#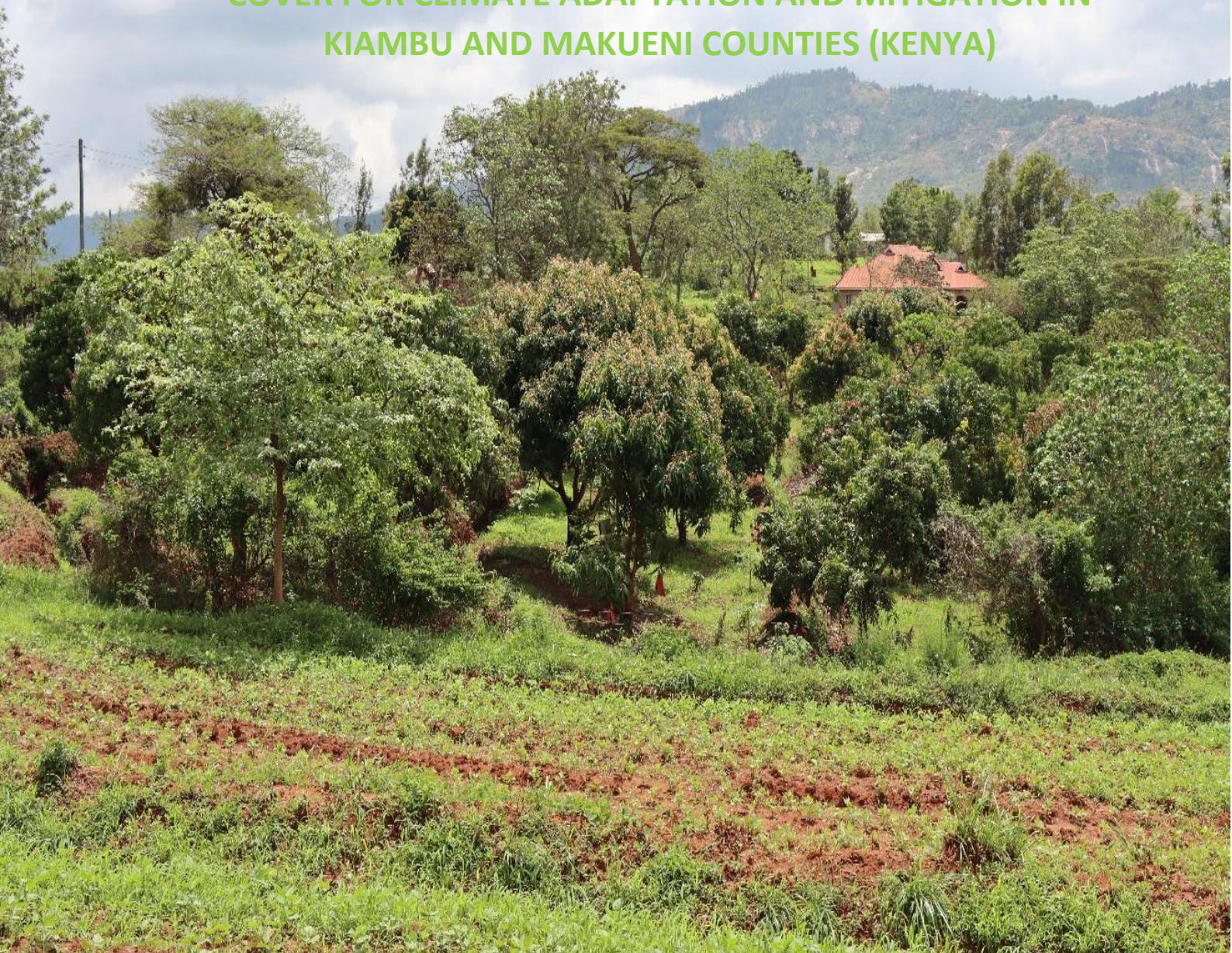 A BASELINE SURVEY REPORT ON CHALLENGES AND OPPORTUNITIES FOR INCREASING ON FARM FRUIT TREES COVER FOR CLIMATE ADAPTATION AND MITIGATION IN KIAMBU AND MAKUENI COUNTIES (KENYA)

Prepared by Denis Wakaba, Anne Kuria, and Catherine Muthuri (CIFOR -ICRAF

Kiambu: 20th -27th July 2022
Makueni: 21st -25th June 2022
2023

ACKNOWLEDGEMENT

Table of Contents

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Fruit trees are vital to smallholder farmers' livelihoods by providing food and nutritional security and improving livelihoods through income generation (Bharucha & Pretty, 2010; Miller et al., 2020). Growing fruits offers tremendous opportunities for enhancing the incomes of small-scale farming families in Kenya and elsewhere in Africa. Fruit trees also provide nutrition to people experiencing poverty who currently suffer from deficiencies in vitamins, minerals, and other micronutrients due to low consumption of these foods (Nosipho Hlophe-Ginindza & Mpandeli, 2021; Ickowitz et al., 2022). Fruits essential sources of vitamins A and C that are lacking in the diets of many Africans. One sure way to increase food and nutritional diversity is by increasing fruit tree diversity. Interventions to improve fruit tree diversity, availability, and quality will likely impact African consumers' health and increase income generation significantly. Therefore, investing in the Kenyan fruit sector has been of great benefit to the country and its people

The cultivation of fruits by smallholders to feed local markets and support export markets presents a tremendous investment opportunity. Eastern Africa, including Kenya, has conducive climates where fruits such as avocados, mangoes, oranges, pawpaws, and macadamia are widely grown. Kenya has an enormous market potential since, in most parts of the country, fruits are available throughout the year. Besides providing products, fruit trees also play an essential role in farming systems by providing ecological services such as soil water conservation through reduced rate of evapotranspiration, shade, climate change mitigation and adaptation, pollination, and soil erosion control, wind control, among others. Complementary benefits of fruit trees to crops have also been widely reported to include micro-climate regulation (Kuyah et al., 2019). These benefits can have an important positive impact on the agricultural sector, as they can reduce production costs and increase crop yields by providing natural protection against drought and pest infestations. This suggests that interventions aimed at improving fruit tree diversity, availability, and quality could lead to numerous positive outcomes in Kenya

1.2 Problem Statement and Justification

Despite fruit tree species playing a key role in meeting global food security, nutrition, and livelihood needs, smallholder farmers face various barriers to their production, hence the low adoption rate. Adoption is limited by various factors, such as decreasing land sizes that lead to competition between planting fruit trees, high-value crops, and high-value non-fruit tree species, such as timber. Other factors include saturation of fruit trees in the preferred niches, low survival rates due to water shortages, pests, and diseases, limited knowledge and skills on tree management, a lack of high-quality germplasm, and a lack of access to markets, among other factors. Also, limited knowledge of the uses and roles played by various fruit tree species in the landscape, including climate change mitigation and adaptation, leads to low adoption of fruit trees.

Despite numerous efforts to increase fruit trees on nonfarming farms in Kenya, adoption is still low. Further past interventions have been characterized by promoting only a few, primarily exotic tree species across varying biophysical and socio-economic contexts. High tree diversity translates to the diversification of products and ecological services derived from trees and promotes the resilience of farming systems. Hence, there is a need to promote higher fruit tree diversity if food security and livelihood benefits are fully realized.

Despite smallholder farmers being the critical custodians of fruit trees, there is limited information regarding their perceptions of their role in climate change mitigation and adaptation, especially in the Kenyan context. Nevertheless, documenting such knowledge can be crucial for motivating smallholder farmers to increase fruit tree farming. However, fruit trees' potential role in climate change mitigation and adaptation has not been adequately documented and explored. However, climate change is expected to become more severe within the current decade. It will thus result in more severe impacts such as drought, desertification, unpredictable rainfall, too much rainfall, heat waves due to rising temperatures, increased disease and pest occurrences, and crop failure. Understanding the role fruit trees could play in a changing climate is critical.

1.2 Baseline Purpose and Objectives

The main aim of the baseline study was to characterize and understand demographic and on-farm factors that influence fruit tree diversity, identify climate mitigation and adaptation roles trees play within smallholder farming landscapes, and assess how tree management influences diversity in smallholder farming systems in the sub-humid Kiambu and semi-arid Makueni counties in Kenya. It also aimed at documenting the current status of tree diversity, exploring farmers' perceptions of the role fruit trees play in climate change mitigation and adaptation, and identifying current knowledge gaps, challenges, and costs associated with fruit tree growing. Finally, explore solutions and opportunities that will lead to increased adoption and retention of fruit trees on the farm. The baseline also aimed at understanding the main qualities and sources of fruit tree planting materials and identifying gaps and opportunities for improved germplasm quality and supply, including identifying capacity needs concerning fruit tree production. It is hypothesized that increasing the population and diversity of fruit trees will lead to better climate change adaptation and mitigation.

Primary data collected through household interviews and field observation was used to identify current agroforestry practices. Barriers and opportunities to incorporating trees on farms. Specific details of perceived adaptation benefits and the gender dynamics surrounding tree planting, decision-making, management, and benefit sharing within households. The data collection tool covered household demographics, farming systems, food security, gender roles in tree planting, understanding of climate change, tree management, and income.

1.3 Research questions

1. What are the characteristics of smallholder farms and farmers in Kiambu and Makueni?
2. What is the contribution of trees to livelihoods and climate change mitigation and adaptation
3. What are the current fruit tree management, propagation, and sourcing practices, costs, challenges, gaps, and opportunities?
4. What is 'farmers' understanding of climate change?

What are farmers'' future aspirations and vision for fruit tree farming in Kiambu and Makueni?

2.0 Methodology

2.1 Survey design

Household survey questionnaires were used in the baseline survey, which combined qualitative and quantitative survey methodologies. The approach was specifically chosen to gather the quantitative data required to establish suitable indicator targets and attitudinal responses. Additionally, focus group discussions were held to corroborate the household results and to gather opinions on local attitudes toward climate change. In the study, we interviewed the adults in the households instead of the household heads. A closed-ended questionnaire was used to gather the data, which covered topics like the household's characteristics, farming practices, tree management, fruit consumption, future aspirations to plant trees, climate change, and sources of household income.

2.2 A sampling of respondents

The sample size selection was made using a finite sample population determination method. Then the survey employed a multi-stage sampling method. Multi-stage sampling is a method of sampling that involves selecting a sample from a larger population in several stages. In the first stage, a sample of two sub-counties was selected from each county. Then, in the second stage, a sample of wards was selected from each sub-county. In the third stage, a sample of villages was selected from the wards, and individuals were randomly selected from each village. This process was repeated for each county until a full sample was obtained. This method allowed us to select a representative sample that is more efficient and cost-effective than other sampling methods.

Additionally, the sampling frame helped us reduce sampling bias by ensuring that all units in the population had an equal chance of being selected (Edgar & Manz, 2017). A simple random approach was used in the last stage of respondent selection. Households were randomly selected, and a total sample size of 220 households was identified. According to Kahan et al. (2015), basic randomization is the most straightforward and efficient way to avoid selection bias.

Table 1Sample Size in Kiambu and Makueni County

County	Sub-County	Sample size	Wards
Kiambu	Githunguri	60	Ngewa, Komothai, and Githunguri
	Gatundu South	60	Ngeda, Ndarugu, and Kiganjo
Makueni	Makueni	50	Makueni and Wote
	Kaiti	50	Ukia, Mukuyuni

In Kenya, the baseline survey was conducted in Makueni and Kiambu counties. The two counties were selected based on their geographical location and agroecological conditions. Humid climates serve Kiambu, while Makueni is served by dry, arid, and semi-arid climates. The two regions have a higher tree population than other areas with similar agro-ecological conditions. Kiambu and Makueni county governments have fully supported tree-planting efforts by working with communities and non-government organizations. Kiambu County is close to Nairobi, the capital of Kenya, and has a high demand for tree products. Semi-subsistence farming systems are the most widespread among farmers in the two counties.

2.3 Study site locations

The map below shows study sites where the baseline survey was undertaken
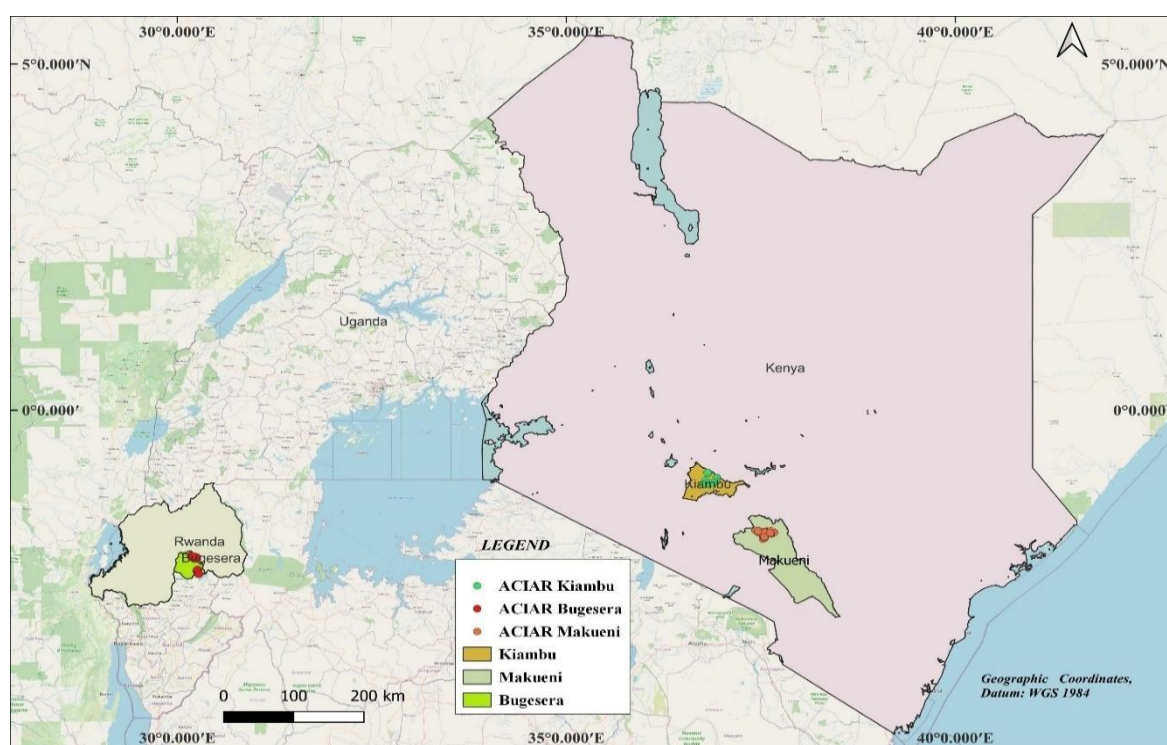
Figure 3 A map of study sites where the survey was conducted

2.3.1 Kiambu County

It is in the central region and covers 2,543.5 km2, with 426.62 km2 of gazette land under forest cover, according to the Kiambu County Integrated Development Plan 2018-2022.

Kiambu County has four major topographical zones: the Upper Highland, the Lower Highland, the Upper Midland, and the Lower Midland. The upper zone extends the Aberdare ranges; the Upper Highland Zone is between 1,800 and 2,550 meters above sea level. It is covered with forests and steep slopes and is essential as a water catchment area. The lower highland zone can be found in Limuru and a few locations in the constituencies of Gatundu North, Gatundu South, Githunguri, and Kabete. Hilly terrain, plateaus, and plains at high altitudes define the region. These regions lie between 1,500 and 1,800 meters above sea level and are mostly tea and dairy zone. At the same time, other activities, such as growing maize, coffee, avocados, horticulture crops, and animals, are also done there.

Figure 1 Photo by Wakaba; Landscape photo in Ndarugu, Kiambu County

Between 1,300 and 1,500 meters above sea level, the upper midland zone includes most of Juja and neighboring constituencies except for Lari. Volcanic middle-level uplands dominate the environment. The lower midland zone partially includes Thika Town (Gatuanyaga), Limuru, and Kikuyu constituencies. A height of 1,200 to 1,360 meters distinguishes the region. The midland zone's soils are fractured and susceptible to erosion. Strict slopes and valleys, which are not ideal for cultivation, are other physical characteristics. Lari and Gatundu's north and south sub-counties are heavily forested.

Kiambu County has bimodal rainfall patterns. Between Mid-March and May, extensive rains are followed by the cold season, which often includes drizzles and frost from June to August and short showers between Mid-October and November. The yearly rainfall varies according to altitude, with higher places receiving up to 2,000 mm and lower areas receiving as little as 600 mm. 1,200 mm of rain falls on average.

2.3.2 Makueni County

Makueni County is in the country's southeast and shares boundaries with the following counties: Taita Taveta to the South, Machakos to the north, Kitui to the east, and Kajiado

to the west. The county, which has a total area of 8,008.7 km2, is located between latitudes 1° 35° and 3° 00° South and longitudes 37° 10° and 38° 30° East. The county is primarily arid and semi-arid and is frequently affected by droughts. Rainfall in the upper regions is between 800 and 900 mm, ranging from 250 to 400 mm in the lower sections. According to the county government of Makueni, there are two rainy seasons: the long rainy season, which lasts from March to May, and the short rainy season, which lasts from November to December.

Figure 2 Photo by Wakaba; Landscape photo in Kaiti Makueni County

2.4 Data collection

Data collection happened in June and July 2022 in the ten wards of Kiambu and Makueni. Ten and two enumerators and one supervisor were involved in a household survey, FGD, and KII. Before the study, enumerators were trained and extensively exposed to the questionnaire used for this study. Then a mock pretest exercise was undertaken to ensure that issues arising from the tool and administration were resolved before the actual activity.

Primary data was gathered through household interviews and one-on-one discussions with focus groups comprising males, females, and people of mixed gender. The Intention was to gather information on the role of gender in tree farming, management, and sharing of the benefits derived from trees on the farm. Key informant interviews (KII) were conducted with agricultural officers, officers within the Ministry of Gender and social protection, county foresters, and community service volunteers, who provided a localized context on the roles of gender in society. Household data was collected using a structured questionnaire uploaded to the ODK-collected. While the focus group discussions and KII were collected using audio recordings, charts, and note-taking,

2.5 Data Analysis Approaches

The data were analyzed descriptively using cross-tabulations and mean comparisons using the t-statistic in STATA. The analyzed data were cross-checked for errors and inconsistencies and then presented in tables, graphs, charts, and figures where

Figure Photo by Wakaba; Enumerator engaging a farmer during data collection in Githunguri-Kiambu County

Appropriate. Brief descriptions accompanied the triangulated tables and figures. A draft report was presented to the stakeholder group for review and then submitted to the editorial team for enhancements.

4.1 Demographic Characterization of the project sites

4.1.1 Household Characteristics in Kiambu County

Household characteristics refer to the traits and features that describe a household. Household characteristics can include the number of inhabitants, the household make-up, and the ages and genders of those who reside there. The occupation of the primary breadwinner, the household members' income and education level, and whether there are any children or elderly members of the household are additional household characteristics. These characteristics can provide valuable information about a household and can be used to study and understand various social, economic, and demographic trends.

The baseline results show a statistical difference between the age of the households, source of labor, level of education, and primary water sources. The age of the household head is crucial for agricultural productivity since it is associated with the amount of farming experience, knowledge, attitude development, and risk aversion associated with adopting agricultural technology (Mwangi & Kariuki, 2015). The mean age of the household's head in Kiambu County is 56 years. There is a statistical difference in the age of the heads of households in Gatundu South and Githunguri Sub-Counties. Household heads in Githunguri (60 years) are more elderly than those from Gatundu south (53 years). Most household heads in Kiambu County have attained secondary education (60%), while a few did not enroll in formal education. There was a significant difference (p=0.05) in the number of household heads with no formal education. Many uneducated households are found in Gatundu South (13%) compared to household heads in the Githunguri (3%) sub-county. The primary source of farm labor in Kiambu County is provided by members of the households (77.5%); however, homes in Gatundu South provided more (85%) than households in Githunguri (70%). Piped water in the homestead is the source for most families; however, there are many households in Gatundu South (33.33%) with piped water

compared to Githunguri (60%). On average, all homes in Kiambu County had one parcel of land.

Table 4.2 Household characteristic of Kiambu County

	(Kiambu)		Githunguri		Gatundu South		p-value
Household demographics	Mean	S. D	Mean	S. D	Mean	S. D	
Age	56.15	1.58	52.61	2.16	59.68	2.22	0.02
Household size	4.00	0.77	3.87	0.27	3.87	0.23	1.00
Number of females	1.78	0.1	1.7	0.14	1.8	0.14	0.45
Number of children	0.90	0.11	0.9	0.15	0.9	0.16	1.00
Land size (acre)	2.60	0.23	2.28	0.30	2.91	0.34	0.13
Have Secondary income	46.20		55		42.4		
Income from secondary sources (KES)	6373	26838	16799	47628	6783	15766	
Gender of the household's head (Male)	51%		51.22		48.78		1.00
Education level of the household's head	No Education	8.3%		3.33%		13.33%	0.05
	Primary	30.8%		26.67%		35.00%	0.32
	Secondary	41.7%		48.33%		35.00%	0.14
	Tertiary	19.2%		21.67%		16.67%	0.49
The primary source of labor	Family	77.5%		70.00%		85.00%	0.05
Number of fields	1.44	0.13	1.40	0.08	1.50	0.1	
Primary water source (piped)	55%		33.33%		60.00%		0.00

In Makueni, the mean age of the household head is 52 years old. However, household heads in Kaiti are more elderly (56 years) than in Makueni (48 years). The average size of the households in Makueni is five members, composed of about two females and two children below the age of 14. Most heads of households in Makueni have attained a primary (37%) and secondary (31%) level of education. Farm labor is mainly provided for by the household members (86). Rain is the primary source of water for home use and crop growing in Makueni agriculture (54%). On average, the family in Makueni owns one parcel of land with an average size of six acres.

Table 3 Households Characteristics for Makueni County

Variable	(Makueni)		Makueni		Kaiti		P-Value
Household demographics	Mean	S. D	Mean	S. D	Mean	S. D	
Age of the household head	52.08	1.36	47.56	2.1	54.6	2.11	0.04
Household size	4.79	0.24	4.85	0.24	4.73	0.31	0.75
Number of females	2.37	0.12	2.37	0.15	2.35	0.18	0.97

Number of children		1.5	0.13	1.5	0.16	1.5	0.21	1.00
Have Secondary income		20.50%		24.10%		16.67%		0.36
Gender of the household's head (Male)		49.00%		51.90%		48.10%		0.64
Education level of the household's head	No Educ	9.8%		3.00%		16.67%		0.02
	Primary	37.3%		35.19%		39.58%		0.65
	Secondary	31.4%		35.19%		27.08%		0.38
	Tertiary	20.6%		25.93%		16.67%		0.36
The primary source of labor	Family	86.27%		81.48%		91.67%		0.14
	Hired	28.43%		31.48%		25.00%		0.47
Number of fields		1.31	0.06	1.24	0.07	1.4	0.11	0.85
Land size		5.97	0.84	6.33	1.44	5.56	0.78	0.65
Primary water source (Rainwater)		53.92%		46.30%		62.50%		0.10

4.1.2 Farm Characteristics
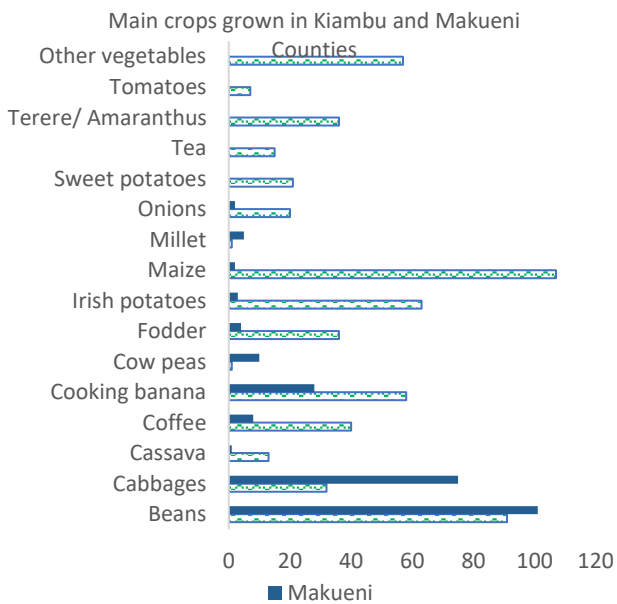
Figure Main crops grown in Makueni and Kaiti sub-counties

The baseline study extended to household farm characteristics in Kiambu and Makueni. In Kiambu, the results show that, on average, families own and manage one farm parcel, which is, on average, 3.5 acres. However, on average, most families had two acres, while some had as many as 15 acres. Lands in Kiambu are used for growing trees and crops (82.5%), crops only (9.17%), and trees only (5.83%). Most of the land managed by families was accrued through inheritance (79%), while others have bought it (11%). The primary land preparation method is by use of howe and jembe (100%), while the water sources used in farming crops come from rainfall (81%), wells (80%), piped water in the farm compounds (69%), rivers and pods (31%), and some other sources (5%). The income garnered from selling trees, and tree products are approximately KES 64442.5. Baseline results show that, on average, farmers in Gatundu South and Kaiti sub-counties grew 20 crop varieties. The main crops produced by households in Githunguri and Gatundu South are maize (89%), beans (76%), Irish potatoes (53%), bananas (48%), vegetables (48%), and coffee (33.3%).

In Makueni, families own and manage one farm parcel, on average, of 5.42 acres. However, on average, most families had two acres, while some had as many as 20 acres. Lands in

Makueni are used for growing trees and crops (93%), crops only (6%), and trees only (1%). Land in Makueni has been acquired through ancestral inheritance (91%), while those acquired through purchase constitute. The main method used to prepare land preparation method uses cattle and oxen (67%) and hoe and jembe (33%); water sources used in farming crops come from rainfall, and rainwater harvested (76%), wells (31%), piped water in the farm compounds (14%), rivers and pods (17%), and some purchases (3%). On average, the study found that households grew six crop varieties on their farm. These crops mainly were maize (99%), beans (74%), cowpeas (28%), and kale (10%) in their kitchen garden.

Challanges of Crop Production

Challenge	Kiambu	Makueni
Lack of ready market	21	7.8
Lack of available labour	17	6.9
High cost of farm inputs	70	38.2
Diseases	56	50
Pests	83	61.8
Wrong crop selection	8	6.9
Low soil moisture	8	25.5
Drought/ inadequate rainfall	51	85.3
Unreliable rainfall	81	83.3
Low soil fertility	38	32.4
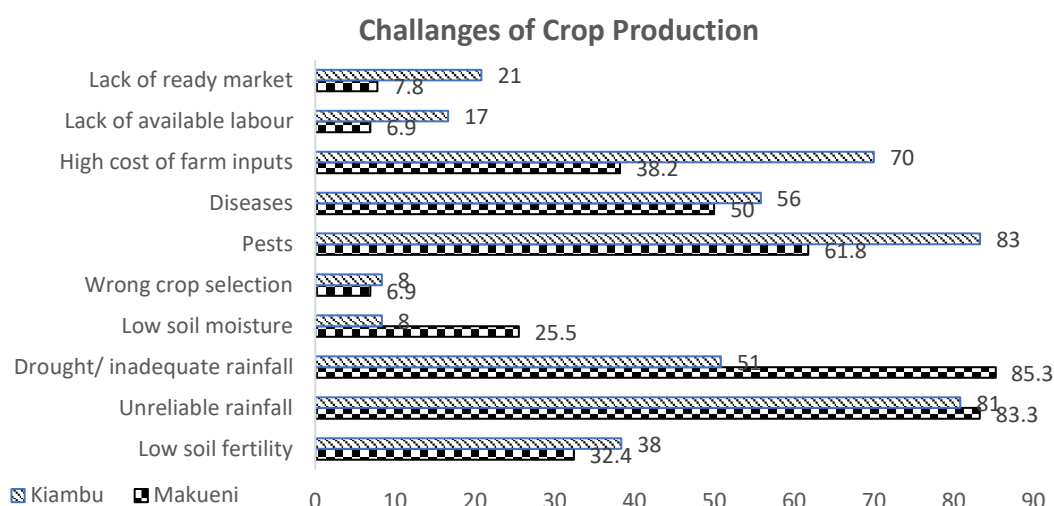
Table 4.3 Farm characteristics in Kiambu and Makueni

Variable		(Kiambu)	Makueni
Land size (ha)		3.5 (0.39)	5.42 (0.79)
Time to reach the market (Min)		32 (27)	73 (32)
Cost of growing fruit trees (Kes)			5352.43 (27409.86)
Income from trees		64442.5 (225852.5)	6152.17 (4980.5)
Crop diversification		20	6
Livestock diversification		7	4
Labor	Family	77.5	28.24
Number of fields		1.44 (0.13)	1.31 (0.06)
Farm characteristics			
Land ownership	Privately owned through customary	79%	91%
	Bought	11%	20%
Main land use	crop only	9.17	5.88
	trees and crops	82.5	93.14

	trees only	5.83	0.98
Land preparation methods	Hoe & jembe	100	33.33
	Cattle, oxen	0	66.67
Main water sources	Piped water	69	14
	Borehole	80	31
	Rainwater	81	76
	Groundwater	5	5
	Buy	5	3
	River	31	17

Figure 6 Challenges facing crop farming in Kiambu and Makueni Counties

4.1.3 What are the main challenges facing crop farming in Makueni and Kiambu Counties

Results show that the main challenges facing crop farming in Kiambu are pests (83%), unreliable rainfall (81%), high costs of farming (73%), disease (56%), low soil fertility (38%), and a lack of market for their produce (21%). While in Makueni, the main challenges affecting crop farming are unreliable rainfall (83%), inadequate rainfall (85%), pests (62%), diseases (50%), low soil fertility (32%), a high cost of inputs (38%), and low soil moisture (26%).

Figure 7 Photo by Wakaba; Crop failure due to drought in Makueni

4.2 The Contribution of Trees to Livelihoods and climate change mitigation and Adaptation

4.2.1 Which non-fruit tree species are found on farms, and what are their uses and niches?

The study asked the respondents to mention all the trees they could identify on their farm. The results show that Grevillea robusta was the most abundant tree species (46%). Grevillea robusta trees were more abundant in Gatundu and are planted in cropland. Other non-tree species identified are Eucalyptus spp (37%) planted in the woodlots and the sloppy lands, especially in Gatundu. Commiphora eminni (23%) was mainly planted along the farm boundaries and used to support crops such as root and aerial yams. The other

trees were scattered on the farms, such as Prunus africana (17%), Croton megalocarpus (17%), and Coffee robusta (16%). It was grown as a cash crop. Results further show that non-fruit trees have been established in the woodlots (96%). Other non-fruit trees are found in the croplands (76%) and around the home compounds (28%), while others have been established along the terraces to control soil erosion (11%). At the same time, others have been established along the boundaries to mark the end of the farm (8%).

Non fruit trees grown in Kiambu

Species	Value
Grevillea robusta	46.4
Eucalyptus spp	36.9
Commiphora eminii	22.5
Croton megalocarpus	17.1
Prunus africana	17.1
Coffea arabica	16.2
Acacia mearnsii	10.8
Albizia gummifera	9.5
Pinus patula	8.6
Croton macrostachyus	7.7
Juniperus procera	6.8
Cupressus lusitanica	6.8
Dovyalis caffra	6.3

Figure non-fruit trees grown in Kiambu

Non fruits niches in Kiambu

Niche	Value
Along terraces and soil erosion control structures	~14
Woodlot	~96
Along internal boundary eg hedges	~7
Along boundary of the farm/field	~5
Scattered in cropland	~82
Home compound	~28
Orchard	~12

Figure 9 non-fruit tree niches in Makueni

In Makueni, there were more non-fruit tree species than in Kiambu. Like Kiambu, Grevillea robusta (58%) was the farm's most common species. Croton megalocarpus (41%), Euphorbia tirucalli (33%), Acacia tortillis (27%), Jacaranda mimosifolia (23%), and Cupress sempervirens (22%) were other most common non-fruit tree species on the farm in Makueni and Kaiti sub-county. Non-fruit tree species in Makueni are in the woodlots (87%),

which also serve as grazing land. Other tree niches for non-fruit trees in Makueni were scattered in the cropland (70%) and around the home compound (26%).

4.2.2 Which fruit tree species are found on farms, and what are their uses and niches?

The study asked the farmers about the fruit tree species grown on their farms and where they grow. The results show that Musa spp is the most common fruit tree species found on farmlands in Kiambu; Musa spp (77%) and Hass, a variety

Non fruit trees in Makueni

Species	Value
Dombeya burgessiae	10
Eucalyptus camalndulensis	10
Grewia bicolor	10
Dovyalis caffra	11
Cordia sinensis	12
Balanites glabra	12
Acacia nilotica	14
Lannea schweinfurthii	15
Azadirachta indica	18
Cupressus lusitanica	18

Fruit trees found in Kiambu farms

Species	Value
Musa spp	77
Hass -Persea americana	77
Fuerte -Persea americana	53
Macadamia integrifolia	48
Mangifera indica	47
Eriobotrya japonica	38
Local variety-Persea americana	33
Solanum betacea	26
Carica papaya	23
Psidium guajava	20
Citrus sinensis	13
Hass Gold (Persea americana)	13
Citrus limon	11
Malus domestica	9
Annona senegalensis	6

Tree Niches:
Maku...
Riparian/ along wate...
Along terraces and soil erosion control st...
Along internal boundary e...
Along boundary of the fa...
Scattered in...
Home compound

Frequency

Figure non-fruit tree niches in Makueni

of Persea americana (77%). Other Persea americana fruit varieties, such as Fuerte (53%) and local variety (33%), appear in plenty. However, Hass gold (13%) on the farms was not abundant. Macadamia integrofilia (48%) and Mangifera indica (47%) are other varieties found on farms.

Figure 13 Photo by Wakaba; Musa Spp, the most common tree species in Kiambu

Most of the fruit trees in Githunguri and Gatundu South are scattered in the crops land (42%), Around the home compound (28%), and in orchards (23%). Trees have been established in these niches. The study went further and asked the farmers why they chose to establish trees in their locations. The results show that ease of management (57%) and safety (51%) of the tree came first. Other factors that informed the location of non-fruit tree was the lack of adequate space (22%), available spaces in the field (11%), and to give room for mechanized farming (10%). The reason that non-fruit species were established in their respective niches is due to the limited spaces on the farms; non-fruit trees can be squeezed into the available space on the farm (41%). The location of the tree species niche is also informed on where it would be easy to manage the tree (42%). Trees are also planted on the location based on their use; trees can serve multiple

Fruit tree niches in Kiambu

Niche	Value
Along terraces and soil…	1.4
Woodlot	2.1
Along internal boundary…	0.7
Along boundary of the…	4.2
Scattered in cropland	41.7
Home compound	27.8
Orchard	22.9

Reason for Fruit tree niche in Kiambu

Reason	Value
Self established	5.8
The area is free from pests	0.3
Give room for mechanised farming	0.7
Multiple uses and multipurpose nature of the…	30
Availability of space- large field sizes	41.4
Lack of adequate space	15
Easy to manage the trees	42.3
Safety of the trees and fruits	25.7

Figure Reason for Fruit tree niche in Kiambu

purposes they do (30%), such as fodder, shade, or product. Young seedlings are also planted where the farmer can provide security (26%).

In Makueni, the most widely grown fruit tree species in the farms is Mangifera indica (74.2%). Citrus sinensis (64%) and Persea Americana (52%) are other fruit tree species on household farms. Surprisingly, despite Makueni being a hot region, many farms are growing Musa spp (49%). Another citrus fruit tree, Citrus limon, was a widely cultivated species (43%). Fruit tree species on the farm in Makueni are scattered on the cropland (82%). Other fruit trees have established homesteads (26%), Along the terraces to control soil erosion (14%), while others are in orchards (14%).

Tree grown in Homestead farms In Makueni County

Tree grown	Percentage
Mangifera indica	74.2
Citrus sinensis	63.6
Persea americana	52.3
Musa spp	49.2
Carica papaya	45.5
Citrus limon	43.2
Annona senegalensis	27.3
Citrus reticulata	22
Passiflora edulis	21.2
Psidium guajava	21.2
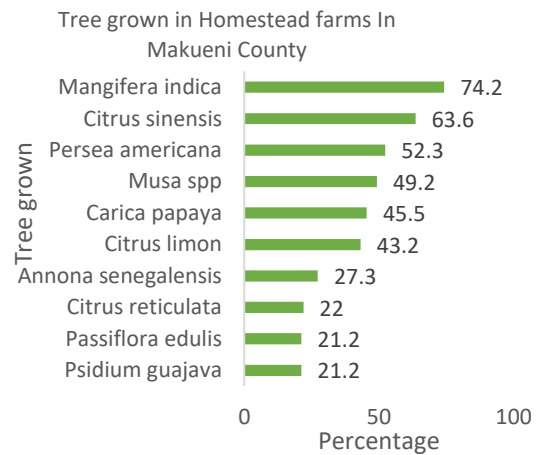
Figure Fruit trees grown on farms In Makueni County

Tree Niches in Makueni

Along terraces and soil erosion control structures	14
Woodlot	1
Along internal boundary eg hedges	7
Along boundary of the farm/field	4
Scattered in cropland	82
Home compound	26
Orchard	12
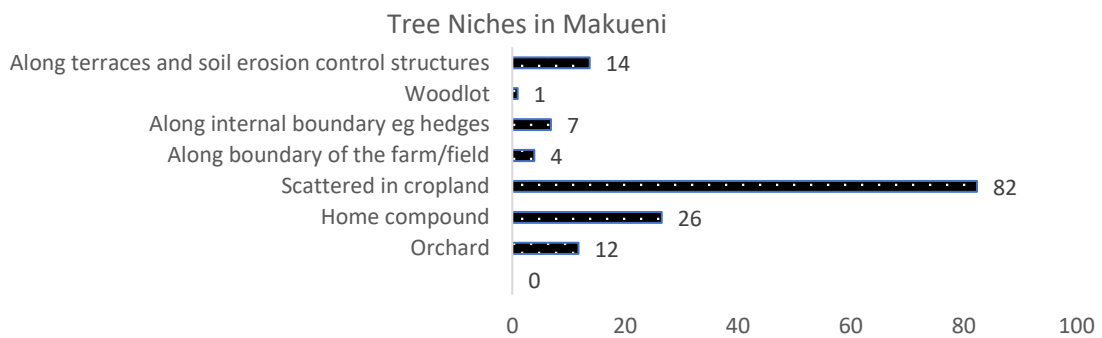
The result shows a similar consideration of where to establish a fruit tree in Kiambu and Makueni. The reason given by farmers for establishing trees in their niches was that it was easy to manage them (49%). Ensure the safety of the tree and destruction from wild animals and browsers such as goats (45%). Lack of spaces (19%) on fam there being the only available space (10%).

Figure 12 Fruit tree Niches in Makueni

Reason for tree niche in Makueni

Give room for mechanised farming	8.3
Multiple uses and multipurpose nature of the…	3
Availability of space- large field sizes	9.8
Lack of adequate space	18.9
Easy to manage the trees	49.2
afety of the trees and fruits	44.7
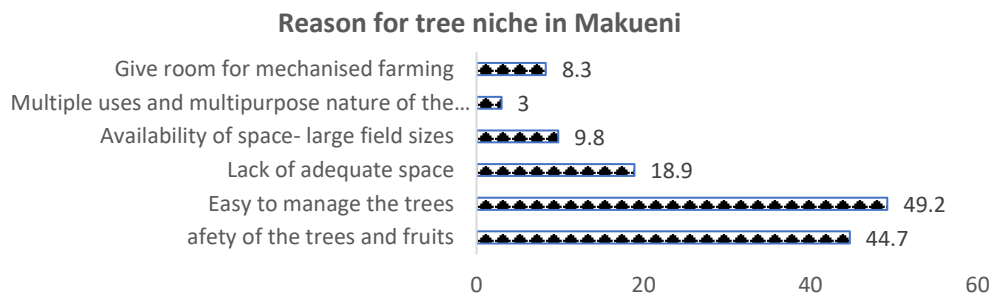
Figure Reason for tree niche in Makueni

4.2 What other ecosystem services do farmers value? Which trees are for Ecosystem Service, and which are for products

4.2.1 Priority trees species in Kiambu and Makueni

Table 4 presents results on the most important tree species for households. The survey asked the household members to mention their families' most important tree species. It emerged that fruit and non-fruit trees were considered essential for them too. Kiambu households view Grevillea robusta (39%) and Eucalyptus spp. (30%) as the most critical non-fruit tree species. At the same time, Persea americana (49.60%), Mangifera indica (7%), and Macadamia integrifolia (7%) are considered essential fruit trees. In Makueni, there was a higher preference for fruit trees among households than non-fruit trees. Mangos (74%), as well as Citrus sinensis (64%), and Persea americana (52%), are priority tree species. Again, Grevillea robusta (43%), Croton megalocarpus (31%), and Euphorbia tirucalli (24%) were considered critical non-fruit trees.

Table 4 Percentage of the most important fruits and non-fruit trees grown in Kiambu County

.	Githunguri	Gatundu South	Total
Coffea arabica	13.50%	16.90%	15.30%
Camellia sinensis	1.90%	13.60%	8.10%
Eucalyptus spp	28.80%	30.50%	29.70%
Prunus Africana	1.90%	1.70%	1.80%
Grevillea robusta	42.30%	35.60%	38.70%
Macadamia integrifolia	5.3%	8.3%	6.80%
Mangifera indica	7.0%	1.7%	4.30%
Persea americana	45.60%	53.30%	49.60%
Macadamia integrifolia	5.3%a	8.3%a	6.80%

Table 5 Most important fruits and non-fruit trees grown in Makueni County

Grevellia/ Mivaliti/ Gruvelia (*Grevillea robusta*)	43.6%
Cloton/ Kithulu/ Ithulu/ Mithulu (*Croton megalocarpus*)	30.8%
Kalialia/ Ndau/ Kamuti ka iia/ Euphobia (*Euphorbia tirucalli*)	24.8%
Kilaa/ Mwaa/Muaa/ Miaa (*Acacia tortillis*)	20.3%
Jacaranda (*Jacaranda mimosifolia*)	17.3%
Kikuu/ Ikuu (*Cupress sempervirens*)	16.5%
Christmas tree/ Muambrella (*Cupressus lusitanica*)	13.5%
Mwarubaine/ Mialuvaini (*Azadirachta indica*)	13.5%
Kyuasi/ Muasi (*Lannea schweinfurthii*)	11.3%

Kisemei/ Isemei (*Acacia nilotica*)	10.5 %
Guava/ Muvela (*Psidium guajava*)	21.2
Passion (*Passiflora edulis*)	21.2
Musandara/ Misandara (*Citrus reticulata*)	22
Kitokomo/ Itokomo/Mitomoko/ Matokomo (*Annona senegalensis*)	27.3
Itimo/Mitimo (*Citrus limon*)	43.2
Mupapai/ Kipapai/ Mivavai (*Carica papaya*)	45.5
Banana (*Musa spp*)	49.2
Avacado/ Ikolovia (*Persea americana*)	52.3
Isungwa/ Muchungwa/ Misungwa (*Citrus sinensis*)	63.6
Kiembe/Mango/ Maembe (*Mangifera indica*)	74.2

4.1.3 What perceived product and service benefits do Kiambu farmers get from tree planting?

After identifying the priority tree species, the study asked the farmers to state the benefits they get from the important tree species on their farms. The results show that farmers planted, and managed trees based on the benefits they got from them. In Kiambu, households are driven by products such as firewood (91%) and timber (85%), live fences (32.4%), ornamental (13.9%), and fruits (15.3%). The ecosystem benefits derived from tree planting did not come out strongly from the Kiambu. However, households in Gatundu South were keen on shade (27%) and windbreak (32%) offered by the tree on the farm. Therefore, the findings suggest that Kiambu households are product-driven and prioritize the trees that can be harvested as products. Similar to Kiambu, farmers in Makueni plant trees for a product, but there was a higher need for ecological services that tree provides. Timber (74%), charcoal (27%), and firewood (57%) are the main products derived from the priority trees growing on the farms. However, there was a higher interest in the agroecological benefits such as shade (32%) and windbreak (32%), particularly in the Kaiti sub-county.

Table 6 Percentage of the product and services farmers get from tree planting

Products	Kiambu	Githunguri	Gatundu South	Makueni	Makueni	Kaiti
Fruits	**15.3**	9.4	20.7	**1.9**	3.8	0
Timber	**84.7**	81.1	87.9	**57.0**	61.5	52.1
Firewood	**91**	90.6	91.4	**74.0**	82.7	64.6
Bee forage	**1.8**	1.9	1.7	**0.9**	1.9	0
Follage	**0**	0.0	0	**7.8**	13.5	2.1
Bean stakes	**1.8**	0.0	3.4	**0.9**	1.9	0

Medicine	**20.7**	20.8	20.7	**3.8**	7.7	0
Ornamental	**18.9**	18.9	19	**2.9**	5.8	0
Household/farm tools	**8.1**	5.7	10.3	**0.9**	1.9	0
Charcoal	**22.5**	24.5	20.7	**27.0**	30.8	22.9
Dead fence	**15.3**	7.5	22.4	**3.9**	5.8	2.1
Ecosystem services						
Live fence	**32.4**	28.3	36.2	**1.9**	3.8	0
Erosion control	**2.7**	3.8	1.7	**0.9**	1.9	0
Riverbank stabilization	**7.2**	3.8	10.3	**7.1**	3.8	10.4
Nitrogen fixation	**3.6**	1.9	5.2	**2.9**	3.8	2.1
Mulch	**16.2**	15.1	17.2	**5.0**	5.8	4.2
Shade	**24.3**	22.6	25.9	**9.0**	13.5	4.2
Windbreak	**27**	18.9	34.5	**32.0**	34.6	29.2
Shelter	**0.0**	0.0	0.0	**32.0**	21.2	43.8

Figure 18 Photo by Wakaba; Photo was taken in Kiambu showing tree products

To understand the driving force of the preference for tree species for products and ecological services. We asked the farmers why the product was essential for them too. The results showed that income (66%) is the main driving factor in Kiambu. The products harnessed from the tree are consumed at the household level or sold to generate revenue. At the same time, tree species for ecological services such as windbreak and shade were vital because they are friendly to crops (25%) and improve soil fertility (25%). In Makueni, the choice of tree species to grow is informed by products and services (ability to improve soil fertility and can be intercropped) derived. Tree growing on the farm is not only driven by direct benefits harnessed but also the indirect benefits derived from them.

Table 7 Percentage of why farmers consider these products vital to them

	Total	Githunguri	Gatundu S	Total	Makueni	Kaiti
Income	66.10	71.20	61.00	14.90	7.50	22.90
Food/ fruit	5.10	8.50	1.70	3.00	5.70	
Friendly to crops/ good for intercropping	25.40	20.30	30.50	52.50	67.90	35.40
Soil fertility improvement	25.40	23.70	27.10	44.60	45.30	43.80
Fast-growing/ maturing	16.90	8.50	25.40	35.60	34.00	37.50

Figure 19 : Tree products that motivate farmers to plant and maintain trees © Denis Wakaba.

The study asked the household about fruit consumption behavior. Results show that Musa Spp is the most consumed fruit in Kiambu, especially in Gatundu South (88.1%). Because the fruits of the tree all year out, results also revealed that it was the most planted tree in Gatundu South. The second most consumed fruit in Both Githunguri (59.3%) and Gatundu South (58.3%) was Citrus sinesis. The third most consumed fruits in Kiambu were Persea americana (Fuerte), Githunguri (26.7%), and Gatundu South (37.3%). The other varieties of avocado that the households consume are the local variety (21.4%) and Hass (9.2%). Baseline results show that

Figure **Fruits consumned in Kiambu in the last 30 days**

most of the fruits consumed within the households have occurred from their farms, and where there are fruits not produced within the family resulting in buying from the local market. Fruits acquired from buying from the neighboring homes and receiving fruits as gifts from neighbors and relatives are minimal.
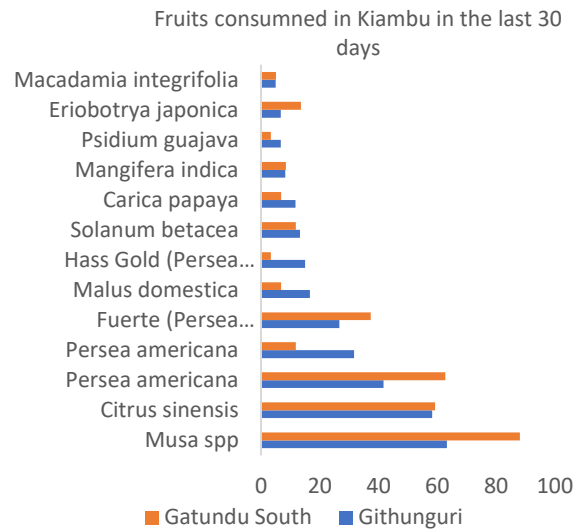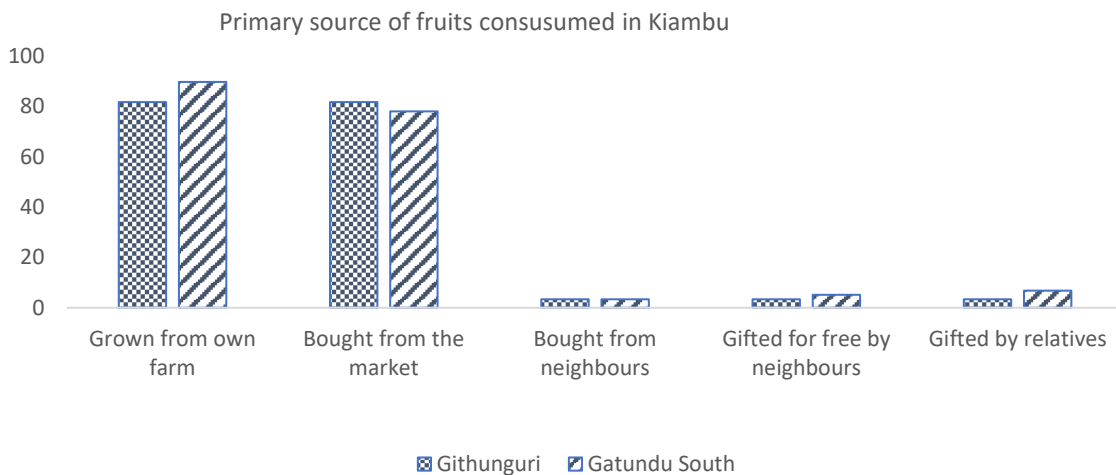
Figure 21 Primary source of fruits consumed in Kiambu

Results show that households in Kiambu are likely to consume fruits when they are in season (56.1%). Secondly, the consumption of fruits in Kiambu county happens yearly as some trees, like Musa Spp, fruits annually (52.2%). Further findings show that people consume fruits because of the health benefits derived (15.1%) and when they are in plenty (14.3%). Few households said that they consume fruits for health benefits.
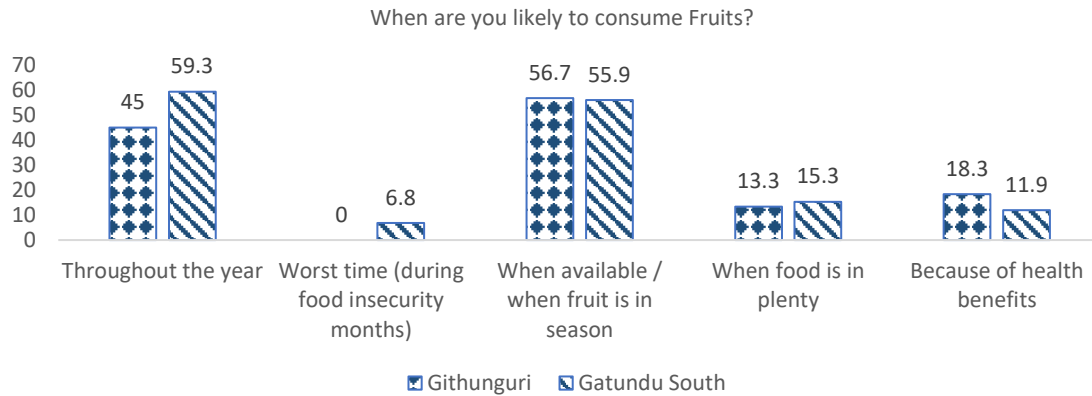
Figure 22 When are you likely to consume Fruits

In Makueni, the study found that the most consumed fruit in Makueni was Citrus sinensis (68%) because the fruit was in season during the survey. Other fruits consumed in substantial quantities were Persea americana (24%) and Carica papaya (26%). These fruits are mainly from their farm (91%) and acquired outside (9%). Households in Makueni consume fruits only under two circumstances: in seasons (86%)

Figure Fruits Consume in the last 30 days in Makueni

and if bought from the market (14%). Mainly these fruits come from own farms (91%), while others are purchased from the nearby local markets (9.3%)

Figure When are you likely to consume the fruits

Figure 25 Source of fruits consumed in the household

4.2.3 What is the contribution of fruit trees to food security

Fruits are eaten as a supplement to food during food scarcity and as complements due to their nutritional value. This study asked the farmers which months they felt vulnerable to food insecurity. Figure 20 shows that the period between February and May is the worst in

Kiambu. While between July to December are the month when there are no cases of food insecurity vulnerability.

In Makueni, the month when the households feel vulnerable to food insecurity begins in May, continues through December, and worsens in August. The periods when they are less
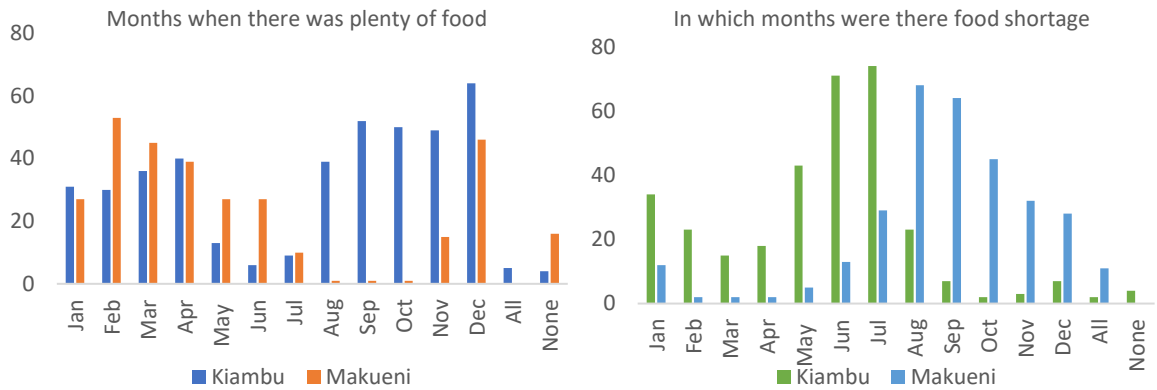
prone to food insecurity start in December and July. The best month for Makueni residents is February. Results from focus group discussions showed that households were less vulnerable during the fruiting period. In Makueni, mango and oranges are the most widely grown trees. The mango fruiting calendar begins in December and last until April, which means that households can better meet their food and income needs throughout the fruiting season

4.3 Fruit tree management, propagation, and sourcing

4.3.1 Which tree fruit tree species have farmers planted in the past five years, for which purpose, and in which niches?

In the baseline, the study set out to investigate the most planted tree species by the farmer in the last five years. Results show that there has been a similar trend in tree planting in Githunguri and Gatundu. Fruit trees are the main species that farmers have been growing; Persea americana, Macadamia integrifolia, Mangifera indica, and Solanum betaceum. In
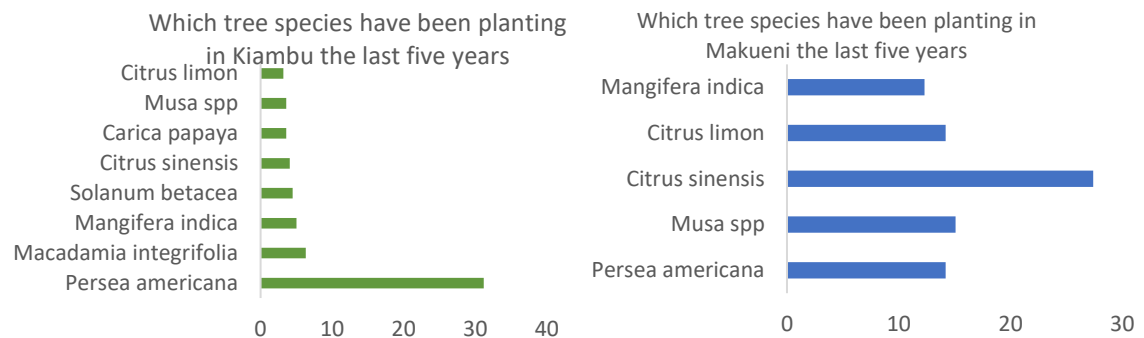
Figure tree that have been planted in Kiambu in the last five years

Figure Trees that has been planted in Makueni in the last five years

Makueni, there are differences in magnitude for the tree species that farmers planted. In Makueni, there was a high planting of Citrus limon, Citrus sinensis, and Mangifera Indica, while in Kaiti, farmers have been planting Persea americana, Musa spp., and Citrus sinensis.

4.3.2 What planting materials did the farmers use, and where were their sources?

The study asked the farmers what the primary sources of planting materials were and where they were sourcing them. The result shows that seedlings were the main form of planting materials in Kiambu (79%) and Makueni (52%). The second primary source of tree-planting

Main type of planting materials

materials was seeds extracted from the fruits and planted directly. Other significant sources of seedlings are grafting, cutting, and wilding. Where they source the planting materials, the study shows that; tree nurseries and traders are the primary sources of tree planting in Kiambu (60%) and Makueni (41%). There was an element of buying tree seedlings from the market (40%), while we can see that in Kiambu, farmers cultivated 17% of the seedlings on the farm (17%).

Sources of the planting materials
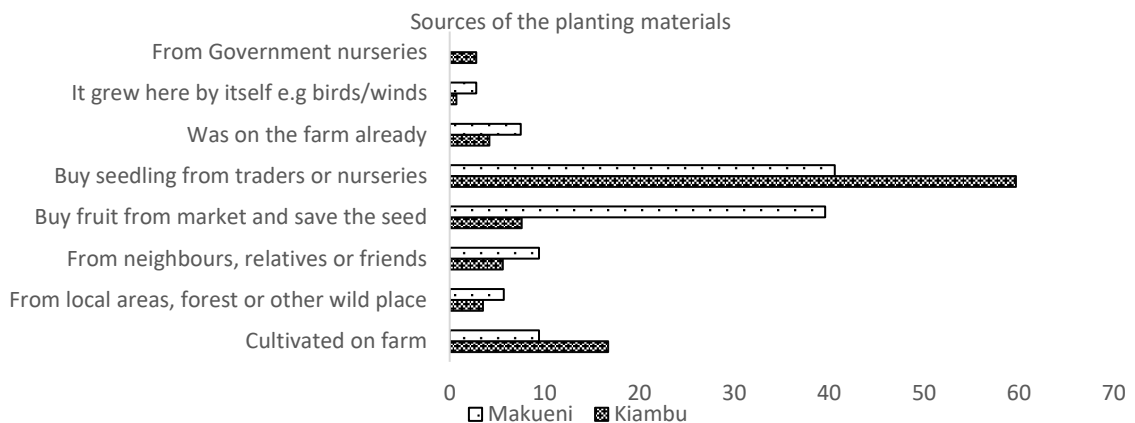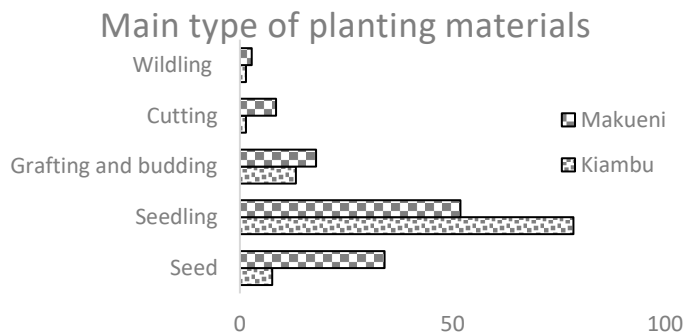
Figure Primary Sources of the planting materials

4.3.3 What tree management practices do farmers employ when growing fruit trees

Regarding the tree management practices exercised by farmers, the study intended to understand some of the methods farmers use to manage the already established trees on the farm. The results show that a high percentage of households are doing at least one tree management practice. Gatundu South has the highest number (93.39%) than Githunguri (76.70%).

In Kiambu, much of the efforts go into manuring (82%), mulching (58%), harvesting (58%) the fruits, grafting (44%), and controlling pests and diseases (45%) control. While in Makueni, much of the work on trees involves weeding, watering, and pest and disease management.
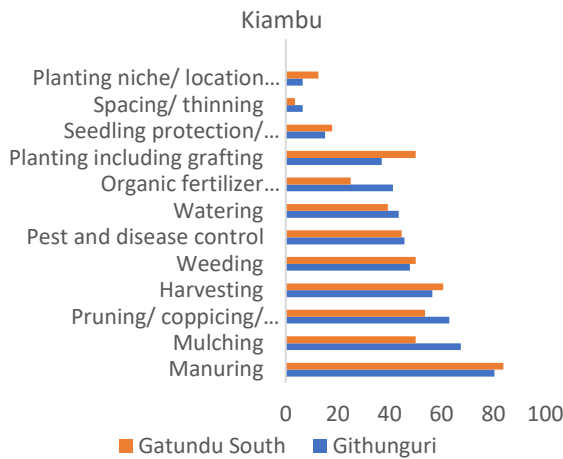
Figure Tree management practices in Kiambu and Makueni
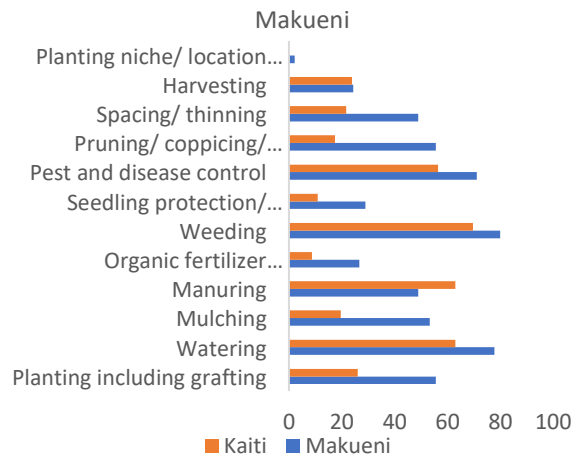
Figure Do you apply any tree management practices on fruit tree (yes)

4.3.4 What training have farmers received on tree production and management?

Figure Have you or anyone in your household received any form of tree production

The baseline study is also set to determine the extension services available to the farmers, how many have access to extension, and the gaps. Respondents were asked whether they had access to any extension service in the last three years. The results show that; Only 23% and 15% of the farmers in Githunguri and Gatundu South had access to an extension service. The results show that much of the tree training is delivered through word of mouth (78.2%), demonstration (32.2%), and demonstration and personally trying out the practice (25.4%).

The households who had an opportunity to receive the training were mainly taught about planting trees, manuring, pruning, and pest and disease management. The topics covered in the two sites of Kiambu county seemed skewed. The data shows that planting and grafting (78.6%), watering (57.1%), mulching (57.1%), application of organic manure (42.9), Pest and diseases management (71.4%), and

pruning (71.4%) in Githunguri. However, in Gatundu South, much of the training was on manuring (66.7%), weddings (55.6%), and harvesting (66.7%).

How was the trainning delivered

Githunguri / Gatundu South

Categories: Demonstration, Demonstration and personally trying out the practice, Training through word of mouth, Given written materials, Internet eg watching youtube

Figure How was the trainning delivered
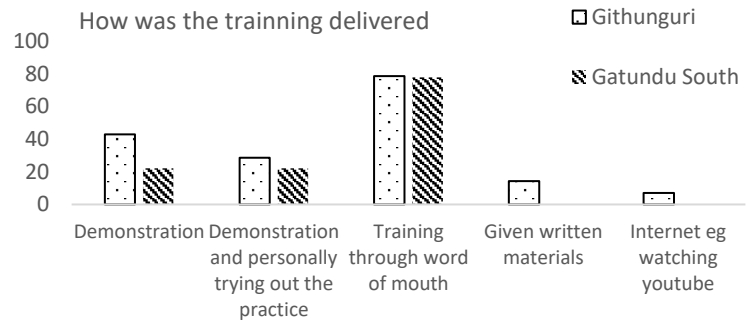
Makueni

In the last two years, only 16% of the households in Makueni have received extension services on tree planting and management. For the households who got an opportunity to receive the extension, the household head (75%) were trained, especially males. The government mainly provides agricultural extension services (43%). The most common form of extension in Makueni was training through the world of the mouth (75%)

What were the trainning offred in Kiambu?

Gatundu South / Githunguri
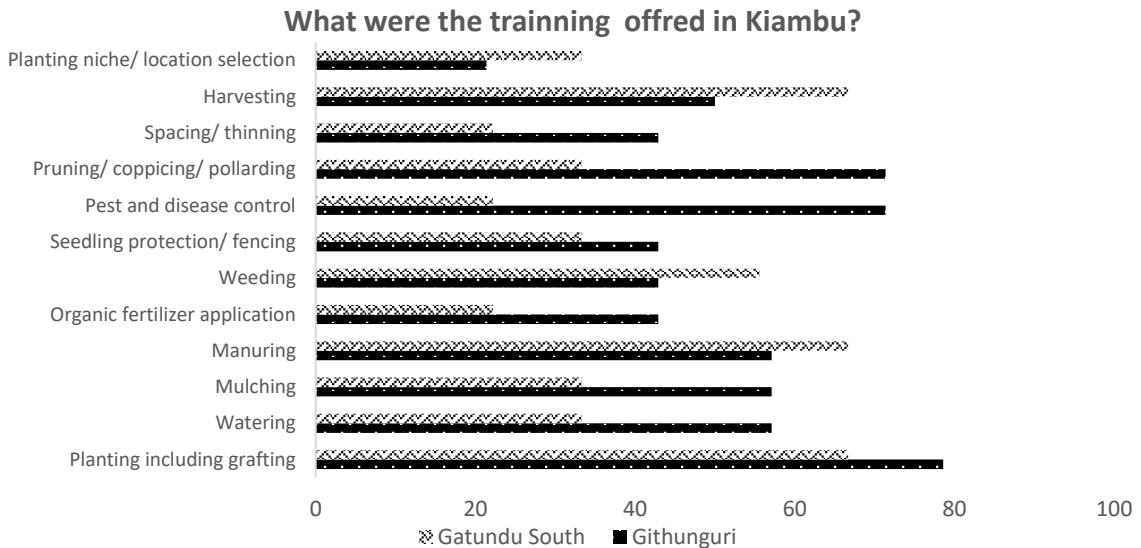
Figure What were the training offered in Kiambu

in Kaiti, while in Makueni was (50%). There was a similar training method through demonstration in Kaiti and Makueni (50%). However, only in Makueni (25%) was training offered through demonstration and personally trying out the practice.

How was the traiining offered

Makueni / Kaiti
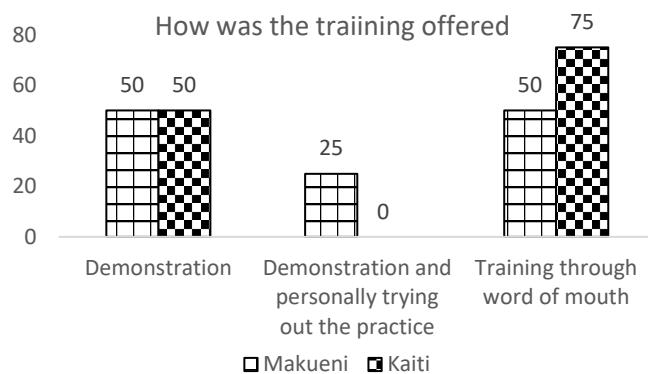
If the extension were to be provided for free, 97% of the farmers would be willing to participate and get the following topics: pest and diseases management (81%), thinning (50%), and water management (27%).

The main form of extension that farmers in the Makueni and Kaiti sub-counties received was on pest and disease controls (75%). However,

33

there seems that In Makueni, training was on pruning (37.5%), spacing (37.5%), seedling protection, Watering crops (62.5%), weeding (12.5%), and grafting of crops (62.5%). In the Kaiti sub-county, the training emphasized applying organic manure (50%) more. Further results reveal that training on seed protection, weeding, and manuring of the tree was not offered to farmers from Kaiti.

Figure How was the training offered in Makueni
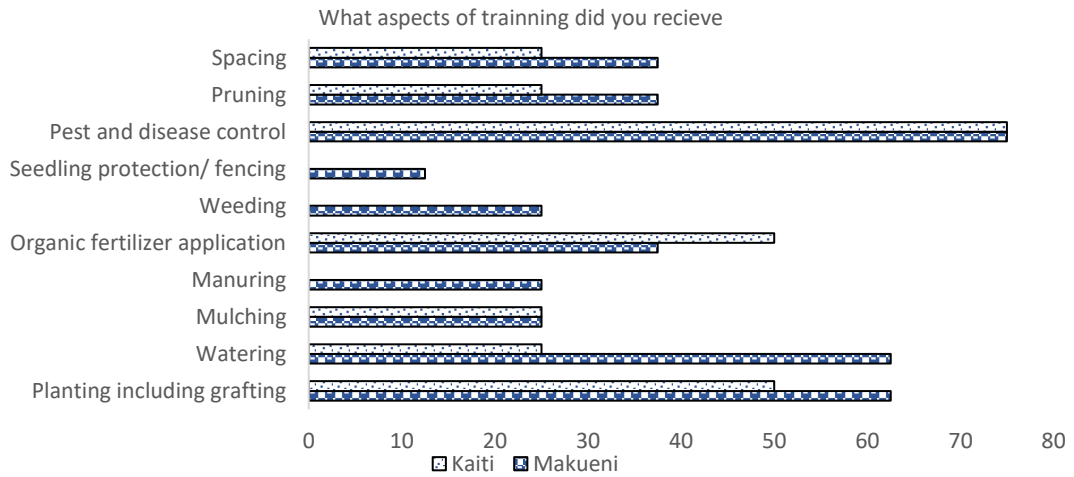
Figure 38 What aspects of training did you receive

4.3.7 What are farmers' capacity development needs/ gaps associated with fruit tree production and management?

If training was to be offered for free, 83.3% and 90% of the households in Githunguri and Gatundu South said they would be willing to attend respectively. We then asked them about the priority topics they would want to be taught. The results show that The study asked on the priority topic farmers were willing to be trained on the results showed that; pest and disease management (75%), young seedlings protection, especially for young plants (40%), and selecting the tree niches (37%) were the most preferred topic. There is a significant difference in preference for training needed on harvesting (0.02) and manuring (0.02). Farmers in Githunguri were more interested in manuring, while farmers in Gatundu were keener on receiving training on harvesting. For the households that did not want to plant a tree in the future, farmers mentioned that they were constrained by space (55%). Others believed trees harbor pests (31%) and that growing trees is expensive due to theft cases (33%).

In Makueni, almost all the households were willing to take up the opportunity to receive extension services. The baseline result shows that Much of the anticipated training is on pest and disease management (87%), Thinning (40%), and pruning (31%). The study tested for a significant difference in extension need. Results show that tree pruning, and Manuring knowledge are demanded more by households from Makueni than in Kaiti.

Table 8 Tree management practices demanded by the farmers in Kiambu and Makueni Counties

Variable	Kiambu	Makueni

	Total	Githunguri	Gatundu	p-value	Total	Makueni	Kaiti	p-value
Mulching	27.19	28.3	26	0.79	19.19	28.85	8.51	0.01
Manuring	34.95	46	24.53	0.02	17.17	19.23	14.89	0.57
Organic Fertilizer	31.07	32.08	30	0.82	28.2	21.15	19.15	0.81
Weeding	29.24	22.64	28	0.53	13.13	17.31	8.51	0.20
Seedling protection	39.81	39.62	40	0.97	13.13	21.15	4.26	0.01
Pest and diseases	74.76	71.7	78	0.46	86.87	80.77	93.62	0.06
Pruning	37.86	33.96	42	0.42	31.31	44.23	17.02	0.00
Thinning	29.13	26.42	32	0.53	40.4	50	29.79	0.04
Harvesting	29.13	18.87	40	0.02	7.07	9.62	4.26	0.30
Planning niche	36.89	33.96	40	0.53	10.1	12.77	7.69	0.41

Figure Would be interested in receiving training on (Kiambu

4.3.6 What are the challenges that farmers face while growing fruit trees?

The farmers who showed interest in expanding tree planting and would be interested in tree planting were asked about the potential threats and challenges in tree growing. The results show limited tree management knowledge (18%), a low survival rate of the seedlings (14%), and a lack of suitable planting materials (15%). There was a significant difference ($p=0.09$) in the knowledge of tree management between farmers from Gatundu (10%) and Githunguri (38%). In Makueni, a household that showed interest in increasing the number of trees on their farm, they said that water shortage (47%) and pests and diseases (40%) are among the main challenges. Market challenges also demotivated farmers to increase the number of trees.

Table 9 Challenges farmers might face when planting more trees in future

	Makueni	Makueni	Kaiti	Kiambu	Githunguri	Gatundu
Lack of quality planting materials	8.77	9.52	8.33	14.28	12.50	15.00
Increased pest and diseases	40.35	33.33	44.44	7.14	12.50	5.00
Water shortage	47.37	38.10	52.78	3.57	0.00	5.00
Low survival rate	3.51	4.76	2.78	14.29	25.00	10.00
Limited knowledge of fruit tree management	15.79	9.52	19.44	17.86	37.50	10.00
Labor intensification	14.04	9.52	16.67	10.71	0.00	15.00

4.3.8 Who makes decisions regarding fruit tree production?

Households' gender role in managing productive assets is critical as it determines the welfare pathway. The study asked the farmers who are in charge of tree management. Results show that in Kiambu and Makueni Counties, tree management is under the household heads domain. While in Makueni, the role of tree manifest is secondly taken by spouses, in Kiambu, workers have been assigned to take care of the trees

36
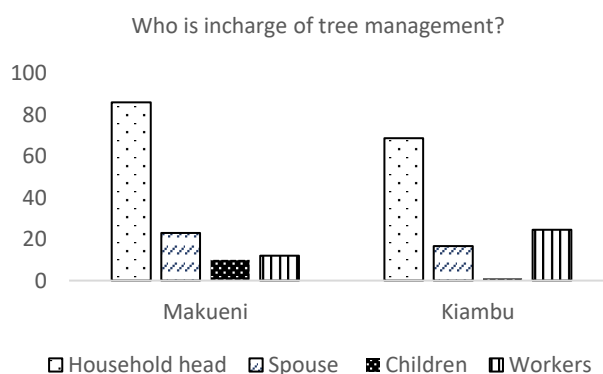
4.5 Farmers' understanding of climate change
4.5.1 Which climate change indicators have farmers noticed in their area?

Farmers in Kiambu (93%) of the households have experienced climate change in the last five years. According to them, climate change has resulted in erratic changes in rainfall patterns (82.30%); sometimes, the rain comes very late and ends before the expected time. The frequency of drought occurrences in Kiambu increased rapidly (96.48%). During the dry season, it becomes hotter than it used to be; farmers compare the temperatures that they are experiencing now compared to five years ago in the same period (50.44%). The frequent invasion of new pests and diseases was also reported to indicate the effect of climate change (56.64%). However, there was a significant difference in farmers' observations of pests and diseases in Githunguri; 47% of the farmers attributed an increase in pests and diseases to climate change, compared to 67% in the Gatundu sub-counties. Flooding is another phenomenon resulting from climate change.

Table 10 Farmers' perceptions regarding the role of fruit trees in climate change adaptation and mitigation

	Kiambu	Githunguri	Gatundu	p-Value	Makueni	Makueni	Kaiti	p-Value
Are you aware of climate change	93.3	95.0	91.3	0.47	86.3	90.7	81.3	0.17
Have you observed the following in the last five years?								
Changes in rain patterns	82.3	82.8	81.8	0.90	88.6	93.9	82.1	0.08
Drought	96.5	96.6	96.4	0.96	97.7	98.0	97.4	0.97
Temperature	50.4	53.5	47.3	0.51	72.7	81.6	61.5	0.04
Disease and Pest	56.6	46.6	67.3	0.03	77.3	85.7	66.7	0.04
Increase flooding	0.9	0.0	1.8	0.30	1.1	2.0	0.0	0.37
Frost and hailstones	27.4	22.4	32.7	0.22	27.3	40.8	10.3	0.00
Strong wind	4.4	0.0	9.1	0.02	22.7	0.0	51.3	0.11
Does fruit trees have a role in mitigating climate change effect?	71.2	72.9	69.5	0.75	67.7	60.4	74.1	0.14
Do you think growing fruit trees could play a role in lessening climate change effect	66.4	61.7	71.2	0.27	48.0	48.2	47.9	0.98

It is uncommon in Kiambu to encounter strong wind (4.4%), hailstones, and frost (27%); they were identified as some of the leading indicators of climate change by farmers from Gatundu South. There was broad recognition that trees can help households and reduce carbon stocks. The proportion of farmers who recognize the ecosystem roles that fruit trees provide on the farms in Githunguri (71%) is higher than that in Gatundu South (68%). Farmers from the two counties seem to believe planting fruit trees would lessen the effect of climate change.

In Makueni, results show that 86.27% of farmers have experienced climate change in the last five years. Similarly to Kiambu, the climatic phenomenon was associated with climate change. Results show that 89% of the farmers indicated that changes in rainfall patterns resulted from climate change—occurrences of frequent drought (98%) and high temperatures (72%). However, an increase in temperature due to climate change was reported more by farmers in Makueni (82%) than in Kaiti (62%). The baseline results reveal that pests and diseases are among the significant issues related to climate change in Makueni (77%). Results showed a significant difference in farmers' attribution of pests and diseases to climate change between Kaiti (66%) and Makueni (85%). These could suggest that farmers in Kaiti are more prone to pests and disease than those in the Makueni sub-county. Like Kiambu County, the problems of hailstones, frost, and strong wind (2.27%) were not reported much. However, there is a significant difference in the occurrence of frost and hailstone in Makueni (41%) compared to Kaiti (10%) sub-counties. Famers in Makueni (67%) believe that fruit trees have a role in climate change mitigation, while 48% think that growing fruit trees could lessen the effect of climate change.

Table 11 Changes observed made by farmers on the climate change indicator.

		Githunguri	Gatundu	Makueni	Kaiti
How has the rainfall amount changed?	More rain	0.0	7.3	0.0	0.0
	No change	0.0	1.8	0.0	0.0
	less rain	100	90.9	100	100
How have the rainfall patterns changed?	Comes early	1.7	3.6	0.0	0.0
	No change	6.9	3.6	0.0	0.0
	Comes late	91.4	92.7	100	100
Have droughts become more frequent?	Less frequent	5.2	3.6	0.0	0.0
	No change	27.6	29.1	3.7	2.1
	More frequent	67.2	67.3	96.3	97.9
How have the temperatures changed?	More heat	53.4	43.6	94.4	89.6
	No change	15.5	14.5	3.7	8.3
	Less heat	31	41.8	1.9	2.1
How have the frost and hailstones changed?	More occurrence	22.4	23.6	50	27.1
	No change	39.7	25.5	44.4	70.8
	Less occurrence	37.9	50.9	5.6	2.1
How has the pest population changed?	less Pest	3.4	3.6	0.0	0.0
	No change	34.5	25.5	18.5	27.1
	More Pest	62.1	70.9	81.5	72.9
How have disease occurrences changed?	Decreased	1.7	1.7	0.0	0.0
	No change	61.7	55.9	25.9	45.8
	Increased	36.7	42.4	74.1	54.2

The survey further enquired about the observed changes in the effect of climate change. The results show a complete rainfall reduction (100%) in all the sub-counties under the study except in Gatundu (90.9%). Additionally, the rain comes later than the expected

dates. Frequent drought occurrences have also become one of the noticeable climate change effects. Results show that drought has become frequent in Makueni and Kiambu. However, drought cases are more frequent in Makueni (97.1%) than in Kiambu (67.3%). The results show that in the last five years, farmers from Kiambu (48.5%) and Makueni (92.0%) have experienced an increase in temperature. At the same time, cases of pests and diseases have been on the rise. Results show that in Kiambu and Makueni, farmers who reported increased pests in the last five years were 66.5% and 77.4%, respectively. At the same time, there were more reported cases of increased diseases in Kiambu (39.9%) and Makueni (64.2%).

5.5.2 How has climate change affected agricultural activities?

Climate change has affected farming practices; the results show that climate change has reduced crop yield across the sub-counties. In Githunguri and Gatundu South, households that faced a reduction in crop yield due to climate change constituted 90% and 88%, respectively. Farmers in Githunguri (61%) and Gatundu South (59%) have changed in planting and harvesting patterns due to climate change. There are also high incidents of crop failure in Githunguri (54%) and Gatundu south (55%). Results show climate change has increased pest and disease infestation, especially in Gatundu south (61%). In Makueni, climate change has affected food production. In Kaiti (90%) and Makueni (93%), a reduction in crop yields is the most devastating effect due to climate change. Climate change has increased pests and diseases in the Makueni (83%) and Kaiti (75%) sub-counties.

Table 12 Effect of climate change on agricultural activities

	Githunguri	Gatundu S	Makueni	Kaiti
Reduced crop yield	89.8	87.5	92.6	89.6
Change in planting time	61	58.9	68.5	43.8
Crop failure	54.2	55.4	61.1	33.3
Increased pests and diseases infestation	47.5	60.7	83.3	75
Reduced soil moisture	3.4	16.1	44.4	27.1

5.5.3.What are the coping strategies due to climate change

The results of coping strategies due to climate change show that households in Gatundu South (71%) and Githunguri (50%) have used high-yielding varieties. Due to climate change, farmers have adopted early maturing crops in Githunguri (40%) and Gatundu South (39%)—application of regenerative agricultural practices such as organic inputs, mulching, and the use of organic manure. For Makueni households, adopting drought-resistant crops is the most adopted coping strategy for farmers from Kaiti (65%) and Makueni (80%) sub-counties. Households have also planted early maturing crops (63%) and used improved crop varieties (44%). Adoption of agricultural conservation practices such as minimum tillage is more pronounced in households in Makueni (33.3%) than in Kaiti (4.2%).

Figure 43Photo by Wakab; Coping strategies due to climate change

Table 13 What are the coping strategies as a result of climate change

	Githunguri	Gatundu South	Makueni	Kaiti
Planting drought-tolerant crops	33.3	27.1	79.6	64.6
Planting early maturing crops	40	39	70.4	56.3
Use of improved crop varieties	50	71.2	51.9	35.4
Use of local varieties that are well suited to the area	10	27.1	11.1	14.6
Practicing crop rotation	15	11.9	24.1	8.3
Minimum tillage	10	15.3	37	12.5
Mulching	33.3	40.7	33.3	4.2
Use of organic manure	33.3	47.5	18.5	6.3
Application of fertilizers and organic inputs	16.7	45.8	1.9	2.1
Rainwater harvesting	8.3	20.3	29.6	22.9
Irrigation	16.7	1.7	33.3	18.8
Using different cropping systems	3.3	13.6	3.7	8.3

4.6 Future aspirations and vision for tree planting

4.6.1 Are farmers interested in planting more fruit trees, in which fields, which niches, and what is the motivation?

The baseline wanted to establish whether farmers were willing to plant more trees in the future to mitigate the effect of climate change and gain benefits from the tree. The results show that Githunguri (87%) had the highest proportion of farmers willing to plant more trees. However, there was a low willingness to plant more trees in the future by farmers from Kaiti (25%). The study further asked the households why they did not want to plant a tree in the future. The results show that water shortage is the main deterrent to planting more trees in the future, especially in Kaiti (53%) and Makueni (38%). Other conspicuous challenges to planting more trees in the future were noted in Githunguri, such as limited knowledge of tree management (38%), low survival rate (25%), and theft cases (13%). Pest and diseases were other challenges hindering farmers' ambitions to plant more trees in the

future, especially in Makueni (33%) and Kaiti (44%). The lack of a market for tree commodities also led to the unwillingness to plant more trees in the future, especially among farmers from Kaiti (25%) and Makueni (33%).
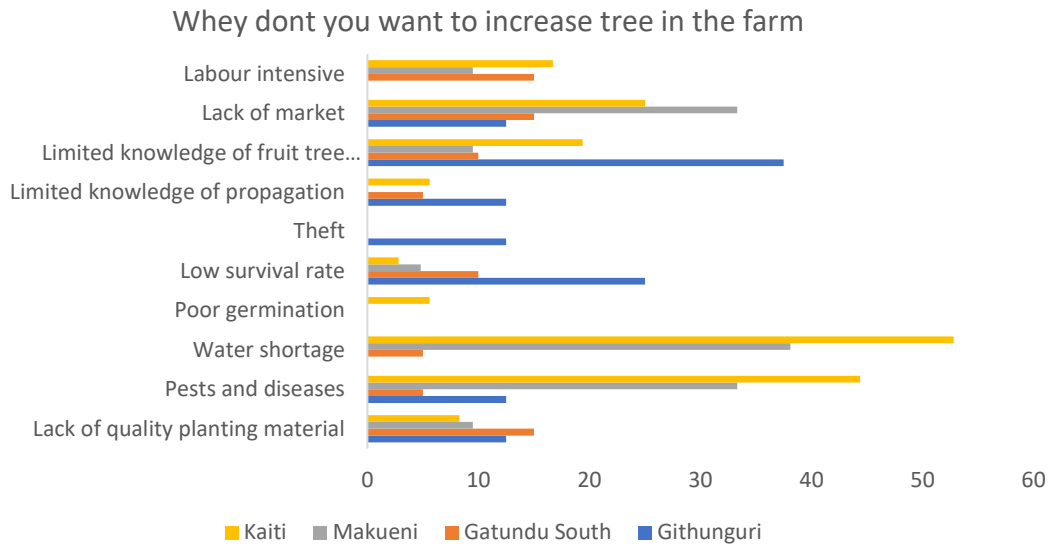
Figure 45 Why don't you want to increase trees on the farm

4.6.2 The reason why farmers would want to increase diverse tree species in future
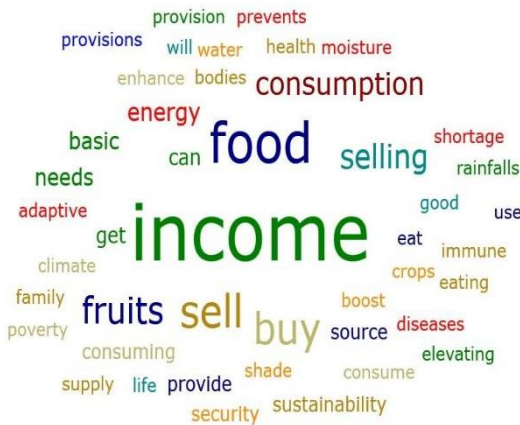
Kiambu County   Makueni County
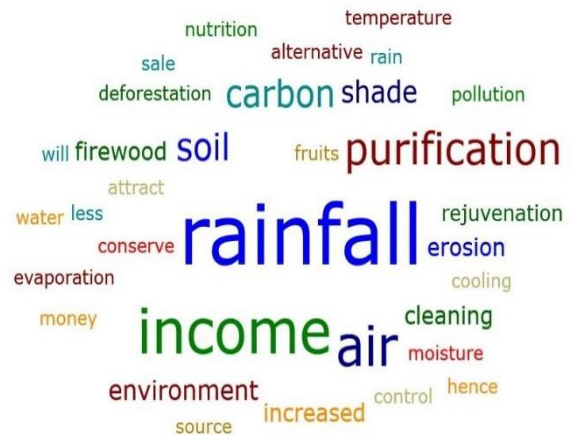
Figure 46 What is the Intention for increasing trees in the future

There is a clear difference in the motivation behind planting diverse trees in Kiambu and Makueni. The quantitative results show that the ecosystem benefits derived from trees are among the main driving forces behind tree planting. In Makueni, the main driving force of tree planting is to attract rainfall, generate income, air purification, and soil erosion control. While in Kiambu, the main driving factor to tree planting is income generation; providing food generates income for subsistence use. These suggest that the households in Makueni are ecosystem driven, while the families in Kiambu are product-driven.

41

4.6.3 Which current and potential future niches are farmers motivated to plant/retain trees? (and what are the reasons for these niches?)

Most of the fruits (58.82%) and non-fruit (48.02%) are found in the croplands, while others have been established near the homestead (44%). There is a significant difference in niches where trees have been established. There are significantly (p=0.00) more trees in the croplands in Gatundu (53%) than in Githunguri (43%), and additionally, there are more trees in the boundaries for the households in Githunguri (6%) than in Gatundu (3%). In Kiambu, there are significantly (p=0.02) more woodlots in Githunguri than in Gatundu—the reason for the establishment of trees in woodlots is that farms in Githunguri are more commercially intensified. The main contributing factors to farmers selecting the tree niche are the availability of the space (41%) and ease of management (42%). Moreso, there was a significant difference in tree establishment in the available areas (p=0.01) between Githunguri (36%) and Gatundu South (47%).

Table 14 Potential tree niches and tree management

Table 5.0 Tree niches in Kiambu		Kiambu	Githunguri	Gatundu	p-Value
Tree niches	Orchards	12.21%	11.46%	12.89%	0.59
	Home compounds	44.39%	46.88%	42.14%	0.24
	In the croplands	48.02%	42.81%	53.46%	0.00
	Along the boundaries	4.79%	6.60%	3.14%	0.05
	Along the hedges	2.97%	3.82%	2.20%	0.24
	Woodlot	1.32%	2.43%	0.31%	0.02
	Terraces	0.99%	0.94%	1.04%	0.91
	Along water bodies	0.33%	0.31%	0.35%	0.97
Fruit tree	Cropland	58.82	85.71	40.00	0.07
Reason for the niche	Security	25.70%	24.57%	26.70%	0.54
	Easy to manage	42.34%	43.25%	41.51%	0.66
	Homestead	14.99%	15.92%	14.15%	0.54
	Availability of space	41.35%	35.64%	46.54%	0.01
	Multiple uses	29.98%	25.61%	33.96%	0.02
	Mechanization	0,66%	0.00%	1.26%	0.06
	Free from Pest	0.33%	0.35%	0.31%	1.00
	Self-established	5,77%	6.23%	5.35%	0.64

In Makueni, most of the non-fruit trees are established in the home compounds (55%) of croplands (44%) and along the boundaries (42%). The results further show more woodlots in Githunguri than in Gatundu South. Fruit trees in Makueni were found to be located in the croplands (78%) and around home compounds (29%). The main reason farmers have established fruit trees in the cropland and near the home compound is the ease of management (58%). There was a significant difference (p=0.01) in tree establishment between farmers in Makueni (69%) and Kaiti (48%). Secondly, farmers would prefer to establish trees in areas with available spaces (20%).

Table 15 presents results for tree niches for trees grown in Kiambu county; most are the establishment.

		Makueni	Makueni	Kaiti	p-Value
Tree niches	Home compounds	54.77%	50.72%	41.10%	0.25
	In the croplands	44.37%	49.28%	39.73%	0.25
	Along the boundaries	41.55	44.93	38.36	0.43
	Along the hedges	11.23	14.49	8.22	0.24
	Woodlot	7.75	13.04	2.74	0.02
	Terraces	2.82	5.80	0.00	0.04
	Along water bodies	2.11	4.35	0.00	0.07
Tree niches for fruit trees	Orchards	8.39	16.18	1.33	0.00
	Home compounds	28.67	23.53	33.33	0.20
	In the croplands	78.32	80.88	76.00	0.48
	Along the boundaries	10.49	20.59	1.33	0.00
	Along the hedges	9.09	13.24	5.33	0.00
	Terraces	9.09	11.76	6.67	0.29
Reason for planting a tree along trees the niche	Security	55.95	60.29	52.00	0.32
	Easy to manage	58.04	69.12	48.00	0.01
	Adequate space	20.28	20.59	20.00	0.93
	Availability of space	9.09	8.82	9.33	0.92
	Multiple uses	2.80	1.47	4.00	0.36
	Mechanization	7.69	8.82	6.67	0.63
	Self-established	2.10	2.94	1.33	0.50

4.6.4 What potential limiting factors do farmers anticipate in planting more trees?

The farmers interested in tree planting were asked about the potential threats and challenges in tree growing. The results show limited tree management knowledge (18%), a low survival rate of the seedlings (14%), and a lack of suitable planning materials (15%). There was a significant difference (p=0.09) in the knowledge of tree management between farmers from Gatundu (10%) and Githunguri (38%). In Makueni, a household that showed interest in increasing the number of trees on their farm said that water shortage (47%) and pests and diseases (40%) are among the main challenges. Market challenges also demotivated farmers to increase the number of tres.

Table 16 Potential threats to tree planting

	Makueni	Makueni	Kaiti	Kiambu	Githunguri	Gatundu
Lack of quality planting materials	8.77	9.52	8.33	14.28	12.50	15.00
Increased pest and diseases	40.35	33.33	44.44	7.14	12.50	5.00
Water shortage	47.37	38.10	52.78	3.57	0.00	5.00
Low survival rate	3.51	4.76	2.78	14.29	25.00	10.00
Limited knowledge of fruit tree management	15.79	9.52	19.44	17.86	37.50	10.00

Labor intensification	14.04	9.52	16.67	10.71	0.00	15.00

The study further asked the respondents unwilling to increase the number of trees in the future for their reasons. The results show that the main concern was limited land spaces on their farms; others felt that trees could harbor pests, and these would make it difficult to manage them. Other farmers, especially from Kaiti (50%), said that some trees have minimal products that can be harvested from them. Theft cases of seedlings, especially in Gatundu south (39%), was also a deterrent to inspiration to plant a tree in future
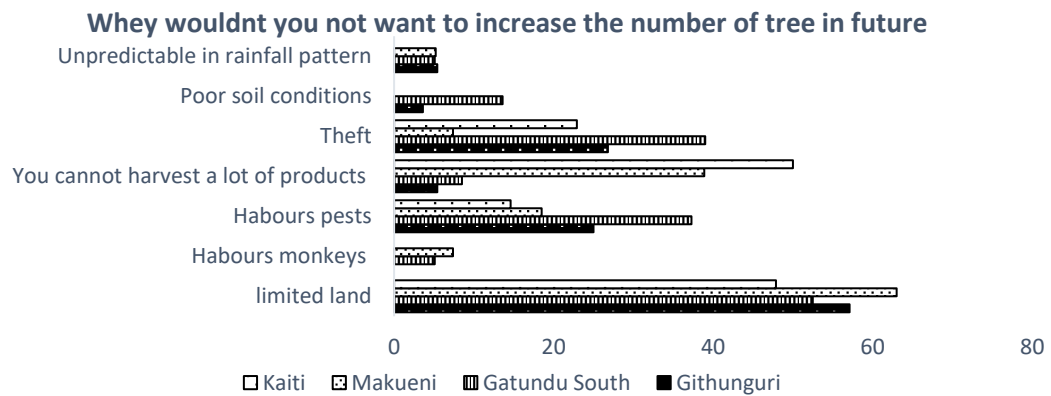
Figure 47 Why wouldn't you want to increase the number of trees in future

5. Conclusions

Assessment of the households' focus on tree farming in Makueni and Kiambu revealed that households in the two counties practice mixed farming, including keeping livestock and growing crops. The households in the two counties are at the semi-subsistence level, where food is produced for home consumption, and the surplus is sold to earn income. The main challenges facing both crop and tree farming are pests and diseases, insecurity, unreliable and inadequate rainfall, and the high cost of farm inputs. The most common non-fruit tree grown in the two counties is Grevilia robusta. Persea Americana is Kiambu's most common fruit tree species, while Citrus sinensis and Mangifera indica are the most common fruit tree species in Makueni County. These trees were found to be growing in cropland. Farmers establish trees on their land because of available spaces and if the tree serves multiple purposes. Farmers in Kiambu prioritize trees that earn them income, provide food and other products such as wood, and the benefits they derive from them. In Makueni, the key focuses were income, food, and ecological services obtained from trees. The most consumed fruits in Kiambu are bananas and oranges, while in Makueni, oranges are the most common. In Kiambu, fruits are consumed all year, while in Makueni, they are consumed when in season. However, in both cases, fruits are sourced from local farms.

Fruits have a role in reducing food insecurity because households report low cases of food insecurity vulnerability within the months when fruits are in season. The primary tree planting materials farmers use in both Makueni and Kimabu are seedlings sourced from tree nursery operators and the market. There has been a low supply of extensions by the government, which is their primary provider. However, the demand for training extension is very high, and the main topics farmers desire to be trained in are diseases, pests, water,

and tree management. The training need coincides with the main challenges farmers have been going through while doing tree growing.

The main observable effects of climate change on the household members were changes in rainfall patterns, temperature increases, and pest and disease incidents, which were found to have increased in the last five years. Climate change has destroyed agricultural activities by decreasing crop yields on farms and increasing pests and diseases. This has resulted in farmers planting early maturing and drought-resistant crops and using improved crop varieties as coping strategies. In the future, many farmers from Kiambu will be willing to plant diverse trees, while there are few farmers in Kaiti. The potential threats to the increasing diversity of trees were found to be increased pests and diseases, water shortages, and a lack of knowledge and skills.

6. Recommendations and next steps

The study identified a considerable gap in providing extension services and limited tree management knowledge. Therefore, this study recommends that farmer training focus on the problems affecting agricultural activities, tree farming, and what farmers need. The training should also be tailored to focus on the priority tree species grown and those farmers wish to plant. Framers appreciate the roles of tree on the farm.

APPENDIX

Annex1; HOUSEHOLDS' MEMBERS REACHED DURING BASELINE STUDY IN KENYA

Kiambu: 20th -27th July 2022

Makueni: 21st -25th June 2022

S/No	County	Name of participant	Gender
1	Kiambu	Lydia Waithira Githan'ga	Female
2	Kiambu	Rachael wanjiku gathaiya	Female
3	Kiambu	Mary wairimu kongo	Female
4	Kiambu	Anastacia wanjiku	Female
5	Kiambu	Margaret wangui	Female
6	Kiambu	Mary wanjiku ndirangu	Female
7	Kiambu	Veronica Wanja	Female
8	Kiambu	Margaret Mukuhi	Female
9	Kiambu	Lilian Mburu	Female
10	Kiambu	Hannah Waithera Waweru	Female
11	Kiambu	Mary Wanjiru	Female
12	Kiambu	Teressiah Muikamba	Female
13	Kiambu	Jane Muthoni	Female
14	Kiambu	Esther Wambui	Female
15	Kiambu	Teresia Ng'endo	Female
16	Kiambu	Zipporah Wanjiru Kabochi	Female
17	Kiambu	Ruth wanjiru mburu	Female
18	Kiambu	Margret nyambura kifue	Female
19	Kiambu	Eunice wanjiku	Female
20	Kiambu	Wanjiru ndichu	Female
21	Kiambu	Priscilla Gathecha	Female
22	Kiambu	Esther Wangui	Female
23	Kiambu	Jane Wairimu	Female
24	Kiambu	Martin kihugi	Female
25	Kiambu	Phyllis wanjiru	Female
26	Kiambu	Mary Kamau	Female
27	Kiambu	Irene Wairimu	Female
28	Kiambu	Loise Njeri	Female
29	Kiambu	Dionisia Njeri	Female
30	Kiambu	Recheal gaitau nganga	Female
31	Kiambu	Susan Wambui	Female
32	Kiambu	Ann Njeri	Female
33	Kiambu	Mary Wanjiru	Female

34	Kiambu	Leah wanjiru (wagakumo)	Female
35	Kiambu	Penninah muthoni gitau	Female
36	Kiambu	Nancy mumbi	Female
37	Kiambu	Hannah njeri	Female
38	Kiambu	Agnes nunga	Female
39	Kiambu	Keziah njeru kamau	Female
40	Kiambu	Teresia njeri mwangi	Female
41	Kiambu	Alice Njeri	Female
42	Kiambu	Racheal Gathoni	Female
43	Kiambu	Margaret Wangari	Female
44	Kiambu	Mercy Chebet	Female
45	Kiambu	Regina Wanjiru Gitau	Female
46	Kiambu	Mary waithira kuria	Female
47	Kiambu	Regina njeri mburu	Female
48	Kiambu	Margaret wanjiru wamugucia	Female
49	Kiambu	Leah michera kiwara	Female
50	Kiambu	Emily Wanjiku	Female
51	Kiambu	Teresia Njambi	Female
52	Kiambu	Ann Wanjira	Female
53	Kiambu	Mary Nduta	Female
54	Kiambu	Wambui wa muhia	Female
55	Kiambu	Susan wanjiku	Female
56	Kiambu	Lucy thanks njoroge	Female
57	Kiambu	Teressiah Njeri	Female
58	Kiambu	Florence Wanjiru	Female
59	Kiambu	Elizabeth Wambui Nginga	Female
60	Kiambu	Mary Nyambura	Female
61	Kiambu	Paul ngaruiya	Male
62	Kiambu	Joseph Njuguna Mwangi	Male
63	Kiambu	James kibe muiruri	Male
64	Kiambu	Steven kinyajui njoroge	Male
65	Kiambu	Kifuri wa thumbi	Male
66	Kiambu	Peter kibuthu	Male
67	Kiambu	Daniel Njuguna	Male
68	Kiambu	Julius Kariuki	Male
69	Kiambu	Daniel Kimani	Male
70	Kiambu	Fredrick Njobi	Male
71	Kiambu	George Muhia	Male
72	Kiambu	Michael Nyingi Kabue	Male
73	Kiambu	Hannah Njeri	Male

74	Kiambu	Kenneth Gachuki Marigi	Male
75	Kiambu	Lucy Ndung'u	Male
76	Kiambu	David muchai maina	Male
77	Kiambu	Joseph njubi makumi	Male
78	Kiambu	Joseph wangoro jovi	Male
79	Kiambu	Samuel kamuthia	Male
80	Kiambu	Kimani richu	Male
81	Kiambu	Moses Mbugua	Male
82	Kiambu	Stephen Njuguna	Male
83	Kiambu	George muigai	Male
84	Kiambu	Stephen macharia	Male
85	Kiambu	Samuel mundati	Male
86	Kiambu	Josphat Turu Ngure	Male
87	Kiambu	David mwai muchami	Male
88	Kiambu	Patrick kimani kinywa	Male
89	Kiambu	Erick wanyoike kimani	Male
90	Kiambu	Paul njoroge mbiri	Male
91	Kiambu	Peter Kabuti	Male
92	Kiambu	David Kimani	Male
93	Kiambu	Francis mugwi thingi	Male
94	Kiambu	Patrick kamau njoroge	Male
95	Kiambu	John kungu mwaura	Male
96	Kiambu	Samuel Kamau Ngugi	Male
97	Kiambu	Thomas Chege	Male
98	Kiambu	Peter Chege	Male
99	Kiambu	Michael Kinuthia Kibere	Male
100	Kiambu	John Ng'ang'a	Male
101	Kiambu	Njoroge Makira	Male
102	Kiambu	Joseph Njuguna Mbugua	Male
103	Kiambu	John Gioko	Male
104	Kiambu	Njenga Njuguna	Male
105	Kiambu	Abraham Mwangi	Male
106	Kiambu	Joseph macharia	Male
107	Kiambu	Paul kinuthia ichoho	Male
108	Kiambu	James kiarie	Male
109	Kiambu	John njeraini wanjema	Male
110	Kiambu	Simon nduru mukano	Male
111	Kiambu	Abraham kamau njuguna	Male
112	Kiambu	John Wanjuu	Male
113	Kiambu	Edward njuguna waweru	Male

114	Kiambu	Peter njoroge kiiru	Male
115	Kiambu	Ndung'u Ikonya	Male
116	Kiambu	Francis kamau	Male
117	Kiambu	Robert kihara njega	Male
118	Kiambu	George karioki nyanjui	Male
119	Kiambu	John kangei mugai	Male
120	Kiambu	Gideon Mbugua Murai	Male
121	Makueni	Alex maingi kaumbulu	Male
122	Makueni	Kyalo mboo	Male
123	Makueni	Kaleli mbandi	Male
124	Makueni	Hellen nthale	Female
125	Makueni	Martha mutuku	Female
126	Makueni	Justus mutinda kilungya	Male
127	Makueni	Patrick muisyo	Male
128	Makueni	Jackson mwikya kioko	Male
129	Makueni	Janniffer kyalo	Female
130	Makueni	Mwedwa mutuli	Male
131	Makueni	Rose Mwatu	Female
132	Makueni	Ann kanini	Female
133	Makueni	Florence Naom	Female
134	Makueni	James kioko	Male
135	Makueni	Samuel sila	Male
136	Makueni	Veronica kanini	Female
137	Makueni	Pius m kakuta	Male
138	Makueni	Zipporah mutuku	Female
139	Makueni	Willy mang'eli	Male
140	Makueni	Makau kimanthi	Male
141	Makueni	Redempta nduku	Female
142	Makueni	Theresia mbiku	Female
143	Makueni	Elizabeth mumbe	Female
144	Makueni	Petronilla mukonyo	Female
145	Makueni	Anne mutete	Female
146	Makueni	Monica wanza	Female
147	Makueni	Phyllis wasya nzuo	Female
148	Makueni	Sylvia muthini muthoka	Female
149	Makueni	Ruth munuve	Female
150	Makueni	Catherine mbinya muithya	Female
151	Makueni	Veronica's kyengo	Female
152	Makueni	Naomi mwololo	Female
153	Makueni	Francis kinyili	Female

154	Makueni	Makisya kioko	Male
155	Makueni	Benjamin musyoki	Male
156	Makueni	Benideta nzoloi	Female
157	Makueni	John mwangangi	Male
158	Makueni	Anne mwelu	Female
159	Makueni	Magdalene Mumbua	Female
160	Makueni	Redempta mukui	Female
161	Makueni	Dominic voola	Male
162	Makueni	Rosemary kamene	Female
163	Makueni	Mary mulekye kitheka	Female
164	Makueni	Agnes mwove	Female
165	Makueni	Elizabeth sutini	Female
166	Makueni	Juliana mueni	Female
167	Makueni	Rose waki	Female
168	Makueni	Beatrice mukii	Female
169	Makueni	Stephen muema mutiso	Male
170	Makueni	Patricia mbuvi	Female
171	Makueni	Paul mwanza ndisya	Male
172	Makueni	Naom kioko	Female
173	Makueni	Bernard kinyili	Male
174	Makueni	Julius muli	Male
175	Makueni	Theresia waeni	Female
176	Makueni	Milca nduku	Female
177	Makueni	Mutuse mbinda	Male
178	Makueni	John mutuse	Male
179	Makueni	Christine muthoka	Female
180	Makueni	Mutiku mwonga	Male
181	Makueni	Jackon ngumbau wavweo	Male
182	Makueni	Janet musyoki	Female
183	Makueni	Willy kasuva	Male
184	Makueni	Boniface kavithi	Male
185	Makueni	Veronica ngumu	Female
186	Makueni	Petronilla kilugya	Female
187	Makueni	Mutindi	Female
188	Makueni	Peninnah wambua	Female
189	Makueni	Jacintah muthini	Female
190	Makueni	Mary munyiva mutisya	Female
191	Makueni	Reginah mutinda	Female
192	Makueni	Phyllis Nduva	Female
193	Makueni	Francis Muthoka	Male

194	Makueni	Japheth nguyo	Male
195	Makueni	Solomon ngolia muli	Male
196	Makueni	Patrick munyao mutunga	Male
197	Makueni	Juliana kyusya	Female
198	Makueni	Teresia nthenya	Female
199	Makueni	Alex musembi	Male
200	Makueni	Annastacia ndunge	Female
201	Makueni	Sarah mueni	Female
202	Makueni	Agnes kiilu kituu	Male
203	Makueni	Victor musyoki mutisya	Male
204	Makueni	Mary mwende mutinda	Female
205	Makueni	Christine mutuku	Female
206	Makueni	Sammy mutua	Male
207	Makueni	Musau kimeu	Female
208	Makueni	Raphael mumo	Male
209	Makueni	Fransca muisyo	Female
210	Makueni	Agnes ndunge	Female
211	Makueni	Francis nzyula	Male
212	Makueni	Aron maingi	Male
213	Makueni	Francisca mwongeli	Female

Annex 2

LIST OF ENUMERATORS INVOLVED IN BASELINE SURVEY.

Kiambu: 20th -27th July 2022

Makueni: 21st -25th June 2022

S/No	Name	County	Gender	Activity
1	Elizabeth Mumbi Kioko	Makueni	F	Households
2	Albanus Muia Mutisya	Makueni	M	Households
3	Stephen Mwangangi Musyoni	Makueni	M	Households
4	Erick Mulei Kithuka	Makueni	M	Households
5	Anne Waithera Njoroge	Kiambu	F	Households
6	Naomi Wamboi Ruhara	Kiambu	F	Households

7.	Mercy Wamaitha Njoki	Kiambu	F	Households
8.	Ndirangu Anthony Chege	Kiambu	M	Households

REFERENCES

Miller, D. C., Muñoz-Mora, J. C., Rasmussen, L. V., & Zezza, A. (2020, September 16). Do Trees on Farms Improve Household Well-Being? Evidence From National Panel Data in Uganda. *Frontiers in Forests and Global Change*, *3*. https://doi.org/10.3389/ffgc.2020.00101

Bharucha, Z., & Pretty, J. (2010, September 27). The roles and values of wild foods in agricultural systems. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 2913–2926. https://doi.org/10.1098/rstb.2010.0123

Ickowitz, A., McMullin, S., Rosenstock, T., Dawson, I., Rowland, D., Powell, B., Mausch, K., Djoudi, H., Sunderland, T., Nurhasan, M., Nowak, A., Gitz, V., Meybeck, A., Jamnadass, R., Guariguata, M. R., Termote, C., & Nasi, R. (2022, July). Transforming food systems with trees and forests. *The Lancet Planetary Health*, *6*(7), e632–e639. https://doi.org/10.1016/s2542-5196(22)00091-2

Nosipho Hlophe-Ginindza, S., & Mpandeli, N. (2021, January 20). The Role of Small-Scale Farmers in Ensuring Food Security in Africa. *Food Security in Africa*. https://doi.org/10.5772/intechopen.91694

Kuyah, S., Whitney, C. W., Jonsson, M., Sileshi, G. W., Öborn, I., Muthuri, C. W., & Luedeling, E. (2019, September 9). Agroforestry delivers a win-win solution for ecosystem services in sub-Saharan Africa. A meta-analysis. *Agronomy for Sustainable Development*, *39*(5). https://doi.org/10.1007/s13593-019-0589-8