Kenya's Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme

Component 4: Science to Inform Design of Community-Level Actions and Policy Decisions

Baseline Survey Report on Trees on-Farm and Assessing Communities' Needs in Indigenous Tree Propagation and Management in Mt. Elgon and Cherengany Ecosystems

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Baseline Survey Report on Trees on-Farm and Assessing Communities' Needs in Indigenous Tree Propagation and Management in Mt. Elgon and Cherengany Ecosystems

Table of Contents

List of Tables

List of Figures

Photos

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We also appreciate the contributions made by the communities of Mt. Elgon and Cherangany Sub-counties for their cooperation during the baseline survey, key informant interviews and Focus Group Discussions.

Affirmation

We affirm that this baseline survey report consists of the findings of the study that was undertaken through gathering information on the baseline of trees on farm and assessing communities needs in indigenous tree propagation the counties of Bungoma, Nandi, West Pokot, Kisumu, Kakamega and Uasin Gishu which are among the eleven counties in which the project is being implemented.

The development of this report has been guided by the Terms of Reference, provided by KEFRI and contributions of individuals and community through key informant interviews, focus group discussions and individual respondents during the study.

This Baseline Survey Report remains the property of KEFRI. Information and data collected must be used only with their consent.

Acronyms

AEZ	AGRO-ECOLOGICAL ZONES
ASAL	ARID AND SEMI ARID LANDS
BAT	BRITISH AMERICAN TOBACCO
CBO	COMMUNITY BASED ORGANIZATION
CFA	COMMUNITY FOREST ASSOCIATON
CM	CENTIMETERS
DBH	DIAMETER AT BREAST HEIGHT
EC	ECOSYSTEM CONSERVATOR
ERC	ENERGY REGULATORY COMMISSION
FAO	FOOD AND AGRICULTURE ORGANIZATION
FGD	FOCUSED GROUP DISCUSSION
GIS	GEOGRAPHICAL INFORMATION SYSTEM
GOK	GOVERNEMNT OF KENYA
GPS	GLOBAL POSITIONING SYSTEM
HA	HECTARE
HH	HOUSEHOLD
KEFRI	KENYA FORESTRY RESEARCH INSTITUTE
KENFAP	KENYA FARMERS PROGRAMME
KFS	KENYA FOREST SERVICE
KG	KILOGRAM
KII	KEY INFORMATION INTERVIEW
KSHS	KENYA SHILLINGS
LC	LOWER CATCHMENT
LN	NATURAL LOGARITHIM
LZ	LOWER ZONE
M.A.S.L	METERS ABOVE SEA LEVEL
M^3	CUBIC METER
MC	MIDDLE CATCHMENT
MT	METRIC TONNE
MZ	MIDDLE ZONE
NEMA	NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY
NGO	NON-GOVERNMENTAL ORGANIZATION
SHG	SELF HELP GROUP
SPSS	STATISTICAL PACKAGE FOR SOCIAL SCIENTISTS
TOR	TERMS OF REFERENCE
UC	UPPER CATCHMENT
UZ	UPPER ZONE
V	VOLUME
WRUA	WATER RESOURCE USERS ASSOCIATION

Executive summary

This Study was based on Component 4 which is: "Science to inform design of community-level actions and policy decisions". This EU funded project is expected to support Kenya to reduce poverty through enhancing the productivity and resilience to climate change of Kenya's water sources..

The ability of Kenya's water towers to continue to provide critical ecosystem services, in a sustained manner to adjacent communities and beneficiaries further afield is being threatened by deforestation and land degradation. Deforestation has reduced Kenya's forest cover from 12% in the 1960s to currently 6.9% (Kenya Forest Service 2013Kenya Forest Cover - unpublished results of mapping of Kenya's forest cover with support from the Government of Japan). Deforestation costs the Kenyan economy an estimated KES 5.8 billion per year (UNEP, (2012a). Kenya. *Integrated Forest Ecosystem Services* Technical Report.) An estimated 50,000ha lost between 2000 and 2010, has resulted in cumulative negative effects amounting to KES 3,652million/year, more than 2.8 times the cash revenue of deforestation. The contribution of forests to Gross Domestic Product (GDP) is estimated to be around 3.6% (Government of Kenya, 2012, National Climate Change Action plan, Nairobi, Kenya).

The aim of the study was to ascertain the ascertain tree cover in Mt. Elgon and Cherangany ecosystems and undertake a capacity assessment of communities' ability to propagate and manage indigenous trees on their farms.

Specifically, the survey sought to:

i) Generate information on on-farm tree cover to ascertain the proportion of the ecosystems covered with trees;

ii) Generate information that would define the extent of interventions with technologies to improve on-farm cover ;

iii) Assess the community needs in propagation and management of the indigenous trees;

iv) Assess the communities' capacity (knowledge, competence and skills) in propagation and management of indigenous trees;

The Project area covers 11 counties (Busia, Kisumu, Siaya, Bungoma, and Trans-Nzoia in Mt. Elgon; and Elgeyo Marakwet, West Pokot, Uasin Gishu, Kakamega, Vihiga and Nandi in Cherangany ecosystem. However six counties were sampled namely West Pokot, Bungoma, Kakamega, Kisumu, Nandi, and Uasin Gishu Counties.

A sample size of 400 farmers was selected in all the six counties, with a confidence level of 95%, and margin of error of 3.4%. From the main sample size of 400 farmers, 10 households were selected using random stratified sampling in 42-subcounties of the ecosystem. Data collection was undertaken using Household questionnaires on Survey to Go application on a digital platform. Survey of on-farm trees was conducted in sampled households. DBH of

trees were measured at 1.3m height and the species identified and recorded. The various tree forms were identified, and recorded. Plant types were recorded as saplings and trees DBH of 2.5-9.9cm and 10cm and above respectively.

Key informant interviews were conducted with KEFRI, KFS, NEMA, Ministry of Agriculture, Ministry of Interior (enforcement), and NGOs. Focused Group Discussions were conducted with Community Forest Association, Tree Nursery managers, and community groups.

Study findings indicate that Majority (64%) of those interviewed were farmers, while others held clerical jobs (2%) and balance (33%) fell under others consisting of pastoralists and workers in the informal sector. Most of the households were male headed (75%), with West Pokot having the highest number of female headed households at 31%. The education level of the household head as mainly primary level and below with graduates and above only 11%.

The average number of household was 5.8, with average farm holding of 3.14 acres in all ecosystems. The farm sizes in counties were as follows: West Pokot 11.8 acres, Bungoma County 2.03, Kakamega 2.42, Nandi 2.75, and Uasin Gishu 3.7 acres. 91% of households interviewed said that they had trees on farm with only 9% saying they had none. The upper catchment in both ecosystems had the highest percentage of persons with trees on farm at 94% while the middle catchment had the highest percentage of those without at 12%.

The main niches for growing trees on farms were woodlots 25%, boundary planting 59% and open cultivated area 12%. Overall, tree management was mainly rated as average. The most practiced management activity was pruning (93%), followed by thinning (21%). The highest score was at 55% with the lowest at 45% especially in the lower zones, where tree planting is hampered by dry weather conditions. The main tree products on-farms were firewood (86%); Timber (70%) and Poles (43%). Other uses were fruits (36%); charcoal (35%); and amenity (11%).

Overall, 67% of persons had planted or protected a tree for natural regeneration in the last 5 years, while 36% had planted none as seen in Fig. 3.3. Most persons had planted less than ten trees (31%), with only 6% having planted more than 100 trees. The trend for the last 5 years has been on a slight decline. Tree cutting is slightly lower than the tree planting rates and this has the effect of leaving more standing trees.

Trees originated mainly from own farm, purchasing, or regeneration. Uasin Gishu had the highest percentage of respondents who purchased seedlings at 80%, whereas Bungoma had 20%. Kisumu had the highest number of respondent relying on own seedlings (49%), and using transplanting of natural regeneration (51%). Nandi County had balance trend of using own seedlings (40%), purchased seedlings (45%), and use of natural regeneration (45%). West Pokot which is a major supplier of charcoal to other counties had the lowest trend on tree origin with 12% of farmers using own seedlings, and purchasing 26%. Tree planting was being done mainly by men (55%) and the whole family unit (34%). Women only planted 7% of trees. Tree planting as a family activity was highest in Uasin Gishu

County (72%) and lowest in Kisumu County (20%), children involvement was high in West Pokot (20%), owing to school greening programmes. Overall tree ownership is male dominated at 61%, as well as the authority to sell 76%.

Trees coverage on-farm was low at 5.4% across all the Counties, with the average number of trees being 6 per household and 4 per acre. The average age of trees was 6 years and the average diameter at breast height was 34 cm. The average standing stock of biomass per household was 2 cubic metres.

Information on indigenous tree species propagation is low, with less than half (44%) of households interviewed having any knowledge on the how to do it. Only 11% of households interviewed had tree nurseries.

Bungoma County had the largest mix of indigenous tree species at 46%, with species count of 664, followed by Kakamega 21%, with a species count of 295, while West Pokot was last in species richness at 4% and a species count of 52 respectively. The most dominant species in all the counties was *Eucalyptus Species* (22%) *Grevillea robusta* (20%) followed by *Cupressus lusitanica* (8%), Mango tree (7%) and Avocado (5%). Indigenous trees were *Markhamia Lutea*(4.7%), *Croton macrostachyus* (2.4%), *Cordia africana* (2%), and *Albizia coriara* (2%). The trees are popular due to their fast growth rate, use as firewood, poles, and charcoal.

The dominant tree species in West Pokot County are Cyprus 26.92%, followed by *Eucalyptus sp.* 21.15% and *Acacia nilotica* 8%. In Bungoma County, *Grevillea robusta* had 27% *Eucalyptus Sp.* 26%, and *Mangifera indica* tree 10%. In Kakamega County, *Eucalyptus* Sp. had 14% *Grevillea robusta* 11%, and *Cupressus lusitanica* 9%. In Kisumu County *Eucalyptus sp*. had 15%, *Grevillea robusta* 14%, followed by *Markhamia lutea* 12% and *Mangifera indica* 9.3%. In Nandi County, *Eucalyptus Sp.* had 24.4, *Cupressus lusitanica* 21.14%, *Acacia mearnsii* 20.3, and *Grevillia* 20.3%, while in Uasin Gishu County *Eucalyptus Sp.* had 29.2 and *Grevillea robusta* 10.1%.

Challenges to on farm tree propagation are mainly in sourcing of seedlings, lack of information on tree propagation, however, there is a lot of potential for tree seedlings propagation in all the Counties, if the following measures are undertaken: Tree planting awareness campaigns need to be enhanced through farmer field schools and demonstration plots; Capacity building on tree nursery management and enhancement of forest extension services. There is also need to promote charcoal production technologies with higher recovery rate, to reduce tree cutting rates on farm for charcoal production.

1 INTRODUCTION

1.1Background

Farm forestry is the practice of growing trees on privately owned agricultural land (on-farm), for household use and sale (FAO, 1989). During the pre- colonial era, communities land use patterns were considerably different depending on their historical background, land use preferences, traditional customs, culture and ecological influence (Cheboiwo, 1991). Trees were an important part of community's resources and tree tenure was recognized depending on species, locality and main usage within the community and access between men and women (Burrow, 1989; Ogendo, 1987; Rocheleau, 1987).

Pre-colonial land use system was therefore directly related to subsistence requirements of the community members as expanding populations needed more food. Forests were the main sources of fertile land which offered employment to community members. As a result, indigenous forests and grasslands were cleared to create agricultural land for food supplies.

Tree growing on farms in Kenya has evolved through several stages that involved clearing of natural forests in the early stages of extensive farming through subsistence to current multibillion commercial oriented enterprises (Cheboiwo, 2015). Some of the reasons for evolutionary changes include claims to land and boundaries marking, recent decline of public forest resources countrywide. This has put farm forestry in pivotal position in provision of various forest products for subsistence and commercial reasons for both local and national markets. Farm forestry produces goods and services such as biodiversity, fauna habitats, watershed protection, carbon sequestration, shade, and recreation scenery, windbreaks, and soil and water conservation.

The Government of Kenya has been involved in promoting tree planting at the farm level with the aim of increasing tree cover to 10% by the year 2030 (Republic of Kenya, 2002a). There have been successful tree planting programs involving rural communities in Kenya led by government rural forest extension services and various non-governmental organizations (NGOs). Green Belt Movement is among the most active NGOs which have assisted planting of over 45 million trees in different parts of Kenya for the last three decades.

Unprecedented human demand for forest products (e.g. fuel wood, poles, timber, herbs) (Kenya Forestry Master Plan 1994; Mulinge and Mueller 1998; Brooks *et al*. 1999), and conversion of forest to agricultural land and subsequent frequent activities of tilling, cropping and grazing are causing more loss of forests and exposing the topsoil of productive lands to soil erosion (Sanchez and Jama 2000). As a result, there is soil fertility loss and consequently a declining agricultural productivity (World Bank 1996; Maithya *et al*. 2006). This combination of poor agricultural practices along with deforestation is resulting in desertification of many areas making farming in these areas less sustainable and causing

a dramatic decline in non-wood and wood resources needed to satisfy fuel, construction and other domestic needs of local people.

Access to additional land for farming has become difficult in Kenya due to the increase in demand for land from a population that is growing rapidly at a rate of 6.6% and 1.8% in urban and rural areas respectively (Central Bureau of Statistics 2002). The population growth rate is higher than the growth rate in agricultural output. Consequently, both per-capita food production and incomes have declined resulting in recurrent food shortages and worsening rural poverty (Maithya *et al*. 2006; FAO 2007a). Hence, improving the use of land and agricultural practices towards sustainable levels is a major challenge in Kenya (Maithya *et al*. 2006; Nyangena 2008; Oluoko-Odingo 2008). Planting of trees along with agricultural crops (termed here as farm forestry (FF)) is considered as a feasible solution to more sustainable land uses (FAO 2007b).

Nearly every developing country around the globe, including Kenya, is practicing some form of farm forestry (McCarthey 2004; FAO 2007b), which ranges from woodlots(Ramadhania *et al*. 2002), alley farming (Mungai *et al*. 2001), plantings around homestead (home gardens) (Nair 2001), boundary planting, to wide-space planting of trees in croplands, and in pastureland (Torquebiau 2000). These practices provide the opportunity for farmers to harness the potential of the various resources within a production unit and provide a means of livelihood diversification (Muchiri *et al*. 2002) which serves as a safety net for local people.

For instance, trees planted within agricultural landscape can help to increase wood and non-wood supplies such as medicine, fodder, construction material and food, while contributing significantly to soil fertility, erosion control, microclimate amelioration and environmental protection (Muchiri *et al*. 2002). Additionally, tree-based systems help to reduce deforestation. Murniati *et al*. (2001) found that local people who diversified their agricultural crop systems to include timber tree species used the native or primary forests less intensively thereby reducing pressure on the primary forests and also reducing the exploitation of nearby conservation or protected areas. Recent work has also highlighted the importance of tree-base farming systems in Carbon sequestration and biodiversity conservation (Kirby and Potvin 2007) and suggested that tree-based systems are much better at accumulating carbon, above and below ground, than pure agriculture.

It is for these benefits that the Government of Kenya, over the last decade, had sought to promote land use systems integrating trees with crops and/or livestock aimed at reducing deforestation, and improving soil and water conservation practices (Pretty 1995; David 1997; Nyangena 2008).

1.2Study objectives

The main objective of the assignment was to ascertain the proportion of tree cover in the two ecosystems and undertake a capacity assessment of communities' ability to propagate and manage indigenous trees.

Specifically, the survey will:

i) Generate information on farm tree cover to ascertain the proportion of the ecosystems covered with trees;

ii) Generate information that would define the extent of interventions with technologies for on-farm trees;

iii) Assess the community needs in propagation and management of the indigenous trees;

iv) Assess the communities' capacity (knowledge, competence and skills) in propagation and management of indigenous trees;

1.3Scope of work

The assignment specifically entailed the following:

Baseline survey of on-farm trees:

i) Development of survey tools;

ii) Uploading of the approved survey tools on a Mobile Data Collection platform with a GIS mapping ability;

iii) Recruitment and training of the enumerators and supervisors;

iv) On-farm and capacity survey;

i) Recruitment and training of enumerators;

ii) Data collection through HH interviews, Focus Group Discussions and Key Informant Interviews;

iii) Data Analysis and Reporting

1.4Terms of reference

The Baseline survey of the on-farm trees entailed a census of trees in the farms around the two ecosystems. Capacity Needs Assessment targeted at the community members around the two ecosystems as the primary beneficiaries, the local and county administration, CFA and WRUAs as well as other key stakeholders in the project and the two ecosystems.

The assignment specifically entailed and not limited to the following:

Baseline survey of on-farm trees:

i) Development of tools for the survey and sharing them with the KEFRI team for approval;

ii) Uploading of the approved survey tools on a Mobile Data Collection platform with a GIS mapping ability;

iii) Recruitment and training of the enumerators and supervisors;

iv) On-farm tree survey in the two ecosystems using local enumerators;

v) Organization and participation in farmers' workshops;

vi) Data analysis and reporting;

Community Capacity Needs Assessment:

i) Development of a capacity assessment tools and sharing with the KEFRI team for approval;
ii) Survey design (including sampling) and sharing with the KEFRI team for approval;
iii) Recruitment and training of enumerators;
iv) Data collection through HH interviews, Focus Group Discussions and Key Informant Interviews;
v) Data Analysis and Reporting
vi) Validation of the report and finalization

2 METHODOLOGY

2.1Study area

The baseline survey on on-farm trees was conducted in Mt. Elgon and Cherangany hills ecosystems. The study area covers 11 counties (Busia, Kisumu, Siaya, Bungoma, and Trans-Nzoia in Mt. Elgon; and Elgeyo Marakwet, Pokot West, Uasin Gishu, Kakamega, Vihiga and Nandi in Cherangany.

2.1.1 Mt. Elgon Ecosystem

Mt. Elgon is one of Kenya's five main water towers with an estimated watershed population of over 1.5 million. Mount Elgon's forest ecosystem covers an area of 236,505ha to the Kenyan side and overlaps with Trans-Nzoia and Bungoma counties (KWS 2011). It was gazetted in 1932 (Ongugo *et al*, 2001) and receives high rainfall, designating it as one of the Kenya's five "water towers" supporting a huge population (van Heist, 1994).The ecosystem comprises of forest resources contributing to socio-economy eg. Firewood, poles or timber, water and fodder. In addition, Mt. Elgon hosts the headwaters of the Nzoia River which provides hydrological services to a range of economic sectors including irrigated agriculture with an estimated watershed population of over 1.5 million.

Mt. Elgon vegetation can be zoned into four: open woodland, tropical moist forest, bamboo and afro-alpine zone. The forest is divided into three management units namely: the natural forest reserve, the commercial exotic plantations and the national park.

2.1.2 Cherangany Hills ecosystem

The Cherangany ecosystem is an important water catchment area and it is one of Kenya's 'Water Towers'. It serves as a watershed between the Lake Victoria and Lake Turkana basins. The Cherangany Hills cuts across four administrative districts in Rift Valley Province that is Trans-Nzoia, West Pokot, Marakwet and Lelan. Spatially, the location of Cherangany Hills is defined by 35^{o} 26'' East and 1^{o}16'' North at an altitude range of 2000-3365m above sea level (CHFESp 2015). CheranganyHills forest ecosystem comprises of a number of forest blocks (12), cutting across three counties, Trans-Nzoia, Elgeyo Marakwet and West Pokot, on the Western ridge of the Great Rift Valley (Figure 1). It covers an area of 120,000 ha, forming the upper catchment of Nzoia, Kerio and Turkwel rivers (KFWG & DRSRS 2004).

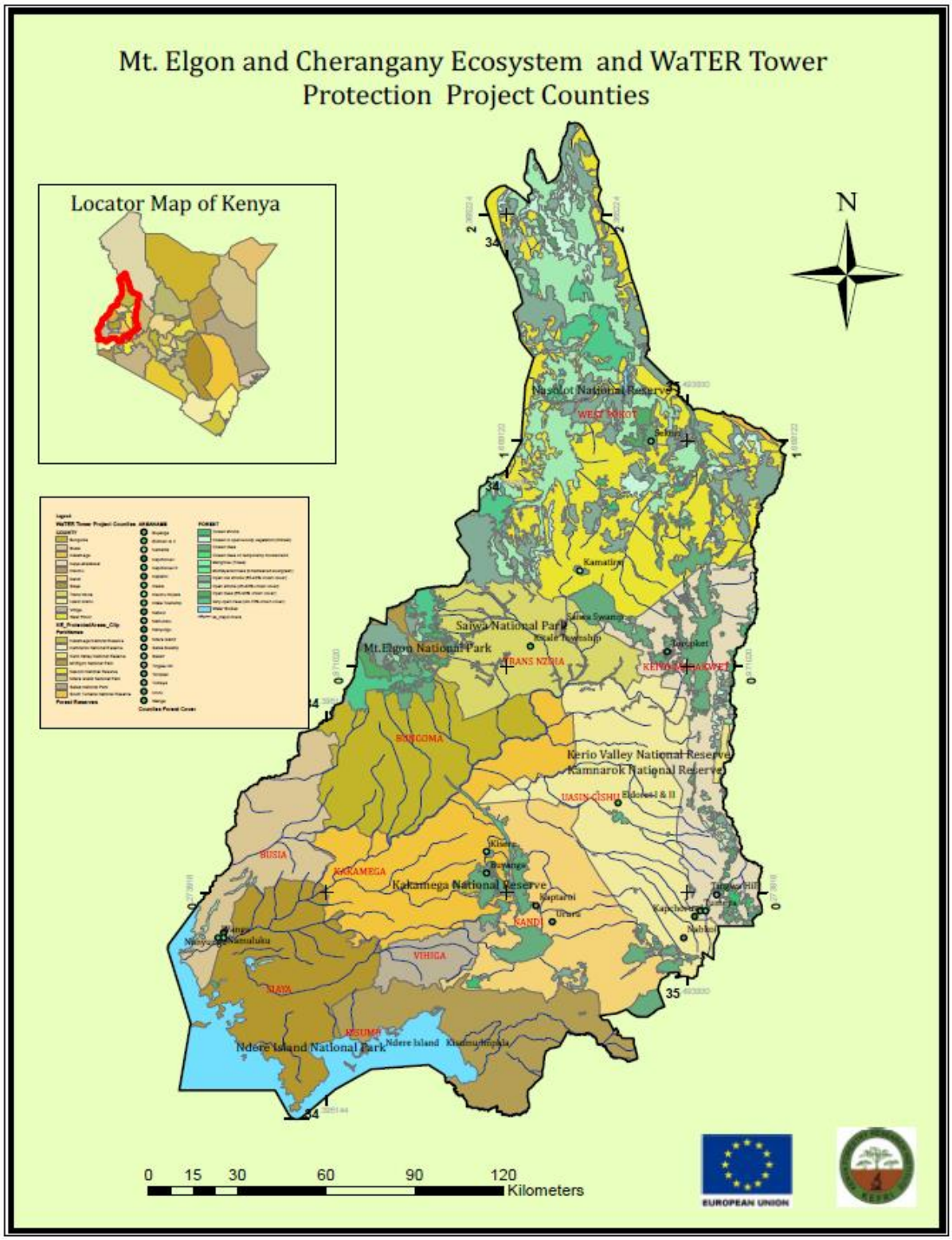


Figure 1 Mt. Elgon and Cherangany Ecosystem

2.2Sampling procedure

Purposive sampling in the two ecosystems was done based on household population in Mt. Elgon and Cherangay ecosystems (2009 population census data). 6 counties (Kisumu, Bungoma, Kakamega, Pokot West Uasin Gishu and Nandi) out of the 11 counties were sampled based on homogeneity to the ecosystem (Figure 1).

The sample size was computed using;

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+(\frac{z^2 \times p(1-p)}{e^2 N})}$$

Where $Population\ Size = N$

$Margin\ of\ error = e$ *(e is percentage, put into decimal form)*

$Z\text{-}score = z$ (The z-score is the number of standard deviations a given proportion is away from the mean).

Table 1 Sample size per county in Mt. Elgon and Cherangany ecosystems

Ecosystem			CL-95% ME-3.5%		
	County	Household population	% HH Distribution per county	Number of HH	Number of sub-counties
Mt. Elgon	Kisumu	226719	17	67	7
	Bungoma	321628	24	95	10
Cherangany Hills	Pokot West	93777	7	28	3
	Uasin Gishu	202291	15	60	6
	Kakamega	355679	26	105	11
	Nandi	154073	11	46	5
	Total	1354167	100	400	42

The Confidence level (95%) and margin of error (3.4%) was used to calculate the sample size of the whole population in Mt. Elgon and Cherangany hills ecosystems.

With different (%) household distribution in each of the counties within the ecosystems, a sample of 400 households representing the population was randomly sampled and interviewed (Table 1). 10 households per sub-county were randomly sampled in the 42 sub-counties of the ecosystem.

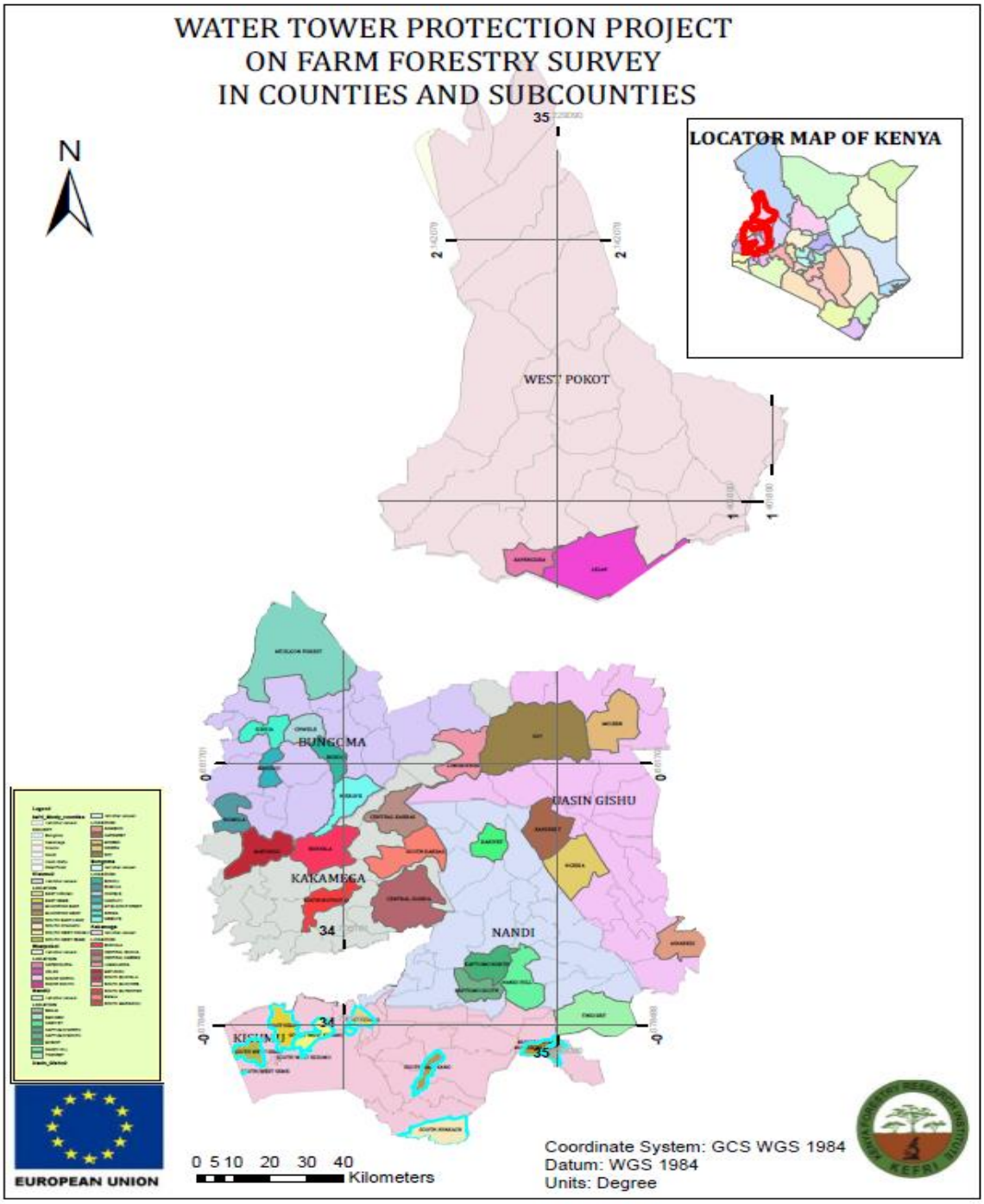


Figure 2 Counties Sampled in Mt. Elgon and Cherangany ecosystems

The survey was undertaken in the following sub-counties in West Pokot, Bungoma, Kakamega, Kisumu, Nandi and Uasin Gishu as shown in (Table 4).

Table 2 Household in Counties and Sub-counties

No.	County	Subcounty	Sample Size
1	West Pokot	North Pokot, South Pokot and Central Pokot	28
2	Bungoma	Sirisia,Mt. Elgon, Kanduyi, Bumula, Kabuchai, Webuye and Bokoli	95
3	Kakamega	Lugari, Lukuyani, Malava, Alurambi, Navakholo, Mumias, Mumias East Matungu, Butere, Kwisero, Shinyalu and Ikolomani	105
4	Kisumu	Nyakach, Seme, Kisumu East, West and Central, Nyando and Muhoroni	67
5	Nandi	Emngwen, Mosop, Nandi Hills, Aldai, Tinderet, and Chesume	46
6	Uasin Gishu	Soy, Moiben, Ainabkhoi, Kaseret, and Kesses	60

2.3Data collection tools

Household surveys (Questionnaire in Appendix 4), FGDs (Guide in Appendix 3) and KIIs(Guide in Appendix 2)were conducted in the ecosystem. A combination of qualitative and quantitative tools was developed for on-farm data collection activities.

2.3.1 Bio-physical survey (on-farm tree survey)

Survey of on-farm trees was conducted in the two ecosystems. The trees DBH were measured at 1.3m height and the species identified and recorded. The various tree forms (Appendix 5) were identified, and recorded. Plant types were recorded as saplings and trees DBH of 2.5-9.9cm and 10cm respectively.

2.3.2 Household survey questionnaire

At the household level, household heads and children (18 and above) were interviewed on on-farm trees, their importance and uses. The information gathered in this survey included practices of on-farm forestry, tree management practices, on-farm forestry products, the challenges and taboos associated with on-farm forestry practices. The survey also identified the tree species, mode of establishment and the major intercrops.

2.3.3 Key informant interviews (guiding questions)

The Key informants targeted were officials of KFS (Ecosystem Conservator), Extension Officers (Ministry of Agriculture and Environment), Local Administration and NGOs.

The guiding questions captured information on the challenges of on-farm forestry, main species grown, sources of seedlings, challenges in indigenous tree propagation and possible technologies that can be used to increase on-farm tree planting.

2.3.4 Focus Group Discussions (guiding questions)

FGDs were held at the sub-county/village level. The representatives of CFA, CBO, and user groups were interviewed to provide information representative of community status of on-farm forestry in the ecosystem.

The FGDs captured information on the main indigenous trees in the area, sources of germ plasm and challenges for indigenous tree planting.

2.3.5 Data analysis and reporting

The baseline survey data was analyzed using SPSS and MS excel. The qualitative data was processed into a narrative account, capturing the topical themes Key Informant and FGDs guide to corroborate quantitative data.

The bio-physical data was collected at farm level on trees on-farm was used to show differences in species richness in the various counties in Mt. Elgon and Cherangany ecosystems.

The density (number per hectare) for each of the plant types was calculated using [**number of plants/plotsize/sample size**]. Determination of size distribution was calculated based on basal area per hectare (m^2/ha). Having recorded the Diameters at Breast Height (DBH), the basal areas were calculated using the formula $\left(\frac{\pi}{4} * \mathbf{10000}\right) * \boldsymbol{DBH^2}$ for each farm.

The biomass volume was also calculated using $\boldsymbol{Ln(V) = a + bLN(D)}$, based on the tree forms in the field Table 3 and Appendix 5.

Where,

V= Usable stem volume in decimetres (dm^3)

D=Tree Diameter at Breast Height in cm (1.3m)

a and b=constants depending on the tree forms

Table 3 Different tree forms and the two constants (a and b)

Tree form	Parameter a	Parameter b
	-2.2945	2.5703
	-1.7322	2.3992
	-1.6493	2.3567
	-1.6840	2.2406

The quantitative data was coded, classified and analyzed and presented in tables, graphs and texts.

Tree Cover: While it was appreciated that tree cover is specific to particular tree species and even regions, the study attempted to calculate and determine tree cover based on:

i. Basal cover: the average amount of an area occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height, and expressed as per unit of land area.

ii. Canopy Cover: The percent of a fixed area covered by the crown of an individual plant species or delimited by the vertical projection of its outermost perimeter; small openings in the crown are included.

Basal cover was calculated by the formula:

Basal Area of a tree (m^2) = $(DBH/2)^2$ x 3.142

To calculate canopy cover, an allometric equation used to predict above ground biomass (AGB) using DBH (cm) or crown area (m^2) as inputs was used. As such, one is able to exploit the near linear relationship between the area of a tree occupied by its crown, and that of the basal areas of its trunk. This way it was possible to calculate crown area from DBH.

The allometric equation adopted from Smalligan, Micheal (Research and Development of the Field Measurement Protocols for the Carbon Benefits Project, Global Observatory for Ecosystem Services, Department of Forestry at Michigan State University - May 2012) has been used in studies for determining above ground biomass quantities in Kenya, including the Mt. Kenya/Aberdares area, mainly for carbon sequestering calculations.

The formula used was:

(i) AGB = exp (-2.403) * (DBH^2.472);

(ii) AGB = exp (1.8128) * (crown area^1.2535)

Where equation (i) = (ii) for the same tree.

Therefore,

(iii) Exp (-2.403) * (DBH^2.472) = exp (1.8128) * (crown area^1.2535); and

(iv) Crown area^1.2535 = exp (-2.403) * (DBH^2.472)/ exp (1.8128)

Therefore, crown area can be directly calculated by the equation:

(v) Crown area in m2 = [exp (-2.403) * (DBH^2.472)/ exp (1.8128)] ^ (1/1.2535)

2.4 Assessment Approach

2.4.1 Preparation and planning

At the commencement of the project, the consultancy held an inception meeting with KEFRI team, in which the consultants presented the inception report.

Specifically, the objective of the meeting was to;

- Harmonize the consultants and clients understanding of the objectives and scope of the assignment;
- Build a consensus on the assignments methodology;
- Agree on the logistical arrangements to execute the project within the given time frame;

2.4.2 Development of data collection tools

A combination of qualitative and quantitative data collection tools were developed for the study. Household survey questionnaire was developed for the household survey, while KII and FGD guides were developed for Key Informant Interviews and FGD interviews respectively.

2.4.3 Recruitment of and training of research assistants and enumerators

A team of research assistants with experience in community based development projects were hired and trained as facilitators as seen in Plate 1and Plate 2.

The training focused on:

a) Understanding of the data collection tools (Household questionnaire. KII and FGD Guides);
b) Understanding of PDA (Personal Digital Assistant-a software for data collection)
c) Sample frame and methodology and
d) Administering the questionnaires.

After the training, the household collection tool was pre-tested on site prior to actual data collection.

Plate 1 Training on Tree Diameter at Breast Height (DBH-1.3m) measurement and Inventory in Bungoma County.

Plate 2 Diameter measurement Training in Bungoma County

2.4.4 Data checks-Data collection, cleaning, analysis and reporting

Strict supervision was conducted by the consultants, coordinators and supervisors to ensure that quality data on on-farm trees was collected. Daily reporting was conducted to address any data gaps experienced by the enumerators in the field. Post collection data cleaning with logical checks was done prior to analysis.

3 PRESENTATION OF SURVEY FINDINGS

3.1Households Sample

The survey targeted 400 households in both the Mt. Elgon and Cherangany ecosystems, covering six counties, namely West Pokot, Bungoma, Kakamega, Kisumu, Nandi, and Uasin Gishu. However, 409 households were interviewed, in the two ecosystems. The overall sample size and distribution as collected in the field is as shown in Figure 3.

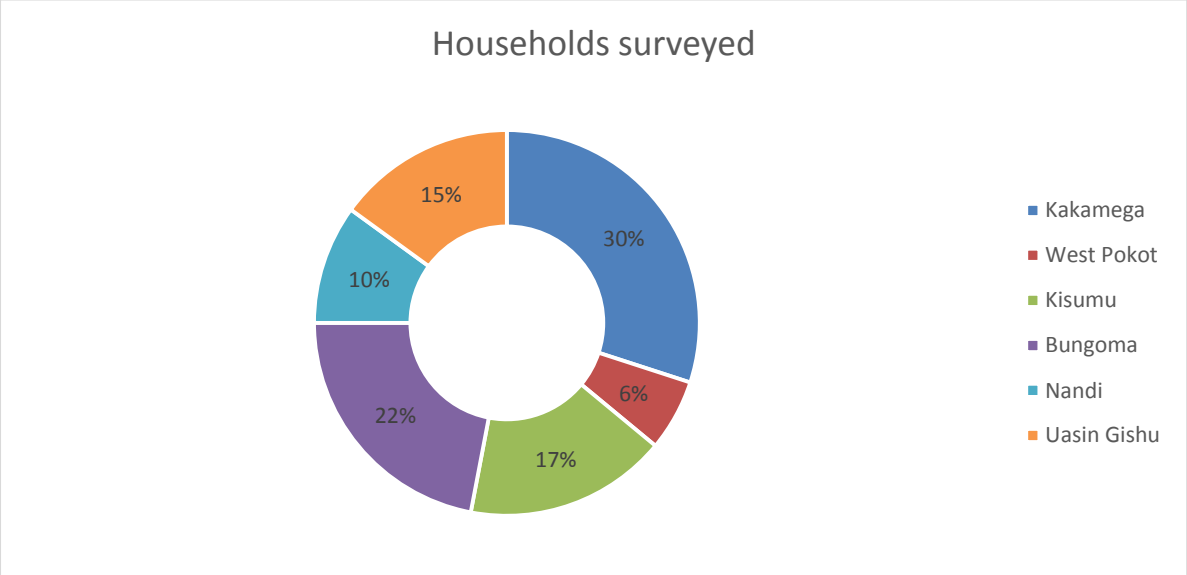


Figure 3 Percentage of Households surveyed per county

Majority (64%) of those interviewed were farmers, while others held clerical jobs (2%) and (33%) fell under other category which consisted of pastoralists and workers in the informal sector. Most of the households were male headed (75%), with Nandi having the highest number of female headed households at 45% (Table 4).

Table 4 Male and Female Headed households per County

Counties	Overall	Kakamega	West Pokot	Kisumu	Bungoma	Nandi	Uasin Gishu
Male	75%	79%	68%	69%	82%	55%	82%
Female	25%	21%	32%	31%	18%	45%	18%

The education level of the household head with basic education (primary to secondary) was 89% while household heads with graduate level and above were 11% (Table 5).

Table 5 Education Level of Household Head per County

	Overall	Kakamega	West	Kisumu	Bungoma	Nandi	Uasin

			Pokot				Gishu
Some primary	22%	40%	36%	13%	7%	21%	10%
Completed primary	16%	20%	12%	20%	5%	19%	20%
Some secondary	13%	12%	20%	20%	11%	14%	7%
Competed secondary	29%	20%	12%	33%	31%	38%	43%
College	8%	3%	0%	0%	24%	5%	10%
Graduate and above	11%	4%	20%	14%	23%	2%	10%
Refused to answer	0%	0%	0%	0%	0%	0%	2%

3.2Key Informants and Focused Groups

Key informant interviews were undertaken during the field visits. The main key informants were from the Kenya Forest Service, the Ecosystem Conservators or their representatives and the relevant County staff.

Plate 3 FGD in West Pokot County

Plate 4 FGD in Uasin Gishu County

Plate 5 FGD in Kakamega County

Plate 6 FGD in Kisumu County

Focused groups interviews were also undertaken with groups based on a random sample taken from the lists provided by the key informants as seen in Plate 3, Plate 4, Plate 5 and Plate 6.

3.3Household Size

The survey targeted one household, and not a farm as the sampling unit. As such, tree measurements were undertaken on the farm holding of one household, even where there were extended family units owning different sections of the same farm.

The number of persons also differed per farm with the average being 5.8, more or less evenly distributed among the three zones. Household sizes are important in terms of biomass demand especially where the primary source of income is the farm.

Table 6 Household Size

Counties	1 person	2 persons	3 persons	4 persons	5 persons	6 persons	7 persons	8 persons	9 persons	10 persons
Kakamega	3	8	14	15	16	13	8	11	2	9
West Pokot	0	4	3	23	3	11	16	17	4	16
Kisumu	6	10	10	16	25	6	10	6	3	10
Bungoma	0	0	6	16	10	30	17	14	1	4
Nandi	0	0	7	9	19	17	12	14	7	17
Uasin Gishu	0	3	14	18	27	22	5	8	0	3

3.4Size of Household Land-holding

The average land holding per household in all the two ecosystems was 2.67 Ha acres but ranged from 0.01 Ha to 40Ha. Farms in the upper catchment had the largest farms averaging 2 Ha, with those in the lower catchments having the least size at 0.75 Ha acres. Overall, 57% of the farms were cultivated with the highest percentage being in the middle catchment with 64%. Overall, areas under trees was 21% more or less equal across the catchments (this is not equivalent to tree cover).

Table 7 Average Land Holding per Household per County Acres

County	Average Land Holding in Ha
Bungoma	0.52
Kakamega	1.37
Nandi	1.03
Uasin Gishu	1.59
West Pokot	10.87
Kisumu	0.62
	2.67

3.5Trees on Farm

3.5.1 Overall

91% of households interviewed said that they had trees on their farms with only 9% saying they had none as shown in Table 8. The upper catchment had the highest percentage of persons with trees on farm at 94% while the middle catchment had the highest percentage of those without trees at 12% Table 8.

Table 8 Percentage of Households with Trees of Farm

Catchment	Observed	Upper catchment	Middle Catchment	Lower Catchment
Total	409	123	158	128
Yes	91%	94%	88%	91%
No	9%	6%	12%	9%

The actual number of trees per household was also high with 202 tree per Ha and 249 tree per household as shown in Table 9.

Table 9 Number of Trees per Household/Hectare

County	Trees per Household	Trees per Hectare
Bungoma	55	107
Kakamega	117	86
Kisumu	89	144
Nandi	590	573
Uasin Gishu	450	283
West Pokot	192	18
Overall average	249	202

3.5.2 Trees on Farm in West Pokot

The main trees grown on farm are *Eucalyptus, Grevillia, Cyprus and Pine*, as they are fast growing and useful for firewood, timber especially in the construction industry. Indigenous

tree species planted on farm are mainly *Croton megalocarpus, Syzygium*, which are preferred due to their fast growth. In the highlands Croton macrostachyus grows naturally on farm, whereas in the lowlands, *Acacia* species are the dominant trees. Farm forestry is practiced on small scale, with trees mainly grown along boundaries to give way for animal grazing.

Sources of energy

Communities mainly depend on forests and individual farms for firewood. Farmers travel for approximately 5 km per day to the forest to source firewood, and they pay a monthly licensee fee of Kshs 100 to the Kenya Forest Service. Though the County is known as the major supplier of charcoal, it has only one registered charcoal producer. The annual charcoal permit license for KFS is valued at Kshs. 2.3 million. The fee is charge Kshs 30 per bag of charcoal, which translates to 76,667 bags of charcoal per year. Charcoal is produced mainly using earth kiln methods, either in own farms or in community land. It was noted that farmers have large farm sizes ranging from 10-1000 acres, which provides them with ample sources of firewood, and also areas for establishment of woodlots on farm. However, that in itself, hinders farmers from engaging in Community Forest Associations as they see no incentive in joining or belong to the groups as can get similar benefits from own farm. Hence the capacity of CFAs as entry points for tree nurseries propagation either for planting in the forest or on farm is very in adequate.

3.5.3 Trees on Farm in Bungoma County

Farm forestry in the county mainly focuses on exotic species such a *Eucalyptus Sp., Grevillea robusta, Casuarina equisetifolia, Markhamia lutea and Cedar.* Trees are mainly grown on boundaries or woodlots where farm sizes permit. The main crop grown in the county is maize which determines tree planting niches. It is worth noting that there are many planted trees disputes especially along shared borders, where farmers complain that the neighbors trees are extending their rooting to their farms and affecting their soil fertility. This in effect has seen farmers preferring not to plant trees on their farms to avoid disputes.

The main sources of seedlings are KFS, CBOs, BAT, individual farmers, wildlings or community tree nurseries. Trees are mainly planted for timber, fuel, posts, medicinal value, wind break and for fruits. The main indigenous trees planted are *Maesopsis eminii, mutoto, mukokwe, Markhamia lutea, Olea capensis, and Prunus africana.* The trees are planted mainly for Timber, fuel, medicinal value, fruits, poles, windbreak, and boundary marking.

Sources of energy

Farmers mainly depend on firewood for energy whereas in the urban areas charcoal is mainly used. Fuelwood is sourced from own farm, and forest for forest adjacent communities. Charcoal is mainly sourced from West Pokot (Acacia species), and Uasin Gishu County (Wattle trees). Farmers also use crop residues, sawdust, from saw millers and

power saws. It was noted that farmers prefer saw dust from power saws as they have large particles and cook for a longer period than the fine dust from saw millers.

KENFAP works with farmers in promoting biogas, and energy saving jikos. Biogas uptake is mainly in schools, whereas energy saving jikos are for individual farmers. It was noted that use of solar is taking shape in hotels and new establishments owing to Energy Regulatory Commission policy on energy use for hotels or establishments consuming more than 100 liters of water per day.

Schools are also high consumers on energy, and it school greening programmes have seen woodlots established in Tongaren.

3.5.4 Trees on Farm Kakamega County

The main tree species planted in the area include *Grevillia robusta, Calliandra calorthyrsu , Prunus africaan, Olea capensis,* and *Maesopis eminii* (Muteere), fagara (*Xydulloxyllum gillettii*) which are mainly used for timber, firewood, medicinal value, and shade. Tree seedlings are sourced from Eshisiru Center in Lurambi. There are also women groups such as *Kujisaidia* women group, Kukuya, Senso motoribike self- help group in Lurambi and Baraka Self Help group in Mahia kalo sublocation.

Farmers also get certified seedlings from KEFRI, while other collect wildlings from mother trees within their reach or from the forest.

Sources of energy

The main source of energy in the county is firewood and charcoal. The firewood is sourced from own farm and the forest. Charcoal is sourced from Uasin Gishu County, and mainly from wattle trees. Farmers are permitted to collect firewood from the forest in return for fee of KShs. 100 per month. There are about 250 farmers who have permits, and it is estimated that about 10% collect firewood twice a day for own use and for resale in the local market. The average volumes of firewood collected from the forest is 8250 head loads per annum, which is a conservative figure owing to the fact that the forest is not fenced, and due to its vastness, it is not feasible to account for every piece from the forest.

Though charcoal production is not very common in the area, there are farmers who engage in the activity and thy use earth kilns.

Tree planting is undertaken mainly for environmental conservation. There has been intense tree planting campaigns in the area, in Churches, Schools, and other educational institutions where they are informed of the importance of tree planting for domestic and commercial purposes. There are many people with commercial woodlots and small plantations on their farms which are basically for timber, poles and firewood.

Due to population pressure, there is lot of pressure on forest resources owing to the fact that the supply does not meet the demand which results in illegal charcoal production, from unsustainable sources.

There are biogas installations in the County which were undertaken by the Kenya Green Zones in Bukhungu location, Shirere Sub-location in Amalemba village, and technology uptake has been positive, and also includes other alternative technologies such as solar for cooking and lighting.

3.5.5 Trees on Farm in Kisumu County

The main species grown in Kisumu County are Eucalyptus camaldulensis, E. grandis, Calliandara calothyrus, Senna Siamea, Grevillea robusta, Leucaena leucocephala, Jacaranda mimosifolia, and Umbrella tree as they do well in dry conditions. Indigenous trees include Acaccia sp., Euclea divinorum,Terminalia brownii and Markhamia lutea. The main reasons for planting of trees are for timber, fire wood, fruits, aesthetics and medicinal value. Seedlings are sourced locally from private tree nurseries, and the most preferred species is Senna siamea, due to its ability to survive in arid and semi-arid areas.

Sources of Energy

Most of the households in the area use firewood as source of energy, and most of it are sourced from nearby bushes, as some farmers do not have trees on their farms. It was noted that 90% of farmers get firewood from community land and from community forests near their homes. Farmers also buy firewood from the markets such as Sondu where a head load goes for KShs. 50. Trees are mainly planted on farm as a legal requirement to satisfy the 10% tree cover promotion, although only a small percentage actually does it. Charcoal is used in urban areas, and it is sourced from West Pokot and Uasin Gishu areas. However a few farmers also burn charcoal on farm using the traditional earth kiln. In rural areas charcoal is preferred in preparing special meals such as chapattis.

During rainy seasons it is a challenge to use firewood and most farmers buy paraffin for cooking.

Communities are also embracing solar energy technologies from distributors such as M-Kopa Solar. Lighting of market centers using solar energy was also noted in Holo and Ahero urban centres.

It was noted that farmers are using improved cook stoves to conserve energy, and most households indicated that the three stone jiko mode of cooking is slowly fading away as most are being joined together using mud and cow dung to conserve energy.

3.5.6 Trees on Farm in Nandi County

The main tree species grown in Nandi County are *Eucalyptus sp., Grevillea robusta, Sesbania sesban, Lukaena lucocephala, Cypress, Pine, Psychum and Fagara microfilia.* Most of the trees grown on farm are exotic however indigenous trees are also grown on a small scale. Indigenous trees grown on the farms are mainly *Markhamia lutea*, *Croton macrostachyus*, *Olea africana* and *Prunus africana*. The main sources of seedlings are the farmers

themselves, who rely on wildlings, KEFRI and local vendors who also rely on wildlings from the natural forests.

The reasons for planting trees are for conserving the environment, timber and firewood. The main on farm forestry products are timber, firewood, poles, bee-hives for honey and charcoal production using wattle trees.

Although farm forestry has been devolved, the transitional development has not taken place. This is a challenge owing to the fact that farmers are supposed to receive extension services from the county government. Extension services are currently being undertaken by one KFS forester for the whole county.

The capacity of organized groups such as CFAs to produce seedlings both exotic and indigenous is low, despite the fact that weather is good and appropriate for tree seedlings propagation. Key among the issues identified are CFAs which are in their formative stages, and lack of market for seedlings, as farmers have access to wildlings on farm or from forest.

Sources of energy

The main source of energy in the County is firewood, charcoal, and biogas. Firewood is sourced from own farm, as well as the forest. The total land under gazetted forests in Nandi County is 62,300 hectares. They have six stations namely Kobujoi, Kimondi, Tindiret, Kapchorua, North Nandi and Cerengoni. Trees in the gazetted forests are 99% indigenous and 1% exotic. Farmers living adjacent to the natural forest pay Monthly Fuel License of Kshs. 100, and according to the records, there are approximately 200 headloads collected per station (6) per year. This translates to 1200 headloads per year. It is worth noting that most farmers depend on firewood from their own farms, whereas institutions rely on the forest for their energy. Charcoal is produced from wattle tree using traditional earth kilns, and there are no registered charcoal producers.

Wood energy is sustainable and friendly in Nandi County, whereas charcoal which is produced using wattle trees is marketable outside the County, its production methods are not friendly to the environment as it requires cutting of a number of trees at once to produce it. In terms of other sources of energy, there have been various interventions through Lake Victoria Environmental Management Programme, focusing on solar and biogas. Mkopa-Solar is also working with communities on solar installation and the uptake is positive.

Farmers are using improved *jikos* both improvised and commercial as well as biogas, in addition, The County government is considering distributing Liquefied Petroleum Gas to rural areas as a way of encouraging them to use alternative sources of energy.

3.5.7 Trees on Farm Uasin Gishu County

The main tree species grown in the County include *Sesbania sesban, Gliricidia sepeum, Casuarina equistifolia, Pinus africana, Juniperus procera, Acaccia mearnsii, Olea africana,*

Croton megalocarpus, and *Acaccia abyssinica*. Indigenous trees grown include *Olea africana, Croton megalocarpus, Syzygium cuminii, Prunus africana, and Spathodea campanulata*. Tree seedlings are sourced from KFS, and established in private tree nurseries, and own farms. Farmers collect wildlings, root suckers e.g. Bamboo, cuttings, vegetative layering. Wattle tree which is very common, is propagated through natural regeneration, and is a good source of firewood and for charcoal production.

Farmers grow trees for timber, firewood, poles, and charcoal production. Timber in the County is supplied from industrial forests, natural forests, and farmlands.

There are various tree planting initiatives in the County such as Eldoret town green initiative which has been successful and many more are ongoing. The initiative was initiated with the objectives of planting more trees around Eldoret town. Youth groups, women groups, universities, NGOs, CBOs and other related authorities are incorporated to ensure that they achieve 1% tree cover per year.

Sources of energy

Farmers depend mainly on firewood, and maize cobs for cooking, and charcoal is used in urban areas, or is produced locally as a source of income. Other sources of energy include gas, kerosene and electricity. There are various charcoal producers association in the county, such as Eldy-cyle Charcoal dealers and Uasin Gishu Charcoal Association. Charcoal is produced mainly using traditional earth kiln. According to KFS the average wood energy supplied from the forest is 7 tonnes per month.

3.6Tree Growing Niches

Tree growing niches refer to the areas within the farm where trees were being grown. At the farm level tree planting is geared towards maximization of wood yield without unduly sacrificing crop yield through tree/crop competition. Hence, trees on farms were found growing in different niches/parts of the farm with the most common pattern[1] being external farm boundaries, followed by compound[5] planting and woodlots.

Table 10 Tree Growing Patterns (%)

Growing Niche	Percentage
Woodlots	26%
Boundary Planting	59%
Windrow	9%

[1] Open-growing - this is growing scattered trees when crown never touches even at full tree maturity (*in a farm this either belongs to the cropland, grazing area or woodland*). Area Boundary- when trees are planted along farm boundaries mainly as a permanent feature to minimize neighbour encroachment (*there are also internal boundaries).* Compound planting - usually in home compounds for shade or ornamental etc. Woodlots - planted alone like a plantation in one part of farm, no crops on such woodlots. Windrows - strategically planted as a windbreak.

Open/cultivated area	12%
Compound	46%
Grazing/areas left for cattle	4%
Scattered trees on farm	24%
Band rows within the farm	3%
Home garden	14%
Scattered trees on grazing lands	5%
Other	1%

Trees planted in open niches (scattered within the farm), and along farm boundaries. aims at ensuring that the trees planted do not adversely impact on crop production, especially through shading. Trees planted within the compound are mainly for aesthetics and shade.

West Pokot and Bungoma Counties had high observed boundary nitches. In West Pokot tree growing nitches were highly dictated by the number of livestock, as more land was left for grazing, as protected trees are ravaged by animals. In Bungoma, trees planted along the boundary were causes of disputes and farmers preferred not to plant trees in order to avoid conflicts or planted trees on one side of the farm and not the other as seen in Plate 7 and Plate 8.

Plate 7 Boundary Planting in West Pokot County

Plate 8 Boundary Planting in Bungoma County

3.7Tree Management Practices

Tree management was gauged *through observations* of application of tree management practices like thinning, weeding around trees, spacing of trees, and pruning. Observations were recorded during the on-farm tree measurements. Overall, tree management was mainly gauged as average. The most practiced management activity was pruning (93%), followed by thinning (21%) Table 11 The highest score was 55% and the lowest, 45% especially in the lower zones, where tree planting is hampered by dry weather conditions. Poor coppicing practices were observed in Bungoma County, which was mainly blamed on personnel employed to cut trees using power saws as seen in Plate 9.

Table 11 Tree Management Patterns

Tree Management Practice	Percentage
Pruning	93%
Pollarding (cutting head)	18%
Thinning	21%
Coppicing	19%
Other	2%

Plate 9 Tree Management Practices in Bungoma County

3.8Age of Trees and Diameter structure

The average age of trees across the two catchments was 9 years with the oldest trees being found in West Pokot, Table 12. Most of these trees were exploited for charcoal production. West Pokot also had the largest tree sizes.

Table 12 Average Tree Age and Diameter

County	Age	DBH
Bungoma	6.94	15.92
Kakamega	9.83	22.29
Kisumu	6.42	15.29
Nandi	9.17	24.84
Uasin Gishu	6.44	24.20
West Pokot	21.26	30.25
Overall average	8.71	22.13

3.9On-Farm Tree Products

On-farm tree products were for subsistence use (49%), and commercial use 51% . 50% of respondents used the products for both commercial and subsistence purposes. The main tree products on-farms were firewood (86%); Timber (70%) and Poles (43%). Other uses were fruits (36%); charcoal (35%); and amenity (11%) Table 13.

Table 13 On-farm Tree Products

Product	Percentage use
Timber	70%
Poles	43%
Firewood	86%
Charcoal	35%
Fruits	36%
Herbs	8%
Fodder	2%
Honey	0%
Amenity	11%
seedlings	5%
Others	3%

3.10 Tree Planting and Tree Cutting Trends

Overall, 67% of the farmers had either planted or protected a tree for natural regeneration in the last 5 years, while 36% had planted none as seen in Figure 4. Most farmers had planted less than ten trees (31%), with only 6% having planted more than 100 trees. The trend for the last 5 years has been on a slight decline.

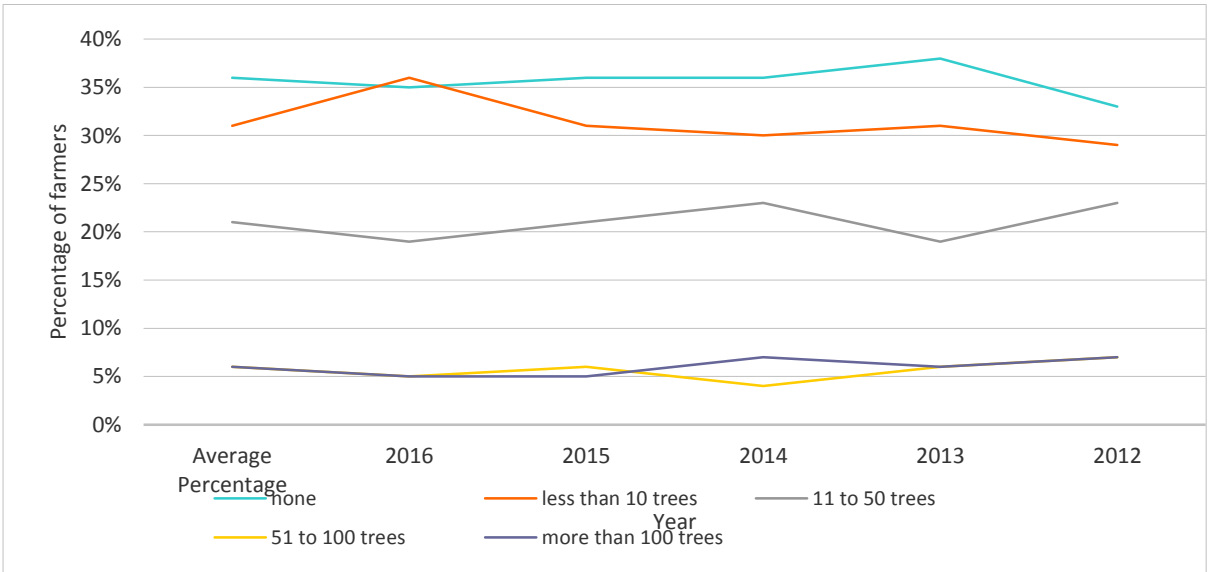


Figure 4 On-farm tree planting trend

Overall tree planting is undertaken by the communities because they can see benefits of tree planting. Tree cutting is slightly lower than the tree planting rates and this has the effect of leaving more standing trees (Figure 5). However it is worth noting that those who cut less than 10 trees are more or less equal to those who plant less than 10 trees. This would mean that the trees left standing basically arise from the high percentage who do not cut trees, and those who plant more than 50 trees.

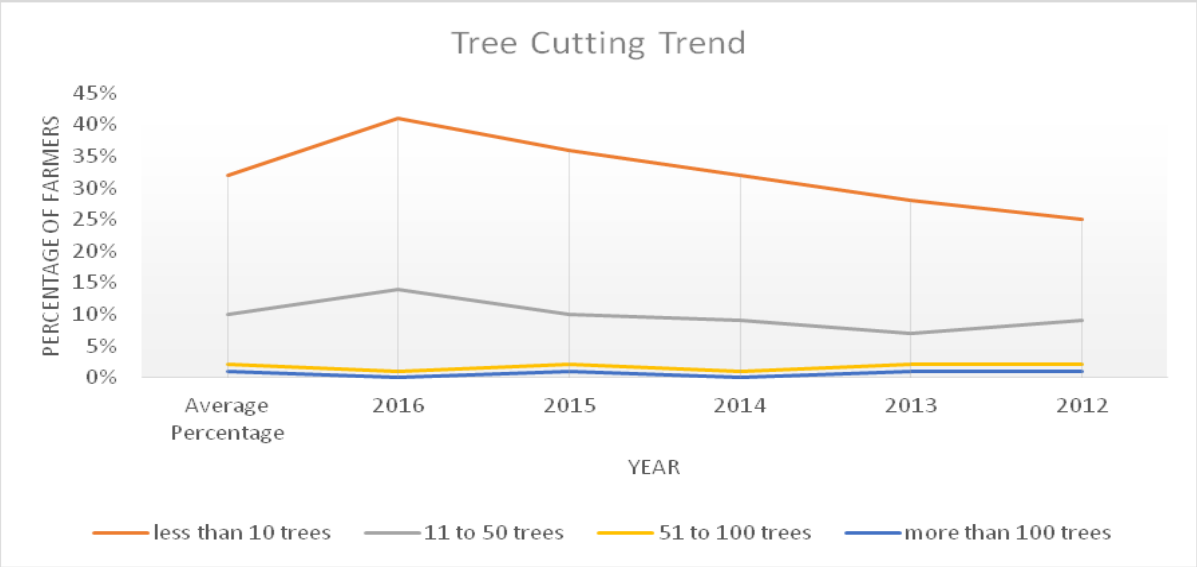


Figure 5 Tree cutting trends

3.11 Trees Origin

Tree origin refers to methods of tree establishment (planted by owner; regenerated; or naturally occurring and deemed natural). From data obtained from tree seedlings propagation, most trees are planted from purchased seedlings (50%), and some raised on farm (33%) Figure 6. Some trees are also regenerated naturally before being transplanted (36%). Uasin Gishu had the highest percentage of respondents who purchased seedlings at 80%, whereas Bungoma had 20%. Kisumu had the highest number of respondents relying on own seedlings (49%), and using transplanted natural regeneration (51%) as shown in Figure 6. Nandi County had a near balance trend of using own seedlings (40%), purchased seedlings (45%), and use of natural regeneration (45%). West Pokot which is a major supplier of charcoal to other Counties, had the lowest trend on tree origin with 12% of farmers using own seedlings, and 26% purchasing, whereas none used natural regeneration, and this can be attributed to poor farming practices where animals are left to graze on farm after harvest, slash and burn, and browsing of seedlings by livestock which is common. This trend raises concern on sustainability of tree products from the County, as Kenya Forest Service is the only known supplier of seedlings in the County

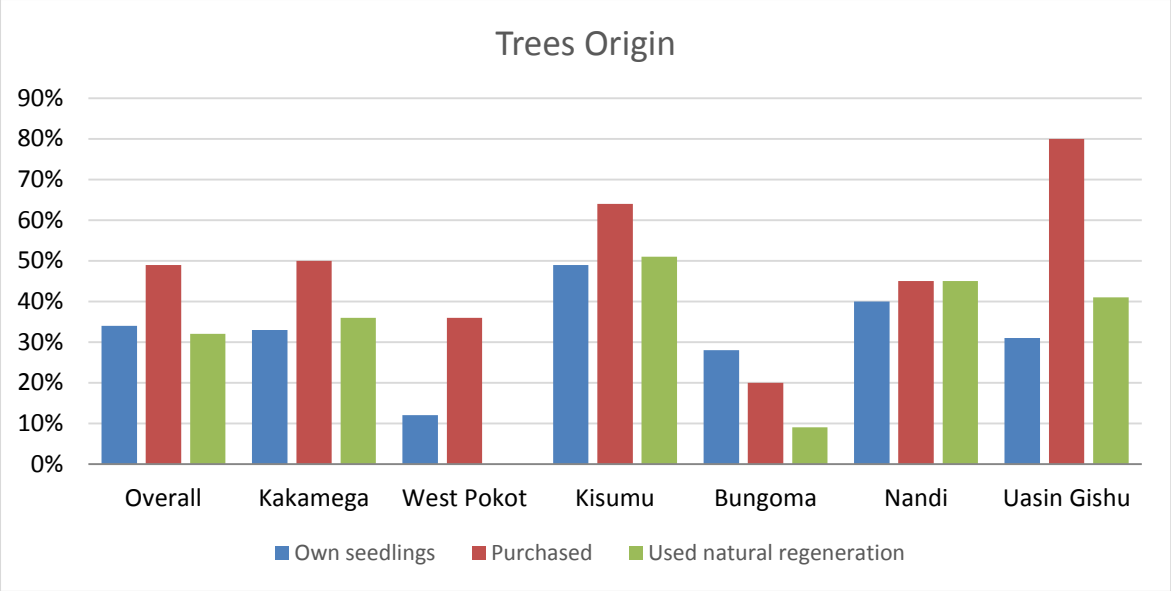


Figure 6 Tree origin

3.12 Tree Planting and Gender

Tree planting was being done mainly by men (55%) and the whole family unit (34%). Women only planted 7% of trees as shown in (Figure 7). This may be because tree ownership is by men (61%) and so is the authority to harvest or sell trees (76%). In addition, there are cultural issues identified in various Counties which impede women from planting trees, such as land ownership, a sign that a woman will not get married out of their homestead, or a woman wants the husband to die. There is need for awareness creation, to demystify the issues. Tree planting as a family activity was high in Uasin Gishu County (72%) and low in Kisumu County (20%), children involvement was high in West Pokot (20%), owing to school greening programmes. At the time of this study, over half a million seedlings had been distributed to various schools by the Kenya Forest Service as part of tree planting campaign targeting schools, to influence behavioural change in homes.

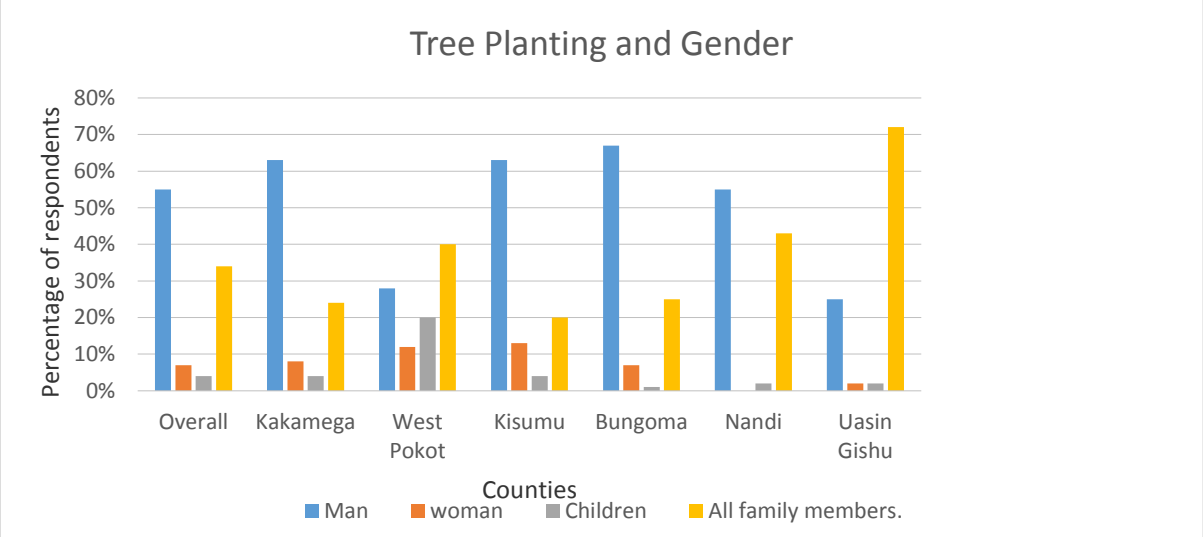


Figure 7 Tree planting and gender

3.13 Tree Ownership

Tree planting and ownership and to authority to harvest are very distinct activities in family circles. In all Counties tree planting is male dominated (55%), and even in Counties that tree planting is a family affair such as Uasin Gishu, tree ownership is overall male dominated (61%) and so is the authority to sell or harvest the trees (76%) as shown in Figure 8 and Figure 9. In Uasin Gishu County, it was observed that farmers were trying to handle this challenge, by dividing their portion of land for small woodlots, which were allocated to children or women, where they plant trees for their own uses, and can sell them to improve their lives.

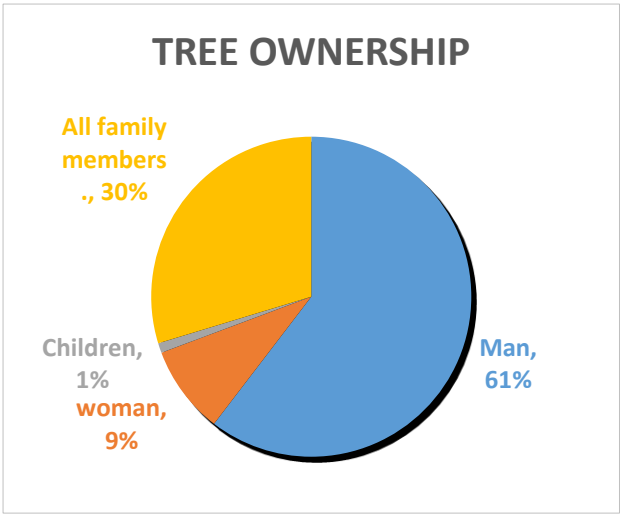


Figure 8 Tree Ownership

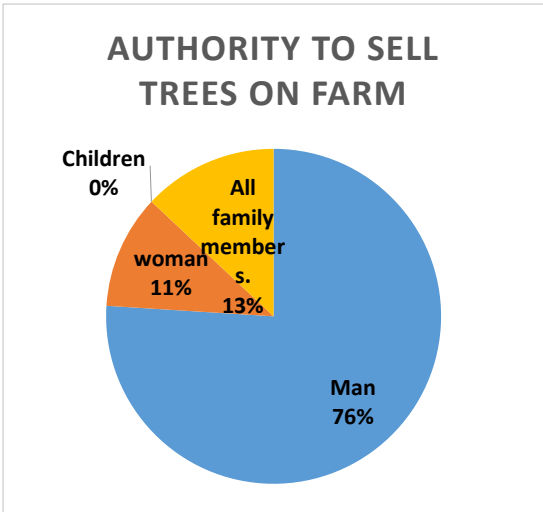


Figure 9 Authority to Harvest or Sell Trees

3.14 Tree cover

As indicated in the methodology, while it was appreciated that tree cover is specific to particular tree species and even regions, the study attempted to calculate and determine tree cover based on:

i. Basal cover: the average amount of an area occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height, and expressed as per unit of land area. Basal cover was calculated by the formula: Basal Area of a tree (m^2) = $(DBH/2)^2$ x 3.142

ii. Canopy Cover: The percent of a fixed area covered by the crown of an individual plant species or delimited by the vertical projection of its outermost perimeter; small openings in the crown are included. To calculate canopy cover, an allometric equation used to predict above ground biomass (AGB) using DBH (cm) or crown area (m^2) as inputs was used. As such, one is able to exploit the near linear relationship between the area of a tree occupied by its crown, and that of the basal areas of its trunk. This way it was possible to calculate crown area from DBH.

Tree cover is below the 10% envisaged in the Constitution of Kenya 2010, with the average across the two catchment being 9.6%. Kisumu had the lowest tree cover at 6.5% followed by Bungoma, with Uasin Gishu, Nandi and West Pokot having the highest with over 10% cover each 2% Table 14.

Table 14 Tree Cover across Counties

County	% Basal tree cover	% Canopy tree cover

Bungoma	0.2%	7.9%
Kakamega	0.3%	9.9%
Kisumu	0.2%	6.5%
Nandi	0.4%	10.7%
Uasin Gishu	0.4%	12.8%
West Pokot	0.3%	10.0%
Overall average	0.3%	9.6%

3.15 Indigenous Trees Species Propagation

Less than half (44%) of households interviewed had any knowledge of indigenous tree species propagation as seen in Figure 10. Of those who had knowledge of indigeneous trees, the knowledge was mainly on propagation of seeds and use of wildlings (68%). There was little knowledge on grafting (9%) and layering (7%), other than in Bungoma County which had higher percentages (23%) in both. Kakamega had a high percentage of 84% knowledge of seeds collection and propagation as shown in Figure 10. Those interviewed (40%) said there was potential to increase indigenous tree seedling propagation in the County. Nandi County had a high percentage (76%) of respondents who use wildlings, which occur naturally on farm and in the natural forest as seen in Figure 11.

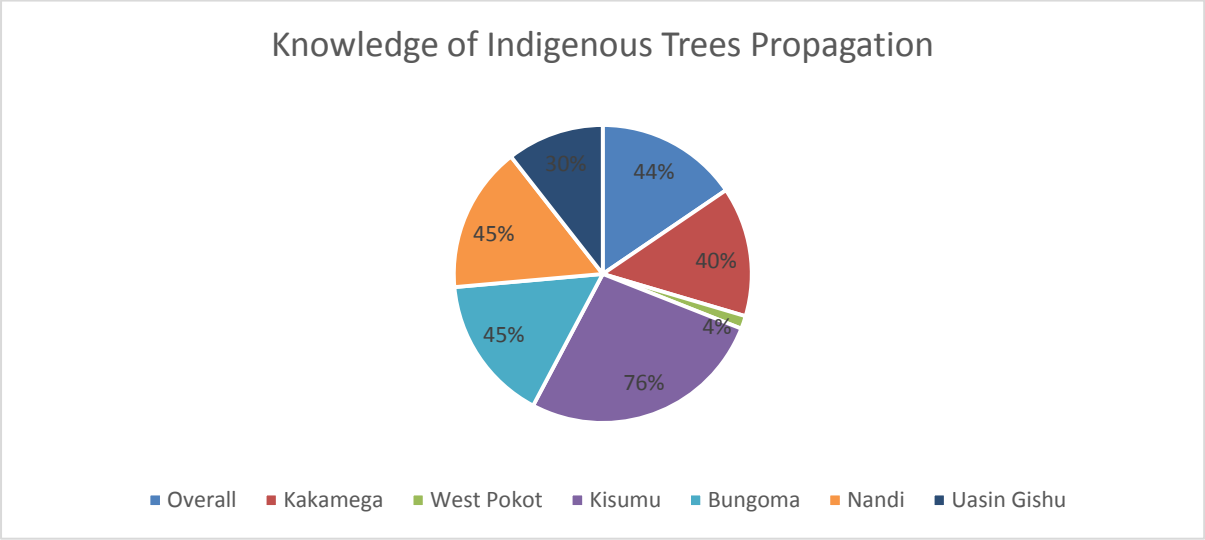


Figure 10 Knowledge of indigenous Trees Propagation

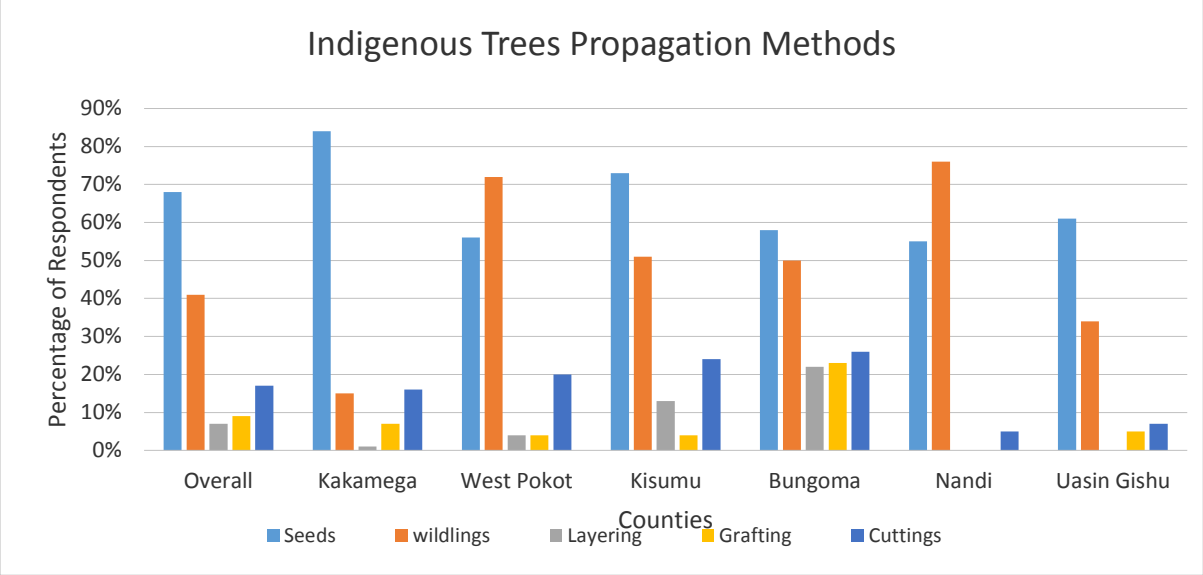


Figure 11 Indigenous Trees Propagation Methods

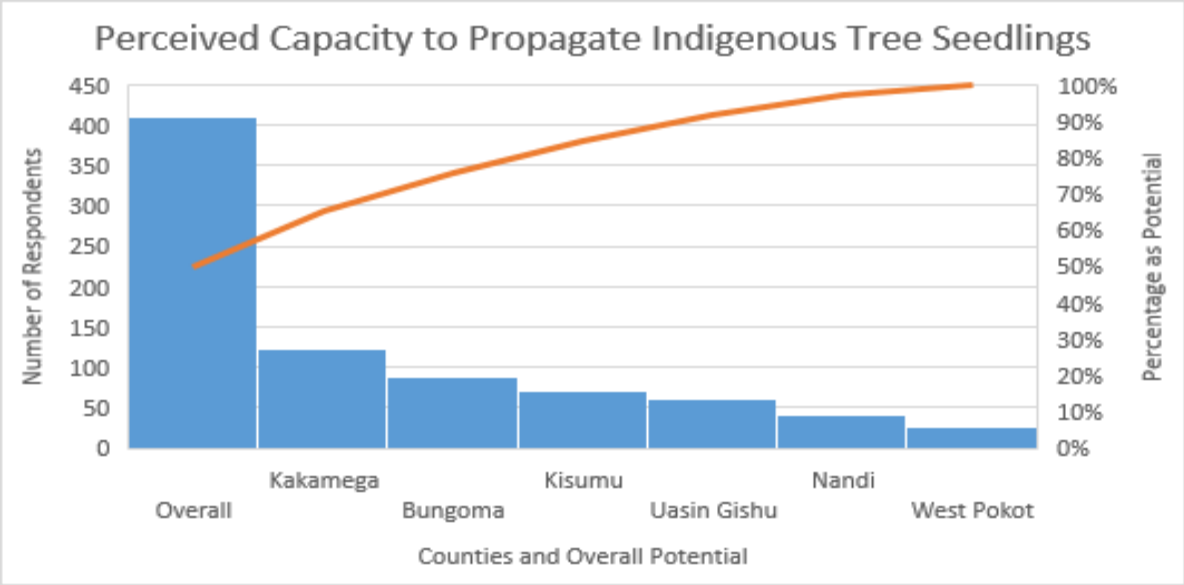


Figure 12 Capacity to Propagate Indigenous Trees Seedlings

3.16 Indigenous Trees Species Nurseries

There was very low (11%) ownership of nurseries at household level. Ownership in counties were as follows; Kakamega (14%), West Pokot (4%), Kisumu (6%), Bungoma (14%), Nandi (21%) and Uasin Gishu (5%). Ownership of the few existing nurseries was primarily private (96%) with a few (4%) being owned by groups as shown in Table 15. There was slightly higher percentage of nurseries in Kakamega and Bungoma, owing to existence of forestry based NGOs, such as VI Agro-forestry which in 2016 planted over 5 million trees in collaboration with communities and local partners. Those who didn't own nurseries or undertake any propagation of indigenous trees mainly said this was because of lack of knowledge (38%) and also due to lack of sufficient land sizes (23%) as shown in Figure 13.

Other reasons cited included labuor intensive (14%), lack of certified seeds (8%), time it takes to propagate seedlings and lack of water (6% each). There were also some cultural reasons (taboos) claimed by a small (9%) percentage of households (Table 16).

Table 15 Tenure of Indigenous Tree Nurseries

Ownership	Percentage
Full/private	96%
partly as group	4%

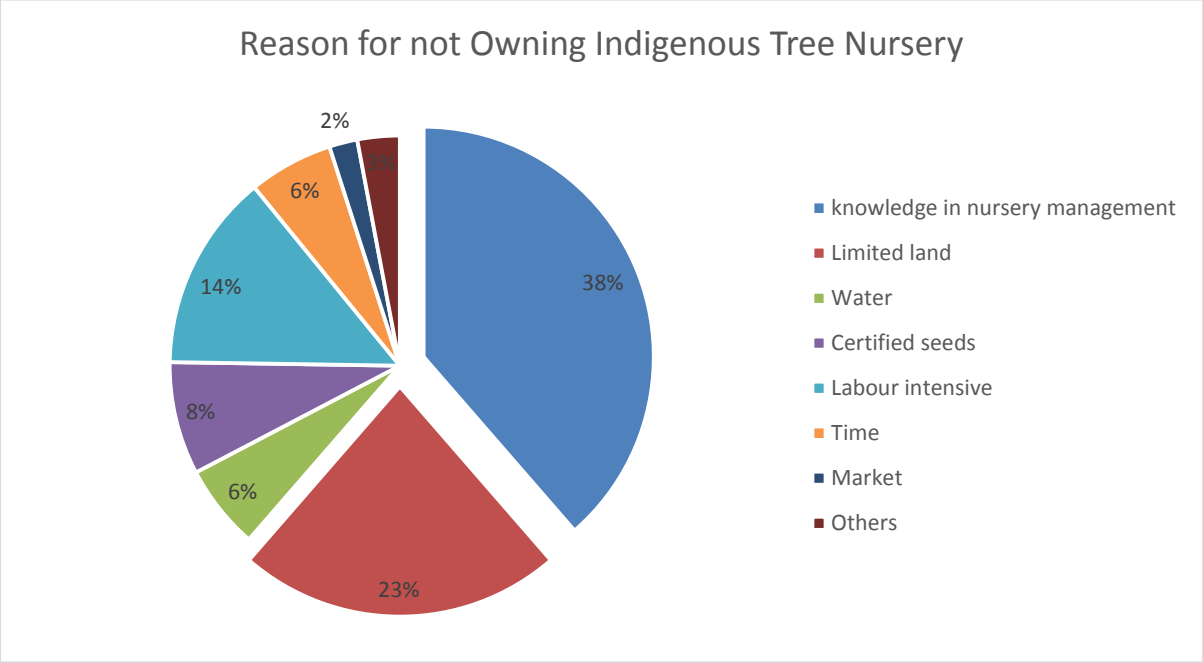


Figure 13 Reasons for not Owning Indigenous Tree Nurseries

Table 16 Taboos Associated with Propagation of particular Indigenous Trees

	Overall	Kakamega	West Pokot	Kisumu	Bungoma	Nandi	Uasin Gishu
Yes	9%	19%	0%	7%	7%	2%	0%
No	91%	81%	100%	93%	93%	98%	100%

3.17 Frequency of Tree Species

Bungoma County had the largest mix of indigenous tree species at 46%, with species count of 664, followed by Kakamega 21%, with a species count of 295, while West Pokot was last in species richness at 4% and a species count of 52 as shown on in Figure 14 and Table 17respectively. The most dominant species in all the Counties was *Eucalyptus Species* (22%) *Grevillea robusta* (20%) followed by *Cupressus Lusitanica* (8%), Mango tree (7%) and Avocado (5%). Indigenous trees were *Makhamia lutea*(4.7%), *Croton macrostachyus* (2.4%), *Cordia Africana* (2%), *Albizia coriara* (2%), as shown on Figure 15. The trees are popular due to fast growth, use as firewood, poles, and charcoal.

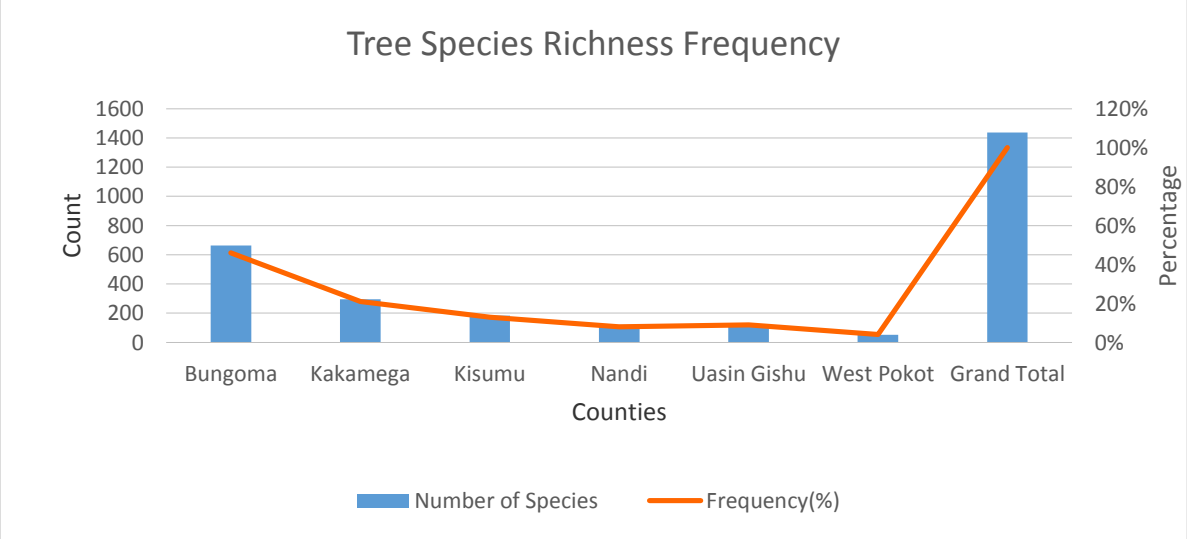


Figure 14 Tree Species Richness Frequency

Table 17 Biodiversity indices

County	Number of Species	Shannon index (H)	Simpson Index(D)
Bungoma	664	6.196711174	2.429955168
Kakamega	295	17.2122231	3.371589612
Kisumu	183	12.94511017	2.95117
Nandi	120	6.963249516	2.314928533
Uasin Gishu	123	5.225906736	1.821336685
West Pokot	52	7.268817204	2.446761209

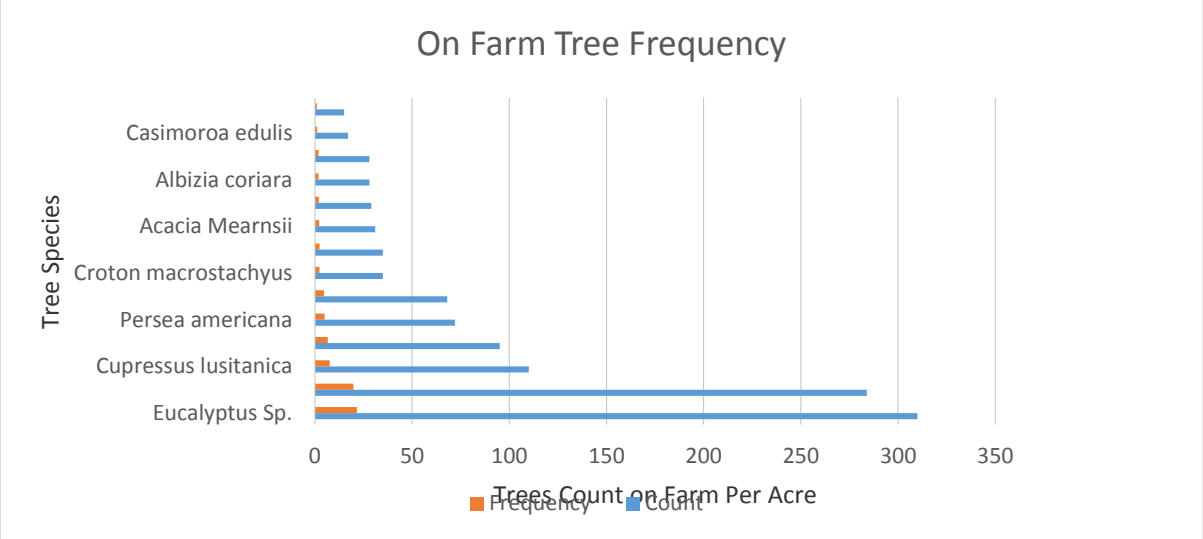


Figure 15 Overall on farm tree Frequency in all six Counties

3.17.1 Dominant Tree species per County

The dominant tree species in West Pokot County is *Cupressus lusitanica* (26.92%), followed by *Eucalyptus sp*. (21.15%) and *Acacia nilotica* (8%) as shown in the initial graph columns in

Figure 16. In Bungoma County, *Grevillia robusta* had 27% *Eucalyptus* Sp. 26%, and Mango trees 10%. In Kakamega County, *Eucalyptus Sp.* had 14% *Grevillia robusta* 11%, and *Cupressus lusitanica* 9%. In Kisumu County *Eucalyptus sp*. had 15%, *Grevillia robusta* 14%, followed by *Markhamia lutea* 12% and Mango 9.3%. In Nandi County, *Eucalptus* Sp. had 24.4%, *Cupressus lusitanica* 21.14%, *Acacia mearnsii* 20.3%, and Grevillia 20.3%, while in Uasin Gishu County *Eucalyptus* Sp. had 29.2% and *Grevillia robusta* 10.1%. The study found that other tree species that had significant dominance included Mango trees and *Markhamia lutea* in all Counties.

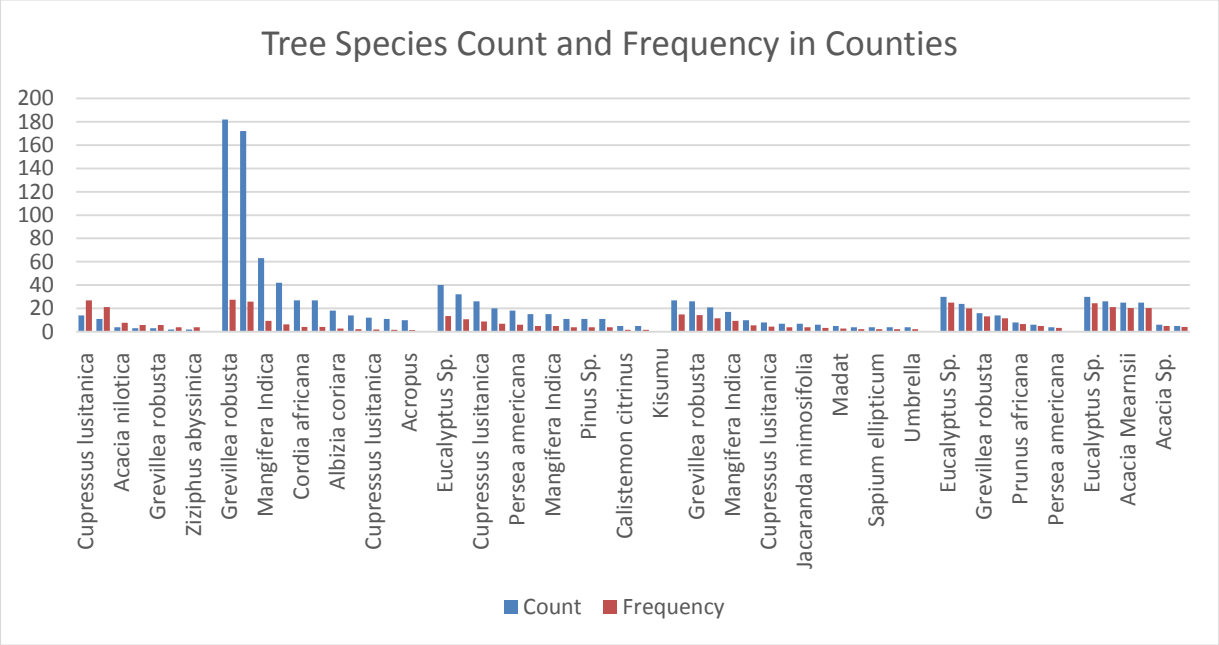


Figure 16 Tree Species Frequencies in all Counties

3.17.2 Uses of Dominant Tree Species

The main dominant tree species in all counties are *Eucalyptus, Grevillia, Mango tree, Avocado tree, Markhamia Lutea, Albizia Casimora* and Casimora edulis. The common uses are for firewood, and timber among other as shown in Table 18.

Table 18 Uses of Dominant Tree Species

Species	Uses
Grevillea robusta	Firewood, timber, Charcoal, Construction, shade, poles,
Eucalyptus sp	Firewood, poles, charcoal, timber, shade, boundary, fencing
Mangifera indica	Fruits, timber, shade, firewood, charcoal, construction, tool handle,
Cupressus lusitanica	Firewood, charcoal, timber, fencing, boundary, poles, posts, shade
Persea americana	Shade, firewood, timber, wind break, boundary, medicine
Markhamia lutea	Firewood, timber, tool handle, shade, boundary, charcoal, construction
Albizia cassimoroa	Shade, timber, firewood, charcoal,
Casimoroa edulis	Fruit, firewood, shade, beautification, charcoal, boundary

4 CHALLENGES PER COUNTY

4.1West Pokot County

The main challenges identified included

- Lack of information on tree seedlings propagation, and tree nursery management
- Livestock invasion of seedlings

4.2Bungoma County

The main challenges included

- Lack of information on indigenous trees propagation
- Lack of capacity from local groups such as CFAs to propagate indigenous tree seedlings
- Tree planting and gender challenges, as women are not allowed to plant trees in some sub tribes in the county
- Some species are not planted in some areas due to cultural beliefs
- Some tree species are associated with witchcraft, hence not propagated. Bamboo should not be planted facing bedroom windows. Umbrella trees spread roots to the houses and are associated with bad omen such as death. *Kumutua* tree if planted near a homestead people associate the owner with witchcraft. *Kumlaa* is used during circumcision, thus the church does not support its propagation, leading to cultural erosion. *Kumtare* if planted it is believed to kill animals. *Kumhendie* if planted on the fence and one tries to harvest; it said bad omen will befall the community. *Kumusiliangokho* if used to cook, it is said that hens will die in the homestead. *Kumbrumbs,* brings evil spirits to households.
- Some trees are only planted by respected clansmen such as *Makhamia lutea (Lusiola)*
- Tiresome to take care of
- Takes time to propagate, and has no immediate or short term returns
- They are not resilient to dry weather, they dry up.
- Seedlings not easily available
- Due to boundary planting issues, people prefer not to plant trees to avoid disputes with their neighbours
- Limited land
- Lack of certified seedlings
- Lack of market for seedlings
- The water requirement for indigenous tree seedlings is intense, yet there is no adequate water in the area.

4.3Kakamega County

The main challenges included

- Lack of market for seedlings
- Some indigenous trees take too long to germinate, while some require proper pre-sourcing treatment, using hot water, and even cracking the seed coat to their dormancy.
- Women are not allowed to plant trees in certain areas, however, awareness campaigns have been undertaken and it is now an accepted norm that women can plant, cut and sell trees for firewood, or make charcoal for sale.
- Small land holding enough for crop production
- Young people have no title deeds, hence desist from planting trees as they are not allowed to harvest, unless with the approval of their parents who at times resist.

4.4Kisumu County

The main challenges included

- In adequate capacity in tree nursery management,
- Inadequate awareness on the importance of on-farm forestry.
- Water scarcity for tree nursery propagation
- Preference to other crops such as maize and beans to trees.
- Most farmers have got small farms sizes that cannot accommodate on farm forestry.
- Lack of title deeds (communal land Tenure) hinders investment on farm
- Low rainfall totals makes tree growing on farm extremely difficult especially in arears around Lake Victoria basin.
- Lack of enough sensitization on on-farm forestry.
- Cost implications associated with tree establishment.
- Negative attitude towards tree establishment.
- Cultural beliefs associated with planting certain tree species.
    - Umbrella trees planted in the compound are said to cause death.
    - There are certain trees that are said to be planted by only witches thus associated with witchcraft when seen in someone's compound.
    - There are certain trees that are said to bring bad omen such as caterpillar infestation.
    - Some trees cannot be harvested for firewood by women such as *Ochol* in Luo.
    - *Afita* tree should not be planted as it is host to deadly insects

- NG'OU TREE-The Luos believe that they attract leopards and snakes hence they fear planting the tree.

4.5Nandi County

The main challenges include:

- Land subdivision into small pieces is forcing farmers to prefer cash crops to tree planting to get maximum returns.
- Lack of markets for mature trees for poles and timber
- The source of the seedlings, the marketing aspect and lack of capacity building and Training.
- Main challenge in indigenous tree propagation is the duration they take to mature and also their limited commercial uses. Most farmers do not want to grow them.
- There are some beliefs especially propagation of certain indigenous trees which cannot be used as firewood during circumcision in Nandi county.

4.6Uasin Gishu County

The main challenges include:

- Government partial approach to research which translates into low adoption of research recommendations.
- Insecurity of land tenure where small scale farmers don't easily access land ..
- Slow progress of community based forestry extension services
- Climate change
- Lack of large pool of knowledge about agroforestry practices and systems
- Lack of financial support
- Lack of infrastructure
- Lack of market for agroforestry products
- High cost of seedlings,
- Time taken for indigenous trees to mature,
- The People cut more trees than they plant.
- People still easy access to the protected forests where they cut trees for firewood and charcoal.
- Maintenance of indigenous trees is very challenging, some seedlings die if they luck enough water
- Some indigenous trees are medicinal, so animals eat them when they are planted, which calls for issues of protection when they are planted.
- Indigenous trees propagation is a challenge to farmers

5 CONCLUSIONS

Tree planting is an activity that is embraced by farmers in all study areas in the counties. It is indeed, notable that most of the farmers interviewed, are interested in tree planting for commercial, or ornamental purposes, even though land scarcity is a hindrance. There is a high preference for exotic trees, as opposed to indigenous trees, due to availability of seedlings, time taken to mature, and expected returns on investments, as one respondent from Uasin Gishu County indicated, " if I plant an indigenous tree now, it will take 25 years, and I would be dead before I see benefits". Another point noted was there is lack of information on indigenous tree seedlings, propagation, and maintenance. This shows that there is need for information sharing, enhancing awareness on tree planting, species selection, propagation, and management.

Tree uses are mainly for timber, firewood, medicine, fruits, and charcoal production. West Pokot and Uasin Gishu Counties are the Major Supplies of charcoal, from indigenous trees and exotic trees. Charcoal is produced using tradition Kilns, with low recovery rate. Hence there is need to introduce new technologies, and train farmers on the same.

Boundary tree planting, intercropping and conflict management has emerged as an important issue in Bungoma County, and one that needs to be addressed, to enhance tree cover.

It is worth noting that the success of tree planting in lies in the existence and establishment of tree nursery on farm, and tree nursery groups. The study findings indicate that Kakamega County had the capacity for over 5 million seedlings than all other counties owing to formation of groups, and Tree Nurseries on farm. In Nandi County, there is high potential for seedlings propagation due to existence of wildings, but tree nursery groups are not well established. Hence the need to strengthen Community Forest Associations in all counties, and Tree Nursery Groups to promote tree planting. These can be supported with establishment of farmer field schools and demonstration plots where farmers can get hands on experience.

Exposure to tree planting techniques and cultures in other parts of the country was noted as an important factor in tree planting. Farmers, who had been exposed to tree planting in other areas where agroforestry is common, indicated that they were encouraged plant more trees on their farm, and which was evident. Hence, there is need to explore use exchange visits as a learning tool in promoting tree planting.

Finally the success of tree planting relies heavily on forest extension service. It was noted that despite, the fact that the services have been devolved, only West Pokot County had extension officers (3), an issue which is needs to be addressed, and enhanced, for sustainability of the project.

6 RECOMMENDATIONS

Overall, there is need to for those counties below the 10% tree cover to plant more trees, while those above maintain their cover.

To meet this target, there is need to have more trees per farm and per hectare. For each of the Counties, the following is recommended in terms of extra trees per farm and per hectare.

Table 19 Recommended increase of trees per farm/hectare across counties

County	Tree per HH	Percentage cover	Required trees to achieve 10% cover	Trees per ha	Extra trees to plant pe HH to achieve 10% cover	Required trees per Ha to achieve 10% cover	Extra trees per Ha to plant to achieve 10% cover
Bungoma	55	7.9%	69.6	106.60	14.62	135	28.3
Kakamega	117	9.9%	118.2	85.65	1.18	87	0.9
Kisumu	89	6.5%	138.0	143.54	48.97	223	79.0
Nandi	590	10.7%	551.4	572.81	38.60	535	37.5
Uasin Gishu	450	12.8%	351.6	283.01	98.44	221	61.9
West Pokot	192	10.0%	192.0	17.66	-	18	-
Overall	30.51	9.6%	31.7	11.45	1.19	12	0.4

Bungoma needs to increase their trees per household by 15 trees, (28 trees per ha) to get to the 10% cover, while Kakamega should slightly increase overall number of trees by 1. On the other hand, Kisumu needs to increase their cover by 49 trees (79 trees per Ha).

Other recommendations include:

1. In West Pokot County, there is need to intensify on farm tree planting through training, establishment of Farmer Field Schools (FFSs) and demonstration plots. The same could be replicated in all the eleven Counties.
2. There is need to establish on farm tree nurseries in West Pokot, as KFS tree nursery is not adequate for the area. It was noted that Giant Bamboo species does well in the area and its propagation and planting should be enhanced.
3. Water is a challenge in West Pokot, hence there is need to support water harvesting technologies, to provide water for homes and for tree growing.
4. There is need to promote sustainable charcoal production in West Pokot using modern technologies, with high recovery rates.
5. Destruction of Acacia trees for charcoal production has long term impact on livelihoods engaging in honey production, which need to be addressed using alternative tree species, or policy direction, such as for every permit given for charcoal transportation, a given number of seedlings are planted.

6. In Bungoma County there is need for intensification of tree growing campaign and conflict resolution training, on boundary tree planting. In addition, there is need for capacity building of CFAs to enhance their tree seedlings production, and forestry management.
7. Kakamega County has high potential for tree seedlings production, hence there is need to link farmers to markets outside the County.
8. In Kisumu County there is need to demystify tree planting of certain species associated with bad omens.
9. Nandi County has high potential for tree seedlings on farm, which need to be exploited. This can be done through capacity building of Community Forest Associations which are in their formative stages.
10. In Uasin Gishu County there is need to promote indigenous trees propagation as the frequency count is low, as most farmers plant exotic trees, leading to loss of biodiversity.
11. There is also need to promote efficient on farm charcoal production methods using modern kilns with high potential for recovery. This will also build capacity of locals who outsource technicians from other counties such as Elgeyo Marakwet.
12. Forest extension service has been devolved. However, in all counties save for West Pokot which has three officers, is wanting, and need to be supported as an entry point in promoting on farm forestry.
13. There is need to provide information on appropriate trees for various agro-ecological zones and their management practices, to enable farmers adopt the technologies.
14. Advice farmers on appropriate harvesting techniques, value added processing technologies and suitable marketing strategies of farm-based tree products.
15. Provide technical information on growth rates, silvicultural operations (spacing, thinning, and pruning), and interaction with agro crops of indigenous species.
16. To overcome the Challenges listed in Chapter 4 per county, the following strategies are recommended:

West Pokot:

- Provide seedlings to farmers
- Enhance tree planting campaigns and the importance of farm forestry
- Recognizing and awarding outstanding farmers

Uasin Gishu:

- Enhance awareness on the importance of indigenous trees, as some parts of the county they are non-existent.
- Information dissemination on indigenous trees propagation
- Provide seedlings
- Provide seed harvesting equipment

- Provide information on charcoal production technologies

Nandi:

- Incentives that could be used to boost on-farm forestry are capacity building and exchange programmes to improve awareness .
- Training farmers and helping them to have access to the market.
- Lack of access to seed propagation materials.
- The capacity need for propagation of indigenous trees in the county is by providing the seedling of indigenous trees to the farmers and also helping them with some extension officers who can guide them.
- Provide farmers with seedlings
- Enhance awareness on the importance of indigenous trees to farmers.
    -
    -

Kisumu:

- Local communities and farmers should be trained on benefits and cultivation of trees so that they can overcome their cultural beliefs and taboos
-

Kakamega:

- Assist tree nursery groups market their products
- Assist groups with tools and equipment for tree nursery propagation

Bungoma:

Public education especially to overcome cultural challenges

Provide tree seedlings

7 Appendix

Appendix 1 On-farm species list

Species	Count	Freq (%)	Species	Count	Freq (%)
Eucalyptus Sp.	310	21.57272	*Christmas tree*	1	0.069589
Grevillea robusta	284	19.7634	*Cornus Volkensii*	1	0.069589
Cupressus lusitanica	110	7.654836	*Diospyros abyssinica*	1	0.069589
Mangifera Indica	95	6.610995	*Eleodendron buchananii*	1	0.069589
Persea americana	72	5.010438	*Entada abyssinica*	1	0.069589
Markhamia lutea	68	4.732081	*Esichisia*	1	0.069589
Croton macrostachyus	35	2.43563	*Family planning*	1	0.069589
Pinus Sp.	35	2.43563	*Ficus natalensis*	1	0.069589
Acacia Mearnsii	31	2.157272	*Ficus thonningii*	1	0.069589
Prunus africana	29	2.018093	*Fucus sycomorus*	1	0.069589
Albizia coriara	28	1.948504	*Garcinia buchananii*	1	0.069589
Cordia africana	28	1.948504	*Grewia bicolor*	1	0.069589
Casimoroa edulis	17	1.18302	*Kigelia africana*	1	0.069589
Jacaranda mimosifolia	15	1.043841	*Lamai*	1	0.069589
Acacia Sp.	13	0.904662	*Lannea Scheweinfurthii*	1	0.069589
Ficus sycomoros	12	0.835073	*Lukemia*	1	0.069589
Juniperus procera	11	0.765484	*lukhule*	1	0.069589
Acropus	10	0.695894	*Lunga*	1	0.069589
Azadirachta indica	10	0.695894	*Macadamia hildebrandii*	1	0.069589
Umbrella	8	0.556715	*Maesopsis eminii*	1	0.069589
Calistemon citrinus	7	0.487126	*Mafwa*	1	0.069589
Lusongofwa	7	0.487126	*Maytenus senegalensis*	1	0.069589
Spathodea campanulata	7	0.487126	*Mboria*	1	0.069589
Casuarina equisetifolia	6	0.417537	*Mesiinatet*	1	0.069589
Chinduli	6	0.417537	*Mgongo chuma*	1	0.069589
Madat	5	0.347947	*Miti kambuni*	1	0.069589
Syzygium cuminii	5	0.347947	*Mkumu*	1	0.069589
Vitex doniana	5	0.347947	*Mkwaju(wanga)*	1	0.069589
Acacia nilotica	4	0.278358	*Mombasa shika mtu*	1	0.069589
Busongofu	4	0.278358	*Mosolen*	1	0.069589
Carica papaya	4	0.278358	*Mshins mtu*	1	0.069589
Erythrina abyssinica	4	0.278358	*Msuchu*	1	0.069589
Sapium ellipticum	4	0.278358	*Mti kompun*	1	0.069589
Syzigium cumuni	4	0.278358	*Mukikhili*	1	0.069589

Species	Count	Freq (%)	Species	Count	Freq (%)
Bridelia micrantha	3	0.208768	*Mukumu*	1	0.069589
Combretum collinum	3	0.208768	*Musilinya*	1	0.069589
Eryobotrya japonica	3	0.208768	*Musomia*	1	0.069589
Euphorbia tirucali	3	0.208768	*Mwinyala matsai*	1	0.069589
Musa acuminata	3	0.208768	*Myrsine melanophloeos*	1	0.069589
omushirinya	3	0.208768	*Nabiili*	1	0.069589
Podocarpus Sp.	3	0.208768	*Ogaka (Luo)*	1	0.069589
Syzygium Cordatum	3	0.208768	*Okwamakora(Luhya)*	1	0.069589
Tamarindus indica	3	0.208768	*Olea capensis*	1	0.069589
Thevetia peruviana	3	0.208768	*Olea europeae*	1	0.069589
Acacia seyal	2	0.139179	*Olukhoni*	1	0.069589
Artocarpus heterphyllus	2	0.139179	*Oluvambo*	1	0.069589
Calliandra calothyrsus	2	0.139179	*Omubao(Bunyala)*	1	0.069589
Euclea divinorum	2	0.139179	*Omukhole*	1	0.069589
Euphobia Sp.	2	0.139179	*Omukhule(Kisa)*	1	0.069589
Kapchebinik	2	0.139179	*Omukhunsu*	1	0.069589
Kashia	2	0.139179	*Omukokongo*	1	0.069589
Kimunandebe	2	0.139179	*Omurave*	1	0.069589
Kumulongo	2	0.139179	*Omutarakwa*	1	0.069589
Lantana camara	2	0.139179	*Omwinyalila (Matsai)*	1	0.069589
Leucena leucocephala	2	0.139179	*Onjak (Luo)*	1	0.069589
Mtororo	2	0.139179	*Owino (Luo)*	1	0.069589
Musaset	2	0.139179	*Palm tree*	1	0.069589
Omusioma	2	0.139179	*Porowo*	1	0.069589
Pappea capensis	2	0.139179	*Rubus apelatus*	1	0.069589
Terminalia brownii	2	0.139179	*Salkina*	1	0.069589
Terminalia mollis	2	0.139179	*Sanandet*	1	0.069589
Tororo	2	0.139179	*Senna Sp.*	1	0.069589
Vangueria infausta	2	0.139179	*Sesbania sesban*	1	0.069589
Ziziphus abyssinica	2	0.139179	*Sikomosi*	1	0.069589
acacia mellifera	1	0.069589	*Sokorya*	1	0.069589
Annona senegalensis	1	0.069589	*Tuino(Pokot)*	1	0.069589
Cedrus brevifolia	1	0.069589	*Vernonia Amygdalyna*	1	0.069589
Chebarus	1	0.069589	*Cheulayaatt*	1	0.069589

Appendix 2 Key Informant Interview Guide

KFS: Ecosystem Conservators, Foresters, NGOs and other Local Administrators

1. What are the main on-farm forestry challenges in the county/sub-county?
2. What are the main species grown?
3. What are the main sources of seedlings/germplasm?
4. What are the main on-farm forestry products?
5. What incentives could be used to boost on-farm forestry?
6. Are any indigenous species planted by the community?
7. What are the main indigenous species planted?
8. What are the capacity needs for propagation of indigenous tree seedlings in the county?
9. What is the source of germplasm for indigenous trees?
10. What are the main challenges in indigenous trees propagation and maintenance in the area?
11. What can be done to overcome these challenges?
12. Are there cultural beliefs to the practice/adoption of on farm forestry?

Appendix 3 Focused Group Discussion Guide

(Tree nursery groups, CFA Committees, WRUAs, CBOs)

1. What is most popular indigenous tree species planted in the area?
2. What is the source of tree seeds and seedlings?
3. What is most used? Seeds or seedlings?
4. What is the cost for seeds and seedlings? (per species)
5. What are the main challenges for indigenous tree planting on farm
6. What are the main challenges facing nurseries in the area?
7. What could be done to overcome these challenges?
8. What is the most common reason for cutting down trees in the area?
9. What tree species are usually cut down in the area, and for what use?
10. Are people in the area trained or sensitized on tree planting? And by whom?
11. What were the impacts of this training?
12. Are exotic species also planted?
13. Are they preferred to indigenous species?
14. If Yes, why?

Appendix 4 Household Questionnaire on Tree Species and Community Awareness of Indigenous Trees Propagation and Management

SECTION A

Questionnaire No. _____ Enumerator's Name _____

Date _____/ _____/2017

Ecosystem area;

County _____ Sub-county _____ Location

DETAILS OF RESPONDENT

Name of the household (Head of Family)

Occupation of the Head of Household (e.g. Farmer, Clerk, etc.)

Number of People in the Household

Gender of the head of household :

Age

Education Level: Primary; Secondary ; Tertiary

DETAILS OF FARM/HOUSEHOLD

1.	Zone (tick one)	Upper catchment □ Middle Catchment □ Lower Catchment□
2.	GPS Location (Coordinates of four corners of farm)	
3.	Altitude (m.a.s.l)	
4.	Total land area (acres)	
5.	Cultivated area (acres)	
6.	Total area under trees (acres)	
7.	Do you have trees on farm?	Yes □ No □
8.	If **NO** (7), Reasons for not planting trees on farm,	
9.	If **YES** (7), a) what are the reasons for planting? b) Which practices have you undertaken?	Woodlots □ Boundary Planting □ Windrow □ Open/cultivated area □ Compound □ Grazing/areas left for cattle □ Scattered trees on farm □ Band rows within the farm □ Home garden □ Scattered trees on grazing lands Other □ (specify).....
10.	What tree management practices does the farmer conduct on the farm?	Pruning □ Pollarding(cutting head) □ Thinning□ Coppicing□ Other□ (specify)
11.	What are the on-farm forestry products(tick)	Timber □ Poles □ Firewood □ Charcoal □ Fruits □ Herbs □ Fodder □ Carvings □ Honey □ Amenity □ seedlings □ Others (list).....
12.	What are the main on-farm forestry products?	Main on farm product / Rank (1,2,3)

13. What are the uses of on farm forest products?	Commercial □ Subsistence □ Both commercial and subsistence □
14. If for commercial purposes, what was the household income (KShs.) per annum for the on farm forest products above from your farm	Timber____ Poles____ Firewood____ Charcoal____ Fruits____ Herbs____ Fodder____ Carvings____ Honey____ Amenity____ Seedlings____ Others____

1. In the past 5 years

▪

Year Description	2012	2013	2014	2015	2016
How many trees (planted and naturally regenerated) have you deliberately protected on your farm					
How many trees have you harvested					
How many tree seedlings did you raise					
How many tree seedlings did you purchase for planting on your farm					
How many tree seedlings did you transplant(naturally growing seedlings)					

▪

2. What was the main reason for harvesting on farm tree?
3. What challenges do you encounter in the practice of on-farm forestry?
4. Who plants trees on farm? Man, woman, Children or all family members.
5. Who owns the trees on farm? Man, woman, Children or all family members.
6. Who has authority to harvest or sell trees on farm? **Man, woman, Children or all family members.**
7. Are there taboos associated with propagation of particular trees? **Yes No**
8. If yes, please mention the taboos
9. Are there benefits associated with trees on farm? **Yes No**

ASSESSING FARMER CAPACITY FOR TREE PROPAGATION

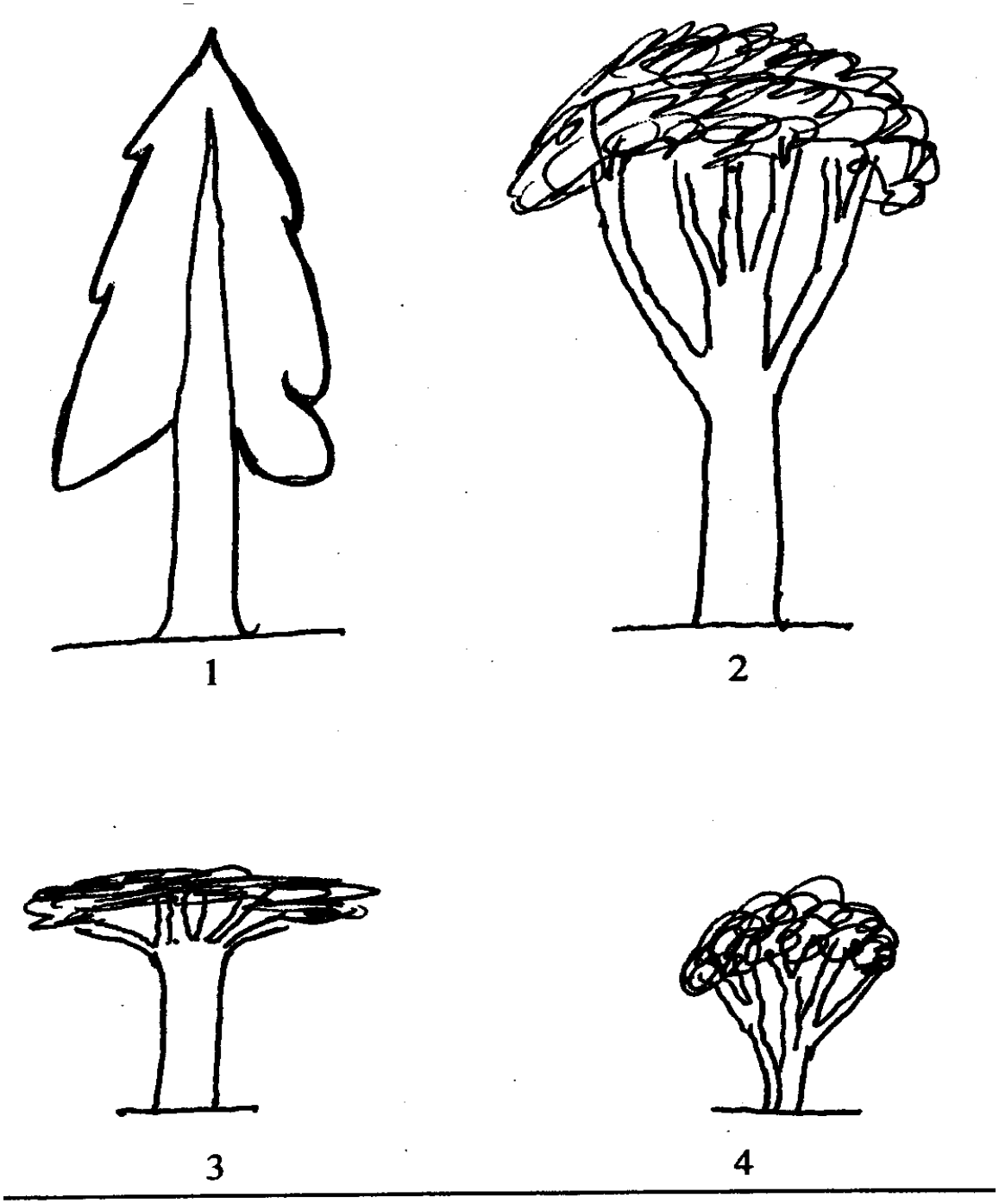
10. Do you own a tree nursery	Yes □ No □	
11. If YES, What is the state of ownership?	Full/private □ partly as group□	
12. If NO, what are the reasons?	1. Lack of knowledge in nursery management 2. Limited land 3. Lack of water 4. Lack of quality seeds 5. Labour intensive 6. It takes long to raise the seedlings 7. Lack of market 8. Others	
13. If YES, what are the main indigenous and exotic seedling species that you raised in the last 12 months?	Indigenous species 1. 2. 3.	Exotic species 1. 2. 3.
14. What are some of the benefits of the tree nursery	1. 3. 2. 4.	
15. Do you have knowledge of indigenous tree propagation	Yes □ No □	
16. What methods of indigenous tree propagation do you use	Seeds □ wildlings □ Layering □ Grafting □ Cuttings□	

17. Do you have the capacity of increasing production of indigenous tree species?	Yes ☐ No ☐
If YES, describe level of capacity	1. Have knowledge in nursery management 2. Available land 4. Accessibility to quality seeds 5. Available ready market
18. What are the main challenges in indigenous tree propagation	1. 3. 2. 4.
19. What are the challenges in indigenous tree nursery management	1. 3. 2. 4.
20. What could be done to improve indigenous tree propagation	1. 3. 2. 4.
21. Where do you obtain the germplasm used for propagation?	1. 3. 2. 4.

Tree No.	Tree Species Name	Local Name	Plant type S;T	Circumference (Cm)	Age (Number of years)	Mode of establishment	Major crops intercropped	Major species uses	Tree forms 1, 2, 3, 4

Key: Plant type-Sapling>7.85<31 cm, Tree>31cm(Circumference) Mode of establishment=Planted or naturally growing	Tree forms: 1 – Exotics such as Cypress, Eucalyptus and Grevillea; 2- E.g. Avocado, Mango; 3- E.g. *Acacia tortilis;* 4- E.g. *Acacia mellifera*

Appendix 5 Major tree forms in the field



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