h**), *Back/joint/bone problems (2f), Cough/colds/flu (1f), Dental problems (1f),* Diarrhoea (1f, **1h**), **Indigestion (1h),** *Lack of appetite (4f),* Malaria (6f, **1h**), *Rheumatism (3f),* Stomach disorders (15f, **5h**), **Ulcers (1h),** Worms (2f, **1h**)	10	7	12	24	39
132	*Lippia kituiensis*	Kithiriti / mathiriti (Mbeere)	S	*2*	*Cough/colds/flu (1f)*	1	0	1	185	-
133	*Lonchocarpus eriocalyx*	Muthigiriri (Mbeere), Muthingiiri (Meru)	T	8	Back/joint/bone problems (2f, **1h**), Chest problems (3f, **1h**), Cough/colds/flu (2f, **5h**), *Low libido (1f), Malaria (1f), Pneumonia (1f), Puscells (1f),* Stomach disorders (1f, **1h**),	7	4	7	37	73
134	*Macadamia tetraphylla*	Mukadamia (Embu)	T		**Allergies (1h)**	0	1	1	-	255
135	*Macaranga kilimandscharica*	Mukarati	S		**Cancer (1h)**	0	1	1	-	218
136	*Mangifera indica*	Muembe	T	45	Allergies (1f, **1h**), *Amoebiasis (2f), Back/joint/bone problems (1f),* Burns (13f, **1h**), *Chest problems (1f),* Cough/colds/flu (25f, **7h**), *Diabetes (1f),* **Goitre (1h), High blood pressure (1h),** Injuries/cuts/wounds (4f, **1h**), *Kwashiakor (1f), Malaria (2f), Pneumonia (1f), Rheumatism (2f), Typhoid (1f)*	13	6	15	9	71
137	*Maranta arundinacea*	Arrow root	H		*Tonsolitis (1f)*	1	0	1	289	-
138	*Markhamia lutea*	Muu / Miu (Embu, Mbeere), Mung'uani/ Kiugu (Meru)	T	*10*	*Amoebiasis (2f), Back/joint/bone problems (1f), Chest problems (1f), Diarrhoea (1f),* **Family planning (1h),** *Injuries/cuts/wounds (1f),* Malaria (1f, **1h**), **Measles (1h), Pancreas problems (1h),** *Rheumatism (1f), STDs (2f), Stomach disorders (1f),* **Typhoid (1h)**	9	5	13	45	58
139	*Maytenus senegalensis*	Muthunthi / Muthuthi (Mbeere)	T	*4*	*Amoebiasis (1f), Back/joint/bone problems (1f), Constipation (1f),* **Cough/colds/flu (1h),** *Fever (1f),* **Indigestions (1h),** Malaria (1f, **1h**), Stomach disorders (5f, **1h**)	6	4	8	65	50
140	*Melia azedarach*	Mukaramatu (Mbeere)	T	*6*	*Immunity booster (1f), Malaria (3f), Stomach disorders (1f), Typhoid (1f)*	4	0	4	52	-
141	*Melia volkensii*	Mukau (Mbeere)	T	6	**Amoebiasis (1h),** *Chest problems (1f),* Cough/colds/flu (3f, **3h**), Malaria (1f, **2h**), **Pneumonia (1h),** *Stomach disorders (1f)*	4	4	6	72	42
142	*Mentha arvensis*				**Cough/colds/flu (1h)**	0	1	1	-	173
143	*Mexican marigold*	Mubangi (Embu, Mbeere), Bangi (Meru)	H	*9*	*Amoebiasis (1f), Back/joint/bone problems (1f),* **Cough/colds/flu (1h),** Dental problems (6f), **Diabetes (1h),** *Headaches (1f), Herbicide in food storage (1f), Injuries/cuts/wounds (5f), Skin diseases (1f),* **T.B. (1h)**	7	3	10	110	49
144	*Milicia excelsa*	Mururi (Embu)	T	8	**Allergies (1h),** *Bites (1f),* **Cancer (1h),** *Cough/colds/flu (2f),* Dental problems (2f, **1h**), **Family planning (1h), High blood pressure (1h),** Malaria (1f, **1h**), *Stomach disorders (1f),* **STDs (1h),** Typhoid (1f, **1h**)	6	8	11	46	26

145	*Millettia dura*	Mubangua (Embu), Muangua (Meru)	T	4	**Allergies (1h),** Cough/colds/flu (1f), Malaria (3f, 2**h**), **Typhoid (1h), Worms (2h)**	2	4	5	96	59
146	*Monanthotaxis schweinfurthii*	Muga njuki (Mbeere)	T	*1*	*Malaria (1f), Rheumatism (1f)*	2	0	2	119	-
147	*Mondia whytei*	Mukuura, muukuro (Meru)	H	3	**Allergies (1h),** Cough/colds/flu (2f, **1h**), **Dental disorders (1h),** *Malaria (1f),* **Rheumatism (1h),** *Stomach disorders (1f)*	3	5	6	204	60
148	*Moringa oleifera*	Moringa(vera)	T	*8*	*AIDS (2f),* Amoebiasis (1f, **1h**), **Asthma (1h),** Blood cleanser (3f), **Blood purifier (1h), Cancer (1h), Chest problems (1h), Cough/colds/flu (1h), Detoxifier (1h), Fibroids (1h), General body health (1h), Immune booster (2h),** Malaria (2f, **4h**), **Protein source (1h), Rheumatism (2h), Stomach acid (1h),** Stomach disorders (1f, **1h**), **Typhoid (1h)**	6	17	18	70	9
149	*Morus alba*	Mutare (Embu, Mbeere), Mutaratare / Ntaratare (Meru)	T	*3*	*Cough/colds/flu (1f), Dental problems (1f), Rheumatism (1f), Stomach disorders (1f), Worms (1f)*	5	0	5	83	-
150	*Musa sp*	Kiongoro kia irigu, Marigu (Embu, Mbeere, Meru)	S	*7*	*Back/joint/bone problems (1f), Burns (1f),* **Cough/colds/flu (2h),** Cancer (1f, **1h**), *Dental problems (1f), Diarrhoea (1f), Injuries/cuts/wounds (3f),* **Leg swellings (1h), Stomach acid (1h),** *Stomach disorders (1f)*	7	4	10	99	81
151	*Myrsine melanophloeos*	Kigeta / mugeta (Mbeere)	T	*5*	*After-birth pains (1f),* Amoebiasis (13f, **6h**), **Back/bone/joints pains (1h), Blood purifier (1h),** *Constipation (1f), Diarrhoea (1f),* **Injuries/cuts/wounds (1h), Kidney disorders (2h),** Lack of appetite (2f, **1h**), Malaria (3f, **1h**), **Prostrate cancer (1h),** *Rheumatism (2f), Skin diseases (1f),* Stomach disorders (11f, **4h**), **Typhoid (2h),** Worms (22f, **19h**)	9	11	16	47	21
152	*Nasturtium sp*	Nasturtium	H		**Antibiotic (1h)**	0	1	1	-	295
153	*Newtonia buchananii*	Mukui (Embu, Mbeere)	T		**Cancer (1h), Malaria (1h), Worms (1h)**	0	3	3	-	75
154	*Newtonia hildebrandtii*	Mukame (Mbeere)	T		*Chest problems (1f)*	1	0	1	275	-
155	*Ocimum basilicum*	Mataa (Mbeere)	H	*5*	*Allergies (1f), Bites (1f), Cough/colds/flu (1f),* **Puscells (1h),** *Stomach disorders (5f), Worms (1f)*	5	1	6	113	269
156	*Ocimum suave/ gratissimum*	Mukandu/makandu (Embu, Mbeere), Gikandu (Meru)	S	*20*	*Chest problems (1f),* Cough/colds/flu (21f, **1h**), *Fever (1f),* **E.N.T. (1h),** *General body weakness (1f),* **Headaches (1h),** *Malaria (2f), Rheumatism (1f), Stomach disorders (3f), Worms (1f)*	8	3	10	43	107
157	*Ocotea usambarensis*	Muthaiti (Embu, Mbeere)	T		**Asthma (1h), Cancer (1h), Cardiac disorders (1h), Chest problems (1h), Cough/colds/flu (4h), Dizziness (1h), High blood pressure (1h), Joints (2h), Malaria (3h), Pneumonia (3h),** Rheumatism (**1f, 2h), Typhoid (1h), Worms (1h),**	1	13	13	246	7
158	*Olea capensis*	Mucharage (Meru)	T	*1*	*Amoebiasis (1f),* **Arthritis (1h),** *Injuries/cuts/wounds (1f), Low libido (1f),* Malaria (1f, **1h**), *Prostrate problems (1f), Rheumatism (2f), Stomach disorders (1f)*	7	2	8	68	101
159	*Olea europaea*	Muthata (Embu, Mbeere), Mutero (Meru)	T	34	Amoebiasis (14f, **4h**), Back/joint/bone problems (32f, **24h**), Chest problems (3f, **1h**), *Cough/colds/flu (6f),* Dislocation (1f, **2h**), Fractures (1f, **1h**), *General body pains (1f), Headaches (1f),* **Immune booster**	18	13	22	8	19

					(1h), *Injuries/cuts/wounds (2f), Internal injuries (1f),* **Lack of appetite (1h),** Malaria (17f, **4h**), **Muscle fatigue (1h),** Pneumonia (1f, **1h**), *Rheumatism (7f), Stomach disorders (5f), Swellings (1f),* Typhoid (3f, **1h**), **Urinary diseases (1h),** Worms (9f, **2h**)					
160	*Opilia campestris*	Muthuma igoro	S		**Diarrhoea (1h)**	0	1	1	-	239
161	*Opuntia sp*	Cactus	T	**2**	**Fibroids (1h),** *Malaria (1f), Rheumatism (1f)*	2	1	3	128	268
162	*Osyris compressa*	Mutera na ukavi	T	*1*	*Back/joint/bone problems (1f), Cough/colds/flu (1f)*	1	0	1	134	-
163	*Osyris lanceolata*	Mutero (Mbeere), Muchai (Meru)	T	9	AIDS (1f, **1h**), **Allergies (1h),** Back/joint/bone problems (6f, **1h**), **Blood purifier (2h),** *Chest problems (1f), General body pains (2f),* **Increases body temperature (1h),** Malaria (1f, **1h**), Pneumonia (1f, **1h**), **Prostrate cancer (1h), Rheumatism (1h),** *Stomach disorders (1f), Worms (1f)*	7	9	13	33	23
164	*Ovariodendron anisatum*	Ndonga (Embu)	H		**Allergies (1h), Amoebiasis (1h), Arthritis (1h), Bites (1h), Cima (1h), Cough/colds/flu (2h), Diabetes (1h), HIV/AIDS (1h), Infertility (1h), Injuries/cuts/wounds (1h), Livestock (placenta removal in cows, 1h), Low libido (1h), Placenta removal (1h), Rheumatism (2h), Snake bites (3h), STDs (2h), Ulcers (1h)**	0	17	17	-	12
165	*Pappea capensis*	Kiba / kibaa / Mubaa / Muvaa (Embu, Mbeere)	T	*7*	*AIDS (1f),* **Arthritis (1h),** Back/joint/bone problems (2f, **3h**), *Bronchitis (1f), Chest problems (1f),* Cough/colds/flu (4f, **2h**), *Diarrhoea (2f),* **General body health (1h), Gouts (1h),** *Malaria (1f),* **Stomach disorders (1h)**	7	6	11	42	61
166	*Parinari curatellifolia*	Mura	S	1	**Bleedings (1h), Diarrhoea (2h), Injuries/cuts/wounds (1h)**	0	3	3	-	185
167	*Passiflora edulis*	Passion	S	**2**	**Amoebiasis (1h),** *Cough/colds/flu (1f),* **Epilepsy (1h), Heart problems (1h), Insomnia (1h), Nervous system problems (1h)**	1	6	7	196	147
168	*Passiflora quadrangularis*	Meruu (Meru)	S	*1*	*Amoebiasis (1f)*	1	0	1	257	-
169	*Pavonia urens*	Murera njau (Meru)	H	*1*	*Rheumatism (1f)*	1	0	1	247	-
170	*Pellaea adiantoides*	Mukinya ithiga (Mbeere)	H		**Painkiller (1h)**	0	1	1	-	290
171	*Pennisetum clandestinum*	Kikuyu grass	H	1	**Diarrhoea (1h),** Worms (1f)	1	1	2	265	240
172	*Pennisetum purpureum*	Thaara (Embu)	S		*Allergies (1f)*	1	0	1	284	-
173	*Pentas zanzibarica*	Mugirimura (Mbeere)	T		*Malaria (1f)*	1	0	1	154	-
174	*Periploca linearifloria*	Mwonge (Embu)	T		*Cough/colds/flu (1f), Malaria (1f)*	2	0	2	94	-
175	*Persia americana*	Avocado	T	*14*	*Amoebiasis (2f),* **Blood purifier (1h),** *Cancer (1f), Cough/colds/flu (1f),* Dental problems (6f, **5h**)*, E.N.T. (1f), Energy boost (1f), General health (1f), Headaches (2f),* **Immune booster (2h),** *Increase blood (1f),* **Malaria (2h), Prostrate cancer (1h),** Rheumatism (1f, **1h**)*, Skin diseases (1f), Stomach disorders* (1f)	12	6	16	40	54
176	*Petroselinum crispum*		H		**Inconsistent Menstrual (1h)**	0	1	1	-	297

177	*Phoenix reclinata*	Gakiridu (Embu)	T		*Chest problems (1f)*	1	0	1	276	-
178	*Piliostigma thonningi*	Mukura / Mukuura (mbeere)	T	*15*	*Amoebiasis (1f), Chest problems (1f),* Cough/colds/flu (19f, **3h**), *Malaria (1f), Typhoid (1f)*	5	1	5	48	178
179	*Pinus sp.*	Pine	T		**Chest problems (1h)**	0	1	1	-	265
180	*Pistacia aethiopica*	Mugegeti (Embu)	T		**Allergies (1h),** Cough/colds/flu (2f, **1h**), *Dental problems (1f),* **Diabetes (1h), Malaria (1h)**	2	4	5	159	45
181	*Plectranthus barbatus*	Mogoya / Mwogoya / Ruogoya / magoya (Embu, Mbeere), Kijara (Meru)	S	25	Amoebiasis (1f, **3h**), **Arthritis (1h), Bilharzia (1h), Brucellosis (2h),** Cough/colds/flu (1f, **1h**), *Dental problems (1f), Eczema (1f),* **Eye problems (1h),** *Headaches (1f), High blood pressure (1f),* **HIV/AIDS (1h),** *Injuries/cuts/wounds (9f),* Malaria (1f, **1h**), **Neutralizes poison (1h),** *Rheumatism (1f),* Stomach disorders (6f, **2h**), Typhoid (2f, **1h**), Worms (4f, **2h**)	12	12	18	11	11
182	*Plectranthus sylvestris*	Muvoru (Mbeere)	S	4	**Allergies (1h), Amoebiasis (3h),** Diarrhoea (1f, **1h), Painkiller (1h), Toothaches (1h), Typhoid (1h)**	1	6	6	248	74
183	*Podocarpus latifolius*	Fodo (Embu)	T	1	**Asthma (1h), Gall bladder (1h)**	0	2	2	-	215
184	*Polyscias kikuyuensis*	Mubiribiri, Mukurukuru (Meru)	T		**Joints (1h), Rheumatism (1h)**	0	2	2	-	166
185	*Prunus africana*	Mwiria (Embu), Muiri (Meru)	T	46	Allergies (5f, **6h**), Amoebiasis (4f, **2h**), **Arthritis (1h),** Back/joint/bone problems (13f, **2h**), **Blood cancer (1h),** Blood cleanser (1f, **1h**), **Brucellosis (1h),** Cancer (1f, **3h**), Cough/colds/flu (5f, **1h**), *Dental problems (3f),* Diabetes (1f, **3h**), *Diarrhoea (1f),* **Epilepsy (1h), Family planning (1h), Fibroids (1h),** *General health (1f), Injuries/cuts/wounds (2f),* **Heart problems (1h), High blood pressure (1h), Increase blood (1h), Indigestion (1h),** Lack of appetite (2f, **1h**), Malaria (1f, **2h**), Meat allergy (7f, **3h**), Pneumonia (1f, **3h**), Prostrate problems (18f, **13h**), Rheumatism (13f, **3h**), Stomach disorders (7f, **1h**), *Tonsolitis (4f),* **Tumour (1h), Typhoid (1h), Ulcers (1h),** Urinary system disorder (2f, **2h**), Worms (3f, **1h**)	20	29	33	5	1
186	*Psidium guajava*	Mubera (Embu)	T	*31*	*Allergies (1f),* Amoebiasis (14f, **2h**), *Back/joint/ bone problems (3f),* **Cough/colds/flu (1h),** *Chest problems (1f),* **Dental problems (2h),** *Diabetes (1f),* Diarrhoea (2f, **1h**), **Goitre (1h),** *Kabacho* (1f), Malaria (1f, **1h**), **Painkiller (1h),** Rheumatism (2f, **1h**), *Skin diseases (1f), Stomach disorders (4f), Typhoid (3f),* Worms (1f, **1h**)	13	9	16	13	22
187	*Psydrax parviflora*	Muratha iga (Meru)	S		*Back/joint/bone problems (1f), Diarrhoea (1f)*	2	0	2	176	-
188	*Punica granatum*	Mukungumanga (Embu, mbeere), Kukumanga (Meru)	T	*3*	*Amoebiasis (3f),* **Infertility (1h),** *Malaria (2f),* **Meat appetite (1h), STDs (1h), Stomachache (1h),** *Tonsolitis (1f)*	3	4	7	115	194
189	*Rauvolfia caffra*	Motuu / mutuu (Mbeere)	T	4	**Allergies (1h),** Amoebiasis (3f, **1h**), *Cough/colds/flu (1f), Pneumonia (1f), Rheumatism (1f), Stomach disorders (1f)*	5	2	6	71	181
190	*Rhamnus priniodes*	Mukithia (Embu), Mugorona (Meru)	T	5	**Allergies (1h),** *Amoebiasis (1f), Back/joint/bone problems (2f), Blood cleanser (1f),* Cough/colds/flu (1f, **1h**), *Dental problems (2f),* **General body health (1h), Lack of appetite (1h),** Malaria (3f,	9	9	15	12	27

					3h), **Meat appetizer (1h),** Pneumonia (1f, **2h**), Rheumatism (4f, **1h**), Stomach disorders (1f), Typhoid (1f), **Worms (1h)**					
191	*Rhamnus staddo*	Mukuru / Mukuuru (Meru)	T	4	Back/joint/bone problems (2f, **1h**), **Chest problems (1h),** *Dental problems (1f),* **Headaches (1h),** Malaria (2f, **1h**), Rheumatism (5f)	4	5	6	81	66
192	*Rhus natalensis*	Muthaguta / Mutheru / Muthigio(Mbeere)	S	**2**	**Back/bone joints problems (1h), Cough/colds/flu (1h), E.N.T. (1h), Lack of appetite (1h), Low libido (1h),** *Malaria (1f), Puscells (1f)*	2	5	7	129	93
193	*Rhus vulgaris*	Muthithio, Murimamuthua (Meru)	S	*1*	*Back/joint/bone problems (1f)*	1	0	1	222	-
194	*Ricinus communis*	Kiariki / Mbariki / Mubariki / Mucariki (Embu, Mbeere), Mwariki (Meru)	S	17	**Arthritis (1h),** *Bites (1f),* Blood cleanser (1f, **1h**), **Burns (1h),** *Constipation (1f),* Cough/colds/flu (2f, **1h**), Dental problems (5f), **Detoxifier (1h),** Family planning (3f, **1h**), Hard stool (1f), **Indigestion (2h),** Injuries/cuts/wounds (4f, **1h**), **Labour pains (1h), Livestock (1h), Low libido (1h),** *Pimples (1f), Pneumonia (1f), Rheumatism (1f),* Stomach disorders (2f, **1h**)	12	12	19	59	90
195	*Rosmarinus officinalis*	Muchai	H	*6*	*Chest problems (1f),* Cough/colds/flu (8f, **1h**), *Lack of appetite (1f),* **Pneumonia (1h), Retarded memory (1h),** Rheumatism (1f, **1h**), **Stomachache (2h), Stress (1h)**	4	6	8	117	44
196	*Rubus pinnatus*	Mutare (Embu)	S	*1*	*Amoebiasis (1f),* **Malaria (1h)**	1	1	2	258	143
197	*Rumex abyssinicus*	Muraiguna (Meru)	S		**Menstrual problems (1h)**	0	1	1	-	258
198	*Saba comorensis*	Mwonge (Embu)	S		**Diabetes (1h)**	0	1	1	-	202
199	*Sarcophyte piriei*	Ibatikanthi (Mbeere)	H		**Snake bites (1h), Stomach disorders (1h)**	0	2	2	-	196
200	*Salvadora persica*	Mukayayu (mbeere)	T		*Typhoid (1f)*	1	0	1	171	-
201	*Schinus molle*	Kigunye / Mutenderia (Mbeere), Ndenderia (Meru)	T	*6*	*Cough/colds/flu (2f), Malaria (1f), Rheumatism (4f)*	3	0	3	79	-
202	*Schkuhria pinata*	Karuria tatha (Mbeere), Gakwinini (Meru)	H	*1*	*Stomach disorders (1f)*	1	0	1	155	-
203	*Schrebera elata*	Mutuma (Mbeere)	T	*1*	*Chest problems (1f)*	1	0	1	250	-
204	*Sclerocarya birrea*	Mururа (mbeere)	T	*1*	*Stomach disorders (1f)*	1	0	1	251	-
205	*Securidaca longipedunculata*	Muguruka (Mbeere)	T	**5**	**Amoebiasis (1h), Asthma (3h), Back/bone joints problems (4h),** Cough/colds/flu (3f, **3h**), *General body pains (1f),* Malaria (3f, **1h**), **Mental disorders (1h),** *Tonsolitis (1f)*	4	6	8	85	30
206	*Senna didymobotrya*	Moino / muino (Embu, mbeere), Kirao / murao (Meru)	S	42	Allergies (7f, **4h**), Amoebiasis (9f, **5h**), *Back/joint/bone problems (1f), Chest congestions (1f), Chicken pox (6f), Constipation (2f),* Cough/colds/flu (2f, **1h**), *Diarrhoea (4f), Fever (2f),* **Gall bladder (1h),** *General body pains (1f), Hard stool (1f),* **Heartburn (1h),** Malaria (12f, **7h**), Measles (8f, **2h**), *Meat allergy (1f),* **Painkiller (1h),** *Pneumonia (2f), Rheumatism (2f),* Skin diseases (5f, **2h**), *Stomach disorders (7f), Swellings (1f),* Typhoid (8f, **3h**), **Urinary system**	21	12	25	1	18

					infections (1h), Worms (2f), **3h**)					
207	*Senna siamea*	Mubeci / Muveci (Mbeere)	T	8	**Allergies (1h),** *Back/joint/bone problems (1f), Cough/colds/flu (1f), Headaches (1f), Injuries/cuts/wounds (2f),* Malaria (2f, **1h**), **T.B. (1h)**	5	3	7	61	68
208	*Senna singuana*	Mukengeta (Mbeere)	T	4	**Anthrax (1h),** *Chicken pox (1f), Cough/colds/flu (1f),* Dental problems (3f, **1h**), **Indigestions (1h),** *Puscells (1f)*	4	3	6	125	199
209	*Sepium elipticum*	Muthatha (Mbeere	T	2	Dental *problems (1f), Malaria (2f)*	2	0	2	124	-
210	*Sida tennicarpa*	Matiki (Mbeere)	T	*1*	*Rheumatism (1f)*	1	0	1	252	-
211	*Solanecio angulatus*	Muturutwa (Meru)	T		**Livestock (1h), Low libido (1h), Pneumonia (1h), Prostrate cancer (1h), STDs (1h), Whooping cough (1h)**	0	6	6	-	103
212	*Solanecio mannii*	Mwathathi (Embu), Gitoromboro (Meru)	T	3	*Dental problems (1f), Malaria (1f),* **Neutralizes poison (1h),** *Rheumatism (1f)*	3	1	4	102	275
213	*Solanum incanum*	Mutongu / ndongu (Embu, Mbeere)	S	*26*	*Amoebiasis (1f),* Asthma (1f, **1h**), **Back/bone joints problems (1h),** *Bites (1f),* **Brucellosis (1h),** *Chest problems (1f), Constipation (1f),* Cough/colds/flu (3f, **3h**), Dental problems (8f, **3h**), *Diarrhoea (2f),* **Family planning (1h), Gastritis (1h),** Malaria (2f, **2h**), **Neutralizes poison (2h),** *Pesticide (1f), Pimples (1f),* **Prostrate cancer (2h),** *Rheumatism (2f),* **Ringworms (3h), Skin diseases (4h),** Snake/spider bites (1f, **4h**), Stomach disorders (18f, **7h**), *Worms (7f),* **T.B. (1h), Typhoid (1h)**	15	15	25	22	8
214	*Solanum nigrum*	Managu (Embu)	H	2	Amoebiasis (1f, **1h**), *Stomach disorders (1f),*	2	1	2	200	224
215	*Solanum tuberosum*	Waru (Embu, Mbeere), Irish potato			**Bites (1h), wounds (1h)**	0	2	2	-	205
216	*Sonchus asper*	Mubiubiu (Embu)	H		*Amoebiasis (1f)*	1	0	1	254	-
217	*Sorghum bicolor*	Mubia (Embu, Mbeere)	H		*Energy boost (1f)*	1	0	1	307	-
218	*Spinacia oleracea*	Spinach	H		*Pneumonia (1f)*	1	0	1	207	-
219	*Sporobolus spp??*	Mugutugutu (Mbeere)	S	*1*	*Back/joint/bone problems (2f), Kidney cleaning (1f), Rheumatism (3f), STDs (1f)*	4	0	4	132	-
220	*Sterculia stenocarpa*	Kiuria (Mbeere)	T	2	Back/joint/bone problems (1f, **1h**), *Kabacho (1f)*	2	1	2	223	250
221	*Strychnos henningsii*	Mutambi (Mbeere), muteta (Embu)	T	**9**	**Arthritis (1h),** Amoebiasis (1f, **1h**), Back/joint/bone problems (1f, **3h**), *Chest problems (1f),*Cough/colds/flu (1f, **2h**), Headaches (2f), Malaria (12f, **14h**), *Stomach disorders (1f,), Swellings (1f),* **Typhoid (1h),** *Worms (1f)*	9	6	11	32	40
222	*Symphytum officinale*	Comfrey	H		**Asthma (1h)**	0	1	1	-	216
223	*Synadenium compactum*	Kiatha (Embu, mbeere), mwatha (meru)	S	2	Eye *problems (1f), Livestock diseases (1f)*	2	0	2	297	-
224	*Syzygium cordatum*	Muriru (Embu)	T	*1*	*Malaria (1f), Typhoid (1f)*	2	0	2	92	-
225	*Syzygium guineense*	Muriru (Mbeere, Meru)	T	*1*	*Back/joint/bone problems (1f), Cough/colds/flu (1f), Diarrhoea (2f),* **HIV/AIDS (1h),** *Malaria (1f), Rheumatism (1f)*	5	1	6	31	160
226	*Tabernaemontan*	Mwerere			**Amoebiasis (1h), Asthma (1h), Malaria**	0	4	4	-	53

	a ventricosa				**(1h), Measles (1h)**					
227	*Tamarindus indica*	Muthithi	T	12	**Allergies (1h),** *Amoebiasis (2f), Back/joint/bone problems (2f), Chicken pox (1f), Cough/colds/flu (2f),* Diarrhoea (3f, **1h**), **Eye problems (1h),** *Lack of appetite (1f), Malaria (1f), Measles (1f),* **Ringworms (1h)**	8	4	11	35	112
228	*Terminalia brownii*	Mururuku (Embu, Mbeere), muthumuki (Meru)	T	*21*	*Amoebiasis (1f), Back/joint/bone problems (3f), Chest problems (2f),* Cough/colds/flu (4f, **1h**), **Diabetes (1h),** *Eye problems (2f),* Family planning (4f, **3h**), *Inflammations (1f),* Injuries/cuts/wounds (7f, **1h**), *Livestock diseases (1f),* Malaria (3f, **3h**), Pneumonia (2f), Rheumatism (2f), Stomach disorders (3f), Worms (1f), **STDs (2h),** *Yellow fever (1f)*	15	5	17	14	43
229	*Tetradenia riparia*	Kiarakaa / marakaa / mwaraka (Meru)	T	*5*	*Amoebiasis (1f), Catalyses vomiting (1f), Dental problems (2f), General body pains (1f), Heartburns (1f), Livestock diseases (1f), Malaria (2f), Pneumonia (1f), Rheumatism (2f), Stomach disorders (1f)*	10	0	10	49	-
230	*Thespesia garckeana*	Mutoo (Embu, Mbeere)	T	*5*	*Amoebiasis (1f), Back/joint/bone problems (2f),* Cough/colds/flu (3f, **2h**), *Malaria (2f), Typhoid (1f),* **Stomach disorders (1h)**	5	2	6	44	113
231	*Tithonia diversifolia*	Kirurite (Embu), Mang'ana (Meru)	S	37	Amoebiasis (9f, **4h**), **Contagious diseases (1h),** *Cough/colds/flu (1f), Headaches (2f), Insecticides (1f), Chicken diseases (1f), Livestock diseases (2f),* Malaria (17f, **5h**), *Pesticide (1f), Pneumonia (1f), Stomach disorders (1f),* Typhoid (38f, **10h**), *Worms (2f)*	12	4	13	19	62
232	*Trema orientalis*	Mubebu (Embu)	T	*3*	*After-birth pains (1f),* **Bacterial infections (1h),** *Chest problems (1f),* Cough/colds/flu (1f, **2h**), *Stomach disorders (1f),* Worms (1f, **1h**),	5	3	6	104	120
233	*Trichilia emetica*	Mutuati (Meru)	T	*8*	*Amoebiasis (4f), Back/joint/bone problems (1f), Cough/colds/flu (2f),* **Epilepsy (1h), Pancreas diseases (1h),** Rheumatism (6f, **1h**), **Worms (1h)**	4	4	7	87	99
234	*Tridax procumbens*	Mwaraciau (Mbeere)	H	*1*	*Dental problems (1f),* **Injuries/cuts/wounds (1h)**	1	1	2	271	261
235	*Triticum aestivum*				**Cancer (1h)**	0	1	1	-	219
236	*Ultica masaica*	Kithaa	H	14	**Arthritis (1h),** *Back/joint/bone problems (1f),* Blood purifier (*2f,* **1h),** *Cough/colds/flu (1f),*Diabetes (1f, **1h**), *Energy boost (1f),* **General body health (1h), Injuries/cuts/wounds (1h),** *Heartburns (1f), High blood pressure (1f),* **Joints (3h),** *Leg swellings (1f),* **Low appetite (1h),** *Low libido (2f), Pneumonia (1f),* Rheumatism (12f, **2h**), **Stomach acid (1h)** *Stomach disorders (1f)*	12	9	18	38	28
237	*Uvaria scheffleri*				**Cough/colds/flu (1h), Lack of appetite (2h), Malaria (1h), Painkiller (1h)**	0	4	4	-	72
238	*Vangueria madagascarensis*	Mubiru (Embu, Mbeere, Meru), Muiru (Meru)	T	5	**Brucellosis (1h), Cholera (1h),** *Heartburns (2f), Loins pains (1f),* **Neutralises effect of other medicinals (1h),** *Pancreatic diseases (1f),* **Poisoning (1h),** *Prostrate problems (1f), Rheumatism (1f),* **Typhoid (1h)**	5	5	10	172	108
239	*Vangueria volkensii*	Mubiruiru / Mukomboiru (Embu, Mbeere)	T	*1*	*Amoebiasis (11f), Kabacho (11f),*	2	0	2	259	-
240	*Vepris nobilis*	Muteretu (Meru)	S	1	**Back/bone/joints problems (1h),** *Malaria (11f), Nausea (11f),* **Pneumonia (1h),** *Rheumatism (11f),* **Worms (1h)**	3	3	6	121	105

241	*Vernonia auriculifera*	Mathakwa (Meru)	H	1	**After birth pains (1h), Amoebiasis (1h), Bilharzia (1h), Gastritis (1h), Measles (1h),** *Stomach disorders (11f),* **Typhoid (1h)**	1	6	7	253	89
242	*Vernonia lasiopus*	Mucatha (Embu, Mbeere)	S	*13*	*Allergies (1f), Amoebiasis (1f),* **Asthma (1h), Cancer (2h),** Dental problems (6f, **3h**), *Diabetes (2f),* **Heartburn (1h),** High blood pressure (2f, **2h**), **Inflammation (1h),** *Livestock (Tonsolitis in cows, 1f),* **Loose bladder (1h), Low libido (1h), Malaria (2h), Reduces addiction (1h), Reduces menstrual flow (1h), Rheumatism (1h), Skin diseases (1h), STDs (1h),** *Stomach disorders (10f), Typhoid (1f), Worms (2f),* **High blood pressure (2h)**	9	15	22	51	30
243	*Viscum sp.*	Shrub			**Diarrhoea (1h), Dysentry (1h), High blood pressure (1h), Insomnia (1h), Nervous system problems (1h)**	0	5	5	-	153
244	*Vitex keniensis*	Muhuru (Embu), muuru (Meru)	T	*2*	*Livestock diseases (1f)*	1	0	1	308	-
245	*Vitex payos*	Muburu (Mbeere)	T	*8*	*Amoebiasis (1f), Back/joint/bone problems (2f),* **Chest problems (1h), Dental problems (1h),** *Diarrhoea (5f),* **Increase blood (1h),** Typhoid (1f, **1h**)	4	4	7	86	104
246	*Warburgia ugandensis*	Muthiga (Embu, Mbeere), Musunui / thurunui (Meru)	T	7	**Allergies (2h),** Amoebiasis (2f, **1h**), **Asthma (3h)**, Back/bone joints problems (2f, **4h**), Chest problems (1f, **3h**), Cough/colds/flu (8f, **10h**), Dental problems (4f, **3h**), **Diabetes (2h),** *Energy boost (1f), General body pains (2f),* **Headaches (1h), High blood pressure (2h), Lack of appetite (1h),** Malaria (10f, **13h**), **Meat appetizer (1h), Pneumonia (1h), Prostrate cancer (1h), Rheumatism (4h), STDs (2h), Swellings (1h), T.B. (3h), Typhoid (2h), Ulcers (1h), Worms (1h),**	16	22	24	17	4
247	*Withania somnifera*	Murumbawe / mugumbawe (Embu)	S	4	**Back/bone/joints problems (1h), Cough/colds/flu (1h),** *Malaria (4f), Puscells (1f)*	2	2	4	130	116
248	*Ximenia americana*	Mutura / mutuura (Embu, Mbeere)	T	9	**Back/bone joints problems (4h),** Dental problems (11f, **2h**), **Increases body temperature (1h),** *Malaria (3f),* Rheumatism (3f, **1h**), **Skin diseases (1h), Stomach acid (1h),** *Stomach disorders (2f), Thorn pricks(1f)*	5	6	9	80	67
249	*Zanha africana*	Mwokia	T		*Malaria (1f)*	1	0	1	157	-
250	*Zanthoxylum chalybeum*	Muguchwa / Mugucwa (Meru), Mukenenga / Muruguci (Mbeere), Mukenera / Mukenenga (Embu)	T	20	Allergies (1f, **2h**), *Back/joint/bone problems (4f),* Chest problems (2, **1h**f), *Constipation (2f),* Cough/colds/flu (12f, **2h**), Dental problems (1f, **2h**), **Fever reliever (1h), Gouts (1h),** *Headaches (1f), Injuries/cuts/wounds (1f),* Malaria (14f, **6h**), *Pains in the flesh (1f),* **Pneumonia (1h),** Rheumatism (1f, **1h**), **Ringworms (1h), STDs (2h),** Stomach disorders (13f), **T.B. (1h)**	10	11	16	20	13
251	*Zanthoxylum usambarensis*	Mung'ang'a (Embu)	T		**Amoebiasis (1h), Arthritis (1h), Back/bone joints problems (1h), Body weakness (1h), Brucellosis (1h),** Cough/colds/flu (1f, **1h**), **Headaches (1h), Joints (1h), Malaria (5h), Rheumatism (2h),** *STDs (1f)* **Stomach disorders (1h), Tonsilitis (1h), Toothaches (4h), Typhoid (3h), Ulcers (1h),**	2	15	16	164	10
252	*Zehneria scabra*	Kangunjwe (Meru)	H		*Constipation (1f)*	1	0	1	286	-

11.3 Appendix 2b: All medicinal plant species mentioned by respondent farmers and herbalists but were not identified botanically (some could be local synonyms) and the diseases treated

In medicinal uses column (6), the conditions in bold were only mentioned by herbalists (traditional healers), the ones in italics were only mentioned by farmers while those in normal script were mentioned by both farmers and herbalists

	Local name	Growth habit	Farms present	Medicinal uses as mentioned by respondents	No of diseases mentioned by			Ranking by	
					Farmers	Herbalists	Total	Farmers	Herbalists
1	Alfafa	H		**Diabetes (1h), Gouts (1h), Rheumatism (1h)**	0	3	3	-	141
2	American Camphor	S		**Cough/colds/flu (2h), Headaches (1h),**	0	2	2	-	121
3	Butonwa	H	7	**Bleedings (1h),** *Heartburns (1f), Injuries/cuts/wounds (10f)*	1	2	3	288	281
4	Gakumu	S		*Headaches (1f), Malaria (1f)*	2	0	2	*118*	-
5	Gakuria ngamba	H	1	*Diarrhoea (1f)*	*1*	*0*	*1*	*229*	-
6	Gakwacii	H		*Stomach disorders (1f)*	*1*	*0*	*1*	*230*	-
7	Gatiki	H		*Rheumatism (1f)*	*1*	*0*	*1*	*231*	-
8	Gatathira	H		**Stomachache (1h)**	0	1	1	-	245
9	Giuta	H		**Wounds (1h)**		1	1	-	260
10	Gichibi	H		*Stomach disorders (1f)*	*1*	*0*	*1*	*232*	-
11	Gikuri	S	1	*Cough/colds/flu (1f)*	*1*	*0*	*1*	*181*	-
12	Gitunduku	S	1	*Amoebiasis (2f), Dental problems (1f), Rheumatism (1f), Stomach disorders (1f), Worms (1f)*	*5*	*0*	*5*	*103*	-
13	India 1	H		**Malaria (1h), Pneumonia (1h)**	0	2	2	-	80
14	India 2	H		**Chest problems (1h), Cough/colds/flu (1h)**	0	2	2	-	123
15	Israel (Munislin)	H		**Malaria (1h)**	0	1	1	-	134
16	Kagutwi			**Malaria (1h)**	0	1	1	-	135
17	Kaimba na muthumbi	S		*Cough/colds/flu (2f),* **Rheumatism (1h)**	*1*	*1*	*2*	-	-
18	Kamuua			**Rheumatism (1h)**	0	1	1	-	225
19	Kanyagawanu			**Low libido (1h)**	0	1	1	-	277
20	Karia ka mugunda	H		*Stomach disorders (1f)*	*1*	*0*	*1*	*238*	-
21	Karitha (keganda)			**Diarrhoea (2h)**	0	1	1	-	236
22	Karuma	H		Malaria (1f, **1h**)	1	1	1	145	136
23	Karumbeta			**Mental disorders (1h)**	0	1	1	-	263
24	Kathakame			**Amoebiasis (1h), Dental disorders (1h), Malaria (1h), Nose bleeding (1h)**	0	4	4	-	64
25	Katharia ndundu			**Diarrhoea (1h), Swellings (1h)**	0	2	2	-	237
26	Kavati			**Amoebiasis (1h), Malaria (1h)**	0	2	2	-	91
27	Kauni	S		*Malaria (1f)*	*1*	*0*	*1*	*146*	-
28	Kiara nkware	S		*Livestock diseases (1f)*	*1*	*0*	*1*	*296*	-
29	Kibaki			**Cough/colds/flu (1h)**	0	1	1	-	170
30	Kibiu	S		*Dental problems (1f)*	*1*	*0*	*1*	*267*	-

31	Kigari	S		*Injuries/cuts/wounds (1f), Skin diseases (1f)*	*2*	*0*	*2*	*279*	-
32	Kinathi			**Diarrhoea (1h),**	0	1	1	-	238
33	King of spices			**Food preservative (1h)**	0	1	1	-	288
34	Kinoria / kinuria	S		Dental problems (1f, **1h**), **Livestock (1h)**	1	2	2	268	210
35	Kirema	H		*Livestock diseases (1f)*	*1*	*0*	*1*	*298*	-
36	Kirerema			**Cough/colds/flu (1h)**	0	1	1	-	171
37	Kiria kia Njogu	H		*Back/joint/bone problems (1f)*	*1*	*0*	*1*	*217*	-
38	Kirigi	S		*Marasmus (1f)*	*1*	*0*	*1*	*274*	-
39	Kirita			**Malaria (1h)**	0	1	1	-	137
40	Kithorokwe			**Rheumatism (1h)**	0	1	1	-	226
41	Kiuruti			**Toothaches (1h)**	0	1	1	-	211
42	Laitang			**Low libido (1h)**	0	1	1	-	278
43	Kithathana	H		*Pesticide (1f)*	*1*	*0*	*1*	*299*	-
44	Kiua	S		*Typhoid (1f)*	*1*	*0*	*1*	*170*	-
45	Kutukuti	T		*Energy boost (1f)*	*1*	*0*	*1*	*300*	-
46	Manysource	T		*Allergies (1f), Cough/colds/flu (1f), Lack of appetite (1f), Obesity (1f)*	*4*	*0*	*4*	*160*	-
47	Mbotwa	S		*Stomach disorders (1f)*	*1*	*0*	*1*	*235*	-
48	Menyua	H		*Worms (2f),* **Amoebiasis (1h)**	*1*	*1*	*2*	*262*	*222*
49	Movukora	S		*Chest problems (1f), Cough/colds/flu (1f)*	0	2	2	161	-
50	Muambo	T		*Rheumatism (1f)*	1	0	1	236	-
51	Mubarita	H		*Back/joint/bone problems (1f), Fractures (1f),* Malaria (5f**, 1h**)	*3*	*1*	*3*	*112*	*138*
52	Muberuberu	T		*Dental problems (1f)*	*1*	*0*	*1*	*269*	-
53	Mubiriti	T		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*186*	-
54	Mubocwa	T		*Malaria (1f)*	*1*	*0*	*1*	*147*	-
55	Mubota	H		*Amoebiasis (16f), Stomach disorders (2f), Typhoid (1f), Worms (1f)*	*4*	*0*	*4*	*89*	-
56	Mububa ndundi	H		*Diarrhoea (1f),* **Dental problems (1h)**	*1*	*1*	*2*	*237*	*212*
57	Mububao	T		**After birth pains (1h),** *Back/joint/bone problems (1f),* **HIV/AIDS (1h), Lack of appetite (1h),** *Malaria (1f), Rheumatism (1f)*	3	3	6	90	127
58	Muburi			**Tonsolitis (1h), Typhoid (1h)**	0	2	2	-	182
59	Muchani	S		**Cancer (1h),** Cough/colds/flu (1f, **3h**), **Increases body temperature (1h),** Malaria (4f, **3h**), **Meat appetite (1h), Pneumonia (2h),** Rheumatism (3f, **1h**), Stomach disorders (1f, **1h**)	4	8	8	62	24
60	Muchore	S		*After-birth pains (1f)*	*1*	*0*	*1*	*301*	-
61	Muchuka			**T.B. (1h)**	0	1	1	-	203
62	Mucigi	S		*Malaria (1f)*	*1*	*0*	*1*	*148*	-
63	Muciko			**Cough/colds/flu (1h)**	0	1	1	-	174
64	Muciriri	H		*Stomach disorders (1f)*	*1*	*0*	*1*	*238*	-
65	Muconoa	H		*Chest problems (1f), Cough/colds/flu (1f)*	*2*	*0*	*2*	*162*	-
66	Mucucuna			**Amoebiasis (1h), Diabetes (1h), Tapeworms (1h), Tonsolitis (1h)**	0	4	4	-	102
67	Mucuki			**Poisoning (1h)**	0	1	1	-	274
68	Mugajogajo			**Malaria (1h), Snake bites (1h)**	0	2	2	-	110
69	Mugaka	H		*Bites (1f), Injuries/cuts/wounds (1f)*	2	0	2	302	-

70	Mugera ng'undu			**Headaches (1h)**	0	1	1	-	262
71	Mugeria			**Lack of appetite (1h)**	0	1	1	-	289
72	Mugii / mukii	S		*Diarrhoea (1f), Malaria (1f), Pneumonia (1f)*	*3*	*0*	*3*	*105*	-
73	Mugu	S		*Malaria (1f)*	*1*	*0*	*1*	*149*	-
74	Muguguu	S		*Rheumatism (1f)*	*1*	*0*	*1*	*239*	-
75	Muguguya	S		*Headaches (1f)*	*1*	*0*	*1*	*240*	-
76	Mugumbao	S		*After-birth pains (1f),* **Allergies (1h),** *Back/joint/bone problems (1f), Fever (1f), Inflammations (1f), Malaria (2f),* Rheumatism (1f, **1h**)*, Stomach disorders (2f),* **Worms (1h)**	*7*	*3*	*9*	*63*	*122*
77	Muguuta			**Amoebiasis (1h), Pneumonia (1h), Rheumatism (1h), Worms (1h)**	0	4	4	-	70
78	Mujani			**Rheumatism (1h)**	0	1	1	-	227
79	Mujehe			**Low libido (1h), Pancreas problems (1h)**	0	2	2	-	241
80	Mukabakabu	T		*Amoebiasis (4f), Diabetes (1f), Stomach disorders (1f)*	*3*	*0*	*3*	*255*	-
81	Mukamwiru	H		*Cough/colds/flu (1f), Injuries/cuts/wounds (7f)*	*2*	*0*	*2*	*187*	-
82	Mukenia			**Eye problems (1h)**	0	1	1	-	267
83	Mukenyuka			**Chest problems (1h)**	0	1	1	-	264
84	Mukinyei			**Stomachache (1h)**	0	1	1	-	246
85	Mukokora	S		**Back/joint/bone problems (1h),** Rheumatism (2f, **1h**)	1	1	2	241	165
86	Mukomothi	H		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*173*	-
87	Mukongorwe			**Dental problems (1h)**	0	1	1	-	213
88	Mukundu			**Chronic Urinary system infections (1h)**	0	1	1	-	291
89	Mukururiti	S		*Back/joint/bone problems (1f), Blood cleanser (1f), Fever (1f), General body pains (1f), Lack of appetite (3f), Malaria (3f), Rheumatism (1f), Stomach disorders (3f)*	*8*	*0*	*8*	*76*	-
90	Mumanku			**Rheumatism (1h)**	0	1	1	-	228
91	Mumbukora	H		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*188*	-
92	Mung'ei	H		*Dental problems (2f),* **Eye problems (1h),** Heartburns (2f, **1h**), *Pimples (1f),* **Stomach acid (1h),** *Typhoid (2f)*	*4*	*3*	*6*	*131*	*191*
93	Mung'othi	T		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*189*	-
94	Mungunangu			**Rheumatism (1h)**	0	1	1	-	229
95	Munoria mbuku	H		*Skin diseases (1f)*	*1*	*0*	*1*	*280*	-
96	Mununku			**Typhoid (1h)**	0	1	1	-	204
97	Munyithia	S		*Cough/colds/flu (1f)*	1	0	1	190	-
98	Munyorora	H		*Cough/colds/flu (1f)*	1	0	1	191	-
99	Muogore			**General body health (1h)**	0	1	1	-	292
100	Muoru	S		*Dental problems (1f),* **Mental disorders (1h),** *Pneumonia (1f),* **STDs (1h)**	*2*	*2*	*4*	*166*	*206*
101	Murakuthi	T		*Back/joint/bone problems (1f)*	*1*	*0*	*1*	*218*	-
102	Murarama	S		*Stomach disorders (1f)*	*1*	*0*	*1*	*242*	-
103	Murega	T		*Amoebiasis (2f), Lack of appetite (1f), Nausea (1f),* **Stomachache (1h),** Worms (1f**, 1h**)	*4*	*2*	*5*	*192*	*186*
104	Murigi mbuga			**Rheumatism (1h)**	0	1	1	-	230
105	Murigiti			**Allergies (1h)**	0	1	1	-	256

106	Murigono			**STDs (1h), Syphillis (1h)**	0	2	2	-	234
107	Murogonjo			**Arthritis (1h), Rheumatism (1h)**	0	2	2	-	179
108	Murora iguru	H		*General health (1f)*	*1*	*0*	*1*	*291*	-
109	Muroroma			**Livestock (1h)**	0	1	1	-	293
110	Muruchio / murucio / murugio	H		Dental problems (7f, **1h**), *Stomach disorders (1f), Rheumatism (1f),* **Typhoid (1h),** *Worms (1f)*	4	2	5	150	125
111	Murugia	H		*Amoebiasis*	*1*	*0*	*1*	*256*	-
112	Muruiri	T		*Lack of appetite (1f)*	*1*	*0*	*1*	*292*	-
113	Muruku			**Diabetes (1h)**	0	1	1	-	201
114	Murumbao	H		*Rheumatism (1f)*	*1*	*0*	*1*	*243*	-
115	Murungarungwa	H		*After-birth pains (1f),* **Back/bone joints problems (2h),** *Diarrhoea (1f),* **Rheumatism (1h),** *Stomach disorders (1f)*	*3*	*2*	*5*	*198*	*163*
116	Murungo	H		*Stomach disorders (1f)*	*1*	*0*	*1*	*244*	-
117	Mururia	S		**Dental problems (1h), Low libido (1h),** Malaria (1f, **1h**),	1	3	3	151	82
118	Mururue			**Cough/colds/flu (1h)**	0	1	1	-	175
119	Murwarua			**STDs (1h)**	0	1	1	-	271
120	Mushroom	H		*E.N.T. (1f),* **Allergies (1h), Heartburn (1h)**	*1*	*2*	*3*	*282*	*254*
121	Musugi	T		*Rheumatism (1f), Stomach disorders (1f)*	*2*	*0*	*2*	*199*	-
122	Mutabithi	T		*Energy boost (1f)*	*1*	*0*	*1*	*303*	-
123	Mutachiuna	S		*Back/joint/bone problems (1f),* **Cancer (1h), Indigestions (1h), Intestinal worms (1h), Joints (1h), Malaria (1h),** Rheumatism (1f, **1h), Typhoid (2h),**	*2*	*7*	*8*	*174*	*33*
124	Mutagona	T		*Stomach disorders (1f)*	*1*	*0*	*1*	*245*	-
125	Mutamai	S		*Worms (1f)*	*1*	*0*	*1*	*263*	-
126	Mutanda arimu			**Malaria (1h), Typhoid (1h)**	0	1	1	-	86
127	Mutangoma	T		*Injuries/cuts/wounds (1f)*	*1*	*0*	*1*	*304*	-
128	Mutarangwi			**Cough/colds/flu (1h), Malaria (1h), Pneumonia (1h)**	0	3	3	-	48
129	Mutawere	H		**Rheumatism (1h), STDs (1h),** *Skin diseases (1f)*	1	2	3	281	187
130	Mutei			**Ulcers (1h)**	0	1	1	-	251
131	Mutere			**Back/bone joints problems (1h), Joints (1h), Pneumonia (1h), Rheumatism (1h)**	0	4	4	-	95
132	Muterendi			**Back/bone joints problems (1h), Diabetes (1h), High blood pressure (2h), Indigestion (1h), Malaria (1h), Typhoid (1h)**	0	6	6	-	38
133	Muteta	T		*Malaria (1f)*	*1*	*0*	*1*	*152*	-
134	Muthaara	S		*Cough/colds/flu (1f), Dental problems (1f), Pneumonia (1f), Prostrate problems (1f), Rheumatism (1f)*	*5*	*0*	*5*	*75*	-
135	Muthakame	H		*Dental problems (1f)*	*1*	*0*	*1*	*270*	-
136	Muthathani	S		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*193*	-
137	Muthathia	T		*Energy boost (1f)*	*1*	*0*	*1*	*305*	-
138	Muthavara	S		*Cough/colds/flu (1f), Stomach disorders (1f)*	*2*	*0*	*2*	*139*	-
139	Muthengera			**Pneumonia (1h)**	0	1	1	-	192
140	Muthi			**Malaria (2h)**	0	1	1	-	139
141	Muthigicu	T		*Back/joint/bone problems (1f)*	*1*	*0*	*1*	*219*	-

142	Muthigui			**Worms (1h)**	0	1	1	-	252
143	Muthii	T		*Back/joint/bone problems (1f),* **Cough/colds/flu (1h)**	*1*	*1*	*2*	*220*	*176*
144	Muthinia			**Amoebiasis (1h), Back/bone joints problems (1h), Malaria (1h), Pneumonia (1h), Tapeworms (1h)**	0	5	5	-	46
145	Muthira nthoni	T		*Low libido (1f)*	*1*	*0*	*1*	*306*	-
146	Muthonjero	H		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*194*	-
147	Muthorokwe			**Rheumatism (1h)**	0	1	1	-	231
148	Muthugi			**Epilepsy (1h), Typhoid (1h)**	0	2	2	-	155
149	Muthuguya	T		**Amoebiasis (1h),** *Pneumonia (1f), Rheumatism (4f),* **Stomachache (1h),** *Tonsolitis (1f)*	3	2	5	158	*156*
150	Muthwea	H		*Back/joint/bone problems (1f)*	*1*	*0*	*1*	*221*	-
151	Mutikimwe	S		**Back/bone joints problems (1h),** *Malaria (1f),* **Painkiller (1h), Rheumatism (1h)**	1	3	4	153	162
152	Mutiru	H		*Back/joint/bone problems (3f),* Cough/colds/flu (1f, **1h**), *Dizziness (1f), Malaria (1f), STDs (1f)*				*66*	*177*
153	Mutorondwe			**Diarrhoea (1h), Worms (1h)**	0	2	2	-	184
154	Mutungurutha			**Meat allergy (1h)**	0	1	1	-	257
155	Mutuntuki			**Amoebiasis (1h)**	0	1	1	-	223
156	Muturu	H		*Stomach disorders (1f)*	*1*	*0*	*1*	*255*	-
157	Muturutwa	S		*Eye problems (1f)*	*1*	*0*	*1*	*278*	-
158	Muugarani	S		*Cough/colds/flu (1f)*	*1*	*0*	*1*	*195*	-
159	Muunkuma	T		*Malaria (1f), Rheumatism (1f)*	*2*	*0*	*2*	*120*	-
160	Muutuutu	H		*Back/joint/bone problems (1f), Swellings (1f)*	*2*	*0*	*2*	*211*	-
161	Muvingiti			**Headaches (1h), Stomach disorders (1h)**	0	2	2	-	189
162	Muvoko			**Malaria (1h), Typhoid (1h)**	0	2	2	-	87
163	Muvorwe			**Cough/colds/flu (1h), Malaria (1h), Pneumonia (1h), Stomach disorders (1h), Worms (1h)**	0	5	5	-	35
164	Muvura ndundu			**Eye problems (1h), Stomach disorders (1h)**	0	2	2	-	190
165	Mwarange			**Blood purifier (1h), Tonsolitis (1h)**	0	2	2	-	276
166	Mwaritha			**Snake bites (1h), Stomach acid (1h)**	0	2	2	-	195
167	Mwei			**Delivery complications (1h)**	0	1	1	-	294
168	Mwiganjo			**Malaria (1h)**	0	1	1	-	140
169	Mwimba iguru	H		*Back/joint/bone problems (1f), Rheumatism (1f),* **Stomach disorders (1h)**	*2*	*1*	*3*	*175*	*247*
170	Mwiro	H		*Prostrate problems (1f)*	*1*	*0*	*1*	*264*	-
171	Mwompo			**Joints (1h), Skin diseases (1h)**	0	2	2	-	207
172	Nchanimura			**Lack of appetite (1h)**	0	1	1	-	296
173	Nduangoka	H		*Malaria (1f), Pneumonia (1f)*	*2*	*0*	*2*	*106*	-
174	Ndubai			**STDs (1h)**	0	1	1	-	272
175	Ngurikuma			**Malaria (1h)**	0	1	1	-	142
176	Njogu ya iria			**Stomachache (1h)**	0	1	1	-	248
177	Nkenkeyia			**Indigestion (1h)**	0	1	1	-	279
178	Nthaku			**Amoebiasis (1h), Malaria (1h)**	0	2	2	-	93

179	Nthangu	H		*Inflammation (1f), Injuries/cuts/wounds (1f)*	*1*	*0*	*1*	*290*	-
180	Nyama ya nthii			**Anthrax (1h), Back/bone/joints problems (jh), Brucellosis (1h), Meat allergy (1h), Placenta removal (1h)**	0	5	5	-	180
181	Queen of midow			**Arthritis (1h), High blood pressure (1h), Nervous system problems (1h)**	0	3	3	-	159
182	Quinine	H		Malaria (1f),	1	0	1	156	-
183	Rai	H		*Malaria (1f),* Pneumonia (2f, **1h**), **Worms (1h)**	*2*	*2*	*3*	*107*	*149*
184	Raibuta			**Worms (1h)**	0	1	1	-	253
185	Ruguru	H		*After-birth pains (1f), Blood cleanser (1f), Cough/colds/flu (1f), Stomach disorders (2f), Rheumatism (1h)*	*5*	*0*	*5*	*140*	*232*
186	Rugwai			**HIV/AIDS (1h), STDs (1h)**	0	2	2	-	124
187	Rwoga			**Blood purifier (1h)**	0	1	1	-	298
188	Sumita			**Malaria (1h)**	0	1	1	-	144
189	Thamwiria	S		*Immunity booster (1f)*	1	0	1	171	-
190	Yeera			**Pneumonia (1h)**	0	1	1	-	193

11.4 Appendix 3A: Farmers' questionnaire

Basic interview and farm details

Interviewer's name _____ Questionnaire number _____

Date _____2008 Interview start time _____

District _____ Catchment/Village _____

GPS details (Latitude ____, ____, ___ Longitude____, ____, ___ Altitude _____M)

Dear farmer

ICRAF works with farmers to ensure that more beneficial trees are planted in farmers' fields in order to increase their sources of income and improve their livelihoods. Medicinal trees are important in that they keep a family healthy and also due to increasing reliance of medicine from trees they are becoming increasingly traded but their wild sources are diminishing and we believe that the future of medicinal trees is in cultivation. The purpose of this interview is to help us understand how medicinal trees can become more cultivated by getting your opinion on how you plant them yourself. We do not want to take a lot of your time and want to thank you in advance for welcoming us. If you feel uncomfortable answering a question, please feel free not to answer.

Thank you

Respondent socio-demographic details

1. Name of respondent _____
2. Age in years _____ (below or 25) (26-35) (36-45) (46-55) (56-65) (above 65)
3. Gender Female (1) Male (2)
4. Level of education Not schooled (1) Primary (2) Village polytechnic (3) Secondary (4) Post secondary (5)
5. Name of farmer if different _____
6. Relationship of respondent to farmer _____
7. Main occupation of household head _____
8. Land size (acres) _____

Analysis of the respondents' perception of disease situation

9. How do you find the disease situation in your community? _____
10. If serious what can you say are the reasons for this situation? (tick all appropriate)
    1. Diseases occur many times in many households _____
    2. Some diseases are very severe when they occur and kill many people _____
    3. We have poor access to medical treatments when people get sick _____
    4. People do not know how to use medicinal trees or other forms of treatments ___
    5. Others (specify) _____

11. Rate the ten most serious diseases below considering the reasons above

Disease	**Farmers personal rating on importance**	**Frequ ency**	**Mortality rates**	**Access to medical treatment**	**Access to alternative treatment eg herbal**

Farmer's rating (5 - most important to 1- least important) Frequency/mortality (3-high, 2-medium, 1-low); Access to medical/alternative treatment (3-difficult, 2-a bit difficult, 1-easy)

12. What measures are you taking to minimize the effect of these diseases in your household (what treatment/control measures)? _____

    _____

13. When you or a household member experiences a disease symptom what is the first thing you do?
    1. Find a known plant material and prepare a herbal treatment _____
    2. Buy an over-the-counter drug _____
    3. Consult a medical clinic or hospital _____
    4. Consult a herbalist _____
    5. Other (specify) _____

Details of medicinal plants known by the respondent

14. Details of plants in the farm that have medicinal value (Questionnaire No ____)

Local name	Botanical name	Growth habit (t,s,h)	Indigenous or exotic	Where planted	Number naturally regenerated	Number planted	Main source of planting material

15. Domestic treatment use of medicinal plants in the farm

(Questionnaire No _____)

Local name	Botanical name	Most important disease treated	Other diseases treated	Do you actually use this plant in your home?	How many are sufficient for home use	Do your neighbours or anybody access this tree from your farm

16. Are there medicinal plant (trees and herbs) species that you know but are not present in your farm (Questionnaire No ____)

Local name	Botanical name	Size class (t,s,h)	Most important disease treated	Other diseases treated	Do you use this plant in your home	Where do you get it from?	Do you get enough material for your use	Why is this species not in your farm

17. Which is the nearest wild sources of medicinal trees/plants _____

18. How far is it from your home (approx km) _____
19. Do you have free access to the sources or is it controlled access _____
20. If controlled access, how is it controlled _____

Farmers preference for medicinal tree species

21. What factors do you consider in order to decide which medicinal plant species to plant or leave in your field when clearing others for food production? Please rate the factors of importance

Factor	**Rate (out of ten –farmer can use small stones to allocate rates)**
Plant treats many diseases	
Availability of seed/lings for planting	
Availability of market for plant medicinal products	
Cultivation technology for the plant is known	
Plant has other uses	
Other	

22. Please rate the medicinal plant species that you prefer most for cultivation. Rate how the factors mentioned above influence your preference for these species

Species name	Rate of influence by factor for preferring this species						
	Germplasm availability	Cultivation technology	Market availability	Knowledge of treatments	Other uses		

1-Low importance 2 - Medium importance 3- High importance

23. How (or where) do you get information **about use of medicinal trees for treatment of diseases** (tick all appropriate)
    - Herbalists _____
    - Nursery operators _____
    - Media (newspapers, radios etc) _____
    - Older relatives (parents, grand parents) _____
    - Neighbours _____
    - Others (specify) _____

24. How (or where) do you get information about **cultivation of medicinal trees**
    - Herbalists _____
    - Nursery operators
    - Government workers _____
    - Workers from other organizations _____
    - Media (newspapers, radios etc) _____
    - Medicinal tree product buyers _____
    - Neighbours _____
    - Others (specify) _____

25. For the species in your farm that you use for treatments, do you find differences in medicinal quality depending on where it is growing Yes _____ No _____

26. If yes, trees on farm can grow in three different sites/patterns as listed below. Of the list below if you were to select a medicinal tree for planting where would you plant it to get the best quality of medicine?
    - Single trees scattered in cropland _____
    - As lines mainly on the outer boundary where they are mixed with other trees ___
    - In a woodlot (area left with many trees growing together) or near rivers _____
    - Others (farmers may specify) _____

Please explain your answer_____

Medicinal tree germplasm access and requirements

27. What else do you think needs to be considered when planting medicinal trees specifically? _____

    _____

28. If scientists were to carry out research to improve medicinal trees for cultivation which aspect do you think should be given the highest priority among these?

Aspect	**Rank**
Fast growth (early harvest)	_____
Resilience after harvesting	_____
High chemical composition	_____
Increased biomass harvest of targeted part	_____
Other (specify)_____	_____

29. Name of the nearest tree nursery _____
30. Distance from farm to the nursery _____

31. Is the nursery functional? Yes/No _____

32. Please give us five medicinal tree species you would like to get from the nursery and whether you would be willing to buy the seedlings and for how much (Ksh)

Species local name	Species scientific name	Price willing to buy (ksh)	Would pay more if improved (Y/N)

Farmers marketing of medicinal plant products

33. Are there medicinal plant species whose products you have been able to sell? Yes/No

    _____

34. For the medicinal plants whose products are sold please give the following details

Local name	Planted or wild collected	Part sold	Who buys	When did you start selling this plant/	Volume sold per year when you started selling	Volume sold per year currently	Any reason for the trend	Is this buyer able to buy more volume?	If yes why cant you sell more

35. Other categories of trees such as fruits, timber etc planted in the farm as the farmer can remember

Category	Number of species	Number of trees	Do you sell this category of products	Where do you sell	Total production per year	Proportion sold

36. Other comments the farmer might have about medicinal tree cultivation and marketing _____

_____

_____

_____

_____

Thank you very much for your responses

Interview end-time _____

11.5 Appendix 3B: Herbalists' questionnaire

Basic interview and practice details

Interviewer's name _____ Questionnaire number _____

Date _____2008 Start time _____

District _____ Catchment/Village _____

GPS details (Latitude ____, ____, ___ Longitude____, ____, ___ Altitude _____M)

Dear healer

ICRAF works with farmers to ensure that more beneficial trees are planted in farmers' fields in order to increase their sources of income and improve their livelihoods. Medicinal trees are important in that they keep a family healthy and also due to increasing reliance of medicine from trees they are becoming increasingly traded but their wild sources are diminishing and we believe that the future of medicinal trees is in cultivation. The purpose of this interview is to help us understand how medicinal trees can become more cultivated by getting your opinion on how you plant them yourself. We do not want to take a lot of your time and want to thank you in advance for welcoming us. If you feel uncomfortable answering a question, please you are free not to answer.

Thank you

Socio demographic details

1. Name of respondent _____
2. Age in years _____ ☐(below or 25) ☐(26-35) ☐(36-45) ☐(46-55) ☐(56-65) ☐ (above 65)
3. Gender ☐Female ☐Male
4. Level of education ☐Primary ☐Secondary ☐Post secondary ☐Village polytechnic
5. For how long have you practiced as an herbalist? _____ years / months

6. How did you become an herbalist
   - Trained by father/grandfather _____
   - Trained by another (unrelated) herbalist _____
   - Trained in an institution _____
   - Just out of interest read books or tried _____
   - Any other (specify) _____

Perception on the status of diseases in the community by the respondent

7. For diseases which you treat in your work please give us rates* below in terms of number of cases consulting for treatment and the severity of the cases

Disease	Frequency	Severity of cases	Mortality rates

Rating * 1-low 2-medium 3-high

8. Are there diseases that are prevalent around that you specifically do not treat? Yes_____/No _____

9. If yes, for diseases which you do no treat in your work please give us rates* below in terms of how prevalent they are and the severity of the affected cases

Disease	Frequency	Severity of cases	Mortality rates

Rating * 1-low 2-medium 3-high

Perception on the supply of medicinal plant materials

10. Please give the proportion of materials that you use in your work from the following categories in percentage

- Herbs (includes all lower plants such as alloes etc) _____
- Shrubs (slightly bigger plants with woodiness) _____
- Trees _____
- Animals _____
- Other (specify) _____

11. Do you get all the materials from around here or do you have to travel long distances for some species _____

12. Which species come from very far?

Species	Growth habit (t,s,h)	Estimate distance to source in Km	Do you collect the species there or purchase	Was this species available around here before	Why is it not available now

Codes used: Size class (**1**: herb, **2**: shrub, **3**: tree);

Reasons for not available (**1**: climate not favorable, **2**: Lack of germplasm, **3:** over-exploitation, **4:** competition for other species uses, **5**: grows in forest and **6**: Cleared for cultivation)

13. Do you think the climate where a medicinal tree is growing affects the quality of the medicinal component? Yes / No _____ Explain _____

_____

_____

14. Do you think the soil where a medicinal tree is growing affects the quality of the medicinal component? Yes / No _____ Explain _____

15. If you were to get herbal material from the same plant species but from different sites which would you prefer

- Forest/woodland or farms _____

Why this preference? _____

- Wetland or dryland _____

Why this preference? _____

- Cold area or warm area _____

Why this preference? _____

16. If you can only get the medicinal plant material from the species from a farm which of the following sites would you prefer

In a site with many plants or tree is isolated _____ Why _____

_____

Fertile site or infertile _____ Why _____

_____

Shaded site or open _____ Why _____

_____

17. What in your opinion would make a medicinal plant be seen as priority for cultivation (please rank criteria in order of importance)

Criteria	**Rank**
Species treats many diseases	
Species becoming scarce in wild sources	
Availability of seed/lings of the species for planting	
Availability of market for the species products	
Cultivation technology known for the species	
Other	

18. Please give the ten medicinal tree species you would most prefer to be cultivated considering their use to treat many diseases and their scarcity

Tree species	**Treats many diseases**	**Getting scarce**

Treats diseases 3-many, 2 not very many, 1, a few; Scarcity 3-very scarce, 2-a bit scarce, 1- not scarce

19. What proportion of the medicinal plant materials that you use is from

- Wild sources (%) _____
- Cultivated farms (%) _____

20. What actions do you take to ensure continued supply of important medicinal tree materials with minimum expenses (tick all appropriate)

- Cultivation in my own farm/ medicinal plant garden _____
- Harvesting with care to preserve species _____
- Working with fellow herbalists to conserve species _____
- Educating the public on the importance of medicinal trees _____
- I have a nursery to supply medicinal tree seedling s for planting _____
- None _____

- Others (specify) _____

21. Do you plant any medicinal species in your farm/herbal garden Yes_____/No_____

22. For medicinal plants that are cultivated in the farm or medicinal plant garden

Local name	Botanical name	Most important disease treated	Other diseases treated	Do you actually use this plant in your work (yes/No)	How long have you used this species in your work	Do you see this species as threatened

23. What other medicinal plants do you use? (**also fill this table for those who do not cultivate medicinal plants**) (Questionnaire no ____

Local name	Botanical name	Growth habit (t, s, h)	Most important disease treated	Other diseases treated	How long have you used this species	Where do you get it from?	Do you collect it yourself or purchase from others	Do you get enough material for your use	What has been the trend of the supply	Do you see this species as threatened	How easy do you think it would be to cultivate this species

24. Do you have a medicinal trees nursery? Yes/No _____

If yes do you sell the seedlings or give away _____

25. How do you stimulate interest to plant medicinal trees by farmers _____

_____

26. If scientists were to carry out research to improve medicinal trees for cultivation which aspect do you think should be given the highest priority among these?

Aspect	**Rank**
Fast growth (early harvest)	_____
Resilience after harvesting	_____
High chemical composition	_____
Increased biomass harvest of targeted part	_____
Other (specify)_____	_____

27. What other comments might you have about medicinal tree cultivation and use in your work

_____

Thank you very much for your responses

Interview end time _____

11.6 Appendix 3C: Market survey questionnaire

Basic interview and practice details

Interviewer's name _____ Questionnaire number _____

Date _____2008 Interview start time _____

District _____

Division / local government jurisdiction _____

Dear trader

ICRAF works with farmers to ensure that more beneficial trees are planted in farmers' fields in order to increase their sources of income and improve their livelihoods. Medicinal trees are important in that they keep a family healthy and also due to increasing reliance of medicine from trees they are becoming increasingly traded but their wild sources are diminishing and we believe that the future of medicinal trees is in cultivation. The purpose of this interview is to help us understand how medicinal trees can become more cultivated by getting your opinion on how this can help the businesses associated with these products. We do not want to take a lot of your time and want to thank you in advance for welcoming us. If you feel uncomfortable answering a question, please you are free not to answer.

Thank you

1. Name of respondent _____
2. Name of business owner (if not same as respondent) _____
3. Relationship of respondent to business owner _____
4. Nature of business

   Herbal medicine (clinic) _____ Pre-processing_____

   Final products _____ Vending / brokerage / collectors _____

   Other (specify) _____
5. What are your sources of medicinal plant material in general?

   % own sourced _____ % bought _____

   % from wild _____ % from cultivation _____

6. Species dealt with (Questionnaire number _____)

Common name	Botanical name	Tree/ shrub/ herb	Part traded	Nature of trade	Who buys	When started to trade	Volume of trade when started	Current volume of trade	Demand greater/ less than supply	Volume sourced from wild	Volume sourced from farmers

7. Do you think the climate where a medicinal tree is growing affects the quality of the medicinal component? (Yes/No) _____

   Please explain your answer _____

   _____

8. Do you think the soil where a medicinal tree is growing affects the quality of the medicinal component? (Yes/No) _____

   Please explain your answer _____

_____

9. If you were to get herbal material from the same plant species but from different sites which would you prefer

   Forest/woodland or farms _____

   Why _____

   Wetland or dryland _____

   Why _____

   Cold area or warm area _____

   Why _____

10. If you can only get the medicinal plant material from the species from a farm which of the following sites would you prefer

    In a site with many plants or tree is isolated _____

    Why _____

    Fertile site or infertile _____

    Why _____

    Shaded site or open _____

    Why _____

11. If scientists were to carry out research to improve medicinal trees for cultivation which aspect do you think should be given the highest priority among these?

Aspect	**Rank**
Fast growth (early harvest)	_____
Resilience after harvesting	_____
High chemical composition	_____
Increased biomass harvest of targeted part	_____
Other (specify)_____	_____

12. What are some of the problems you experience in your business as pertains to tree species _____

    _____

13. What would say are the advantages of having medicinal trees cultivated by farmers for the market_____

    _____

14. What would say are the disadvantages of having medicinal trees cultivated by farmers for the market_____

    _____

15. Other comments on medicinal plants market _____

_____

16. If you buy medicinal products for your business please give us names and contacts for some of your suppliers so that we could also get their comments

Name of supplier	**Contact (Telephone preferred)**

17. If you sell medicinal products as your business (not for herbal clinics) please give us names and contacts for some of your buyers so that we could also get their comments

Name of buyer	**Contact (Telephone preferred)**

Thank you very much for you responses

Interview end time _____

Appendix 3D. Nursery operators' questionnaire

Basic interview and nursery details

Interviewer's name _____ Questionnaire number _____

Date _____2008 Start time _____

District _____ Division _____

GPS details (Latitude ____, ____, ___ Longitude____, ____, ___ Altitude _____M)

Dear nursery operator

ICRAF works with farmers to ensure that more beneficial trees are planted in farmers' fields in order to increase their sources of income and improve their livelihoods. Medicinal trees are important in that they keep a family healthy and also due to increasing reliance of medicine from trees they are becoming increasingly traded but their wild sources are diminishing and we believe that the future of medicinal trees is in cultivation. The purpose of this interview is to help us understand how medicinal trees can become more cultivated by getting your opinion on how you raise them and supply to farmers. We do not want to take a lot of your time and want to thank you in advance for welcoming us. If you feel uncomfortable answering a question, please you are free not to answer.

Thank you

Socio demographic details

1. Name of respondent _____
2. Age in years _____ ☐(below or 25) ☐(26-35) ☐(36-45) ☐(45-55) ☐(55-65) ☐(above 65)
3. Gender ☐Female ☐Male
4. Level of education ☐Primary ☐Secondary ☐Post secondary ☐Village polytechnic
5. Category of nursery (tick) Group _____Individual _____ central _____
6. Estimate size of nursery _____
7. Average tree seedling production per year _____
8. How long have you operated the nursery _____ years
9. Is the nursery the only enterprise you have (yes/no) _____

10. If no please list all the enterprises you have and the average contribution to your household income in the table below

Enterprise	**Estimate income proportion**
Nursery	
Livestock	
Crops	
Trees	
Employment	
Business	

11. Do you only have tree seedlings in your nursery or there are other enterprises also? (tick) Trees only _____ Other enterprises also _____

12. If you have other enterprises please give us the details below

Enterprise	**Proportion of nursery space occupied**
Tree seedlings	
Flowers	
Manure	

13. For the tree seedlings you deal with in your nursery please give us the details below (even for those not currently present)

Category of trees	Number of species produced last year	Total number of seedlings produced last year	Total number of seedlings **supplied**[1] last year	Total number of seedlings **demanded**[2] last year
Timber				
Fruits				
Medicinal				
Fodder				

1. All seedlings that went out of the nursery either sold, given away or planted in own farm
2. The total number of seedlings supplied plus any that clients may have asked for but the nursery operator did not supply because they were not available

14. For the medicinal trees seedlings in the nursery please give the following details (Questionnaire number _____)

Species local name	Botanical name	Indigenous / exotic	Tree/ shrub	Propagation method	Source of seeds	Any problems with propagation	Current number of seedlings	Number of seedlings supplied last season	Was the demand higher or lower than seedlings produced

15. Are there other medicinal tree species that you deal with or would like to deal with that are not in the nursery Yes/No _____ . If yes please give details below

Species local name	Botanical name	Indigenous / exotic	Tree/ shrub	Why is this species not in the nursery	Is it available in other nurseries	Any problems with propagation	Demand trend (high or low)

16. How do you compare the demand for medicinal trees species with other categories (tick)

    Demand for medicinal trees species is higher than others _____

    Demand for medicinal trees species is lower than others _____

    Demand for medicinal trees species is the same as others _____

17. How do you compare the trend of the demand for medicinal trees species for the years you have been operating the nursery (tick)

    Demand for medicinal trees species is increasing _____

    Demand for medicinal trees species is decreasing _____

    Demand for medicinal trees species is constant _____

18. What could be the reasons for the trend in the question above _____

    _____

19. Would you encourage farmers to plant more of medicinal trees? Yes _____ No_____
20. If yes, what efforts do you undertake to encourage farmers to plant medicinal trees especially those that are new to them _____

    _____

21. Any other comments nursery operator might have about medicinal trees cultivation

    _____

Thank you very much for your responses

Interview end time _____

12 Table of abbreviations

AEZ	Agroecological zone
ANOVA	Analysis of Variance
ENT	Ear, Nose and Throat infections
FAO	United Nations Food and Agriculture Organization
HIV AIDS	Human Immunodeficiency Virus that causes tha Acquired Immunodeficincy Syndrome
ICRAF	International Centre for Research in Agroforestry (now rebdranded World Agroforestry Centre)
IIRR	International Institute for Rural Reconstruction
KFS	Kenya Forests Service
MAPs.	Medicinal and aromatic plants
MDGs	Millenium development goals
MKEPP	Mt. Kenya East Pilot Project for Natural Resources Management
SPSS	Statistical Package for Social Sciences
STDs	Sexually transmitted diseases
THPs	Traditional Health Practitioners (also referred to in the text as herbalists)
WHO	United Nations World Helath Organization

13 CV

Personal data	
Name	KIURA, Jonathan Muriuki
Date of Birth	7 September 1973
Place of Birth	Mbeere
Country	Kenya
Nationality	Kenyan
Marital status	Married with two children
University	Moi University, Kenyatta Univeristy, Kenya
Education	BSc (Forestry), MEnvs (Agroforestry)
Professional experience	Ten years at World Agroforestry Centre (ICRAF since October 2000) Tree domestication research and development projects. Research interests at smallholder farming systems developing on-farm tree nursery systems and other projects related to imcreased tree planting on-farms especially medicinal trees species
Vienna	January 2011