ANALYSIS OF FACTORS INFLUENCING THE ADOPTION OF AGROFORESTRY TECHNOLOGY AMONG SMALLHOLDER FARMERS IN BUMULA SUB-COUNTY BUNGOMA COUNTY, KENYA

BY

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A THESIS SUBMITTED TO THE SCHOOL OF AGRICULTURE AND NATURAL RESOURCES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN AGRICULTURAL ECONOMICS AND RESOURCE MANAGEMENT

MOI UNIVERSITY

2021

DECLARATION

Declaration by Candidate

I hereby declare that this thesis is my own original work and has not been submitted for a degree award in any other institution of higher learning.

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DEDICATION

I dedicate this thesis to my beloved parents Mr. Abednego Wambua and Mrs. Joyce Wavinya for their unending love, support and guidance that has made me a hardworking, trustworthy and responsible person. Special gratitude goes to my beloved husband Nicholas Mwendwa and my daughter Miah Wendo for their encouragement, material and moral support throughout the period of writing this thesis.

ACKNOWLEDGEMENT

I acknowledge the Almighty God for the gift of life and knowledge. My sincere gratitude goes to my supervisors, Dr. Ernest Saina and Dr. Bernard Langat, whose guidance, support and encouragement have enabled me in completing this thesis. I am grateful to my family members and friends for their moral and financial support that ensured this work is completed on time.

I sincerely thank the sampled farmers in Bumula Sub-county who voluntarily gave all the information requested in the questionnaire. Same applies to the enumerators for their unreserved assistance whenever I requested.

ABSTRACT

Agroforestry is considered as a direct link to poverty alleviation and livelihood improvement. There is need for promotion and adoption of modern farming technologies to increase agricultural productivity, improve fodder, fuel wood availability and farm incomes. This study analysed the demographic factors that influence the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County. Smallholder farmers in this region have been facing challenges of low and declining soil fertility reflected in low agricultural production, fodder and fuel wood shortages and low incomes from farming activities, which has caused widespread among over half of the households. The study carried out in Bumula Sub-County applied field survey. Data was collected from a sample of 751 small scale farmers using structured and semi-structured questionnaires. The target population was 18580 smallholder farmers in Bumula Sub-County. Simple random sampling procedure followed by systematic sampling was used to identify the respondents. The theory underpinning this study was the Theory of adoption. To ensure the results quality, logit model was adopted. The collected data was analysed using STATA software. Results from the study showed that institutional factors such as access to extension services, belonging to a farmer group and access to market influenced the adoption of agroforestry technology with (p-values 0.000<0.05), (p-values 0.011<0.05), and(p-values 0.000<0.05) respectively. Economic factors such as Land size, cost of technology, tree planting materials and farm income positively influenced the adoption of agroforestry technology in Bumula sub-County with p-values (p-values 0.000<0.05), (p-values 0.000<0.05) and (p-values 0.008<0.05) respectively. It is concluded that access to extension services, belonging to a farmer group, access to market, Land size, cost of technology, tree planting materials and farm income influenced the adoption of agroforestry technology in Bumula Sub-county. It was recommended that the Government and other stakeholders should enhance farmers' knowledge and literacy through extension education so as to improve adoption levels of agroforestry technology. There is need for government to provide marketing facilities to small scale agroforestry farmers. This could be done by construction of agroforestry processing facilities at village level to enable farmers to supply their products directly to the market and avoid selling through brokers.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

AF - Agroforestry

EMCA - Environmental Management and Co-ordination Act

FAO - Food and Agricultural Organization

ICRAF - International Centre for Research in Agroforestry

ILEG - Institute for Law and Environmental Governance

MPTS - Multi Purpose Trees and Shrubs

NARS - National Agricultural Research Systems.

NGO - Non-Governmental Organization.

N - Nitrogen

NPVs - Net Present Values.

P - Phosphorus

RoK - Republic of Kenya

SHF - Smallholder Farmers

OPERATIONAL DEFINITION OF TERMS

Adoption: A process through which an individual passes from awareness of the technology and progresses through a series of steps that end in appropriate and effective usage.

Agroforestry Technology; A systematic land use system in which woody perennials (trees, shrubs) are deliberately grown on the same land management unit with agricultural crops (perennial or annual) and /or livestock in some spatial arrangement or temporary sequence. Some of the technologies include; - alley cropping, home gardens, boundary tree planting, hedges, live fences, woodlots and homestead planting.

Climate change Adaptation: This is taking principle actions to deal with climate change. It requires adjustments in societal behavior and practices to better cope with the impacts of a changing climate.

Climate change Mitigation: This is the efforts to reduce or prevent the amount of greenhouse gases in the atmosphere or enhancing their sinks.

Gender: it is the sex of the farmers either Female or Male.

Net Present Value: Is the present value of future cash flows minus the present value of the cost of investment.

Small-holder famers: Farmers producing in plots of land ranging between 0.1 – 15 acre and depending on family labor exclusively (Ministry of Agriculture, Bumula Sub-County Office 2016). These are farmers doing agricultural crop and livestock production.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter gives a background to the study, the research problem, general and specific objectives, hypotheses, justification of the study and the scope of the study.

1.1 Background to the Study

Agroforestry, is the deliberate integration of trees on farms with agricultural crops and/or livestock landscape. It seeks to sustain and diversify production for increased economic, social and environmental benefits for all level land (ICRAF, 2011). This technology can be either a spatial arrangement, for examples trees growing in a field at the same time as the crop, or in a time sequence, for example shrubs grown on a fallow for restoration of soil fertility. Agroforestry technology often involves management of trees and shrubs and utilization of their products mostly called multipurpose trees and shrubs (MPTS). The MPTS will have an impact on the other components in the land-use system. Hence, agroforestry technology is normally characterized by economic and ecological interactions between woody perennials and crops or livestock. Almost all trees and shrubs can be said to be MPTS, but the concept was introduced to distinguish the multiple role often played by trees and shrubs in an agroforestry system setting from the single purpose of wood production in pure forest plantations setting. Tree growing in such forest areas normally aims at meeting human demands for wood for industrial purposes, and is often called industrial forestry.

Social forestry related to Agroforestry, is a slightly wider concept as it includes tree growing for ornamental purposes in urban areas and in avenues. Farm forestry can be regarded as almost synonymous to agroforestry, but it may also include large-scale forest production on private farms, an activity that would fall outside the definition of agroforestry. The term community forestry has been used to stress the involvement of people in tree-growing efforts, although people are much involved in all agroforestry activity. In many countries the concept of community forestry has now been replaced by those of farm forestry or agroforestry. This change is the result of the de-emphasis of communal efforts which have often proven less fruitful than was predicted some years ago (Nair, 1993).

During the past two decades, researchers have worked with farmers throughout the tropics to identify and develop improved agroforestry practices that build on local indigenous knowledge and offer substantial benefits to households and the environment (Franzel 1999). The Kenyan government has not been left behind, throughout its history, it has attempted to come up with ambitious agricultural policies and strategies seeking to enhance agricultural production and performance as a tool to improve the livelihood of majority of its citizens that are also rural based. Some of the practices that came with these efforts included new methods of soil conservation, improved livestock management production, and changes in land tenure system, agroforestry, among others. However, these practices have been received and implemented with various degrees of success and failure depending on the region of the country (Scherrs, 1995). In many developing countries, agricultural development activities are increasingly focused on helping small scale farmers who have not benefited from the Green Revolution. About 80 percent of deforested areas are used for agriculture, often on degraded soils. Experience indicates that most of these farmers do not have adequate land and the financial resources to invest in irrigated and high-input monocultures typically associated with the green revolution technologies are not available. In most cases, these small scale farmers cultivate land under rain-fed conditions in arid, semi-arid, and hilly regions where soils are marginally arable, degraded, or generally unsuitable for sustained intensive monoculture. Many communities are engaged in diversified farming practices, usually producing a mixture of annual, perennial, and retention of tree on farmlands as well as rearing livestock (Weston *et al*., 2015). Not only practiced in Kenya, agroforestry is a long-established farming practice in many parts of the world.

Production and protection are, theoretically, two fundamental attributes of all agroforestry practices. This implies that agroforestry systems have a productive function yielding one or more products that usually meet basic needs, as well as a service role which is protecting and maintaining the production degree of commercialization. Raintree (1986) argues that any land-use system, regardless of its type can be described and evaluated in terms of the output of relevant basic needs such as food, energy, shelter, raw materials, and cash. This is the logic which underlies the basic-needs approach within the methodology for agroforestry diagnosis and design, developed by ICRAF. Additionally, this approach recognizes the service roles of woody perennials as factors contributing to the production of one or more of these basic needs. For example, soil conservation affected by appropriate agroforestry practices can be expressed in terms of its contribution to augmenting the sustainability of crop production. Similarly, amelioration of microclimate through well designed arrangements of trees and crops (for example shelterbelts) can be evaluated in terms of its effects on crop yields, etc. However, the emphasis on production of outputs should not diminish the importance of sustainability. Although production is a very important consideration in agroforestry, it is the sustainability attribute that makes it different from other approaches to land use. Moreover, all agroforestry systems produce more than one basic-need output. Therefore, all agroforestry systems have both productive and protective roles, though in varying degrees. Depending on the relative dominance of the particular role, the system can be termed productive or protective. Production of a particular output should not, therefore, be used as the sole criterion for classifying agroforestry systems. However, production of an output, or for that matter any other aspect, may be chosen as a basis for undertaking an evaluation of available agroforestry options.

During the late 1970s and early 1980s, several enumerations of agroforestry practices were presented from various geographical regions at seminars and workshops. Notable among them are the group discussions held at ICRAF, in Nairobi. The Agroforestry System Description Series in Agroforestry Systems, which is a major output from ICRAF's Agroforestry Systems Inventory Project (Nair, 1990) is a concerted effort in describing several existing agroforestry systems. Most of these agroforestry system characterizations pertain to specific ecological conditions of different geographical regions. It is thus easy to find several descriptions of agroforestry systems in, say, the highland as well as the tropical highlands. Descriptions of existing systems, as well as recommendations of potential agroforestry technologies, for specific agro ecological zones, include a mixture of various forms of agroforestry in terms of the nature and arrangement of components. There can be agrisilvicultural, silvopastoral or agrosilvopastoral systems in any of the ecological regions. For example, Young, A. (1989) analyzed the agroforestry potential for sloping lands using the primary data collected by ICRAF's Agroforestry Systems Inventory Project and others for eight systems in sloping lands in various parts of the world, which showed that all three basic categories of agroforestry can be found in this particular land form. Similarly, Nair *et al.*, (2009) examined the agroforestry options in the context of land clearing in the humid tropics. Demographic criteria for classifying Agroforestry such as scale of production and level of technology input and management have also been used as a basis for classifying agroforestry systems.

Agroforestry systems are grouped into commercial, intermediate and subsistence systems (Lundgren B. O 1989). The term commercial is used when the major aim of the system is production of the output (usually a single commodity) for sale. In these systems, the scale of operations is often medium to large and land ownership may be Government, corporate or private; labor is normally paid or otherwise contracted. Examples include commercial production of agricultural plantation crops such as rubber, oil palm, and coconut, with permanent understories of food crops, or integration of pasture and animals. Another example is commercial production of shade-tolerant plantation crops like coffee, tea, and cacao under overstorey shade trees; rotational timber/food crops systems in which a short phase of food-crop production is used as a silvicultural method to ensure establishment of the timber species and commercial grazing and ranching under large-scale timber and pulp plantations.

Intermediate agroforestry systems are those that are intermediate between commercial and subsistence scales of production and management. It is the production of perennial cash crops and subsistence crops undertaken on medium-to-small-sized farms where the cash crops satisfy cash needs, and the food crops meet the family's food needs. Usually farmers who either own the land, or have long-term tenancy rights to land, reside and work on the land themselves, and are supplemented by paid temporary labor. The main features distinguishing the intermediate system from the commercial system at one end and from the subsistence system on the other are holding size and level of economic prosperity. Several agroforestry systems in many parts of the world can be grouped as intermediate systems, especially those based on plantation crops such as coffee, cacao, and coconut. Similarly, there are several intermediate agroforestry systems based on a large number of fruit trees, especially in the Asia-Pacific region (Nair, 1990), and short-rotation timber species such as Paraserianthes (Albizia) falcataria in the Philippines and Indonesia.

Anthropologists define subsistence farmers as those who produce most of what they consume, or consume most of what they produce. Farmers who do not, or cannot, produce enough for the needs of their families are also usually considered under this category. Subsistence agroforestry systems are those where the use of land is directed toward satisfying basic needs and is managed by the owner or occupant and his/her family. Cash crops, including the sale of surplus commodities, may well be part of these systems, but are only supplementary.

Most of the agroforestry systems practiced in various parts of the developing countries come under the subsistence category. Forms of traditional shifting cultivation found throughout the tropics are the most widespread example. However, not all subsistence agroforestry systems are as "undesirable" or resource-depleting as traditional shifting cultivation. For example, the integrated, multi-species homegarden system found in almost all densely populated areas is an ecologically sound agroforestry system (Fransisca, 2014). Similarly, several sustainable systems of a subsistence nature can be found in many other regions.

The socioeconomic and management criteria classification of Agroforestry systems is yet another way of stratifying the systems for a purpose oriented action plan. Such an approach will be useful in development efforts. However, there are some drawbacks if these criteria are accepted as the primary basis for classifying the systems. First, the criteria for defining the various classes are not easily quantifiable; the standards set for such a differentiation will reflect the general socioeconomic situation of a given locality. What is considered as a "subsistence" system in one location may well fall under the "intermediate" or even a higher category in another setting. Moreover, these class boundaries will also change with time. A good example is the gum-Arabic production system of the Sudan. It used to be a flourishing "intermediate" .system consisting of a planned rotation of Acacia Senegal for gum production for 7-12 years. Acacia Senegal also provided fodder and fuel wood and improved soil fertility but with the advent of artificial substitutes for gum Arabic, the Acacia senegal/millet system has now degenerated into a shrinking subsistence system (Meijer *et al.*, 2015).

Socioeconomic factors that are likely to change with time and management conditions cannot be rigidly adopted as a satisfactory basis for an objective classification scheme, but they can be employed as a basis for grouping the systems for a defined objective or action plan.

1.2 Problem Statement

Small-holder farmers in Bumula Sub-County are facing challenges of low and declining soil fertility reflected in low agricultural production, fodder and fuel wood shortages and low incomes from farming activities despite the region experiencing high rainfall amount compared to other regions in Kenya. This has caused widespread poverty among over half of the households (Ngugi Eston *et al.*, 2013), severe food insecurity, high rural-to-urban migration and high degradation of the environment.

Kenya constitution and economic blueprint Vision 2030 of 10% tree cover requirement for every household (ROK, 2005) has made this condition worse. Most of the households own between 0.1 and 15 acres of land. As population grows there will be more and more land fragmentation. Stakeholders in Bumula Sub-county have come up with agroforestry technology to fix the existing challenges since this is a technology that does not require extra piece of land and is able to serve both economic and environmental benefits to the farmer. However, the adoption levels of agroforestry technology are very low (Mzoba *et al*., 2011).

1.3 Objectives of the Study

1.3.1 General objective

The main purpose for this study was to analyse the factors influencing the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

1.3.2 Specific objectives

i. To determine the level of adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

ii. To determine the effect of institutional factors such as access to extension services, frequency of extension visits and belonging to a farmer group access to credit facilities and access to market on adoption of agroforestry technology among small-holder farmers in Bumula sub-county.

iii. To determine the effect of economic factors such as land size, cost of technology, farm income, off-farm income, availability of tree planting materials and maturity period of trees on adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

1.4 Hypotheses

H_{01} : Institutional factors such as access to extension services, frequency of extension visits, belonging to a farmer group, access to credit facilities and access to market do not significantly influence the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

H_{02} : Economic factors such as land size, cost of technology, farm income, off-farm income, availability of tree planting materials and maturity period of trees do not significantly influence the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

1.5 Justification of the Study

Agroforestry is a technology that seems to be doing well locally and internationally. It's a technology that was introduced with a target of increasing agricultural crop and livestock production, fuel wood and supply environmental benefits. The research was designed to analyse the factors that influence adoption of the technology. The analysis was expected to reveal the significance the significance of both institutional and economic factors on the adoption of agroforestry technology.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter is a review finding from different authors, which are aimed at shedding some light on the trend of agroforestry commercialization. This chapter contains the following; - agroforestry Worldwide, agroforestry in Kenya, agroforestry in Bungoma County, role of agroforestry and agroforestry policies

2.1 Agroforestry Technology Worldwide

One of the most widespread anthropogenic changes affecting the planet is forest conversion for alternative human use, resulting in environmental degradation and climate change. Farmers depending on subsistence agriculture are most vulnerable to the effects of environmental degradation and climate change, since their lack of economic resources restricts access to alternative livelihoods. In sub-Saharan Africa, declining crop yields are exacerbated by depleting soil fertility and climate variability (Meijer *et al.*, 2015).

Human population growth has resulted in more intensive agriculture and land use pressures.

Many attempts to promote agroforestry technology adoption worldwide have been met with poor rates. An estimated 1.2 billion people in developing countries have adopted and rely on agroforestry practices to sustain their agricultural productivity and income (FAO 2011). GEF (2005) estimates that about 15.2 million hectares of forest land are lost every year in the tropics alone mostly to Agricultural expansion and human settlement. Coxhead *et al.*, (2001) concur that Agricultural growth in uplands of tropical developing countries was associated with deforestation, land degradation and diminishing watershed functions. For example, forests in Thailand were disappearing at an alarming rate, and it was a great catastrophe caused by floods in South Thailand that reflected the serious consequences of deforestation to the public and stimulated reforestation by the Government and private sectors (Kijkar, 1993). Nearly 3 billion people worldwide depend on wood, primarily from Natural forests and trees outside forest areas as main sources of household energy (World Bank, 1992). In Indonesia, trees such as *Calliandra calothyrsus* which are too small for timber are widely grown for domestic fuel wood (National academy of Sciences, 1980).

Production of trees under Agroforestry technology increases National tree cover by relieving pressure of depending on Natural forests for forest products. There is higher net present values for agroforestry systems when compared to monoculture systems, yet farmers in developing countries show low rates of adoption (Fransisca, 2015). However, with low rate of adoption, agroforestry is partly practiced in Africa. For many years, farmers in Africa have been testing improved tree fallows in several countries including Kenya, Zambia, Cameroon, Tanzania, and Malawi, in collaboration with researchers of ICRAF and national agricultural research systems (NARS). Crop improvement in on-station and researcher-managed on-farm trials at sites in Kenya, Zambia, Cameroon, Tanzania and Malawi have been encouraging (Kwesiga and Coe, 1994; ICRAF, 1997). The challenge now is to assess whether more farmers can achieve similar crop improvement and whether they are able and willing to incorporate and commercialize improved tree production into their farming systems. In some countries, local leaders have played influential role in promoting agroforestry technology adoption. For instance, in Zambia, local leaders played important roles in promoting improved fallows sensitizing and mobilizing their constituents to plant improved fallows, and in some cases, promoted the enforcement of by-laws to remove two of the main constraints to agroforestry adoption: the setting of uncontrolled fires and free grazing of livestock (Ajayi et al 2003). In Kenya, perceived economic importance of agroforestry practice by individual farmers is considered key to adoption of any agroforestry practice (Oino P. *et al.*, 2013)

2.2 Agroforestry Technology in Kenya

The diverse use of the forest resources often generates conflict between economic development and conservation objectives. The global trend towards industrialization is the greatest threat to forest resources. Industrial development has resulted to destruction of forests by global warming which affects micro habitats and changes the ecosystems that support forests. In Kenya the biggest cause of forest degradation is conversion of forest land into settlement and agricultural uses. ROK (2005) states that Kenya's forests are found in prime regions of high agricultural potential where people are in great need for agricultural land. Since Kenya's economy is agricultural based, there is a need to balance between community development needs and the conservation of forests. There is need for the government to come up with strategies for achieving an appropriate balance (FAO, 2010). The new forest Act has provisions that support forest conservation and community development ROK (2005). A major step towards this direction is support of Agro forestry adoption.

In Kenya between 1990 and 1995, forest cover changed by about 17% with an average loss of 3% per year largely because of settling the landless. This further states that loss of forests through excision, population pressure and climate change is estimated at close to 5,000 ha per year and loss through excision and forest fires estimated at 15,000 ha annually. The usefulness of trees has always conflicted with need for Agricultural land in Kenya (ILEG, 2004) and there is need to educate communities on the importance of agroforestry to be self-reliant on the demand for tree products and services. Wood fuel meets 70% of domestic energy in Kenya. A study examining energy demand between 1983 and 2000 predicted that fuel wood and charcoal consumption were to grow at 3% and 4% respectively per annum (Energy Alternatives Africa, March 2003). Agro-forestry technology adoption in Central Kenya and part of Eastern Provinces, have achieved considerable success, which is a pointer to the importance of Agroforestry in provision of energy if applied to other districts. Also a phenomenon of population pressure leading to a decline in tree cover is discounted as it has been demonstrated that as land continues to be subdivided tree cover may actually rise (Nyangi, 1999).

The past decade has seen a market improvement in understanding the various factors that must be addressed when dealing with conservation of Natural Resources (Fischer, 1995), which included among others Agro-forestry knowledge and Environmental conditions among others. Before the colonial rule in Kenya in 1904, land tenure relations based on a communal property rights regime, religious beliefs and local farm forestry practices contributed to conservation. The traditional Kayas and sacred grooves and shrines were located in forests and local Institutions were able to manage and sustain them. The local Institutions headed by elders decided how the Kaya forest could be used, which trees could be cut and why, what herbal and ritual plants could be gathered and how close cultivation could come to the forest edge. Restraints on cutting trees were included in customary tenure rights and land use practice. These were reinforced by cultural beliefs about the nature of trees. Indigenous Agro-forestry practices tried to maintain some tree cover but did not want to halt deforestation (Masese, 2004). However, customary law and beliefs have diminished under the pressure of modernization. Therefore, there is need to appraise the problem from a modern perspective.

In Kenya, the forest policy of 1968 focused on catchments management and timber production with strong Government control of forest sector, and today, EMCA of 1999 and the Forest Act no. 7 2005, support sustainable forest management in Kenya (Ludeki *et al.,* 2004. Farmers will invest in improving their land for annual crop production only if that land is a critical part of their livelihood strategy and only if the investments compete favorably with alternative opportunities (Oino P. *et al.,* 2013).

2.3 Agroforestry Technology in Bungoma County

Agroforestry technology is a traditional practice with inhabitants practicing three major agroforestry systems namely, agrosilviculture, silvopasture and agrosilviculture. Within these systems, five major agroforestry practices are widely undertaken. The most common practices are mixed farming, dispersed trees in crop lands, home gardens, trees along hedges, farm boundaries, woodlots and home compounds (Wafuke, 2012).From a practical perspective, Bingaman County is food deficit and largely relies on the Uganda border for much of its food supply annually Agroforestry, if integrated at the household level, has the potential to provide economic, social and environmental benefits that are capable of addressing household income, fuel, food supply and environment related challenges. Since independence, there have been several agroforestry-related activities initiated in Bingaman County through the various agricultural departments and recently, the nongovernmental organizations (Oino, *et al.,* 2013).

Enters et al (2004) observed that a farmer's adoption of agroforestry technology depends on the following criteria: food (supplying immediate household needs), income (providing cash to service other needs), future (providing savings for longer-term needs, such as, education for children), building (providing wood materials for construction of new house for instance), and erosion control (activities that minimize soil loss). Therefore, agroforestry technology offers many entry points to improve the household status, income and health of women and children. Cultural beliefs influence agroforestry adoption and commercialization. For instance, ritual and taboo prohibitions against planting or using certain tree products are powerful determinants of people's actions, and often hold more local influence than rules and formal legislation set by national government (Kiptot & Franzel, 2011).

Tree planting activities in western Kenya are dominated by men and it has been effectively sustained through cultural practices. Just as ownership of land is by custom denied to women, ownership of trees is also denied to women. To ensure that this vital customary requirement is sustained, certain reasons are advanced as to why women are not allowed to plant trees. Most of the reasons may scare women from active participation in tree planting activities thus preserving male dominance. The reasons advanced in western Kenya to inhibit women from planting trees include fatalistic beliefs such as if a woman plants a tree, she could become barren; if a woman plants a tree, her husband could die; if a woman plants a tree, the action is viewed as direct challenge to the husband's supremacy in the household. It is seen as seeking to claim equality in the home and such an action could result in divorce; and during the construction of a house, wood from a tree planted by a woman could not be used. However, despite the beliefs, women contribute to planting of trees by promoting seedling to men in their households, while in women headed households, women take the initiative and plant preferred trees depending on their uses (Wafuke, S. 2012). It is worth noting that the rural poor have different motivational factors that influence their participation in agroforestry ranging from economic, environmental, medicinal, livelihood and socio-cultural factors. For instance, women have a stronger interest in trees for domestic use for example firewood and medicines while men prefer trees for earning cash for example through timber Harvesting.

2.4 Role of Agroforestry Technology

Agroforestry has been demonstrated to offer a wide range of benefits to farmers including the positive effect on their livelihoods through increasing crop yield and increased food security and income (Ajayi *et al.,* 2009), as well as improving farmers' ability to deal with the effects of climate change through improved rain use efficiency and yield stability under rain-fed agriculture (Sileshi *et al.,* 2011). In addition, agroforestry is known for providing benefits to the environment by providing various ecosystem services (Nair *et al.,* 2009). For example, Ajayi *et al.,* (2011) have shown that fertilizer tree systems are inexpensive technologies that significantly raise crop yields, reduce food insecurity and enhance environmental services and resilience of agro-ecologies in southern Africa.

AF is a promising land-use practice to maintain or increase agricultural productivity while preserving or improving agricultural land fertility. It does not convert agricultural land to forests, but rather leaves land in production agriculture, while integrating trees into farm and ranch operations to accomplish economic, environmental, and social goals. Recent studies show that AF practices in Africa have a huge potential to sequester atmospheric carbon dioxide (Luedeling *et al.,* 2011). AF practices have considerable potential in helping solve some of Africa's main land-use problem s (FAO 2013) through the provision of a wide range of tree products for domestic use or sale. Agroforestry can contribute toward achieving the Millennium Development Goals in African countries (Swallow *et al.,* 2009). AF plays a significant role in increasing agricultural productivity by nutrient recycling, reducing soil erosion, and improving soil fertility and by enhancing farm income compared to conventional crop production. AF can also potentially reduce deforestation while increasing food, fodder, and fuel wood production. Benefits that accrue from the usage of AF include food and nutrition security, increased income and assets, and improved land management. It also creates environmental and management synergies. Trees under this technology can provide food, shelter, energy, medicine, cash income, raw materials for craft, fodder and forage and resources to meet social obligations (Mbwambo *et al.,* 2013).

There is increasing evidence that the potential of AF to reduce poverty is real and can be put to effective use in the Poverty Reduction Strategies of many countries in Africa. In forest-scarce countries, AF has expanded greatly on small farms. In Kenya and Ethiopia, for example, farms account for most timber and pole production. In AF systems, the cost of tree production may be lower due to joint production with crops and livestock. Trees have a positive effect on the incomes of associated crops, as in the case of use as windbreaks (Jama and Zeila 2005). When we consider the environmental benefits of AF, we recall great global events such as the 1992 Rio Earth Summit. Agenda 21, the blueprint for action in the twenty-first century adopted by world leaders meeting at the Summit, identifies AF as one way of rehabilitating the degraded dry lands of the world. AF, one of the several approaches for improving land use, is also frequently invoked as an answer to shortages of fuel wood, cash income, animal fodder, and building materials. The environmental benefits of AF includes soil erosion control, improvement of soil quality through increased nitrogen input, improvement of water dynamics and increased activity of soil biota. AF systems such as woodlots do supply fuel wood and can therefore alleviate the demand from natural forests and hence reduce deforestation. They have also shown that they can sequester carbon, though at different rates depending on the species used and management regimes and systems (Sileshi *et al.*, 2007).

AF systems have also demonstrated their ability to conserve biodiversity and suppress insect pests and weeds (Sileshi *et al.,* 2007) better than monoculture agricultural systems. Mafongoya *et al.,* (2008) discuss some of the technically feasible and financially affordable technologies which are appropriate and available to farmers. For further details on the socioeconomic challenges and constraints that limit the adoption of these options. Improved fallows are said to be less risky than fertilized maize in the following ways: in an event of total crop failure, a farmer using inorganic fertilizer would lose his/her investment which is usually higher than that of improved fallows; improved fallows require little or no cash input; benefits of improved fallows are likely to spread over 3 years whereas those of inorganic fertilizers take place in a single year and improved fallows improve the soil structure and organic matter content of the soil thereby enhancing the soil’s ability to retain moisture during drought years. Inorganic fertilizers also pose another risk in that in some years, fertilizers may be delivered too late in the season to have an effect on crop yields (Matata et al 2010).

Profitability for biomass transfer technology was assessed and economic returns were analyzed for maize, kale and tomatoes. Results indicated that biomass transfer was more profitable on high-valued crops and not on maize, and that, even on high value crops, it is necessary to add low doses of inorganic phosphorus since most soils lack it (Place *et al.,* 2001). Apart from rehabilitating land, species of Pine could be used for furniture, pulp, paper, chopsticks and toys. In Utange Mombasa, farmers grow coconuts, maize, mangoes, pawpaw, and cashew nuts and also keep livestock. Agroforestry reduces pressure on the existing indigenous forests as it diversifies farm production and provides both subsistence and income through products such as timber, fuel wood and fodder. In addition, agroforestry contributes to soil and water conservation besides soil fertility (Ludeki, 2004). In Nambale division of Busia district (Kenya), farmers have planted *Sesbania sesban* on terraces to control soil erosion, to provide fuel wood and green manure (Soita Wafuke, 2012).

Agroforestry technology does not require added space since it's incorporated in the same piece of land with crops and livestock. It also offers multiple benefits like source of firewood, food (fruits), economical on fertilizer since agroforestry trees fix nutrients into the soil. *Leucaena lucecophala and calliandra callothyrusis* are examples of agroforestry trees that are used to substitute dairy meal in dairy production. According to a research done by Margaret Lukuyu et al (2007), three kilograms of fresh calliandra species forage equals one kilogram of dairy meal, which is quite economical since most of the small-holder farmers cannot afford dairy meal for their dairy cattle.

Production of trees under Agroforestry practices increases National tree cover by relieving pressure of depending on Natural forests for forest products (Wakhungu, 2014). There is higher net present values (NPVs) for agroforestry systems when compared to monoculture systems. Agro forestry technologies are a solution to these challenges faced by small scale farmers ;- Fodder production (*Calliandra* *callothyrusis, Grivellia robusta, Leucaena lucecophala*) diversification of food sources (fruits, crop produce, dairy products), increased soil fertility by the nutrient fixing characteristic of agroforestry trees and erosion control and increased wood supply especially from short term trees. For example *Sesbania sesban* takes at most one year to mature (Fransisca, 2015).

Although agroforestry has been practiced by these farming communities for a long time, there is inadequate awareness about its potential to the millions that live in poverty. In the past 3 decades, agroforestry has progressed as a science-based pathway for achieving important objectives in natural resource management and poverty alleviation (Kabwe G., 2010)

2.5 Agroforestry Policies

Policies specifically meant to promote perennial crops are increasingly seen as necessary to achieve development goals. International and national forest policies have had a detrimental impact on small-holders' decision to plant trees. The Kenya Forest Service faces a number of challenges such as poor management, competing land use, increasing demand for forest products, unsustainable exploitation among others (Ludeki *et al.,* 2004). Although certain specific forest uses such as hunting, grazing, cultivation and felling of indigenous trees are banned, these activities still occur in the forest (ROK, 2005). However, the draft forest policy of 2000 proposes a number of actions to be put in place to overcome the challenges. The main objective of the draft policy is to provide continuous guidance to all Kenyans on the sustainable management of forests through promotion of participatory forest management and enhancing communities and other stakeholders in the management of indigenous forests (Ludeki *et al.*, 2004). Draft forest policy 2000 and EMCA 1999, both aims at taking measures that encourage the planting of trees and woodlots by individual land owners, Institutions and by community groups.

2.6 Adoption Studies

Both logit and probit models have been widely used in adoption studies (Green and Ng'onyala, 1993).

A study by Isaac et al (2015) on the influence of demographic characteristics on the adoption of improved potato varieties by smallholder farmers in Mumberes Division in Baringo County, Kenya using Logit model. The results showed that perception, extension service, credit access, inputs and market access were statistically significant determinants of the adoption of improved potato varieties.

Francisca Luumi (2014) conducted a research on the Attitude, adoption and economic potentials of agroforestry in Kilosa district, Morogoro Region Tanzania using the Logit model. She concluded that farm labor, attitude, land productivity, commercialization and land resource conservation were the factors that influence the adoption levels of agroforestry.

Research by Nassari (2013) that used logit model to study the institutional and socio-economic factors influencing adoption of conservation agriculture with trees in Karatu and Mwanga districts, Tanzania, showed that age, gender and education levels as the determinants of conservation agriculture with trees technology adoption.

Agomuo and Orisakwe (2011) carried out a research on the Adoption of Improved Agroforestry Technologies among Contact Farmers in Imo State, Nigeria. Regression analysis and pearson product moment correlation results showed that age negatively influenced while education level, farm size, income, extension contact and credit access positively influenced the adoption of improved agroforestry technologies.

A logit model study on Adoption of agro-forestry technologies among smallholder farmers by Parwada et al (2010) concluded that land ownership, awareness, training, drought, labor and local institutions statistically influenced the adoption of agroforestry technologies.

A study by Marian (2002) that used a logit model to study the effects of socio-economic factors on farmers' decision to adopt soil conservation practices in farms adjacent to Saiwa Swamp National Park in Kenya. The findings showed that the level of education, extension service family size, off-farm income and farm sizes were statistically significant in explaining why individual households might have adopted agroforestry.

Lwayo (2000), examined the factors influencing the adoption of farm forestry in Busia District of Kenya. He used the logit model in his study and concluded that well up farmers were better adopters of farm forestry compared to the poor famers. The adoption idea was attributed to better capital resource access among the rich.

Pankh and Negatu (1999) studied the effect of farmers' perception and other factors on the adoption of agricultural technology among households in Moret and Jirn Distints of Ethiopia using the probit model. The study found out that perception on product marketability and grain yield stood as the key adoption decision constraints.

A study by Ng'onyola (1993) using the multivariate Logistic analysis to determine the factors influencing fertilizer adoption. Farming systems, crop variety, crop, off-farm income and credit access were found to significantly influence the adoption of fertilizer adoption.

2.7 Conceptual Framework

Agroforestry is a useful means of strengthening livelihoods since it creates and uses a range of assets. Success in agroforestry is drawn upon all categories of capital assets. This study conceptualizes that, if agroforestry technology is promoted in Bumula Sub-County, there will be increased output in production. The adoption of agroforestry technology is the dependent variable of the study while the demographic factors influencing the adoption of agroforestry technology the independent variables.

During the study the adoption of agroforestry technology was hypothesized to be influenced by demographic factors.

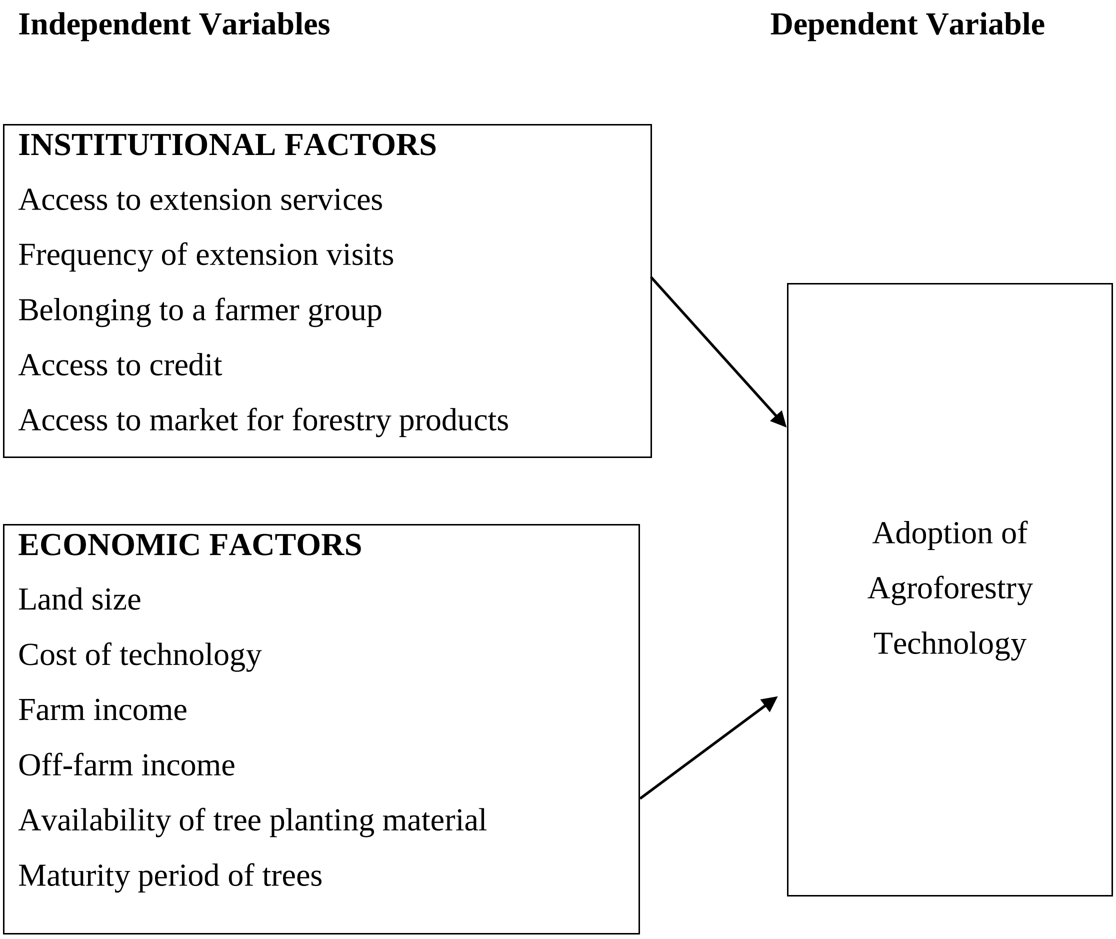

Figure 2.1: Conceptual Framework

Source: Researcher’s own Conceptualization, (2017)

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter explains the methodology that was used to undertake the research. It covers the study area, research design, target population, sample size, sampling design, and data collection instruments / procedures and data analysis techniques.

3.1. Study Area

This study was carried out in Bumula Sub-County.

Bumula Sub-County.

Bumula is a Sub-County in the larger Bungoma County. It has seven administrative wards namely -; South Bukusu, Bumula, Khasoko, Kabula, Kimaeti, West Bukusu and Siboti.

Agriculture is the major occupation and source of income that drives the economy of this Sub-County with Maize, Sunflower, Sugarcane, Coffee, Tobacco, Potatoes, Beans and cotton being the main crops. Agriculture is the main source of household food and provides raw materials to agro based industries. Three agroforestry systems are practiced here agrosilviculture, silvopasture and agrosilvipasture. It has two-season rain regime, the long rains covering March to July while the short rains start in August to October. (Ngugi *et al.,* 2013).

Bumula Sub-County soils are predominantly Feralsols. The soils have been mined of their nutrients due to continuous cropping with little addition of quality inputs. The availability of major nutrients N, and P is low in the districts (Ngugi *et al.,* 2013).

3.2 Research Design

The research design selected for this study was field survey in which sampled group provided information to the problem under study. This design enabled the researcher to examine the effects of naturally occurring influences of independent variables (Demographic factors) on the dependent variables (Adoption of agroforestry technology). Moreover, the design allowed the researcher to apply aspects of survey research to track adoption of agroforestr4y technology in Bumula Sub-County.

Small holder farm households in Bumula Sub-County doing agricultural crop and livestock production were the units of analysis because it is in these households where major adoption decisions are made.

3.2.1 Target Population

The study generally targeted all Small-holder farmers that are doing agricultural crop and livestock production. Bumula Sub-County has a population of 18,580 small-holder farmers (Ministry of Agriculture Bumula Sub-County office, 2016).

3.2.2 Type of Data

This study was based on primary data obtained through formal administration of questionnaires to small-holder farmers. The information included household land size (in acres), cost of technology(in Kshs), Availability of tree planting materials, maturity period of agroforestry trees, farm income (in Kshs), off-farm income (in Kshs), access to extension services, frequency of extension visits, access to market, belonging to a farmer group and access to credit.

3.2.3 Sample Size Determination

The target population was greater than 10,000 therefore the researcher used the approach by Kothari (1990).

$$n = Z^2 pqN / e^2 (N-1) + Z^2 pq \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

Where,

n- Sample size

Z- Value of standard variate at a given confidence level which will be worked out from table under normal curve at 95% confidence level z=1.96

p- Sample proportion p=0.5

q = 1-p

N- Target population

e- Error term a value of 0.05 was used

Sample size determination is as follows;

$n=1.96^2 *0.5*0.5* 18,580 /0.05^2 *18,580 +1.96^2 *0.5*0.5$

n= 385

Gay & Diehl (1992) stated that sample size should be as large as time and other resources can allow. He further argued that large sample sizes enhance the likelihood of yielding statistically significant results Alreck & Settle (1995) suggests that larger samples are the best compared to smaller ones. He gave 1,000 as the best sample size for a study. This study therefore used a sample size of 751. The sample size was large enough to allow reasonable and accurate interpretation of the results.

3.2.4 Sampling Procedure.

A cluster sampling procedure was used to identify the study sub-groups (wards) in Bumula Sub-County, namely-: South Bukusu, Bumula, Khasoko, Kabula, Kimaeti, West Bukusu and Siboti. Therefore the study area was divided into seven wards.

Proportionate sampling was used to determine the number of smallholder farmers in each given ward. The total number of small holder farmers in the seven wards is 18580. The sample required for each ward was proportionately determined as shown in table 3.1.

Table 3.1: Description of the Proportionately Determined Sample Size Per Ward.

ID	Ward	Ward Population	Sample size per ward
1	South Bukusu	2957	119
2	Bumula	3231	133
3	Khasoko	1963	81
4	Kabula	2321	94
5	Kimaeti	2776	113
6	West Bukusu	2189	88
7	Siboti	3143	123
Total		18580	**751**

Source: Researchers own tabulation 2017

Random sampling was then used to identify the first respondent in each ward, then systematic sampling was used to determine successive respondents.

3.2.5 Data Collection Instruments

Questionnaires were used as instruments of data collection. The questionnaires contained both structured and semi-structured questions and administered to the respondents. To validate the survey instrument, 10 questionnaires were pre-tested on respondents outside the study area in Lwandanyi ward Malakisi Sub-County. Then they were revised accordingly.

3.3 Theoretical Framework

The diffusion of innovation theory proposed and popularized by Rodgers, (1995) was the base of this study. The theory is concisely explained below.

3.3.1 The Diffusion of Innovation Theory

This study is based on the diffusion of innovation theory by Rodgers (1995). Diffusion is a process where by an innovation is adopted and gains acceptance by a given community (Rodgers, 1995). There are four factors that influence the diffusion process. They include-; the innovation itself, how information about the innovation is communicated, time and the nature of the social system into which the innovation is being introduced (Rodgers, 1995). Understanding how these factors and a multitude of others interact to impede the adoption of a given product among members of a specific adopter group is very important.

A wide range of theories from different disciplines, each focusing on different elements of the innovation process combine to create a meta-theory of diffusion (Rodgers, 1995). The genesis of modern diffusion research was provided by a study by Ryan and Lowa State University in 1943. This study used interviews on adopters of an innovation to observe the factors related to adoption (Rodgers, 1995). The four theories discussed by Rodgers (1995) are among the mostly used diffusion theories. They include -; innovation Decision process, Rate of Adoption, Individual Innovativeness and Perceived Attributes theories.

Innovation Decision Process (IDP): This theory by Rodgers (1995) states that diffusion is an overtime occurring process with five discrete stages. These stages are knowledge, persuasion, decision, implementation and confirmation.

Individual Innovativeness: The individual Innovativeness theory by Rodgers (1995) sates that people who are believed to being innovative will adopt an innovation before the less predisposed. It categorizes individual innovativeness using a bell shaped distribution depending on percentage of potential adopters theorized to fall into each category.

Rate of Adoption: a theory by Rodgers (1995) states that innovations are diffused over time in an s-shaped curve pattern resemblance. It theorizes that an innovation goes through a period of gradual slow growth before it experiences a relatively rapid and dramatic growth where the innovation's rate of adoption gradually stabilizes then finally decline.

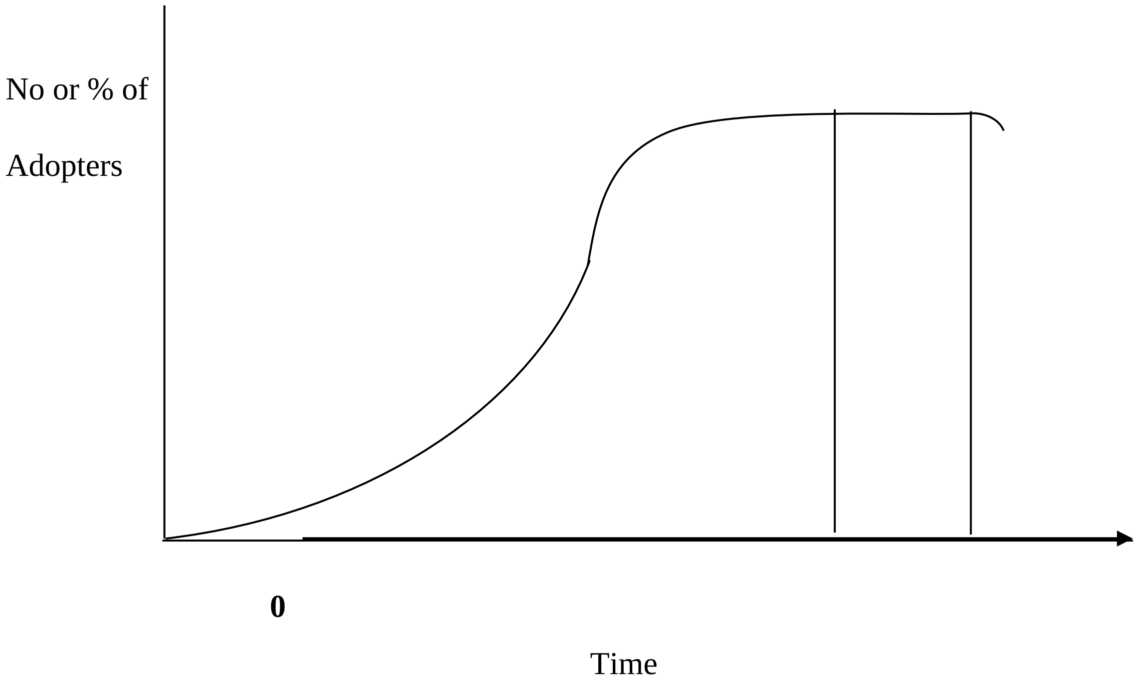

Figure 3.1 Rate of Adoption.
Source Rodgers (1995)

Perceived Attributes: The perceived Attributes Theory by Rodgers (1995) states that potential adopters decide on innovation according to the perceptions in regard to five attributes of the innovation which are triability, observability, relative vantage, complexity and compatibility. The theory argues that an innovation will get increased diffusion rate if the potential adopters perceive that the innovation can be tried on limited basis prior to adoption, if it offers observable results, if it has an advantage over other innovations, if it is not generally complex and if it is compatible with existing values ad practices**.**

3.4 Emperical Models

In the analysis of binary choice problems like for the case of Agroforestry technology adoption, empirical researches generally involve three functional forms of statistics which include the Linear probability model, the Logit Model and the Probit Model (Gujarati,2007, Aldriche and Nelson, 1984). The easiest of the three models is the linear probability model. In this model the difference in the disturbances is uniformly distributed. According to Cox (1970) this model has a major drawback: unless restrictions are placed on the β's (which are again used to estimate *V*), the estimated coefficients can imply probabilities outside the interval [---*L, L*]. Therefore the logit and probit models are used more often. Besides this drawback, it is unrealistic to assume the Interval [---*L, L*], and zero probabilities outside this interval. Besides this drawback, it is unrealistic to assume the interval [---L, L], and zero probabilities outside this interval.

The Logit Model and the Probit Model are the cumulative probability distribution Models. The Linear Probability Model is limited by the fact that predictions can lie outside the limiting interval, which is 0-1 brought about by the Probability laws (Gujarati, 2007). This limitation of linear models forces arbitrary defining of outcomes outside the (0-1) interval (Capps and Kramer, 1986). Both probit and logit models use cumulative probability functions that estimate distribution of the difference between error terms associated with a given choice. The models thus have homoscedastic error terms.

Marginal effects of independent variables are assumed to be constant in linear probability models. It will therefore be realistic to use either probit or logit models in analysis the demographic factors influencing the adoption of agroforestry technology in Bumula Sub-County because adoption of the technologies is non-linearly related to the explanatory variables. Logit and probit models enable analysis of qualitative, categorical or a mixture of both variables. According to Aldiche and Nelson (1984), neither logit nor probit has advantage over the other. However, coefficients for logit are 1.8 times the value of those of probit models. The choice of these two models depend on -; (i) convenience of computer program availability and flexibility for the models (ii) personal experiences and also preference in the models.

3.4.1 Specification of Logit Model

To analyse the institutional and economic factors that influence the adoption of agroforestry technology, logit estimation model was used. The estimation of logit model based on cumulative probability function is:

$$Y = \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_4\chi_4 + \beta_5\chi_5 + \beta_6\chi_6 + \beta_7\chi_7 + \beta_8\chi_8 + \beta_9\chi_9 + \beta_{10}\chi_{10} + \beta_{11}\chi_{11} + \varepsilon \text{..........} 3.2$$

X_1= Access to extension services. Binary: 1 if yes, 0 if otherwise.

X_2= Frequency of extension visits

X_3= Belonging to a farmer group. Binary: 1 if yes, 0 if otherwise.

X_4= Access to credit. Binary: 1 if yes, 0 if otherwise.

X_5= Access to market for forestry products. Binary: 1 if yes, 0 if otherwise.

X_6= Land size

X_7= Cost of technology

X_8=Farm income

X_9=Off-farm income

X_{10}= Availability of tree planting materials

X_{11}= Maturity period of trees.

A priori $\beta 1$, β_2, β_3, β_4, β_5, β_8, β_{10} and β_{11} were expected to be positive while β_7, β_9 and β_{11} were expected to be negative. β_6 could go either way.

Table 4.0 Estimation of Logit Model

Name	Measurement unit	A prior expected sign
Access to extension	Yes=1; No=0	Positive
Frequency of extension visits	No. of Visits	Positive
Belonging to a farmer group	Yes = 1; No = 0	Positive
Access to credit	Yes = 1; No = 0	Positive
Access to market for forestry products	Yes = 1; No = 0	Positive
Land size	Size in Acres	Could go either way
Cost of technology	Cost in Kshs	Negative
Farm income	Sales in Kshs	Positive
Off-farm income	Sales in Kshs	Negative
Availability of tree planting material	Easily available=1; Difficult to find=2; Not available=3	Positive
Maturity period of trees	One year=1; Between 2-5 years=2; Between 5-10 years=3; More than 10 years=4	Negative

3.5 Estimation of Adoption Level

The level of adoption is measured by determining the adoption index where the level of adoption is defined as the proportion of number of farmers who have adopted the technology to the total number of farmers and is worked out as a percentage ((Adesina and Zinna, 1993), Kipkemei, 2014). It is given as follows:

$$Level of\ Adoption = \frac{No\ of\ Farmers who\ Adopted selected Technology}{Sample Size} \times 100 \ldots (3.18)$$

Adoption studies in agriculture generally attempt to establish factors that influence adoption of a technology in a specific locality. It was nonetheless recognized that attributes influencing adoption of agricultural technology are inherent in the farmer and the farm, in the technology itself and the farmer's objective (Adesina and Zinna, 1993). Farmer and farm attributes that influence adoption include, but are not limited to, farm size, agro-ecological zone and education level. The technologies' attributes are commonly considered in terms of whether they are embodied or disembodied (such as knowledge). It is also critical to establish technologies' other requirements. For example, is there complementarity between the introduced technology and other technologies currently practiced or not practiced? The kind of farming that is practiced; commercial versus subsistence farming, is also another attribute that can influence adoption of new technologies.

To analyze farmers' adoption of agroforestry technology, a qualitative (binary) dependent variable function was used. Binary function cannot be estimated through OLS method since the predicted values from the resultant linear probability model cannot be constrained to the required interval without imposing restrictions on the values of independent variables. Binary functions can, however, be estimated through maximum likelihood method.

3.6 Data Analysis

The data collected was cleaned of any errors made during data collection and the data was coded and summarized.

The data was then subsequently analyzed using the STATA Econometric software. Descriptive statistics like mean, maximum, minimum and deviation values were used to summarize quantitative variables. A regression analysis was carried out for logit estimation. And inferential statistics was used to infer sample results to the general.

3.7 Scope and Limitations of the Study

The study did not cover all farmers in the Sub-County but a sample representative of the whole population. The Sub-County has a population of 18,580 small-holder farmers and a sample of 751 Small-holder farmers were used due to insufficient financial resources and time.

To minimize errors, doubtful responses were verified and clarified by asking indirect questions. In some respondents, probing questions were asked. Training and close supervision of the enumerators were among the strategies used to improve quality of data. Some of the limitations faced was language barrier. Bumula Sub-County is occupied mainly by the Bukusu sub-tribe and with majority of the respondents being middle aged, some farmers could not answer in Swahili or English. The researcher used an interpreter who translated the questions to the farmers. Another challenge faced was culture. According to the Bukusu sub-tribe, women are not allowed to plant trees hence when the researcher came across a woman respondent sometimes they could agree to participate in the exercise and some could decline on grounds of that is a taboo. On these occurrences, the researcher had to move to the next respondent.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

This section of the thesis presents the research findings based on the objectives of the study. It comprises of testing research hypotheses, descriptive statistics of the sampled respondents, outcomes on the level of agroforestry technology adoption, outcomes on the demographic factors affecting agroforestry technology adoption and goodness of fit of the model.

4.1 Diagnostic Tests

The results of diagnostic tests are reported in table 4.2.4.

Table 4.1 Model Diagnostic Checks

Log-Lik Intercept Only:	-513.189	Log-Lik Full Model:	-250.247
D(740):	500.495	LR(10):	525.884
		Prob > LR:	0.000
McFadden's R2:	0.512	McFadden's Adj R2:	0.491
ML (Cox-Snell) R2:	0.504	Cragg-Uhler(Nagelkerke) R2:	0.676
McKelvey & Zavoina's R2:	0.825		
Variance of y*:	18.836	Variance of error:	3.290
Count R2:	0.859	Adj Count R2:	0.672
AIC:	0.696	AIC*n:	522.495
BIC:	-4399.345	BIC':	-459.670
BIC used by Stata:	573.330	AIC used by Stata:	522.495

Source: Author's Survey, 2017

The model fits the data very well. Stata SPost command returns a list of goodness of-of-fit measures. D-740 eleven parameters and one cut740 = 751 – 11. The value of McFadden's R2 was 51.2 per cent while that of ML (Cox-Snell) R2 was 50.4 and that of McKelvey & Zavoina's R2 was 82.5 percent. An interesting results was that adjusted R2 was 49.1 per cent Crag-Uhler (Nagelkerke) recorded an R2 value of 67.6 percent and Count R2 registered the highest value 85.9 per cent. The model was also well identified BIC was -4399.345. The more negative BIC the better the fit (Long and Freese, 2009, P 86) and AIC was 522.495. The overall fit of the model was also significant (p – value 0.000 < 0.05).

4.2 Descriptive Statistics

This unit presents the summary statistics that were used in analyzing the factors that affect agroforestry technology adoption. The results are as shown in table 4.0.2.

Table 4.2 Summary Statistic Results

Variable	Obs	Mean	Std. Dev.	Min	Max
Adoption	751	.4407457	.4968074	0	1
Age	751	45.38881	10.70156	22	71
Cost	751	1.250333	.5830236	0	1
Maturity	751	.861518	.3456354	0	1
Materials	751	2.700399	.6105625	1	3
Land size	751	8.398591	4.03566	.5	15
Market	751	.1225033	.3280847	0	1
Farm Income	751	58280	36676.28	3200	150000
Off-farm income	751	28690	24873.18	0	84000
Extension	751	.4873502	.5001731	0	1
Frequency	751	4.948802	.3290368	4	6
Membership	751	.9733688	.1611102	0	1
Credit	751	.6111851	.487806	0	1

Source: Author’s Survey, 2017

4.2.1 Age of the Respondent

The results give a summary statistics of the age of respondents. This results indicate that the average age of the respondents is 45 years with the youngest participant having 22 years while the oldest was 71 years of age. This implies that the respondents are mainly of middle age indicating that the middle age farmers could adopt agroforestry technologies more than any other group.

These results are supported by Orisakwe et al (2011) who found that the highest percentage of adopters of improved agroforestry technologies are between 41 and 50 years of age.

4.2.2 Land size

Land is an important determinant in technology choice (Kipkemei, 2014). Table 4.2 gives summary statistics of land size of the respondents. It shows that household land sizes were 8.39 acres on average with the smallest land size being 0.5 acres and the largest being 15 acres. This implies that farmers with larger pieces of land are more likely to adopt agroforestry technology compared to the smaller land size owners. These results were supported by Kannan (2002) who in his study in India reported that majority of the respondents had medium size of land holdings.

4.2.3 Belonging to a Farmer Group

The results are as shown in table 4.2. 42.6 percent of the respondents do not belong to any farmer group while 57.4 percent are members of specific farmer group, implying that farmers belonging to farmer groups are more likely to adopt agroforestry technology compared to non-members.

Group meetings of farmers held oftenly are useful in providing information on a technology and exchanging information and ideas among members in the group (Pattamarakha *et al.,* 1996). The more social relations the farmers have, the earlier they tend to adopt innovations. The farmers who are members of farmers' organizations are among the first to adopt technologies (Aksoy *et al.,* 2011).

Formation of farmers groups by far is the foremost strategy used the world over by decision makers to encourage adoption of new technology (Bwire, 2008).

4.2.4 Access to Extension Services

The results show that 51.3 percent of the households have access to extension services. The remaining 48.7 percent have not received any extension services. This is an indication that a good number of farmers have not been able to access extension services. The results also imply that farmers who have access to extension services are more likely to adopt any agricultural technology. This agrees with a study by Quddus (2012), who concluded that level of technology adoption by smallholder farmers is highly dependent upon extension services.

Efficient extension services for agricultural products will in one way or another help increase wealth or acquire more land, hence increasing the adoption levels (Bwire Joseph., 2008).

4.2.5 Frequency of Extension Visits

Househods have only received extension visits yearly or irregulary. 8.1225 percent of the respodents have received a visit from extension personnel yearly, 89.2144 percent receiving irregular extension visits and 2.6631 percent have not received any visits. This implies that most of the farmers only receive extension visits irregularly. This is because the extension personnel are few in number and also do not have efficient transport means.

For impact of extension to be felt and seen, frequency of the extension visits should be regular and more often. Frequent extension contacts are expected to positively impact on adoption of dairy technology by farmers (Bonabana-Wabbi,2002).

4.2.6 Cost of Technology

The summary statistic results show that 69.5 per cent of the respodents spent between 0 and 10,000 shillings , 22.1 percent spent between 10,000 to 50,000 shillings , 8.1 percent spend between 50,000 and 100,000 shiilings and 0.3 per cent sped over 100,000 shillings to prepare their land and buy planting materials. 69.5 per cent of the farmers in this region spend low finances on seed and seedling as well as land preparation. Capital is very core for any kind of enetrprise and it greatly influences the commitment and its success

4.2.7 Access to credit

61.1 percent of the respodents have access to credit unlike the remaining 38.9 per cent that have no access. Farmers who participate in farmer groups have a Village Saving and Loaning Association (VSLA). In these VSLA groups they save and loan money from the group. They have set standards on how much a share should cost, then members save in terms of shares. During loaning, a member should get signatory of three leaders, the secretary, treasurer and the chair person. In many cases these activity involve less amount of money hence when loaning is done, members get little. However VSLA is safe compared to other financial institutions since their interest rates are very low and the security is low. Sometimes a member might get access to credit from the VSLA but end up spending the money on other needs like school fees, medication and food. Credit is a stimulus for production, but this credit should be specifically targeting improving the specific farming technology (Bwire, 2008). Access to credit is important in technology adoption. In some cases access to credit is tied to a particular technological package (Mugisha *et al.,* 2012).

4.2.8 Access to Market

Information was collected on access to market by agroforestry farmers in Bumula Sub-County and results are in table 4.2.

The results indicated that 52.5 percent of the households accessed market for their agroforestry products and 44.5 percent did not have accessed market of their produce. This work is consistent with a study by Bwire (2008) with the findings that remunerative markets for agricultural products will in one or another help increase wealth or acquire more land, hence increasing the adoption levels. Beshir (2014) also established that Market access is one other important variable for the adoption of improved technologies. This is due to the fact that a relatively closer distance of farmers' home to the market enables and facilitates marketing of inputs and outputs.

4.2.9 Maturity Period of Trees

Based on the results in table 4.0.2, 11.1 per cent of the respodents are influenced by the maturity period while of trees whhile 88.9 per cent of the respodents are not influenced by the maturity period of trees in their decision to practice agroforestry.

Most agroforestry trees start offering multiple benefits to the farmer before they reach maturity stage. These benefits include firewood from tree prunnings, soil improvement and fertility increase through nutrient fixation and also humus from the tree leaf falls. For example C*roton megalocarpus.* Another benefit is fodder production by agroforestry trees like *leucaena lucecophala calliandra callothyrusis*, *Sesbania sesban, syzigium spp* and *Grivellia robusta.* Trees for improved fallow like *Acioa barterii, Anthonontha macrophyta* and *Gliricidia sepium* do not reach maturity period. This is because these trees are planted inorder to tap the deep leached nutrients in the soil, then when they reach a certain growing stage they are cut down into small pieces and mixed with the soil inorder to provide those ntrients at the top level soil for the next crop to be planted. Green manure or composting trees like *Casuarina oligodon* which is a practice mostly used in hilly regions do not reach maturity period to supply the farmers needs.

4.2.10 Availability of Planting Materials

The results show that 33.3 per cent of respodents find agrofrestry planting materials easily available. 13.8 per cent find agroforestry trees planting materials difficult to find while 52.9 percent of the households find agroforestry planing materials not available.

A big percentage (52.9 per cent) can not access tree seeds and seedling and this is among the reasons the adoption level of the agroforestry technology is low. In some cases the farmer may be able to find the planting material. However, they might not be able to afford them. These farmers depend on farm income as their source of livelihood and battle their income between several household needs which include food, shelter, clothing, school fees, hospital bills and medicine hence they might not have enough to purchase the palnting materials if need be.

4.2.10.1 Farm Income

Information on income sources was sought since income is an important determinant in technology choice (Mose, 2013). The results showed that Households' average farm income for one year was 58280 with minimum 3,200 and maximum 150,000. Many farmers depend on farm income to implement agroforestry technology which is supported by Van den Berg (2013) who did a study and concluded that low level of reliance on own-farm income may contribute to low adoption levels of technologies.

4.2.10.2 Off-farm Income

The more time farmers spend working off their farms, the less likely they are to adopt new technologies. (Mugisha *et al.*, 2012). Households' average off-farm income for one year was 28,690 with minimum zero and maximum 84,000. Farmers involved in off farm activities tend to spend less time on the farm and as such they lose touch with what is happening in the field of agriculture consequently missing out on innovations. The off-farm income was averagely low compared to farm income. This is a motivating factor for farmers to adopt agroforestry technology and other improved technologies because they depend more on farm income to sustain their lives.

4.3 The Level of Adoption

The study sought to estimate the level of adoption of agroforestry technology among small-holder farmers in Bumula Sub-County and results showed that adoption level was 44.1 per cent. This was fairly high as compared with Kipkemei (2014) who found adoption levels to be in the case of adoption of dairy technology. This adoption level is also lower than Gebremichael and Gebremedhin, (2014) who found adoption of improved box hive was 54.6 per cent in the case of Ethiopia.

4.4 Test of Hypotheses

The first hypothesis of the study stated that Institutional factors such as access to extension services, frequency of extension visits, belonging to a farmer group, access to credit facilities and access to market do not significantly influence the adoption of agroforestry technology among smallholder farmers in Bumula Sub-County. Based on this results, this hypothesis was rejected. To test this hypothesis ordinal logit regression model was estimated and results are presented in table 4.1.5.

Table 4.3 Logit Regression Results

Ordered logistic regression			LR chi2 (11)	535.90
			Log likelihood	-245.23989
			Prob > chi2	0.0000
			Pseudo R2	0.5221
Adoption	Coef.	Std. Err.	Z	P>|z|
Cost	-0.1117154	.02737175	-4.08	0.000
Maturity period	-0.0359393	.0981336	-0.37	0.714
Materials	0.2301223	.0739524	3.11	0.002
Land size	0.1449018	.01370085	10.58	0.000
Market access	0.0008736	.00025	3.49	0.000
Farm income	0.0484743	.0182491	2.66	0.008
Off-farm income	-0.0340624	.0531267	-0.64	0.521
Extension	0.260386	.0573186	4.54	0.000
Frequency	0.0000147	.0000226	0.65	0.515
Membership	0.9239576	.3644704	2.54	0.011
Credit	0.0266133	.0381174	0.70	0.485
Intercept	-8.703506	3.470447	-15.50546	-1.901555

Source: Survey Data, 2017

Results indicated R2 of 0.552 showing that the fitted variables explained 55.2 per cent of the variation of dependent variable. Further the value F statistic was significant (p – value 0.000 < 0.05) showing the variables fitted the model very well. Further the absolute value of log-likelihood was a large number 245.23989 > 30.

Regression results showed that Access to extension services, market access and belonging to a farmer group were positive and significant (p- value < 0.05). Access to extension services had a p-value of 0.000< 0.05, and a positive coefficient. This implies that the adoption of agroforestry technology will increase by 26 per cent if access to extension service was to increase by one unit. Beshir, (2014) supported this by his conclusion that access to extension services positively influence adoption of improved technologies. Market access had a positive coefficient and was significant (p- value 0.000<0.05). A unit increase in market access will cause a 0.08 per cent increase in adoption of agroforestry technology. Belonging to a farmer group was positive a significant (p-value of 0.011< 0.05)

Based on this results, the first hypothesis was rejected. It was therefore concluded that Institutional factors such as access to extension services, belonging to a farmer group, access to credit facilities and access to market were significant determinants of adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

The second hypothesis stated that economic factors such as cost of technology, maturity period of trees, tree planting materials, land size, farm income and off-farm income do not significantly influence the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

Regression results showed that economic factors such as cost of technology, availability of tree planting materials, Land size and farm income were significant determinants of adoption of agroforestry technology. Cost of technology was negative and significant (p – value 0.000 < 0.05). The coefficient indicated that if cost of technology increase by one unit adoption of agroforestry technology was likely to reduce by 11.1 per cent. Availability of tree planting materials was positive and significant (p-value 0.002< 0.05). The coefficient implies that if availability of tree planting materials increase by one unit, agroforestry technology adoption was likely to increase by 23.0 percent. Land size had a positive and significant influence on adoption of agroforestry technology (p – value 0.000 <0.05). The coefficient was positive implying that if land size was to increase by one unit, adoption of agroforestry technology was to increase by 14.4 per cent.

Based on these results the second hypothesis was rejected. Therefore, it was concluded that economic factors such as cost of technology, maturity period of trees, availability of tree planting materials, land size and farm income were significant determinants of adoption of agroforestry technology among small-holder farmers in Bumula Sub-County

4.5 Marginal Effects after Ologit

Table 4.4 presents the results of marginal effect after ologit. Result indicate that the independent variables predict the chances of adoption on average by 8.02 times.

Table 4.4 Marginal Effects Results.

y = Pr(lfp==0) predict)	0.08022224				
Variable	dy/dx	Std. Err	Z	P>|z|	X
Cost	-0.082431	0.07101	-1.16	0.246	.238349
Maturity period	-0.0026518	0.00599	-0.44	0.658	8
Materials	-0.01698	0.01263	-1.34	0.179	12.2916
Land size	0.1069182	0.08551	1.25	0.211	1.85466
Market access	0.0000645	0.00005	1.17	0.240	2266.88
Farm income	0.0035768	0.00334	1.07	0.284	45.1039
Off-farm income	-0.0025134	0.00287	-0.88	0.381	0
Extension	0.019213	0.01614	1.19	0.234	7.47743
Frequency	1.08e-06	0.00000	0.52	0.600	23071
Membership	0.6817572	0.53415	1.28	0.202	.678923
Credit	0.0019637	0.00319	-0.62	0.538	9.25033

Source: Author's Survey, 2017

The results indicate that as cost of production increases the farmers are 8.2431 less likely to adopt agroforestry technology. Farmers who found tree planting materials available, accessed market of agroforestry products, accessed extension services, are members of a farmer group and who accessed credit were more likely to adopt agroforestry technology. As household land sizes increases, chances of the farmers to adopt agroforestry technology was 10.69182 times.

The marginal effect results show that as farm income increases, farmers were 0.35768 times more likely to adopt agroforestry technology while as off-farm income increases farmers were 0.25134 less likely to adopt agroforestry technology. This was an indication that increased off-farm income made farmers to switch to other economic activities that are more profitable than agroforestry.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents a summary of the main findings, conclusions and recommendations as well as suggestions for further research.

5.1 Main Findings

This study sought to determine the factors influencing the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County. The main findings of the study are summarized in the ensuing sections:

5.1.1 Level of Adoption

The level of adoption of agroforestry technology among small-holder farmers in Bumula Sub-County was 44.07 per cent. This was fairly high as compared with Kipkemei (2014) who found adoption levels to be in the case of adoption of dairy technology. Similarly the findings were comparable Gebremichael and Gebremedhin (2014) who found adoption of improved box hive to be 54.6 percent in Northern Ethiopia.

5.1.2 Institutional Determinants of the Adoption of Agroforestry Technology.

The first objective of the study was to determine the effect of institutional factors such as access to extension services, frequency of extension visits, belonging to a farmer group, access to credit facilities and access to market on adoption of agroforestry technology among small-holder farmers in Bumula sub-county. The study found that access to extension services, belonging to a farmer group and access to market were significant. This is an indication that as farmers receive extension services, they gain knowledge on the economic benefits of practicing agroforestry technology and it influences their decision to adopt the technology regardless of the number of visits farmers get from extension personnel. A study by Kitti (2013) is in support of the same. Farmers who belong to a farmer group were also most likely to get extension services as well as motivation from fellow members to adopt the technology. Vi-Agroforestry, an NGO working in this region, recruits farmers only if they are in groups. This organization is the major promoter of agroforestry technology in this Sub-County. It is most likely that a farmer who does not belong to a group of farmers will not be able to get the awareness. Access to market was also significant. When a farmer knows that there is a ready market for their products then they will be confident in adopting the technology.

5.1.3 Economic Determinants of the adoption of Agroforestry Technology

The third objective was to determine if economic factors such as land size, cost of technology, availability of tree planting materials, farm income, off-farm income and maturity period of trees affected the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County. The study results showed that Land size, cost of technology, tree planting materials and farm income significantly influence the adoption of agroforestry technology among smallholder farmers in Bumula Sub-County. The availability of planting materials was positive and significant. The easier it is for a farmer to access the tree planting materials the likelihood for the farmer to adopt this technology. Farm income was positive and significantly influenced the adoption of agroforestry technology among smallholder farmers in Bumula Sub-County. Most of the farmers depend on farm income to sustain themselves hence their ability to adopt a new technology they require finances from their farm output. Land size and cost of technology also play a positive role in the adoption of agroforestry technology in Bumula Sub-County.

5.2 Conclusions

The first objective was to determine the level of adoption of agroforestry technology in Bumula Sub-County. Based on the study results, it was concluded that farmers have adopted the technology though at low levels. The study results showed an adoption level of 44.07 per cent.

The second objective was to determine the effect of institutional factors such as access to extension services, frequency of extension visits and belonging to a farmer group access to credit facilities and access to market on adoption of agroforestry technology among small-holder farmers in Bumula sub-county. Access to extension services, belonging to a farmer group, and access to market influence the adoption of agroforestry technology among small-holder farmers in Bumula sub-county.

The third objective was to determine the effect of economic factors such as land size, cost of technology, availability of tree planting materials, farm income, off-farm income and maturity period of trees on adoption of agroforestry technology among small-holder farmers in Bumula Sub-County. Land size, cost of technology, tree planting materials and farm income influence the adoption of agroforestry technology among small-holder farmers in Bumula Sub-County.

5.3 Recommendations

From these research findings, it was recommended that -:

First, the Government and other stakeholders should enhance farmers' knowledge and literacy level through extension education so as to improve adoption levels of agroforestry technology. This may be done by employing more extension personnel so as to increase access to extension services and also increase the frequency of extension visits through provision of means of transport to improve their coverage. It has been shown that access to extension improves dissemination of useful information to farmers that helps them in planning and making informed decisions and hence improving adoption of modern farming technologies.

Second, the government should start programs to fund and educate agroforestry women farmers in the community since the results showed bigger percentage of the adopters were women. This could be done by organizing field days and establishment of Farmers Training Centres in order for them to access adult education with ease, increasing the number of extension personnel so that farmers access the services and learn especially the agroforestry practices and self-harvesting skills of tree seeds so as to subsidize buying and reduce the cost of production by employing more extension personnel and establishing more field days and farmer seminars. This will also help the farmers to understand in addition that agroforestry does not necessarily require an extra piece of land since it can be incorporated on the crop land. This can be done by encouraging farmers to practice agroforestry even in fragmented and small pieces of land.

Third, the government through Kenya Forest Service should mobilize farmers to put up tree nurseries to meet the high demand for tree seeds and seedlings. This could be achieved through promotion of small scale self-help groups that deal with nurseries.

Fourth, the Government, County Government and other stakeholders should provide marketing facilities to small scale agroforestry farmers. This could be done by construction of agroforestry processing facilities at village level to enable farmers to supply their products directly to the market and avoid selling through brokers. This in turn will increase their income and hence improve their livelihoods.

5.4 Suggestions for Future Research

During the research period, there were issues that came up and need further research. For example this research was carried out in Bumula Sub-County hence it is suggested that this research be replicated on a wider region or in a different county.

Secondly, there is need for research on commercialization of agroforestry technology and the impacts be documented for the benefit of the farmers.

Thirdly, there is Vi-agroforestry that only recruits farmer who are members of farmer's group. There is need for a research to be conducted to provide insight of the impact of this organization on farmers' ability to take adoption decisions on agroforestry.

During the research, it was realized that farmers engage in some activities that negatively affect the adoption of agroforestry technology like monocropping and incorporation of non-agroforestry trees on croplands. There is need for a research to be conducted on the economic benefits of farming activities for farmers to be aware of economically viable farming activities.

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APPENDICES

Appendix I: Questionnaire

My name is Catherine Wambua a student of Moi University undertaking a research titled **"Analysis of factors influencing the adoption of agroforestry technology among smallholder farmers in Bumula sub-county Bumula Sub-county, Kenya".** I am collecting data to assist in the research. I kindly request you to respond to the questionnaire so as to get information to assist in achieving my study objectives. All the information supplied will be treated confidential but will be used to improve the agricultural productivity and thus economic welfare of the people in Bumula Sub-County and other areas where agroforestry technology is practiced.

Thank you for your support and corporation.

Write your answers in the spaces provided or indicate in the boxes provided by either a tick. Whichever is applicable to your situation.

Name of Sub-county……………………………………………………………………

Name of Ward ……………………………………………………………………….

<u>Respondent bio data</u>

Name/ No of Respondent…………………………….. What is your age? ……….

Gender: Female ☐ Male ☐

Do you practice agroforestry technology on your farm? Yes ☐ No ☐

Institutional factors

1. Do you receive extension services? Yes ☐ No ☐

   If Yes name the sources ………………………………………………….

2. How often do you receive extension services?

    i. Weekly ☐
    ii. Fortnightly ☐
    iii. Monthly ☐
    iv. Yearly ☐
    v. Irregular ☐
    vi. Never ☐

3. Do you belong to a farmer group? Yes ☐ No ☐

   If Yes, name the group……………………………………………………..

   ……………………………………………………………………………………

   ……………………………………….………………………………………….

4. Do you have access to credit? Yes No

   If Yes, name the institutions that offers you credit,

    i. …………………………………………………………………………
    ii. …………………………………………………………………………
    iii. …………………………………………………………………………

5. a) Do you have access to market for your farm products? Yes ☐ No ☐

   If Yes where do you market your products?

   …………………………………………………………………………

   ……………………………………………………………………………

   b) How easy do you market your products?

    i. Very easy 1
    ii. Fairly easy 2
    iii. Difficult 3

Economic factors

6. What is the size of your land? ……………………………………………….

   ……………..…………………………………………………………………

7. How much did you spend on land preparation and planting materials for the year 2016?

   ……………………………………………………………………………
   ……………………………………………………………………………
   …………………

8. How much did you get from the agroforestry practices on your farm in the year 2016?
   ……………………………………………………………………………
   ……………………………………………………………………………
   ……………………………………………………………………………
   …………..

9. Do you have off- farm enterprises? Yes ☐ No ☐

   a) If Yes which off-farm enterprises are you doing?

   ……………………………………………………………………………
   ……………………………………………………………………………
   ………………..…

   b) How much did you get from your off-farm enterprises?

      ……………………………………………………………………………
      ……………………………………………………………………………
      ………………..

10. On a range of 1-3 indicate how available are the tree planting materials i.e seeds and seedlings? (1 being easily available, 2 being difficult to find and 3 being not available)

    i. 1 ☐

    ii. 2 ☐

    iii. 3 ☐

11. a) Has the maturity period(s) of the trees on your farm influenced your decision on a given agroforestry practice

    Yes ☐ No ☐

    b) How fast do the trees on your farm take to mature?

    i. one year ☐
    ii. Between 1-5 years ☐
    iii. Between 5-10 years ☐
    iv. More than 10 years ☐

Appendix II: Bumula Sub- County