ADOPTION OF MELIA (*Melia volkensii,* Gürke) BY FARMERS IN MAKUENI COUNTY, KENYA

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N50/CTY/PT/23530/2013

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF ENVIRONMENTAL STUDIES AND COMMUNITY DEVELOPMENT IN THE SCHOOL OF ENVIRONMENTAL STUDIES OF KENYATTA UNIVERSITY

NOVEMBER, 2021

DECLARATION

Declaration by candidate

This research thesis is my original work and has not been presented for a degree in any other university or any other award.

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ACKNOWLEDGMENT

I would like to appreciate all who made this work possible and successful. I am indebted to my supervisors, Dr. Joseph Kurauka and Dr. Mary Baaru for their guidance, insights, and support throughout. My heartfelt appreciation goes to my husband, Dr. Geoffrey Ndegwa, for financial and spiritual support as I undertook the research work. I really appreciate my classmates and workmates for encouragement and positive criticism as I undertook this work. Lastly, to the Almighty God for the grace to carry out this work successfully. May the Lord bless you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Selective logging of hardwood species in the natural woodlands of Eastern Kenya has led to a drastic decline of hardwood species available for building and construction in the region. One of the species immensely affected is *Melia volkensii*, Gürke (Meliaceae, Mahogany family) a hard wood, fast maturing species indigenous in Eastern Kenya, whose wood fetches high market prices. Through agroforestry, its adoption has been promoted by government and non-governmental organizations, to restore it as well as fill in the rising demand for hardwood timber. Establishment and management of *Melia volkensii* to maturity and harvesting requires high investment capital. The rewards are long-term as the tree takes 10-15 years to maturity for timber harvesting. The study therefore hypothesizes that household's income level influences its adoption. Households with higher income are more likely to invest in *M.volkensii* compared to low-income households. The objectives of the study were to investigate the agroforestry practices in which *M.volkensii* was adopted, to assess the role of household income levels in adoption and to investigate the major challenges facing its adoption. The study was conducted in Kibwezi subcounty, Makueni county, which was purposively selected due to high number of *M.volkensii* growers compared to other counties. Descriptive research design was employed. Through random sampling, a sample of 120 households of *M.volkensii* adopters and 80 non-adopters was identified. Data was collected through a semi-structured questionnaire administered to an adult or adult equivalent in each household. The data was analysed using SPSS and Ms. Excel. A logit regression was used to determine the characteristics that influenced adoption of *Melia*. On agroforestry practices, intercropping and household planting were the most preferred practices by 80% and 71% of the respondents respectively. ANOVA test on the mean number of trees in the different practices was significant (p=0.00), with woodlots holding the greatest number of trees. The results showed that household income level significantly influenced adoption (p=0.00). The challenges faced during adoption were lack of capital, unavailability seedings, lack of information, labour demand and competition with crops. Log regression was conducted on factors affecting adoption showed that the significant factors were gender and education of the household head, household size, farm size, access to credit, household income and distance to the nearest market center. The study concluded that the preferred agroforestry practices for *M.volkensii* were intercropping for timber and homestead planting for seed production, hence recommends interventions such as trainings, fit for these practices. Household income level influenced adoption; thus, the study recommended provision of affordable credit to encourage adoption. On the challenges, the study recommended strengthening farmer groups and resource centers so that information is easily available and training farmers on seed production and nursery management.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

The drylands cover 40% of the earth's surface and support 30% of the global population (FAO, 2019). The inhabitants are mostly poor with16% living in chronic poverty (Ministry of devolution and the ASALS, 2019). The drylands are subjected to unsustainable land use practices, extreme climate conditions and population growth, which lead to land fragmentation, food insecurity, carbon emissions and social and political instability (UNCCD, 2020).

In Kenya, land degradation and loss of land cover is quickly leading to loss of biodiversity and livelihood (Kiruki *et al*., 2016). The woodlands are subjected to fragmentation and selective logging of hardwood species for fuel, building materials, grazing and clearing land for agriculture (Ndegwa *et al.,* 2016), thus diminishing the social and economic services offered by these woodlands.

Agroforestry has been found effective in restoration of degraded woodlands through agroforestry practices such as boundary planting, fruit orchards, woodlots, fodder banks and homestead planting among others (Wanjira and Muriuki, 2020). The species under restoration in the drylands include *Melia volkensii, Grevillea robusta* A.Cunn. ex R.Br. and *Eucalyptus camaldulensis* Dehnh for timber (Wekesa *et al.,* 2012). In addition, *Croton megalocarpus* Hutch, *Senna siamea* (Lam.) H.S.Irwin & Barneby, *Acacia species* and *Azadirachta indica* A. Jussieu (Wanira and Muriuki, 2020) are planted for fuel, shade and fodder. Among these species, studies have shown that *M. volkensii* is highly profitable (Wekesa *et al.*,2012) and provides resilience during draught seasons (de Leeuw *et al*., 2014).

M. volkensii is a draught resistant hardwood tree species indigenous in Eastern Africa. It is a multipurpose species valued for hardwood timber, whose quality compares to that of mahogany (Mulatya *et al.,* 2002). The wood is termite resistant making it suitable for poles, doors and window frames. Other uses include fodder, fuelwood, wood carving, bee forage and medicinal bark (Wekesa *et al*.,2012). However, its adoption rate by farmers is rather slow, necessitating this study, which aims at evaluating the role of income in its adoption as well as the challenges experienced by farmers.

Unlike conventional agriculture that generates immediate income, the return on investment of some agroforestry practices occur after several years, thus farmers have to absorb the initial costs of establishment and management before the investment finally pays off (FAO, 2013). This is the case with *M. volkensii*, as it takes about 10-15 years to maturity for timber. In addition, its establishment requires high initial capital investment, meaning only the food-secure and opportunity seeking farmers can afford to invest in it (Sanou *et al.*,2017). This led to the hypothesis that resource poor farmers may not invest in *M. volkensii* despite the projected high returns. While efforts to introduce *M. volkensii* in the study area would seem ideal to the implementing agents, understanding the challenges farmers faced during adoption was also vital.

Lastly, successful agroforestry practices are those that seamlessly integrate with existing farming practices and utilize the existing mechanical and technical resources and knowledge (Walia and Walia.,2020), such that a farmer does not have to make major changes to accommodate the practice. Thus, the study will evaluate the most favored agroforestry practices for *M. volkensii* by the farmers.

1.2 Statement of the Problem

Natural woodlands in Eastern Kenya are highly depleted of *M. volkensii* due to selective logging and fragmentation of land, creating high demand for hardwood timber. Integration of *M. volkensii* on farmland creates opportunities to meet the demand for timber as well as conservation of the species. Although a good number of farmers has adopted *M.volkensii*, there remains a demand- supply gap for its timber, which necessitated this study (Muthike and Githiomi, 2020).

Adoption is a matrix of biophysical and socio-economic factors (Mwase *et al.*, 2015). Agroforestry technologies need to integrate with existing farming enterprises, minimize displacement of existing crops and utilize existing mechanical and technical resources (Walia and Walia., 2020). The study sought to understand how farmers integrated *M.*

volkensii into their farms, focusing on four basic agroforestry practices; intercropping, woodlots, homestead planting and boundary planting, as presented by Maluki *et al.* (2016).

The activities involved in establishment and management of *M.volkensii* included land preparation, pitting, planting, fencing, weeding, annual pruning, security, harvesting and processing of logs to roundwood and timber and transportation to the market (Wekesa *et al*., 2012). These activities are labor intensive and expensive making *M. volkensii* farming a high-cost venture (Wekesa *et al.*, 2012), in a region whose poverty index ranges between 34-44%, compared to the national index of 36.1% (Diwakar and Shepherd, 2018). It was therefore hypothesized that only households with high income were able to venture into *M. volkensii* farming.

1.3 Objectives

1.3.1. General Objective

The general objective of this study was to assess the adoption of *Melia* by farmers in Makueni county, Kenya, focusing on the role of income and challenges.

1.3.2 Specific Objectives

1. To examine the agroforestry practices in which *M. volkensii* was adopted in Makueni County, Kenya.
2. To assess the effect of household income levels on adoption of *M. volkensii* in Makueni County, Kenya.
3. To investigate the challenges faced in adoption of *M. volkensii* by small holder farmers in Makueni County, Kenya.

1.4 Research Questions

1) In which agroforestry practices is *M. volkensii* adopted in Makueni county, Kenya?
2) How does household income level affect adoption of *M. volkensii* by farmers in Makueni County, Kenya?
3) Which are the major challenges faced by farmers in Makueni County, Kenya during growth of *M. volkensii*?

1.5 Hypotheses

Ho_1: There is no significant difference in adoption of *M. volkensii* between different agroforestry practices found in Makueni County, Kenya.

$Ho_{2:}$ Income levels do not significantly influence the decision to adopt *Melia* in Makueni County, Kenya.

$Ho_{3:}$ Challenges faced by farmers do not hinder adoption of *M. volkensii* in Makueni County, Kenya.

1.6 Significance of the Study

The study sought to understand the major challenges the adopters faced during *M. volkensii* growing. The results and recommendations of the study would provide valuable inputs to the decisions made by policy makers, government, and non-governmental organizations as they promote *M. volkensii* adoption in Eastern Kenya. Understanding the barriers to adoption would enable them devise strategies to enable farmers sustainably invest in *M. volkensii.*

1.7 Limitation of the Study

The challenges experienced during data collection were terrain of the study area, which was rocky and hilly in some areas. In addition, the distance between households in some instances was far. The study overcame these challenges by engaging a local guide who was familiar with the region for ease of navigation. There were some instances where farmers were reluctant to disclose information. A clear explanation of the intention of the research was given and supporting documents presented. This created confidence among the respondents, thus participating in the research.

1.8 Conceptual Framework

A conceptual framework is a diagrammatic representation of the interaction between the variables. Figure 1.1 shows how the variables in the study interact.

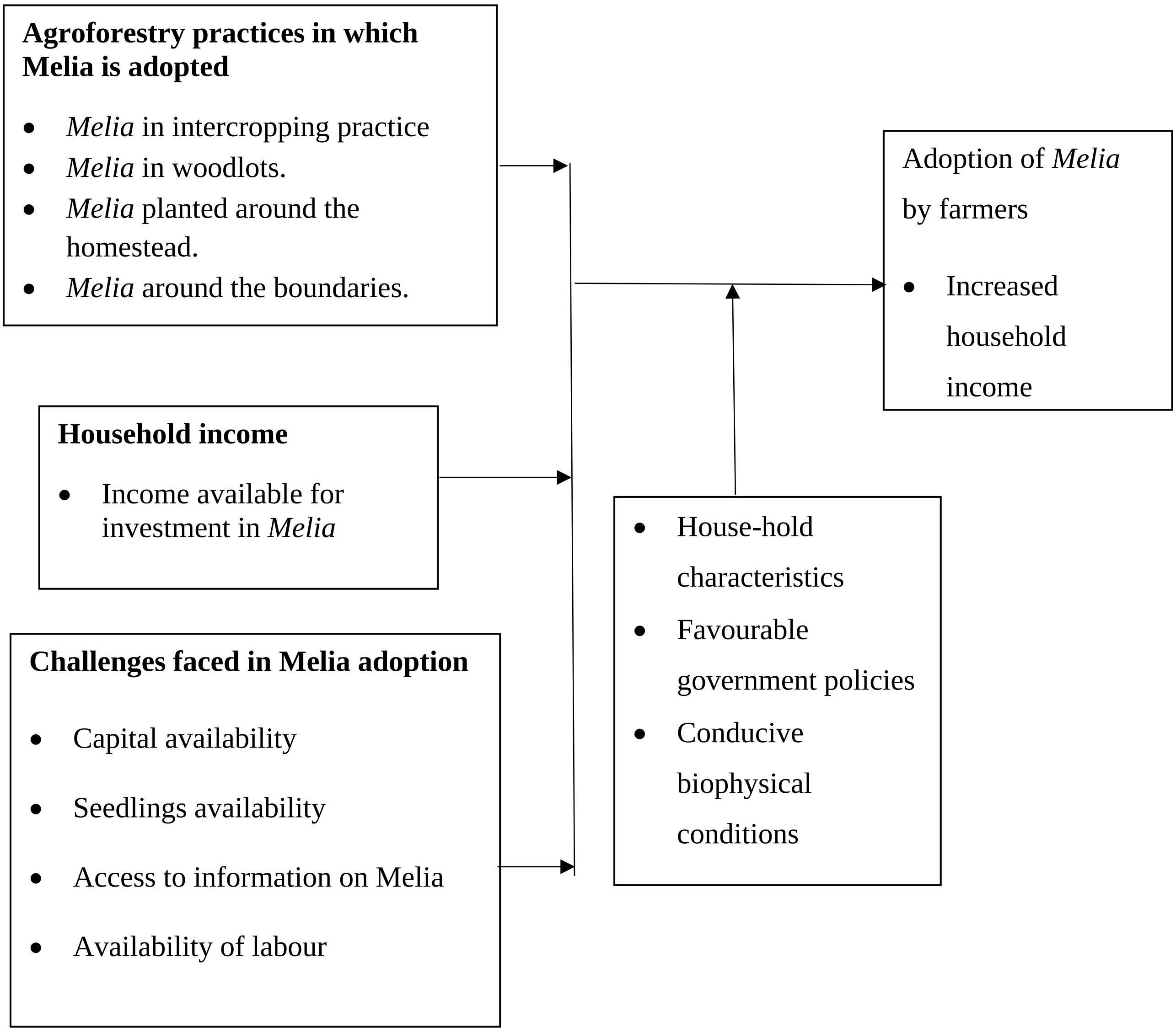

Figure 1.1. Conceptual Framework

Source: Researcher, (2021)

The study postulated that the dependent variable; adoption of *M. volkensii* by farmers was influenced by the household income levels, the ability of *M. volkensii* to integrate within the existing farming practices and the ability of farmers to address the existing challenges in adoption. Households with higher income levels were able to meet their immediate needs and have surplus income for investment in *M. volkensii*. On the other hand, households with low-income levels preferred to invest in ventures that have quicker returns, for example food crops.

Further, the experiences and challenges faced by early adopters during adoption and the ability of farmers to overcome these challenges does influence the adoption decision. Lastly, farmers adopt agroforestry practices that integrate well with their existing farming practices, equipment, and knowledge pool. Therefore, the ability of *M.volkensii* to meet these requirements influenced the adoption decision. These independent variables work in a set of intervening variables, which included household characteristics, policies, and conducive physical conditions. There needs to be right policies in place to support growing of *M. volkensii*, which could include ease of access to permits when harvesting and transporting tree logs. Further, the right physical environment for example good rains and access to water during dry seasons would support adoption. Interaction among these variables led to an increase in household income.

CHAPTER TWO
LITERATURE REVIEW

This chapter contains review of related literature as per the objectives of the study. Accordingly, the literature in this chapter was reviewed as per the following themes: the agroforestry practices in which *M. volkensii* has been adopted, household income levels, and challenges faced during adoption.

2.1 *Melia volkensii* Gürke: Taxonomy, Ecological Distribution and Uses

2.1.1 Taxonomy

Melia volkensii belongs to the family Meliaceae or the mahogany family, which has about 53 known genera and 600 species spread across the tropics and subtropics of the globe (Romeo, 2005). There are six species of Meliacea under study for potential to provide pesticides; *Azadirachta indica* A.Juss, *Azadirachta excelsa* (Jack) Jacobs, *Azadirachta indica* A. Juss, Azadirachta *siamensis* Velton, *Melia azedarach* L, *Melia toosendan Sieb, and Melia volkensii*, (Jaoko *et al*., 2020). The most common species of Meliacea in Kenya are *Melia azedarach*, also known as Chinaberry tree, famous for high quality timber and *Melia volkensii* (Jaoko *et al.*, 2020).

Melia volkensii has coppicing characteristics (Mulanda *et al*., 2012) and a dark heartwood which compares favourably with *Ocotea usambarensis* Engl. (camphor) and *Vitex keniensi*s Turrill (Meru oak) (Mulatya and Misenya, 2004). Its wood is termite resistant (Mulatya and Misenya, 2004). At the age of 5 years, under good management, it can be harvested for poles while it can be harvested for timber at the age of 10 to 15 years (Mulatya *et al*., 2002). It grows to a height of up to 20meters with a stem diameter of 25cm. Plate 1 below shows a young *M. volkensii* tree about 5 years old.

Plate 1: ***Melia volkensii*** **tree**

2.1.2 Ecological Distribution

The genus *Melia* is spread in the tropics of Africa, temperate Asia and in China (Jaoko *et al*., 2020). It is indigenous in the drylands of Eastern Africa (Ethiopia, Somalia, Tanzania and Kenya), and has been promoted for restoration of degraded landscapes in these regions (Luvanda *et al.,* 2015). In Kenya, *M.volkensii* is present in the Eastern Kenya region, in Taita Taveta, Makueni, Kitui, Meru and Wajir (Kamondo *et al.,*2016).

2.1.3 Uses of *Melia volkensii*

Melia volkensii is a fast- maturing multipurpose hard wood species. The multiple uses include timber which is suitable for making roof rafters, window and door frames, mortars and acoustic drums (Mulatya and Misenya, 2004; Mulatya *et al.,* 2002) due to the termite resistance properties. It's also used for poles, as an alternative to cedar which is increasingly diminishing from the market.   Compared to other timber species like

Grevillea robusta., *Senna siamea* and *Leucaena leucocephala* (Lam.) de Wit, studies rate *M. volkensii* among the best performing in the drylands (Mulatya and Misenya, 2004).

Its other uses include fodder (fruit and leaves), wood carving, fuelwood, medicine (bark), bee forage, mulch, and green leaf manure (Wekesa *et al*., 2012). Jaoko *et al*. (2020) reports that it has chemical compounds that repels desert locusts and inhibits growth of yellow fever mosquito larvae, thus potential for production of pesticides.

2.2 Agroforestry in the Arid and Semi-arid Lands of Kenya

Drylands cover 40% of the earth surface, supporting 30% of the global population (FAO, 2019). They are characterized by annual rainfall of less that 500mm, with a high spatial and temporal variability. The drylands' inhabitants are majorly poor, with over 16% living in chronic poverty (Ministry of devolution and the ASALS, 2019). Desertification is often driven by unsustainable land use practices, extreme climate conditions and population growth, which lead to land fragmentation, food insecurity, carbon emissions and social and political instability (UNCCD, 2020).

At a global level, there are efforts in place to respond to these challenges and counter desertification. Examples are the great green wall of the Sahara, which aims to build a green belt across the Sahara (UNCCD, 2020) and the Sahel irrigation initiative (World Bank, 2017). These initiatives aim at restoration of biodiversity, water, and soil conservation, building climate resilience and food security.

In Kenya, the arid and semiarid lands occupy about 89% of the country, hosting 38% of the population. They support 90% of the wildlife and 70% of the livestock herd (Ministry of Devolution and the ASALS, 2019). Restoration of the drylands involves introduction of draught tolerant species or species indigenous in the geographical region. These efforts are often successful when the species under restoration have multiple benefits to the community and easily integrate with existing farming practices (Walia and Walia, 2020).

On farmland, restoration is often done through agroforestry, where trees are deliberately introduced or retained in agricultural land (Magugu *et al.*, 2018). In the arid and semiarid lands, Wanjira and Muriuki (2020) indicate that agroforestry interventions work within the context of livelihood and resilience strategies, which targets high value tree species for income generation; sustainable rangeland management and largescale farming mechanization, where the right tree-crop configuration is done to allow mechanized farming.

Agroforestry is practiced in different systems namely: silvo-pastoral system where tree species are introduced in pastoral lands (Sunderland and Rowland *et al.,* 2019); agrosilvopastoral system where crop production is integrated with tree planting and fodder production; and agrosilvo systems where trees are introduced among annual crops. Agroforestry practices arise from these broad categories depending on the needs they respond to and the ease of management. Examples of these are hedgerows, woodlots, alley cropping, intercropping with annual crops, water conservation structures, home-gardening and boundary planting (ibid).

The choice for agroforestry practices among farmer vary on farm, at community and at landscape level and depend on the ability to meet farmers' physical and ecological needs (FAO, 2013). For example, in Costa Rica Cocoa plantations were intercropped with fast growing timber species, which not only offered shade to the cocoa plant, but also offered a form of "insurance in case of crop failure (Somarriba and Beer, 2010). Farmers in the highlands of Columbia were less likely to adopt agroforestry as they were already practicing coffee and tea farming, while those on lowlands were quick to adopt agroforestry fodder practices and homestead planting for fodder and shade respectively as they experienced longer drier periods (Rojas *et al.,* 2020).

Farmers invest in agroforestry practices if the expected rewards are higher than alternative land uses (Saha *et al.,* 2018). In Columbia woodlots, through farmer managed natural regeneration were the most preferred because they took little time and resources to establish and provided wood for fuel and construction while plantation forests were least preferred due to high labour intensity during establishment (Rojas *et al.,* 2020).

In Western Kenya, woodlots were established for commercial purposes and fuel by farmers with larger portions of land for building materials, income, fuel production and environmental services (Ndegwa *et al*., 2016). They were preferred because they allowed for mechanized harvesting without destruction of crops (Mandila *et al.*, 2015). Woodlots are also established in land unsuitable for crop production (Gebru *et al.*, 2019; Ndayambaje *et al*., 2013). Plate 2 below shows a *Melia volkensii* woodlot in Kibwezi subcounty.

Plate 2: ***Melia volkensii*** **woodlot**

Intercropping of trees on farm increases diversity and creates sustainability (Gebru *et al.,* 2019). It is suitable for multipurpose tree species that bring complementarity between trees and crops, for example where trees are planted to provide shade to cocoa (Somarriba and Beer, 2010) or where leguminous tree species are introduced on farm for nitrogen-fixation and soil restoration while providing fuel, fodder, building materials, food and medicine (Barros *et al*., 2017). A study by Wekesa *et al.,* (2012) indicated that profitability of *Melia volkensii* depended on the level of integration into the existing farming practices and value addition of trees. In the study, *M. volkensii* trees intercropped with green grams fetched the highest prices because of the symbiotic relationship as green grams are nitrogen fixing (ibid).

Around the homestead, multipurpose tree species are introduced in homegardens and often planted for multiple purposes such as fuel, fruits, fodder and shade (Maluki *et al.,* 2016). Homegardens are located close to the residences, they contain a high diversity of crops and trees, their production is supplemental, they occupy a small area and require very little investment to establish (Galhena *et al.,* 2013). A study done in Sri-Lanka indicated that homegardens provided food and nutrition security and income during political unrest periods, where farming in the fields was not possible (ibid).

Studies indicate that forest wood trees are often planted along the boundaries to control animal movement (Maluki *et al.*, 2016) and provide fodder and wood material for construction. In the tropics, fencing poles are often exposed to decay, requiring frequent replacement (Baker *et al.,* 2012), thus boundary planting offers long lasting solutions. In Central Kenya, *Grevillea robusta* is grown along boundaries providing timber and demarcation of land portions. *Melia volkensii* plays similar roles in Eastern Kenya (Kuyah *et al.,* 2020). In West Pokot, Kenya, boundary planting was the most common agroforestry practice because it suited *Croton megalocarpus* Hutchinson *and Grevellia robusta,* which were the most preferred tree species. Further it was an old practice, thus farmers were knowledgeable about it (Mandila *et al.,* 2015).

The choice of different agroforestry practices differs depending on the benefits they provide to farmers, socio-economic aspects such as land size, land ownership, initial investment versus derived income and political stability, thus the success in one region cannot be extrapolated to another region. There is therefore need to examine the agroforestry practices in which *Melia volkensii* is adopted in Makueni and the determinants of these choices.

2.3 Income as a Driver for Adoption of Agroforestry Practices

Often, agroforestry is perennial, hence the breakeven point may occur after some years (FAO, 2013). As such, farmers absorb the initial loss, before the ventures become economically profitable, hence farmers with diverse income sources, either from agriculture or other non-farm sources are more likely to venture into agroforestry

(Kassie, 2017). Income gained from agroforestry activities on the other hand acts as a motivation for farmers to adopt agroforestry technologies (Kiyani *et al*., 2017).

A study conducted by Sanou *et al*. (2017) on drivers of farmers' decision to adopt agroforestry in the Sudanian Savanna zone and Burkina Faso showed that household wealth was statistically significant in farmers' participation in tree conservation programmes. Further, Magugu *et al*. (2018) in their study on adoption of agroforestry in Nyando, Western Kenya, concluded that sub-subsistent (peasant and chronically food insecure) and subsistent (periodically food insecure) farmers were less likely to adopt agroforestry until provided with support inform of information and inputs. On the other hand, supra subsistent (peasant farmers with adequate resources, but constrained during illness or severe drought) were likely to adopt if provided with adequate information (Sanou *et al.,* 2017).

Mwase *et al*. (2015) in their study on factors affecting adoption of agroforestry and evergreen agriculture in Sothern Africa indicated that the high cost of initial investment was a barrier to adoption, thus households with low income were less likely to engage in agroforestry. As such, farmers engaged in agroforestry activities often have higher income that those engaged in pure agriculture. A study by Kiyani *et al*. (2017) indicated that the annual income of agroforestry adopters was significantly higher than that of non-adopters, which was a motivation for adoption of agroforestry (Sanou *et al*., 2017). On the other hand, a study on adoption of climate smart agriculture indicated that increased income was least likely to influence the adoption of fodder trees, with number of uses, availability of seedlings and maturity period taking more weight in influencing adoption (Morgon *et al*., 2015).

Agroforestry is a long-term investment and getting financing sources may encourage adoption (Rojas *et al.,* 2020). A study by Rojas *et al*. (2020) on factors affecting adoption of agroforestry practices in silvopastoral systems of Columbia indicated that farmers who had taken a loan in the past five years were more likely to invest in agroforestry by 5%, because the credit covered the initial costs of investment. Further, Oduro *et al*. (2018) reported that grants, incentives and subsidies, farming inputs, training and access to markets enhanced adoption of agroforestry products in Ghana.

Households that engaged in non-farm agroforestry activities to diversify their income were more likely to engage in agroforestry as noted by Kassie (2017), who indicated that farmers engaging in off-farm activities had less time and labour to engage in crop farming activities and thus chose to plant timber trees on farm, which was less time and labour involving. In addition, off-farm activities off-set cash constraints in a household and acted as a safety net, enabling farmers to invest in long term ventures such as agroforestry (Dhakal and Rai, 2020; Kassie, 2017).

Agroforestry value chains provide a range of income generation opportunities, most of which are less exploited. For *M. volkensii* in Kenya, the opportunities lie in seed collection and handling, seedling production, round wood and timber production (Luvanda *et al.*, 2015). However, success in these value chain activities is dependent on access to infrastructure and institutions. For example, Kassie (2017) reported less adoption of timber trees by farmers located away from roads, due to challenges in transportation of products to the market. Accessibility challenges also hinder access to agroforestry information, as extension workers do not easily reach these areas (Coulibaly *et al.*, 2016).

2.4 Barriers of Agroforestry Adoption

2.4.1 Lack of Capital for Investment in Agroforestry

Some agroforestry technologies are capital intensive and returns are often delayed as trees are perennial (Yila, 2016) thus investment capital is often a challenge to farmers adopting agroforestry for the first time. A study by Kiyani *et al*. (2017) on benefits and challenges in agroforestry adoption indicated that lack of capital was a challenge to 87% of the adopters of agroforestry technologies. Masibo *et al.* (2018) indicated that inadequate capital significantly affected adoption of homegardens, riparian planting, windbreaks, shade trees and boundary planting. Further, a scoping study on agroforestry technologies by Yila (2016) indicated that resource endowment (income, assets, livestock and labour) positively influenced agroforestry adoption in 60% of the studies under review.

Lack of capital could be solved by giving subsidies to farmers (Kiyani *et al.*, 2017) thus reducing the investment needs. Mwase *et al.* (2015) reported an increase in agroforestry adoption by 25% when farmers were given cash transfers as incentives and by 75% of farmers when early rewards from agroforestry were expected. Other forms of incentives that could advance adoption are tax breaks and concessional loans (Wanjira and Muriuki, 2020). Rojas *et al*. (2020) indicated that access to credit to cover for the initial cost of establishment and management positively influenced adoption of agroforestry practices, especially with good credit management systems. Yila (2016) recommends public-private partnerships, which would link small holder farmers to markets, engage major corporations and guarantee sustainability.

2.4.2 Competing Land Uses

Where land parcels are small, farmers tend to prioritize activities that meet their immediate needs, for example crop production and livestock rearing. Masibo *et al.* (2018) reported that competing land uses was a challenge with riparian planting, windbreaks, shade trees, woodlots, and boundary planting around Chepalungu Forest, Kenya.

A study by Mwase *et al.* (2015) on adoption of agroforestry and evergreen agriculture in Southern Africa reported 47.2% failure of adoption due to limited land. Further, Dhakal and Rai (2020) reported that farmers with large farm sizes were more likely to adopt woodlots as they had enough land for crop production and agroforestry. In addition, these were less risk averse. Farmers with smaller land portions on the other hand practiced alley cropping, although trees competed for nutrients and shade with food crops, thus risking the expected harvest (Dhakal and Rai, 2020).

A study in Ethiopia suggested that where non-food crop production was taking place, agroforestry adoption was likely to reduce, because the land apportioned for non-food crops and agroforestry competed. Agroforestry was likely to occur on degraded land, where crop production was limited (Kassie, 2016).

2.4.3 Raising Tree Nurseries

Raising successful tree nurseries is critical in agroforestry adoption as it determines the quality of products from these trees. Different tree seeds require different treatments regarding collection, breaking dormancy, nursery management and transplanting. Tree nursery operators therefore require knowledge and resources to avail quality seedlings for planting. Collection of seeds needs to take into consideration the genetic attributes of the mother tree (Kipkemboi *et al.*, 2018), thus the procedure involves identification of plus trees, from which seeds are collected (Kamondo *et al*., 2016). Farmers, unless guided, do not know how to identify plus trees, thus compromising the seed quality.

Seed processing varies with different species. Methods of breaking dormancy for example are soaking in cold water (*Tephrosia vogelii* and *Sesbania sesban* seeds), soaking in hot water, (*Acacia mangium* seeds), seedcoat nicking or cutting (*Acacia xanthopholoea*) or cracking nuts to extract seeds (*Melia volkensii* and *Podocarpus falcutus*) (Mbora and Wekesa, 2016).

Raising successful tree nurseries involves getting a good location, which is accessible by users, has reliable water source, good planting soil, safe from livestock, strong winds and on a gentle slope (World Agroforestry Centre, 2013). Nursery operators need to have knowledge of raising seeds till they are ready for transplanting as well as managing diseases and pests (World Agroforestry Centre, 2013).

A study conducted in Ethiopia reported that the main challenges in seedling production were lack of quality germplasm, water availability and market challenges, due to free distribution of seedlings by government and non-governmental tree nurseries (Dedefo *et al.*, 2016). Masibo *et al*. (2018) reported that challenges experienced in raising tree nurseries in Chepalungu forest area were unavailability of water supply, poor road network which hindered accessibility, lack of quality soils and inexperienced seed collectors who compromised the seed quality and lack of capital to ensure quality seedlings were raised.

Access to quality germplasm affects adoption of agroforestry technologies. In a study conducted in Uganda, lack of quality seedlings was a challenge to 49.5% of the respondents, which led to a proposal to establish community satellite nurseries to counter this challenge (Ntakimanye *et al*., 2020). Another study in Nigeria suggested that free distribution of tree seedlings to farmers could counter the challenge of accessibility to seedlings by farmers (Adedayo and Oluronke, 2014). Gosling *et al*. (2021) indicate that free distribution of seedlings lowers a farmer's investment cost and increases the probability of adoption. A study conducted in Uganda recommended formation of policies and guidelines to streamline seed collection and production of tree seedlings to ensure only quality seedlings were available for planting (Ntakimanye *et al*., 2020). Wekesa *et al.* (2012) also reported that *M. volkensii* seedlings were more costly, as its farmers spent more on propagation structures and labour.

Survival of tree seedlings is critical for successful tree planting initiatives. A study conducted on seedling survival rates in various parts of Kenya and Ethiopia showed that tree seedling survival in Kibwezi East was at 33.8% (Magaju *et al.,* 2020). The factors that influenced survival rates in Kenya were soil fertility, watering regime, hole size and the niche (Magaju *et al.,* 2020). Seedlings planted along internal boundaries and woodlands had a higher survival rate because they were protected from livestock (ibid).

2.4.4 Access to Information on Agroforestry Adoption

Access to information is key in agroforestry adoption. Agroforestry knowledge is transmitted through personal communication, extension agencies, face to face meetings, for example in farmer groups or barazaas, demonstration farm and public event. In the recent times, dispersion of information has embraced information communication technologies (ICTs) such use of GPS systems, mobile technologies, radios, televisions and the internet. ICT sources are rather complex for farmers unless they are cost-effective and farmers are educated enough to use them effectively (Wawire *et al*., 2017).

Farmer field days, demonstrations and workshops provided farmers with a two-way communication channel, creating opportunities for farmers to give feedback and also opportunities for genuine participation in trainings (Adolwa *et al*., 2012). Participation in group trainings provide farmers with opportunities to build networks, share technical information and build trust, which is necessary in diffusion of technologies (Rojas *et al*., 2020).

According to a study by Gitonga and Mukoya (2016) on influence of information sources on adoption of agroforestry practices in Kajiado sub-county, Kenya, the use of ICTs, neighboring farmers, extension agents and group meetings were statistically significant in influencing adoption of agroforestry practices. In a different study conducted in Western Kenya, radio and farmer field days were regarded by 13-19% of farmers as the most accessible, reliable and informative communication channels (Adolwa *et al.*, 2012).

Access to information through extension services positively influences adoption of agroforestry (Coulibaly *et al.*, 2016). A study by Liliane *et al. (*2020) also indicated that access to extension services was positively corelated to adoption of agroforestry, but it was not significant in predicting the decision to adopt agroforestry.

2.5 Literature Gap

The literature review section above has presented evidence on adoption of agroforestry practices and common barriers to adoption. Agroforestry practices ought to be compatible with and complement the existing farming practices. Further, the role of income as a driver to adoption has been discussed as well as barriers that hinder adoption of agroforestry technologies. However, there was little evidence on the agroforestry practices preferred for *Melia volkensii* given its economic importance in Eastern Kenya, the role household income plays in its adoption and the barriers farmers face during adoption. There is therefore need to collect data on its adoption to fill this gap and advance its adoption.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter presents the study area and the research design. It also presents the sampling procedure; the data collection instruments and the data analysis procedure.

3.1 Study Area

A description of the study area in aspects of location, climate and rainfall, population size, and food crops grown is given below.

3.1.1. Location

This study was conducted in Kibwezi sub-county, Makueni County (Figure 3.1) which was selected due to a higher adoption rate of *M. volkensii* compared to other counties in Eastern Kenya (Luvanda *et al*., 2015). The county lies between Latitude 1°35' and 3°00' South and Longitude 37°10' and 38°30' East. It has an area of 8,034 square kilometers. out of which 474.1 Km^2 form the Tsavo West National Park and 724.3 Km^2 form the Chyulu Game Reserve (Government of Makueni County, 2018). Administratively, Kibwezi sub-county is divided into two political constituencies: Kibwezi West and Kibwezi East. Through random sampling, data was collected from Kibwezi East, Kikumbulyu South Ward, Kinyambu and Kalungu sub-locations.

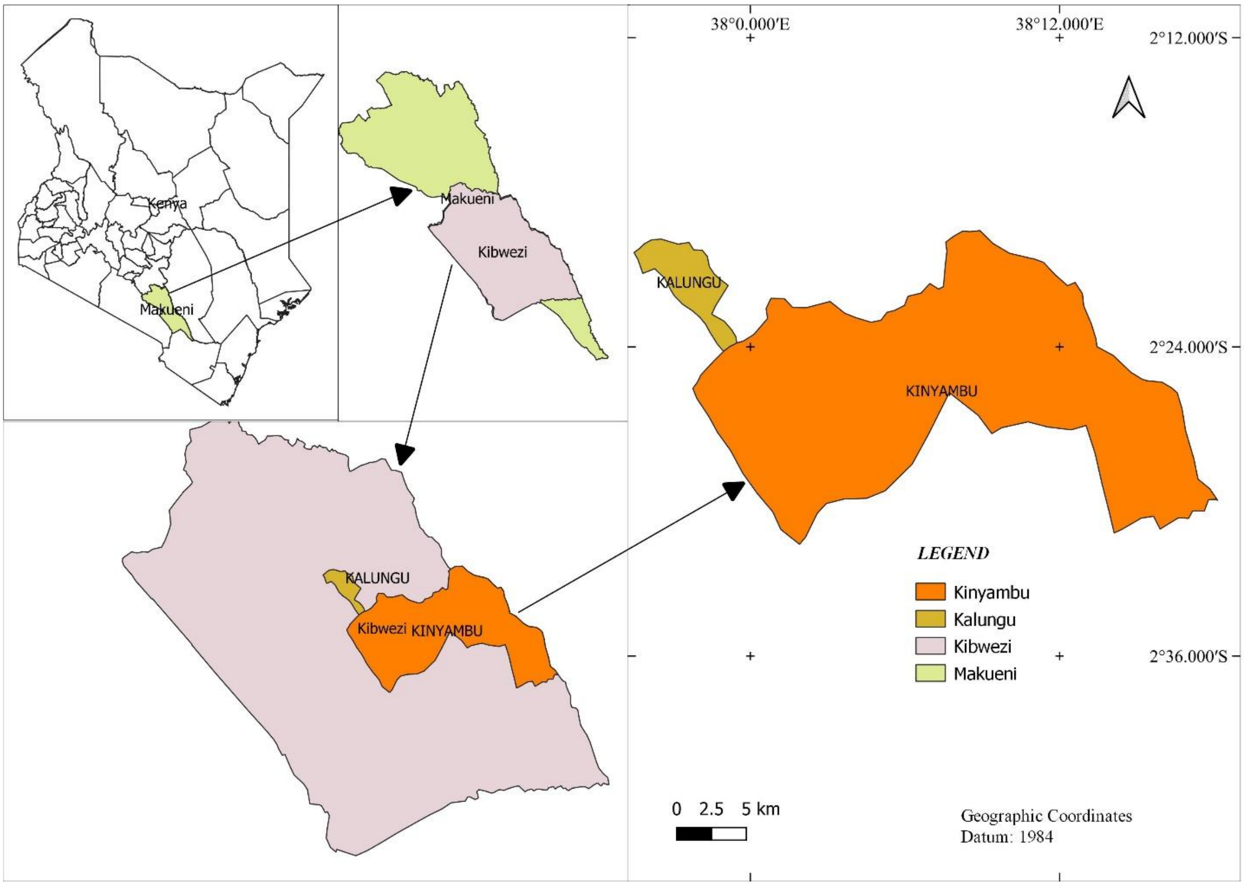

Figure 3.1: Study area showing the study area

3.1.2. Climate and Rainfall

Makueni County lies in the arid and semi-arid zone of Kenya (Maluki *et al.*, 2016). Kibwezi sub-county falls under agroecological zones IV to V. Agroecological zone IV is semi-arid, with rainfall ranging between 500-1000mm (Government of Makueni County, 2019). The natural vegetation is woodland dominated by *Acacia* species and shrubs. Agroecological zone V is much drier, with rainfall ranging from 300-600mm, dominated by savannah grass, *Acacia* species and thorny bushes (Government of Makueni County, 2019). Maximum temperature ranges from 25–32^{0}C while minimum temperatures range between 15–20^{o}C.

Kibwezi lies at an altitude of between 500-1000m above sea level and rainfall is bimodal, poorly distributed and occurring with high intensity. The long rains occur between October and December while the short rains occur between March and June (Maluki *et al.*, 2016).

3.1.3. Population Size

According to KNBS (2019), the county had a population of 987,653 (49.58% male; 50.42% female) in 244,669 households, with an average household size of 4.0 people. Kibwezi sub-county had a population of 197,000 people, which formed 20% of the total population in Makueni County and a population density of 63 persons per square kilometer (KNBS, 2019). Kinyambu and Kalungu sub-locations had a population of 9,807 and 5,523 people respectively (KNBS, 2019).

The illiteracy rate stood at 22.41% against the national rate of 28.59%. Most of the residents obtained secondary education, which had an enrollment rate of 76.6% (Government of Makueni County, 2019). Makueni County has a poverty index of 34-44% compared to the national index of 36.1% (Diwakar and Shepherd, 2018).

3.1.4. Crops Grown in Kibwezi Subcounty

The main crops grown are maize, green grams, pigeon peas, sorghum, mangoes, pawpaw and oranges. The county mainly relies on agriculture which accounts for 78% of the household income (Government of Makueni County, 2019).

3.2 Research Design

The study employed descriptive research design. Descriptive research design sheds light on current issues or problems by describing the characteristics or behavior of a sample population (Dudovskiy, 2018). The research design was selected because of the need to understand the role household income plays in adoption of *Melia volkensii* in Kibwezi sub-county through the use of both qualitative and quantitative data.

3.3 Target Population

Kinyambu and Kalungu sublocations had a total household size of 3988 households (KNBS, 2019). From these households, the target population for the study was 200 households, which comprised of 120 adopters (farmers with *Melia volkensii* on farm) and 80 non-adopters (farmers not planting *Melia volkensii*).

3.4 Sampling Procedure

Babbie (2020) indicates that sampling procedures allow a study to be conducted on a section of a population and the results are applied to the entire population. The study applied purposive sampling to select the Sub-County in which data would be collected. Purposive sampling uses past information of a group in relation to its relevance to the study (Alston and Bowles, 2018) and is used to identify cases for detailed investigation. Simple random sampling was then used to select the sublocations within which data collection would take place. Kinyambu and Kalungu sublocations were identified.

The study population was divided into two strata, based on whether or not farmers planted *M.volkensii* on farm. Farmers with *M.volkensii* were categorized as adopters while those without were categorized as non-adopters.

3.5 Sample Size

With the help of the local administration and village heads, lists of adopters and non-adopters in both sublocations were drawn. From these a total 1200 households were identified as adopters and 800 non-adopters. A sample size of 10% was randomly drawn from each cluster, based on the recommended 10% cluster sampling by DESA (2005), leading to identification of 120 adopters and 80 non-adopters.

3.6 Data Collection Instruments

To collect quantitative data, a semi-structured questionnaire was administered individually to the sample population. It was administered to the household head where available or a dependent of above 18 years where the household head was unavailable. A questionnaire was preferred due to its convenience both to the researcher and respondents. In addition to administering the questionnaire, observations on the farmland were made to corroborate the data provided. At the beginning of data collection process, the questionnaire was coded to the open data kit (ODK) system for ease in data collection and entry. The responses were keyed into the ODK during data collection and downloaded into excel file at the end of the data collection for analysis.

3.7 Validity of Research Instruments and Pilot Study

Validity is a measure of the extent to which the research instrument measures the intended phenomenon. A panel of experts was used to establish the content validity of the questionnaire. These were the two supervisors and three agroforestry experts from the World Agroforestry Centre. The comments were integrated into the questionnaire accordingly.

Random sampling was used to select 30 households outside those sampled for the study. The questionnaire was administered to these households as a test. This was done two weeks prior to data collection and was necessary to verify the reliability of the survey instrument. The piloting considered the timing for each survey; efficiency of the tools used in data collection, clustered questions, wrong phrasing, inconsistent and vague questions as well as anticipated analysis technique. All corrections were made before the data collection process began.

3.8 Data Analysis

At the end of data collection, the data was checked for completeness and downloaded from ODK to an excel file. Ms-Excel was used to analyse the quantitative data through descriptive statistics of mean, percentages and frequencies and presented in tables and graphs. This was done to describe the distribution of the sample according to their social-economic characteristics, which included farm sizes, education level of the household head, income sources for both adopters and non-adopters, information sources, seedling sources and credit sources. Further Z-test and Chi^2 tests were conducted in Statistical Package for Social Sciences (SPSS), to determine the statistical significance of the household characteristics (age of household head, household size, gender of household head), farm size, market distance and access to credit.

On data obtained from objective 1; agroforestry practices in which *Melia volkensii* was adopted, ANOVA tests were done on the mean harvest age and mean number of trees in each practice. Using Statistical Package for the Social Sciences (SPSS), logit regression was done to test for significance of the factors influencing adoption of *Melia volkensii*. Logit regression was preferred as it is mostly used in decision making, tests for the significance of each variable as well as goodness of fit assessment (Boateng and Abaye, 2019). The regression model according to Gujarati (1995) is presented below:

$$Li = 1n\left(\frac{Pi}{1 - Pi}\right) = \beta O + \beta_1 \times 1$$

where pi = the probability that Y = 1 (that the event occurs or probability of using); 1 − Pi = the probability that Y = 0 (that using does not occur); L = the natural log of the odds ratio or logit; βi = the slope, measures the change in L (logit) for a unit change in the explanatory variables (X); β0 = the intercept. It is the value of the log odd ratio; pi/1+pi when X or the explanatory variable is zero.

Qualitative data was analyzed through context analysis and thematic analysis with emphasis being placed on holistic description.

3.9 Ethical Considerations During the Study

Upon approval of the proposal, a research permit was obtained from the National Council for Science and Technology. The permit was presented to the local chief and village elders to seek authority and support during data collection. It was clarified that the data was for academic purposes only and that the respondents were at liberty to respond or withdraw from the study, in the event of discomfort at any stage of the data collection process.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results obtained from the study. It is divided into four sub-sections. The first section is the household demographics of adopters and non-adopters, the second section presents the agroforestry practices, the third section presents the results on income as a factor influencing adoption and the final section presents results on challenges faced during adoption of *Melia volkensii.*

4.1 Response Rate

The research targeted 200 respondents and all the 200 (100%) respondents successfully participated in the study. This was considered a good response rate according to Sivo *et al*. (2006), who indicated that a response rate above 90% was authoritative.

4.2 Household Demographics

The study sought to establish the demographic information about the households that participated in the study. This included age of household heads, household size, education level, gender of the household heads, income and land size. It was perceived that these characteristics played a role in farmers' decisions adoption of *Melia volkensii.*

4.2.1. Age of Household Heads

Table 4.1 below shows the age brackets of the respondents.

Table 4.1. Age of household heads

Age bracket	Adopters (n)	% adopters	Non-adopters (n)	% non-adopters
<20	0	0%	0	0%
20-29	2	2%	3	4%
30-39	18	15%	6	8%
40-49	33	28%	13	16%
50-59	32	27%	19	24%
60-69	20	17%	22	28%
>70	15	13%	17	21%
Total	120	100%	80.00	100%

As displayed above, there were no respondents below 20 years of age. In the age bracket of 20-29 years, the non-adopters were 4% compared to adopters who were 2%. However, in the age brackets of 30-39 years, 40-49 years and 50-59 years, the adopters were 15%, 28% and 27% respectively, compared to the non-adopters who were 8%, 16% and 24% respectively. Among those in the age bracket of 60-69 years and over 70 years, the non-adopters were 28% and 21% respectively, compared to the adopters who were 17% and 13% respectively. This was an indication that *M. volkensii* was mostly adopted by the middle-aged group of between 30 and 59 years.

4.2.2 Household Size

Table 4.2 below shows the household size of both adopters and non-adopters.

Table 4.2. Household size

Household size	Adopters (n)	% Adopters	Non-adopters (n)	% Non-adopters
1-2	15	13%	14	18%
3-4	46	38%	43	54%
5-6	39	33%	22	28%
>6	20	17%	1	1%
Total	120	100%	80	100%

Among the adopters, smaller household sizes of between 1-2 members and 3-4 members were 13% and 38% respectively, compared to 18% and 54% among the non-adopters. The adopter group had larger household sizes; those with between 5-6 members were 33% compared to 28% among the non-adopters, while households with above 6 members were 17% compared to only 1% among the non-adopters. This was an indication of the role played by household members in providing labour for *M.volkensii.*

4.2.3 Gender of the Household Heads

Table 4.3 below shows the gender of the household head among the adopters and non-adopters.

Table 4.3. Gender of the household heads

Gender of household head	Adopters	% adopters	Non-adopters	% Non-adopters
Female	12	10%	60	75%
Male	108	90%	20	25%
Total	120	100%	80	100%

The results also show that 90% of the adopter households were male headed compared to 25% of the non-adopter households. The results could be attributed to the inclination by male-headed households to plant timber trees for investment purposes, as opposed to female headed households that were inclined to growing multi-purpose tree species that provided fuel, fodder and fruits and improved soil fertility (Kiptot and Franzel, 2011).

4.2.4 Education Level of the Household Heads

The education level of the household head was important in the study and the responses are displayed in table 4.4 below.

Table 4.4. Education level of respondents

Education level	Adopters (n)	% Adopters	Non-adopters(n)	%Non-adopters
Completed tertiary college/university	25	21%	13	16%
Completed secondary school	34	28%	28	35%
Dropped out of secondary school	29	24%	17	21%
Completed primary school	26	22%	12	15%
Dropped out of primary school	3	3%	5	6%
Never gone to school	3	3%	5	6%
Total	120	100%	80.00	100%

M.volkensii adopters had higher education level compared to non-adopters in all categories except the category of those who dropped out primary school and those who never went to school. In both groups, majority of the respondents complete secondary school education; 28% among the adopters and 35% among the non-adopters. Further, those who dropped out of secondary school were 24% among the adopters and 21% among the non-adopters while those who completed primary education were 22% among the adopters and 15% non-adopters. This is an indication that education influenced adoption of *M. volkensii.*

4.2.5 Land Size

The study sought data on household land size as this was deemed important in adoption of *M. volkensii.* The data obtained is presented in table 4.5 below.

Table 4.5: The Mean Land Size by Adoption Status

	Adopters	Non-adopters	Z test	P value
Size of land owned by the household (acres)	5.48	3.94	3.57	0.02

On average, adopters of *M. volkensii* had larger parcels of land (5.48 acres) as compared to the non-adopters (3.94 acres). The difference in land size was significantly at P<0.05 confidence level. This could be attributed to the vital role played by land size when it comes to the adoption of *M. volkensii*. A household with larger land size has enough space to meet the needs for food crops and investment in *M. volkensii*. Besides, higher household income might be attributed to bigger land sizes as it encourages crop diversification, which directly boosts the disposable household income, which can be used to invest in *M. volkensii.*

The results tally with those reported by Kassie *et al*. (2017) where land size had a positive effect on adoption of agroforestry. In addition, Saha *et al.* (2018) reported similar results where large landholders were more likely to engage in agroforestry activities; they were able to take more risks and therefore survived adverse climate and crop failure seasons. A possible explanation was that farmers with large land parcels enjoyed the economies of scale, where the fixed costs of production were enjoyed over a large piece of land compared to a small land portion (Magugu *et al.,* 2018). However, Magugu *et al.* (2018) also reported that even farmers with small parcels of land may adopt agroforestry technologies, especially of multi-purpose tree species and soil conservation purposes.

4.2.6 Distance to the Nearest Market Center

Regarding access to public facilities and other services, there were variations in reported access to the nearest trading centres. Table 4.6 below shows that while *M. volkensii* adopters were closer (12.13 walking time in minutes) to the nearest market centers the non-adopters walked a longer distance (17.50 walking time in minutes) to reach the nearest market center.

Table 4.6. Distance to the nearest market center

Variable	Adopters	Non-adopters	Z-test	P value
Distance to the nearest market center	12.13	17.50	-2.06	0.04

This result demonstrates the importance of accessibility to information and other resources needed for adoption of *M. volkensii*. Adopters could easily access information, inputs and market for their products compared to the non-adopters.

Similar results have been reported by Kassie (2016) where distance to the nearest market significantly influenced adoption of agroforestry technologies. This is attributed to the ease of logistics, especially in transportation of logs and timber to the market (Binam *et al*., 2017). Kassie (2016) also reported a drop in adoption of Eucalyptus trees as one moved away from the shopping centers in Ethiopia. Proximity to the market gives opportunities to the farmers to supply building materials, timber and fuel wood. Dhakal and Rai (2020) reported increased probability for adoption of agroforestry with increase in distance from the forest to the household, as farmers found it difficult to access the forest, hence opted to plant trees on farm to meet their wood demand. Farmers closer to market centers have access to extension services, information and resource centers, hence have higher probability to adopt agroforestry (Gitonga and Mukoya, 2016).

4.3 Credit for *M.volkensii* Investment

Two aspects of credit were evaluated in the study. These were access to credit by the respondents and the available credit sources. Credit was considered important is this study as *M.volkensii* establishment and management requires financial investment.

4.3.1 Access to Credit

From table 4.7 below, 45% of the adopters had access to credit compared to 11% of the non- adopters. Credit access influenced adoption of *M.volkensii* in the study area ($p<0.05$).

Table 4.7. Access to credit.

Variable	Adopters	Non-adopters	Chi^2	P value
Access to credit	45.00%	11.00%	- 9.364	0.02

The respondents indicated that lack of capital for investment hindered adoption. Similar reports have been made, where credit or localized credit subsidies positively influenced adoption of agroforestry technologies in Ghana (Oduro *et al.,* 2018). In addition, use of credit to cover the initial cost of establishment of agroforestry was found to help farmers overcome the adoption barrier of lack of liquidity in Colombia (Rojas *et al.*, 2020). Similar results were reported by Zerihun (2020) in South Africa, where farmers who had access to credit were two times more likely to adopt agroforestry technologies that those who did not. Sanou *et al.* (2017) reported that in systems that hinder women from accessing credit and loan facilities, adoption of agroforestry technologies was low.

4.3.2 Sources of Credit

The study sought information on the sources of credit available for both adopters and non- adopters. From table 4.8 below, 26% of the adopters obtained credit from banks compared to 13% of the non-adopters. Cooperatives provided credit to 35% of the adopters and 38% of the non-adopters while credit from friends and family was accessed by 39% of the adopters and 50% of the non-adopters.

Table 4.8: Sources of credit for adopters and non-adopters

Credit source	Adopters (n)	%Adopters	Non-adopters(n)	% Non-adopters
Bank	14	26%	1	13%
Cooperative	19	35%	3	38%
Friends/family	21	39%	4	50%
Total	54	100%	8	100%

More adopters than non-adopters obtained credit from formal sources (banks and cooperatives), which was an indication of the ability to service the loans. For both adopters and non-adopters, credit from family and friends was the most accessible. This was an indication that affordable and low-risk credit facilities provided opportunities for adoption of *M. volkensii*, especially in the initial establishment. Olagunju *et al.* (2021), in a study conducted in Nigeria reported that the largest credit source for farmers was fellow farmers, through farmer groups, followed by cooperative societies. Binam *et al.,* (2017) in the Sahel, reported similar results, where farmer groups engaged in marketing and provision of credit to their group members. These sources were preferred due to ease of access, minimal formalities, and timely disbursement (Binam *et al*.,2017).

A study conducted by Moahid and Maharjan (2020), in Afghanistan indicated that at household level, access to formal credit significantly increased with increase in crop diversity, access to extension services and increase in the household size. These results tally with the results of this study, where more adopters that non-adopters of *M. volkensii* had access to bank credit facilities, as they were more assured of an income stream to repay the loan. They also had larger farm sizes, which were used as collateral for the loans unlike the non-adopters (Binam *et al*., 2017).

4.4 Log Regression on Demographic Factors Influencing Adoption of *M. volkensii*

A logit regression analysis was used to determine how demographic factors influenced adoption of *M. volkensii*. The logit model results have a strong explanatory power as demonstrated by the pseudo-R-square of 0.62; hence 62% variation in the dependent variables could be explained by the independent variables used in the regression, as indicated in table 4.9.

Table 4.9: Demographic factors influencing *M. volkensii* adoption

Variables	Coef.	S.E.	P value
Socio-economic factors			
Age of household head (years)	-0.02	0.01	0.07
Education of the household head (years)	0.04	0.05	0.04
Gender of the household head (1=male)	3.34	0.518	0.00
Household size (adult equivalent)	0.38	0.12	0.01
Major occupation of the household head (1=off-firm)	0.11	0.16	0.28
Log annual household income	1.77	0.71	0.00
Farm and Institutional factors			
Farm size (acres)	0.18	0.07	0.94
Distance to nearest market center (walking time in minutes)	-0.03	0.01	0.04
Access to credit	0.48	0.35	0.02
Constant	-10.31	4.08	
Sample size (n)	200		
Pseudo R square	0.62		
LR chi^2 (9)	166.32		

Education of the household head positively and significantly influenced the adoption of *M. volkensii*. Farmers who had obtained formal education were more likely to invest in *M. volkensii* compared to those with no formal education. The results tally with those obtained by Persha *et al.* (2015) who indicated that there was a higher probability of adoption of labour intensive, long-term agroforestry investments when a household head obtained formal education. Kiyani *et al.* (2017) also argue that more educated farmers are often the opinion leaders; they are innovative and willing to take risks. On the other hand, illiterate farmers have little access to information and tend to stick to their comfort zones, thus more informal education is required to boost their skills and capacities to adopt new technologies (Kiyani *et al.*, 2017). Similar results were reported by Saha *et al.* (2018) who reported that educated farmers had better access to innovations and information, thus more adoption of agroforestry technologies.

The gender of the household head had a positive influence on the adoption of *M.volkensii*. Male headed household were more likely to adopt *M. volkensii* as compared to female headed households. The results on the gender of the household head are similar to those reported by Kiptot and Franzel (2011) who indicated that men were more interested in timber trees while women were more likely to grow multi-purpose tree species that provided fuel, fodder and fruits and improved soil fertility. *M. volkensii*, being a primarily timber species therefore was likely to be preferred in male-headed households. Further, gender related decision making especially on resource allocation does influence the choice of agroforestry technologies and men were more likely to establish plantations on farm (Sanou *et al*., 2017). Magaju *et al.* (2020) reported that on labour division in tree planting, men were involved in labour intensive activities such as pruning and fencing while women were involved in activities as watering, mulching, and application of manure. This was an indication that where man-labour was not available in a household, it had to be outsourced, thus increasing the transaction cost of *M. volkensii* establishment in such households. However, Oduro *et al.* (2018) reported that in instances where tree planting programmes were available, gender of the household head did not play a role in adoption decisions.

The results reveal a difference in household sizes among both adopters and non-adopters. Measured in adult equivalent, the difference was significant and influenced adoption of *M. volkensii*. This indicated that *Melia* investment was labour intensive. Persha *et al.* (2015), reported similar results where households with more labour availability were likely to undertake labour- intensive, long-term agroforestry investments. Similar results are echoed by Liliane *et al*. (2020) whose study concluded that household size positively influenced adoption of labor-intensive agricultural technologies as they relaxed the labour demand.

Access to credit had a positive and significant difference indicating that access to credit increased the likelihood of *M.volkensii* adoption. This result can be attributed to the financial leverage access to credit had meeting the costs of initial investment. To encourage investment in *M. volkensii*, supporting access to affordable credit facilities and subsidies would be crucial.

Distance to the nearest market center had a negative and significant effect on *M.volkensii* adoption, indicating that farmers closer to the market centres were likely to adopt *M. volkensii*. This indicated that to reach to farmers further from the nearest centre, infrastructure was necessary. Another option would be organizing farmer groups in these regions in order to create leverage and reduce transaction costs.

4.5 Sources of Information on *Melia volkensii*

The results show that 29% of the adopters got information on *Melia* from farmer groups and resource centres, 24% from extension officers and only 17% from radio. On the other hand, 62.5% of the non-adopters got their information from radio, 23% from farmer groups and 15% from extension officers. No one from the non-adopter group visited resource centres.

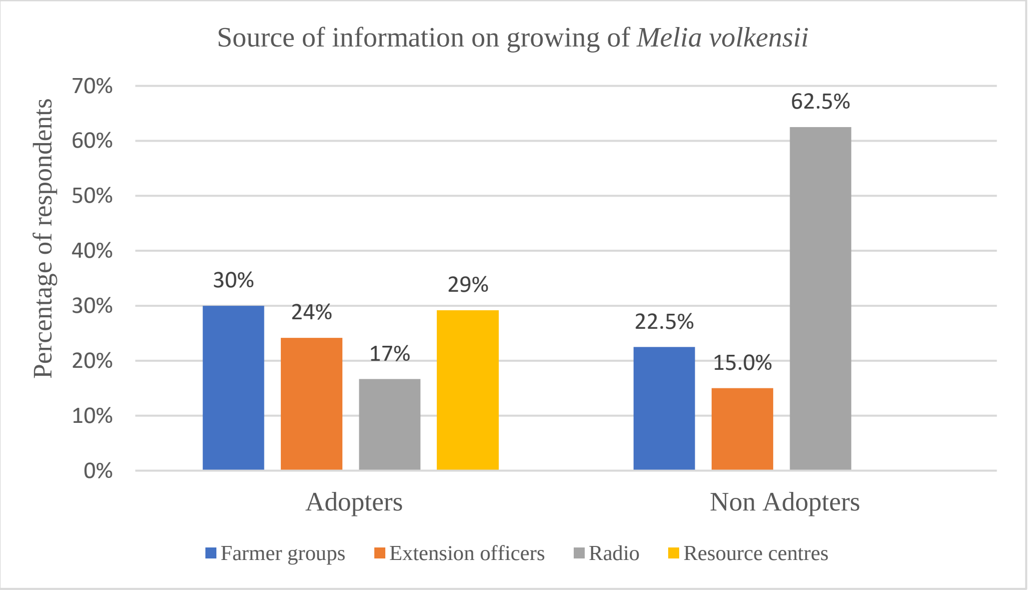

Figure 4.1: Sources of information on growing of *M. volkensii*

Mass media is recommended for raising awareness to a large population within a short period of time (Dhehibi *et al*., 2020), which explains the reason non-adopters got information mostly from radio. Excessive use of mass media however is ineffective to the target audience as it distributes theoretical rather than practical information (Gitonga and Mukoya, 2016). In their study, Dhehibi *et al.* (2020), reported that use of extension staff, other farmers and ICT (Information and Communication Technologies) were preferred in that order for information dissemination. While use of extension officers for dissemination of agroforestry information is effective, they are often not able to reach all target farmers, thus if used alone decreases the probability of adoption (Coulibaly *et al.*, 2016). In addition, Mwase *et al.* (2015), argues that where different extension agencies are present, instances of conflicting messages may occur. Further, FAO (2013), indicated that limited experience and low capacity among extension agents may negatively impact on adoption rates.

Cramb (2013), on the other hand argues that agroforestry innovations are not unidirectional-from research innovation to farmers, rather they evolve among researchers, development practitioners and farmers, and thus extension officers are not necessarily knowledge transfer agents. "The knowledge they transfer becomes "raw material" for farmer experimentation", thus the importance of farmer groups. The farmer groups therefore provide platforms for their participation, learning and appraisal (ibid) and diffusion of the technology among other farmers.

In their study, Luvanda *et al.* (2015) reported that there was formation of a model farmers' group for *Melia* in Eastern Kenya, from whose farms other farmers could learn. Similar recommendations were made by Mwase *et al.* (2015) who argued that farmers' participation in defining appropriate technology promoted adoption of agroforestry. Farmers from the study area reported benefitting more from fellow farmers compared to resource centers as most complained of long distances to the resource centres. Resource centres were accessed by adopters only in this study area because they are designed to provide targeted information (Dhehibi *et al.,* 2020). Face to face communication channel is often successful in dissemination of agroforestry information but selection of communication methods should be strategic and realistic to fit the target audience (Gitonga and Mukoya. 2016).

4.6 Sources of *M. volkensii* Seedlings

Government institutions were the biggest suppliers of seedlings at 57% followed by private nurseries at 32% and lastly, community group nurseries supplied seedlings to 12% of the respondents (figure 4.2).

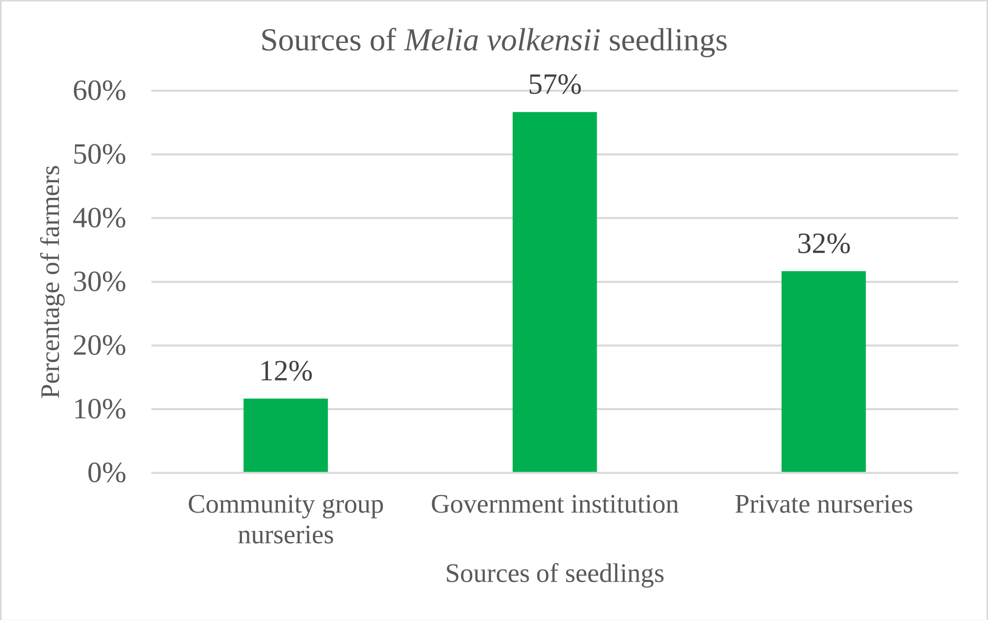

Figure 4.2: Source of *M.volkensii* seedlings

According to the report given by farmers, seedlings available to farmers during planting season did not meet the market demand. Indeed, Mwase *et al.* (2015) had similar observations that where government institutions were responsible for production and distribution of planting materials, they hardly meet the demand due to low funding by their governments, hence non-governmental organizations (NGOs) and community-based (CBOs) organizations filled in the demand gap. While the latter compromised on quality of the seeds, Cramb (2013) noted that quality of seedlings did not deter farmers from adoption. This however presented a risk of distribution and multiplication of low-quality seeds, which eventually would lower the timber quality (ibid).

FAO (2013) indicates that in most developing counties, germplasm production is an underdeveloped field and most farmers are unaware of propagation methods. The seed collection and germplasm multiplication of *Melia* is largely informal and presents a huge opportunity for regularization, through training and certification of nurseries (Odoi *et al*., 2019). There are opportunities around seed and seedling production for the community and private sector nurseries with the support of government institutions to produce quality germplasm and for government institutions to provide training and certification of these materials.

4.7 Agroforestry Practices Under *M. volkensii*

To respond to objective 1 on the preferred agroforestry practices for *M. volkensii*, three aspects were investigated. These were the number of farmers with *M. volkensii* in the different agroforestry practices, the crops grown by adopters and non-adopters, the harvest ages of *M. volkensii* under the various agroforestry practices and the number of tree under these agroforestry practices. The harvest age and number of trees was done to evaluate whether they influenced the choice of agroforestry practices for *M. volkensii.*

4.7.1 Farmers with *M. volkensii* Under Different Agroforestry Practices

Figure 4.3 below shows the percentage of farmers with *M.volkensii* under the different practices. The results showed that intercropping and homestead planting were the most preferred practices for *M. volkensii*, with 80% and 71% of the farmers practicing them respectively. Woodlots and boundary planting were least preferred, with only 23% and 13% of the farmers practicing these respectively.

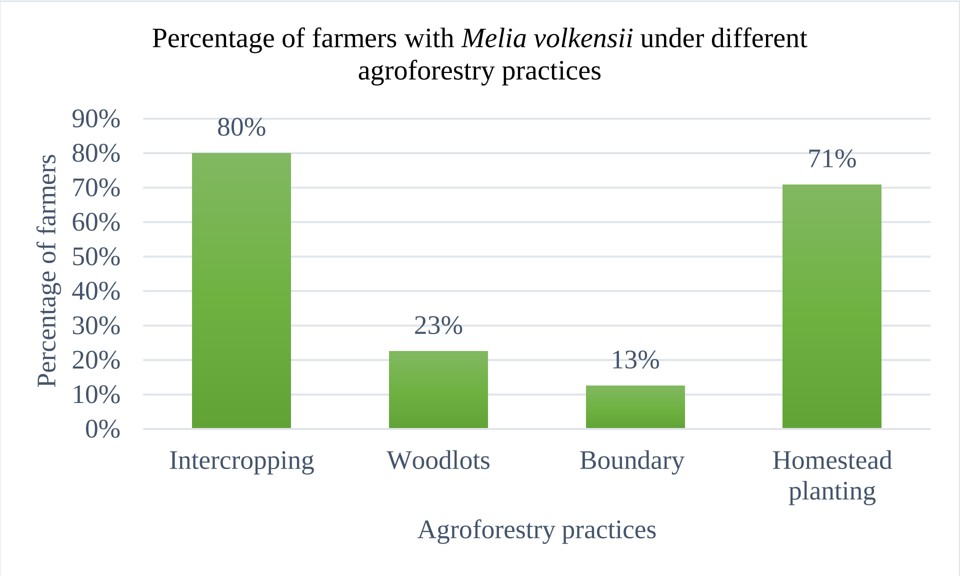

Figure 4.3. Percentage of households with *M. volkensii* under different agroforestry practices

From the results, the study rejects the null hypothesis 1, which stated that there was no significant difference in adoption of *M. volkensii* among agroforestry practices in

Kibwezi sub-county in Makueni county. The results showed preference for intercropping and homestead planting.

The study sought to establish whether or not farmers altered the agroforestry practices as *M.volkensii* grew of farms. Table 4.10 below indicates that in all agroforestry practices, the age of *Melia* trees ranged from very young to almost mature trees. This was an indication that the agroforestry practices did not change as *M.volkensii* grew on farm.

Table 4.10 Average age (in years) of trees on farm in the different agroforestry practices

Agroforestry practice	Mean age	Minimum	Maximum	Std. Deviation
Intercropping	7.75	1.5	15	2.90
Homestead planting	8.35	2.5	15	3.26
Boundary planting	7.53	3	13	2.80
Woodlots	6.78	3.5	11	2.04

Possible explanation for the preference of intercropping would be the economies of scope realized in intercropping (Gosling *et al.*, 2021) where activities such as land preparation and weeding are done, when tending to food crops. This lowers the cost of production. A study by Wekesa *et al*. (2012) reported that the net present value of *Melia volkensii* was highest when the species was intercropped with green grams during establishment. This could be because the trees benefit from the nitrogen-fixation character of green grams and could explain the preference for intercropping as the study area is a large producer of green grams. In addition, intercropping with legumes ensures total weed control among the trees until harvest, which is required for the first three years of planting *M. volkensii* (KFS, 2018). In a study on evaluating growth performance of *M. volkensii* in Kifu forest, Uganda, the results indicated that *M. volkensii* performed best when intercropped with shorter crops such as tomatoes rather than taller crops such a maize, due to shading (Ongerep *et al*., 2016).

The preference for intercropping of *M. volkensii* could also have been because of small land portions which did not allow for woodlot establishment. Mwase *et al.* (2015) reported similar results, where intercropping of trees on farm was the most common practice among farmers with an average land sizes. In another study by Saha *et al.* (2018) intercropping of timber and fruit trees was practiced for income; both in the short and long-term, among farmers with smaller land portions. Although not significant, intercropped tree species had the fastest average maturity rate of 11.25 years. Given that *Melia* is an income-generating investment, the earlier maturity age could have been a reason for the high preference for intercropping. Similar results were reported by Mwase *et al.* (2015) where early rewards for trees species was an adoption enabler.

4.7.2 Harvest Ages for *M.volkensii* in the Different Agroforestry Practices

The harvest age of *M. volkensii* was different in the various agroforestry practices, with intercropped trees maturing fastest at an average age of 11.55 years, followed by trees on the boundary at 13.50 years. Woodlots and trees around the homestead matured at a mean age of 13.67 and 14.20 years respectively (table 4.11).

Table 4.11: Average harvest age of *M. volkensii* under different agroforestry practices

Agroforestry practice	Mean	Minimum	Maximum	Std. Deviation
Homestead planting	14.20	9.00	19.00	1.906
Boundary planting	13.50	11.50	16.00	1.24
Woodlots	13.67	11.00	16.00	1.27
Intercropping	11.55	8.00	15.00	1.30

ANOVA test was conducted on the mean harvest age to determine its significance in selection of agroforestry practices for *M.volkensii* by farmers. The results showed that there was no significant difference between harvest ages of trees planted in the different places (P>0.05).

Table 4.12: Analysis of variance (ANOVA) on harvest age

Source	SS	df	MS	F	Prob > F
Between groups	13344.9	3	4448.30137	0.71	0.5491
Within groups	1372588	218	6296.27497		
Total	1385933	221	6271.18935		

Homestead planting is preferred for multipurpose trees that provided food and fuel in the short term, while awaiting the long-term benefits of wood and timber (Mandila *et al*., 2015). Moreover, Mandila *et al*. (2015) also reported that homestead planting was preferred in Bangladesh because the trees were easy to manage, provided household fuel and food and cushioned farmers during crop failure. Home gardens are reported to have high genetic diversity and high potential for in-situ genetic conservation (Avilez *et al*., 2020). With the long maturity period reported for *Melia* trees under homestead planting and the few number of trees, it is unlikely that farmers established these for timber, rather they established them for genetic conservation and seed harvesting. It is convenient for them to collect the seeds and establish nurseries within the home compound.

Studies report that woodlots are established for production of poles and timber for income generation (Saha *et al.*, 2018; Mandila *et al*., 2015) where farmers have large tracks of land. In this study, *Melia* woodlots took the longest time to maturity and may not have been preferred because generally farmers had small portions of land, which did not allow them to set aside portions for woodlot establishment.

Boundary planting was preferred for multipurpose tree species, those providing food, fuel, shade aesthetic value and demarcation. Tress on boundaries reduce soil erosion while acting as wind barriers and are easy to establish and manage (Mandila *et al.*,2015). Boundary planting in Bangladesh was preferred for fencing and soil stabilization (Saha *et al.*, 2018) hence was not the most appropriate practice for *M. volkensii* as it is harvested after a duration of time.

4.7.3 Number of Trees in the Different Agroforestry Practices

In terms of the number of trees planted, woodlots held the greatest number of trees at a mean of 263 trees. This was followed by trees under intercropping with a mean of 123 trees. Trees under boundary and homestead planting had an average of 27 and 51 tress, respectively (table 4.13).

Table 4.13: Number of *M. volkensii* trees under different agroforestry practices

Agroforestry practices	Mean	Minimum	Maximum	Std. Deviation
Boundary planting	27.00	9.00	55.00	15.82
Intercropping	124.00	15.00	356.00	70.81
Around homestead	51.00	18.00	125.00	30.50
Woodlots	263.00	135.00	450.00	83.95

To establish whether the number of trees significantly influenced choice of agroforestry practices for *M.volkensii*, ANOVA test on the mean number of trees was conducted. There was a significant difference in the number of trees planted on the boundaries, intercropped, around the homestead and on woodlots ($p<0.05$).

Table 4.14: Analysis of variance (ANOVA) on mean number of trees

Source	SS	df	MS	F	Prob > F
Between groups	974232.8	3	324744.272	73.27	0.000
Within groups	970615	219	4432.03206		
Total	1944848	222	8760.57585		

Woodlots had significantly high number of trees compared to the other practices. However, this did not influence the choice of agroforestry practices for *M.volkensii.*

4.7.4 Crops Grown by Adopters and Non-adopters

From the results, both adopters and non-adopters grew similar food crops, an indication that *M. volkensii* integrated well with food crops. The main food crops grown in the study area were maize by 80% of the adopters and 73% of the non-adopters, beans by 64% of the adopters and 68% of the non-adopters and cowpeas by 26% of both the adopters and non-adopters. Other crops were green grams, kales, pigeon peas, sorghum, spinach and other vegetables, sweet potatoes and millet.

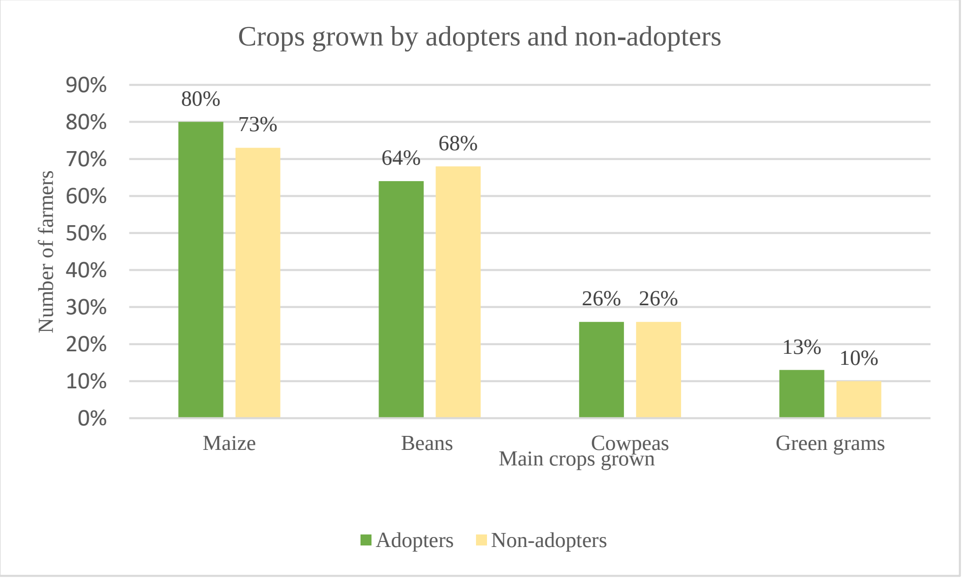

Figure 4.4: Crops grown by adopters and non-adopters of *M.volkensii*

4.8 Role of Income on Adoption of *M. volkensii*

To establish the role played by household income in adoption of *M. volknesii,* information on income sources and household expenditure was sought.

4.8.1 Sources of Household Income

Table 4.15 below shows the four main sources of household income, the frequencies and mean annual income for each source. The income sources are farming, businesses, formal employment and casual labour.

Table 4.15. Sources of income for adopters and non-adopters

Income source	Respondents (n)	% responses	0-20000	21000-40000	41000-60000	61000-80000	>80000	Mean Annual Income (KES)
Farming (n=117) - 59%	Adopters (n=42)	35%	11	5	2	13	11	56 105.42
	Non-adopters (n=75)	94%	17	2	10	25	21	44 627.50
Businesses (n=71)-36%	Adopters(n=52)	43%	20	16	11	5		30 761.90
	Non-adopters(n=19)	24%	12	5	1	1		21 676.92
Formal employment (n=66)-33%	Adopters (n=44)	37%	10	10	9	2	13	183,568.84
	Non-adopters(n=22)	28%	1	6	3	0	12	125,611.11
Casual labour (n=24)-12%	Adopters (n=17)	14%	6	1	7	2	1	55,593.33
	Non-adopters(n=7)	9%	2	1	1	0	3	51, 611.11

Farming was the largest source of income for 59% of the respondents, followed by businesses for 36% of the respondents, formal employment for 33% and casual labour for 12% of the respondents. Adopters obtained most of their income from businesses and formal employment at 43% and 37% of the respondents respectively compared to 24% and 28% respectively among the non-adopters. 94% of the non-adopters earned from farming activities compared to only 35% among the adopters. The results suggest that adopters were engaged in off- farm activities, which brought in additional income, with which they invested in *M. volkensii.* Log regression showed a positive and significant difference in annual income between adopters and non-adopters. The study thus rejects the null hypothesis 2, which stated that, "Household income levels do not significantly influence the decision to adopt M. volkensii in Makueni county".

Magugu *et al.* (2018), reported that household income had a strong correlation with farm-size, which in turn had a strong correlation with adoption of agroforestry technologies. The initial investment in agroforestry technologies is high and often a disincentive for adoption. Mwase *et al.* (2015), reported a 75% failure to adopt agroforestry technologies among farmers who could not afford the initial costs of investment, including labour. Where incentives are availed, small holder farmers adopt agroforestry technologies in anticipation of income derived from agroforestry. This was evidenced by Oduro *et al.* (2018) who reported that in a support programme, over 90% of participating farmers were motivated by expected income.

Adopters had more income coming from other sources other than sale of *Melia* trees than non-adopters, thus had residual income to invest in *M. volkensii* ventures. Kassie *et al.* (2017) noted that where non-farm income was increasing, farmers were more likely to spend more time engaging in non-farm activities; decreasing the time spent in food production and in-turn engaging more in agroforestry activities, especially timber trees, which required less of their time. In addition, non- farm activities were more likely to increase the household income thus increasing the residual income, which could be directed into long-term investments (Magugu *et al*., 2018; Saha *et al.*,2018) such as *M. volkensii* ventures.

Adopters had made investment in farm equipment such as ploughs and tractors, which were rented out to other farmers, thus raising income from rent. This could be because sale of *Melia* trees gave farmers the opportunity to earn a lot of money at a go, thus making huge investments such as constructing rental houses and buying ploughs and tractors for rent, creating diverse sources of regular income flow. Kassie *et al*. (2017) reported similar results where farmers who owned several oxen were more likely to establish agroforestry plantations. In addition, such investments engaged the farmers in more non-farm activities, thus raising the household income levels (Kassie *et al.*, 2017).

In their study on adoption of agroforestry technologies in Makueni county, Maluki *et al.* (2015), reported that farmers were engaged in fruit, forest wood and fodder trees agroforestry technologies and that agroforestry products were the highest income earners for farmers. During data collection among the adopters, some indicated that from the experience gained from *Melia* seed extraction and nursery establishment, they often got casual employment opportunities from farmers that were recently establishing *Melia* on their farms. There was no significant difference in income obtained from crops and livestock, businesses and formal employment, an indication that both *M. volkensii* adopters and non-adopters were exposed to similar opportunities in business, employment and similar market conditions for their livestock and food crops.

4.8.2 Household Expenditure

The results on household expenditure showed significantly higher expenditure on school fees and food among the *M. volkensii* adopters compared to non-adopters.

Table 4.16: Annual Average Expenditure of the Households

Type of expenditure	Adopters	Non-adopters	z-test
School fees	35,304.00	33,636.13	-1.84*
Rent (house, farm)	38,969.79	31,358.97	-1.767
Food	30,967.08	34,953.75	1.82*
Transportation	3,550.38	3,299.68	-1.59

Note: *=significant at 95% confidence level

The respondents reported that with the income earned from *Melia* they were able to enroll their school going children to local private schools, which were more expensive than government schools, but had better education offered. In addition, they were able to buy school reading books without much strain. Expenditure on food was significantly different with adopters spending less money on food compared to non-adopters. This could be attributed to the fact that *M. volkensii* adopters had larger land sizes, thus were able to grow enough food for their local consumption and storage for dry seasons. Non-adopters on the other had had smaller land sizes, which could not produce much for household consumption, storage, and sale to meet basic household needs. Magugu *et al*. (2018) indicated that peasant farmers often grappled with retail food prices, mostly when their production was insufficient to meet their needs.

4.9 Challenges Experienced During Adoption of *M. volkensii*

On the challenges affecting adoption of *Melia volkensii*, 37.5% indicated lack of capital, 18.8% cited high labour demand and a similar percentage indicated lack of seedlings, 17.5% had no access to information while 7.5% cited competition with food crops.

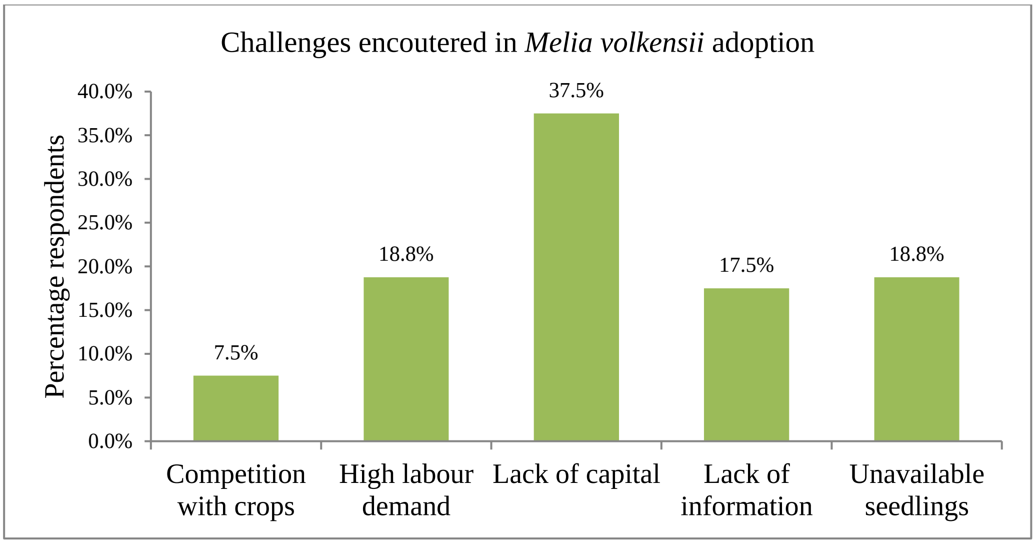

Figure 4.5: Challenges experienced during adoption of *M. volkensii*

The challenges in access to seedlings included lack of access to quality seeds and seedlings, poor nursery management skills that led to low germination rates at the nursery and low survival rate of seedlings during dry seasons. The farmers indicated that they used traditional seed extraction equipment, which often damaged the seeds. Poor seed handling and nursery management led to low germination rates, hence most of them indicated that they planted many seeds to increase the number that germinated, while others said they often irrigated the nurseries. Others kept regular contact with suppliers to "book" the seedlings when planting season neared.

In their study, Luvanda *et al*. (2015) reported that only 7.7% of the seed collectors in Eastern Kenya had access to the nutcracker fabricated by Kenya Forest Research Institute (KEFRI). Additionally, over 68% of the seed collectors used the seeds on their own farms, thus the unavailability of seeds in the market. The demand for seeds and seedlings was huge, and there was a gap in availing quality germplasm to farmers. The results tally with a report by Mulanda *et al.* (2012) who indicated that challenges in seed extraction, poor germination and high post-germination mortality hampered propagation of *Melia volkensii*. Odoi *et al.* (2019) in their study on tree seed and seedling supply and distribution system in Uganda reported that when seed collection and multiplication is left to the local farmers, little attention is given to quality, therefore inferior seed quality is distributed. Kiyani *et al.* (2017) also reported lack of access to quality seeds as a hinderance to adoption of agroforestry technologies. This differs with Cramb (2013) who reported that lack of quality seeds did not deter farmers from adopting agroforestry technologies.

Lack of capital was a challenge to 37.5% of the non-adopters. This result is further supported by the low access to credit by the same group. Provision of long-term credit facilities presents an opportunity for adoption (FAO, 2013) of *Melia* in Makueni. Cramb (2013) explains that success in adoption of straw treatment technology in China was advanced by strong government policy, provision of subsidized credit and supply of subsidized urea. Further, Rojas *et al*. (2013) indicated that farmers adopted agroforestry technologies with low establishment costs.

Intervention by government agencies in partnership with other development organizations in Makueni could work towards providing farmers with long-term credit facilities and other subsidies (Kiyani *et al.,* 2017) which could go a long way in promoting adoption of *Melia*. Interventions should not just revolve around production of *Melia* timber, but rather along the entire value chain; from germplasm production to sourcing for markets. This is because if the law of demand and supply applies, there would be production of so much wood at a time, which would flood the available market and lower prices, disincentivizing farmers in the end.

High labour demand was a challenge to 18.8% of the non-adopters. Initial establishment of *M. volkensii* management involves activities such as land preparation, pitting, planting, fencing, weeding, annual pruning, harvesting and processing of trees to timber and transportation to the market (Wekesa *et al.*, 2012) which were done during long rains, when planting of food crops was taking place, thus raising the labour demand. These activities are costly, yet profits are realized only at the end of a rotational cycle.

The results tally with those reported by Gosling *et al.* (2021) who indicated that agroforestry is hit hard by labour demands and while there are means of overcoming capital constraints for example through credit, overcoming labour challenges is much more difficult. Labour demands could be eased by improving economies of scope (Gosling *et al*., 2021) for example through intercropping, where land preparation for food crops and *Melia* tree planting is done once. Meijer *et al.* (2015) reported that high labour requirement was a disincentive for adoption of agroforestry technologies and Mwase *et al*. (2015) reported that farmers often modified agroforestry interventions to respond to high labour demand.

Management of seedlings and saplings also involve protecting them from animals for example cattle that trample on them and goats which often browse on the bark. Farmers therefore make changes to protect the saplings for example by fencing or restricting animal movement by tethering. Rojas *et al.* (2020) for example reported low adoption of agroforestry technologies that required additional management to protect seedlings from being trampled by cattle, as farmers were already used to ranches.

Access to information is vital in adoption of agroforestry technologies, as it is through this information that farmers learn about silvicultural practices, increasing quality of production (Gosling *et al*., 2021). Coulibaly *et al.* (2016) reported similar results where farmers without access to training on fertilizer trees did not take it up. Further, Zerihun (2020), indicated that farmers with frequent access to extension services were five times more likely to adopt agroforestry than those without access to extension services. It is therefore vital to improve infrastructure in the study area, so that information resources are more accessible to all farmers.

Competition between crops and trees especially when the trees are young and getting nutrients from the topsoil does occur, more so in the study area, where water is scarce, and soils are mostly sandy hence little ability to retain water. Competition between crops and trees is reduced by proper temporal and spatial management of food crops and trees (Norrlin *et al*., 2020). To reduce shading of crops by tree branches, regular pruning is encouraged. A study on performance of *M. volkensii* under different agroforestry practices concluded that performance and survival rate was best where intercropping was done with shorter food crops and maintenance (weeding and pruning) was done (Ongerep *et al.,* 2016). KFS (2018), gives spacing distances when intercropping *M. volkensii* with various crops such as cowpeas and green grams.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of findings presented in chapter four, draw the conclusions, and present recommendations based on the findings.

5.1 Summary

The study examined household demographic characteristics influencing adoption of *M. volkensii* in Kibwezi sub-county, the agroforestry practices in which *M. volkensii* was adopted, how household income influenced adoption and the major challenges faced during growth of *M. volkensii* in the study area.

On the household demographics, the variables that significantly influenced adoption were education level of the household head, the gender of the household head, the household size measured in adult equivalent, the farm size, distance to the nearest market and access to credit.

On objective one, intercropping and homestead planting were the most preferred practices for *M. volkensii*. There were mutual benefits in intercropping practices, where cost of production was lower because of economies of scope, which reduced the establishment costs. In addition, the trees were clean- weeded throughout, thus faster maturity and pruning was done to avoid shade for the food crops, hence achieving clean boles for the trees. Intercropped *M. volkensii* matured fastest though not significantly different from trees in the other practices. This study suggests that homestead planting was preferred for ease in seed collection, as private nurseries were the second largest seed sources in the study area. In addition, the trees provided shade around the homestead.

Woodlots were often established by farmers with larger parcels of land, or those that were engaged in off-farm activities, hence did not have time for cultivation of food crops. Boundary planting was the least preferred practice for *Melia* tree species because it was preferred for multi-purpose trees that mark farm boundaries and not timber species, which would later be harvested. There was no difference in the food crops and other tree species grown by both adopters and non-adopters, thereby indicating that *Melia* did not alter the farmers' farming practices.

On the second objective of the role of income on adoption of *M. volkensii,* adopters significantly higher household income compared to non-adopters. With the higher income, the study suggests that they were able to meet the immediate household needs as well as the costs of establishment of *M. volkensii*. Additionally, selling *Melia* timber brought in huge income at once, which was used for off-farm investment, thus in turn increasing the household income. Access to credit facilities significantly influenced adoption, which was an indication of higher possibility of adoption if affordable credit was availed to non-adopters. On credit sources, family and friends was the biggest source of credit for both adopters and non-adopters, followed by cooperatives. This was an indication that farmers were willing to take credit, therefore making it available and affordable was vital.

On the third objective, the challenges faced during adoption, results indicated that adoption was hampered by lack of capital, unavailability of seedlings, lack of adequate information and high labour demand. On capital, non-adopters viewed *Melia* investment as very expensive with long term benefits. Because they did not have diverse sources of income to cater for daily expenses as they waited for *Melia* to mature, they opted for other farming practices. Further, both adopters and non-adopters faced challenges with accessibility of seedlings. The seedlings from the government institutions could not meet the demand. Those that owned private nurseries established them for their own farms first before selling the surplus. Additionally, the success rates of private nurseries was low due to lack of skills and knowledge in seed handling. Community nurseries were the fewest and most respondents indicated that management of these nurseries was a challenge. *M. volkensii* ventures had high labour demand, as labour was required during planting, weeding, annual pruning, fencing and harvesting. Planting was done at the onset of the long rains, when the rest of the planting was taking place, thus raising the labour demand even further.

Lastly, non-adopters perceived lack of adequate information as an impediment to adoption of *Melia*. While the majority had received information through radio, it did not give detailed information as would one-on one communication, provided by extension staff, farmer groups and resource centers. Access to information especially for farmers who lived further from the shopping centres was a challenge. The distance from the farm to the nearest shopping center was significantly different, indicating that accessibility was vital in adoption of *M. volkensii.*

5.2 Conclusions

The first objective was to identify the agroforestry practices in which *M. volkensii* was adopted. From the findings, it was concluded that intercropping and homestead planting were the most preferred agroforestry practices for *M. volkensii.*

The study also sought to find out how household income levels affected adoption of *M. volkensii*. The results indicated that households with higher income levels were more likely to invest in *M. volkensii* compared to those with lower household income levels.

The third objective was to identify the major challenges hampering adoption of *M. volkensii*. These challenges were lack of capital, high labour demand, unavailability of seedlings, lack of information and competition with crops. Lastly, the study, based on the log analysis concludes that *M. volkensii* has potential of improving the livelihoods of households in the study area, should farmers be given support in addressing the challenges highlighted in the study.

5.3 Recommendations

Based on the findings and conclusion in relation to the objectives, the following recommendations are proposed;

1. From objective one, the government and other institutions promoting *M. volkensii* need to understand that the most preferred agroforestry practice is intercropping for timber and develop interventions that are fit for this practice. These interventions should include education and information sessions for farmers who view *Melia* as a competitor for nutrients. In addition, farmers with smaller land portions, who may not engage in timber production can be engaged

in homestead planting of *Melia* trees for seedling production. These would increase the supply of planting materials as well as create income for them.

2. On objective two, interventions targeted to low-income households could be developed by research and development organizations, characterized by incentive components and provision of affordable credit facilities for investment in *Melia* as most non-adopters indicated they lacked capital to invest. These programs should also empower farmers on investment options, so that they are able to make subsequent *Melia* investments without support, hence achieving sustainability.
3. On objective three, the study recommends empowering more farmers to produce high quality seedlings through training on seed collection, extraction, nursery management and transplanting by extension officers and provision of modern equipment for seed extraction. In addition, provision of more adequate information through establishment of resource centers, strengthening farmer groups and facilitating the extension officers to reach more farmers could go a long way in increasing investment in *Melia*. Training farmers is necessary especially for those who had not obtained formal education, to bring them to the same level with the adopter group. For non- adopter group that are not engaged directly in *Melia* production, they could be trained on the same and provide affordable labour to the adopters.

5.4 Suggestions for Further Research

Further studies should focus on a wholistic study on *M. volkensii* value chain in Eastern Kenya. The study revealed gaps in seedling production, which also presents opportunities for investment as well as further research. Other components of the *Melia* value chain ought to be studied as well as there could be more opportunities lying in these.

REFERENCES

Adedayo A.G. and Oluronke S. (2014). Farmers' Perception and Adoption of Agroforestry Practices in Osun State, Nigeria. Forest Res 3: 127. DOI: 10.4172/2168-9776.1000127. Retrieved on 12/5/2019.

Adolwa I.S., Okoth P.F., Mulwa R.M., Esilaba A.O., Mairura F.S., Nambiro E. (2012). Analysis of Communication and Dissemination Channels Influencing the Adoption of Integrated Soil Fertility Management in Western Kenya. The Journal of Agricultural Education and Extension, 18:1, 71-86, DOI: 10.1080/1389224X.2012.638782. Retrieved on 3/8/2021.

Alston M and Bowles W (2018). Research for social workers: An introduction to methods (4th ed.). Allen & Unwin, Crows Nest, Australia ISBN 978-1-76029-744-2, pp. 522, paperback, NZD56.99.

Avilez-López, T., van der Wal, H., Aldasoro-Maya, E. et al. Home gardens' agrobiodiversity and owners' knowledge of their ecological, economic and socio-cultural multifunctionality: a case study in the lowlands of Tabasco, México. J Ethnobiology Ethnomedicine 16, 42 (2020). https://doi.org/10.1186/s13002-020-00392-2. Retrieved on 3/8/2021.

Babbie, E.A. (2020). The practice of social research. South Melbourne, Australia: Cengage AU.

Barros R.A., Silva M.J., Moura I., Ramalho J.C., Hanson C.M., Ribeiro N.S. (2017). The Potential of Tree and Shrub Legumes in Agroforestry Systems, Nitrogen in Agriculture - Updates, Amanullah and Shah Fahad, IntechOpen, DOI: 10.5772/intechopen.69995. Available from: https://www.intechopen.com/chapters/56359 Retrieved on 8/8/2020

Binam J.N. Place F., Djalal A.A., Kalinganire A. (2017). Effects of local institutions on the adoption of agroforestry innovations: evidence of farmer managed natural regeneration and its implications for rural livelihoods in the Sahel, Agricultural and Food Economics. Springer, Heidelberg.

Boateng, E.Y. and Abaye, D.A. (2019). A Review of the Logistic Regression Model with Emphasis on Medical Research. Journal of Data Analysis and Information Processing, 7, 190-207. https://doi.org/10.4236/jdaip.2019.74012. Retrieved on 14/10/2021.

Coulibaly J., Chiputwa B., Nakelse T., Kundhlande G. (2017). Adoption of agroforestry and the impact on household food security among farmers in Malawi. Agricultural Systems, DOI:10.1016/j.agsy.2017.03.017. Retrieved on 14/10/2021

Cramb R.A. (2013). Processes Influencing the Successful Adoption of New Technologies by Smallholders. Australian Centre for International Agricultural Research (ACIAR). Canberra, Australia.

De Leeuw J, Njenga M, Wagner B, Iiyama M. (2014). Treesilience, an assessment of the resilience provided by trees in the drylands of Eastern Africa. Nairobi, Kenya: ICRAF. Development. Science Direct, 2014.

Dedefo K., Derero A., Tesfaye Y., Muriuki J. (2016). Tree nursery and seed procurement characteristics influence on seedling quality in Oromia, Ethiopia. Forests, Trees and Livelihoods, DOI: 10.1080/14728028.2016.1221365. Retrieved on 13/10/2021

Dhakal A. and Rai K.R. (2020). Who Adopts Agroforestry in a Subsistence Economy? Lessons from the Terai of Nepal. Forests. MPDI Journal, Basel, Switzerland.

Dhehibi B, Rudiger U, Moyo HP, Dhraief M.Z. (2020). Agricultural Technology Transfer Preferences of Smallholder Farmers in Tunisia’s Arid Regions. Sustainability Journal, 2020.

Diwakar V and Shepherd A. (2018). Understanding Poverty in Kenya; A multidimensional analysis. Chronic Poverty Advisory Network, Getting to Zero. Retrieved on 5/5/2020 from www.chronicpoverty.org

Dudovskiy J. (2018). The Ultimate Guide to Writing a Dissertation in Business Studies: A Step-by-Step Assistance.e-book retrieved from https://research-methodology.net/ on 20/08/2021.

FAO (2019). Trees, forests and land use in drylands: the first global assessment- full report. FAO Forestry Paper No.184. Rome.

FAO. (2013). Advancing Agroforestry on the Policy Agenda: A guide for decision-makers, by G. Buttoud, in collaboration with O. Ajayi, G. Detlefsen, F. Place & E. Torquebiau. Agroforestry Working Paper no. 1. Food and Agriculture Organization of the United Nations. FAO, Rome.

Galhena H.D., Freed R., Maredia K.M. (2013). Homegardens: a promising approach to enhance household food security and wellbeing. Agric & Food Security. Retrieved on 20/7/2021 from https://doi.org/10.1186/2048-7010-2-8.

Gebru B.M.,Wang S.W.,Kim S.J., Lee W.K. (2019). Socio-Ecological Niche and Factors Affecting Agroforestry Practice Adoption in Different Agroecologies of Southern Tigray, Ethiopia. Sustainability Journal, USA.

Gitonga S., and Mukoya W. (2016). An Evaluation of the Influence of Information Sources on Adoption of Agroforestry Practices in Kajiado Central Sub-County, Kenya. Universal Journal of Agricultural Research, USA.

Gosling E., Knoke T., Reith., Caceres R.A., Paul C. (2021). Which Socio-economic Conditions Drive the Selection of Agroforestry at the Forest Frontier? Springer, USA.

Government of Makueni County (2018). Makueni County Integrated Development Plan (CIDP) 2018-22. Government of Kenya. Nairobi, Kenya.

Government of Makueni County (2019). FY 2020-21 Makueni County Annual Development Plan. Government of Kenya, Nairobi, Kenya.

Government of Makueni County. (2019). Makueni County Spatial Plan (2019-2029). The Government of Makueni County, Wote-Makueni.

Gujarati D.N. (1995). Basic Econometrics, 3rd Edition. New York: McGraw-Hill, 1995. ISBN 0-07-025214-9. Retrieved on 12/9/2020.

Jaoko V, Taning C, Backx S, Mulatya J, Abeele J, Magomere T, Olubayo F, Mangelinckx S, Werbrouck S, Smagghe G. (2020). The Phytochemical Composition of *Melia volkensii* and Its Potential for Insect Pest Management. Plants journal. MPDI Journal, Basel, Switzerland.

Kamondo B.M., Kariuki J.G., Luvanda A.M., Muturi G.M. and Ochieng D. (2016). (eds). Guideline on Production, Distribution and Use of Improved Melia Seed and Seedlings in the Drylands of Kenya. KEFRI, Kenya.

Kassie G.W. (2017). Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. Environmental Systems Research. DOI:10.1186/s40068-017-0085-6 retrieved on 22/03/2021.

Kassie G.W. (2016). Agroforestry and land productivity: Evidence from rural Ethiopia. Cogent Food & Agriculture, United Kingdom.

Kenya Forest Service (KFS) (2018) A Guide to *Melia volkensii* Growing in the Dryland Areas of Kenya. Kenya Forest Service, Nairobi, Kenya.

Kenya National Bureau of Statistics (KNBS) (2019). 2019 Kenya Population and Housing Census, volume II: Distribution of population by Administrative units. Nairobi, Kenya.

Kipkemboi, K., Odhiambo O.K., & Odwori P. (2019). Adoption of Tree Nursery Practices as Strategic Enterprise at Millenium Villages Project, Siaya County, Kenya. Africa Environmental Review Journal. University of Eldoret, Eldoret, Kenya.

Kiptot E. and Franzel S. (2011). Gender and agroforestry in Africa: are women participating? ICRAF Occasional Paper No. 13. Nairobi: World Agroforestry Centre.

Kiruki H.M, Zanden E.H, Malek z. Verburg P.H. (2016). Land cover change and woodland degradation in a charcoal Producing semi-arid area in Kenya. Land Degradation & Development, John Wiley and Sons Ltd, USA.

Kiyani P, Andoh J, Lee Y, Lee D.K. (2017). Benefits and challenges of agroforestry adoption: a case of Musebeya sector, Nyamagabe District in southern province of Rwanda. Forest Science and Technology Journal, Taylor and Francis Ltd, United Kingdom.

Kuyah S., Sileshi G.W., Luedeling E., Akinifesi F.K., Whiney W.C., Bayala J., Kuntashula K., Dimobe K., Mafongoya P.L. (2020). Potential of Agroforestry to Enhance Livelihood Security in Africa. Springer Nature Singapore.

Liliane M., Ezekiel N., Gathuru G. (2020). Socio-economic and institutional factors affecting smallholders farmers to adopt agroforestry practices in southern province of Rwanda. International Journal of Agricultural Science and Food Technology, India.

Luvanda A.M., Musyoki J., Cheboiwo J., L. Wekesa Ozawa M. (2015). An Assessment of the Socio-economic Importance of *Melia volkensii* based Enterprises in Kenya. KEFRI, Kenya.

Magaju C.,Winowiecki L.A.,Crossland M.,Frija a., Ouerghemmi H., Hagazi., Sola P., Ochenje I., Kiura E., Kuria A., Muriuki J., Carsan S., Hadgu K., Bonaiuti E., Sinclair F. (2020). Assessing Context-Specific Factors to Increase Tree Survival for Scaling Ecosystem Restoration Efforts in East Africa. MPDI Journal, Basel, Switzerland.

Magugu J.W, Feng S, Huang Q, Ototo GO. (2018). Socio-economic factors affecting agro-forestry technology adoption in Nyando, Kenya. Journal of Water and Land Development. Poland.

Maluki, M.J, Kimiti J.M, Nguluu S, Musyoki J.K. (2016). Adoption levels of agroforestry tree types and practices by smallholders in the semi-arid areas of

Kenya: A case of Makueni County. Journal of Agricultural Extension and Rural Development, USA.

Mandila B., Hitimana J, Kiplagat A., Mengich E. and Wekesa T. (2015). Prevalence and Adoption of Agroforestry Technologies and Practices in Semi-Arid Regions of West-Pokot County, Kenya. Research Journal of Agriculture and Forestry Sciences, India.

Masibo M.M., Hitimana J., Yegon A.S., Owino Y.O. (2018). Challenges Affecting the Adoption of Agroforestry Practices around Chepalungu Forest in Bomet County, Kenya. Asian Journal of Advanced Research and Reports, India.

Mbora A and Wekesa A. (2016). Agroforestry Tree Seed Training Handbook, A Handbook for Community Facilitators. VI Agroforestry, Nairobi, Kenya.

Meijer S.S, Catacutan D, Ajayi C.O, Sileshi, G.W, and Nieuwenhuis M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability, United Kingdom.

Moahid M. and Maharjan L.K. (2020). Factors Affecting Farmers' Access to Formal and Informal Credit: Evidence from Rural Afghanistan. Sustainability journal, USA.

Morgon C.,Rioux J., Kirui J. (2015). Barriers, incentives and benefits in the adoption of climate-smart agriculture Lessons from the MICCA pilot project in Kenya. Food and Agriculture Organization Of The United Nations Rome, 2015.

Mulanda E.S., Adero O.M., Amugune O.N., Akunda E., Kinyamario I.J. (2012). High-Frequency Regeneration of the Drought-Tolerant Tree *Melia volkensii* Gurke Using Low-Cost Agrochemical Thidiazuron. Hindawi Biotechnology Research International. United Kingdom.

Mulatya J and Misenya, T. (2004). *M. volkensii* growth in the southern drylands of Kenya. A paper in the proceedings of the first national workshop on recent

Mukau (***M. volkensii*** Gurke) research and development held at KEFRI Kitui from 16th to 19th November 2004.

Mulatya J., Wilson J., Ong C.K., Deans, J.D. (2002). Root architecture of *Melia volkensii* provenances and plant types in dryland farming in Kenya. Agroforestry Systems, Springer, Netherlands.

Muthike G. and Githiomi J. (2020) Value chain analysis of farm grown *Melia volkensii* (Gurke) timber in the South Eastern Dry lands of Kenya. Journal of Horticulture and Forestry. United Kingdom.

Mwase W, Sefasi A, Njoloma J, Nyoka BI, Manduwa D, Nyaika J. (2015). Factors Affecting Adoption of Agroforestry and Evergreen Agriculture in Southern Africa. Environment and Natural Resources Research, Mahidol University, Thiland.

Ndayambaje D.J., Heijman M.J.W., Mohren J.M.G., (2013). Farm woodlots in rural Rwanda: purposes and determinants. Agroforestry Systems, Springer, Netherlands.

Ndayambaje, J. D., Heijman, W. J. M., & Mohren, G. M. J. (2013). Farm woodlots in rural Rwanda: purposes and determinants. Agroforestry Systems, Springer, Netherlands.

Ndegwa G, Nehren U, Grüninger F, Iiyama, Anhuf D. (2016). Charcoal production through selective logging leads to degradation of dry woodlands: a case study from Mutomo District, Kenya. Journal of Arid Land.

Norrlin S.M., Ghaley B.B., Rintoul J.L.N. (2020). Agroforestry Benefits and Challenges for Adoption in Europe and Beyond. Sustainability journal, USA.

Ntakimanye A., Galabuzi C., Kwaga P., Werikhe G., Sekitto I., Wanambwa I., Kimenya G., Agaba H., Muthuri C. (2020). Factors Affecting Adoption of Agroforestry Technologies by Women and Young Farmers in the Mt. Elgon Region, Eastern Uganda. World Agroforestry Centre, Nairobi, Kenya.

Odoi, J. Boaz, Buyinza, J., & Okia, C. (2019). Tree Seed and Seedling Supply and Distribution System in Uganda. Small-scale Forestry, Springer, Netherlands.

Oduro K.A, Arts B, Kyereh B, Mohren G. (2018). Farmers' Motivations to Plant and Manage On-Farm Trees in Ghana. Small-scale Forestry, Springer, Netherlands.

Olagunju K.O., Ogunniyi A.I., Oyetunde-Usman Z., Omotayo A.O., Awotide B.A. (2021). Does agricultural cooperative membership impact technical efficiency of maize production in Nigeria: An analysis correcting for biases from observed and unobserved attributes. PLOS ONE, United Kingdom.

Ongerep S., Kidia J., Masibo M., Kabonessa B., and Musimenta S. (2016). Evaluating the Growth Performance of Melia volkensii in Kifu Forest, a Potential Timber Plantation Species in Uganda. Vegetos 29:2 doi:http://dx.doi.org/10.4172/2229-4473.1000125. Retrieved on 14/9/2021.

Persha L., Stickler M.M., Huntington H. (2015). Does stronger land tenure security incentivize smallholder climate-smart agriculture? Understanding drivers of agricultural investment in Zambia's Eastern province. Paper prepared for presentation at the "2015 World Bank Conference on Land and Poverty". The World Bank - Washington DC, March 23-27, 2015

Rojas R.J, Russy S, Roco L,Munoz D.F, Engler A. (2020). Factors Affecting the Adoption of Agroforestry Practices: Insights from Silvopastoral Systems of Colombia. Forests. MPDI Journal. MPDI Journal, Basel, Switzerland.

Romeo J.T. (2005). Chemical Ecology and Phytochemistry of Forest Ecosystems. University of South Florida, USA.

Saha S, Sharmin A, Biswas R, Ashaduzzaman Md. (2018). Farmers' Perception and Adoption of Agroforestry Practices in Faridpur District of Bangladesh. International Journal of Environment, Agriculture and Biotechnology, India.

Sanou L, Savadogo P, Ezebilo E.E, Thiombiano A. (2017). Drivers of farmers' decisions to adopt agroforestry: Evidence from the Sudanian savanna zone, Burkina Faso. Renewable Agriculture and Food Systems. Cambridge University, United Kingdom.

Sivo A.S., Saunders C., Chang Q., Jiang J.J. (2006) How Low Should You Go? Low Response Rates and the Validity of Inference in IS Questionnaire Research. Journal of the Association for Information Systems. NY, USA.

Somarriba E., Beer J. (2010). Productivity of Theobroma cacao agroforestry systems with timber or legume service shade trees. Agroforest Systems, Springer, Netherlands.

Sunderland C.H.T. and Rowland D. (2019). Chapter 6- Forests, Land Use, and Challenges to Climate Stability and Food Security. Sustainable Food and Agriculture. Academic press, doi.org/10.1016/B978-0-12-812134-4.00006-6. Retrieved on 13/10/2021.

The World Bank (2017). Sahel Irrigation Initiative Support Project. Retrieved from https://projects.worldbank.org/en/projects-operations/project-detail/P154482?lang=en on 19/7/2021.

United Nations Convention to Combat Desertification (UNCCD) (2020). *The Great Green Wall Initiative.* Retrieved from https://www.unccd.int/actions/great-green-wall-initiative on 19/7/2021.

United Nations Department of Economics and Social Affairs (DESA) (2005). Designing Household Survey Samples: Practical Guidelines. United Nations, New York, USA.

Walia s., Walia U. (2020). Farming systems and sustainable agriculture. Scientific Publishers, India.

Wanjira E. and Muriuki J. (2020). Review of the Status of Agroforestry Practices in Kenya. Background study for preparation of Kenya National Agroforestry Strategy (2021-2030). DOI:10.13140/RG.2.2.35739.59681. Retrieved on 25/6/2020

Wawire A.W., Wangia S.M., Okello J.J. (2017). Determinants of Use of Information and Communication Technologies in Agriculture: The Case of Kenya Agricultural Commodity Exchange in Bungoma County, Kenya. Journal of Agricultural Science. Canada.

Wekesa L., Muturi G., Mulatya J., Esilaba A.O., Keya G.A . and Ihure S. (2012). Economic viability of *Melia volkensii* (Gurkii) production on smallholdings in drylands of Kenya. International Research Journal of Agricultural Science and Soil Science, USA.

World Agroforestry Centre (ICRAF) (2013). Establishing a tree nursery in Kenya. Retrieved from https://www.fao.org/3/CA3116EN/ca3116en.pdf on3/08/2021.

Yila O. (2016). A scoping study to document the agroforestry technologies/practices/systems, and their characterization, release, adoption and use by farmers in Kenya. World Agroforestry Centre, Nairobi, Kenya.

Zerihun M.F. (2020). Institutional Analysis of Adoption of Agroforestry Practices in the Eastern Cape Province of South Africa. Southern African Journal of Environmental Education, Vol. 36, 2020, South Africa.

APPENDICES

Appendix I: Letter of introduction

KENYATTA UNIVERSITY

SCHOOL OF ENVIRONMENTAL STUDIES

To whom it may concern

Dear Sir/Madam

RE: ROLE OF INCOME AND PERCEPTION IN ADOPTION AND MANAGEMENT OF *MELIA* VOLKENSII BY FARMERS IN MAKUENI COUNTY, KENYA

I am a post graduate student at Kenyatta University, conducting the study of subject as part of my academic requirements. The information provided will be treated with utmost privacy and will not be used for purposes outside this study. There will be no form of identification required in the study.

Your positive response and support is highly appreciated.

Thank you;

Sincerely,

Appendix II: Questionnaire

Caroline Gathoni

Dear Respondent

This questionnaire is a data collection tool for a study titled, "The role of income and perception in adoption and management of *Melia volkensii* by farmers in Makueni county, Kenya". This research is for academic purposes only and the data provided will be used as such. We greatly appreciate your responses.

SECTION A: Household details					
Questionnaire no.		Village		Date	
SECTION B: Household identification- respondent should be household head or spouse					
Name of respondent:			Gender	☐Female ☐ Male	
Relationship to household head			HH Head name (if different)		
HH head age (yrs)	______years		Household size	______ Adults;_____ children between 6 and 18years; ______ Children below 6 years	
HH head education level: ☐					
Code for education level: **0= never gone to school; 1=dropped out of primary school; 2=completed primary school; 3=Dropped out of High school; 4=Completed high school; 5=In tertiary college/university; 6=completed tertiary college/university; 999= Other** (Specify)__________________					
Occupation of head of household: ☐ 1=Formal employment (permanent and pensionable); 2= Business (e.g shop, hardware etc) / trade (eg carpentry, tailoring, welding etc); 2= Casual labor; 3= farming; 4= Unemployed/ laid off/ looking for work; 5= House Keeping or raising children full-time; 6= Retired; 999= Other (please specify________________)					

B.1.Did you migrate to the current location? I___I **1= YES 0=No** If the answer is **YES**, when? (Year) __________
B.2. What is the size of your land in hectares? [ ] ***(To covert acres to hectares use 1ha= 2.5 Acres)***
B.3. i) If you own the land, how did you acquire it? **1= Bought ; 2= Inherited ; 3=Given by government; 4=Borrowed; 5= Given by relative ; 999=Other** (specify)________________________________ ii) Do you have a title deed for the land? [ ] **1= YES ; 0=No**
B.4. If you do not own the land, under what terms are you living in/using it? **1= Leased; 2=Squatting; 3=Rented ; 4=Communal ownership ; 999= Other** (specify)____________________________ B.5. Approximate distance from the shopping Centre. 1+

C.1 Agroforestry practices for Melia volkensii

For farmers with *M.volkensii* on their farms- Interviewer to go around the farm making observations

Agroforestry Practice	Number of trees	Current Age	Harvest age
Boundary planting			
Intercropping			
Around homestead			
Woodlot			
Others			

C.2 For intercropped trees, with which crops are they intercropped? *(list)*

C.3 What is the intended use of the trees? 1= commercial, 2= subsistence use

C.4 what are the uses of Melia on your farm? 1= timber, 2= fuel, 3=fodder, 999=others

C.5 Where did you source the seedlings from?1=Government institution? 2= private nursery, 3= community group nursery
999= other

C.6 Other trees planted on the farm *(list)*

C.7 How easy was it to establish Melia on your farm? 1=Very easy, 2=somewhat easy,3=Difficult 4=very difficult

C.8 What were the two biggest challenges in establishing and managing Melia on your farm? (List)

C.9 How did you overcome these challenges (list)

C.10 Have you accessed credit to establish Melia? 1=Yes, 2=No.

C.10.a If yes, please name the sources 1=Bank, 2= Cooperative, 3= from friends/family, 999=others

C.10.b if no, why

C.11 Did you alter your agroforestry systems to accommodate *Melia volkensii*? 1=yes, 2=No

C.11 b. Explain each answer. **Yes.** (By altering, a farmer will have changed/given up some crops or trees to accommodate
M. volkensii or will have changed the way he previously planned his farm)

No(by no, the farmer introduced *Melia volkensii* into the farm without making alterations in any way.
Could be because there was idle land etc.)

C.12 What sources of information do you access on M. volkensii? 1= From extension officers, 2=farmer groups,
3=resource centers.4=Radio; 5=Televisions set 6=friend; 7= Neighbor, 8=Relative

If from extension officers, from which organization (s)?

SECTION D: Income

Please indicate the sources of income in the table below

D.1. Please indicate the sources of income for the household in the table below

No.	Source	HH member(s) involved	How regularly (Days per month)	Amount (per month)	Amount (per Annum)
1	Formal employment				
2	Casual labour				
3	Selling farm produce (crop and animal products except timber and wood fuel)				
4	Timber (other than *M. volkensii*)				
	Timber from *M. volkensii*				
6	Charcoal				
7	Brick making				
8	honey				
9	Sand harvesting				

10	Remittances				
11	Rent (house, farm, equipment)				
12	Business (not dealing with own farm products)				
13	Other (specify)_____________				
	Codes	1=father; 2=mother; 3=son; 4=daughter; 999=other _______	1=less than one week; 2= 1 week; 3=2 weeks; 4=3 weeks; 5= full month		

Please indicate the types of expenditure in the table below

No.	Type of expenditure	Amount (per month)	Amount (per Annum)
1.	School fees		
2.	Rent(house, farm)		
3.	Food		
4.	Fuel- timber, charcoal, gas, electricity		
5.	Clothing		
6.	Farm inputs		
7.	Tree seedlings		
8.	Transportation		
9.	Other (specify)_____________		

Appendix III: Research Authorization Letter from Graduate School

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Our Ref: N50/CTY/PT/23530/2013 **DATE:** 11th March, 2019

Director General,
National Commission for Science, Technology
and Innovation
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MS. CAROLINE GATHONI – REG. NO. N50/27705/13

I write to introduce Ms. Caroline Gathoni who is a Postgraduate Student of this University. She is registered for M.Env. Studies degree programme in the **Department of Environmental Studies & Community Development.**

Ms. Gathoni intends to conduct research for a M.Env. Studies thesis Proposal entitled, **"Role of Income and Perception in Adoption and Management of *Melia Volkensii* by Farmers in Makueni County, Kenya."**

Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

EO/cww

Appendix IV: Approval letter from Graduate School

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Dean, Graduate School

DATE: 11th August, 2019

TO: **Ms. Caroline Gathoni**
C/o Department of Env. Studies &
Community Development

REF: N50/CTY/PT/23530/13

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 9th January, 2019.

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

HARRIET ISABOKE
FOR: DEAN, GRADUATE SCHOOL

CC. Chairman, Department of Environmental Studies & Community Development

Supervisors:

1. Dr. Mary Baaru
   C/o Department of Environmental Studies & Community Development
   Kenyatta University

2. Dr. Joseph Karauka
   C/o Department of Environmental Studies & Community Development
   Kenyatta University

HI/cww