ASSESSMENT OF INDIGENOUS TREE SPECIES CONSERVATION IN SUBSISTENCE AGRICULTURAL PRODUCTION SYSTEMS: A CASE STUDY OF LARI SUB-COUNTY, KIAMBU COUNTY

KAMAU MARYGORETTI WAWIRA

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Department of Geography & Environmental Studies

University of Nairobi, Kenya

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ABSTRACT

Conservation of indigenous trees is important because they regulate nutrients, build organic matter of top soil, fix nitrogen and create habitat for beneficial soil micro-organisms. The objective of this study was to assess existing on farm indigenous tree species in Lari Sub-County, their location on the landscape and rationale for retaining them. Lari Sub County was purposively selected because of the land use/ cover changes since the 1940's. Kinale ward was selected because it has a higher percentage of indigenous forest cover while Kijabe has most of its forests converted to agricultural and other land uses due to population pressure. Systematic sampling was used to identify 57 farms in Kinale ward and 39 farms in Kijabe ward.

Data was collected using structured questionnaires, complemented by key informant interviews in the two wards. Location of trees on the farm was done using GPS technology. Since the GPS points were recorded in degrees and minutes the excel data was first converted to decimal degrees for compatibility with the GIS software (ArcGIS). Each research assistant in-charge of collecting data was assigned a GPS with which they identified and logged the coordinates of the trees on the farm. These coordinates were converted into data layers (for Kijabe and Kinale) and were displayed in the GIS software (ArcGIS) and converted to GIS layers by clicking on Excel to Shape file conversion tool. The layers were then overlaid on Kijabe and Kinale wards layers for map preparation. In the map preparation window (layer out) the trees layer was double-clicked to display symbolization tool that enabled choosing and assigning different symbols and colors to different tree species. Other map information like the grid, legend, north arrow and scale bar were added to the maps by clicking on their respective display tools in the map window. The maps were then saved in either jpeg format by clicking on map export tool and assigning map names.

The results showed that various indigenous tree species are retained on-farm such as *Acacia abyssinica, Olea capensis, Ficus thorningii, Brachylaena hutchinsii, Allophyllus abyssinicus, Vitex keniensis and Prunnus Africana*. Indigenous trees scattered onfarm accounted for 57.4% along the boundary, 38.9% around the homestead 2.6% inside the farm and on riverine areas 1.1%. Soil conservation, timber, and fuel wood, were given as the main reasons for conserving indigenous tree species on the farm. Because of economic reasons and decreased land sizes, approximately 60% of the 96 farms visited are resulting to planting exotic trees.

In conclusion, indigenous trees are important because they regulate nutrients, build organic matter of top soil, fix nitrogen and create habitat for beneficial micro-organisms. Findings from the study indicate significant decrease of indigenous trees conservation due to high maturity span for exotic trees. The study therefore recommends genetic research to shorten maturity spans of indigenous trees. There is need to promote the alternative uses of indigenous trees as well as reinforce the 10% tree cover to include that 2% of the latter should be indigenous in nature.

DECLARATION

Declaration by the candidate

This research study is my original work and has not been presented for any other degree or any other award in any other university or institution of higher learning

NAME: Marygoretti Wawira Kamau

REG No: C50/64730/2010

Signature: ..... **Date**: .....

Declaration by the supervisors

We hereby certify that the candidate under our supervision developed this thesis and submitted it for review.

Dr. T. Thenya

Department of Geography and Environmental Studies

University of Nairobi

Signature:..... **Date**: .....

Prof. David Mungai

Wangari Maathai Institute for Peace and Environmental Studies

University of Nairobi

Signature: ..... **Date**: .....

DEDICATION

This research work is dedicated to my beloved husband Peter Kariuki Gachagua and my sweet daughter Michelle Mukami Gachagua. May you grow to love indigenous trees as I do.

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FAO: Food and Agricultural Organization

GDP: Gross Domestic Product

ICRAF: International Centre for Research in Agroforestry (World Agro-forestry Centre)

IUCN: International Union for Conservation of Nature

KEFRI: Kenya Forest Research Institute

KFS: Kenya Forest Service

UNFCCC: United Nation Framework Convention for Climate Change

UN: United Nations

WFN: World Forest Network

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Trees have been part of local land use systems for millennia in the world. The products derived from them, such as food, medicine, cooking fuel, animal fodder and construction materials, are critical for the subsistence of hundreds of millions of people throughout the world. Trees in rural landscapes also have protective functions at farm, landscape and global levels. They maintain soil fertility, allow more efficient water and nutrient resource use, control water erosion, and contribute to micro-climate moderation. The ecosystem services they provide at a global level in carbon sequestration and biodiversity conservation are also significant. Trees in human settlements are no less important.

Globally, between years 2000 (averaged 2000 – 2002) to 2010 (averaged 2008 – 2010) a statistical analysis by the world Agroforestry centre showed that the amount of tree cover on agricultural land increased substantially, with the area of >10% tree cover increasing 3%, or more than 828,000 km2. South America showed the largest increase in area with >10% tree cover: more than 489,000 km2: an increase of 12.6%. South Asia also showed a large increase (6.7%), along with East Asia (5%), Oceania (3.2%) and Southeast Asia (2.7%). In Central America, the area with >10% tree cover increased by 1.6% to become 96% of all agricultural land. For Sub-Saharan Africa, we found an increase of 2%. Only Northern and Central Asia showed a decrease: -2.9%. Tree cover apparently is still on the increase as a common feature on agricultural land throughout the world. It is essential that this is recognized by all involved in agricultural production, planning and policy development (Zomer *et, al*.2014).

Removal of trees from landscapes has for long been seen as a sign of intensification and progress, especially where mechanization of agriculture was involved (Zomer et, al 2014). Kenya is among developing countries in sub-Saharan Africa that shares problems of deforestation with other eastern Africa nations due to conversion of forests to other land use especially agriculture and settlement to meet the needs of ever increasing human population. Globally, around 13 million hectares of forest were converted to other uses , largely agriculture, or lost through natural causes each year in the last decade. This compares with a revised figure of 16 million hectares per year in the 1990s (UN, 2013). Estimates of the change in forest area over time provide an indication of the demand for land for forestry and other uses. Deforestation contributes 6.17% of global anthropogenic CO2 emissions to the atmosphere (Baccini *et, al.* 2012).

Data on the status and the trends in forest area are crucial to decisions about forest, land-use policies and resource allocations; but they need to be combined with information on other aspects such as forest health and vitality, and socio-economic and environmental functions and values of forests. In relation to the study by Zomer *et, al*. 2009, this research study agrees with the findings showing that there is apparent ubiquity and importance to quantify the extent of on

farm trees at the global level. The study also agrees that it has been hard to find reliable data on the actual extent of on farm trees around the world. This lack of data, and more fundamental misconceptions of what tree-crop integration is, had led to an assumption that it is globally of little importance. Such misunderstandings lead to suboptimal policy decisions and can best be reversed by providing objective, data-based measures of the extent of tree-crop integration. This research therefore, aimed at assessing the current number of indigenous on farm tree cover in agricultural production systems in Lari Sub County, Kiambu County in Kenya.

The agriculture/environment interface, according to Altieri and Nicholls 2005, is a growing source of problems, due to not only the frequently denounced negative effects of agriculture on the environment, but also to the increasingly strong constraints that environmental conservation places on small scale farmers and collective rangeland management. It is widely recognized that change in agricultural land use is an important driver of biodiversity loss in developing countries (Wretenberg and Berg, 2010). According to FAO (2010), the tree covered farm lands in the period 2000-2010 is estimated at 5.2 million hectares per year at the global level. This is down from 8.3 million hectares per year in the period 1990-2000.

In Kenya, limited studies have been carried out to assess factors associated with tree planting and retention by farmers in order to realize the expected output of improving tree/forest cover (Oeba *et, al.* 2012). The decision by farmers to plant trees may be difficult due to many land use needs especially agriculture in enhancing food security of about 40 million Kenyans. Subsequently, land size for farm forestry has continued to shrink as a result of high land fragmentation and settlement, unsupportive land tenure arrangements whereby women, married sons and other landless have limited access to land for either tree planting or management of naturally growing woodlands.

A study by (Oeba *et, al*. 2012) shows that integrating trees on farm that are otherwise dominated by few annual crops contributes to income diversification and spreads the risk of crop failure. In addition, higher intra and inter species diversity and a more complex vegetation structure enhance resilience of (agro) ecosystems against environmental and socio-economic changes and increase their productivity and multi-functionality. Indigenous tree species have the highest priority for conservation to prevent their extinction in their threatened natural habitat (Dawson *et, al.* 2009). By integrating more indigenous tree species into farms, additional habitat for these species is provided and farmers can benefit from the multiple tree products and services (Acharya 2006) resulting in conservation through use.

Approximately 64.63% of indigenous forests are found in gazetted Forest Reserves. Plantation forests represent just over 9.76% of the total cover in Kenya (Wass, 1995). "Deforestation deprived Kenya's economy of 5.8 billion shillings ($68 million) in 2010 and 6.6 billion shillings in 2009, far outstripping the roughly 1.3 billion shillings injected from forestry and logging each year," according to a UNEP news release on the joint UNEP-Kenya Forest Service (KFS) study

2010. Outside forest reserves in Kenya cover 0.18 million ha which is 14.5% of total land mass of Kenya (Wass, 1995). A recent study (Zomer *et, al*. 2009) has shown the importance of trees outside forests at a global scale: almost half of the agricultural land in the world (more than 1 billion hectares) has tree cover of more than 10 percent. However, in most countries trees outside forests are still poorly reported in the official statistics used to support national decision-making and policy. The most basic information – such as location, number, species, spatial organization, biomass, growth and production – is often lacking. Trees outside forests are thus most often ignored in land-use planning and development policies. One major reason for this lack of information is the difficulty and cost of assessing trees outside forests at the national scale. In Lari farms are dotted with remnants of indigenous trees e.g. Muthaiti-Kikuyu, common name – Camphorwood, Scientific name *Octea usambarensis*, Mukeu –Kikuyu, common name – croton tree, scientific name – *Melia volkensii* to mention a few in agricultural farms. There are those that germinated in the natural systems while others have been deliberately planted by farmers. It is for this reason that this research was undertaken to find out the types of indigenous trees, where they are grown and why they are retained in agricultural production systems in Lari Sub County that will provide crucial information to contribute to land use planning and development policies among other afforestation programmes.

1.2 Statement of Research Problem

One quarter of the terrestrial surface is composed of cultural systems, while in the tropics, 70% of the land has already been converted into pastures, agriculture, or a mixture of managed landscapes (Goulart *et.al*, 2012). Increasing pressures are being placed in forested areas due to changing farming systems, charcoal production and, more recently, climate change. Agricultural expansion is recognized as the most significant human alteration of the global environment. It is estimated that 40% of deforestation worldwide comes from subsistence farming (UNFCCC, 2010). The loss of natural forests results in the loss of all the resources such as timber, fuel wood and non-wood forest products and services such as conservation of soil, water and biological diversity that a forest provides. Furthermore, agricultural expansion has modified landscapes, making them more vulnerable to invasion by exotic species. Only 1.7 % of Kenya remains forested, with islands of trees in a sea of rural subsistence agriculture (WFN 2009). Population growth is exerting considerable pressure on Kenya's natural resources.

According to Ester Boserup theory on population growth which states that as human populations increase, they adopt more productive technologies (e.g. agriculture and other systems of ecosystem engineering), increasing the carrying capacity of human environments as needed. Small, family-owned farms that use agro-ecological techniques come closest to mimicking natural forest habitat, thereby creating corridors that allow plants and animals to migrate between forest fragments (Clements *et al*, 2010). In Lari farms are dotted with remnants of indigenous trees. There are those that germinated in the natural systems while others have been deliberately planted by farmers. Most of these indigenous trees can be found either planted

along the fence to mark boundaries or within the farms to act as a source of shade or fuel wood. Indication of a few tree species in Lari actually remaining are *Melia Volkensii (*Mukeu(kikuyu) croton tree*), Ocotea usambarensis (*muthaiti (kikuyu) camphor wood*)* and *Vitex keniensis* Muhuru –(Kikuyu) Meru Oak) to mention but a few. The reasons why farmers opted to keep these trees was not fully understood. However, they had a few reasons as to why they preferred to still maintain indigenous forests on farm as discussed in the chapter 5 on results and discussions.

The future of forests and tree resources basically depends on the growth and management of woody biomass which lies outside Kenya's forest estates. Sustainable land-use planning, effective organization of this tree resource and co-ordinated land distribution can become a reality. However users, including farmers and livestock keepers, must participate in the on-farm tree management decision making to safeguard trees outside forests. There are various drivers that enhance the protection of indigenous trees in various subsistence production systems which include policies, cultural aspects, economic, technological and ecological aspects which we need to understand. Increased population growth led to increased forest encroachment which had a negative impact to the ecology as well as livelihoods of residents then. Little is however known as to the extent of which indigenous tree species still exists on farm in Lari Sub County.

1.3 Research questions

1. What are the types of indigenous trees within Lari Sub County?
2. Where are the indigenous trees grown on farm?
3. Why are the indigenous trees conserved or eliminated in subsistence agricultural production systems?
4. What are the benefits at farm level attained from maintaining the indigenous trees on farm?
5. What is the relationship between the age of the farmer to indigenous tree species on farm?

1.4 Research Objectives

1.4.1 Overall objective

To assess the indigenous trees species conserved in subsistence agricultural production systems in Lari Sub County of Kiambu County in Kenya

1.4.2 Specific Objectives

1. To take an inventory of existing indigenous tree species on-farm
2. To find out the relative location of indigenous trees on-farm
3. To analyze the rationale for retention of indigenous trees on-farm

1.5 Hypotheses

1. There are no indigenous tree species in Lari Sub County.
2. There are no reasons as to why indigenous tree species are maintained on farm in Lari Sub County
3. There are no benefits of maintaining indigenous tree species on farm

1.6 Justification of the study

All indigenous trees grow naturally. According to the Kenya Forest Service (KFS), Kenya's forests have always been a key factor in ensuring that rainfall patterns remain stable as they enable agricultural activities to thrive (KFS, 2005). However, due to massive deforestation and industrial farming systems, people no longer have access to these natural tree-given services. Forest patches and trees in agricultural landscapes are an important resource for many smallholding farmers in tropical regions. Apart from providing food, fodder, and fiber, the trees, woodlots, and forest patches also provide many other ecosystem services such as water and soil fertility regulation, amelioration of local microclimate, and shade (Dewees 1995, Harvey and Haber 1999, Harvey *et al.* 2005, Muleta *et al*. 2011, Smukler *et al*. 2012). Moreover, such forest patches and trees can contribute to biodiversity conservation because they connect forest fragments, serve as habitats, and ease pressure on protected forest areas (Manning *et, al.* 2006, Bhagwat *et, al*. 2008, Perfecto and Vandermeer 2008, Pulido-Santacruz and Renjifo 2011). Farmers' practices in the management of agricultural landscapes influence biodiversity with implications for livelihoods, ecosystem service provision, and biodiversity conservation.

Tilmal *et, al*. 2001 predict that feeding a population of 9 billion using current methods could result in converting another 1 billion hectares of natural habitat to agricultural production, primarily in the developing world, together with a doubling or tripling of nitrogen and phosphorous inputs, a twofold increase in water consumption and a threefold increase in pesticide use. A 1997 study in the journal *Nature* estimated the global value of the goods and services that forest ecosystems provide —from timber to climate regulation to water supply to recreation at some US$4.7 trillion a year, or more than a quarter of that year's world GDP of US$18 trillion (Constanza *et, al.* 1997, World Bank, 2002).

Indigenous trees have the ability to maintain and improve agricultural production in the area by protecting water supplies, controlling soil erosion, improving soil fertility, and stabilizing soils.

The ability of indigenous trees to recycle nutrients, build organic matter of top soil, fix nitrogen, and create habitat for beneficial micro-organisms such as earthworms is helpful in fertilizing the farm. The advantage of indigenous trees is that they can be intercropped with annual crops to provide agro-forestry benefits. This type of tree includes *Acacia albida, Acacia nilotica, Acacia tortilis, Burkea Africana, Comiphora eminii, Cordia Africana, Olea capensis, Prunus africana, Melia Volkensii , Ocotea Usambarensis* and *Ficus thonningii* among others. The trees found on-farm are mostly referred to as 'trees outside forests' however the most basic information – such as location, number, species, spatial organization, biomass, growth and production – is often lacking. Trees outside forests are thus most often ignored in land-use planning and development policies. One major reason for this lack of information is the difficulty and cost of assessing trees outside forests at the national scale. This study aimed at exploring the indigenous trees diversity found in the subsistent agricultural production systems in Lari district in Kiambu. Information generated justified the existence of some indigenous species on farm and also the reasons why some species still remain on the farm. This information is useful since it contributes to literature background on development of future land use planning programs and policies which may help in conserving the remaining on-farm biodiversity due to the likely importance of environmental services they provide.

1.7 Scope of the study and limitations

The focus of this research was to assess the extent to which indigenous trees are conserved in agricultural production systems in Lari Sub County. The research focused on the location, number, species and spatial organization of existing indigenous trees on farm. Agricultural production systems might directly affect the efficacy of conservation of indigenous tree species on farm and might be attributed to loss of trees. Agricultural expansion is recognized as the most significant human alteration of the global environment. It is estimated that 40% of deforestation worldwide comes from subsistence farming (UNFCCC). The main economic activity in Lari Sub County is agriculture both at subsistence level and semi-commercial level in small pieces of land of about 0.8 ha. The research aimed to find out the extent within which remnant indigenous trees are conserved within the subsistence farming system which can also influence the biodiversity conservation in the region. The research used questionnaires and observation sheet as data collection tools. The research was divided into two parts, where the first included be a comprehensive literature review especially on issues related to conservation of trees in agricultural production systems as well as a field survey. The duration of the literature review and field research took one month to finalize. Financial limitations were experienced in undertaking the study thus it didn't happen as planned. The terrain of Lari is rugged and it is not easy to navigate that is why the study population selected included farms that are bordering along the major roads. Other limitation experienced during the study was the increased number of farmers who wanted to participate in the exercise. However, we tackled this by assuring them that this was an academic study and there was a methodology that we used in achieving the

desired sample size of 96 respondents. Weather was a major limitation since data was collected during the cold rainy season; it was therefore not so easy to navigate to the farms.

Operational definitions

Subsistence agricultural production system: is self-sufficiency farming in which the farmers focus on growing enough food to feed themselves and their families.

Indigenous tree species: These are the original tree species that were found on the land or trees that grow naturally in forests and are planted on farm

Indigenous tree species conservation: These are deliberate efforts taken by farmers to ensure that the tree species that were originally found on the farm are retained for biodiversity, aesthetic or economic purposes.

Biodiversity conservation: number and species of indigenous tree species found on farm in Lari sub county

Mixed farming; the art and science of growing crops and keeping animals

Mixed cropping; the art and science of growing different types of crops on farm.

Farm: This is a unit of land that is under cultivation where people keep animals as well as grow crops for subsistence or commercial use.

CHAPTER TWO: LITERATURE REVIEW

2.1 Forests and agro-ecosystem functioning

Forest ecosystems play multiple roles at global as well as local levels and provide a range of important economic, social and environmental goods and service that impact on the well-being of poor rural communities, local and national economies and global environmental health (IUCN, 2003). Out-grower schemes under various forms of contract with wood processing industries can also provide valuable sources of wood supply (Lungo *et, al*. 2002). Individual forest ecosystems provide many protective, scientific and commercial services, ranging from living space and food to climate regulation and genetic resources (FAO, 1994). Rural populations depend on the products of forests as well as on their environmental services (FAO, 1994). Forests support agriculture by providing materials for farm implements, harvesting and transportation equipment, crop storage containers and dryers as well as fuel for crop processing (FAO, 1995). Forests contribute to food security in many ways. However, these multiple benefits and services are valued differently by different people. Moreover, local, national and international interests also differ. For a number of reasons, the roles that forests are expected to play in local, national and global development change dramatically over time.

In agricultural systems, biodiversity performs ecosystem services beyond production of food, fiber, fuel, and income (Altieri, 1999). Agro ecosystems are ecosystems in which humans have exerted a deliberate selectivity on the composition of their biota i.e. crops and livestock maintained by the farmer, replacing to a greater or lesser degree the natural flora or fauna on site (Hawkins *et, al*. 1996). Examples include recycling of nutrients, control of local microclimate, regulation of local hydrological processes, regulation of the abundance of undesirable organisms, and detoxification of noxious chemicals. These renewal processes and ecosystem services are largely biological; therefore their persistence depends upon maintenance of biological diversity (Altieri, 1994). Farmer's decisions regarding planned diversity on the farm have consequences not only for the harvested produce, but also for associated diversity and non-harvested components which may contribute to ecological sustainability (Vandermeer *et, al*. 1998). When these natural services are lost due to biological simplification, the economic and environmental costs can be quite significant (Altieri, 1999). In agro-ecosystems, biodiversity performs a variety of ecological services beyond the production of food, including recycling of nutrients, regulation of micro climate and local hydrological processes, suppression of undesirable organisms and detoxification of noxious chemicals (Altieri, 1999). Economically, in agriculture the burdens include the need to supply crops with costly external inputs, because agro ecosystems deprived of basic regulating functional components lack the capacity to sponsor their own soil fertility and pest regulation. Complex (multi-species) agro-ecosystems change rapidly as a result of farmers decisions based on their perception of opportunities and constraints.

Approximately 30% of the global land area is currently forested (Schmidt *et, al.* 2009). It is estimated that at the global level, forestry formally contributes some 2 per cent to world GDP or more than US$ 600 billion per annum (FAO, 1997; Lomborg, 2001). The State of the World's Forests 2003 report emphasizes, forests can help in important ways to reduce food insecurity, alleviate poverty, improve the sustainability of agricultural production and enhance the environment in which many impoverished rural people live all over the developing world (FAO, 2003). However, the actual contribution of forests to the world economy is considered to be much higher, though extremely difficult to quantify (IUCN, 2003). With approximately 75% of Kenya's estimated 30 million population living in rural areas and an annual population growth rate estimated at 2.7% (World Bank, 1999), the threat of extinction to forest habitats becomes all too real. Increasingly trees are being planted to support agricultural production systems, community livelihoods, alleviate poverty and to provide food security (FAO, 2002). Communities and smallholder investors, including individual farmers, grow trees as shelterbelts, home gardens, woodlots and a diverse range of agroforestry systems to provide wood, non-wood forest products, fuelwood, fodder and shelter (Carle *et, al* 2002).

Kenya has a relatively low forest cover. Closed canopy forest covers about 1.24 million ha. Plantations cover 0.16 million ha. The total forest area is less than 3 per cent of the total land area of Kenya. Most of the indigenous forests occur in high potential areas where they are under severe pressure and competition from other forms of land use (FAO, 2002). Approximately 64.63% of indigenous forests are found in gazetted Forest Reserves (Wass, 1995). These are forests that are climatically restricted to the Central Highlands and the Nyanza Plateau, in areas below an altitude of 3,000 meters. The exceptions to this geographically limited area are forests occurring as islands on top of inselberg structures in the lower parts of the country, riverine forests and forests in the narrow coastal belt with rainfall over 1,000 mm. Over 88% (representing 1.24 million ha) of Kenya's forest cover is indigenous forests (Wass, 1995)

Table 2.1: Vegetation and Land-Use Cover

Type of Vegetation	**% of total area of Kenya**
Indigenous Forests	2.1%
Plantation	3%
Woodland	3.7%
Bushland	42.9%
Wooded Grassland	18.5%
Mangrove	1%

Type of Vegetation	% of total area of Kenya
Grassland	2.1%
Desert	13.7%
Farmland and Urban Development	16.5%
Total	100%

Source: Wass, 1995.

The future of forests is intricately tied to the future of the local population and the conservation of the forests depends upon the sustainability of local rural livelihoods (IUCN, 2003). It is well understood that native vegetation, especially remnant vegetation provides, the best range of habitat to sustain and enhance biodiversity (PIRSA). Recently published findings by (Gorr *et, al.* 2009), found that farm forestry shelterbelts provided benefits to bird, bat and insect biodiversity. They also found evidence that shelterbelts helped to suppress exotic bird spp. and other pests. Farm forestry is an appealing option to sequester carbon on agricultural lands because it can capture and store significant amounts of carbon while still leaving the bulk of land in agricultural production. Afforestation of agricultural land has also been shown to enhance stocks of soil carbon (Lal, 2005). Work in Australia has shown that crop yield increases more than 20% were achieved in the zone extending out to a distance of ten or so times the wind break height (Cleugh, 2003).

2.2 Deforestation for agricultural expansion

Tropical forest loss in Africa, on the other hand, is caused more by small-scale agricultural activities and less by large-scale commercial agriculture (DeFries *et al*. 2010; Fisher 2010; Rudel *et al*. 2009).Africa's rising population growth (with some countries such as Kenya recording a 10 per cent growth in the last decade), the continuous degradation of agricultural lands because of over and poor utilization, and increasing scarcity of water on the continent have raised questions about the suitability of the current classic agricultural system (Scherr, 1994). Agroforestry strategies have been oriented to intensification, with most new trees being established in or around cropland, and the use of new species appropriate to intensive intercropping (Scherr, 1994). Over the years, the natural forest cover in Kenya has been reduced mainly because of different anthropogenic activities, particularly encroachment for agricultural expansion, forest excisions for settlements and infrastructural development; in addition there have been incidences of illegal logging (Collins and Clifton 1984, Beentje 1988). As a result, both the ecosystem services values (intrinsic e.g. for biodiversity) and the ecosystem function values (instrumental, e.g., regulation of hydrology) of the forests have been affected. Impact observed in the ecosystems have included changes in hydrology as manifested in increased incidences of floods (Olang' and Kundu 2011) and those in biodiversity as manifested in losses of medicinal plants.

Nearly one-third of terrestrial lands have agricultural crops or planted pastures as a dominant land use (accounting for at least 30% of total area), thus having a profound ecological effect on the whole landscape (Scherr *et, al*. 2007). Up to 50% of the globe's agricultural land and 60% of ecosystem services are now affected by some degree of degradation, with agricultural land use the chief cause of land degradation (MA 2005; Bossio *et al.* 2004). Induced innovation theory (Boserup 1965; Ruttan and Hayami 1984) suggests that degradation may be self-correcting, as resource scarcity or rising private and/or social costs from degradation induce the development and use of new agricultural and resource management practices. Ruthenberg's 1980 classic study of "Farming Systems in the Tropics" summarizes a large literature documenting the agricultural innovations historically associated with increasing population density and increasing market integration in different agro ecological zones. This evidence is particularly compelling in that most innovation was endogenous, or the process of informal borrowing and adaptation of technology between trading zones. Ruthenberg associates many of the technical changes in crop management, crops and landscape management explicitly with crises in soil management. Other work in induced innovation has documented similar evolution of farming systems in the areas of mechanization (Pingali, Bigot, and Binswanger 1987) and livestock management (McIntire, Bourzat, and Pingali 1992).

2.3 Policies influencing indigenous tree conservation

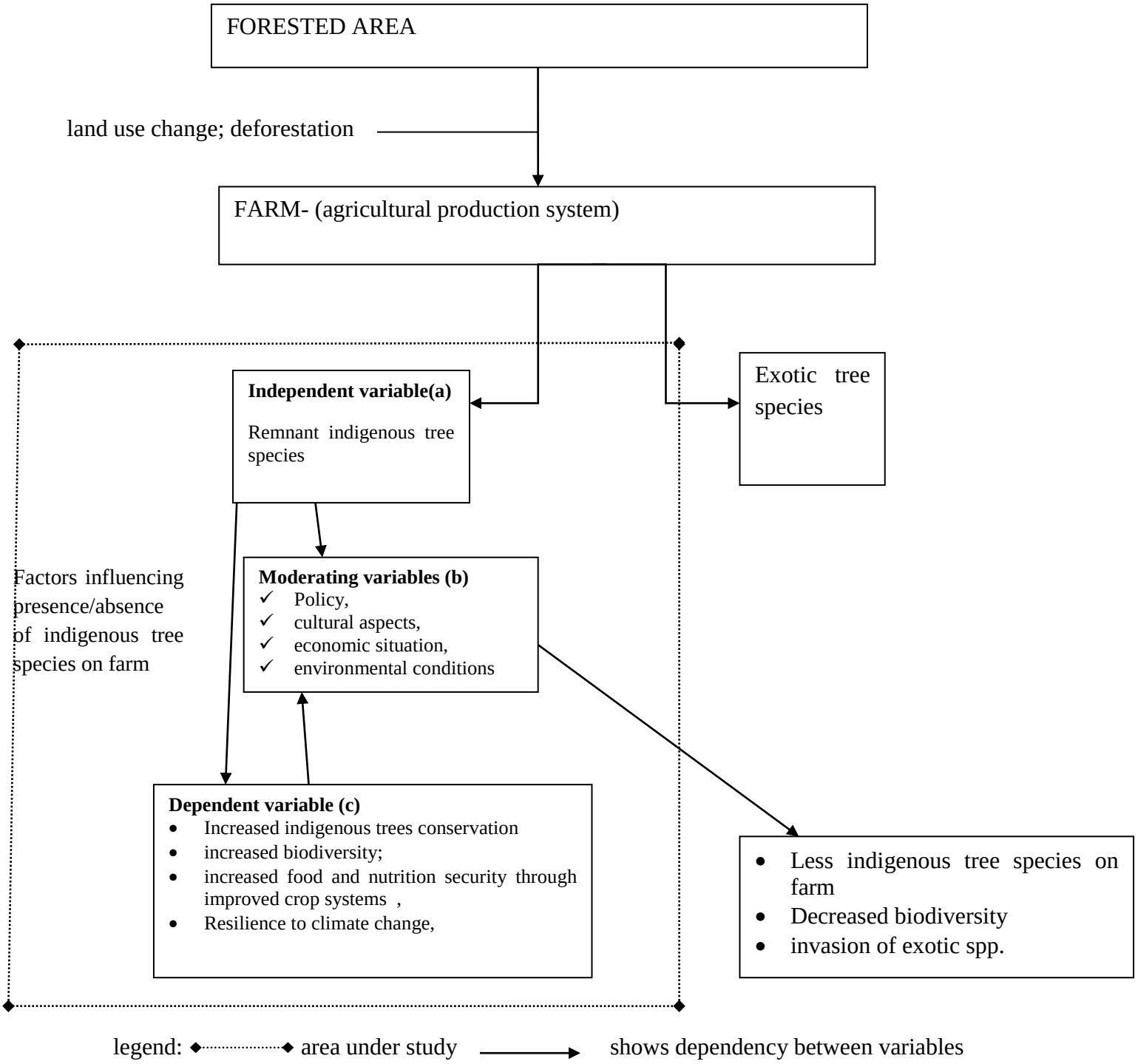
The Forest Policy 2014 has a clause on protection of indigenous forests and it aims at "promoting ex-situ and in-situ conservation of forest genetic resources" as well as "encourage and support land owners to sustainably manage natural and riverine forests. The Forests Act (2005) has recognized the importance of involving stakeholders including local communities in the management of forests. The Kenyan Agriculture Act Cap, 318 of 1980 (revised 1986) has the stated objectives to promote and sustain agricultural production, provide for the conservation of the soil and its fertility, and stimulate the development of agricultural land in accordance with the accepted practices of good land management and good husbandry. Authorized officers are empowered to prohibit the clearing of vegetation and the grazing of livestock and to require the planting of trees to protect the soil from erosion and impose penalties under the Act. In the past, the President (former his excellency Daniel Toroitich Arap Moi) made pronouncements that have direct bearing on forests. For example, in 1986, the President declared a ban on the felling of indigenous trees (IUCN, 1996). One of the purposes of agroforestry tree domestication is enhancement of stability and productivity of agro-ecosystems by diversifying on-farm tree species composition (presence and abundance). Diversification and intensification of land use through domestication of agroforestry trees is one of the three pillars of the research of the World Agroforestry Centre (Kindt and Lengkeek, 1999; ICRAF, 2000). In this research we aimed to investigate, tree species diversity at subsistence agricultural production systems with a specific focus on individual subsistence farms. The results will be interpreted as options for diversification planning for farm-level tree diversity in landscapes where farmer management dominates the presence of trees, although spontaneous regeneration of trees still occurs.

2.4 Research Gaps

There is minimal research on documenting the indigenous tree species diversity within the country. However, Kindt R. *et. al*, 2005 presented a paper on biodiversity conservation through agroforestry where they did a complete tree census in 10 farms in Western Kenya. The paper focused mainly on species diversity on farm. This research focused on the same but with particular emphasis on census, location and factors influencing conservation of the indigenous tree species on subsistence farms in Lari Sub County.

2.5 Conceptual framework

Figure 2.1: SUBSISTENCE AGRICULTURAL PRODUCTION SYSTEM; i.e. (FARM)



Source: Researchers 2015

Explanation of the logical framework

Generally, Fig 1 represents subsistence agricultural production system where there are various variables that affect how it operates and can provide a rationale in which can derive sustainable development in the long run.

Independent variable (a): Indigenous trees are slowly getting depleted due to encroachment to natural forests due to increased population growth and land use change. Remnant indigenous trees can sometimes be found in some agricultural farm lands while in some are completely non-existent and are now fully replaced by faster and early maturing exotic trees. According to Malthusian theory of population growth he hypothesized that unchecked population growth would quickly exceed carrying capacity leading to overpopulation and social problems and basically people will start to die. One of the social problems that has been created is encroachment to natural forest in search for agricultural land and subsequently climate change vagaries. However, Ester Boserup says that you just have to upgrade the productivity of the food supply. Under pressure of numbers, with more mouths to feed, people put more labour and more intense effort into feeding themselves, and find ways to get more food production out of the land. They cultivate the land more intensively; they add extra manure, extra fertiliser, extra water and improve their crops. They invent their way out of the Malthusian crisis. Indeed, the Malthusian trap may even drive the development of technology. This led to change of land use and forest vegetation was cleared to pave way for agricultural expansion. In the process, most of the indigenous tree species were cut down and only remnants of them can be found especially in subsistence agricultural farming systems. The species in focus found in Lari Sub County are e.g. Muthaiti-Kikuyu, common name –Camphorwood, Scientific name *Octea usambarensis*, Mukeu –Kikuyu, common name – croton tree, scientific name – *Melia volkensii* however, the research found other indigenous tree species see chapter on results and discussions.

Moderating variable (b): Traditional Ecological Knowledge, in which indigenous peoples acquired the knowledge base over hundreds of years through direct experience and contact with the environment. Indigenous stewardship models is the physical, spiritual, mental, emotional, and intuitive relationship of indigenous peoples with all aspects and elements of their environment. These relationships include, but are not limited to, a combination of knowledge, experience, tradition, places, locality, all living and nonliving things, skills, practices, theories, social strategies, moments, spirituality, history, heritage, and more; and may not be fully embraced by people who fail to understand all those dimensions. The research explored the various factors that actually influence the reason why the independent variables on this study exist and how the moderating variables provides the environment for them to exist.

Dependent variables (c): Although there has been, and still is, debate on the precise definition of the concept of sustainable development (Hofkes, 1998) a broad consensus exists that it means that economic activities should be consistent with: sustainable use of renewable natural

resources, protection of ecosystem features and functions, preservation of biological diversity, a level of harmful emissions remaining below critical (assimilative) thresholds, and avoidance of irreversible damage to the environment and nature (Daly 1990). So as forests are a means of livelihoods, the independent and dependent variables are present then indigenous tree species will definitely be conserved on farm that will accrue to the various benefits associated with environmental and agricultural sustainability; increased food and nutrition security, decreased vulnerability to climate change, improved crop systems and eco-tourism. Therefore a+b=c but c is a subset of Sustainable Development.

In conclusion when for variable A to exist these are the indigenous trees the independent variable other factors need to be taken into consideration e.g. the moderating variable. If these two variables exist then it will lead to the dependent variables c which will eventually lead to sustainable development.

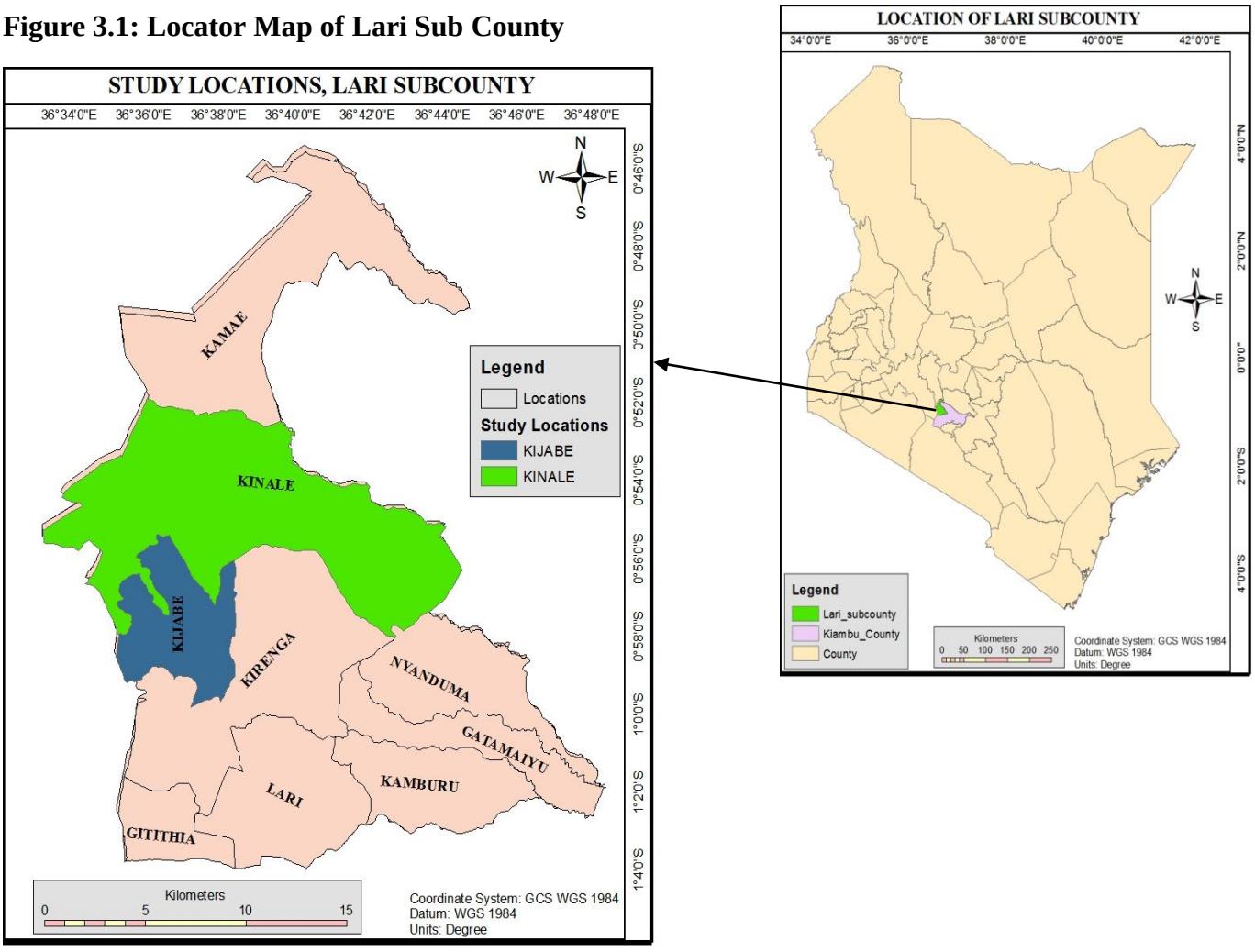
CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Geographical location

Lari district covers an area of 439.20 km^2 (169.58 sq mi) with an elevation of 2200m (7200ft absl.). The study area covers two wards Kinale 112.3 km2 with a population density of 130 the agro ecological zone is depicted by Sheep and Dairy land use sub location, Forest land use sub location, Tea Dairy land use sub location and Wheat barley zone. Kijabe on the other hand lies in 29.8 km^2 with a population density of 711 the agro ecological zone lies in Wheat-Maize-Pyrethrum zone, wheat-barley zone and Tea and Dairy zone. The land use in Lari is classified as sheep and dairy zone with permanent cropping possibilities, dividable in a long cropping season followed by medium one. It ranges from 2415 to 2591m a.s.l and receives 1150 to 1276mm mean annual rainfall. Kereita Forest is in Lari District in Kiambu County. The forest forms part of the Aberdare Forest Reserve., while to the east, it borders the Uplands Forest Station. The forest covers a total of 4,722 hectares.

Figure 3.1: Locator Map of Lari Sub County



The forest lies within the Upper Highland Zone and forms an extension of the Aberdare range lying at an altitude of 1,800 meters above sea level. The forested area of Lari lies within the Kikuyu escarpment which is facing massive destruction, resulting in rapid biodiversity loss and reduced environmental value (KENVO 2012). Farms neighboring the forest had been over-cultivated, resulting in low productivity with very low returns. A lack of livelihood alternatives and a high demand for forest products meant that illegal exploitation of the forest thrived. Cases of charcoal burning and illegal logging were common in many parts of the forest across the entire Kikuyu escarpment (Gichora *et, al* 2010). Lari district was selected to explore the magnitude of depletion of forest cover and what is actually remaining on farm. The study sites are based in two wards.

3.1.2 Biophysical characteristics

Kiambu county has 3 main agro-ecological zones namely, the upper highlands, upper midlands and the lower highlands. Lari Sub County lies in the upper highlands and is characterized as the sheep, dairy and tea zones. The area forms the main catchments area for natural channels with well-drained soils. It is mainly in Lari and parts of Githunguri and Limuru Divisions. The climate in the area is largely influenced by altitude. The rainfall averages 1500mm/year, well distributed and reliable and has largely influenced agricultural activities in the landscape. Temperatures range from 70C to 340C in the Upper Highlands to the Lower Midlands. Rainfall is bimodal with the long rain occurring in the months of March to May followed by a cool season during July and august and culminating in the short rain in October and November. The rainfall is well distributed and reliable and has largely influenced agricultural activities in the landscape.

Majority of the people in the county depend on agriculture for their livelihood, with 304,449 directly or indirectly employed in the sector. Coffee, tea and pineapples are the main cash crops while maize, beans, and Irish potatoes are the main food crops commonly grown in small scale in the upper highlands of Limuru, Kikuyu, Gatundu North and South Constituencies. The land is purely an agriculture zone and agricultural practices are rain dependent. In relation to the land use patterns, Lari lies in the high to moderate fertility where livestock, tea, coffee and horticulture agro enterprises are practiced. The district has three broad categories of soil on the high level uplands, on the volcanic foot ridges and on the plateaus. The soils on the high level uplands developed from volcanic rocks and are generally well drained and very deep, and are red or dark reddish brown or grey silt clay loams. The soils have high organic carbon content (3-4%), which reflects high level of applied organic matter, low nitrogen, while phosphorus levels remain average (Makokha Stella, Kimani Stephen et. al).There is use of both organic matter and inorganic fertilizers for soil fertility. These are found in the Lari Sub County and are of high fertility, and they are also found in the forest zone. The soils are well drained, extremely deep, grey or red or dark brown friable clays. These soils cover major crops like coffee, tea and pyrethrum.

Forest covers about 37,000 ha with 13,000 ha located in a different landscape. The highest percentage of this forest is natural indigenous forest and a small section of exotic tree plantation for timber production. The forest is designated as an Important Biodiversity Area and listed by Birdlife International in the highest category "critical'' for conservation action (Bennun and Njoroge 1999). It hosts a variety of important global species and is particularly rich in bird life. It is home to 140 bird species, 20 of which are considered rare ("BirdLife", 2007). The forest is an important community asset which has been a main source of forest products including water, fuel wood, herbal medicine, fodder for livestock, building materials as well as leisure space. The forest is an important catchment area that supplies water to the Kenyan capital, Nairobi (Kuria and Githiru 2007). The surface water and sub-surface water resources in the landscape are abundant. There are a number of permanent rivers, springs, wells and boreholes. Reliability of these water sources is very high as most of the rivers and water facilities are perennial. A substantial percentage of households in the landscape also harness rain water through roof catchment. Similarly, underground water resources are greatly exploited and boreholes drilled have high yields with good potential for irrigation with the proper mechanization.

3.1.3 Population

The population in Lari is 123,895 according to the 2009 census report with a density of 282/Km^2 439.2 sq km. The majority of the people depend on small scale farming with the average size of the land being 0.8 hectares. Tea farming is largely practiced by residents of the eastern part of Lari these areas include Kagwe, Kagaa, Gatamaiyu and Matimbei areas. Crops grown for sale include vegetables such as cabbage, coriander, spinach and kale (sukuma wiki). Vegetable farming in the constituency is largely favored by the large amounts of rainfall received throughout the year and the continuous cold seasons. where they grow various types of cash and subsistence crops and keep livestock in their small holdings. There are two major markets for vegetables in the constituency; Soko Mjinga Market and Nyambari Godown Sukuma Wiki Market. Both markets supply approximately 1,500 bags of kale per day to the major towns in Kenya. Lorries also ferry tonnes of cabbage from Kinale location daily to various towns in Kenya. Lari also produces majority of the pears found in Kenya, with most of the crop grown in Nyambari, Gitithia, Githirioni, Kirenga, Kimende and Kambaa locations. Many farmers in the area rear dairy cows. While the milk is produced mainly for personal consumption, the surplus is sold, usually to dairy cooperatives that have local offices in Lari. There are three milk processing plants in the area: Sundale Dairy Products in Uplands, Green Land Dairy in Nyambari, and Kinale Milk processing Plant in Kinale. The male population is 60,632 while the female population is 63,283 almost a 50:50 ratio in terms of gender (KNBS, 2010). The district is divided into 9 wards a clear elaboration shown in Table 2.

Table 3.1: Population density within Lari sub county

Ward	Area (sq Km)	Population	Population density	Sub-locations (sampling frame)
Kamae	74.2	11,418	154	Kamae Kamukombini
Kinale	112.3	14,589	130	Kinale, Mukeu
Kijabe	29.8	21,176	711	Bathi, Magina, Mabuini, Kijabe
Githithia	16.0	8158	509	Githithia, Nyambari
Lari	41.7	9,801	235	Lari Scheme, Githirioni
Kirenga	73.5	16,348	223	Kirenga, Gituaba, Kambaa, Escarpment
Gatamaiyu	91.7	14,066 (14,066)	153	Gatamaiyu, Nyanduma, Kamburu

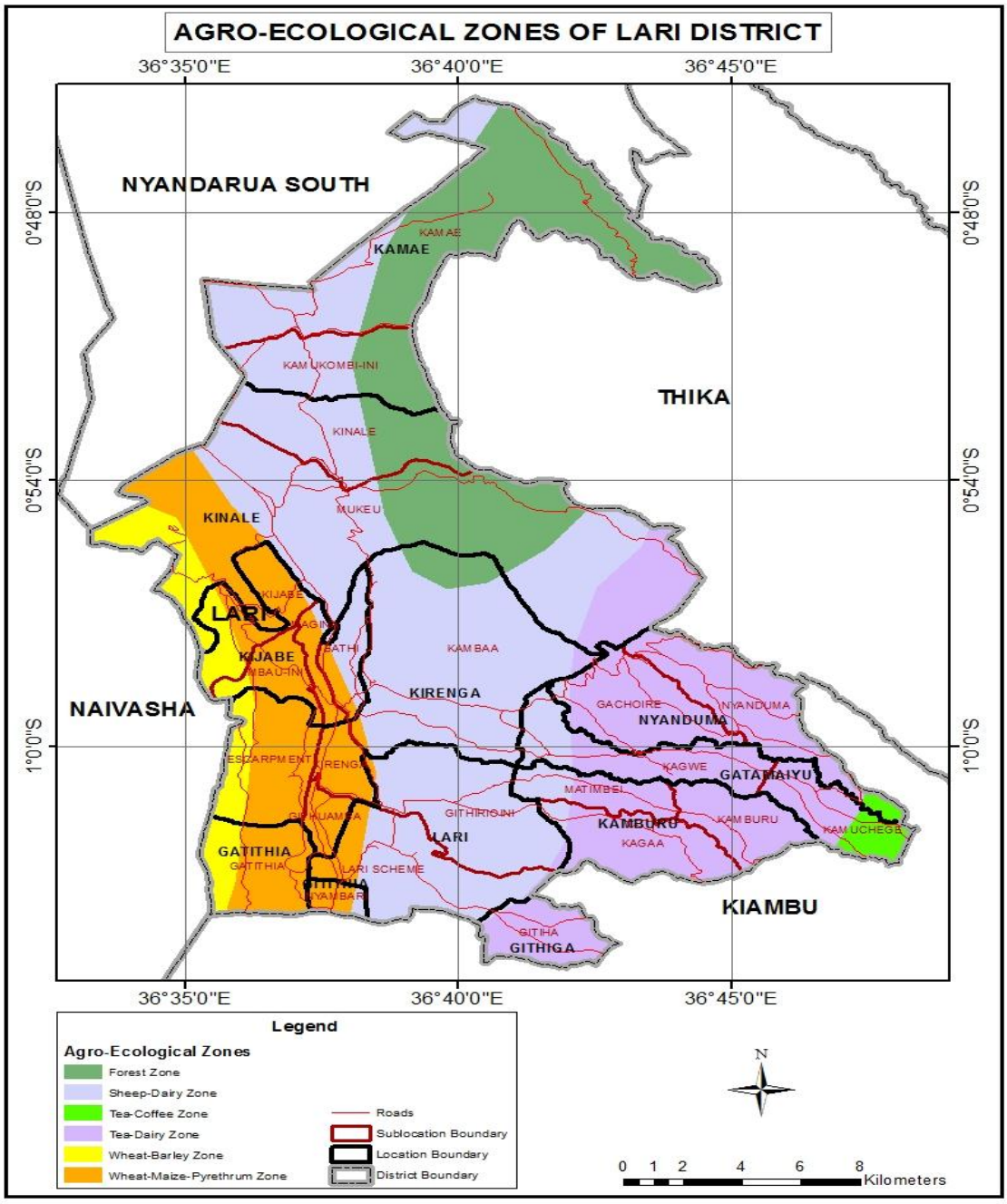
Source: KNBS 2010

Based on the population density, the study sites selected were Kinale and Kijabe wards where a comparative analysis of the conservation/erosion of indigenous trees on farm was undertaken.

3.1.4 Land use

Majority of residents in Lari practice agriculture as the main source of livelihood however majority are subsistence farmers. The majority of the people depend on small scale farming with the average size of the land being 0.8 ha where they grow various types of cash and subsistence crops and keep livestock in their small holdings. The crops grown include 23 vegetables, five legumes, five root crops, four cereals, two commercial flowers, 12 fodder crops and 18 fruits. Most of these are grown for the urban markets in Kenya. Kiambu county has wide variations in altitude, rainfall and temperatures between the highland and lowland areas combined with differences in the underlying geology (Fig 2) that give rise to a variety of soil types in the district. As a whole, soils fall under five categories which can be classified into general fertility groups as shown in table 3.

Figure 3.2: Agro-ecological zones map of Lari sub county



Source: FAO 2014

Table 1.2: Land use pattern and estimated soil fertility in Kiambu County

Land use pattern	Estimated soil fertility	Area (sq Km)
Forest, sheep, dairy cattle, pyrethrum and vegetables	High fertility	318.63
Livestock, tea, coffee and horticulture	High to moderate fertility	1225.5
Pineapples, avocadoes, onions, lettuce, maize and beans	Moderate fertility	490.2
Katumani maize, sisal, cotton, sorghum, millet, cassava, tobacco, onions, and tomatoes	Low fertility	49.02
Ranching and drought resistant crops	Variable fertility	367.65

Source: Kiambu District development plan 1988-1993

3.2 Study Design

The study design adopted for this research was both descriptive as well as cross sectional research designs. The study was designed to capture two agro ecological zones; these were selected through purposive sampling based on the agro ecological characteristics and population size. The sample selected through multi-stage sampling was subjected to both observation and interrogative data collection. The descriptive study design was majorly to observe the indigenous trees within farms. However, only a cross section of farmers was selected to participate in the study since data collection was only done for farms along major roads. The purpose of selecting these farms was based on the assumption that farms nearer to the major road networks hardly had any indigenous trees because of the already high demand for timber.

3.3 Type and Sources of Data

The data that was collected in this research was both quantitative and qualitative type of data. The data collected aimed to prove/disapprove that natural trees/indigenous trees are actually existing in dotted subsistence farming systems for various reasons and for certain benefits that may not be quantifiable. Data collected was both primary and secondary data.

Secondary data was sourced from Journals, reports, policy papers; this helped in enriching the literature review as well as the introduction of this report. The reports also assisted a lot in

forming major conclusions and recommendations as to why it was important to still maintain indigenous trees on farm.

Primary data was collected through administration of questionnaires to capture the cultural aspects, economic and environmental aspects that influence either the planting of cutting down of indigenous tree species on farm. Pictorial evidence was collected through photographs and aimed to prove or disapprove the hypothesis. A Species inventory recording schedule was used to determine the kind of tree species found on the farm. An observation list was designed to capture this data. Spatial data was collected through global positioning system to provide relative location of farm under study, the relative location of trees on farm this was recorded as the longitude and latitude of the trees on the farm.

3.4 Sampling Procedure

Focus is in Lari sub county. Based on the population density and agro ecological differences purposive sampling was done among the 9 wards in Lari Sub County and 2 wards were selected for the study i.e. Kinale-dry and Kijabe-wet wards. Multi-stage sampling was used to get the sample population within the wards. Multi-stage sampling is refers to sampling plans where the sampling is carried out in stages using smaller and smaller sampling units at each stage. First study sites were sampled through purpose sampling methodology based on agro ecology and population sizes. Thereafter, major roads were identified within both Kinale and Kijabe wards and identified a common starting point for data collection. The starting point was at the district office of each sub location and every 5^{th} farm to the right side of the road after the district office was selected to be part of the sample for the particular sub location. The farm along the major road bordering the sub location under study formed the random starting point for getting the next sample within the sub location. This interval between the 5^{th} farm and the 10^{th} farm is referred to as the sampling interval, is calculated by dividing the population size by the desired sample size. The study engaged 96 farms in Kinale and Kijabe. The advantage of using this method was that despite the study sites being selected in advance, systematic sampling was thought of as being random, provided the periodic interval is determined beforehand and the starting point was random. This was done along major roads within each sub-location the walk took place in a north south and east west direction. The study unit under each ward was the farm where there was a farmer.

3.5 Sample Size

The total population of area under study was 35,765 persons in Kinale and Kijabe. In Kinale the population was 14,589 and Kijabe 21,176 persons with a population density of 130 and 711 respectively. The required sample size of 96 households was determined by the total population of the study area following sampling methodology (Anderson *et al*., 2007).

$$n = \frac{pqZ^2}{E^2}$$

Where n = sample size, p = proportion of the population containing the major interest, q = 1-p, z = confidence level (α = 1.96), E = acceptable/allowable error. Since the proportion of the population is not known, p=0.5, q = 1-0.5= 0.5, Z = 1.96 and E = 0.1. This results to a sample of 96 respondents who were selected from the population.

$$n = 0.5 * 0.5 * 1.96 * 1.96$$

$$0.1 * 0.1$$

$$n = 96$$

Kinale has the lowest population density so get 60% of the sample population (57 households) while Kijabe gets 40% of the population (39 households).

3.6 Data Collection

The population of interest was selected from selected subsistence farms in Lari Sub County of Kiambu County. As explained above, Lari has seven wards therefore, within Kinale and Kijabe wards sampling frames were developed within the sub-locations for primary data collection

For primary data the research collected data through

A transect walk along major roads was done during data collection. From the starting point, enumerators collected data with an interval of 5 farms in between. Data collection was done in two fold, interviews at household level were done and also observation method using a checklist was done. Key agricultural field officers were identified and engaged during data collection to assist in identification of the various indigenous trees on farm. Global Positioning Systems was used to collect spatial data of trees on farm. This helped to describe the reasons why the trees are situated in a particular area e.g. boundary trees, near the homestead etc.

Structured Questionnaire, A reconnaissance visit was done to both Kinale and Kijabe wards prior the study to seek permission from relevant authorities to conduct studies. Notices and fliers were then circulated churches, collection centers and market places in both Kinale and Kijabe wards as advised by the chief of these wards. A pre-test study was then conducted to assess the reliability and validity of research instruments and was rectified accordingly in preparation for field work. 5 enumerators were then identified and trained on the objective and purpose under which data collection will be done. The training encompassed how to administer the questionnaire and the use of GPS gadget for positioning of trees and filling in the observation schedule. The 5 enumerators trained were then matched to 10 support field officers 5 from each ward who worked for the ministry of agriculture. The reason was to introduce them to the residents and enable respondents to give truthful answers as well as act as interpreters to local language commonly spoken in Lari which is Kikuyu. Data collection was done for first 2 days in Kinale (Mukeu and Kinale sub locations) and then 3 days Kijabe (Bathi, Mbauini, Kijabe and Magina sub locations) wards. In relation to the numbers reached and the size of the sub locations

respondents the number of questionnaires varied per ward in Kijabe (10 Bathi, 10 Magina, 10 Mbauini and 6 Kijabe) ward were administered in Kinale (25 Mukeu and 32 in Kinale) questionnaires were administered.

Tree inventory: a tree inventory observation schedule that was developed prior the field work enabled data collection on farm. A walk in the farm under study through the permission from the owner was necessary for effective data collection. This enabled data on the relative position, height, breath and reasons for maintaining of the trees on the farm to be recorded on the schedule. Photographic evidence of some of the trees on the farm was also taken. The research encouraged the farm owner to take the walk together on farm to help identify the name of tree in local language and the recorded on the observation schedule, the name of the tree, the era/age of tree, position in the farm, purpose of tree, relative height of tree, diameter and breast height and status of the tree (pruned, damaged etc.). The 10 field officers supported a lot especially in determining the name of tree since it was sometimes hard for the enumerators or farmer himself to identify the tree by name.

Spatial data collection

This was done using global positioning system to give the relative position (using longitude and latitude) of tree on the farm.

Step by step procedure for spatial analysis

- Since the GPS points were recorded in degrees and minutes the excel data was first converted to decimal degrees for compatibility with the GIS software (ArcGIS).
- The converted data layers (for Kijabe and Kinale) were displayed in the GIS software (ArcGIS) and converted to GIS layers by clicking on Excel to Shape file conversion tool.
- The layers were then overlaid on Kijabe and Kinale wards layers for map preparation.
- In the map preparation window (layer out) the trees layer was double-clicked to display symbolization tool that enabled choosing and assigning different symbols and colors to different tree species.
- Other map information like the grid, legend, north arrow and scale bar were added to the maps by clicking on their respective display tools in the map window.
- The maps were then saved in either jpeg format by clicking on map export tool and assigning map names.

Key Informants Interviews (KII), a list of questions was administered to key informants to compliment the questionnaire. The targeted key informants included; agricultural officers,

representatives from KENVO a local NGO that works on indigenous protection of forests, local chiefs per ward and the Kenya Forest Service.

3.7 Ethical considerations

Confidentiality of the responses was another factor that the study took into consideration and respondents were assured as such before administration of the questionnaire. No personal data was collected in this study and hence privacy of the respondents cannot be breached. The data collection was done on a voluntary basis and respondents were not coerced to respond to the questionnaire.

3.8 Data Analysis

Both qualitative and quantitative data were collected during the research studies. Data from the questionnaire that was coded both had opened ended and close ended questions. These data was put in Ms. Excel and afterwards exported to the SPSS tool. Data cleaning was done to eliminate chances of error during analysis. Quantitative data was analysed through descriptive statistics which majorly consisted of getting the means, modes, median and averages. Correlational analysis within the SPSS software was then used to show how variables were related.

3.9 Study limitations

Some limitations that were encountered during the study were:

Terrain: Lari terrain is hilly and from one farm to the other one has to criss cross even through forested areas. It was a bit tiring to move from one farm to the other.

Weather: It was cold and humid when we went to collect data. Some of the enumerators got pneumonia during the data collection exercise.

Financial limitations: The study was expensive.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

It is widely recognized that change in agricultural land use is an important driver of biodiversity loss in developing countries (Wretenberg and Berg, 2010). The research results are presented as such

a) Gender influence on indigenous tree conservation in Lari sub county.

There are various factors that influence the indigenous tree species on the farm. Household characteristics is one of the factors that influence the presence or absence of indigenous tree species on farm and most often than not dictate where these trees are located on the farm. 96 households were targeted in this study and of them 19.8% were female headed households. Gender diversity in relation to conservation of indigenous trees was tapped to see the level of influence.

Gender and cultural beliefs and taboos play an important role in conservation of tree species on the farm. The socially ascribed gender roles in relation to tree planting activities and use of tree resources can have significant implications for tree planting. For instance although women provide labour in planting and managing trees, it is the men who decide on use and disposal of tree resources (Ndei, 2014). The presence of cultural beliefs and taboos associated with planting can have an impact on conservation of useful tree species on the farm as they inhibit conservation of certain tree species. Traditionally, planting or cutting of certain tree species was prohibited and this helped to conserve some of the endangered indigenous species. Although these cultural beliefs affect men and women, they are more restrictive to women when it comes to participation in conservation of trees. Women in most cases cannot take decisions on issues concerning tree cutting and selling in the community; male permission is usually sought. This study therefore recommends need for gender sensitization especially in decision making that promote indigenous trees conservation on farm.

b) Socio economic activities and its influence on existence of indigenous tree species in Lari sub County.

The socio-economic activities practiced by household heads, form a major basis on the indigenous tree inventory in Lari sub County. As shown in table 5, it depicts farmers keep a higher percentage of indigenous trees. The probable cause is that they practice farming as a business and know the importance of conserving trees.

Table 2.1: socio-economic activities of respondents of Kinale and Kijabe wards

Occupation	Business	Farming	Salaried	Total
Indigenous trees frequency on farm	7	81	8	96
Percentage	7.3	84.4	8.3	100

Source: Research findings 2015

This forms a great opportunity to advocate for indigenous trees conservations among the farming community. Tree domestication is a way of rebuilding and reconciling with the ecosystem. Integrating indigenous trees into our farms is nothing new—it only seems new because modern farming doesn't respect biodiversity and has veered from the true practices of farming; those practices which have been occurring in traditional farming systems across Kenya. This study therefore recommends sensitization campaigns among the farming community to promote indigenous tree conservation. Currently there is already the rule of having at least 10% of land cover under trees within homesteads, but it's normally not practiced especially by farmers who own small land parcels. Therefore this study recommends that within the 10% rule at least 2% of the trees planted should be indigenous trees.

c) Influence of literacy levels on indigenous tree species diversity in Lari sub County

Behavior change in different communities is majorly influenced by the level of education of the constituents. In Lari sub County, major household heads had a moderate literacy level of 30.2% and 36.5% at both secondary and upper primary respectively. According to KNBS 2013 report, a total of 40% of Kiambu county residents had secondary level of education or above. From the table 6 we see that those household heads who didn't go to school conserve low indigenous tree species on farm also comparative to those with very high level of education those in University and college. This can be attributed to the fact that these people with very high education levels may be more affluent in nature and have low tolerance to indigenous trees and may prefer to grow faster growing exotic trees.

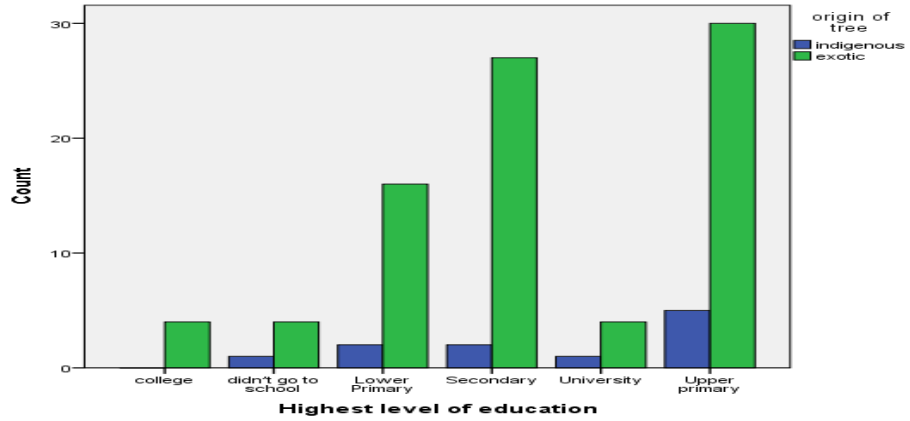
Table 4.2: Educational level of household

Highest level of education	University	College	Secondary	Upper primary	Lower	Didn't go to school	Total
Indigenous trees frequency on farm	5	4	29	35	18	5	96
Percentage	5.2	4.2	30.2	36.5	18.8	5.2	100

Source: Research findings 2015

Figure 4.1 shows exactly how level of education influences the decision to grow indigenous trees.

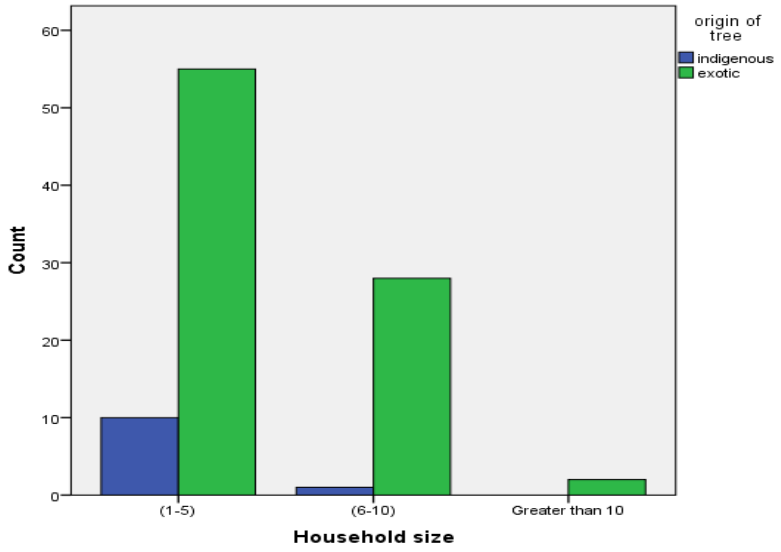
Figure 4.1: How level of education influences decision on conserving indigenous trees



This indicates that, ingenious education is a part of respondents' cultural and social identities, well-being, sustainable development and intellectual and cultural vitality which plays a crucial role for the successful conservation of the environment. From the figure 4.1 shows that most of the people who had gone only up to upper primary had the highest level of indigenous trees conservation. The study therefore recommends sensitization efforts on benefits of indigenous trees to total population.

d) Agricultural intensification and its influence in indigenous trees conservation in Lari Sub County

Figure 4.2: household size and agricultural intensification



The average household size in both Kinale and Kijabe ranged from 1->10 persons per household. This number depicted the actual number of members living in the households during the study period. From the findings figure 6 shows that the bigger the household size the less the indigenous trees that existed on farm. Only

10% of the indigenous trees existed in households having 1-5 persons and approximately 2% for those having 6-10 persons whereas there were no indigenous trees in households that had more than 10 persons per household. The study assumes that the higher the population pressure on a farm land may directly affect the economic activity on farm. Therefore most of the farms that had many people the food requirement needs is higher and thereby high agricultural intensification as opposed to tree planting. The study therefore echoes the Boserup's theory on population growth and agricultural intensification. Agriculture is the predominant economic activity within Kiambu county. It is the leading sub sector in terms of employment, food security, income earnings and overall contribution to the socio-economic wellbeing of the people. The agricultural production system mostly practiced in both Kinale and Kijabe is mixed cropping. Agricultural production systems are mostly influenced by the household sizes. The higher the household size the less the conservation of indigenous trees.

4.1.1 Inventory of indigenous trees on farm

A number of indigenous tree species were found on farm within the 96 households interviewed in both Kinale and Kijabe wards.

Table 4.3: indigenous trees on farm in Lari Sub County

Name of tree (kik) as reffered to by farmers	**Common name**	**Scientific name**
Murera	Thorn tree	*Acacia abyssinica*
Mokumo/mugumo	Strangler fig	*Ficus thorningii*
Mubuu	Silk oak	*Brachylaena hutchinsii*
Muchami	Allophylus	*Allophyllus abyssinicus*
Muhoro/muhoru	Meru oak	*Vitex keniensis*
Muiri	Red stink wood	*Prunnus africana*
Mukeu	Dombeya	*Dombeya torrida*
Mukindori	Croton	*Croton megalocarpus*
Mutamaiyu	African olive	*Olea europaena*
Mutarakwa	African juniper	*Juniperus procera*
Mutati	Parasol tree	*Poliscias kikuyensis*

Name of tree (kik) as reffered to by farmers	**Common name**	**Scientific name**
Muthai	Schefflera	*Schefflera volkensii*
Muthegera	Podo	*Podocarpus milanjianus*
Mugaita	Rapanea	*Rapanea Ralanophloes /Myrisna melanophloes*

Source: Research findings 2015

4.1.2 Indigenous tree species occurrence in Lari sub county

Understanding the extent and distribution of trees on agricultural land, at the landscape level, including the numbers and characteristics of farmers and farming communities within those landscapes, can help to assess the importance and role of indigenous trees both to the livelihood of farming communities as well as to overall global agricultural production (Robert *et al.* 2009). Farmers control tree species densities and presence and hence the species diversity on farms, depending on their preferences and individual use needs.

Table 4.4: Indigenous tree occurrence in Lari sub county- Kinale ward

Name of tree	African Juniper	African Olive	Dombeya	Meru Oak	Parasol tree	Podo	Rapanea	Red stink Wood	Silk Oak	Strangler Fig	Total
Frequency	6612	89	70	32	9	94	1	89	15	2	7013
percentage	94.28	1.3	1:00	0.46	0.13	1.54	0.01	1.3	0.01	0.03	100

Source: Research findings 2015

Table 4.5: Indigenous tree occurrence in Lari sub county- Kijabe ward

Name of tree	African Juniper	African Olive	Dombeya	Meru Oak	Parasol tree	Podo	Red stink Wood	Allophylus	Croton	Schefflera	Thorn tree	Total
Frequency	94	23	297	10003	14	14	126	2	5	3	10	10641
percentage	0.91	0.29	2.84	94.22	0.14	0.14	1.22	0.03	0.06	0.05	0.10	100

Source: Research findings 2015

Table 7 and 8 shows a diversity index of the indigenous tree species still found on farm in Lari Sub County per ward. Frequency in the two tables (7 and 8) means the head count of the tree species found in the 96 farms subjected to the study. A diversity index is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. The value of a diversity index increases both when the number of types increases and when evenness increases. From the tables, we see that there is highest diversity of indigenous tree species in Kijabe than Kinale ward. From the tables we see that the highest amount of indigenous trees found is the Meru Oak (*Vitex Keniensis*) variety which is highest in Kijabe while the African Juniper tree dominates the Kinale wards farms. The lowest diversity is found for Silk Oak (*Brachylaena hutchinsii*) and Rapanea (*Rapanea ralanophloes*) species in both Kinale and Kijabe wards. From the table we also see that there is no Strangler fig, Silk Oak and Rapanea tree species in Kijabe and in Kinale there is no Allophyllus (*Allophyllus abyssinicus*), Croton (*Croton megalocarpus*), Schefflera (*Schefflera volkensii*) and Thorn trees (*Acacia abyssinica*). From the table 12 we see that the parasol tree and podo trees occurrence is equal in Kijabe ward.

4.2 Relative location of indigenous trees species on farm in Lari sub County

The study analyzed where these indigenous trees grows most within Lari sub County. This was categorized into 4 regions. Scattered on farm (SF) these are trees that grew almost anywhere inside the farm but not near the homestead area. The second category was boundary trees (B) these trees are those that were grown purposively as fences to mark the boundary between one farm and the other. The third category Homestead (H) this showed the trees that grew near the homestead area but not where the farmer is practicing agriculture. The last category was on Riverine (R) these are the trees that grew along streams/rivers that were passing via the farms.

4.2.1 Relative position of indigenous trees on farms in Lari sub County

Table 4.6: Relative position of indigenous trees on farm

Relative position of tree on farm	Scattered on farm	Boundary	Homestead	Riverine	Total
Frequency	10134	6876	456	188	17654
Percentage	57.4	38.9	2.6	1.1	100

Source: Research findings 2015

Table 9 shows 57.4% of the indigenous trees found in Lari Sub County are scattered on the farm. The major rationale for this would be the fact that these trees create a conducive ecosystem that encourage agricultural undergrowth. Only 1.1% of the trees were found on riverine areas. In table 10 we see the total head count of the various tree species found in Kinale and Kijabe (table 11) wards

Table 4.7: Relative position of indigenous trees in Kinale ward

Relative location of tree	**Name of indigenous trees**										**Total**
	African Juniper	African Olive	Dombeya	Meru Oak	Parasol Tree	Podo	Rapanea	Red Stink Wood	Silk Oak	Strangler fig	
Boundary	6608	2	22	6				3			6641
Scattered on farm		5	36	5	6	5		1	15		73
Riverine		60	5	5	3		1	70			143
Homestead	4	22	7	16		89		15		2	156
Total	6612	89	70	32	9	94	1	89	15	2	**7013**

Table 10 shows that the highest number of indigenous trees found in Kinale ward in Lari Sub County are mostly located at the boundary and these trees are African Juniper (*Juniperus Procera*). Within the homestead we see that all indigenous trees found in Kinale are found also at the homestead. Dombeya (*Dombeya torrida*) has the highest number of trees scattered on various farms in Kinale ward. The Red stink wood (*Prunnus africana*) tree is found majorly on riverine areas while the Podo (*Podocarpus milanjianus*) tree has the highest diversity within the homestead.

Table 4.8 : Relative position of indigenous trees in Kijabe ward

Relative location of tree	**Name of indigenous trees**											**Total**
	African Juniper	African Olive	Dombeya	Meru Oak	Parasol Tree	Podo	Red Stink Wood	Allophylus	Croton	Schefflera	Thorn tree	
Boundary	26	16	143		5	12	23				10	235
Scattered on farm			60	10000			1					10061
Riverine		3	40	1	1							45
Homestead	68	4	54	2	8	2	102	2	55	3		300
Total	94	23	297	10003	14	14	126	2	55	3	10	**10641**

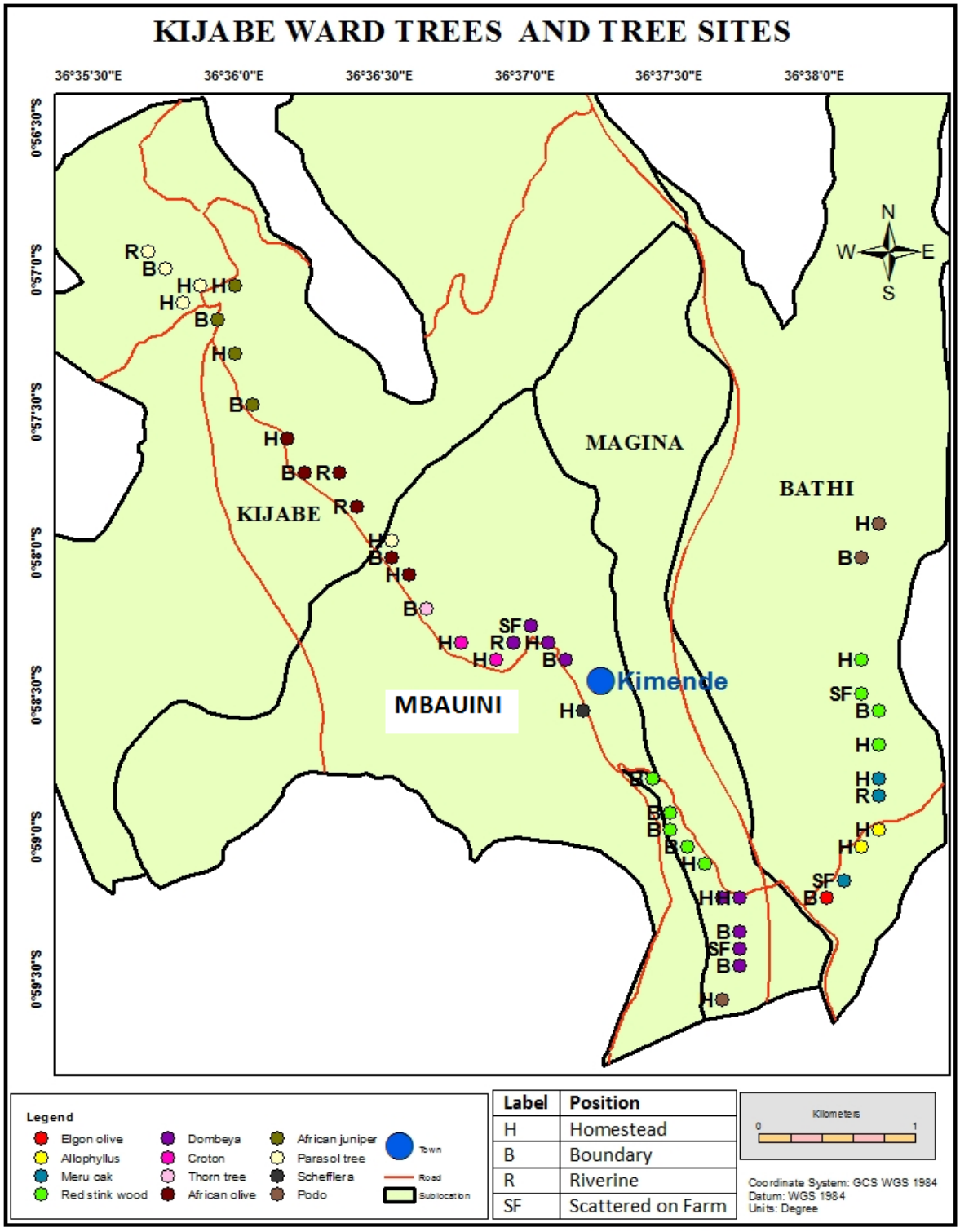
Source: Research findings 2015

Table 11 shows the relative position of indigenous trees in Kijabe ward and it shows that Meru Oak (*Vitex keniensis*) has the highest diversity in Kijabe and most of it is scattered within the farms. The Red Stink Wood (*Prunnus africana*) has the highest diversity in terms of trees found within the homestead while Dombeya (*Dombeya torrida*) has the highest diversity in terms of trees found within boundary and riverine areas.

The study found out that most of the trees are concentrated in Mbauini, Bathi and Kijabe sub divisions very little indigenous trees were found in Magina. From the 39 farms visited in Kijabe, the study counted 10,641 indigenous trees. 7,013 indigenous trees were found in the 57 farms visited in Kinale. Some of the indigenous tree compositions found in Lari include *Acacia abyssinica, Ficus thorningii, Brachylaena hutchinsii, Allophyllus abyssinicus, Vitex keniensis, Prunnus Africana.* These trees relative location was majorly homestead, boundary and scattered on farm. There is a high population of indigenous trees found in Mukeu as opposed to Kinale wards. The reasons for fewer indigenous tree species on farm in Kinale was majorly because most of the farms practiced horticultural farming. This system of production mainly requires specialization of either crop mainly cabbages, potatoes, carrots, beet root, cucumber to name a few and fruit trees.

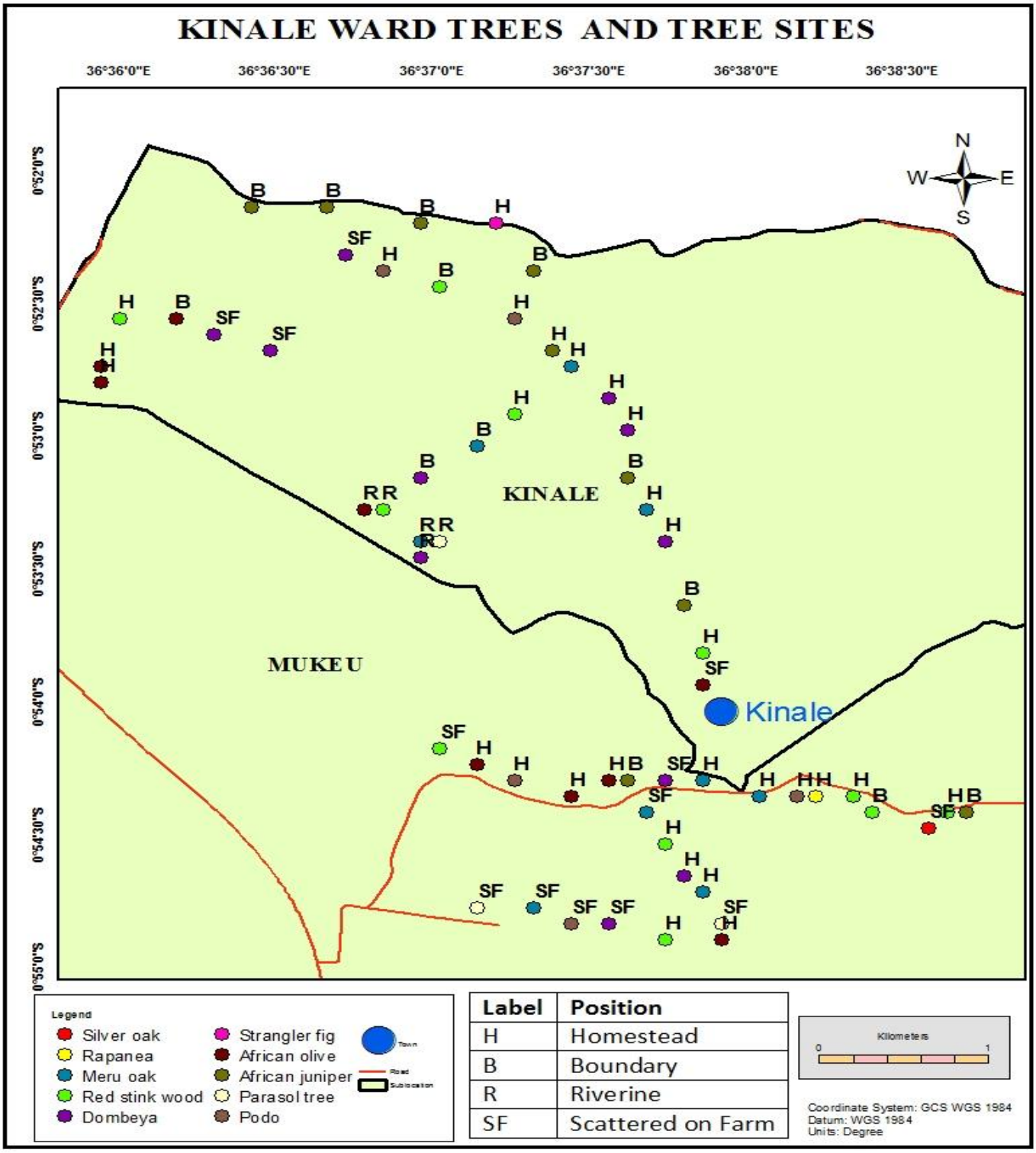
4.2.2 Map representation of indigenous tree sites in Kijabe and Kinale wards

Figure 4.3: Indigenous tree sites in Kijabe ward



Source: Research findings 2015

Figure 4.4: Indigenous tree sites in Kinale ward



Source: Research findings 2015

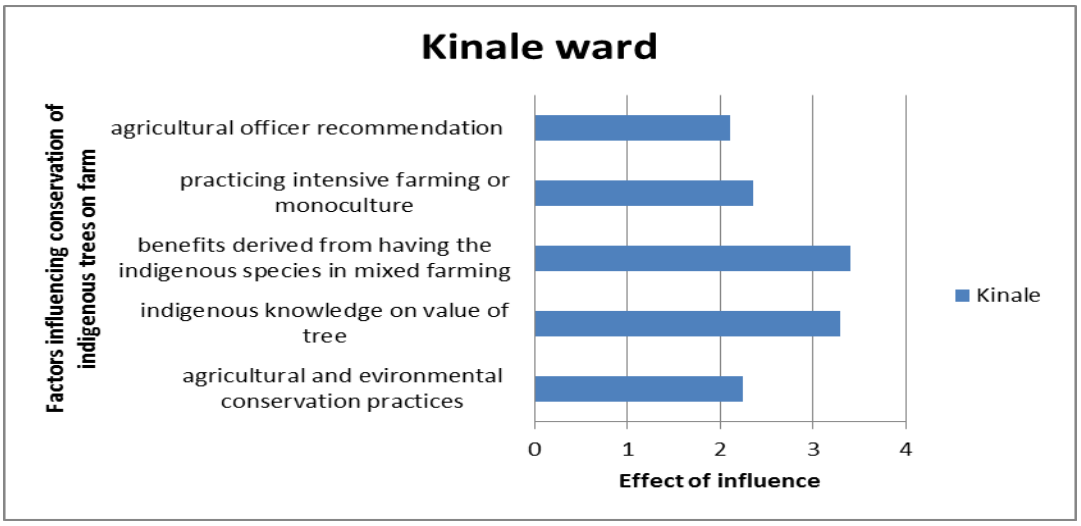
4.3 Rationale for retaining indigenous trees on farm in Lari Sub County

There are various reasons as to why indigenous trees are retained on farm in Lari sub County. Growing trees can be an induced innovation to help maintain agricultural productivity because they may reduce erosion and enrich the soil (Scherr, 1995) or to increase carrying capacity of the shallow soils (Carson, 1989). It is a livelihoods' option often mentioned and increasingly promoted by land-use managers and international development agencies (Zomer *et, al*. 2014). Farmer's willingness to grow trees depend on many factors (A.M. Filius, 1997). The research study sought to find out the factors that actually influenced farmers to retain indigenous trees on their farms.

4.3.1 Degree of influence of factors affecting conservation of indigenous trees on farm in Lari sub County

Among the factors analyzed on what influences farmers to retain or conserve the indigenous trees on farm included; agricultural and environmental conservation practices, indigenous knowledge on value of tree, benefits derived from having the indigenous species in mixed farming, practicing intensive farming or monoculture and agricultural officer recommendation. The research used a likert scale (0-5) to describe the degree of influence o meant to a very low extent while 4 meant to a great extent.

Figure 4.5: Degree of influence of factors affecting conservation of indigenous trees on farm in Kinale ward in Lari Sub County

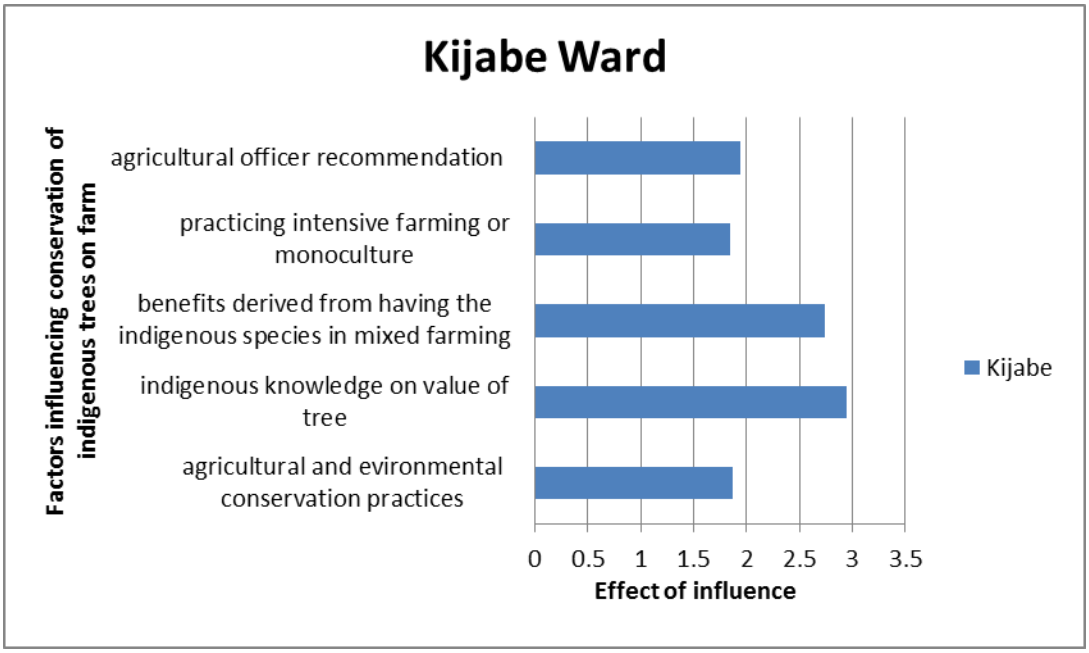


Source: Research findings 2015

An average weighting from the scores given from respondents ranging from (0-5) gave the results in Fig 4.5 As depicted from Fig 4.5, the x axis measures the effect of influence in percentage, we see that the major factor influencing conservation of indigenous trees on farm in Kinale ward in Lari Sub County is due to the benefits derived from having indigenous tree species in mixed farming. The total number of indigenous trees found in Kinale is 7,012 from the

farms visited. This factor selected as the highest can be attributed by the fact that in Kinale most of the farmers practice horticultural farming and especially in vegetable farming including potatoes, French beans, cabbages, kales etc.

Figure 4.6 :Degree of influence of factors affecting conservation of indigenous trees on farm in Kijabe ward in Lari sub county



Source: Research findings 2015

In Kijabe, there are a total of 10,641 indigenous tree species in the 39 farms visited. Fig 4.6 depicts, the highest weighted average is the factor scored as indigenous knowledge on value of tree. On the x axis we see the measure and effect of influence of factors in percentage. Most of the farms in Kijabe are small farms lying on average land size of $1/8^{th}$ – 1 acre. The temperature in Kijabe area is also a bit warmer than in Kinale. The main agricultural crop in Kijabe is Maize since it does well in these conditions.

Discussions

The low levels of likelihood of farmers to plant and retain trees in Lari Sub County may be attributed to small land holdings due to high population especially in Kijabe where the land sizes are significantly smaller. In Kinale, the nature of their farming activities were dairy, horticultural and subsistence crops. This may have delineated them from active participation in tree farming as most of the land was needed for pasture and food crops. This was in contrast with Kijabe where the farm sizes were smaller and the major motivation of planting indigenous trees on farm was due to the sensitization efforts by KENVO (Kenya Environment volunteers) and also there is presence of the ministry of agriculture within the ward. Discussions held with farmers during data collection in this region pointed out that majority of them viewed indigenous tree growing

as a long-term investment with no immediate cash to offset household needs, hence lowly prioritized. Therefore, chances of finding indigenous trees on farm of varied sizes were small reflecting less retention. There is high market for poles in Lari Sub County therefore farmers are resorting to planting more and more exotic trees. During the visit, we visited the Kinale man made forest that is mostly characterized by Cypress and there was no undergrowth. At one point during the data collection we visited the forested areas and we saw that there is high level of illegal logging of trees for firewood and poles. This demonstrated the need for farmers in Lari Sub County to grow more and more exotic trees than indigenous trees and for higher economic returns.

4.3.2 Uses of indigenous trees

There are various uses of indigenous trees found on farm in Lari constituency. This is one of the rationale why some of the farmers still have indigenous tree species on farm. Some trees have medicinal properties like *Ficus thoorgingii, Acacia abyssinica, Allophyllus abyssinicus, Prunnus Africana, Croton megalocarpus and Octea usambarensis* these trees can be used to treat diarrhoea, hemorrhage, jaundice, headaches, burns, venereal diseases etc. Other trees are specially used as insect repellants or as acaricides e.g.*Acacia abyssinica. Podocarpus milanjanus, Vitex keniensis, Acacia abyssinica* and *Prunnus Africana* makes very good timber for construction. Indigenous trees also make very good fodder for animal and can therefore be used as feed e.g. the *Acacia abyssinica* and *Melia volkensii.* See annex 1 use of indigenous trees found in Lari constituency.

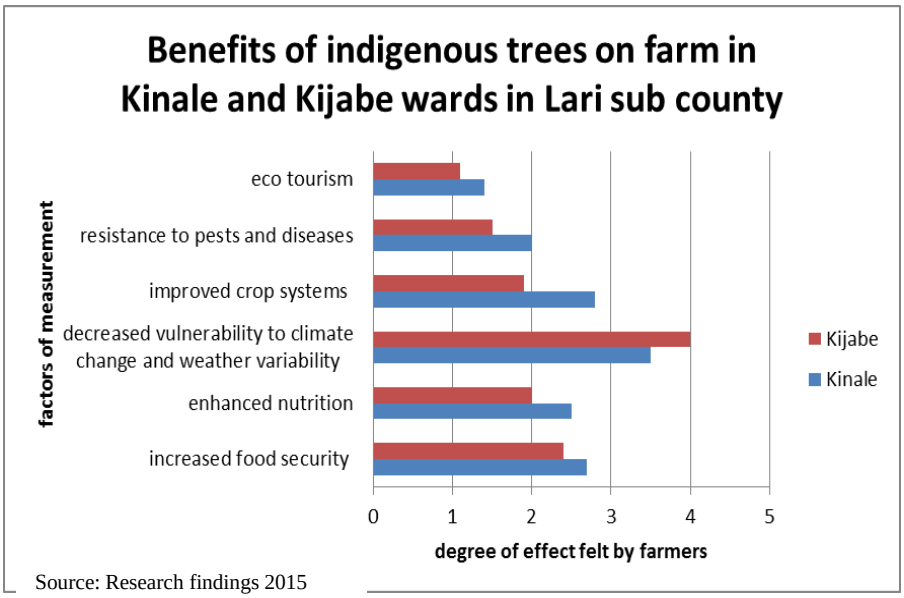
However, some indigenous trees fall under threat of extinction e.g. the trees *Juniperus procera* (Mutarakwa), *Olea europaena* (Mutamaiyu) *and Ficus thoorningii* (Mugumo) fall under the IUCN red list of endangered species. Endangered tree species need to be conserved so as to benefit from the ecological services that they give to the environment. This is because the resilience of traditional farming systems highly depended on diversification of crops and livestock enterprises. The tradition agricultural systems have inherent mechanisms for nutrient recycling.

4.3.3 Trees for the future

Given that most Kenyans rely on wood and charcoal for their daily cooking needs, the Kenya Forest Service (KFS) implemented the charcoal rules 2009 which outlines the law on producing, transporting and trading charcoal in an effort to commercialise charcoal production. Through issuing licenses, KFS hope to be able to track and control charcoal production and ensure it comes from a sustainable supply, maintaining Kenya's trees for future generations. Within Lari Sub County in Kinale and Kijabe, measures have been put in place to control the cutting of trees even within farms. The law states that if you want to cut a tree on the farm you must seek permission from the County administrators, Chief, Kenya Forest Service or a relevant authority to sustain the carbon sinks within the country. From the study, we found that this is not always the case. 74.5% of the respondents seek permission from the chief before cutting their trees on

farm. This shows that government needs to tighten controls especially if it will aim at increasing the forest cover within the country.

4.3.4 Effect of indigenous trees on farm



Source: Research findings 2015

Trees in farming systems are found either in forest fallows within shifting cultivation systems; as relics from land clearance by slash and-burn, or as a result of deliberate management and / or planting. The integration of indigenous trees in farming systems to provide environmental services and / or products that are either traded or used domestically to confer multiple livelihood benefits, especially for smallholder farmers in the tropics beset with poverty, malnutrition and hunger. The research study sought to find out the degree to which conserving/planting indigenous tree species on their farms influenced their lives. Parameters under consideration are shown in the figure above. From the graph we see that the most important factor is that scored the highest as "decreased vulnerability to climate change and weather variability".

The numbers of trees in farmland can contribute to:- (i) the restoration of lost productive capacity in farm land, especially infertile degraded land, through the rehabilitation of agro-ecosystem functions (ii) the creation of new opportunities for greater and more diversified production with enhanced utility and profitability through the domestication of indigenous tree species conferring nutritional and health benefits, and (iii) the promotion of local enterprise, value-addition, entrepreneurism and job creation in rural communities through commercialization.

4.4 Plate of indigenous Tree species in Kinale and Kijabe

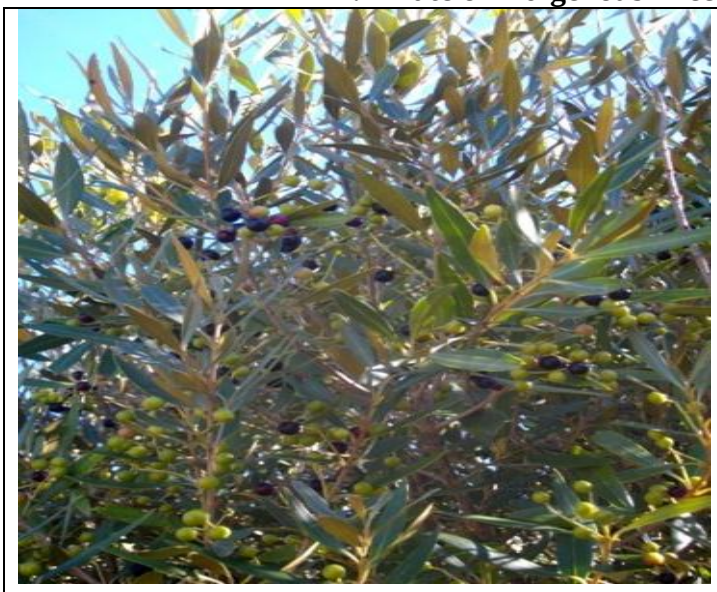


Plate 4.1: *Olea europaea (var.Africana*) – (Mutamaiyu)

Plate 4.2: *Melia volkensii* – (Mukeu)

Plate 4.1: *Juniperus procera* (Mutarakwa),on a farmers land in Kijabe

Plate 4.2: *Poliscias kikuyensis* (Mutati) in a farmers land in Kinale

Plate by researcher year 2014

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the results, conclusions and recommendations of the study

5.2 Summary of key findings

This research aimed at assessing the remaining indigenous tree species on farm, where they are found and why they are retained in Lari sub County. In total 96 households/farms were visited and questionnaires administered . From the 96 farms visited a total of 17,653 indigenous trees on farm in both Kinale and Kijabe wards were observed. There were 7,013 and 10,641 trees in Kinale and Kijabe wards respectively. Indigenous tree species found on the farm included *Acacia abyssinica, Olea capensis , Ficus thorningii, Brachylaena hutchinsii, Allophyllus abyssinicus, Vitex keniensis, Prunnus africana , Dombeya torrida, Croton megalocarpus, Olea europaena, Juniperus procera, Poliscias kikuyensis, Schefflera volkensii, Podocarpus milanjianus, Rapanea Ralanophloes /Myrisna melanophloes.*

Four spatial distribution patterns of trees on farm were identified. These were trees growing within homestead (H), boundary tress (B), Riverine trees (R) and trees Scattered on Farm (SF). 95% of the indigenous trees in Kinale were boundary trees and 95% of the trees in Kijabe were scattered on the farm. Very few indigenous trees in both wards grew along riverine areas and homestead.

Various factors as shown in chapter 4 led to the retention of indigenous trees on farms. These include influence by stakeholders which in this case intervention by agricultural officers, use of tree for medicinal value and protecting the trees for the future. From the findings we also see that issues related to food security and decreased vulnerability to climate change. However, a huge gap still remains as to the extent to which residents of Lari and Kenya in general know about the huge benefits that are attributed by conserving indigenous biodiversity.

5.3 Conclusions from the study findings

In conclusion there are indigenous tree species found in Lari sub County. Their presence is influenced by gender, education levels, socio economic activity and agricultural production system practiced based on household sizes. There are more indigenous trees in Kijabe than Kinale wards.

Most of the indigenous tree species in Lari Sub County are found scattered on the farm and this can be attributed to their importance of regulating nutrients, build organic matter of top soil, fix nitrogen and create habitat for beneficial micro-organisms. There are very few indigenous tree species growing on riverine areas and homestead.

Indigenous trees are still retained in Lari Sub County and the reasons for this is attributed to their effect on the environment as a buffer for food security and decreased vulnerability to climate change. They are also retained due to major efforts that have been put in place by the ministry of agriculture through agricultural extension officers. Residents in Lari recognize that there are very many benefits from indigenous trees that range from medicinal to timber and its important to preserve these trees for the future generations.

5.4 Recommendations

Findings for the study have outlined the critical need to conserve the existing indigenous cover on farms. From the conclusions made in this study, the following recommendations are made:

- Need to promote the use of indigenous trees for multiple purposes e.g. carbon sequestration, medicinal values and biodiversity conservation.
- Collaborative approaches to research on reduction of maturity span of indigenous tree between universities and research institutions like ICRAF
- Capacity building of farmers and younger generation through the development of a pictorial directory of indigenous trees found in Kenya.
- Lobbying for 2% of the 10% recommended tree cover to be indigenous trees as a source of livelihoods for farmers.
- Introduction of a replanting rule especially for indigenous trees “if one indigenous tree is cut plant two indigenous trees to replace”.

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Appendix 1: USE OF INDIGENOUS TREES FOUND IN LARI CONSTITUENCY

NAME OF TREE	USE OF TREE
Acacia abyssinica	Propagation of Acacia abyssinica is through self-seeding and root suckers. Pretreatment is important to accelerate germination but not essential. Scarification and sulphuric acid treatment are normally used. This tree can act as a Poison: The smoke produced by burning the wood of A. abyssinica acts as a fumigant against insects and lice. Chemicals in the bark of A. abyssinica kill the freshwater snails that carry bilharzia parasites and algae growing in ponds. Methanolic extracts from the bark of A. seyal applied to ponds display agricidal properties. Molluscidal properties have been demonstrated with spray-dried powder of ethyl extracts, which are effective against schistomiasis vectors Biomphalaria pfeifferi and Bulinus truncatus. Make syrup: Gum talha from A. abyssinica is eaten when fresh, although it has slightly acid taste. It is also mixed with pulp from the fruit of Balanites aegyptiaca to make a syrup. Animal feed: The bark is extensively used for feeding cattle, sheep and goats during the dry season. When fresh, it is smooth and relatively soft. In February to March (the dry season in Kenya) thick branches are lopped and animals browse the bark and eat the leaves, which are relatively few at that time. The pods and leaves are nutritious and palatable to livestock. The feed value crude protein content is 11-15 % in leaves and 15-24 % in fruits. Digestible protein is 8-12 % in leaves and 13-15 % in fruits, which have a high digestibility. Leaves, pods and flowers are a major source of early dry-season fodder for sheep and goats over much of Africa. A. abyssinica is considered the best fodder plant in northern Nigeria and the Sahelian savannah. In the dry season in western Sudan, the Fulani drive their cattle to the districts where it grows. Branches (sometimes even the entire crown) are lopped in times of fodder scarcity. Apiculture: Its yellow fragrant flowers yield a white-coloured honey with mild aroma. Fuel wood: A. abyssinica produces good, dense firewood that is used widely throughout its range. The smoke is pleasantly fragrant and the wood burns rather quickly. In Chad the tree is considered to provide the best fuelwood. A. abyssinica is an important source of rural energy as both firewood and charcoal. Trees managed on a 10-15 years rotation yield 10-35 cubic m/ha of fuelwood a year. Fragrant: In Sudan it is used to make a fragrant fire over which women perfume

NAME OF TREE	USE OF TREE
	themselves. Fibre: Roots are used for making staves. The bark of A. abyssinica is used for making rope. The fibre has promising technological characteristics for use as particleboard. Timber: The wood is pale yellow to medium brown, with localized pinkish-brown patches and some dark mahogany-red heartwood in larger or older individuals. A. abyssinica wood has potential in rural areas as timber. If the tree is grown with few knots and straight grain, sprayed with insecticide after felling, and treated with preservatives, the timber works well and is hard and tough. It produces a hard, dark wood, called shittim wood, with interlocked, irregular and coarse-textured grain. It takes good a polish but is susceptible to insect attack. Therefore, it must be properly treated by splitting it, putting it under water for a few weeks and then drying it thoroughly. Shittim wood was used by ancient Egyptians for pharaohs' coffins. Shade or shelter: Where it grows, A. seyal abyssinica offers shade to livestock in the dry season. Tannin or dyestuff: Pods and bark contain 20% tannin. Gum is mixed with soot and powdered Nubian sandstone for black and red ink. The bark contains 18-30 % tannins and is a source of red dye. Medicine: The bark, leaves and gums are used for colds, diarrhoea, hemorrhage, jaundice, headache and burns. A bark decoction is used against leprosy and dysentery, is a stimulant and acts as a purgative for humans and animals. Exposure to smoke is believed to relieve rheumatic pains. A root decoction mixed with leaves of Combretum glutinosum and curdled milk causes strong diuresis. Gum or resin: A. abyssinica gum (talha gum) is darker and inferior in quality to that of A. senegal (gum arabic). However, it forms 10% of the Sudanese gum exported to India and Europe. The gum is edible when fresh, with a slightly acidic taste.
Olea capensis	The heartwood, often traded as 'ironwood', is in high demand for flooring, carpentry and panelling, and is widely used for house and bridge construction, counter and table tops, railway sleepers, tool handles and wagon parts. It produces beautiful furniture, turnery and sliced veneer, and is often used by African artists. It is suitable for interior trim, sporting goods, toys, novelties and agricultural implements. In South Africa it has been used traditionally to make assegais (is a pole weapon used for throwing or hurling, usually a light spear or javelin made of wood and pointed with iron). It is also used as firewood and for charcoal production.

NAME OF TREE	USE OF TREE
	The oily fruits are edible and are used in southern Africa in the preparation of beer and lemonade. In East Africa bark decoctions are used as an emetic and anthelmintic, and to treat malaria, venereal diseases and female sterility; bark ash is applied as a dressing to wounds. In Swaziland bark decoctions are taken to treat peptic ulcers, and in South Africa the bark is used for skin lightening. In southern Africa root powder is applied to fractures and joint swellings, and leaf infusions to treat infections of the respiratory tract and pains. The foliage serves as fodder, especially during the dry season. The flowers produce nectar for honey bees. In South Africa Olea capensis has been used as stock for grafting olive cultivars from the Mediterranean region. The tree is considered sacred by the Maasai people and is commonly used in ceremonies.
Ficus thoorningii	LAND IMPROVEMENT: It is planted as a live fence with the intention of using the leaves as mulch or green manure, for producing shade or for fodder. It is also highly regarded for its ability to store water and conserve soil. MEDICINE: The bark is quite important in local medicine as it can be used to treat colds, sore throats, diarrhoea, wounds, and to stimulate lactation. FIBRE: Bark cloth is obtained by cutting out a strip or cylinder of bark which causes the tree to produce a fine matted covering of red, slender roots over the wound. This covering is used as bark cloth. OTHER USES: The tree is used for ceremonial and sacred purposes. The wood is light (495 kg per m3), easy to work, but not durable
Brachylaena hutchinsii	The wood, commonly traded as 'muhuhu' is mainly used for construction, first-grade flooring, joinery, interior trim, furniture, fence posts, toys, novelties, boxes, crates, tool handles, carving and turnery. In Kenya it is one of the most highly favoured woods for carving, in Tanzania also for fence posts. In South Africa it is popular for main posts of local houses. It is also suitable for bridges, hydraulic works, poles, piles, cabinet work and railway sleepers. It is considered an excellent firewood and is used for charcoal production. In traditional medicine, root decoctions are used to treat schistosomiasis and leaves to treat diabetes. The aromatic oil extracted from the wood is used for perfumery. In Kenya Brachylaena huillensis is planted as ornamental and boundary tree around dwellings.
Allophyllus	Medicinal: *Allophyllus abyssinicus* has a wealth of medicinal uses. It is used for

NAME OF TREE	USE OF TREE
abyssinicus	stomach upset and pain, the bark is chewed to protect against scurvy, an infusion is taken for dysentery and diarrhoea. In Nigeria it is one of the standard drugs for treating diarrhoea. It has also been used to eliminate stomach worms, as an antiseptic for open wounds and as an expectorant for treating coughs. The species has also been used in veterinary medicine, for example as a molluscicide to reduce liver-flukes in cattle. The pods are desirable as fodder for cattle, and the leaves, young shoots and young pods are thought to aid milk production. *Allophyllus abyssinicus* wood burns without too much smoke and provides good charcoal. The flowers provide both pollen and nectar for bees. The species is suitable for live fencing, mine timber, railway sleepers, boat building, wheels, and water wells as its wood is durable and resistant to borers and termites. The sap-wood and heart-wood was used in ancient Egypt for house beams, furniture, panelling and statues as it was regarded as impervious to insect and fungus attack. The bark contains tannins and has been used to preserve and soften leather. Phytochemical analysis has shown the presence of two types of tannin (gallotannins and catechins) which explain its therapeutic action as well as its use in tanning hides. Gum is present in the bark but tends to be dark in colour. This species may indeed have been the original source of the true gum arabic which is now obtained commercially from Senegalia senegal. The *Allophyllus abyssinicus* gum, samogh or samuk (arabic) is sold in balls and it is commercially of inferior quality. It has been used as an emulsifying agent and emollient. It is edible and is used to relieve throat and chest complaints.
Vitex keniensis	It's listed as an endangered species by IUCN Food: The fruit is edible but usually eaten only in an emergency Fuel: V. keniensis is a suitable source of firewood. Timber: Wood is pale greyish-brown, coarse textured with well-marked growth zones and often with a wavy grain figure; seasons well. The heartwood of trees over 60 cm in diameter is often dark and very decorative. The timber is hard and durable, very pale and similar to teak. It works easily and is used for cabinet work, panelling, veneer, furniture and coffin boards
Prunnus africana	The timber is a hardwood employed in the manufacture of axe and hoe handles, utensils, wagons, floors, chopping blocks, carving, bridge decks, and furniture. The wood is tough, heavy, straight-grained, and pink, with a pungent bitter-almond smell

NAME OF TREE	USE OF TREE
	when first cut, turning mahogony and odorless later. The active ingredients in Prunus africana are effective treatment for benign prostatic hyperplasia and prostate gland hypertrophy (enlarged prostate gland), ailments that affect about 60% of men over the age of 50, especially in Europe and USA. Traditional healers also use the bark in treatment of stomach ache and wound dressing, infusion of leaves is used to improve appetite, treatment of both bacterial and non-bacterial chronic prostesis and genital infection as well as hirsutism in women.
Dombeya torrida	Fodder: Farmers believe leaf fodder is of high quality for both cattle and goats. The tree comes into leaf and is pruned for fodder towards the end of the dry season, a time when fodder is extremely scarce. Goats eat the large, fleshy drupes after they fall. The fruit pulp is reported to contain almost 10% crude fat and over 12% crude protein; the mature leaves are reported to contain over 5% crude fat and 21% crude protein. Apiculture: *Dombeya torrida* is one of the principal species used to make log hives because the wood is easily worked and shaped. The flowers are said to provide excellent bee forage. Fuel: Branches lopped during routine management and to provide fodder are often left to dry in the field before being used for firewood. The firewood produces an unpleasant smoke, and the tree is said to produce poor quality charcoal. Timber: The wood is easily worked and shaped, making it suitable for making acoustic drums, containers and mortars. The coarse-textured heartwood with a density of around 0.62 works easily, planes well, is durable and extremely termite and decay resistant comparing favourably with Ocotea usambarensis, Vitex keniensis and Khaya species. The timber is valued locally for door and window frames, doors shutters, rafters, poles and furniture. Poison: Leaf preparations are used as flea and fly repellents; they are said to be particularly effective on goat kids. Antifeed activity against Schistocerca gregaria is reported; larvicidal and growth inhibitory effects have also been observed against mosquitoes. Soil improver: A few farmers have suggested that the heavy leaf fall of M. volkensii during the later stages of crop development may increase crop yields. Intercropping: Most farmers in Kenya believe that *Dombeya torrida* is compatible with all crops grown. This, however, is dependent upon good silvicultural practice in reducing the shade effect of canopies, which would otherwise adversely affect light-

NAME OF TREE	USE OF TREE
	demanding crops such as sorghum and millet. Due to its deep rooting nature, its interference with ox-plough cultivation is minimal.
Croton megalocarpus	Fodder: The seed is incorporated in poultry feeds, as its protein content is high (50%). Fuel: Well-dried nuts are reportedly used in some areas together with charcoal in cooking stoves. The tree is also utilized for firewood. Apiculture: This species produces a dark-ambered honey with strong flavour. Timber: Wood is of medium weight, hard, termite-resistant, strong; it is used for timber and building poles. Medicine: 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.
Olea europaea (Var. Africana)	African Olive is considered to be one of the most serious environmental weeds in the Central Hunter region, because of its ability to completely alter ecosystems through crowding and shading (Peake 2005). African Olive invasion leads to a loss in native plant diversity, and research into restoration ecology is needed, particularly for sites with an established cover of African Olive where bush regeneration, and cutting and poisoning are the main methods of control.
Juniperus procera	The larger trees of this species are prized for timber, having good, workable and decay-resistant wood. It is used for fence posts and shingles on roofs, for construction, furniture, cabinet making, and the manufacture of pencils. It is grown in plantations in Africa and India, but only on a limited scale; in horticulture it is mostly confined to public parks in Ethiopia and Kenya, including cemeteries. Outside Africa it is only planted in a few botanic gardens; under glass in temperate climate regions or outside in warmer countries. This species has been logged in many areas, but it is still too common to be threatened with extinction. Depletion of old growth forest groves of this species threatens to occur in Kenya and Ethiopia and from an ecological point of view there is certainly a conservation issue regarding the only juniper in sub-Saharan Africa.
Poliscias kikuyensis	The tree can be used for fuel but it generally offers poor quality fuel wood. It produces soft white wood timber used in boxmaking; the tree trunk can be useful in beehive making. The tree offers various ecological services to the environment e.g. Erosion control: Can be used in protecting riverbanks. Shade or shelter: P. kikuyuensis offers a mild shade with its high leaf crown.

NAME OF TREE	USE OF TREE
	Soil improver: The leaf litter can serve well as mulch; usually soil under the tree is quite fertile. Ornamental: P. kikuyuensis is a graceful fast-growing tree suitable for planting in gardens or avenues. Intercropping: The tree has a high crown offering little shade unlikely to harm other crops
Schefflera volkensii	Uses of trees are Fuel: *Schefflera volkensii* is a good source of firewood and charcoal. Timber: The heartwood is light yellowish-brown, darkening to a deep brown on exposure; sapwood slightly paler, not clearly demarcated. The texture is medium to fine and even; grain interlocked producing a stripe figure; sometimes lustrous; timber has a distinct camphor scent. The wood seasons well and is resistant to acids and fungi but not to termites. It can be used for furniture, railway-coach frames, joinery, panelling, building poles and the production of veneer. Medicine: Bark or roots are pounded, water added and the resulting paste applied on swellings such as those on the throat and other tumours. Inner bark may be pounded, mixed with Brucea spp and Myrica salicifolia and taken in a meat soup as a remedy for abscess, whooping cough and measles. In Kenya, the Taita people boil the bark in water and use it to treat a fatal childhood disease called 'nyago' characterized by strong muscular contractions, stomach pains and disturbed breathing, or it may be scraped and the resulting powder used to dress wounds. Malaria and backache are treated using juice obtained from roots that have been pounded and soaked in water
Podocarpus milanjianus	This species is an important timber tree in many parts of tropical Africa. Its wood is valued for carpentry and joinery as it is light coloured, even grained, easily worked, and large trees yield good sizes of sawn timber. More specialized uses requiring high grade timber are veneer, furniture making, cabinet making, interior trim, household utensils, and wood carving. It has been used in afforestation on a small scale in several African countries, within and perhaps without its natural range. It is not known to be used in horticulture and is probably restricted to a few botanic gardens in Africa and/or other tropical countries or in glasshouses in cooler regions.

Appendix 2: Questionnaire to Assess Indigenous Trees Conservation in Subsistence Agricultural Production Systems in Lari Sub County

Introduction to the questionnaire:

My name is '*name of enumerator'* and I am representing Mrs. Marygoretti Kamau an Environmental Planning and Management Student from the University of Nairobi. We are carrying out a research on indigenous tree species within agricultural farms within Lari district specifically in Kinale and Kijabe wards. I am therefore going to ask you questions concerning the existing indigenous tree species within your farm and why you actually have them. I would kindly request you to allocate some of your time into helping us respond to questions regarding the status of indigenous trees within your farm. The information that you provide for this study is only for academic use only and will be treated with confidentiality. Your participation to this exercise is voluntary. Thank you for your time.

Please answer the following questions to the best of your knowledge. Tick or answer in the space provided – this is misplaced

Name of enumerator: .....

Ward: .....

Sub location: .....

Name of farmer: .....

1. HOUSEHOLD CHARACTERISTICS

1.1. Name of household head----------

1.2. What is household size?

a) 0-5
b) 5-10
c) >10

1.3. Is the household, a single parent-household? (Yes=1; No=2)

1.4. How many members of household are below 18 years?

1.5. What is the gender of the household head? Male = 1; Female =2

1.6. What is age of household head? (Below 35 years = 1; 35 and above = 2)

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2. LAND

2.1 What is the size of this land in acres?

a) >1/8 acre
b) 1/8 -1/2 acre
c) 1/2 -1 acre
d) >1 acre

2.2 What is the kind of ownership of land

a) Family owned
b) Rented
c) Government owned
d) others please specify

2.3 What is the verification document to determine ownership of the land

d) ownership title

e) allotment letter

f) lease agreement

g) none

2.4 What is the total size of land under agricultural production?

a) 1/4 of the land
b) 1/2 of land
c) 3/4 of land
d) whole land

2.5 Which part of the land is under tree production?

a) centre of the farm
b) Fence of farm
c) scattered on farm
d) no trees on farm

2.6 What is the use of land under no production?

a) farmhouse

b) stony/rocky place

c) arable land

d) other (specify)

2.8 Which year did you settle in this land?

a) Jomo Kenyatta Era
b) Moi Era - When he just started
c) Moi Era - After second term of office
d) Uhuru Kenyatta Era

AGRICULTURAL PRODUCTION SYSTEM

1. How long have you been engaged in farming?

a) 0-10years

b) 10-20 years

c) 20-30years

d) 30 years and above

2. What kind of farming do you practice?

a) Subsistence

b) commercial

4. What production system is found in your farm?

a) Mono cropping

b) Mixed Cropping

c) Animal rearing only

d) Animal and crop

5. Why did you opt to practice the production system identified above: (multiple answers is ok)

a) Influence by neighbors

b) Environmental conservation

c) Erosion control/soil conservation

d) others (specify)_____

TREES ON-FARM (Observation Schedule)

1. What species trees are they and how many?

Name of tree	**use of tree –** fruit tree, medicinal, sacred, Food, Shade, Ornamental/aesthetic, Compulsory-must grow by government, Found the tree	Relative position of tree on farm	position of tree on farm	Number of trees

		there, Soil conservation others (Specify)?				
Local	scientific		Longitude	Latitude	Boundary, homestead, riverine, scattered on farm	

2. Do u seek permission to cut the trees on your farm

yes or no?----------

who is the authority you seek permission from?

a) Government (DC, DO, DAO etc)

b) Community elders

c) Environmental Officials

d) Others (specify)

3. Are there any trees on your farm that were eliminated? Yes or No----------

a) If yes why were they eliminated?

---

b) If yes which trees were eliminated? Please list them

INDIGENOUS KNOWLEDGE

1. which among the following factors influence your decision on indigenous trees species on the farm. Use a rating of 1-5 with 1 indicating no effect and 5 indicating very great effect.

Factor	1	2	3	4	5
Agricultural and environment conservation policies in place					
indigenous knowledge on the value of the tree					
Benefits derived from having the indigenous species in mixed farming					
Practicing intensive farming or monoculture					
Agricultural officer recommendation					

2. what effect you or the environment has benefited from your indigenous farming. Use a rating of 1-5 with 1 indicating not at all and 5 indicating very great extent.

Benefit from indigenous farming	1	2	3	4	5
Increased food security					
Enhanced nutrition					
Decreased vulnerability to climate change and weather variability					
Improved crop systems					
Resistance to pests and diseases					
Eco tourism – people visits to view for financial benefit to you					

3. What measures do you think should be taken to ensure that more indigenous tree species should be conserved to prevent erosion of our natural forests especially off forests?

_____

_____

END

Appendix 3: KEY INFORMANTS QUESTIONNAIRE

Target population

- Foresters
- Community Forest association members
- Environmental Officer Lari

1. How many households are there in Lari? You can obtain this from census report?
    a) 10000-20000
    b) 20000-100000
    c) 100000-500000
    d) >500000
2. How many households are Female headed? How many households are Male headed?

Female headed	Male headed
a) 10000-20000 b) 20000-100000 c) 100000-500000 d) >500000	a) 10000-20000 b) 20000-100000 c) 100000-500000 d) >500000

3. What are the general land sizes per household in Lari
    a) >1/8 acre
    b) 1/8 -1/2 acre
    c) 1/2 -1 acre
    d) >1 acre
4. What is the tenure systems in Lari?
    a) Individual tenure - with land title deeds
    b) Individual tenure - with share certificate

c) Communal tenure
d) Public land

5. What are the common land uses

a) Agricultural production (both livestock and crops)
b) Forest
c) Industries
d) rental/housing

6. What is the history of deforestation and how has it affected the conservation of indigenous trees?

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7. How have the local people participated in ensuring the conservation of indigenous trees in the area?

a) Afforestation planting by trees on farm
b) Caring for the trees on farm
c) advocacy campaigns against cutting of trees
d) Others (specify) .....

8. which type of exotic tree species have been introduced within the district? How has this led to adoption or erosion of indigenous tree species within the district?

Type of exotic tree	Purpose of tree	How it has led to the adoption or erosion of indigenous tree species within the district because of the value of tree

.

9. What agricultural production system is practiced within Lari and how has it contributed towards deforestation?

    a) Mono cropping
    b) Mixed Cropping
    c) Animal rearing only
    d) Animal and crop

10. Are there controls against deforestation in the district? yes/no if yes what are the

Controls	Policies/laws that are pro-biodiversity conservation within agricultural production systems
a) policies b) Laws/regulations c) County government d) Others please specify	