

MAKERERE



UNIVERSITY

**POTENTIAL CONTRIBUTION OF FARM FORESTRY SYSTEMS TO WOOD
PRODUCTION IN GREATER MUBENDE, CENTRAL UGANDA**

BY

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Declaration

I, **James Galandi**, declare that this Dissertation is my original work, apart from where acknowledgement was made and has never been presented anywhere or to any institution of higher learning for any award.

Signature.....

Date.....

Approval

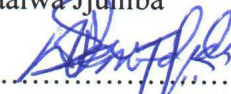
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Dedication

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List of Acronyms and Abbreviations

CDI	Clinton Development Initiative
CFR	Central Forest Reserve
DFO	District Forestry Officer
Ecotrust	Environmental Conservation Trust
FAO	Food and Agricultural Organization
FFS	Farm Forestry Systems
FIEFOC	Farm Income Enhancement and Forest Conservation
GDP	Growth Domestic Product
GPS	Geographical Positioning System
MEMD	Ministry of Energy and Mineral Development
MTIC	Ministry of Trade Industry and Cooperatives
MWE	Ministry of Water and Environment
NFC	New Forests Company
SD	Standard Deviation
SDGs	Sustainable Development Goals
SPGS	Sawlog Production Grant Scheme
Spp	Species
UBOS	Uganda Bureau of Statistics
UCCA	Uganda Consortium on Corporate Accountability
ULII	Uganda Legal Information Institute
UTGA	Uganda Timber Growers Association

Abstract

Limited consideration of small and medium tree planters by most researchers in academic and programme based research has remained a great limitation to promoting Farm Forestry in most developing countries over the years. Despite the contribution from small scale tree farmers in reducing wood products supply gap, major scientific research attention has always been directed to large scale tree farmers resulting into limited scientific information on how small and medium scale tree farmers contribute towards wood supply in Uganda and beyond. This study aimed at diagnosing the contribution of Farm Forestry Systems in the face of the forecasted wood supply gap in Uganda. Specifically, the study sought to: Characterize Farm Forestry Systems, assess factors motivating engagement in Farm Forestry, determine growth performance of the most grown tree species in different FFS and investigate challenges affecting and actions to enhance wood production in the study area.

A descriptive research design employing a cross-sectional field survey with qualitative and quantitative data collection approaches were adopted. Descriptive design was used to facilitate describing the state of affairs as they actually existed. During data collection, interviews were conducted with 63 Tree and 64 Non-tree farmers. Tree inventory and field observations, Geo-spatial analysis and review of literature were conducted. Descriptive statistics, Cross tabulation, Independent samples Man Whitney test, and Correspondence Analysis were used in the data analysis.

Results indicated that woodlot system was the most practiced Farm Forestry System among the farmers. *Eucalyptus* was the most grown tree species at a proportion of 62% amongst the investigated farmers followed by *Pine* (24%) and *Grevillea* (11%). The men dominated on-farm tree planting in the area, with the youthful farmers most active in tree planting. The tree farmers in the area dominantly owned land under the mailo tenure system with the majority indicating that they had acquired their land through buying. Respondents dominantly owned land of less than 2 acres and obtained their planting materials from private tree nurseries. The study also indicated a significant statistical difference between tree and non-tree farmers in terms of their household sizes, period of stay in the area, age and farm-land distance from the homesteads. It was also revealed that non-tree farmers were mainly limited from engaging in tree farming due to limited land. Considering the MAI, growth performance of trees under woodlot system was generally better than those in other systems. Tree farmers were dominantly challenged with limited access to technical training in tree management and they indicated that formation of farmer groups and access to affordable credit facilities could enhance their involvement in wood production.

Women need to be encouraged and supported to be part of on-farm forestry to enable them harness from the benefits of incorporating trees on their farmlands. There is also a need for tree farmers to be supported and sensitized on the choice of the Farm Forestry System and the tree species to integrate in their crops and pasture fields. Tree farmers should be organized into collective action groups to enable them jointly; seek financial support from different government initiatives, lobby for technical extension services from local government officials like the office of the DFO and also access contractual markets. The study also points out the need for establishing demonstration farms to allow for peer learning and proper involvement of tree farmers in innovations aimed at developing local solutions to local challenges.

CHAPTER ONE: INTRODUCTION

1.1 Background

Globally, forest cover has reduced by 51% and currently forests cover 31% of the world's land surface (Adams, 2012). In sub-Saharan Africa, forest cover reduced from 27.3% in 2000 to 25% in 2015 (FAO, 2016). Uganda's forest cover reduced from 4.9 million hectares in 1990 to 1.8 million hectares in 2015 translating into a loss of 3.1 million hectares (65%) in 25 years with an average annual forest loss of about 122,000 hectares (MWE, 2017&Josephat, 2018). The reduction in forest cover has been attributed to deforestation as a result of high population increase, poor governance in the forestry sector, illegal and unregulated trade of forest products, unsecured forest tenure rights, conversion of forest land to other land use types such as agriculture and urbanization, and rampant felling of trees for timber, poles, firewood and charcoal burning (MWE, 2016). These decreases have resulted into what SPGS (SPGS, 2014) described as timber famine and an environmental catastrophe .

Uganda is characterized by a natural resource-based economy with the forestry sector contributing about 8.7% to GDP and employing up to one million people of the population (MWE, 2016). Besides the natural forests that currently cover approximately 10% of the total land area in the country (UBOS, 2019), tree planting at different scales has overtime supplemented the wood requirements. According to MEMD (2013), Uganda annually consumes 32.1 million tons of biomass constituting; 28,1.8 and 2.3 million tons of fuel wood, charcoal and poles and timber respectively. In the study by Kaboggoza (2011) the demand for industrial round wood from plantations /woodlots was projected to increase from 3,614,000 m³ in 2020 to 10,434,000 m³ in 2030, while that for sawn wood would increase from 687,000 m³ in 2020 to 879,000 m³ in 2030. Nabanyumya (2017a) estimated that 70,000 ha of trees had been established under the major tree planting programmes in Uganda. These include Sawlog Production Grant Scheme (SPGS) support for commercial timber plantations, woodlot support and community support extending up to 47,000 ha; planting by the National Forestry Authority (NFA) (including community support) covering 12,540 ha; while tree planting by NGOs and other private individuals cover 10,920 ha. All these indicate a need for more trees to reduce the wood supply gap in the country.

Tugumisirize (2017) estimated that Uganda currently needs 1.5 million tons of round wood to supply only sawn timber annually and this demand is expected to continue increasing at a rate of 2.3% per annum, if so the wood supply gap will decrease. Since the existing plantations will meet internal sawn timber demand by 2026 about 10,000 ha of mature crop will be required annually to meet sawn timber demand only, translating into about 200,000 ha of industrial timber plantations that need to have been established by 2033 and another 200,000 ha of forest plantations will be needed to enter the regional export market and meet the need for other wood products like transmission poles, pulp, and charcoal (Tugumisirize, 2017). Nabanyumya (2017a) also indicated that in order to meet the future demands for timber from domestic supply, 150,000 ha of well-managed timber plantations are needed by 2025. Tugumisirize (2017)'s study further indicated that while all the paper used in the country is imported and the demand for paper is expected to continue increasing at a rate of 3.7% per annum, the existing tree establishments are too small to attract investment in pulp and paper both in the short and long run. The estimated production potential and demand for wood resources clearly indicate an imbalance in the wood sector. Noting from other parts of the world such as south and south east Asia, smallholder forestry has been developed to supply large volumes of timber that is consumed and traded (Anyonge & Roshetko, 2003; Nair, 2008). Similarly, Uganda with most of the land in rural areas fragmented (Kashambuzi, 2012; SPGS, 2010) and faced with competition from alternative land uses, smallholder tree growing is an attractive option to increase wood production since it allows for the integration of trees on agricultural farms (Nabanyumya, 2017).

This supply gap may however be over-estimated due to the very limited consideration of wood from small holder tree systems that could be referred to as Farm Forestry System (FFS) that are known to be broadly distributed in the Country other than plantations. There is currently no universally agreed upon definition of Farm Forestry. The term has been used to mean planting of trees on farm (Nair, 1993) and in most cases used interchangeably with agro forestry. The study is adopting the definition from the Department of Agriculture and Water Resources, Australian (2016), as the commercial integration of trees on farm. The trees are managed for the production of saleable products such as timber, fuel wood and carbon credits (Resources, 2010). Farm forestry can be implemented in a number of forms including woodlots, belts, alleys and wide scattered trees.

1.2 Problem Statement

The estimates and projections for the demand and supply of wood products in Uganda have largely been based on large scale tree plantations (Tugumisirize, 2017), with limited consideration of small and medium scale establishments that also make a contribution to the wood sector. However, Small-tree holders are becoming increasingly important producers of timber and poles as reported in India, Vietnam, Philippines & Tanzania (Bertomeu & Gimenez, 2006). Similarly, small-scale tree planting in the country has been promoted by several government and non-government initiatives over time. The government of Uganda, through National Forestry Authority (NFA) community support and other tree planting projects such as the Farm Income Enhancement and Forestry Conservation (FIEFOC) project, has distributed tree seedlings to small and medium scale land holders (FIEFOC, 2017). Vi Agroforestry has since the year 1983 supported small scale farmers to adopt Agroforestry systems (Vi Agroforestry, 2015), while Ecotrust has concentrated on promoting growing of indigenous trees for carbon markets (Ecotrust, 2015). In addition, there are several individual efforts which have resulted in several scattered woodlots, boundary planting and tree rows as these may close the wood supply gap in Uganda.

As noted by Kiyangi (2016), Farm Forestry has been adopted by small scale farmers so as to improve agricultural production and increase on farm income. The wood from these Farm Forestry Systems (FFS) contribute to the wood sector in the country as reported by UTGA (2014). This report indicated that most of the wood sold and consumed in the peri-urban areas is harvested from the FFSs. Despite this acknowledged contribution, there is limited formal documentation of the contribution of these systems to the Ugandan wood sector (MWE, 2018). This renders the estimation and/or projection of the country's wood supply gap inconsistent with the potential reality. It is on this basis therefore that a diagnosis for the FFS is desired to unveil the potential contribution of these systems to the wood sector in Uganda.

1.3 Objectives of the study

1.3.1 Aim

The overall aim of the study was to diagnose the contribution of Farm Forestry Systems in meeting the forecasted wood supply gap in Uganda.

1.3.2 Specific objectives

The Specific objectives were:

1. To characterize the Farm Forestry Systems in the area
2. To assess the factors motivating engagement in Farm Forestry in the area
3. To determine the growth performance of the most grown tree species in the area
4. To investigate the main challenges affecting and actions to enhance engagement in Farm Forestry in the area

1.4 Research questions

The following research questions were investigated:

- a. Which dominant Farm Forestry Systems are practiced across individuals of different socio-economic characteristics?
- b. To what extent do farmers' socio-demographic and economic characteristics influence their engagement in Farm Forestry?
- c. What are the reasons for non-engagement in tree growing on-farm?
- d. Is there a difference in the growth performance of trees in the identified Farm Forestry Systems?
- e. How do silvicultural practices affect growth performance of trees under different Farm Forestry Systems?
- f. What are the challenges encountered by farmers in practicing Farm Forestry and how are they overcoming these challenges?

1.5 Significance of the study

The Forestry Policy statement 6 (Forestry Policy, 2001) provides for promotion of tree-growing on farms in all farming systems, and innovative mechanisms for the delivery of forestry extension and advisory services. The study therefore contributes to meeting the provision of the Forestry Policy through its recommendations on the appropriate Farm Forestry System and the tree species to be planted on farm and how challenges encountered by tree farmers can be overcome.

The findings also contribute to the achievement of the Uganda's Nationally Determined Contributions NDC (2015) which aims at increasing forest cover to 21% in 2030 through providing the possible actions and strategies to enhance wood production on farm and the recommended

actions to involve women in tree planting and ownership. Such recommendations when implemented can also contribute to the attainment of SDG 15 which aims at increasing forest cover.

The study findings will also inform Mubende District local government, especially the office of the DFO and other tree planting initiatives on the selection of appropriate farm forestry systems and tree species to incorporate on farm. Study findings will be availed to the district officials and will be encouraged to ensure dissemination of the results to the stakeholders through organizing workshops, seminars and talk shows about tree planting on farm. This will enhance and encourage households to engage in on farm wood production thus increasing local wood supply and enhance local communities' livelihoods.

The study contributes to narrowing the knowledge and academic literature gap on the contribution of Farm Forestry wood supply in addressing the country's wood supply gap since it lays a foundation for other studies especially the quantitative studies aimed at modeling and projecting the potential contribution of farm grown wood to the national wood supply.

1.6 Operational definitions of key terms/concepts

In this study, the following operational definitions were used; -

Farm forestry: Is the commercial integration of trees on farm.

The trees are managed for the production of saleable products like timber, fuel wood, and carbon credits.

Farm forestry systems: Specific local management practices and arrangements that integrate tree species and crops in a specified surrounding environment and socio-economic functioning.

Agroforestry: Land management *system* that deliberately combines trees with crops and/or livestock, on the same piece of land at the same time with both ecological and socio-economic benefits.

It is the Management and integration of trees, crops and/or livestock on the same piece of land for multiple benefits like agricultural productivity, soil protection, fodder, timber and non-timber products, and other environmental services.

Woodlot:	A parcel of a woodland or forest (<i>not exceeding 10 acres</i>) capable of small-scale production of forest products such as wood fuel, saw logs, and pulpwood.
Kibanja:	A piece of land that is owned by a person without the land title but with the consent of the landlord and pays a rental fee/annual ground rent to the land lord.
Kibanja holder:	A person who settles or settled on the mailo land with the consent of the land lord and pays a rental fee/ annual ground rent.
Mailo land:	Land where permanent ownership of a large plot of land belongs to landlords who acquired it through the 1900 Buganda agreement, while at the same time tenants on the land are recognized and they also have rights to live on and utilize the land.
Lease hold:	Land where a property owner grants the right to another party the exclusive possession of land for a stated time period regularly in exchange for a rental fee
Public land:	Land owned by the government and has the right to lease it to any company or individual on specific terms and covenants.

CHAPTER TWO: LITERATURE REVIEW

2.1 Characterization of the Farm Forestry Systems

Characterization of smallholder Farm Forestry Systems refers to describing the various categories of farms, their demographics, attributes, production trends, and existing production systems (Nyambo, 2019). Farm Forestry Systems are many but their distribution in various places depends on many varying factors. Monica *et al.*, (2017) reported the extent and intensity of management, agro-ecological and socio-economic factors as such factors change from place to place, the species planted also varies in performance such as growth in volume and height.

2.1.1 Woodlots

Kaboggoza (2011) reported that planting trees as single stands in form of woodlots/woodlands by smallholder farmers is common in Uganda. The most common exotic tree species used in Uganda on-farm woodlots are *Eucalyptus* species, *Grevillea robusta*, *Calliandra calothyrsus*, *Senna spectabilis*, *Gliricidia sepium*, *Sesbania sesban*, and *Leucaena* spp because they are fast growing and respond positively to frequent cutting Sebuliba *et al.*, (2012). Kalanzi et al., reported Pine species as the most grown especially in Mubende and Gulu districts due to the favorable site conditions and climatic factors. Hence, many households in Uganda own woodlots of different sizes; however, their yields are location-specific and vary under different agro ecological zones and silvicultural treatments.

As reported by Appiah and Pappinen (2010), nearly every developing country around the globe including Kenya is practicing some form of Farm Forestry; which ranges from woodlots, planting around homesteads(home gardens), boundary planting to wide-space planting of trees in croplands, and in pasture land. Woodlands can be planted for timber production which can be for use on the farm, for example fencing posts, or for commercial purposes, or both (Hugh, 2003) and also provide shade, create wildlife habitats and for educational purposes. Rudel (2009) reported that a wide variety of landholders have established plantations in developing countries, small holders in Africa created woodlots behind their houses, corporations have planted extensive tree farms in Australia, North America and south America while villages in the main land Southeast Asia have planted trees in nearby uplands.

2.1.2 Boundary trees

As seen in Budongo forest, buffer zone agro-forestry as a strategy can provide alternative sources of forest products commonly harvested from protected forests (Kasolo & Temu, 2008). Boundary planting involves the planting of trees along the perimeters of farmers' properties for land delimitation, timber, fuel wood, soil conservation and wind protection (CDI, 2011). Less shading tree species that do not compete with crops are used and here, *Grevillea robusta*, *Cupressus lusitanica*, *Euphorbia tirucalli*, *Erythrina abyssinica*, and *Dracaena afromontana* are mostly cited hence managing this system, farmers are able to continue cropping trees right up to the edge of the homestead. According to Baker *et.al.*, (2014), the boundary planting system is designed to provide high valued merchantable timber products on a sustainable basis in addition to providing the function of a natural barrier.

As seen elsewhere in the outside world like Washington by the Seattle Department of Transportation (2017) some farmers practice strip tree planting. Planting strips are planted with low growing perennials, ornamental grasses, shrubs, herbs or edible plants, vegetables and this is mainly practiced by small holder farmers who have limited land and capital to invest in tree planting but in the due course they help to supply tree products. Some trees are planted around crop gardens (boundary tree planting) around protected or threatened resources and as a result they benefit the local community while at the same time providing an extra layer of protection to a conservation area.

2.1.3 Scattered trees on-farm/Intercropping

The use of scattered trees and shrubs is a traditional practice in the various land use systems in the country. Dilrukshi *et.al.*, (2013) reported that trees are spatially distributed in form of home gardens which are found in both rural and urban areas in predominantly small-scale subsistence agriculture. People plant house hold gardens close to dwelling for security, convenience and special care as they require low capital input and simple technology. Many small-scale peasant farmers need to diversify farm products and end up integrating trees in agricultural systems as these mixed stands contribute to the production of timber, poles and other tree products as well as house hold food security. While Gwali *et.al.*, (2015) noted that, coffee farming in Uganda is practiced in mixed stands that involve intercropping with trees and food crops, Reinhard (2018) reported that some trees such as *Markhamia lutea* and *Ficus natalensis* are found scattered on

farms especially in coffee where they either arise from natural regeneration or planted due to their high germinability rate. Such trees also provide shade, firewood as well as poles and timber for construction.

In Kenya, Farm forestry practices are mainly centered on scattered trees in field crops and around homesteads on farm holdings up to about 2.5 hectares, as was also observed by Appiah and Pappinen (2010). Trees planted in the highland areas include; *Acacia mearnsii*, *Sesbania sesban*, in the medium elevation zones, *Calliandra calothyrsus*, *Leucaena diversifolia*, *Eucalyptus globulus*, *Jacaranda mimosifolia* while those which are found in the low elevation zones are; *Senna species*, *Casuarina cunninghamian* and *Eucalyptus species* (Ndayambajje, 2013). Onguso et. al.,(2012) reported that at times, farmers prefer scattered *Grevillea spp* in their gardens because it grows very fast and its leaves decompose easily.

On the other hand, one may want to know how decisions are made in the above Farm Forestry Systems but according to Seline (2014), there are many instances where joint decisions are made by husbands and wives together but when it comes to tree planting and management, decisions are more often made by the husband alone compared to other agricultural activities such as crop planting and fertilizer application. In patrilineal households, where husbands hold land titles/agreements, decisions about tree planting and management are more often made by the household head while in matrilineal households, where land rights are transferred along the female lines, joint decision making is more common. Similarly, in male headed households, the head tends to make decisions about tree planting but in female –headed households’ decisions are more likely to be made jointly. Studies done by Kiptot and Franzel (2011) showed that men usually have the overall authority as pertains to tree products that are considered to have high returns, women have rights of collection and use of fruits but are restricted from harvesting fuel wood of high value timber such as *Markhamia lutea*.

If you let a monkey choose if it wants one banana now or six bananas later, the monkey will always choose the one banana now (Laura, 2017) which implies that the youth cannot trust that adults alone will save their future so they have to take their future in their hands by planting trees given the fact that they are still energetic at this stage. Kallio (2013) on the other hand highlights that old people participate in tree planting because they need relatively low labour inputs compared to other agricultural crops. Studies done in Ethiopia by Belay et al.,(2019) showed that tree growing is

affected by a wide range of variables, such as marital status , family size which means more people in the family provide more labour, education level which equips knowledge and skills to farmers and land holding. Young farmers are found to be more innovative than older farmers but older heads are more experienced and efficient in planting and managing more tree species than the youth.

Studies done by Jesse (2018) indicate that tree growing is a lucrative long term opportunity/ investment for investors and entrepreneurs as well as a boom for the environment. If a farmer stays in an area for quite a longer time, access to land and having security over it becomes easy as this can motivate him/her to grow more trees; access to land, resources and investments in and around forests can propel women, youth and other rural entrepreneurs to be agents of change in the transformation to a sustainable world (FAO, 2018).

Looking at land tenure, ownership and mode of acquisition, Kallio (2013) reports that the often unclear land tenure as seen in Indonesia and other areas in the tropics can discourage farmers from planting or managing trees if they cannot ensure the right to use or sell trees. Changes to forest governance structures that are strengthening local rights over the land and trees have been occurring throughout the tropics (Luttrell et al., 2011) and such changes can encourage people to plant and manage trees but on the other hand it can make it difficult to those with land limitations. FAO (2018) reported that strengthening tenure rights presents an opportunity to enhance gender equitable access to forests and trees, as well as encouraging a long-term, sustainable approach to forest management.

According to Appiah and Pappinen (2010) that access to additional land has become difficult in Kenya due to the increase in demand for land from a population that is growing rapidly in urban and rural areas. There are many land tenure systems in Uganda but the recognized ones include; the mailo, leasehold, public and customary land (ULII, 1998& UCCA, 2018). Considering land size, most of the tree farmers have only very small areas of land such that they have little choice but to plant staple food crops that provide annual returns, instead of the relatively slow growing trees (Jesse, 2018), males occupy large pieces of land under forestry as compared to women across the various Farm Forestry Systems and a result , women have limited access to land (FAO, 2018& Bose et al., 2017). The species are fast growing and respond positively to frequent cutting Sebuliba *et al.* (2012).

A report by Kallio (2013) also indicates that farmers who own large areas of land normally tend to plant and manage trees more than those with limited land. Small land areas can be more easily protected from damage such as forest fires or diseases and there is an incentive to focus on quality production. On the other hand, small sized land provides small volumes of wood which can make harvesting and transportation to the market easy. Proximity and Location of the land is very important for example if a farmer is living and working far from his/her land, planting it with trees is a productive option and, in some cases, it was reported to secure control over the land while they are away. On the other hand, farmers often live in or near their farms, enabling them to protect and manage their trees in a more efficient manner (Rudel, 2009&Kallio, 2013). Terra *etal.*,(2009) pointed out that the success of agroforestry practices is linked to evolution of local knowledge, advanced scientific knowledge and modern technologies which includes sources where Farmers get the planting materials such as seedlings.

2.2 Factors motivating engagement in Farm Forestry

2.2.1 Engagement in Farm Forestry

Carter (2009) pointed out that when the mean age of an individual is longer it means that he/she is much settled and can motivate him to grow trees compared to one with a lower mean age, individuals who are completely illiterates find difficulties in tree growing due to limited knowledge. However, when the number of people are many in a household, it could be a major source of labour for tree management (Belay et al., 2019). If a person stays in an area for quite a longer time, access to land and having security over it becomes easy as this can motivate him/her to grow more trees (FAO, 2018).

According to Ouya (2016), the more land possessed by a farmer, the more he/she is motivated to plant trees and he adds that farmers decide on the tree species to keep based on where their farm is located in terms of ecology, rainfall and land topography, farmer's environment, farmers' agro ecological zone but also on their needs and their asset profiles. If one is near the homestead, it becomes easy to supervise and manage trees; as a result the period of engagement in tree growing increases and this leads such a farmer to join a farmer association in order to solve some challenges (Rudel, 2009&Kallio, 2013). Farmers grow trees to meet their specific household needs which change as their household situations change and are influenced by a number of factors such as availability of land and labor, types of trees available, techniques for, and risk involved in growing

them, guaranteed benefits as well as markets for both forest products and employment of family labor (Malla, 2012).

According to Kallio (2013), some socioeconomic factors are found to be positively correlated with silvicultural management activity; namely larger planted areas, years as a member in farmers group, positive attitudes towards tree planting, and higher numbers of household members contributing to income generation.. Studies by Onguso et al.,(2012) report that farmer's age, farm size, land value, erosion rate, tenure system, expected net returns/resource endowment, site description/biophysical factors, and market incentives as factors that influence tree growing.

Otsieno *etal.*,(2014) observes that farm sizes, species preferences, end use of tree products, access to and availability of preferred germ plasm and planting materials, availability of resources for raising seedlings, access to extension services, and marketing constraints as well as biological and technical factors such as diseases, pests and planting methodologies are established as important factors influencing Farm Forestry and tree planting in generally in Kenya. In Uganda as reported by Kulindwa (2016), the following factors were seen to be affecting tree growing on farm: Households' land sizes, households' awareness of tree planting programmes, tree planting for wood energy, and the age of the head of the household.

However, in terms of duration, when one stays in an area, can plant trees to act as natural barriers and get high merchantable timber. Similar findings were reported by Baker *etal.*,(2014) in his study about boundary tree planting where he also said that it secures land. However, Huge (2003) asserted that planting trees in woodlots helps a farmer to get higher incomes through the sale of large quantities of wood because land is secured but this can be achieved after staying in an area for a reasonable period of time. Also choosing scattered system normally enables one to get a variety of products including food for home consumption, wood as it was also asserted by Gwali *et al.*,(2015).

In the same way research carried out in Kenya by Appiah and Pappinen (2010) reported that some ladies are landless and others have small pieces as this limit them from engaging in tree planting. However, those people were only looking at duration of stay in relation to FFS not putting in mind the culture of farmers which could have a negative impact on tree growing. Looking at land holding, in Kenya, Farm Forestry practices are mainly centered on scattered trees in field crops

and around homesteads on farm holdings up to about 2.5 hectares, as was also observed by Appiah and Pappinen (2010). The household land holding is also an important variable in tree growing because having adequate land enables household to diversify its cropping patterns into cash crops such as plantation forestry (Kiyangi et al., 2016). Also, household endowment such land holding can be positively related to adopting new technologies. It was reported by Carter (2009) that only a few people are landless and most people were having enough land to put some aside for tree growing.

2.2.2 Reasons for Non-Engagement in Tree Planting

Cultural beliefs have strong influence on agroforestry adoption (Kiptot and Franzel, 2011). They include ritual prohibitions against planting or using certain trees, regulations on where trees may be planted, limitations on who may plant trees and legislation set by national government. However, this study did not look at cultural influence on tree planting and so there is a need for further research on this topic. As highlighted by Seline (Seline, 2014), it is often assumed that decision making is dominated by the head of the household, usually the oldest male and so it is wondered whether more trees can actually get planted than if these decisions are made by women.

The overall gender disparity between rights and actual rural ownership continues to be vast in Latin America and despite the legal reforms in the region, rural and indigenous women continue to have limited access and property rights to forest and agricultural land (Bose et al., 2017). The report by Kate (2015) shows that men dominate tree planting and management but women participate in tree planting activities; however the participation of women is low in enterprises that considered men's domain, such as timber and high in enterprises that have little or no commercial value such as collection of indigenous fruits and vegetables (Kiptot and Franzel, 2011). Studies done by Jesse (2018) indicated that tree growing is a lucrative long term opportunity/ investment for investors and entrepreneurs as well as a boom for the environment.

2.3 Factors Determining Growth Performance of Trees in Farm Forestry Systems

Parameters like height, diameter at breast height (dbh) are used when determining tree growth. To compute volume of the individual trees, diameter or tree girth (circumference/perimeter) of the stem is measured using calipers or diameter tapes and height is measured using either a calibrated pole, a tape or a suunto clinometer instrument (Zerihun & Yemiru, 2013). If the cross-section of a tree is determined using the diameter at breast height, then it is called basal area, denoted by “g”.

$g = (\pi d^2/4) \text{ cm}^2$ but basal area is commonly expressed in square meters (m^2) and so it becomes $g = (\pi d^2/40000) \text{ m}^2$.

As noted by FAO (1980), dominant height is defined as the height of the 100 thickest stems (stems with the largest diameter) per hectare thus the number of trees required for dominant height estimation is the plot area times 100. Trees with broken or significantly damaged tops are not used in height sampling. The average diameter-height ratio is then used to derive the height of the trees whose heights cannot be measured (Malimbwi, 1997). That is:

$$\frac{Dbh}{hd} = x$$

Where;

Dbh=diameter of tree with dominant height

hd=dominant height

x=Average diameter- height ratio.

$$\left(\frac{d}{h}\right) = x$$

$$h = \left(\frac{d}{x}\right) \text{ where,}$$

h=Derived height (height of un measured trees)

d= diameter of tree

x= average diameter- height ratio

The volume of each tree is then calculated using the formular below:

$$Vi = ghf \quad \text{Where;}$$

g=basal area of an individual tree.

$$g = \left(\frac{\pi d^2}{40,000}\right) \text{ m}^2.$$

$$Vi = \left(\frac{\pi d^2}{40,000}\right) * h * f$$

Where,

$$\pi = 3.14$$

d=diameter of the tree

h=Height of tree

f=0.51 for Pine (Jigme, 2017) and 0.52 for Eucalyptus and Grevillea (FAO, 1981 & FAO, 2013)

The volume per hectare is calculated as:

$$V_{ii} = \frac{V_i}{\text{Area of stand}} \text{ m}^3/\text{ha}$$

The MAI of the individual tree is computed by; $\text{MAI} = \frac{V_{ii}}{\text{Age}} \text{ m}^3 \text{ per year}$ (Malimbwi, 1997).

Where V_{ii} =volume of tree, m^3

The total volume of the trees is then computed to ascertain the total volume per hectare.

The total volume (V_{iii}) of the stand is given by;

$$V_{iii} = \left(\frac{\text{Total volumes of trees}}{\text{Stand area}} \right) \text{ m}^3/\text{ha}$$

From the above, the total MAI of the trees/stand per hectare is given by

$$\text{MAI} = \frac{V_{iii}}{\text{Age}} \left(\frac{\text{m}^3}{\text{ha}} / \text{yr} \right)$$

The mean annual increment (MAI) or mean annual growth refers to the average growth per year a tree or stand of trees has exhibited/experienced at a specified age or the average change in volume over the whole life of the tree (Malimbwi, 1997). Mean annual increment (MAI) is also defined as the total increment of a tree or stand (standing crop plus thinnings) up to a given age divided by that age. Mean annual increment (MAI) represents the average annual growth a tree or stand of trees has exhibited up to a specified age (Malimbwi, 1997).

Since the typical growth patterns of most trees is bell-shaped, the MAI starts out small, increases to a maximum value as the tree matures, then declines slowly over the remainder of the tree's life. Throughout this, the MAI always remains positive. The culmination of mean annual increment (CMAI) is the age in the growth cycle of a tree or stand at which the MAI of volume, basal area, diameter, or height is at its maximum. This point at which the MAI peaks is commonly used to identify the stand's rotation age that maximizes volume over time.

Wood volume is a cubic measure of the amount of wood, or wood plus bark, present in an individual tree, group of trees, or stand, usually measured in cubic meters, but may be measured in other units specific to intended commercial products but it is usually expressed quantitatively as a function of diameter, or diameter and height or merchantable length (FAO, 2018). As it has been reported by SPGS (SPGS, 2014) in Uganda, every year trees accumulate an average of about 25 cubic meters of wood volume compared to 19 or less in other countries.

While in Panama, growth rates tend to be slower, the mean annual increment fluctuates between 5 and 22m³/ha/y, with an average annual increment of 11m³/ha/yr at age 7-11 years (Gerald, 1986), in South Africa, *Pinus caribaea* has average mean annual increment (MAI) of about 22m³/ha/yr (Meyenfeldt *etal.*, 1978); and 30m³/ha/yr. In Uganda, the mean annual increment (MAI) of *Pinus caribaea* was reported to be about 20m³/ha/yr (S P G S, 2007; Kaboggoza, 2011). According to Kalanzi et al., (2014), *P. caribaea* trees registered good growth rates in Gulu and Mubende where their MAI was reported to be between 15 and 19m³/ha/y and poor growth rates in Nakasongola with a MAI of 4.619m³/ha/y.

Comparisons of growth performance are made basing on the MAI for the stands/gardens of different areas/sites or Farm Forestry Systems. Aakala *etal.*, (2013) noted that the potential growth of a young tree is greater than that of an older tree of the same size and so older trees grow more solely than young trees (all else being equal). Growth and yield of trees can be influenced by factors such as mix of tree species in the stand, stand age, stocking/ density, competition and management practices (Malimbwi, 1997). Reukema (1966) Postulated that merchantable volume or dbh growth increases as spacing increases and mortality increases with increasing number of trees. Studies carried out in Canada by Baskerville (1965) reported that volume of stem wood, as well as branch wood and total volume tend to increase linearly with increasing density. This implies that the production of wood increases when the stocking rate also increases.

Studies done by Ovington (1945) in Kent were in line with Baskerville (1965)'s findings only that they emphasized that production increases with increased stocking up to the point where full occupancy of the site is achieved and beyond this, increased density does not affect the amount of growth but only its distribution-on a small number of relatively large trees at low densities and a large number of smaller trees at high densities. However, the researcher argues that having no measurements for the previous years would not be possible to predict the future volumes of wood

supply in Uganda. It is on this basis that the researcher used the MAI to project the future wood production from the different identified Farm Forestry Systems.

2.4 Challenges related to engagement in Farm Forestry

In a study carried out in Nigeria, Danjuma et al.,(2014) highlighted that limited access to planting materials such as plastic bags, fencing wire, watering can and young tree shoot are some of the challenge to tree growers especially at the initial stages of forming up Nurseries for trees. On the other hand, lack of regular income, lack of access to germplasm, tree-crop competition, low timber price, policy disincentives to tree harvesting and marketing and poor tree growth resulting from farmers' reluctance to carry out proper management practices, have been reported as the major constraints to adoption and profitable tree farming (Bertomeu, 2008). Reported other challenges to tree growing include increasing reduction of land among the increasing numbers of households or family members, inadequate credit facilities for purchasing Farm Forestry inputs, continued decline in agricultural output due to increased land degradation and lack of information or poor education on improved practices (Appiah and Pappinen, 2010). In addition to the above problems Carter (2009) noted that labour, pests and diseases, climate change variability, fire, weeds, thieves, land, transport, Hail stones, drought and soil infertility are a major threat in tree growing in Uganda.

According to Kallio (2013), Long rotation lengths, lack of capital, low wood prices, and poor access to production inputs or markets are found to be the main constraints to current and future smallholder tree planting. Lack of funding, quality seeds, good extension services and research were reported to be critical barriers of tree growing for commercial wood supply (SPGS, 2014). Kate (2015) pointed out gender as a major factor highlighting that the household head is the main decision maker in tree planting. Tree planting and management are mainly seen as the domain of men but there is significant participation by women in tree planting activities. Husbands generally dig the holes, prepare the planting sites and fire breaks and take care of pruning and weeding, whereas wives help with getting seedlings to the planting sites, watering the seedlings, applying manure and sweeping leaves around the planted trees.

2.4.1 Measures to Enhance Engagement in Farm Forestry

Through grower's field meetings, tree farmers interact and learn from one another (SPGS, 2014). According to SPGS (2016), a tree farmer needs to carry out many silvicultural practices in order

to come up with better quality tree products. Such practices include weeding, access pruning, thinning, coppicing, protection against forest fires, protection against animals, as well as protection against pests and diseases. While more diverse land use can prevent pests (Carter, 2009), Nyeko et al., (2005), reported that termites can be controlled by trenching, queen removal, chemicals, red pepper, dregs of local brew, used engine oil, sealing vents, fire, paraffin, wood ash, mud fish intestine, dead snake, hot water, cow dung, *Bidens pilosa* and human urine. Diseases can be managed by proper site species matching, timely weeding and destroying anthills.

According to Wilnhammer (2009), wood supply can be enhanced by training and education in tree management of owners and forest work force, land consolidation programmes, voluntary land swapping, stimulating voluntary formation of forest owner groupings, and establishment of service centers aiming at advising the forest owner. On addition, Tree farmer group formation plays an enabling role for small holder farmers to get easy access to extension services especially on silviculture, marketing of trees and accessing quality subsidized seedlings through their links and strong relationship with New Forest Company, District local government and other organizations (Fischer & Qaim, 2012). Studies carried out by Bertomeu (2008) revealed that proper tree spacing provides higher economic returns given the fact that: Crops can be planted in the alleys between rows of trees for longer period, trees will grow faster because of the more intensive management and favorable light regime and farmers would benefit from reduction of area lost to trees and lower tree establishment and management costs.

A combination of on-farm trials with active involvement of farmers in design and management and more training plus improvement in extension and dissemination methods will solve the challenges. As noted by FAO (1989) in Italy, planting boundary trees around our farm or homesteads can help to control environmental hazards such as storm as this helps also to reduce the noise from neighbours and pollution caused by dangerous gases.

There is also a need to invest in agricultural intensification where farmers undertake permanent cultivation and employ techniques such as manuring and composting to maintain soil fertility, the need for credit lines or facilities such as introduction of microfinance schemes to create access to grants and loans by the developing agencies and education of farmers is essentially a prerequisite for improving agriculture and consequently the living conditions of rural people (Appiah and Pappinen, 2010).

CHAPTER THREE: STUDY AREA AND METHODS

3.1 Description of the Study Area

3.1.1 Location and size

The study was carried out in Mubende district located in the Central region of Uganda. It borders Mityana district in the East, Kyegegwa and Kibaale in the West, Kiboga and Kyankwanzi in the North, Sembabule and Gomba in the South. The district has 14 sub counties and it is located at latitude $0^{\circ} 35' 21''$ N, longitude $31^{\circ} 21' 36''$ E with a total area of 4,646 km², 160kms West of Kampala. The study was conducted in Madudu and Kalwana sub counties (Figure3.1) which were purposively selected basing on their involvement in tree planting activities with a strong practice of smallholder on-farm tree planting (MDLG, 2018) hence making them suitable for the study.

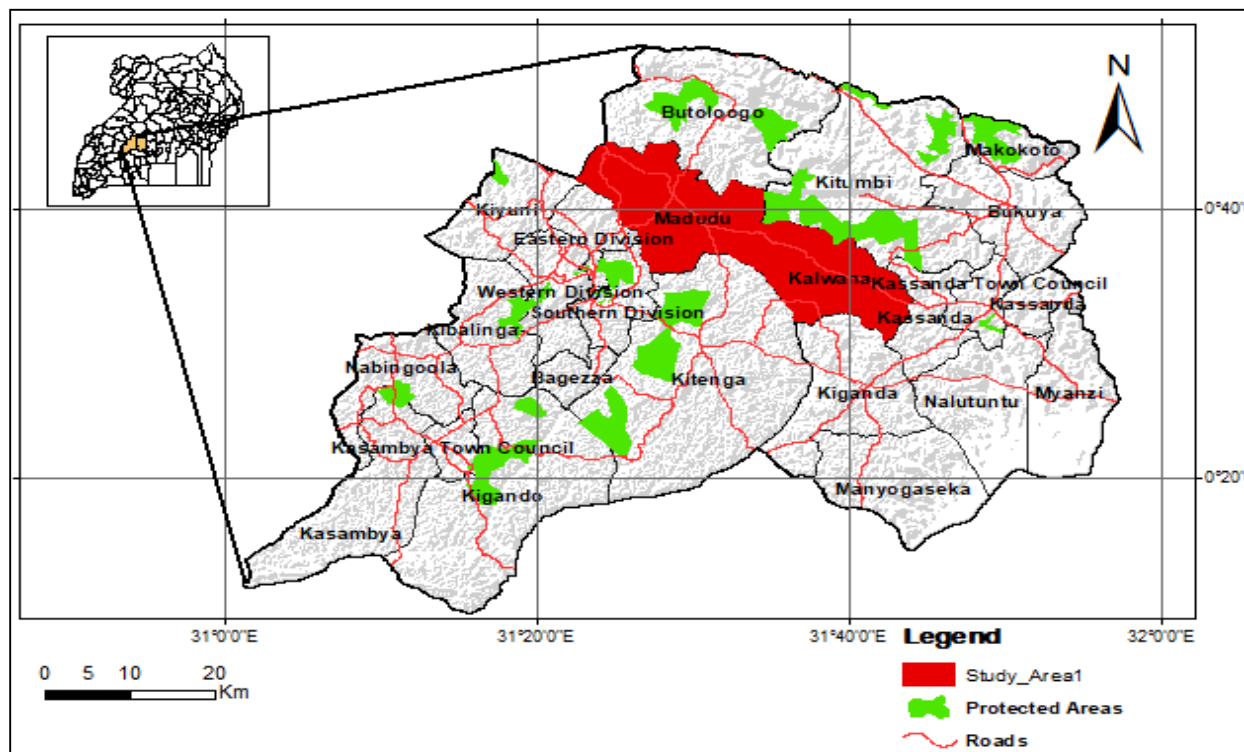


Figure 3 1 Map of study area

3.1.2 Biophysical Conditions

Mubende is mainly covered by Lowland surfaces and Upland surfaces are evident to the Northern border East of Butoloogo and Bukuya. Tors and Inselbergs are found on the Western part of Nabingoola Sub County. Generally, it's a plateau with hilly ridges known as Mubende Hills (MDLG, 2011). The topography/altitude is 106-154m above sea level. Drainage is facilitated by Lakes; Wamala, Kitumbi, Katonga, Nkusi, Kuzizi and Mayanja-Kato, and Rivers; Nabakazi, Kisojo and Katabalanga in Kasambya, Kitenga and Kiganda. The high altitude ensures favorable climate with medium temperature ranging from 17°C to 29°C with moderate rainfall and temperature (MDLG, 2011). The rainfall pattern is bi-modal with two seasons from March to May and September to November and the annual rainfall varying between 560 mm to 1,272 mm. Across the study area, the soil structure is mostly characterized by sandy clay, sandy-clay-loam or clay loam which appeared most and they are yellow-reddish in color (Max, 2018)

3.1.3 Land Use and Land Cover

The district has a total area of 758 km² land under wetlands. The permanent wetlands cover 171.7 km² while the seasonal wetlands cover 586.4 km² and of these the papyrus swamps cover approximately 159.5km (MDLG, 2011). In terms of vegetation, 23% of the total land area (1,239 km²) is Forests and Woodlots while the rest is under crop production, wetlands and livestock. Natural high forests are found mainly in Busujju county, woodlands cover the largest part of the district especially in the counties of Buwekula and Kassanda (MDLG, 2013). There are 22 Gazetted central forest reserves (CFR) covering a total land area of 32,404Ha and one local forest reserve of 85Ha (Mubende District, 2004). Mubende district was selected for this study because it has approximately 87,137Ha of private forests planted by mainly smallholder tree farmers in scattered woodlots ranging from 1-10ha (Mubende District, 2004). The smallholders mainly plant Eucalyptus species with pine whose seed sources include Australia, Brazil and South Africa while other species are planted at a smaller scale.

3.1.4 Socio-economic Characteristics

The population is 706,256; 49% females, 51% males (UBOS, 2016) and 83.5% rural whose ethnicity includes the Bantu: Baganda; 36.1% followed by Banyoro 14%, Banyankole 11.4%, Bakiga 10.7%, Bafumbira 9.9%, Banyarwanda 6.8%, Bakhonzo 3.1%, Batoro 2.5%, Basoga 0.7% & others 4.6% (MDLG, 2013). In terms of accessibility there is a road network of 4,308 kms of

which 260 kms are trunk roads, 1048 kms are feeder roads and the remaining 3000 km are community roads (MTIC, 2018). Financial Services include registered SACCOs and commercial banks spread across the district while the economic activities include; agriculture, fishing, mining, tourism, lumbering, grain processing, fruit production and chalk making (MTIC, 2018). Agriculture is by far the main economic activity in the district. Over 70% of the populations depend on subsistence farming as the main source of livelihood where they also grow trees on farm and rear some animals. The rest of the population depends on employment income, trading, and cottage industries. Maize so far is the major crop produced in the district both as food crop and cash crop, followed by Banana food, cassava, beans, sweet potatoes, banana beer, G/nuts, Irish potatoes and sweet bananas (MDLG, 2011).

Land in Mubende is mainly Mailo and under the Mailo tenure, most of the farmers own the land on the arrangement of Kibanja, with only a few of private mailo holders recorded (Oboikol, 2014) while most farmers own land ranging from >1 and < 4 acres.

3.2 Methods

3.2.1 The Study design

The research followed a descriptive research design employing a cross-sectional field survey; it adopted qualitative and quantitative data collection and analysis approaches. The descriptive design was used because it enabled the researcher to describe/explain the state of affairs as they actually existed or in the form in which they were found.

3.2.2 Sampling procedure and Size

Mubende and Kassanda districts were purposively selected, the two districts were predominantly comprised of rural communities with a population estimated to be 413,553 and 275,266 for Mubende and Kassanda respectively according to the National Population Housing Census 2014 (UBOS, 2018). The cross-sectional household survey was conducted in the Sub-counties of Madudu and Kalwana which were selected basing on their involvement in tree planting activities with a strong practice of smallholder tree plantations and Farm Forestry with planting and retention of a variety of multipurpose trees on farms (Mubende District Local Government (MDLG), 2018). Across the 90 villages within the two sub counties, 19 villages were randomly selected from which 127 respondents were selected. However, basing on Krejcie and Morgan (1970), the targeted

population for the tree and non-tree farmers was 190. Of the total respondents, 63 tree farmers were purposively selected on the criterion of owning at least 20 trees on their farms while the 64 non-tree farmers were also purposively selected on a principle of being within close proximity (<1 Km) with the selected tree farmers.

Table 3. 1 Sampling Procedure and Size of Tree and non- Tree Farmers (n=127)

Subcounty	Madudu	Kalwana
Parishes	Dalamba Naluwondwa Kansambya	Kikandwa Kasaazi Mayirikiti
Villages	n= 9 (Purposive selection)	N= 10 (Purposive selection)
Tree growers	n=24 (Random selection)	n=39 (Random selection)
Non-tree growers	n=16 (Purposive selection)	n=48 (Purposive selection)

3.2.3 Data Collection Procedure and Tools

a) Review of related Literature

Relevant literatures were reviewed from sources including; Scholarly published articles, Government of Uganda published documents, books, Institutional reports and newsletters like SPGS publications. Mainly literatures of not more than ten years were reviewed but also relevant old literatures were considered to clarify the claims. Scholarly published articles, Government of Uganda published documents, books, Institutional reports and newsletters were used in reviewing related literature because through providing a wealth of knowledge, they promoted the researcher's active reading, provoked deep thinking and provided evidence and clarity for the researcher's claims. These were also aimed at deepening the researcher's understanding of the subject under study and also assess the collective evidence on diagnosis of the Farm Forestry Systems. They were also relevant in helping the researcher enrich on the literature review section of the dissertation.

b) Individual Household Interviews

Interviews were conducted with 63 tree farmers and 64 non-tree farmers using a semi-structured questionnaire (Appendix I & II). The interview emphasized the aspects aimed at; (i) characterizing the Farm Forestry Systems (*land ownership and size, tree species, spacing, age and size of the farm*), (ii) assess the factors motivating engagement in Farm Forestry (iii) investigating the main

challenges and actions to enhance engagement in wood production from their FFSs. Semi-structured questionnaires were used in Individual Household Interviews because they allowed Informants the freedom to express their views in their own terms, provided reliable comparable qualitative data, provided opportunity for learning and helped the researcher to become acquainted with community members.

c) Mapping and Inventory of the Farm Forestry Systems

The Individual FFS were mapped to establish the area and plot-levels assessments. Since most farmers that were practicing boundary and scattered systems did not have many trees on their farms, the researcher took inventory of all their trees. For the woodlots, rectangular and square shaped plots of; 10*10 m², 20*10 m², 20*20 m², 30*20 m², and 30*30 m² were laid out on the different woodlots depending on their sizes. The plots were established along the transect lines at 30-40m interval within the woodlots to reduce the effects of having micro sites and the number of lines laid depended on the size of the woodlot. The GPS was used to measure the area of the plots, determine the bearings and the directions of the transect lines. In each plot, all the trees' diameter at breast height (DBH) was measured using a diameter tape, their height measured using a Suunto clinometer and other qualitative observations on the tree quality and growth nature like diseased trees, bent and broken tops, fox tail trees were noted. The parameters measured and other variables observed were recorded on a Field Form (Appendix iii).

3.2.4 Data Analysis

a) Characterizing Farm Forestry Systems

To characterize FFS in the area, Descriptive statistics such as frequencies, percentages and cross tabulations were used to summarize attributes on (i) the socio-economic characteristics of the farmers; (ii) the dominant FFS and engagement by sex of respondents (iii) the land under trees including: size, tenure, ownership and mode of acquisition (iv) tree species planted (v) decision making on Farm Forestry engagements (Nyambo, 2019). Correspondence Analysis (CA) was also conducted to determine, the relationship between; the size of land holding and the Farm Forestry System practiced; the seed sources across the different Farm Forestry Systems (Kennedy et al., 1996) Cross tabulation was also used to determine the proportional relationship across the various responses for example; land tenure versus mode of land acquisition versus the FFS practiced (Kallio, 2013).

b) Assessing the Factors motivating engagement in Farm Forestry

To study the factors influencing engagement in Farm Forestry, descriptive statistics were used to summarize and demonstrate factors and cross tabulation used to demonstrate the relationship among the studied socio-demographic variables and the factors influencing the decision to engage in Farm Forestry. Mann-Whitney U test was conducted to test the statistical difference of the selected socio-demographic variables and engagement in Farm Forestry.

c) Assessing Growth Performance of Trees in Farm Forestry Systems

To assess the growth performance of trees under the different FFS, the total volume of the trees in the different plots/stands was obtained using the formula, $V_i = ghf$ and thereafter the Mean Annual Increment (MAI) computed for each plot/stand as indicated following (Malimbwi, 1997)

The average diameter-height ratio was used to derive the height of the trees whose heights were not measured, that is:

$\frac{Dbh}{hd} = x$ Where; Dbh=diameter of tree with dominant height; hd=dominant height; x=Average diameter- height ratio.

$$\left(\frac{d}{h}\right) = x$$

$h = \left(\frac{d}{x}\right)$ where=Derived height (height of un measured trees); d= diameter of tree; x= average diameter- height ratio

The volume of each tree was then calculated using the formular below:

$V_i = ghf$ Where; g=basal area of an individual tree.

$$g = \left(\frac{\pi d^2}{40000}\right) m^2.$$

$$V_i = \left(\frac{\pi d^2}{40000}\right) * h * f$$

Where, $\pi=3.14$; d=diameter of the tree; h=Height of tree; f=0.51 for Pine (Jigme, 2017) and 0.52 for Eucalyptus and Grevillea (FAO,1981& FAO, 2013)

The volume per hectare was calculated as:

$$V_{ii} = \frac{V_i}{\text{Area of stand}} \text{ m}^3/\text{ha}$$

The MAI of the individual tree was computed by; $\text{MAI} = \frac{V_{ii}}{\text{Age}} \text{ m}^3 \text{ per year.}$

Where V_{ii} =volume of tree, m^3

The total volume of the trees was computed and then volume per hectare

The total volume (V_{iii}) of the stand was given by;

$$V_{iii} = \left(\frac{\text{Total volumes of trees}}{\text{Stand area}} \right) \text{ m}^3/\text{ha}$$

From the above, the total MAI of the trees/stand per hectare was given by

$$\text{MAI} = \frac{V_{iii}}{\text{Age}} \left(\frac{\text{m}^3}{\text{ha}} / \text{yr} \right)$$

Site comparisons using the computed MAI across the FFS were also carried out to evaluate the growth performance of trees under the different Farm Forestry Systems.

d) Assessing the Challenges and actions in Farm Forestry Systems

To assess the challenges limiting FFS and investigate the actions to enhance wood production from FFS, descriptive statistics like percentages and cross tabulation was used to clearly demonstrate the particular challenges faced across the studied Farm Forestry Systems (Kallio, 2013). This was done through considering the most dominant responses to be key messages from each category.

CHAPTER FOUR: RESULTS

4.1 Characterization of Farm Forestry Systems

The characterization of the Farm Forestry Systems considered; (i) the socio-economic characteristics of tree farmers; (ii) the dominant Farm Forestry Systems and engagement by sex of respondents (iii) the land under trees including: size, tenure, ownership and mode of acquisition (iv) tree species planted and (iv) decision making in farm forestry engagements.

4.1.1 The socio-demographic characteristics of tree farmers

A number of variables relating to the tree farmers' demographic characteristics were enumerated (Table 4.1).

Table 4. 1 Socio-demographic characteristics of Tree Farmers (n=63)

Characteristic of the Respondent	Attribute	% of Respondent
Sex	Male	84
	Female	16
Age Category (Years)	≤30	10
	31-45	40
	46-60	27
	>60	23
Marital status	Single	08
	Married	92
Education level	No formal education	13
	Primary	59
	Secondary	20
	Tertiary	08
Household size (People)	1-4	16
	5-10	55
	>10	29
Period of stay in the area (Years)	≤ 10	25
	>10	75
Major source of livelihood	On farm	87
	Off farm	13
Access to land	Yes	100
	No	
Size of land (Acres)	≤ 2	59
	2.1 – 5	27
	> 5	14

Majority of the respondents were males, while the dominant age group was 31-45 years. Most of the respondents were married, with household size of 5-10 members and had completed primary level of education. All the respondents had access to land and the majority had lived in the area for more than 10 years and thus could ably engage in a discussion about tree farming.

4.1.2 The dominant Farm Forestry Systems

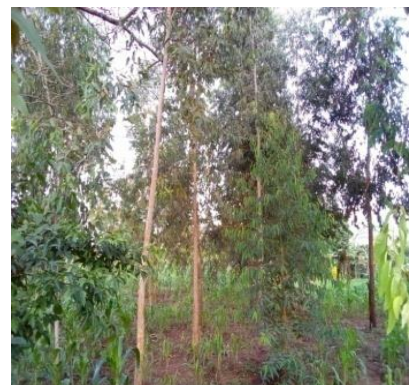
The Farm Forestry Systems (FFS) reported by the respondents in the study area were boundary (36%), woodlot (56%) and scattered trees on farm. Farmers who practiced the system for scattered trees tended to mix trees with other crops which resulted into the scattered of trees in different spots in the gardens/farms, those who got involved in woodlots mainly planted only trees on a specified piece of land while the farmers who practiced boundary system only planted trees around their crop gardens (Plate 4.1).



Boundary Trees



Woodlot



Scattered Trees

Plate 4. 1 Farm Forestry Systems in the study area

Woodlot systems were established mostly by males (32%) while women (11%) were more engaged in the boundary systems. None of the female respondents reported ownership of trees under the scattered tree system (Figure 4.1).

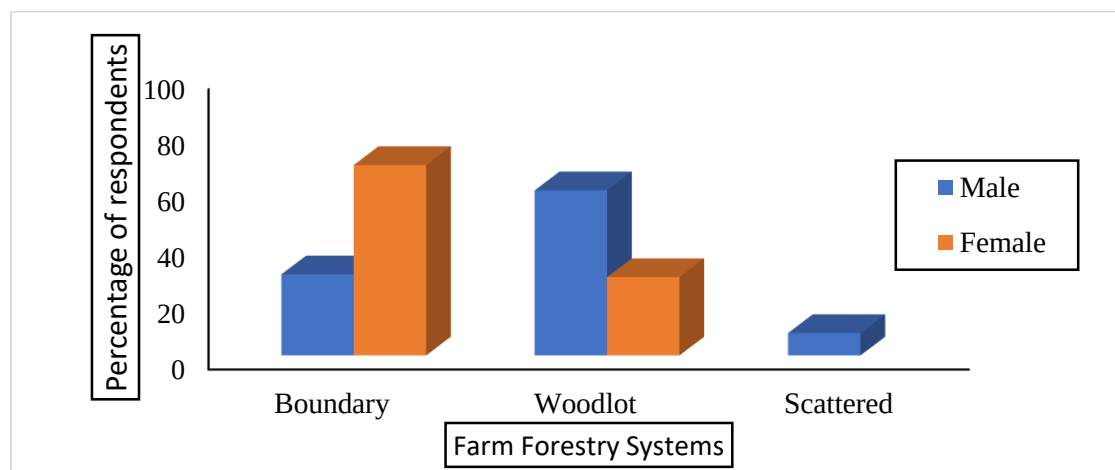


Figure 4. 1 Farm Forestry System and sex of respondent

4.1.3 Land Tenure, Ownership and Mode of Acquisition

Trees were reported to be planted on land under different tenure by 87%, 5% and 8% of the respondents on Mailo, Leasehold and Public land respectively. Under the Mailo tenure, most of the farmers owned the land on Kibanja arrangement with only a few of private mailo holders. In area, respondents reported three modes of land acquisition which included buying, inheriting and renting (Table 4.2).

Table 4. 2 Farm Forestry System, Land tenure and land acquisition mode

Land tenure	Mode of acquisition	Farm Forestry Systems		
		Boundary (n=23)	Woodlot (n=35)	Scattered (n=5)
Mailo-Kibanja (n=48)	Bought	28%	43%	7%
	Inherited	8%	10%	1%
	Rented	1%	1%	1%
Private Mailo (n=7)	Bought	85%	10%	
	Inherited	5%		
Leasehold (n=3)	Bought	50%		
	Inherited	50%		
Public land (n=5)	Bought	21%	7%	
	Inherited	36%	36%	

Most of the tree farmers on Mailo-Kibanja, had bought their land and practiced mainly woodlot system. Majority of the farmers on private mailo had also reportedly planted trees at the boundaries. The respondents that had inherited land under the Public tenure regime had both boundary and woodlot systems. The scattered farm forestry system was evident for only Kibanja holders

Majority of the male respondents who had bought and rented land mostly practiced the woodlot systems, while most of the women who bought land mainly planted trees at the boundaries. The female respondents who had inherited land reported that they usually plant trees either under boundary or woodlot system (Figure 4.2).

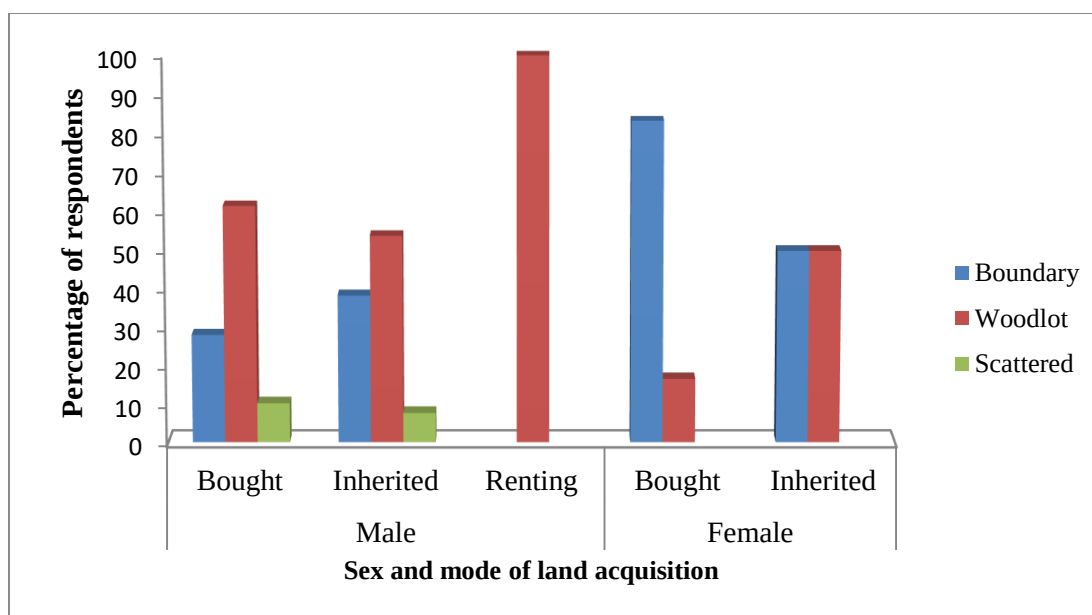


Figure 4. 2 Sex, mode of land acquisition and Farm Forestry Systems

4.1.4 Land Sizes, Farm Forestry Systems and Species planted

The land area under trees ranged from 0.07 to 50 acres and 60% of the respondents had less than two (2) acres under various farm forestry systems. There were more males (43%) than females (22%) with more than 2 acres of farm forestry land. The main tree species planted in the different farm forestry systems included; *Eucalyptus spp*, *Pinus spp*, *Clonal Eucalyptus*, *Grevillea spp*, *Markhamia lutea* and *Ficus natalensis*. In general, there was a higher preference reported by 62%, 24% and 11% of the respondents for *Eucalyptus spp*, *Pinus spp* and *Grevillea Spp* respectively although the tree species planted varied by the land size and farm forestry system practiced (Table 4.3).

Table 4. 3 Land size, Species and System

Land size	Species	Farm Forestry System		
		Boundary (%)	Woodlot (%)	Scattered (%)
0-2	<i>Eucalyptus Spp</i>	33	67	
	<i>Pinus Spp</i>	55	36	09
	<i>Grevillea spp</i>	100		
2.1-5	<i>Eucalyptus Spp</i>	18	73	09
	<i>Pinus Spp</i>		100	
	<i>Grevillea spp</i>	34	33	33
> 5	<i>Eucalyptus Spp</i>		100	
	<i>Pinus Spp</i>	100		

Almost all the tree farmers with less than 2 acres of land had planted *Eucalyptus* and *Pinus* species either as boundary or woodlot plantings. Only a few of these farmers had scattered *Pine* on their

farmlands and *Grevillea* was only planted under the boundary system. The majority of the respondents with more than 2 acres of land had *Eucalyptus* woodlots and *Pinus spp* at the boundaries with almost equal proportion of *Grevillea spp* across the three systems. When a correspondence analysis between FFS and land size was carried out, it showed that boundary and woodlots had an association with all land sizes but the scattered system indicated an association with only land sizes of 2.1-4 acres Figure 4.4.

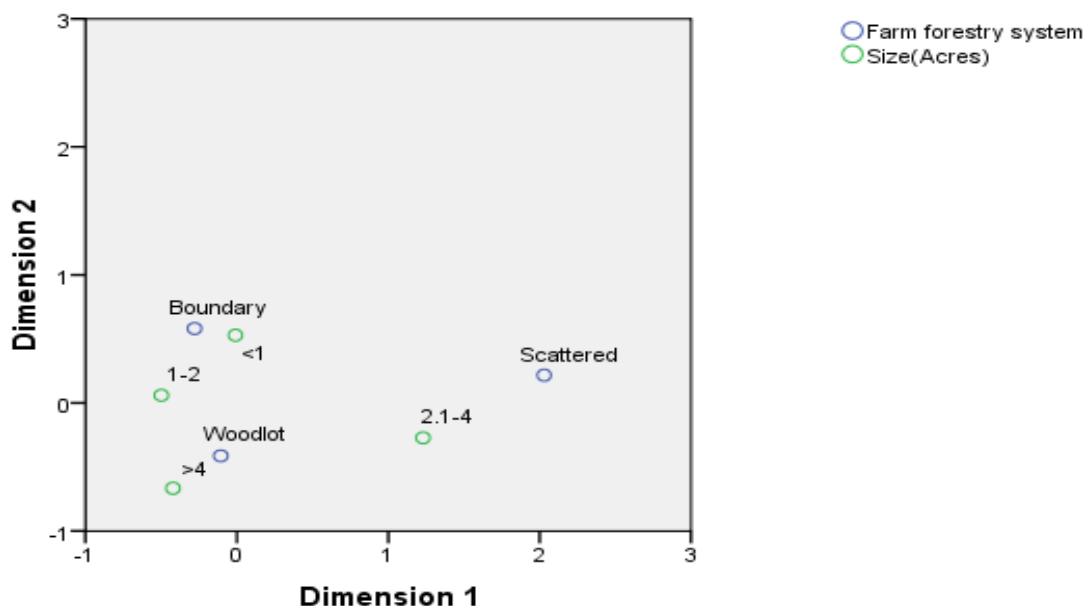


Figure 4. 3 Symmetrical Normalization for FFS and Land Size

Further disaggregating the data on tree species planted by sex, it was revealed that more males were engaged in tree planting across the farm forestry systems. The females were mainly involved in the boundary system and the males dominated the woodlot system. The males mainly planted *Eucalyptus Spp* across the systems while the females mainly planted *Pinus Spp* at the boundaries as well as *Eucalyptus Spp* in the woodlots (Table 4.4).

Table 4. 4 Species planted under the different FFS

Farm Forestry System	Sex of respondent	Tree species				
		<i>Eucalyptus spp</i>	<i>Pinus spp</i>	<i>Grevillea spp</i>	<i>Markhamia a spp</i>	<i>Ficus spp</i>
Boundary	Male	50	31	19		
	Female	14	57	29		
Woodlot	Male	84	13	3		
	Female	67	33			
Scattered	Male	20	20	20	20	20
	Female					

The seedlings used were mostly obtained from private nurseries and the nursery for New Forests Company (NFC) with very few farmers obtaining planting materials from neighbors' gardens. Most seedlings from the NFC nursery could be associated with proximity since almost all the villages (in Kalwana Sub-County) that are nearest to NFC mainly sourced their seedlings from NFC nurseries.

The results from the Correspondence Analysis also indicated a strong association ($X^2 = 22.011$, $df = 4$, $p = 0.001$) between source of seedlings and the Farm Forestry Systems (Table 4.5).

Table 4. 5 Correspondence table between source of seedlings and FFS

Source of seedlings	Farm Forestry Systems			X^2	df	p
	Boundary	Woodlot	Scattered			
New Forests Company (NFC)	16	12	1	22.011	4	0.001
Private Nursery	7	22	2			
Neighbor's garden	0	1	2			

Particular systems were associated with given seedlings sources whereby most of the farmers who were practicing boundary tree planting were mainly getting seedlings from the NFC, those of woodlots were mainly close to private nurseries but not very far from NFC while those who practiced scattered tree planting were mainly depending on neighbors' private nurseries. (Figure 4.4). The strength of this relationship was found to be strong (*Singular Value* = 0.505, $X^2 = 22.011$, $p = 0.001$).

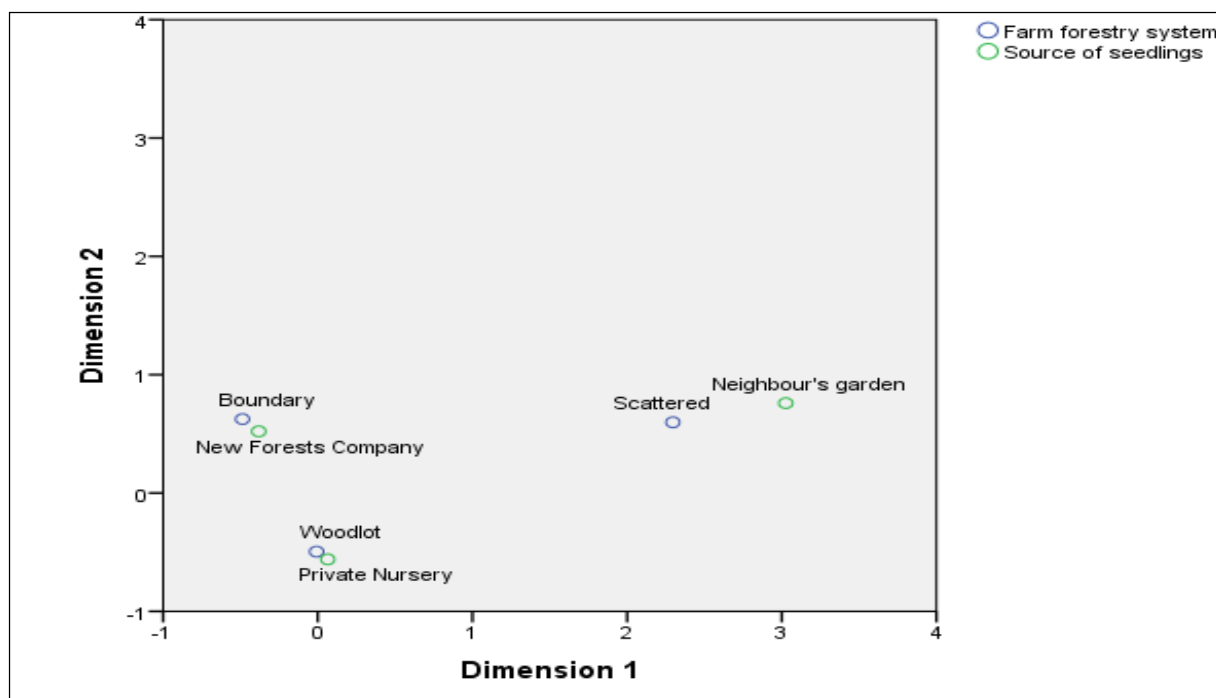


Figure 4. 4 Symmetrical Normalization for Source of seedlings and FFS points

4.1.5 Species Planted for different Products

The trees planted in the various Farm Forestry Systems were mainly for poles and timber. Eucalyptus was reported as the most planted for both poles and timber in the woodlot system by 60% and 28% of the respondents respectively (Table 4.6).

Table 4. 6 Species planted for different products

Target Product	Species	Boundary	Woodlot	Scattered trees
Poles	<i>Eucalyptus spp</i>	19%	60%	5%
	<i>Pinus spp</i>		3%	
	<i>Clonal eucalyptus</i>		5%	
	<i>Ficus spp</i>	3%	3%	3%
Timber	<i>Eucalyptus spp</i>	12%	28%	1%
	<i>Pinus spp</i>	17%	17%	4%
	<i>Clonal eucalyptus</i>		2%	
	<i>Grevillea</i>	8%		1%
	<i>Markhamia spp</i>	1%		2%
	<i>Ficus spp</i>		3%	2%

It was reported by 60% of the respondents that *Eucalyptus spp* was mainly planted for poles in the woodlot system and the least planted for the same product in the boundary and scattered was *Ficus*

spp. The dominant tree species planted for timber in the woodlot system was *Eucalyptus spp*, *Pinus spp* in the boundary while the least planted species for timber in the scattered system was *Grevillea spp* (Table 4.6).

Considering the sex-disaggregated data, the trees planted by males in the woodlot system was mainly for timber while the women planted trees for timber mainly under the boundary system, while the trees planted in the woodlots were mainly for poles (Figure 4.5).

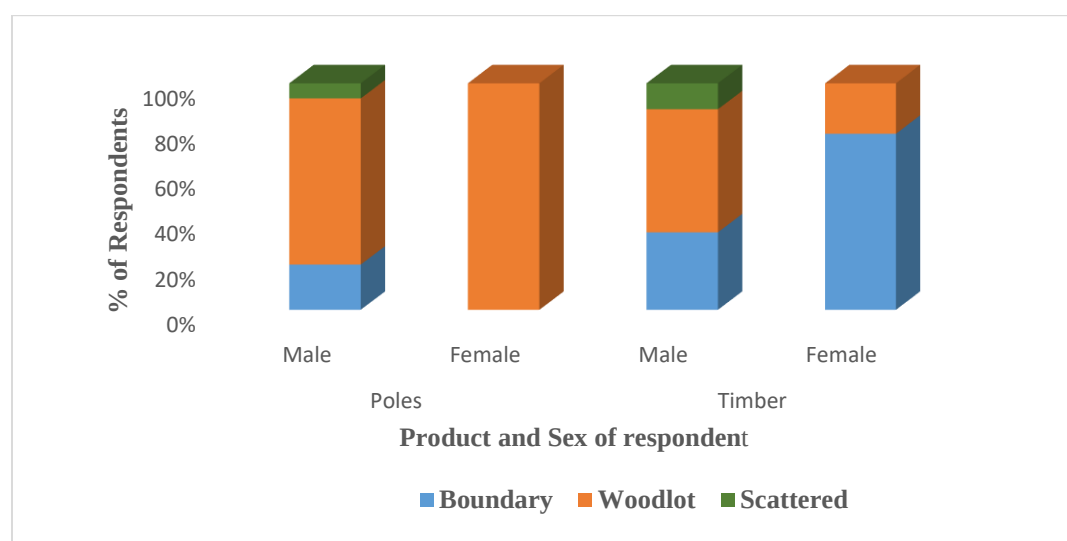


Figure 4. 5 Target products for different respondents (sex) practicing Farm Forestry

4.1.6 Decision making in Farm Forestry engagements

Decision making in relation to species to be planted and the target product was varied. The variations in decision making across the different land owners are presented in Table 4.7.

Table 4. 7 Decision making and land ownership

Land/Tree owner	Decisions maker (%)		
	Self	spouse	Joint
Husband	92	6	2
Wife	100		
Both husband and wife		25	75
Other adults	20		80

The results indicated that decision making was mainly dependent on who owned the trees/land. Where the land was owned by the husband or the wife, decision making was majorly self.

However, where the land was owned by both husband and wife or other adults, decision making was majorly joint.

4.2 Factors influencing engagements in Farm Forestry

4.2.1 Socio-economic characteristics of tree and non-tree farmers

The social economic characteristics of tree and non-tree planting farmers varied including age, education level, household size, size of land, and period of stay in the study area (Table 4.8).

Table 4. 8 Social economic attributes for tree and Non-tree farmers (n=127)

Variable	Tree farmers (n=63)		Non-tree farmers (n=64)	
	Mean	SD	Mean	SD
Age of the farmer (<i>Yrs</i>)	48.35	14.48	37.39	16.40
Education level (<i>Yrs</i>)	5.59	3.89	6.81	4.13
Household Size (<i>People</i>)	2.87	1.251	2.03	0.908
Period of stay in the Village (<i>Yrs</i>)	26.61	16.91	18.33	15.07
Total land owned by the Household (<i>Acres</i>)	4.24	8.78	2.90	3.23
Distance of farmland from homestead (<i>km</i>)	0.57	0.97	1.16	0.92
Period of engagement in tree planting (<i>Yrs</i>)	7.29	5.55		
Period of belonging to farmer association (<i>Yrs</i>)	2.54	4.51		

The mean level of education, distance of farm land from homestead, house hold size and total land owned by both the tree and non-tree farmers were similar for the two categories. However, the average age, and period of stay in the area of the tree farmers was higher than that of the non-tree farmers. It was observed that tree farmers' engagement in farmer association was a recent development in the studied communities. The farmers' age and the period of stay across the two categories had a high SD thus the two variables' data values were greatly spread from the mean. The data values for the level of education, household size and distance of households from the farmlands was not so spread from their respective means since they have a smaller SD (Table 4.9). Tree farmers were significantly older than the non-tree farmers. Also, tree farmers had significantly bigger household sizes compared to the non-tree farmers and they had also stayed in the area for significantly longer period. The non-tree farmers were significantly staying far away from their farmlands. However, the findings did not indicate a statistical difference in the land size owned by either social categories.

Table 4. 9 Independent samples Mann-Whitney test out-put on the difference in socio-economic characteristics of Tree farmers and Non-tree farmers

	Age of the farmer (Yrs)	Household size (People)	Period of stay in the area (Yrs)	Land owned (Acres)	Farmland Distance from homestead (Km)
Tree farmers-mean ranks (<i>n</i> =63)	78.29	76.79	73.46	59.63	47.84
Non-tree farmers-mean ranks (<i>n</i> =64)	49.93	51.41	54.69	62.49	75.29
<i>P-Value</i>	.000	.000	.004	.653	.000

4.2.2 Land Holding for the Households

Across tabulation of the land owned by tree and non-tree farmers showed that generally tree farmers owned more land than the non-tree farmers (Figure 4.6)

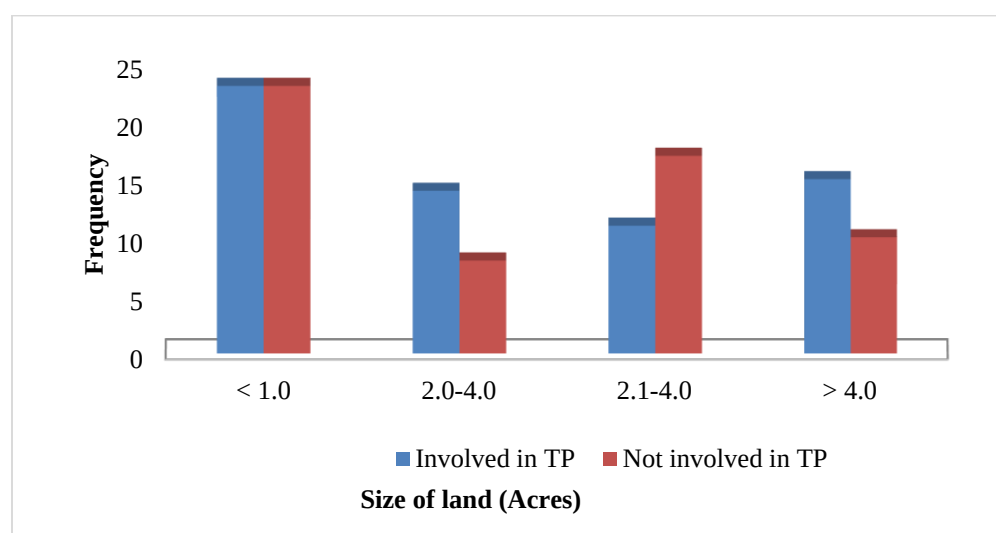


Figure 4. 6 Land size owned across the households

The study indicated that there was an equal number of tree farmers and non-tree farmers that owned land under the <1acre land size category. More tree farmers reported to be having land under the > 4 acres land size category compared to non-farmers. Under the 2.1-4.0 acres land size category, more land was reportedly owned by non-tree farmers than the tree farmers.

4.2.3 Reasons for Non-Engagement in Tree Planting

The reasons for not engaging in tree planting were disaggregated by sex and these included; limited land, lack of financial capital, long rotation period of trees, lack of technical support, the fear of trees draining the soil and poor markets for wood (Figure 4.7)

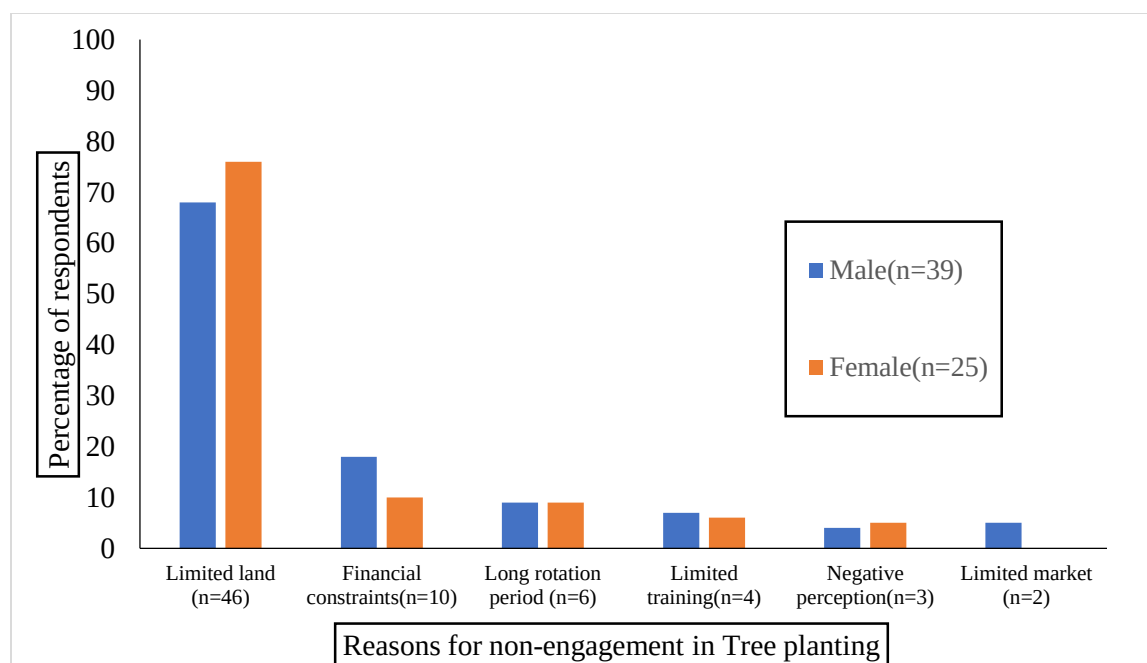


Figure 4. 7 Reasons for non- engagement in Tree Planting

Limited access to land was the most reported challenge across the sex categories. However, it was more reported among the female respondents. More males than females were limited by inadequate finance to buy seedlings and other farm inputs. An equal proportion of males and females attributed their non-engagement to long rotation period of trees. The results also indicated that only the males were concerned with the limited wood markets and the negative perception such as fear for trees draining the soil was most reported by female respondents.

4.3 Growth Performance of Trees

The growth performance of trees in the most dominant FFSs was investigated including the woodlot and boundary system.

4.3.1 Growth Performance of trees planted in the Boundary system

The tree species most planted in boundary farm forestry system included *Eucalyptus grandis*, *Grevillea robusta* and *Pinus caribaea*. These species were planted purposely for poles and timber production (Table 4.10).

Table 4. 10 Tree species, Targeted product and Spacing

Tree species	Target product	Spacing (m)	Number of Farms (n)
<i>Eucalyptus grandis</i> (n=7)	Poles	2*2	1
	Timber	2.5*2.5	1
		3*3	4
		3.5*3.5	1
<i>Grevillea robusta</i> (n=5)	Timber	2.5*2.5	1
		3*3	2
		4*4	1
		6*6	1
<i>Pinus caribaea</i> (n=5)	Poles	2*2	1
		2.3*2.3	1
		2.5*2.5	1
		4*4	1
	Timber	5*5	1

Generally, farmers planted the species (*E. grandis* and *P. caribaea*) at a shorter spacing where the targeted product was poles compared to where timber was the target product. *G. robusta* stands were planted and maintained only for timber production.

During the time of the study, the age of the tree stands ranged from 2-10 years. Different management activities had been undertaken including weeding, pruning, and thinning (Table 4.11). These activities had an effect on the stocking levels and thus growth performance and volume. However, the stocking for stands in the boundary system was heavily reliant on the number of established tree lines and spacing.

Table 4. 11 Tree management practices and growth performance in the boundary system

Tree Species	Age (Yrs)	No. Farms (n)	Tree Spacing(m)	Silviculture Activity under taken	Stocking (Trees/ha)	Average volume (M ³ /ha)	Average MAI (M ³ /ha/yr)
<i>Eucalyptus grandis</i> (n=7)	2	2	3*3	Weeding	116	6.31	3.2
	3	1	2.5*2.5	Weeding & 1 st Thinning	89	10.07	3.4
	4	2	3.5*3.5	Weeding & 1 st Thinning	248	10.62	2.9
	5	1	3*3	Weeding	36	6.23	1.2
	7	1	2*2	Weeding	21	4.79	0.7
<i>Grevillea robusta</i> (n=5)	2	1	3*3	Weeding	135	3.62	1.8
	4	2	3.5*3.5	Weeding	56	8.33	2.1
	6	1	2.5*2.5	Weeding & Pruning	129	43.19	7.2
	10	1	6*6	Weeding	533	107.54	10.8
<i>Pinus caribaea</i> (n=5)	2	1	2.3*2.3	Weeding & Pruning	63	0.66	0.3
	4	1	4*4	Weeding & 1 st Thinning	371	34.53	8.6
	5	1	2*2	Weeding & Pruning	39	4.73	0.9
	7	1	5*5	Weeding & Pruning	109	28.54	4.1
	10	1	2.5*2.5	Weeding & Pruning	620	87.44	8.7

Generally, weeding had been done across the stands of the different tree species. Pruning had been done in *G. robusta* of 6 years and throughout *P. caribaea* stands except that of 4 years. Thinning had not been carried out in the *G. robusta* stands, while for *E. grandis*, while it had been carried for the *E. grandis* stands of 3 and 4 years. Pruning was mostly reported for *P. caribaea* stands. The thinning and pruning regimes had been carried out within the expected age bracket of (1-3) years for *E. grandis* and (4-6) years for *P. caribaea*.

Stocking in a boundary system is dependent on the number of tree lines established, initial tree spacing and thinning regimes undertaken. For the investigated boundary systems, stocking of *E. grandis* was highest for stands of 4 years while *G. robusta* and *P. caribaea* was highest for stands of 10 years. Eucalyptus stands at an older age generally had a lower stocking compared to the younger ones. Volume, which is dependent on tree diameter, also often explained by age, was varying. Across the different species, stand volumes were high either for trees at bigger spacings and/or where 1st thinning had been carried out. Given the variations in stand volume, average MAI also displayed a similar pattern. Thus, given the variations in the; number of tree lines established, tree species and initial spacing, there was no particular pattern of the MAI trend under the boundary system.

4.3.2 Growth Performance of trees in the Woodlot system

The most grown tree species under the woodlot system included *Clonal eucalyptus*, *Eucalyptus grandis* and *Pinus caribaea* and these had been purposively planted for provision of poles and timber. The spacing varied greatly ranging from 1.8*1.8 m to 3*3 m (Table 4.12).

Table 4. 12 Tree Species, Target Product and Spacing

Tree Species	Target product	Spacing (m)	Number of Farms (no.)
<i>Clonal Eucalyptus</i> (n=2)	Timber	3*3	2
	Poles	1.8*1.8	1
<i>Eucalyptus grandis</i> (n=18)		2.3*2.3	1
	Timber	2.5*2.5	2
		3*3	14
<i>Pinus caribaea</i> (N=5)	Poles	2*2	1
		2.5*2.5	1
	Timber	3*3	3

For all the species, stands planted at a spacing of up to 2.5*2.5 m had been targeted for poles, while all stands planted targeting timber as the main product had been established at 3*3m.

During the time of the study, the age of the tree stands ranged from 3 to 8 years, and, different management activities had been undertaken including weeding, pruning and thinning (Table 13). These activities had an effect on the stocking levels and thus volume and growth performance.

Table 4. 13 Tree management practices and growth performance

Tree Species	Age (Yrs)	Spacing (m)	Silvicultural Activities	Stocking (Trees/ha)	Average volume (M ³ /ha)	Average MAI (M ³ /ha/yr)	No. of Farms (n)
<i>Clonal Eucalyptus</i> (n=2)	3	3*3	Weeding	738	28.8	9.6	1
	7	3*3	Weeding	920	40.7	5.8	1
<i>Eucalyptus grandis</i> (n=18)	1	2.5*2.5	Weeding	1225	13.8	13.8	1
	2	1.8*1.8	Weeding	1281	21.4	10.7	3
	3	2.3*2.3	Weeding & 1 st Thinning	638	38.4	12.8	5
	4	3*3	Weeding & 1 st Thinning	848	58.1	14.5	4
	6	3*3	Weeding & 1 st Thinning	963	61.2	10.2	1
	7	3*3	Weeding & 1 st Thinning	894	122.7	17.5	3
	8	3*3	Weeding & 1 st Thinning	851	142.4	17.8	1
<i>Pinus caribaea</i> (n=5)	4	2.5*2.5	Weeding, Pruning&1 st Thinning	1540	70	17.5	2
	6	2*2	Weeding & Pruning	1188	103.8	17.3	1
	8	3*3	Weeding & Pruning	744	136.4	17.1	2

Most of the *E. grandis* stands were below 5 years and established at a spacing of less than 3*3 m, with the exception of the stands of 4 years that had been established at a spacing of 3*3 m, just like the older stands. While weeding had been reported for the *C. Eucalyptus* stands, no thinning was reportedly done despite the age range of 3-7 years. For *E. grandis*, weeding had continuously been done for all stands, and, 1st thinning undertaken for all stands between the age of 3-8 years. For *P. caribaea*, weeding and pruning was reportedly done for all stands, while 1st thinning had been done only for the stand of 4 years. Stocking in woodlot system was dependent on initial spacing and thinning regimes undertaken. For the investigated woodlot systems, stocking of *C. eucalyptus* was highest for stands of 7 years, 6 years in *E. grandis* while that of *P. caribaea* was highest for stands of 8 years. Generally, volume was highest in tree stands above 3 years and

mainly where first thinning had been carried out. The MAI in *C. eucalyptus* and *P. caribaea* was decreasing as the trees matured however, there was no clear pattern of MAI trends in *E. grandis*.

4.4 Key Challenges and Actions to enhance engagement in Farm Forestry

4.4.1 Challenges encountered in tree growing

The tree farmers reported several challenges they encountered in tree farming, including; pests and diseases, financial constraints, lack of markets, lack of technical support, limited land (small land sizes), long rotation period and environmental hazards (Table 4.14).

Table 4. 14 Challenges encountered in the various FFS by sex of respondents

Challenges	Boundary		Woodlot		Scattered	
	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
Pests and diseases	22	14	54	5	5	
Financial constraints	12	12	58	6	6	6
Limited markets/low prices	3				25	
Lack of technical support	38	8	54			
Limited land	31	9	50	5	5	
Long rotation period	23		69		8	
Environmental hazards	27	27	40	6		

An investigation of the challenges encountered under the different FFS revealed that respondents with woodlots encountered the most challenges, while those with scattered trees reported the least. In the boundary system, males were mainly challenged by lack of technical support which included; limited trainings in tree management while the females were mainly limited by environmental hazards such as storm and fire.

Under the woodlot FFS, men mostly reported long rotation period followed by financial constraints, technical support and pests and diseases while the women equally reported financial constraints (limiting them to buy seedlings and tools/equipment) and environmental hazards.

4.4.2 Actions needed to enhance engagement in Farm Forestry

Various measures were reported by the tree farmers that could enhance engagement in tree planting in the study area. These included use of chemicals such as *Tricel* to kill the deadly termites that destroy trees, acquisition of loans, trainings in tree management, forming tree farmer groups, access to quality seedlings, subsidized tools and equipment and planting wind breaks (4.15).

Table 4. 15 Challenges and actions to enhance engagement in Farm Forestry

Challenges	Actions	% distribution of actions
Pests and diseases (n=18)	Use of chemicals such as <i>Tricel</i>	66.6
	Trainings in tree management	22.3
	Forming tree farmer groups	11.1
Financial constraints (n=15)	Acquisition of loans	67.7
	Forming tree farmer groups	20
	Subsidized tools and equipment	13.7
Limited markets/low prices (n=6)	Forming tree farmer groups	83.4
	Trainings in tree management	16.7
Lack of technical support (n=15)	Trainings in tree management	86.7
	Forming tree farmer groups	13.3
Limited land (n=21)	Acquisition of loans	81
	Forming tree farmer groups	9.5
	Trainings in tree management	9.5
Long rotation period (n=18)	Access to quality seedlings	55.5
	Trainings in tree management	27.8
	Forming tree farmer groups	16.7
Environmental hazards (n=15)	Planting wind breaks	46.7
	Trainings in tree management	26.7
	Access to quality seedlings	13.3
	Forming tree farmer groups	13.3

Trainings in tree management and forming tree farmer groups were the mostly reported measures across the Farm Forestry Systems for addressing majority of the challenges to enhance engagement in tree planting. However, chemicals were needed in order to control pests and diseases mainly termites, loans purposely for buying more land for tree farming as well as buying quality seedlings, subsidized tools and equipment. There was a need for quality seedlings in order to achieve quick returns from trees and wind breaks to control environmental hazards like storm.

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Characterization of Farm Forestry Systems

5.1.1 Farm Forestry Systems and landholdings

In terms of dominant Farm Forestry Systems, 55% of the tree farmers in this study were engaged in woodlot FFS characterized by fast growing tree species and land holding of less than 2 acres were most dominant. This was attributed to the availability of large areas of land among the tree farmers and similar findings were reported in Indonesia by Kallio (2013). This finding was further supported by a study which revealed that most rural areas in Uganda had engaged in tree growing with a focus on fast growing species (e.g. *Eucalyptus*) as a strategy of meeting the increasing demand for fuel-wood and construction materials following the rapidly growing population (Ndayambajje, 2013). Findings also revealed *pine* trees being many in the area and this was similar to Kalanzi et al., (2014)'s report that *pine* trees were the most grown particularly in Mubende and Gulu as this was attributed to its fast growth rates. Also, the dominance of woodlot systems could be attributed to the expected profits/high returns, the relatively low risks associated with tree growing, the provision of good seedlings and training they get from the New Forests Company. The results were in conformity with Kaboggoza (2011)'s findings in Uganda.

In the boundary system, farmers tended to plant trees around the crop farms and women were more engaged. Farmers argued that they practiced this system purposely to delimit their land, conserve soil as well as getting the tree products. Similar findings were reported by Kasolo & Temu (2008) and Clinton Development Initiative, (2011). Baker *et al.*, (2014) also conforms to the farmer's views by noting that boundary planting system is designed to provide high valued merchantable timber products on a sustainable basis in addition to providing the function of a natural barrier. In addition, one of the reasons for boundary tree planting could have been the need to sequester carbon dioxide.

The scattered system was the least practiced in the study area where by farmers tended to clear the land for crop farming and only plant widely spaced trees on farm. This finding is similar to Katja *et al.*, (2011) who found out that in Kenya, exotic tree species displace indigenous ones on farms. Further, scattered FFS have also been linked to subsistence farming (Dilrukshi et al., 2013). Due to inadequate knowledge coupled with lack of enough land to carry out large scale commercial production, farmers tend to diversify their farm products on the same piece of land which leads to

integration of trees in their agricultural systems for timber and poles. Another perspective is hinged on cultural related notions where mixed farming is one of the highly practiced methods. According to Gwali *et al.*, (2015), farmers usually intercrop coffee and trees on their farmland. Although this study did not explore culture and tree planting, there could be an implication which needs further research.

As it has also been reported by Kallio (2013), farmers usually have limited rights over their land and this could have been one of the reasons as to why many did not fully participate in tree growing. Accordingly, strengthening tenure rights can encourage both men and women to participate in tree farming (FAO, 2018) of such farmers. Even then encouraging farmers to plant trees may be difficult due to the ever increasing population in the region (Appiah and Pappinen 2010) that has led to observations by FAO (2018) and Bose *et al.*, (2017), most of the tree farmers to have very small land holdings which are mainly used to plant staple food crops instead of the relatively slow growing trees (Jesse, 2018).

Having land holding of less than 2 acres by most males under various Farm Forestry Systems reveals that varying land sizes significantly influence the adoption of various FFS by tree famers. This could be attributed to size of the land influencing land utilization behavior among land owners. Many farmers reported that irrespective of the land being small or big, they chose to plant *Eucalyptus* because it is quick maturing to give quick returns. Onguso *et al.*,(2012) attested similar findings in Kenya where land size plays a big role in influencing people to plant trees. Those with larger areas of land planted many trees and manage them well compared to those with limited land. Those with small land areas also asserted that fire, pest and disease protection is easy leading to quality products. Similar studies were carried out in Indonesia by Kallio (2013) revealing similar results highlighting that small sized land provides small volumes of wood which can make harvesting and transportation to the market easy.

5.1.2 Farmers engagement by sex and land ownership

More males participating in tree growing could be attributed to the rights possessed by men over land that could have motivated them to grow trees. Just as reported by (Bose *et al.*, 2017) more men compared to women inherit land, which could explain men's more participation in tree planting than women. Further, traditionally, men are the bread winners responsible for obtaining money to pay school dues as well as for buying basic needs for the family (Seline, 2014). However,

women reported participation in labour demanding activities such as watering and weeding trees. This is similar to results from Malawi, where men dominate tree planting, ownership and management but women participate in tree planting activities (Kate 2015).

The youthful farmers (31-45 years) dominating the participation in tree planting implies that they are still energetic and can easily supervise and plan for their farms. This conforms to the findings in Mexico where the youth are more active in tree planting compared to the old people (Laura, 2017). Some farmers at an old age participated in tree planting since the trees require relatively low daily labour input compare to other agricultural crops. Similar findings were reported in Indonesia (Kallio, 2013). In addition, more married respondents participated in tree growing which could be attributed to the responsibilities assumed by couples in securing basic needs such as school fees, timber and poles for construction in their households. This conforms to the findings by Belay et al., (2019) which showed that marital status was significantly related to tree growing in Ethiopia.

Most of the respondents having attained only primary education level could have motivated them to participate in tree growing in order to generate money to educate their children beyond their level of education. Respondents with education above primary level reported to have acquired knowledge and skills about tree management while at school. They claimed that this is what encouraged them to plant trees. This was in agreement with (Belay *et. al.*, 2019)who highlighted that education is an important factor in farmers' understanding and interpreting of agricultural information received. Considering household size, majority of the respondents had between 5-10 members and they reported that it was a reliable source of labour for their tree farms. Past studies in Ethiopia (Belay et al., 2019) also confirmed that more people in the family may provide more labour for tree growing. Majority (75%) of the respondents had stayed in the area for more than ten years and had access to land holdings of less than 2 acres whose dominant land tenure system was mailo land. This could have motivated them to engage in on-farm activities including tree farming for future income generation since they had security over their land (FAO,2018).On the other hand, the respondents reported a number of off-farm livelihood activities such as petty business, Boda-boda transportation, house construction , treating people and teaching as these could provide a quick source of income compared to growing trees which are long term investments (Jesse, 2018).

5.1.3 Proximity, location, Species, target product and decision making

That the location of a farmer's land in relation to a range of factors such as house, natural forest, market, had an effect on the farmer's decision on whether to plant and manage trees or not. Working far from home (*be it temporarily or permanently*) was the main strategy for some groups of people seeking better livelihoods. If a farmer lives and works far from his/her land, planting the land with trees would be preferred to be the most productive and secure option of protecting the land while they are away (Rudel, 2009 & Kallio, 2013). On the other hand, farmers living near or on their farms are able to protect and manage their trees in a more efficient manner. This is so because the presence of trees on some farms usually reduces the household time spent and labour burden of collecting forest products from distant areas, especially if natural forests are scarce (Kallio, 2013). In addition, the evolution of technology for producing improved seedlings and clones has a strong linkage to Farm Forestry System selected by farmers. The fact that there is a significant relationship this study found that where farmers got seedlings during tree planting had a significant relationship with the type of FFS they practiced, similar studies in Indonesia have also emphasized that local knowledge through getting seedlings from neighbours, advanced scientific knowledge and modern technologies is a factor in successful tree growing (Terra *etal.*, 2009).

Eucalyptus being the most planted species in the woodlot Systems for mainly poles and timber has been attributed to fast growing and are able to coppice (Sebuliba et al., 2012). However, the least planted for the same product in the boundary and scattered systems was *Ficus natalensis*. Respondents reported that there was limited interest in *Ficus natalensis* given the fact that it requires large growth spaces due to its large crown and have a low market value. *Pinus spp* was mostly planted at the boundary noting that it secures the land from encroachers given its long rotation period. Farmers who planted trees in the scattered system for timber, mostly planted *Grevillea robusta*. This was mainly because *Grevillea robusta* is a fast-growing tree with leaves that quickly decompose adding manure to soil.

Decision making on the type of Farm Forestry System, tree species to plant and tree product to target was dependent on who owned the land. Indeed, where a male or female had bought the land alone and the agreement was indicating his/her name, the decisions were made by him/her. This signified that since the land belonged to him/her, even the trees were his/her. Where the agreement of the land was showing co-ownership, decision making and property ownership was joint. Some

females reporting that they had inherited land from their relatives and after divorcing or losing their husbands, constructed their houses implied that they had full authority over it. Other studies, e.g. Seline (2014), Kiptot and Franzel (2011), are contrary to these findings observing that often decision making is dominated by the head of the household, usually the oldest male and that men usually have the overall authority as pertains to tree products that are considered to have high returns.

5.2 Factors influencing engagement in Farm Forestry

The socio-economic attributes studied showed that the age, household size, period of stay in the area and land size for the tree farmers were much higher than those of the non-tree farmers. The farm lands for both categories were near their homesteads. The tree farmers were much older than the non-tree farmers which could indicate that they were more settled and established compared to the younger non-tree farmers. The non- tree farmers were slightly better educated compared to the tree farmers which could have given them more opportunities to engage in off-farm activities that require more skills. In line with Carter (2009)'s findings, illiterate tree farmers would have challenges in planting trees as they may fail to distinguish species that are faster growing and produce better products. Their inability to read or write could limit their ability to access production facilities such as loans.

The tree farmers, compared to non-tree farmers, had more household members (on average 9) which was in line with Belay *et al.*, (2019)'s observations implying that the larger the household size, the more cheap labour available for the household farming activities. Having stayed in the area longer, tree farmers could have had opportunities to acquire more land and gain more skills for tree production. If a farmer stays in an area for quite a longer time, access to land and having security over it becomes easy and this could motivate him/her to grow more trees (FAO, 2018). Similar to (Carter, 2009)'s observations, non-tree farmers who did not have land or had small pieces of land were young people who were yet to get land of their own and they tended to survive as casual laborers. It is anticipated that many of the young and landless will acquire land overtime and would then be able to join tree planting. People stay in the village they tend to work, buy land and later transit into long term investment strategies like perennial crops and Tree species compared to the visitors and new arrivals. However, most of the tree farmers' land was in close proximity to their homesteads making it easy to supervise their farms, which was in line with Rudel, (2009) and Kallio (2013)'s findings.

The major source of income for the tree farmers was on-farm activities and this could have forced them to join farmers' associations such that they solve the challenges of market and gaining more knowledge about tree management. However, although the major livelihood activity for non-tree farmers was farming, they spent much of their time on off-farm activities. This they attributed to the quick income obtained compared to waiting for a long time for tree products. It is anticipated that people who choose to engage in tree planting are likely to shift from FFS to the more commercial wood production systems given their increased experience, knowledge and networks. In this study, farmers were found to first engage in tree planting for long durations before joining tree growing networks and the average recruitment time to farmers associations was about 3 years.

One could ask whether duration of stay in the area had an impact on Farm Forestry engagement. Appiah and Pappinen (2010)'s study in Kenya revealed that duration of stay in an area can influence individuals' access to land as well as their ability and interest in planting trees. In this study, respondents who had stayed in the area for less than 10 years were less involved in tree planting given that many were landless, while others had small pieces of land. Respondents who had stayed in the area for less than 10 years mainly planted trees at the boundaries of their farms in order to secure their land given that trees act as natural barriers in addition to providing high merchantable timber at maturity. This conforms with Baker *et al.*, (2014)'s finding in Nicaragua where staying in an area for a long time can motivate a farmer to engage in woodlot planting due to the need for large volumes of timber and poles for selling in the future and also for land security. The finding is also similar to Huge (2003)'s observations in England. Respondents who had lived in the area for between 11-30 years preferred scattered tree systems which could be attributed to the need to diversify farm products (timber, poles and food) similar to what Gwali *et al.*, (2015) reported for central Uganda.

Conversely, the household land holding is also an important variable in tree growing (Nair, 1993). Having adequate land enables household to diversify its cropping patterns into cash crops such as plantation forestry (Kiyangi *et al.*, 2016). With such observations, respondents in the study area who had less than 2 acres of land reported finding it difficult to boost the tree planting activity without adopting new technologies as a result of limited land. Carter (2009) reported similar findings in Uganda asserting that some people have enough land for tree growing while others are landless and Appiah and Pappinen (2010) reported related findings in Kenya noting that some people own small pieces of land which limits tree growing. Some farmers were not engaged in tree

farming and so, limited land, lack of financial capital, long rotation period of trees, lack of technical support, the fear of trees draining the soil and poor markets for wood were the reasons sighted for not engaging in tree planting. The rural and indigenous women continue to have limited access and property rights to forest and agricultural land as is the case in Latin America. In conformity with the results, in Malawi, men tend to dominate ownership of land and decision making (Seline, 2014& Kate,2015).

Similarly, respondents reporting limited financial capital has been attributed to the need to buy inputs such as tools, equipment and quality seedlings, an equal number of males and females expressed their concern that trees take long to mature for a farmer to get quick returns and buy basic needs and that is why they mainly got involved in off-farm activities. Supporting the findings, Jesse (2018)'s research in India indicated that tree growing is a lucrative long term investment for investors and entrepreneurs as well as a boom for the environment. Limited to this study, some cultures prohibit planting of certain types of trees, have rituals and regulations on where to plant them, who to plant as this could have been among the limitations as it was revealed in Kenya Kiptot. The respondents asserted that they had never had any training about tree planting which limited their participation in tree planting. In line with the finding, Kulindwa (2016) and Wilnhammer (2009)'s research revealed similar results in Tanzania noting that if farmers are not trained, tree management becomes a problem.

5.3 Tree Growth Performance

5.3.1 Tree growth performance in Boundary System

The spacing ranged from 2*2m to 3.5*3.5m for *E. grandis*, 2.5*2.5m to 6*6m for *G. robusta* and 2*2m to 5*5m for *P. caribaea*. However, SPGS (2009) recommends ranges of 2*2 to 3*3m for *E. grandis* and *G. robusta* while 2.7*2.7m to 3*3m for *P. caribaea*. The variation in spacing was reported to be as a result of limited training in tree spacing and shortage of land among tree farmers. The timing of silvicultural practices such as thinning and pruning had been mostly carried out in line with the SPGS (2006) recommendation of 2-3 years for *E. grandis* and 4-6 years for *P. caribaea* (SPGS, 2009). However, thinning had not been carried in *G. robusta* and the rest of the *E. grandis* and *P. caribaea* stands. This was due to lack of ready markets for the thinnings and being quite expensive to undertake the operations, similar findings were reported by SPGS (2009). The MAI for *E. grandis* started big, remained constant up to 3 years and there after it started declining as the trees matured. However, there was a steady and continuous increase in the MAIs

of *G. robusta* and *P. caribaea*. The trends of MAIs for the different tree species were different from the expected one where MAI starts small, increases to a maximum value as the trees mature and then it starts declining gradually (Malimbwi, 1997). The MAIs of *P. caribaea* of about 5 years were not in line with Kalanzi et al., (2014)'s findings in Uganda (Gulu and Mubende) that the MAI of pine trees was between 15 and 19M³/ha/yr.

The variation of the tree MAIs in the different stands from the normal could be due to disturbances by grazing animals, pests and diseases and the poor stocking (SPGS, 2009&Kalanzi et al., 2014). Eucalyptus stands at an older age generally had lower volumes and MAIs compared to the younger ones, this could be attributed to the thinning that was undertaken at 3 and 4 years. Also, the reduced stocking of Eucalyptus stands of 3 years could have accounted for larger diameters of trees resulting into a relatively higher volume and an exceptionally higher MAI. Kalanzi et al.,(2014) also explained that trees that exhibit higher MAIs tend to have greater Dbh and this increases the volume and possibly the MAI which could be the one of the reasons for some exceptionally higher MAIs in trees. Still in relation to stocking that was slightly higher in *Grevillea* and *Pinus* stands of 10 years, the tree production in terms of volume and MAI was observed to be higher in comparison with other stands. Similar findings were reported in Kent by Ovington (1945) and Baskerville (1965) in Canada clarifying that when stocking increases, production in terms of volume and MAI also increases.

5.3.2 Tree growth performance in the Woodlot System

Under woodlot system, the spacing ranged from 1.8*1.8m to 3*3m for *C. eucalyptus* and *E. grandis*, 2*2m to 3*3m for *P. caribaea*. However, SPGS (2009) recommended ranges of 2*2 to 3*3m for *C. eucalyptus* and *E. grandis*, while 2.7*2.7m to 3*3m is good for *P. caribaea*. The variation in spacing from the expected was blamed on limited training in tree spacing and shortage of land among tree farmers. The timing of silvicultural practices such as thinning and pruning had been carried out in line with the SPGS (2006 &2009) and Kalanzi et al.,(2014)who recommended 2-3 years for *E. grandis* and 4-6 years for *P. caribaea*. However, thinning had not been carried in *C. eucalyptus* and the rest of the *E. grandis* and *P. caribaea* stands. This was due to lack of ready markets for the thinned trees and being quite expensive to undertake the operation, similar findings were reported by SPGS (2009). The MAI for *E. grandis* indicated an irregular trend across the stands thus the MAI pattern was not in line with the expected one where MAI gradually increases to a maximum value as the trees mature and then progressively

declines (Malimbwi, 1997). MAIs of *P. caribaea* of about 5 years were in line with Kalanzi *et al.*, (2014)'s findings in Uganda (Gulu and Mubende) that the MAI of pine trees was between 15 and 19 M³/ha/yr.

In *C. eucalyptus* stands, there was increase in stand volume and a reduction in MAI from 3 to 7 years respectively. The increase in volume could be attributed to the recommended spacing applied (3*3) as also reported by Reukema (1966) in Washington and the reduction in MAI could be due to failure to conduct thinning which might have caused stiff competition among individual trees. Thinning had been done in *Eucalyptus* and *Pinus* stands at above 2 years and this showed resultant increase in volume and MAI but leveled off at 6 years before it rose again. The sharp rise in production had been attributed to the space which might have been created between trees causing a reduction in the competition for nutrients, water and sun light among individual trees.

Alternatively, the differences in the Volumes and MAIs in the different stands could also be attributed to disturbances by grazing animals, fires, pests and diseases (SPGS, 2009 & Kalanzi *et al.*, 2014). They highlighted that such disturbances cause stunted growth of trees. In Washington, uniform results were reported by Reukema (1966) when he compared growth performance of thinned and unthinned trees. Kalanzi *et al.*, (2014) also explained that trees that exhibit higher MAIs tend to have greater DBH and heights which could be the very reason for the observed exceptionally higher MAIs in the study results. It is also possible that other factors such as seedling source may have contributed to the observed trends in volume and MAI in the tree stands. Generally, the production in terms of volume and MAI for *P. caribaea* was decreasing with increasing age and decreasing stocking. The lower volume and MAI of *P. caribaea* at 8 years could be attributed to the lower stocking. Baskerville (1965) reported similar results in Canada highlighting how volume increases linearly with increasing density.

5.4 Key Challenges and actions to enhance engagement in Farm Forestry

Pests, diseases, financial capital, limited markets, lack of technical support, limited land, long rotation period and environment hazards were the challenges reported by farmers in tree growing. Termites were attributed to the destruction of other vegetation on which they could feed so they resorted to the planted trees. The findings were indistinguishable from those of Nyeko *et al.*, (2005) where termites were reported to be destructive in Ugandan wood farms. However, chemicals were needed in order to control pests and diseases mainly termites that destroy the trees. Declaring lack

of financial capital to purchase inputs such as good quality seedlings, pesticides, irrigation equipment and hire of labour by farmers was linked to low prices of the agricultural and tree products where they could get money to boost the tree planting activities. SPGS, (2014)'s research in Uganda yielded close results highlighting inadequate extension services and research. Others mentioned small pieces of land coupled with land wrangles which associated with Mailo land whose titles are expensive to obtain in order to assume full ownership especially for those who had stayed in the area for a short period. Onguso et al., (2012) submitted close results after a research in Kenya exploring mainly how land size challenges tree farmers.

Farmers argued that there were imbalances in distributing farm activities such as males getting involved in digging the holes, preparing the planting sites and fire breaks and selling, whereas females helped with getting seedlings to the planting sites, watering the seedlings, applying manure and sweeping leaves around the planted trees, pruning and weeding. This kind of patriarchy dominance down surges female involvement in Tree farming. Studies done by Kate (2015) in Malawi pointed identical findings claiming that gender is a major barrier where male sex is more dominant in tree planting than the female sex since most males individually buy and own land and therefore the main decision makers. Some respondents stated being discouraged by friends, environmental hazards like fires, drought and strong winds but this was linked to high levels of ignorance, conservatism and unwillingness to change from their traditional attitudes, lack of training in commercial Farm Forestry Farming and actions to enhance wood production from Farm Forestry Systems earlier discussed. Similar findings were reported by Otsieno *et al.*, (2014) in Kenya and Ouya (2016) in Ethiopia emphasizing the need for training in tree growing for the success of increased wood supply.

Consequently, the main actions desired among the tree farmers included: Chemicals (Pesticides and insecticides), loans, trainings in tree management, better quality seedlings, tools and equipment, forming tree farmer groups and planting wind breaks. Farmers expressed the need for chemicals such that they could control the deadly termites and other pests and diseases that destroy the trees. Conversely, Nyeko, Olubayo & Agricultural Research and Extension Network (2005) recommend embracing traditional local knowledge to control pests and diseases. According to them, tree farmers could be taught to use trenching, red pepper, dregs of local brew, used engine oil, sealing vents, fire, paraffin, wood ash, mud fish intestine, dead snake, hot water, cow dung,

Bidens pilosa and human urine to curb the problem of termites. Furthermore, disease management should be through acquisition of proper site species matching, timely weeding and destroying anthills. Males mainly reported the need for loans as this was attributed to the necessity of buying more land for tree planting, buying tools and equipment, machinery like tractors, pruning knives and paying laborers. The reports for the need for loans were tallying with the findings of Appiah and Pappinen (2010) and Danjuma et al.,(2014).

On the other hand, trainings especially in tree management activities such as gap filling, weeding, pruning, thinning and spacing was reported among men who planted woodlots and boundary trees on farm. Females did not express the need for such as this was attributed to spending much of their time at home doing house work activities and so they have limited time compared to men. Wilnhammer (2009) proposes that consistent training in tree management of owners and forest work force could enhance wood supply for either timber or poles . Wilnhammer (2009) further proposes more programmatic solutions linked to land consolidation programmes, voluntary land swapping, stimulating voluntary formation of forest owner groupings, and establishment of service centres aiming at advising the forest owner which were not highlighted by the farmers who participated in this study. On addition, Tree farmer group formation plays an enabling role for small holder farmers to get easy access to extension services especially on silviculture, marketing of trees and accessing quality subsidized seedlings through their links and strong relationship with New Forest Company, District local government and other organizations (Fischer & Qaim, 2012). Males involved in boundary and woodlot tree planting cited better quality seedlings asserting that the trees they plant take long to reach harvesting age, are easily attacked by pests and diseases yet farmers require quick returns to fulfill their basic needs. In Nigeria, Danjuma *et al.*,(2014) highlighted similar findings.

Similarly, Planting windbreaks was attributed to the need to control environmental hazards particularly storm that destroys large volumes of trees when it occurs, reduce potential damage to homes, outbuildings, cropland, and livestock. it can add shade, esthetic appeal to your property, and serve as a haven for wildlife, insulation from noise and unpleasant smells emanating from neighboring properties. Similar results were presented by FAO (1989) in in Italy. Across the Farm Forestry Systems, tools and equipment were reported to be very expensive and rare such as pruning knives, tractors and Lorries. However, they argued the government and non-government

organizations to provide them to farmers for free or at subsidized rates. Forming tree farmer groups was reported across the systems especially by males who participated in woodlot and scattered tree planting given that it could help them to obtain better markets for the tree products and also acquire new skills of managing trees. These findings conform to what SPGS (2014) noted that through grower's field meetings, tree farmers interact and learn from one another.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Despite the level of engagement in small-holder tree planting in Uganda and the potential contribution of these systems in reducing wood product supply gap, several of the previous studies have focused on the large-scale tree farmers. This could have implications on the estimated/projected wood supply gap for the country. This study characterized the farm forestry systems in the greater Mubende to provide insights on the role these systems can play in addressing wood supply gap in Uganda

There were three Farm Forestry Systems including Woodlot, Boundary and scattered systems with Woodlot system being most dominant. *Eucalyptus species* was the most grown and most of the farmers were operating under Mailo land. Farmers had varying sources of seedlings including NFC tree nurseries, private tree nurseries and the source of planting materials had an indication on the type of Farm Forestry System employed by farmers. Given the patriarchal nature of the society, males dominated tree planting across all Farm Forestry Systems since most had individually bought and owned land and also the main decision makers over land.

The key factors that influenced tree growing in the area were the period of stay in an area, land size, as well as availability of financial capital. Non-tree farmers were limited from engaging in tree farming by limited access to land.

MAI increased with Age until the turn off point, and MAI (growth) starts to decline.

The growth performance of trees under Woodlot system was better than that of Boundary. *G. robusta* in the Boundary and *E. grandis* in the woodlot system had a better growth performance compared to the rest of the species.

The challenges encountered in tree farming, included; pests and diseases, financial constraints, lack of markets, lack of technical support, limited land (small land sizes), long rotation period and environmental hazards.

Use of chemicals, acquisition of loans, trainings, access of quality seedlings, subsidized tools and equipment as well as forming tree farmer groups could be used to overcome the challenges.

6.2 Recommendations

Based on the study findings, the following recommendations have been put forward:

Tree farmers should be encouraged and sensitized on the types of Farm Forestry System and the tree species to integrate on with their crops and pasture fields for enhancing wood production.

Tree farmers with large pieces of land should be mainly encouraged to practice woodlot system while those with smaller pieces of land could practice boundary or scattered systems.

There is need to organize tree farmers into collective action groups to enable them jointly; seek financial support from different government initiatives and lobby for technical extension services related to tree growing and management.

There is need for further investigation into growth patterns of trees with more samples per age category, similar silvicultural practices and spacing.

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APPENDICES

Appendix I: Questionnaire for Tree Farmers

No.

SECTION A: SOCIO DEMOGRAPHIC (BACKGROUND INFORMATION)

1. Sub county-----2. Parish-----3. Village-----
-
4. Sex: (i) Male ----- (ii) Female-----

5. Age (Yrs) -----
6. Marital status: (i)Single----- (ii) Married..... (iii) Divorced----- (iv) Widowed-----

7. Education level -----
8. Household size-----
9. Period of stay in the area (years) -----
10. Major livelihood activity.....
11. Other livelihood activities.....
12. Do you have access to land? (i) Yes..... (ii) No.....
13. If yes, complete the table below:

Parcel	Distance from homestead	Size (acres)	Mode of acquisition (bought, inherited, renting, given)	Activities on land	Who makes decision on parcel (Wife, Husband, Girl/Boy Child, Both wife and husband. All)
1					
2					
3					
4					

OBJECTIVE 1: CHARACTERISATION OF FARM FORESTRY SYSTEMS

14. Location of farm forestry system

Farm forestry system	Distance from the home	Spatial location		
		36N (Easting)	UTM (Northings)	Elevation

15. Characteristics of existing farm forestry systems

Farm forestry system	Total area (acres)	Land ownership	Species planted	Who owns the trees	Age (Yrs)	Spacing	Source of seedlings	Silvicultural management activities undertaken	Expected product(s)

Land ownership; (i) Kibanja; (ii) Private mailo; (iii) Lease hold; (iv) Public land; (v) Customary; (v) Communal

Who owns the trees; (i) Husband, (ii) Wife, (iii) Both husband and wife, (iv) Son, (v) Daughter, (vi) others-specify

16. Management activities undertaken

Management activities	Frequency (No of times a year/in a rotation)	Equipment used	Labour used (Specify male or female)	Reason for carrying out activity	Support received	Source of support	Period support was provided	Impact of support on Wood Production
Weeding								
Pruning								
Thinning								
Spraying								
Pollarding								

Labour used (male or female); (i) Hired labour; (ii) Family labour (iii) cooperative/group labour

OBJECTIVE 3: MOTIVATIONAL FACTORS & BENEFITS

17. How long have you engaged in tree planting?

.....

18. a) What motivated you to grow trees? /Why did you grow these trees?

b) What have you benefited from engaging in the given farm forestry system?

.....

.....

19. Do you belong to any tree farmer grouping (formal/informal)?(i) Yes..... (ii) No.....

20. If yes, name the grouping

.....How long have you been a member of the above group?

.....

21. Name the benefits that you have got from the above group.

.....

22. Market value

a) How do you get information about the prices of your tree products?

.....

b) To whom do you sell the different tree products?

.....

c) Who determines the price of your tree products?

.....

23. Motivations for farm forestry system

Farm forestry system	Species	No of rotations	Motivational factors	Rank of factors	External support Received	Source of support	Impact of support on performance of trees

24. Have you received any technical support for tree growing? (i)Yes----- (ii) No-----

25. If yes, fill in the table below

Technical Support	Focus of support	Source of support	Frequency/number of times given	Effect on your activity of tree growing

SECTION D: ACTIONS TO ENHANCE WOOD PRODUCTION FROM FARM FORESTRY SYSTEMS

26. Challenges faced in tree growing?

Farm forestry system	Species planted	Age	Challenge	Rank	Effect on trees	Action to solve challenge	If action, why?	What more could be done	What support do you need	From whom do you need the support

END THANK YOU SO MUCH

Appendix II: Questionnaire for Non-Tree farmers

No.

SECTION A: SOCIO DEMOGRAPHIC (BACKGROUND INFORMATION)

1. Sub county-----2. Parish-----3. Village-----

4. Sex: (i) Male ----- (ii) Female-----
 5. Age (Yrs) -----
 6. Marital status: (i) Single ----- (ii) Married..... (iii) Divorced ----- (iv) Widowed ----
 7. Education level-----
 8. Household size-----
 9. Period of stay in the area (years) -----
 10. Major livelihood activity.....
 11. Other livelihood activities.....
 12. Do you have access to land? (i) Yes.....(ii) No.....
 13. If yes, complete the table below:

Parcel	Distance from the homestead	Size (acres)	Mode of Acquisition (bought, inherited, renting, given)	Activities on land	Who makes decision on parcel (Wife, Husband, Children-(boy/girl), All
1					
2					

SECTION B: MOTIVATION FOR TREE GROWING

14. Why don't you get involved in tree planting?

..... 15.If you had the opportunity, would you plant trees? (i) Yes..... (ii) No.....

16. If not why?

17. If yes, what would motivate you to plant trees?

.....

18. What actions can be done in order to motivate you to plant trees?

Action	Actor

END THANK YOU SO MUCH

Appendix I11: Forest Level Data collection form

No-----

Forest Owner	Area (Acres/Ha)	Village	Sub county

FOREST MANAGEMENT PRACTICES

Main Species	Pruning	Thinning	Weeding	Any other observations *e.g. Fire, grazing
Current forest Condition:				

PLOT LEVEL DATA:

Plot size	Plot Shape	Easting/36N	Northing/UTM	Elevation

TREE LEVEL DATA:

Tree No	Diameter (cm)		Quality (code)	Species if not main Species
1.				
2.				
3.				
4.				

Codes for tree quality

CT = Crook tree BT =Bent tree DT =Diseased tree BUT =Burnt tree	BR =Broken tree FX =Foxtail tree SB = Slightly bent
--	---