ADOPTION OF AGROFORESTRY TECHNOLOGIES AMONG SMALL SCALE FARMERS IN NZOIA LOCATION, LUGARI DISTRICT, KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

I hereby declare that this is my original work and has not been presented in any other University for the award of a degree.

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RECOMMENDATION

This work has been submitted with our approval as University Supervisors.

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Dr. P. Makenzi

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DEDICATION

God my creator in whose love I delight. My parents who faithfully instilled in me values that continues to inspire me to this day. To my wife Edna Wafuke and children, Erastus Wafuke, Eric Wafuke and Elvis Wafuke who continue to give me inspiration and love to work hard. Finally friends whose love, inspiration and company have continued to give my life good reason to aspire for big achievements.

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ABSTRACT

In rural Kenya, wood remains important for both construction and fuel wood. Since most rural people in high potential areas experience deficit in fuel wood and other wood products, there is need to increase production through employment of on-farm production technologies that ensure sufficient supply. Adoption of Agro forestry technologies in rural Kenya has been promoted by both the government and NGOS in order to achieve wood sufficiency. However the adoption of Agro forestry technologies by small scale farmers has been low leading to persistence of wood fuel deficit. The purpose of this study therefore was to investigate social-economic and cultural factors that influence adoption of Agro forestry technologies among small scale farmers. The study employed an ex-post-facto survey design, involving data collection on what already exist and not designed by the researcher. The study was contacted in Nzoia location, Lugari district. A sample of 201 small scale farmers who were selected using stratified proportionate random sampling in the location was used in the study. Data analysis was done using SPSS and to achieve the study objectives, descriptive, correlation and regression analysis were used. The study found out that farm size, sex (gender), land tenure, and farm preparation methods influences adoption of Agro forestry technologies in the study area but traditional believes and taboos do not. It was also found out that most small scale farmers were motivated to adopt these technologies by the many uses of trees and scrubs they plant on their farms. Though farmers' interaction with the extension staff was low, the adoption rate was significant and so this study recommends that extension services to encourage more small scale farmers adopt these technologies be intensified.

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LIST OF ACRONYMS AND ABBREVIATIONS

CBS	Central Bureau of Statistics
EMCA	Environmental Management and Co-ordination Act
FAO	Food and Agricultural Organization
GEF	Global Environment Facility
ICRAF	International Centre for Research in Agro forestry
ILEG	Institute for Law and Environmental Governance
ROK	Republic of Kenya

CHAPTER ONE

1.0 INTRODUCTION

Environmental resources support economic production and consumption opportunities. However, the loss of environmental resources such as forests has caused a global concern. The annual forest losses within the tropics alone, is estimated at 15.2 million hectares (GEF, 2005). Most Governments in developing countries see forest resources as assets to exploit without reinvestment to ensure sustainability. In Kenya, deforestation is still rampant particularly in villages and among highland farmers where land for cultivation is priority. Population pressure, improper Government policies and disruption of indigenous traditional land-use management practices, have contributed to accelerated degradation of forest land and loss of Biodiversity in Kenya (Kio and Abu, 1994). Thus consequently put forest cover in Kenya at less than 1.7% below the world recommended cover of 10%. It is therefore against this background that efforts to improve Agro-forestry technologies aimed at the integration of compatible components of Forestry and Agricultural Production System should be encouraged. EMCA, (1999), has come up with measures to encourage the planting of trees and woodlots by individual land users, Institutions and by Community organized groups. Ludeki *et. al,*. (2004), has recommended farm forestry as an opportunity to protect existing forests.

A wide range of factors influence farmers decision to adopt any form of Agro-forestry technology, and it ranges from household subsistence considerations, tenure arrangements, market for tree crops, Government policies, level of education and level of income. The Forest Act no. 7 of 2005 recognizes the importance of farm forestry as it diversifies farm production and provides both subsistence and income through such products as timber, fuel wood, herbal medicine, fodder and soil conservation. Agro-forestry technologies seek to increase land productivity and income generation with environmental rehabilitation and diversification of agro-ecosystems.

Ministry Of Finance And Planning (2000) indicates that more than 56 per cent of the projected population live below poverty line. Nzoia location of Likuyani division Lugari district, also experiences high level of poverty. This is where other systems of income generation such as

milk production are failing and people rely mostly on crop production. There is therefore, need to investigate socio-economic and cultural factors influencing the adoption of Agro-forestry technologies as a potential to enhancing diversification of farm production and increase income generation at household level.

1.2 Statement of the Problem

Nzoia location is an agricultural area and production of maize is the main occupation of most small scale farmers. Due to high demand for maize production, other land use systems are slowly collapsing. Dairy production is declining due to diminishing grazing areas as farmers continue to increase land for maize production. Wood supply is becoming a major problem as farmers pay little attention to Agro forestry practices. While some of the benefits of Agro forestry technologies are fodder production, diversification of food sources, increased soil fertility and increased wood supply. It is not known how socio – economic and cultural issues influence the adoption of these technologies. This research, therefore led to investigating the influences of these factors on Agro forestry technology adoption.

1.3 Objectives

The broad objective of the study was to investigate adoption levels of Agro-forestry technologies among small scale farmers in Nzoia location.

1.3.1 Specific Objectives

i. To conduct an inventory of agro-forestry technologies applied in Nzoia location.
ii. To investigate the factors that influence adoption of Agro forestry technologies in Nzoia location
iii. To asses the benefits of agro-forestry technologies at household level in Nzoia location

1.3.2 Research Questions

i. What are the commonly adopted agro-forestry technologies among small-scale farmers in Nzoia location?
ii. What are the factors that influence agroforestry technologies in Nzoia location?
iii. What are the major benefits of Agro forestry technologies at household level in Nzoia location?

1.4 Justification

Nzoia location is an Agricultural area and maize production is the main occupation of most small scale farmers. The 1999 National Population Census put the human population here at 22,195 people on a land area of 55.2 km^2 (CBS, 1999). The increase in population has led to subdivision of land into smaller units and intensified maize cultivation, grazing areas have also shrunk and dairy production is slowly collapsing denying farmers a key alternative source of income. Grazing and cultivation areas have hampered bush growths that were sources of firewood. There is therefore, need to harmonize various land production systems through Agro forestry technologies.

Through Agro forestry technologies, farmers are able to meet fuel wood needs, fodder for dairy production and increased fertility for farm crop production. Trees under Agro forestry technologies are known to improve the environment in terms of social, economic and ecological status ICRAF (1992); GEF (2002). This study established the status of Agro forestry technologies practices within Nzoia location, Lugari District. A program to be adopted at the household level, to enhance on-farm forestry will be developed based on these findings. The program will integrate the local people's needs, their valued tree species and the benefits accruing out of certain preferred Agro forestry tree species. These results will help communities, stakeholders and policy makers to understand the need for on-farm afforestation in Kenya.

1.5 Scope and Limitation of the Study

The research area covered four sub-locations; Musemwa; Vinyenya; Mois Bridge; Matunda and concentrated on Socio-economic and Cultural factors influencing the adoption of Agro forestry technologies in the location (Nzoia).

CHAPTER TWO

2.0 LITERATURE REVIEW

Forests provide essential goods and services such as watershed management, flood and erosion control, food, herbal medicine, and maintaining environmental quality and Biodiversity (Gradwohl *et al.,* 1990).

2.1. Causes of Forest Degradation

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. This has been noted in major equatorial forests like the Amazon. 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 dire 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, 2001). 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.

2.2. Agricultural Expansion and Excisions

GEF (2005), currently, 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).

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 (ILEG, 2004). 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 farm forestry to be self reliant on the demand for tree products and services.

2.3 Fuel wood Demand and Illegal Logging

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 Kenya, 70% of domestic energy supply is met by wood fuel. 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 and Social forestry in Central Kenya (Kiambu, Murang'a, Nyeri, Kirinyaga) and part of Eastern Provinces (Meru and Embu districts), have achieved considerable success, which is a pointer to the importance of Agriculture 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). 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 Agro-forestry practices increases National tree cover by relieving pressure of depending on Natural forests for forest products.

2.4 Conservation of Forests

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 include, secure land tenure, cultural aspects, Agro-forestry knowledge, labour, availability of seedlings, 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 (Nyamweru 1998 and Masese, 2004) and sacred grooves and shrines were

located in forests and local Institutions were able to manage and sustain them (Lelo, 1994, Nyamweru, 1998).

Masese (2004) and Nyamweru (1998), reported that the local Institutions (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 (Castro, 1993). However, customary law and beliefs have diminished under the pressure of modernization. Therefore, there is need to appraise the problem from a modern perspective.

Philippines forest policy of 1988, was for forests to conserve soil and the environment and meet subsistence needs of the local people (Shively, 1999). In Kenya, the forest policy of 1968 focused on catchments management and timber production with strong Government control of forest sector (Ludeki et al, 2004). Today, EMCA of 1999 and the Forest Act no. 7 2005 (Ludeki *et al*, 2004), support sustainable forest management in Kenya.

2.5 Role of Agro forestry

Agro-forestry practices contribute a wide range of products and services. Trees under this practice (Agro-forestry) may provide food, shelter, energy, medicine, cash income, raw materials for craft, fodder and forage and resources to meet social obligations (ICRAF 1992 and GEF 2002).

In Thailand, reforestation was restricted to only few species such as teak (*Tectona gramolis),* pines (*Pinus spp), Eucalyptus spp, Melia azedarach, Leucaena leucocephala* and *Prunus ceraloides.* It was found that apart from rehabilitating land, species of Pine could be used for furniture, pulp, paper, chopsticks and toys (Kijkars, 1993). In Utange Mombasa, farmers grow coconuts, maize, mangoes, pawpaw, cashew nuts and also keep livestock (ICRAF, 1994). Agro-forestry 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, agro-forestry contributes to soil and water conservation besides soil fertility (Ludeki *et al.,* 2004). In Tanzania for example, the Chagga farmers are self sufficient in fodder produced primarily from the trees and shrubs grown in home gardens (Fernandes et al, 1984). 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 (ICRAF 1992). There is therefore, need to establish the perceived benefits of Agro-forestry in Nzoia location to allow for better decision making on conservation in this location.

2.6. Factors Influencing Adoption of Agro forestry Technologies

Adoption of Agro forestry technologies may be influenced by a number of factors. Economic value of trees is a key factor in farmers' adoption (Scherrs, 1995) and the type of tree species available to the farmers for planting. Farmers in most cases tend to accept multipurpose and fast growing tree species that yield benefits early rather than those that have long maturity periods (Sharma, 1995). Another factor that determines farmers' adoption is the availability of labour. Labour shortage has tended to discriminate against categories of farmers (Aboud, 1997), when tree production requires a high input of labour (Kerkhof, 1990), farmers tend to resist. They prefer small gradual changes in farming methods that are not labour intensive. Nyeri (Kenya), farmers gave reasons for not planting trees with crops as: trees shade crops and reduce yields, and that farm units were small (Chitere, 1985). On the other hand reasons given by farmers in favour of interplanting trees with crops included the fact that trees had no effect on crops and provides green manure. In Rwanda, for example in a place called Nyabisindu, farmers noted that the planting and use of *L. leucocephala* and *C. calothyrsus* for fodder increased milk production and dung for manure leading to improved crop production and household income (Kerkhof, 1990).

In Murang'a Kenya for instance, farmers plant fruit trees with vegetables in home gardens to supplement the family diet and generate extra income. They plant trees on hedges for timber and as wind breaks and also to mark property boundaries (ICRAF, 1994). In Western Kenya, *S. sesban* is inter planted with maize, beans and sorghum. It has light crown and minimal effects on Agricultural crops, is fast growing and produces firewood in about a year (ICRAF, 1994).

The reasons why farmers adopt farm practices quickly at one time than another is influenced by the direct benefits to their well being (Lionberger, 1960). Most factors that influence adoption of Agro forestry technologies revolve around social-economic and cultural issues (Noordin, 1996).

2.7 The Influence of Socio-Economic Factors

Socio-economic factors are aspects that relate to social and economic conditions in communities and less to the cultural and biophysical environment. These include: income, occupation, education level, farm size and family size. These factors variously influence the adoption of farm forestry technologies among farmers. In Western Kenya, income, occupation and education level were found to influence tree planting (Ong'ayo, 1993).

The adoption of on-farm tree planting in Central Kenya was influenced by land size (Chitere, 1985). The author noted that farmers in Nyeri were reluctant to plant trees on their farms because trees shade on crops and their farms were small. Tree species, crops grown, farm size and local planting practices were found to influence Agro forestry adoption in Western Kenya (Kimwe and Noordin, 1994). Most studies show relationship between adoption and income as a direct one. For instance, in Nigeria, adopters were older, wealthier farmers who own more than average amounts of land (FAO, 1989). Level of education as a socio-economic factor influencing adoption of Agro forestry development and production system has been found to be controversial (Lionberger, 1960). The author argues that the relationship between a farmer's level of Education and farm practice is indirect except where persons learn new practices in school and where this is not the case, education may merely create a favourable mental atmosphere for acceptance of new practices. Misiko (1976) notes that education of farmers prompts them to prefer better and well paying jobs at the expense of their farms. Education enhances ones ability to receive and understand information but affects adoption behaviour (Ragland and Lal, 1993).

2.8 The Influence of Socio-Cultural Factors

This refers to norms, rules and attitudes that govern the meaning of certain activities for individual and groups. They also may govern the organization of activities and behaviour of individuals in the course of participation in such groups (Ongugo, 1992). Activities that are

designed around existing cultural and social structures, taking into consideration local customs, beliefs, values and even taboos, are socio-cultural. For the purpose of this study, socio-cultural factors will include land tenure, traditional beliefs, public awareness and availability of extension services. Farmers' adoption of Agro forestry practices also vary with socio-cultural practices of the community and that adoption by an enforced policy frequently do not work (Young, 1989). Young (1989) argues that conservation is likely to be most effective where it is conducted with the active cooperation of farmers, in their perceived interests and integrate other measures of Agricultural improvements.

The extent of Agro forestry and the involvement of the local farmers are directly related to the flexibility of the land tenure system (Adayoju, 1984). This shows that land tenure is crucial in the adoption of Agro forestry technologies by farmers (Binswanger, 1980). Land tenure refers to possession or holding of the rights associated with each parcel of land. Most farmers in Kenya find it unacceptable and unattractive to invest in tree planting on land which is not confirmed legally as theirs (Tengnas, 1994). Related to land tenure is also tree tenure. Farmers who do not own the land tend to feel they cannot possibly own the trees hence lack the need to plant them. In Vihiga district, Kenya, women insisted on the issue of sorting out tree ownership before being persuaded to plant trees (Ipara, 1992). In Kitui secure tree and land tenure and a relative freedom to harvest trees and sell products were found to be an incentive for farmers to adopt tree planting (Makindi, 2002).

Certain traditional beliefs have also been found to be a factor in the adoption of Agro forestry practices. In Kenya, among certain communities, women cannot plant trees because doing so is believed to be an act of ownership over land (Gichuki and Njoroge, 1989). In other communities, trees belong to men regardless of who plants them. In Western Kenya for example, there are distinct tree species for men and women (Kerkhof, 1992). Women are not allowed to plant certain tree species- it's believed if she does she becomes barren. Ipara (1992) noted that among communities that hold these beliefs and taboos, traditional land tenure and ownership rights are based on male patrilineage. Certain tree species are associated with certain beliefs and bad omen and therefore, should not be planted at all by community members even if

they are beneficial in any way. It is further noted by Ipara (1992) that tree planting decisions in many communities is a domain of the male head of the household. However, the author also found out that female headed household had more land under trees than male headed households. This explains the role of women in society, which meant they get affected more in case of scarcity of forest resources (Mutoro, 1997). The study on community participation in wildlife conservation around Ol Donyo Sabuk National Park Machakos District Kenya, by Lelo (1994) found out that women were more crucial stakeholders in environmental management and conservation than men. These studies clearly show that women cannot be ignored in the environmental conservation activities and if put on forefront, women achieve more than men. Nyerere (1988) also observed that less than half of the population couldn't develop the Nation alone without women participation.

2.9 Constraints to Farmers Adoption of Agro forestry Technologies

The importance of trees and need to retain and remove them has always conflicted with the need for Agricultural land (FAO, 2000). Tree planting generally coincides with Agricultural activities which are always given first priority. The need to provide food through agriculture is a first priority all over the world while the need to conserve forests is to ensure sustainability of the global ecosystem (Sharma, 1992). Due to the fact that a large percentage of the world's land resources are arid and cannot support food production, there is competition for the productive land between agriculture and forests. This is why Agro forestry is the best option for optimizing land resource use (Sharma, 1992).

2.10 Policies

Policies specifically meant to promote perennial crops are increasingly seen as necessary to achieve development goals (Shiverly, 1999). International and National forest policies have had a detrimental impact on small holders' decision to plant trees. Like in Kenya the application of the Chief's Act which regulates tree cutting discourages small scale farmers from growing as many as they otherwise might. The policies immediate intention is to prevent indiscriminate felling of trees (ICRAF, 1992), which makes farmers unsure of why they should plant trees that they cannot cut for their needs without Chief's authority.

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, 2004). 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. With such policies in place, this research hopes to encourage farmers in Nzoia location to plant trees on the farms for sustainable land management and for economic gains that accrue from such Agro-forestry practices.

2.11 Land and Tree Tenure Rights

Land tenure refers to the possession or holding of the rights to the use of land. Agro forestry production systems that involve the local farmers will directly be related to the flexibility of the land tenure system (Adayoju, 1984). Secure tenure provides for proper incentives for farmers to make investments in the long term productivity of their land (Panayotou, 1993). In Kenya, most farmers find it unacceptable and unattractive to invest in tree production on land, which is not legally theirs (Tengnas, 1994). Busienei (1991) found out that the low participation in Agro forestry activities in Ainabkoi Division of Uasin Gichu district was due to lack of title deeds.

Closely related to land tenure is the issue of tree tenure. Farmers who do not legally own land tend to feel they cannot possibly own the trees and hence see no need of planting them. Ipara (1992), noted that women in Vihiga District Kenya, called for sorting out of the issue of tree ownership before being persuaded to plant them. This is because men are believed to be the owners of land and even when women plant trees on such farms, men always have express rights to cut them down for their own benefits without consulting the women. This weakens women participation in agro forestry practices. In Kitui District Kenya, it was found out by Makindi

(2002) that secure tree and land tenure and a relative freedom to harvest trees and sell products were an incentive for farmers to adopt tree planting. Land ownership rights and gender equity in the tree tenure system can greatly promote Agro forestry technologies.

2.12 Traditional Beliefs and Taboos

Certain traditional beliefs are found to be a factor in the farmers' adoption of Agro forestry technologies. Among some communities in Kenya, women cannot plant trees because doing so may mean ownership of land (Gichuki and Njoroge, 1989). In some communities, trees belong to men regardless of who plants them. There are distinct men and women tree species in Western Kenya (Kerkhof, 1992). For example the traditional Fig trees are only planted by men and women are not even allowed to cut branches from such trees – "She will become barren", communities that hold these beliefs and taboos, traditional land tenure and ownership rights are based on male patronage (Ipara, 1992). Certain tree species are associated with bad omen and are not allowed to be planted at all by community members however beneficial they may be. It was also believed that tree planting decisions in many communities are the domain of male heads of household. These traditional beliefs and taboos in modern societies should be discarded so as farmers move with the changing Agricultural technologies as they hold key to conservation of our Natural Resources. In some communities in Kenya, like Kikuyu's and among the Luo of South Nyanza, people placed curses on trees so as to protect them (Leakey, 1977). Among the Luo of South Nyanza, there were traditional taboos about cutting or planting of certain tree species (Diamond, 1992).

2.13 Farm Size

The high rate of increase in population in Kenya has led to fragmentation of land (Aboud, 1992). For example in the coffee subsistence zones of Kenya, the land parcels are small and shared by too many people, so that after planting cash and food crops, there is limited space for planting of trees (Bradley, 1991). Many Agro forestry technologies require reasonable farm size (Ragland and Lal, 1993). A study in Bangladesh found out that tree planting increased with the amount of homestead land owned and the farmers whose main source of income was non-agricultural were more likely to decide to plant trees in their homestead (Salam *et al,* 2000). The size of land will

most of the time determine the type of land use practices to be put on it and in Kenya, a farmer's food security is key to other land uses.

2.14 Summary of Literature Review

Adoption is the decision to make full use of an idea and practice a new technology and is an important requirement in sustained increase in agricultural production, fuel wood availability and income. Past theories in research, adoption and factors influencing adoption have been reviewed. In as much as adoption is important in Agro forestry based production systems, utilization of Agro forestry technologies is still low. To ensure sustained goods and services, it is important that small scale farmers adopt these Agro forestry technologies.

However, a number of socio-economic and cultural factors influencing the adoption of these technologies differ in different communities and regions. This research therefore aims to establish how these factors influence Agro forestry technology adoption in Nzoia location.

2.15 Conceptual Framework

The conceptual framework (Figure 1), explains the factors that determine the farmers decision to practice Agro forestry in the study area.

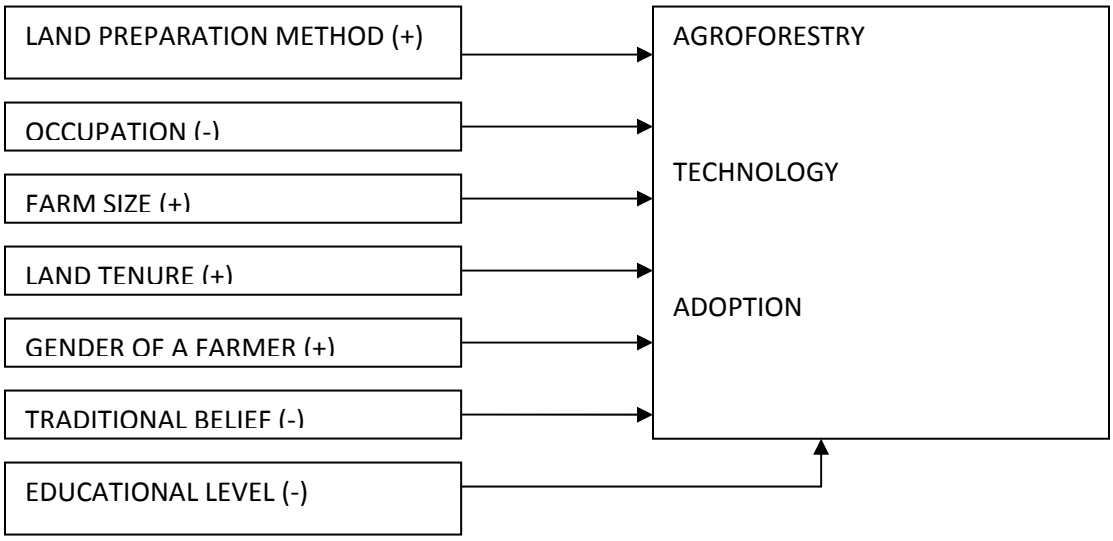

Figure 1: Conceptual framework

The arrow points to the dependent variable (Agro forestry technology adoption) from the independent variables. Farmers are assumed to optimize their present value of net benefits on land if all factors are held constant. However, farmers' decision to adopt Agro forestry technology would be determined by changing factors such as Land preparation methods, farm size, land tenure and Gender of household head as indicated by (+) sign in the diagram above.

2.16. Operationalization of Variables

2.16.1 Socio-Cultural Factors

This research will refer to norms, rules and attitudes that govern the meaning of certain activities for individuals and groups. These include, cultural beliefs which means what people do, options that influence the choices of tree species to be planted, where they are planted on the farm, who plants, who nurses the seedlings and who has the rights. Also includes land tenure and how land ownership influences tree production, public awareness and how such knowledge influences Agro forestry practices. These were obtained from the questions; what are the reasons for not planting trees on your farm, what tree species are you allowed to plant culturally, what ownership is your land?

2.16.2 Socio-Economic Factors

These are factors that relate more to social and economic well being of the communities. They include age, family size, income occupation, educational level and farm size. They were addressed in questions such as what is your occupation, level of education and what is the size of your farm? Does the size of the farm influence your tree planting in anyway?

2.16.3 Agro forestry Technologies

This referred to deliberate integration of certain tree species with crops on the farm also referred to as agro forestry practices. Some of the technologies included, home gardens, boundary tree planting, hedges, live fences, woodlots and homestead planting. These were gathered from the respondents from such questions as what influences your choice of Agro forestry technologies. It was used interchangeably with on-farm forestry.

2.16.4 Small Scale Farmers

These are farmers who own 0.1 to 15 acres of land

2.16.5 Public Awareness on Agro forestry Technologies

This referred to prior knowledge that a farmer had concerning Agro forestry practices. Because of the disseminated information on Agro forestry by extension officers, the farmer was assumed to seek tree seedlings to plant on his farm and this information was captured in the questionnaire by questions such as; have you heard of Agro forestry? From Who? How often are you visited by extension officers?

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

Lugari District was curved out of the large Kakamega district in 1998. It is one of the eight (8) districts in Western province. It borders Kakamega and Nandi to the South, Bungoma to the West, Uasin Gishu to the East and Trans-Nzoia to the North. It lies between longitude $34^0$28'and 35^0 East and between latitude $0^0$25' and 1^0 North of the Equator (ROK, 2002 – 2008).

3.1.1 Area, Administrative Units and Demography

The district has a total land area of 670.2 km^2 with a population of 234,536 people and an average household size of five (5) people. It is divided into three Divisions namely; Lugari, Likuyani and Matete. Matete Division has an area of 101.9 Km^2 with two (2) Locations and seven (7) Sub-locations. Lugari Division occupies an area of 266.3 km^2 with four (4) Locations and eight (8) Sub-locations. Likuyani Division has a total land area of 302.0 km^2 being the biggest of the three divisions of Lugari district. This division has four (4) Locations. Nzoia Location is one of the four (4) locations of Likuyani division and it has a total area of 55.2 km^2 with a population of 22,195 people an average of five (5) people per household (ROK, 2002 – 08).

3.1.2 Topography and Climate

Lugari district lies between altitudes 1,300m and 1,800m above sea level. It is hilly and rocky towards the East, which gradually falls into a plain as it progresses to the South.

General climate and rainfall patterns are of equatorial type. Temperatures vary between 6^0C and 23^0C in the high altitude areas and between 18^0C and 24^0C in low altitude areas. The rainfall pattern is bimodal with long rains occurring in March to August while short rains are experienced in October to November. The average annual rainfall is between 1000mm and 1600mm (ROK, 2002 – 08)

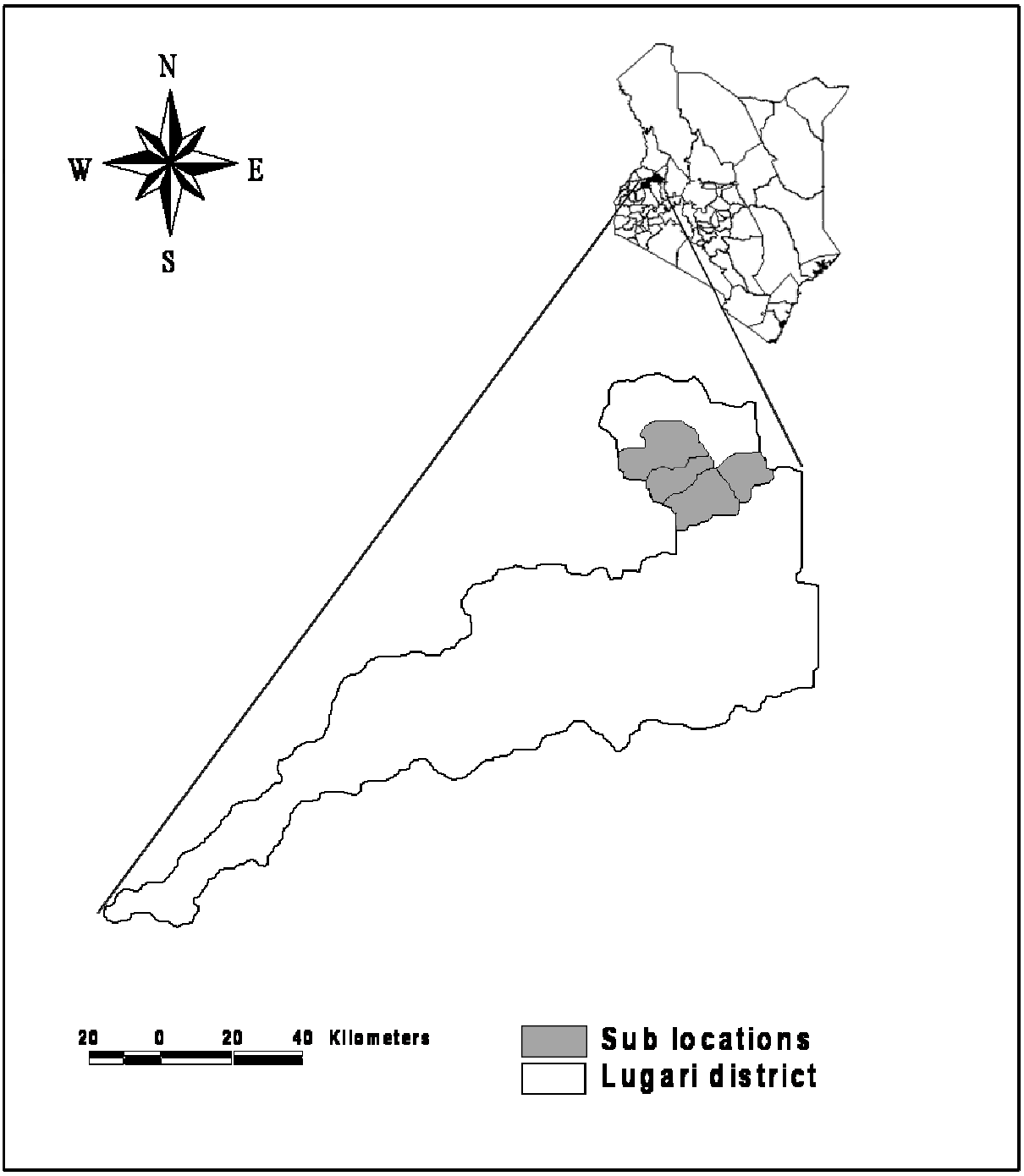

Figure 2: Map of Kenya showing Lugari district and Nzoia location, the study area

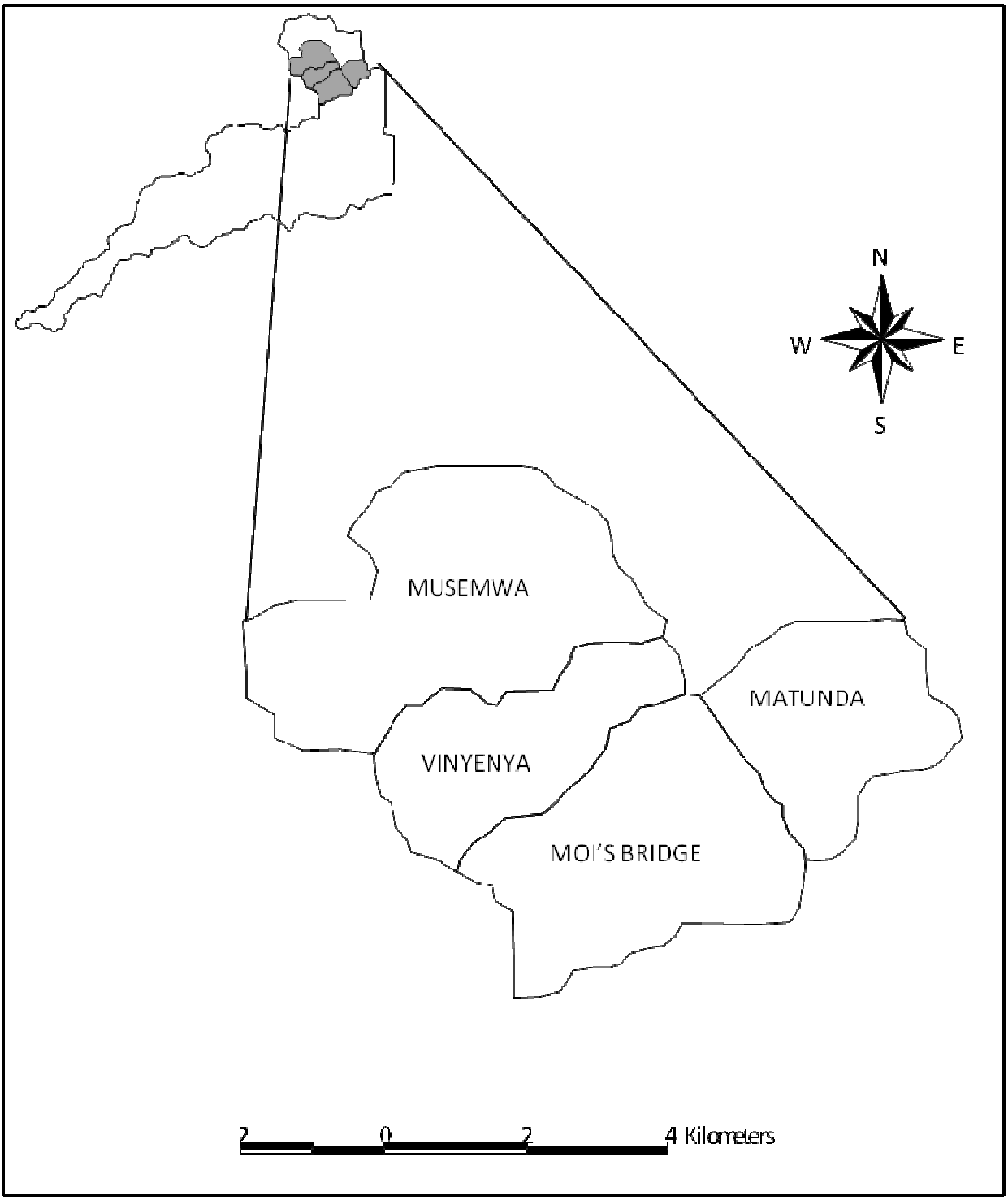

Figure 3: Study Area - Map of Nzoia Location and Sub-locations

3.1.3. Natural Resources

The district is endowed with fertile soils for crop production and has three plantation forest blocks. These include Nzoia, Turbo and Lugari plantations of mostly *Pinus patula, Cuppresus lusitanica, Eucalyptus spp* and Wattle. The district has two major rivers. River Nzoia originates from the Cherangani Hills in Trans-Nzoia District, it forms the Northern part of the boundary with Bungoma District. Another river is the Kipkaren River which enters the district shortly after the Kipkaren Market and flows down South to join River Nzoia shortly after Lugari Railway Station (ROK, 2002-08)

3.1.4. Land Use Practices

Most people in the district are farmers and keep livestock as well as grow crops. The average farm size 10 ha. Main food crops include; maize, beans, sweet potatoes, cassava, and sorghum. Cash crops include; coffee, sunflower, sugarcane, bananas, passion fruits and mangoes. Main livestock breed kept are dairy cows for milk production – which plays an important part as food supplements and for household income (ROK, 2002 – 08)

3.2. Research Design

The study employed an ex-post-facto survey design, involving data collection on what already exist and not designed by the researcher (Fraenkel and Wallen, 2000). In this study, the adoption of Agroforestry technologies were not introduced by the research as a treatment but rather small scale farmers were found practicing. Randomly selected household were interviewed across the four sub-locations of Matunda, Moi's Bridge, Musemwa and Vinyenya (Table1).

3.3 Data Collection

A reconnaissance survey to the study area was carried out for the purpose of familiarization and pre-testing of the questionnaire. This facilitated necessary adjustments to the questionnaire and increased the reliability of the data. Data was collected on the following variables: land tenure, tree tenure, cultural beliefs and taboos, farm size, knowledge about Agro forestry technologies and their benefits.

3.4. Data Sources

Both primary and secondary data collection methods were applied to gather data on different variables while personal observations were done to enhance the data.

3.4.1. Primary Data Sources

This involved a standard semi-structured questionnaire (appendix 1) that was administered to the randomly selected household heads. The questionnaire aimed at collecting socio-economic and cultural information about the household. It particularly sought information on land tenure, tree tenure, cultural beliefs and taboos in tree production, farm size and the benefits of Agro forestry technologies.

3.4.2. Secondary Data Sources

This included data from government sources, Kenya Forest Services (KFS), Journals, books ICRAF Publications and Internet materials, which deal with Agro forestry issues and the specific study area.

3.5. Sampling Frame and Sample Size

The total number of household in the location (N) constituted the sampling frame and the units of sampling were the individual households. The sample size was calculated based on the equation by Rees (1995)

$$S = \frac{X^2 NP(1-P)}{D^2(N-1) + X^2 P(1-P)}$$

Where

S = Required sample

N = Population of household in the study area

P = Sample proportion which is favoured in the population to give 95% Confidence level.

D = Degree of accuracy which is reflected by the amount of error that can be tolerated in the fluctuation of sample proportion P.

X^2 = Chi-square value corresponding to one degree of freedom relative to desired confidence.

The location (Nzoia) had a population of 22,195 people with an average household size of 5 persons. If the required degree of accuracy is 0.002, a sample proportion of 20% and a Chi-square value of 0.016 at 0.01 or 99% confidence level substituting:

$$\text{Sample size} = \frac{0.016 \times {}^{22,195}/_{5} \times 20\% \times (1\text{-}20\%)}{0.002^2({}^{22,195}/_{5} - 1) + 0.016\ (20\%)\ (1\text{-}20\%)} = 559.46$$

The sample size of 559 obtained from the calculations above, is the optimum size for a representative study in the study area, however, this study used 240 sampling units due to a limitation of funds and time. This sample size is adequate since SPSS package analysis needs a minimum of 200 samples for accurate analysis.

3.6. Sampling Procedures

A sample of 240 small-scale farmers was used in the study. Stratified proportionate random sampling and non-probability sampling procedures were used to obtain a sample of 240 respondents in the four sub-locations.

The study area is a location with four (4) Sub-locations only: 200 sample questionnaires and 40 to cater for attrition totaling to 240 samples, a sample size proportionate to the number of households in each Sub-location was obtained by random sampling. However, during data cleaning only 201 samples were valid for analysis.

Table 1: Stratified Proportionate Random Sampling

Sub-Location	**Population**	**No. of Household**	**Area Km^2**	**Sample Size**
Musemwa	3,209	582	19.5	31
Vinyenya	4,012	771	10.1	40
Moi's Bridge	5,385	1,003	15.6	53
Matunda	9,589	2,210	10	116
Total	22,195	4,566	55.2	240

Source: CBS, (1999)

The research made use of non-probability sampling also referred to as purposive sampling and was used to select key informants for interview. These included extension staff in the location, village leaders and specific farmers who might have successfully practiced Agro forestry technologies on their farms. The procedure has the advantage of being easy to administer, is less costly and respondents are selected depending on their knowledge, experience, availability and relevance to the study.

3.7. Research Instruments

To effectively obtain data, questionnaires, and personal observations were used.

3.7.1. Questionnaires

This involved a standard semi-structured questionnaire that was used to collect data from the households. The questionnaire consisted of both open and closed ended questions based on research objectives. The questionnaire enhanced personal contact with respondents so that more information to survey could be realized. The Questionnaire gathered information on socio-economic and socio-cultural aspects within Nzoia Location.

3.7.2. Key Informants

The key informants included local men and women leaders who have influence in the community. They provided information on the planting of trees, use of trees and knowledge of Agro forestry technologies in the study area.

3.7.3. Observations

The researcher made observation in the study area. This approach was important in comparing the reported information with the actual occurrences in the study area. This was used to assess variables such as trees planted within the farm, species planted, estimation of farm size and type of Agro forestry technologies Adopted.

3.8 Data Analysis

Data was coded and processed to remove outliers' information and analyzed using Statistical Package for Social Sciences (SPSS Version 11.5). Both descriptive and analytical procedures were used. Correlation and regression analysis was used to analyze the relationship between farm

size and farm preparation methods and their influences on adoption of Agro forestry technologies. Descriptive analysis was used to analyze, common Agro forestry technologies, land tenure system, type of agricultural activity, traditional believes and taboos and major benefits of Agro forestry technology adoption.

Table 2: Variables used in MNL regression

Variable name	Description	Unit	Expected sign
Age	Age of household head	Years	
Farm size	Farm size in acres	Acres	
EDUC	Education level of household head	Years	
Sex	Gender of household head	1=M; 2=F	
AWARE	Awareness (extension services) on tree planting	1=Y; 2=N	
TITTLE	Possession of land title deed	1=Y; 2=N	
BELWOMEN	Believes on issues of tree planting and women	1=Y; 2=N	
TRACTLPR	Dummy for tractor land preparation	1=Y; 2=N	
OXENLPREP	Dummy for oxen land preparation	1=Y; 2=N	

To determine the factors that influence the adoption level, multinomial logistic regression model was used. This model was adopted due to: the nature of depended variables being discrete in nature, with three categories. The fact that the model estimates the probability or likelihood of a farmer falling in one of the adoption levels given the socio economic and cultural factors. The model being useful for situations in which you want to be able to classify subjects based on values of asset of predictor variables. This model is similar to logistic regression but it is more general because a dependent variable is not restricted to two categories. The probability of a given household being in one of the three levels of adoption given asset of explanatory variable is given by the expression below:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon_i$ ……(1)

Where β_0 =constant; $\beta_1 \ldots \beta_{13}$= estimated coefficients; Y=level of adoption; $X_1 - X_n$ are the explanatory variables and is the error term.

The following are the variables used in the Multinomial Logistic regression.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 General Discussions:

This chapter presents the results and general discussions on the findings. The results are presented in tables and figures and plates (photographs). The farmers were asked to respond to a set of questions on their characteristics that have an influence on the adoption of Agro forestry technologies. These included the age distribution of the farmers, marital status of farmer, education level, family sizes, their income levels, contacts with extension staff, land tenure, tree tenure rights, tradition believes and taboos and their farm preparation methods.

4.2 Number of farmers with different Agro forestry technologies

The following Agro forestry technologies are practiced by farmers in the study area: Woodlots, Tree planting on the homestead, Home gardens, Hedge planting and Boundary marking. Table 3 shows the percentage number of farmers practicing each of the technologies. Boundary marking and hedges were the most commonly practiced while woodlots have the least percentage of farmers. The results further indicate that farmers practice more than one form of Agro forestry technology resulting to the high overall percentage for each technology. The results also show that the adoption of Agro forestry technologies in the location was very high.

Table 3: Percentage number of farmers practicing different Agro forestry technologies

Agro forestry Technology	**Percentage No. of farmers**
Boundary marking	92.0
Hedges	81.6
Planting on Homesteads	76.6
Home garden	75.6
Wood lots	64.2

A comparison of the adoption levels in the 4 sub locations is shown in figure 4.

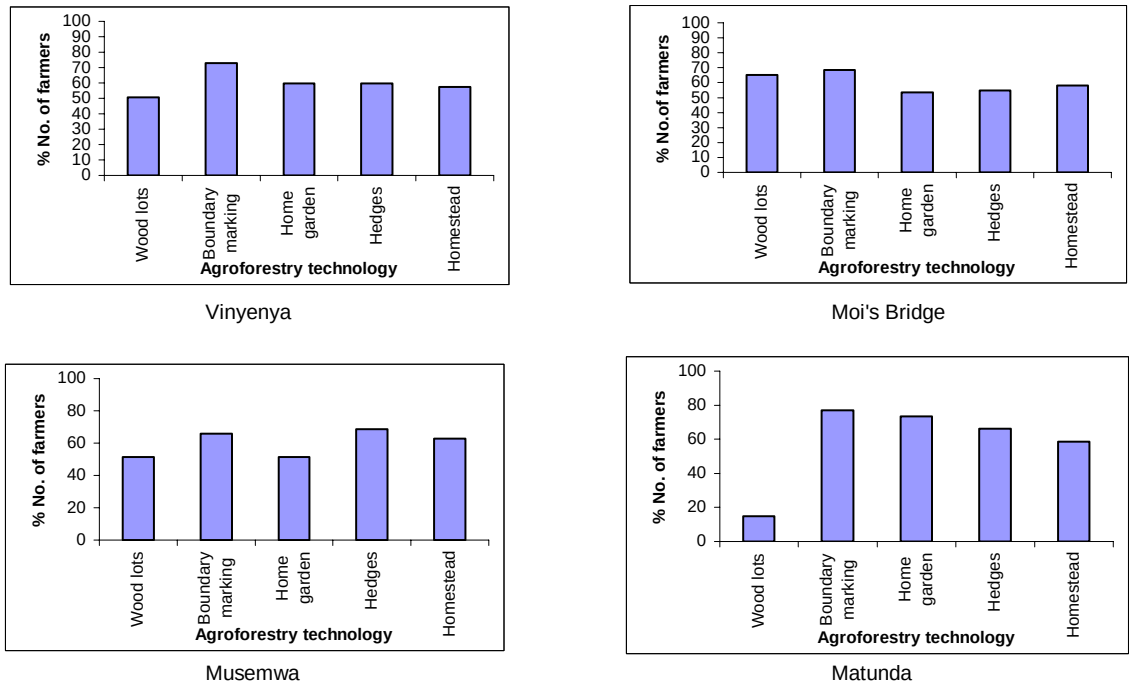

Figure 4: A comparison of adoption levels in the four sub locations

Boundary marking was highly ranked in all the 4 sub locations indicating its preference. It was characterized by planting trees a long boundary of two different farms (**Plate 1**). This technology was important for marking property rights and at the same time providing poles, timber, fuel wood and acting as windbreaks to reduce the effects of strong winds on ploughed fields and crops from being flattened. Most farmers also acknowledged the fact that it saves them the costs of buying barbed wires and poles for fencing off their farms. Tree species mostly observed for use in this technology included, *Grevillea robusta, Croton megalocarpus, Cupressus lusitanica* and *Acacia Spp.*

These results agrees with the findings of Tengnas (1994), who observed that in small scale farming areas, boundary planting reduces wind speed and that trees on boundaries which are regularly pollarded can meet most of a family's need for firewood while ensuring a properly

demarcated boundary. Here, *G. robusta* and *C. lusitanica* were common sources of firewood. Sharma (1995) indicated that farmers in most cases tend to accept multipurpose and fast growing tree species that yield benefits early rather than those that take long maturity periods. Lionberger (1960) explained this habit by stating that different farmers prefer different technologies based on farm size and the direct benefits to their well being. So farmers will also strive to adopt technologies that give them more benefits, boundary planting, provides poles, timber, fuel wood, marks property rights and protects farmer's crops against strong winds hence was highly adopted.

Plate 1: An integrated boundary planting of *Grivellea robusta* and *Agave sisalana*

Hedge technology was the second highest adopted technology by farmers in the study area. Like boundary marking, hedges are trees and shrubs planted in thick bushes around farms and mainly play the role of fences and aesthetics. The tree species that were found commonly used in this technology included: *Lantana camara, Dovyalis caffra, Cupressus lusistanica* and *Psidium guajava.* This technology also helps in soil erosion control, protection of cultivated fields against destruction and Fuel wood ICRAF (1992). They further noted that, in Murang'a District of Kenya, farmers planted trees on hedges for timber and as wind breakers, fuel wood and food.

Warner (1993) concurs that the most popular niches for trees is in or bordering on cropland, near homestead, in woodlots or on boundaries and that farmers manage for subsistence and commercial production of building materials (Poles and timber) fruits and fuel wood.

Plate 2: A hedge showing a well trimmed *Dovyalis caffra* live fence

Homestead planting technology was a common practice across the four sub-locations and third most adopted technology by the farmers. This technology involved planting of trees in the homestead which had a number of uses; providing shade, beauty, fruits, timber fuel wood and acting as windbreakers. The most common tree species under this technology included, *Mangifera. indica, Eriobotrya japonica, P. Americana, P. guajava* as fruit trees and *Spathodea campanulata, Markhamia lutea, Prunus africana, Terminalia mentalis, Pinus patula, Casuarina equisetifolia* and *Jacaranda mimosifolia,* for shade, timber, Fuel wood and herbal medicines.

However, some farmers pointed out that some species of trees are believed to bring bad omen in the home if planted. This is a habit that would discourage tree planting in the study area. The following cases were specifically pointed out.

*Spathodea campanulata (*Nandi flame): Is associated with causing death by attracting lightening especially when it flowers. Its red flowers are believed to attract lightening during the rain season and therefore not commonly favoured in homestead planting. *Terminalia mentalis* –Is an umbrella-layered tree and is believed to cause death to members of the family every time it makes an umbrella layer or when its roots reach the house.

*Ficus sycomorus (*fig tree) was planted as a ritual tree and was considered sacred for performing certain rituals like burial ceremony accorded an old man who had planted it in the home. It is only planted by men of a certain lineage in the family (mostly first born).

These limitations to tree planting identified in the study area agree with the findings of Gichuki and Njoroge (1989), who stated that certain traditional beliefs were a negative factor in adoption of Agro forestry practices. Also Kerkhof (1992) noted that in Western Kenya, there are distinct tree species for men and women. Women were not allowed to plant certain tree species and it was believed if she did she becomes barren. Ipara (1992), also noted in Western Kenya, certain tree species were associated with bad omen and were not allowed to be planted at all by community members, however, beneficial they could be.

Plate 3: *Mangifera indica*, *Persia americana*, and *Eryabotrya japonica* with cows under shade in a homestead

Home garden as an Agro forestry technology was adopted across all the four Sub-Locations. Home gardens involved mostly fruit trees integrated with fodder crops, vegetables, beans and even maize on small gardens near the homestead. Fruit trees included *Persia americana, Psidium guajava, Carica papaya and citrus spp.* Fodder tress included *Sesbania Sesban, Leucaena leucocephala, Calliandra calothyrsus, Mangifera indica,* bananas and Napier grass. Those farmers who had fodder crops and didn't own livestock confirmed that they sell to those with livestock and that there is a good market for such crops. These findings are also in line with Kerkhof (1990) who noted that farmers in Rwanda who planted and used *L. leucocephala* and *C. calothyrsus* for fodder in home gardens increased their milk production and dung for manure, which further led to improved crop production and household income.

Similar findings from the Chagga home gardens (Kerkhof, 1990) show that farmers were sufficient in fodder produced primarily from tree and shrubs. Studies by ICRAF (1992) in Western Kenya found that *S. Sesban* is inter planted with maize, beans and sorghum because it has light crown with minimal effects on Agricultural crops, is fast growing and produced firewood in about a year. This is also in line with the findings of Sharma (1995) who found out that farmers in most cases tend to accept multipurpose and fast growing tree species that yield benefits early rather than those with long maturity periods.

Plate 4: Home garden planted with *Persia americana*, *Carica papaya*, maize and bananas

Woodlot agro forestry technology though lowest ranked was adopted in all the four sub-locations in the study area (Table 3 and Figure 4). Woodlots comprise of sections of the farm set aside purposely for tree planting. Woodlots were most common (65% of all respondents) in Moi's Bridge sub location and least common in Matunda sub location. This may confirm that as farm size increases, preference for woodlots increase because farmers have the ability to set aside a portion of their land purposely for trees like in Mois Bridge sub location where farm sizes were relatively big compared to Matunda where farm sizes were small and woodlots were less common (Appendix IV farm holdings). Salam *et al*, (2000) found out that in Bangladesh, planting trees in the homestead increased with the amount of homestead land owned and farmers whose main source of income was non-agricultural were more likely to plant trees in their homestead for income generation including uses like fruits, poles and timber.

This technology was dominated by *Eucalyptus saligna, Acacia Mearnsii,* and *Grevillea robusta.* Results also showed that woodlots were mostly planted in poor (waste) land within the farm for rehabilitation of eroded areas. It was also valued for controlling soil erosion on sloping landscapes and along river banks. Important products from woodlots include timber, poles, fuel wood and as a source of household income. The results agree with Tengnas (1994) who noted that woodlots can be a source of high level wood production for domestic or cash income, a good way of making savings and those woodlots can meet most domestic needs of poles, timber, and firewood.

The forest Act number 7 of 2005 and EMCA 1999, both encourage the planting of trees and woodlots by individual land owners, Institutions and by community groups. Such policies will go along way promoting on farm woodlot development for sustainable land use management and increased economic gains to farmers accruing from such Agro forestry technologies.

Plate 5: A young woodlot of *Eucalypyus saligna* with species of *Markhamia lutea*

4.3. Factors Influencing Adoption of Agro-Forestry Technologies

Farmers were compared as low, moderate and high adopters depending on the frequency of occurrence of the various Agro forestry technologies in their farms. The indicators for Agro forestry adoption were woodlots, boundary planting, home gardens, hedge planting and homestead planting. Six (6) points were awarded for best performers and zero(0) for non adopters for each technology noted. All the points were aggregated and adoption level allocated to the farmers depending on the number of total points scored. Each farmer was allocated to one of the three levels of adoption namely Low adopter (0 – 10 points), Moderate adopters (11 – 20 points) and High adopters (21 – 30 points).

The number of farmers in each category is given in figure 5. The results show that adoption rate in the study area is high with most of the farmers interviewed classified as high adopters. It shows that farmers have integrated a variety of Agro forestry technologies in their farms which can be classified as very good. Musemwa and Matunda sub locations had the biggest number of high adopters and at the same time happened to have smaller farm sizes while Moi's Bridge with average big farm sizes had the lowest adoption levels (Appendix IV, farm holdings), this means that farmers with small farm sizes tend to diversify farm production to meet household needs more than big farm holders. Moi's bridge had a few low adopters (6.2%), this can be attributed to

existence of large farms of maize where mechanized farming is used in land preparation. Mechanized farming was noted to have a negative correlation on Agro forestry (Nair, 1990).

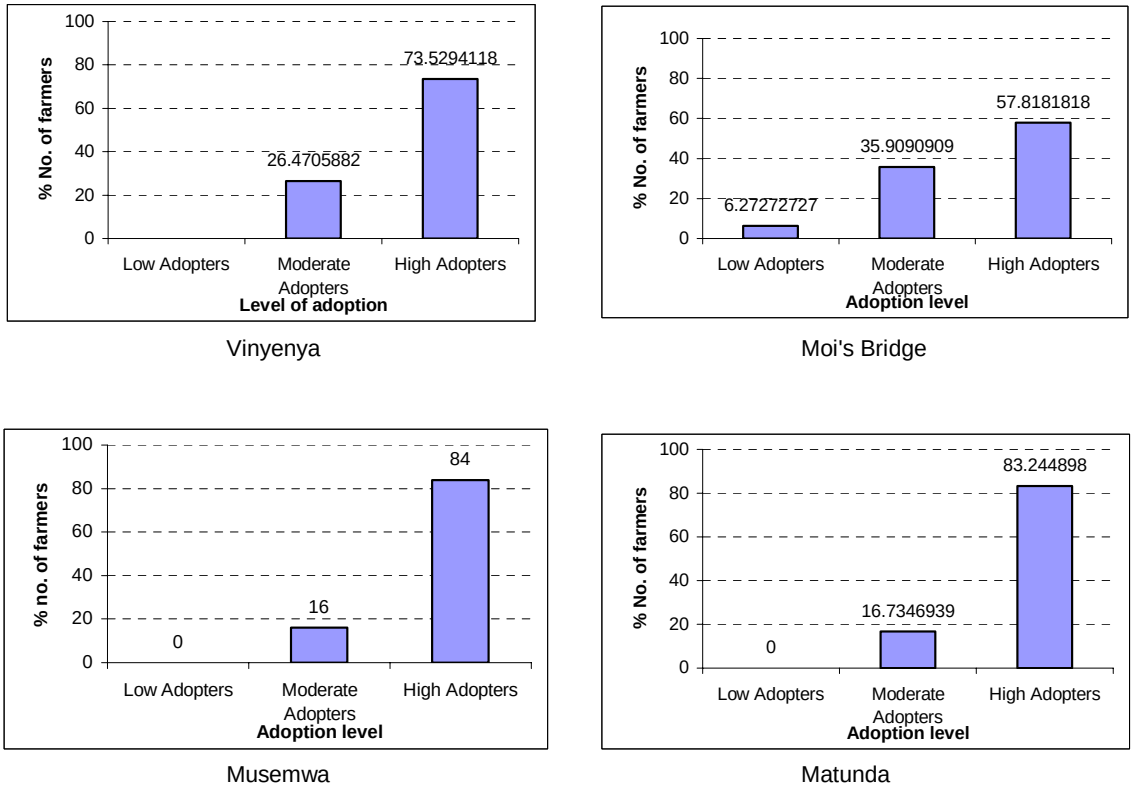

Figure 5: Level of Adoption for Agro forestry Practices by Sub Location

4.4 Likelihood Ratio Test for Factors Influencing Adoption Level

The likelihood ration test shows the contribution of each variable to model. The variables with significant influence to the model (P< 0.05), were sex, ownership of title deed, farm size and land preparation method (Table 4).

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. It therefore follows that Age (with P> 0.05 at = 0.812), Awareness (at P = 0.402 more than P< 0.05), Traditional beliefs and Taboos (at

P = < 0.126 more than P < 0.05) and Education level (at P = 0.961 more than P< 0.05) had no influence on Agro forestry technology adoption.

Table 4: Likelihood Ratio Test for factors influencing Agro forestry technology Adoption

Effect	**-2 Log Likelihood of Reduced Model**	**Chi-Square**	**df**	**Sig.**
Intercept	304.442(a)	.000	0	.
AGE	304.858	.416	2	.812
FARMSIZE	305.247	.805	2	.019*
EDUC	304.521	.079	2	.961
SEX	313.626	9.185	2	.010*
AWARE	306.265	1.823	2	.402
TITTLE	306.821	2.380	2	.044*
BELWOMEN	308.580	4.139	2	.126
FARMPRPMD1	310.058	5.617	4	.020*

* Significant difference (P<0.05)

Majority of the respondents were aged below 50 years (73.3%) out of which 18% were less than 30 years. Only 26.8% of the respondents were aged above 51 years. The majority of the farmers (73.3%) were of a prime age considered to be very productive in farm activities. However, age was found not significant in influencing Agro forestry technology adoption (P > 0.05), P = 0.812 in this study. This is in line with the findings of Ndeima (2002) and Waswa (2000) who found out that there was no relationship between age and technology adoption. However, Aboud (1997) found out that farmers adopted agro forestry technologies to varying degrees according to Age. Also Ragland and Lal (1993), found out that the age of a household head significantly influenced the adoption of vegetative contour strips.

The results may imply that young people in the area are involved in formal employment and business activities that supplement household income than on farm tree production. This is also

the age where one is energetic enough and wants to make more money from other ventures that one realizes quick returns unlike trees that take long to give tangible returns.

On the issue of awareness, majority of the respondents (75%) said that the extension staff had not visited them at all. 23.4% said were rarely visited and only 1% acknowledged having been visited yearly. Therefore awareness had no significance ($P > 0.05$ at $P = 0.402$) contribution to adoption of Agro forestry technology in the area. The high adoption level in this location despite the poor extension services has to do with the area being in former white settlers (settlement scheme established in 1966) and the need by farmers to be self sufficient in wood and their products. This is in agreement with the findings of Ragland and Lal (1993), who found that the frequency of extension contact with farmers was not significant to the adoption of Agro forestry technologies. Chitere (1985) in a study to establish the extent to which farmers adopt recommended practices found that nearly all farmers in areas previously occupied by European Settlers were knowledgeable about improved farming practices.

The farmers level of education was as follows, 54% had no education at all, 5% had gone up to primary level, 16% secondary level of education, 11% had gone up to college level and those with University level were 14%. This variable was found not significant in the adoption of Agro forestry technologies in the study area ($P > 0.05$, at $P = 0.961$). Misiko (1976) noted that, level of education as a socio-economic factor in the adoption of Agro forestry development and production system has been controversial and further noted that the relationship between a farmers level of education and farm practices is indirect except where persons learn new practices otherwise education prompts them to prefer better and well paying jobs at the expense of their farms. This is further supported by Ragland and Lal (1993), they noted that education enhances ones ability to receive and understand information but affects adoption behaviour. However, Amudavi (1993), Chitere and Dourve (1985), and Ndiema (2002) in their respective studies found that education was a significant factor in facilitating awareness and adoption of agricultural technologies.

Majority of the farmers (52.7%) denied they harbor traditional believes and taboos concerning tree planting and use to discriminate women. They noted that women were their partners in the

management of household affairs and could not afford to discriminate against them. 46.3% believed women should not plant trees, should not utilize certain tree species and should not own land. However, this variable was found not significant in influencing agro forestry technologies in Nzoia location (table 6, Sig. 0.126 more than 0.05 confidence level).This was due to the fact that times have changed and even women are inheriting land in their families (from 52.7% of respondents and personal observation). In traditional Luhya customs, planting a tree, defined property right and ownership and men then, believed that women were married to bear children and not to inherit land. Land inheritance and succession rights were only vested in the sons, but this is slowly changing and all the children are being treated equally. Women in most cases assume the duties of laborers on the farm, weeding food crops, looking after livestock, fetching firewood, water, nurturing trees and so appreciating them is paramount. Women are mostly residents on the farm and therefore adoption of agro forestry technologies very much depends on the extent at which they are involved. This explains why adoption in the study area is high. The factors that were found to significantly influence adoption of Agro forestry technologies were analyzed further.

4.5 Farm Size

The relationship between farm size and adoption of Agro forestry technology was best explained by a linear function $y = -3.5749x + 96.449$ ($R^2 = 0.9444$) indicating that as farm size increases, the level of adoption of an Agro forestry technology decreases (Figure 6). The results explain that farmers with smaller pieces of land opt to practice Agro forestry more than those with bigger chunks of land. The farmers with smaller pieces of land had a variety of Agro forestry technologies on their farms.

Many (90%) of the respondents had farm sizes less than 6 Acres and only a small number (10%) of the respondents had farm sizes between 6 and 15 acres (Appendix IV: farm holdings). However, there was significant relation between farm sizes and Agro forestry technology adoption ($P > 0.05$) $P = 0.019$ (Table 6) among the respondents. Agro forestry technology adoption significantly depended on farm sizes. Respondents had acknowledged that farm sizes were small, yet the adoption level was high with moderate and high adopters making up 86.8%

of the respondents (Appendix IV, level of adoption). This means that small farm sizes are not a constraint to production and that farmers understood the need for being self sufficient in wood and wood products. They pointed out the rising cost of fuel wood and poles being a driving force in their adoption of agro forestry technologies.

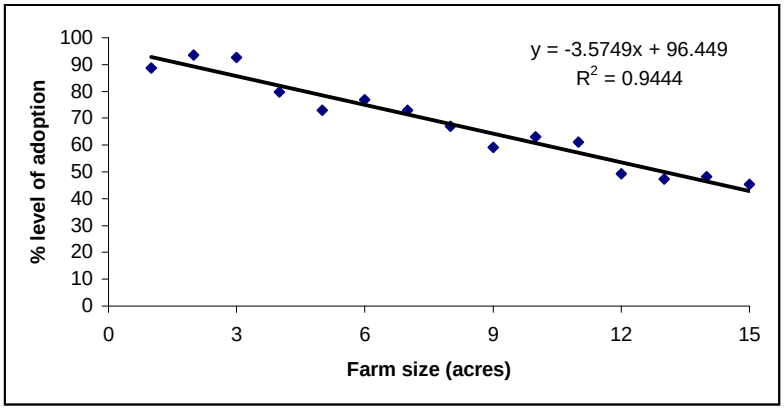

Figure 6: The negative correlation between farm size and adoption level

Therefore, Farmers here have incorporated tree farming in order to maximize returns from their otherwise small parcels of land to meet the ever increasing demand for wood. This concurs with the finding by, Chitere (1985), who found out that in Central Kenya, adoption of on-farm tree planting was influenced by land size. Similarly, farm size is an important factor in the adoption of Agro forestry practices in Western Kenya (Kimwe and Noordin, 1994). Nyangi (1999) argues that as population increases leading to fragmentation of land, so does the rise in tree cover on farms. So farm size is not a constraint to Agro forestry technology adoption in Nzoia location and because of small farm sizes, farmers have adopted agro forestry technologies as a means of diversifying household income for food security and self sufficiency in wood and wood products. As farm sizes become small and smaller, cultivation by farmers becomes intensive in order to meet family food requirements and therefore the realization by farmers to plant trees in their farms conserves the would have exhausted soils for improved farm production and environmental conservation.

4.6 Sex (Gender) of Household Head

The sex of a household head is important in the sense that most decisions are made by the head. Majority of the respondents 118 (59%) were male heads of household and only 83 (41%) were women who mostly stood in for their husbands who were away working in towns or those who were widows. In this study sex was found to significantly influence Agro forestry adoption $P<0.05$ at 0.010 (Table 4). Figure 7 further illustrates this.

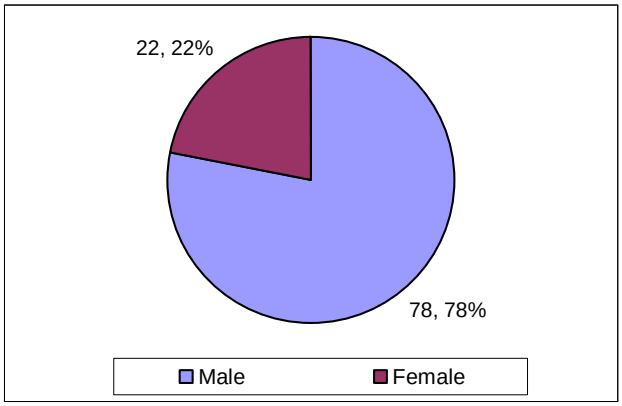

Figure 7: The percentage of decision makers in farms classified as high adopters

In most African culture and Luhya culture in particular, a man is a head of a household and most decisions affecting the household are made by him. Although Ragland and Lal (1993), found gender not to have influence on the adoption of Agro forestry technologies, studies done elsewhere confirms that gender does influence adoption. What this means is that the outcome vary from one community to another. Ipara (1992); noted that tree planting decisions in many communities is a domain of the male head of a household. However, studies by Kamumu (1998), observed that gender might not be a factor in the adoption of entire innovation but a factor in the adoption of specific technologies. Labour for tree tending was mainly provided by the children (63%). Whole family members being involved in tree tending (16%), wives provide (14%), both wife and husband (5%) and husband who tend tree only (2%). Most respondents attributed their low adoption rates to shortage of farm labour. They utilize children in the family during holidays and weekends to provide farm labour but once schools resume, then labour becomes scarce. A study done elsewhere confirms this. Kerkhof (1990) and Aboud (1997) in their respective studies found that labour shortage tends to discriminate against categories of farmers

and that when tree production requires a high input of labour, farmers tend to resist. Farmers prefer small gradual changes in farming methods that are not labour intensive. The Chiefs interviewed also noted that farm labour was a hindrance to locals attending barazas whenever they are called and this denies them important information on farm management and tree husbandry.

Table 5: Percentage contribution of family members in tending trees

Tree Tending	**Percent contribution**
Wife	14.0
Children	63.0
Both wife and husband	5.0
Husband	2.0
Whole family	16.0
N = 201	100

4.7 Land tenure

This variable was found to be a significant factor in Agro forestry technology adoption in Nzoia Location ($P < 0.05$ at 0.044) (Table 4). Land tenure refers to the possession or holding of the rights to the use of land. Agro forestry production systems that involve local farmers will directly be related to the flexibility of the land tenure system. Secure tenure provides for proper incentives for farmers to make investments in the long-term productivity of their land. Only 5% of respondents recorded in high adoption farms were living on other people's land. They were either renting or were guarding the land on behalf of relatives. The other 95% of high adopters were living on their own land. With the ownership of a title deed the farmer is assured of the trees he/she plants on that particular piece of land. The study by Tengnas (1994), found out that in Kenya most farmers find it unacceptable and unattractive to invest in tree production on land that is not legally theirs. This is also supported by Busienei (1991), who found out that the low participation in Agro forestry activities in Ainabkoi Division of Uasin Gishu District was due to lack of title deeds. A farmer's ownership of land with all due legal rights that include title deed

is important to a farmer's investment on the farm since he/she knows that whatever is invested on such land is fully owned. This factor also explains why moderate and high adopters were significant in the study area.

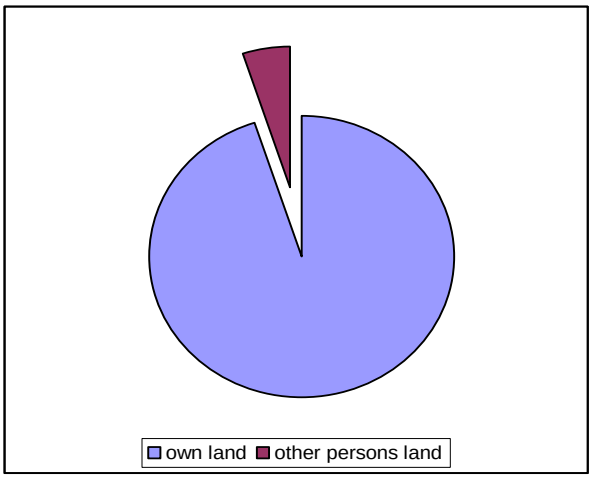

Figure 8: The percentage of high adopter with tenure rights

The majority of farmers (71%) interviewed gave sources of their seedlings as buying from private nurseries, 26.9% get from their own on-farm nurseries and only 2% borrow from friends.

Table 6: Sources of seedlings for tree planting

Source	Percent respondents
From on-farm nurseries	26.9
Bought from private nurseries	71.0
Borrow from friends	2.0
Total (n=201)	100

They decried the high cost of buying the tree seedlings and want the nurseries by forest department (now forest service) to be revived and given to farmers free or at a small cost to promote on-farm tree production. The results show the willingness of farmers to plant trees despite the fact that these seedlings may have to be bought. These findings illustrate a great need by farmers of the study area to plant trees.

4.8 Farm preparation methods

Adoption of Agro forestry technologies differed with farm preparation methods. Farmers with large farms and using mechanized farming had lower adoption levels as compared with those using manual land preparation methods. This best explains why there were high adoption levels in Matunda sub location as opposed to Mois bridge sub location where farms are relatively big and allows mechanized farming (Appendix IV, Farm holdings). Since farming methods were always analyzed by farm size, Figure 9 shows how the increase in farm size decreased Agro forestry adoption level.

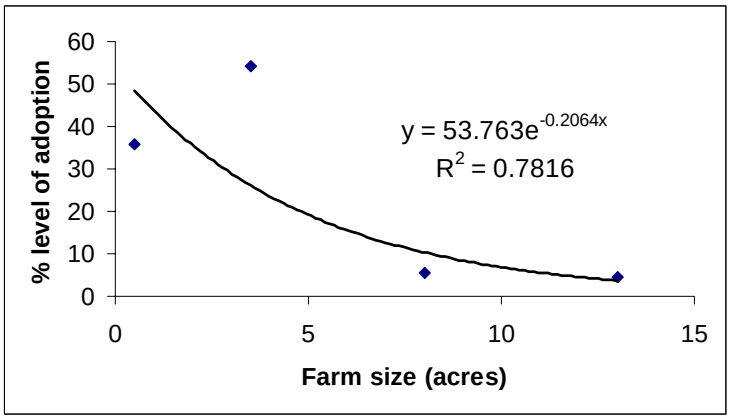

Figure 9: Level of agroforestry technology adoption and farm size

Mechanized ploughing needs less tree populations and especially for tractors, which need movement space hence farmers with relatively large farms and using tractors in the study area were found to be low adopters of agro forestry technologies. In Kenya, the usefulness of trees has always conflicted with need for Agricultural land (ILEG, 2004).

4.9 Uses of Trees and their Products

The results (Table 7) show that firewood is the most common reason why farmers practice Agro forestry technologies. In this rural setting where forests are far from the farms, the farmers have no alternative sources of firewood but to plant the trees in the farms. In Kenya, 70% of domestic energy supply is met by wood fuel (Energy Alternatives Africa, March 2003). Kinyanjui (2007)

found out that farmers in Kenya are quick in adopting new technologies that provide them with basic facilities like fuel wood and with the diminishing forest cover (DRSRS and KFWG, 2006) such a response by farmers is highly appreciated.

Table 7: Uses for the trees identified in the study area

Use of trees	Frequency of observation
Firewood	97
Boundary marks	77
Food/Fruits	48
Timber	33
Wind breaks	32
Poles	28
Live fence	25
fodder for animals	25
Soil conservation	25
Shade	23
Aesthetic	22
Herbal medicine	15
Total	450

In the same regard, farmers have maximized the use of trees as boundary marks because besides the variety of uses that the trees have, live fences marked by huge trees are a more permanent boundary mark than the metallic beacons and can be pollarded to provide the much needed fire wood.

Kenya is a developing country and therefore the cost of alternative energy sources in the rural areas is costly. For example Kerosene was retailing at Kshs. 82.00 per litre during the study period, which is hardly enough for lighting in a week and this drives those who cannot afford into using unhealthy energy alternatives like the one in Plate 6 above. In Kenya, 70% of domestic energy supply is met by wood fuel (Energy Alternatives Africa, March 2003). This shows how heavily dependent on fuel wood the rural folks are and Nzoia Location was not exceptional. This may explain the high response among the farmers citing firewood as the reason for planting trees on the farms. Since the trees on-farm are readily available for use as fuel wood

and the farmer incurs no costs at a time of cutting a tree for fuel wood, the technology should be encouraged in uplifting the livelihoods of the communities living in the study area.

Plate 6: Charcoal brickets made from cow dung used as fuel for cooking

This is also supported by the fact that many farmers in the study area confirmed they sell trees for fuel wood to commercial fuel wood agents (plate 7) and this brings them income to pay fees and meet other household needs during times of scarcity.

Farmers in the study area also plant trees as a source of food. With the rising poverty levels and food insecurity in Kenya (MFP, 2000), farmers have adopted this technology to improve food security and enhance their living standards. This is also advocated in the millennium development goal number one (to eradicate extreme poverty and hunger).

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Plate 7: A commercial firewood vendor splitting firewood ready for the market

Promotion of Agro forestry technologies that are geared toward farm food diversification should be encouraged by improving marketing and rural road infrastructure to help farmers access markets for their farm produce. These will reduce rural poverty and enhance food security.

The same could be the reason for farmers who have planted trees for medicinal purposes. Kinyanjui (2007) found out that planting of trees for medicinal purposes is on the rise among forest adjacent communities of Kenya and cited cases in which commercial exploitation of *Mondia whyitei* and *P. Africana* (plate 8) products are ongoing. Given that the cost of conventional medicine is expensive and only a few people can afford, it becomes important to promote planting and use of medicinal plants in the area as already adopted by farmers. Table 8 shows the common tree species used for treatment of specific ailments in the study area. The farmers acknowledged the importance of fodder crops. They noted that their farms were small and could not afford large herds of livestock due to small grazing areas. They have planted fodder crops and kept only one or two dairy cows for family milk and income. In addition, farmers noted that despite not owning any livestock, they planted fodder crops since there was ready market from those who kept dairy animals.

Plate 8: *Persia Americana* tree with healthy fruits

The fodder crops and shrubs included, *L. leucocephala* and *C. calothysus,* planted in home gardens and Napier grass and *S. sesban* planted as vegetative strips to control soil erosion. They also provided green manure and firewood.

Table 8: Medicinal Trees and Ailment Treated

Species Name	Local name Luhya	Treatment
Prunus africana	Mwiritsa	Bark boiled, used for prostrate glands treatment (non malignant swellings) Leaves boiled, used for non symptomic fevers and malaria
Kigelia africana	Morabe	Bark is boiled and used to treat high blood pressure Fruit used to treat external rushes and measles
Erythrina abyssinica	Murembe	Believed to treat mumps, one runs to and from the tree very early in the morning before others wake up. The bark is boiled and liquid used to treat indigestion Leaves treat ulcers
Terminalia browni	Omulaa	Roots are boiled and liquid used for treatment of malaria and yellow fever

These findings also agree with the findings of ICRAF (1992) in Nambale division of Busia District, where farmers were planting *S. sesban* on terraces to control soil erosion, provide fuel wood and green manure.

Plate 9: S*esbania sesban* trees planted along the hedge of maize field

This is also supported by the findings of Kerkhof (1990) during a research in Rwanda (Nyabisindu), who found out that farmers noted the planting and use of *L. leucocephala* and *C. calothysus* for fodder increased their milk production and dung for manure leading to improved crop production and household income.

Figure 10: A boy cutting a banana stem used as fodder for cattle

The findings by ICRAF (1992) and GEF (2002), noted that under Agro forestry practices trees contribute a wide range of products and services. They provide food, shelter, energy, medicine, and cash income, raw materials for craft, fodder and forage. Before the inception of conventional medicines, herbal medicine was used for treatment of livestock and human and the information was passed from generation to generation.

Other uses of trees that farmers have in the study area included soil conservation, aesthetic value, construction poles, shade and windbreaks. In general the high uptake of Agro forestry technologies in the area can be attributed to being in former white settler farms where farmers inherited best farming methods that promoted soil conservation practices for improved crop yields. Land tenure regime which translates into tree tenure must have also played a significant role in the improved adoption rate in the study area. This is supported by Chitere (1985), who in a study to establish the extent to which farmers adopted recommended practices, found that nearly all farmers in areas previously occupied by European settlers were knowledgeable about improved farming practices. All these uses have been identified in the study area and only need to be studied further to find the specific profitability of each technology.

4.10 Constraint to Agro forestry production in Nzoia location

Some of the problems highlighted by farmers in the study area relating to Agro forestry adoption included cost of buying seedlings 24.4%, farm labour 27.4%, Extension services 25.9% and Traditional believes 21.9% (Appendix IV, constraints to tree planting in Agro forestry systems). Given the high adoption rate in this area despite high cost of buying seedlings and limited Extension services, shows that farmers understood the importance of trees and their products and willing to plant trees at whatever cost. Also since they owned title deeds, gave them the confidence of utilizing their farms to their best production levels. Extension services are poor and only 24.4% of the farmers acknowledged having come in contact with the extension staff (Appendix IV, visits by extension staff). However, extension staff in the division cited a problem of inadequate funding from the Government to facilitate them reach the farmers. The Government on its part should allocate adequate funding to the field staff to promote extension services and come up with mechanisms to subsidize cost of seedlings to farmers.

Farmers also pointed out that, farm labour was a constraint. Farm labour is required in planting and watering of seedlings and so most farmers when overwhelmed with other farm chore activities fail to water planted seedlings leaving them to whither. This fact was also cited by the chiefs as a reason behind most farmers not attending barazas where important information on tree planting is disseminated.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The major aim of the study was to investigate the adoption of agroforestry technologies in Nzoia location. The research study concluded that:

Agro forestry technology adoption in the study area is high. There are a variety of Agro forestry technologies that have been adopted.

The major factors influencing agroforestry adoption in the area were sex, land tenure, farm size and farm preparation method.

The agroforestry technologies practiced in Nzoia location have many benefits including control of soil erosion, boundary marking, wood fuel energy provision, fodder provision and food provision

5.2 Recommendations

The recommendations from the study include

i. There is a need to further study the specific economic benefits that the farmers get from each of the Agro forestry technology adopted.

ii. Since farmers already know and understand the uses of Agro forestry tree species in the area, need to be supported in the provision of free seedlings and extension services to further improve on their wellbeing.

iii. The Government should promote the extension services by allocating sufficient funds to facilitate extension staff to reach farmers frequently to teach new ideas in Agro forestry.

6.0 REFERENCES

Aboud, A.A. (1992). Population pressure, Environmental Degradation and farmers' Adaptive Strategies in Nakuru District of Kenya, Unpublished PhD, thesis, University of Illinois at Urbana – Champaign, 1992, Urbana, Illinois.

Aboud, A.A. (1997). Relevance of the Novel Development Paradigms in Environmental Conservation:" Evidence of Njoro Farmers, Kenya, Egerton University, Njoro, Kenya.

Adeyoju, S.K. (1984). Some Tenural and Legal Aspects of Agro forestry in Socio Economic and Institutional Aspects of Agro forestry. United Nations University, Tokyo, Japan.

Amudavi, M.A. (1993). Influence of Soil Eco-nomic Factors on Adoption of Maize Related Tech-nologies: The case of Smallholder Farmers in Hamisi, Kakamega district. (Unpublished MSc Thesis). Melbourne: University of Melbourne.

Binswanger, H.P. (1980). Attitudes Towards Risk: Experimental Measurement in Rural India American Journal of Agricultural Economics Vol. 1, Saybrook Press Inc. Chigago, U.S.A.

Bradley, Phillip N. (1991). Wood fuel, women and woodlots. The Foundations of a wood fuel Development strategy for East Africa. Macmillan Education Limited, London and Basingstoker.

Busienei, R.J.K. (1991). The Potential of Woment's Participation in Agro frestry in Ainabkoi Division, Uasin Gishu. M. PHIL Thesis (Unpublished). Moi University, Eldoret, Kenya.

Castro, A.P. (1993). Property Regimes and Institutional Arrangements. Concepts and their Relevance in Managing the Village. *Indian Journal of Agricultural Economics*. **48 (3)**: 557-565.

Central Bureau of Statistics (CBS). (1999). Kenya National Population and Housing Census.

Chitere, P.A. (1985). Agro frestry Plots for Rural Kenya Project. Socio-Economic Survey Report. Mazingira Institute, Nairobi, Kenya.

Coxhead, Rola, A., and Kim, K. (2001). How do Natural markets and price policies affect land use at the forest margin? Evidence from the Phillipines. *Journal of Land economics*. **77 (2)**: 250 – 257.

Department of Resource Surveys and Remote Sensing (DRSRS) and Kenya Forests Working Group (KFWG) (2006). *Changes in Forest Cover in Kenya's Five Water Towers*. 2003-2005. East African wildlife society 45 pp.

Diamond, N.K. (1992). Trees for the poorest Equity and Agroforestry Extension in South West Kenya. PhD dissertation, Department of wildland Resource Science, University of Califonia, Berkdey, CA

Fernandes, E.C.M., Oktingati, A. and Maghembe, J. (1984). The Chagga home gardens. ICRAF, Nairobi, Kenya.

Fischer, R. J. (1995). Collaborative Management of Forests for Conservation and Development: The International Union for the Conservation of Nature (IUCN) and The World wide Fund for Nature.

Food and Agricultural Organization of the United Nations. (2001). Governance principles for Concessions and Contracts in Public Forest Rome, Italy.

Food and Agriculture Organization of the United Nations. (1989). Forestry and Food Security, FAO Forestry Paper No. 90 FAO. Rome, Italy.

Fraenkel, J.R. and Wallen, N.E. (2000). How to Design and Evaluate Research in education, New York: N.Y: MCGraw – Hill Publishing Co.

Gichuki, J.J.and Njoroge, S.N.J. (1989). Socio-economic Aspects in Agro forestry. Permanent Presidential Commission on Soil Conservation and Afforestation, Nairobi, Kenya.

Global Environment Facility. (2002). The Challenge of Sustainability, Washington, D.C. U.S.A.

Global Environment Facility. (2005). What Kind of World? The Challenge of Land Degradation. Washington, D.C. U.S.A.

Gradwohl, J.and Greenberge, R. (1990). Saving the Tropical Forest. Earth Scan Publications. London, UK.

Institute for Law and Environmental Governance. (2004). Community Guide to Environmental Management in Kenya. Kingston House, Flat 4, Ngong Road, Nairobi, Kenya.

International Centre for Research in Agro forestry. (1992). A Selection of Useful Trees and Shrubs for Kenya. ICRAF, Nairobi, Kenya.

Ipara, H.I. (1992). Socio-economic Factors Affecting the Particiaption of women in Agrofrestry Activities in Sabatia Division in Vihiga, Kenya. M. phil, Thesis (Unpublished) Moi University, Eldoret, Kenya.

Kerkhof, P. (1990). Agrofrestry in Africa, A survey of project experience. Jolly and Barber Ltd. Rugby, Great Britain.

Kerkhof, P. (1992). Agorfrestry in Africa: A survey of project experience, Ipara Publication Ltd. Nairobi, Kenya.

Kijkar, S. (1993). Pines for Watershed Reforastation in Thailand. Journal of Malaysian Forester. 1993.56 (1-2), 43 – 48.

Kimwe, S. and Noordin, Q. (1994). Planting Sites and Configuration; Agroforestry Field Manual, KWAP and ETC. Nairobi, Kenya.

Kinyanjui, J.M. (2007). The readiness of community forest associations to take up Participatory Forest Management. *Proceedings of the 1st National Conference on Participatory Forest Management*. June 6th-8th. KEFRI, Kenya.

Kio, P.R., and Abu, J.E. (1994). Environmental Accounting and Mechanism for Reconciling Land Use Pressure on Forests. Malaysia Forester Journal. 1994.**57** (1-4) 40 – 52.

Leakey, L.S.B. (1977). The Southern Kikuyu before 1903. Vol.1. Academic press New York.

Lelo, F.K. (1994). Humanization of Wildlife Management: A case study of Ol Donyo Sabuk National Park, Kenya. Unpublished PhD Dissertation. Clerk University, Massachusettes, U.S.A.

Lionberger, F.H. (1960). Adoption of New Ideas and Practices. Iowa State University Press, Lowa, U.S.A.

Ludeki, J.V. Wamukoya, G.M. and Walubengo, D. (2004). Environmental Management in Kenya: A Guide to the Draft Forest Policy, 2004, Forest Action Network, Nairobi, Kenya.

Makindi, S.M. (2002). Issues in the Adoption of Social Forestry: The case of Kitui Farmers in Kenya. Unpublished MSc. Thesis, Egerton University Njoro, Kenya

Masese, R. (2004). Indigenous Mechanisms in conflict Management. The case of Arabuko Sokoke Forest and Shimba Hills National Forest Reserves. Forest Action Network, Nairobi, Kenya.

Ministry of Finance and Planning (2000). Poverty in Kenya Volume I: Incidence and Depth of Poverty in Kenya. Nairobi.

Misiko, P. (1976). Incentives and Disincentives Influencing Farmer Adoption of Agricultural Innovations. A case Study of Bungoma District, Kenya. PhD. Thesis, Cornell University, U.S.A.

Mutoro, B.A. (1997). Woman working wonders: Small Scale Farming and the Role of Women in Vihiga District, Kenya. A Case Study of North Maragoli Thesis Publishers, Amsterdam, Netherlands.

Nair, P.K. (1990). The Prospects for Agroforestry in the Tropics. World Bank Technical Paper No131.

National Academy of Sciences. (1980). Firewood Crops, Shrubs and Tree Species for Energy Production, Washington DC, USA.

National Environment Management Authority. (2004). State of Environment Report. NEMA, Kenya.

Ndiema, A.C. (2002). Factors Affection the adoption of selected wheat (*Triticum aestivum*) production technologies by farmers in Njoro and Rongai divisions of Nakuru district Kenya, unpublished Msc thesis, Egerton University, Kenya

Noordin, Q. (1996). Community Participation in Agroforestry Development and Extension: The Experience of the Kenya Woodfuel and Agroforestry Programme (KWAP), Busia, Kenya.

Nyamweru, C. (1998). Sacred Groves and Environmental Conservation. Saint Lawrence University, Canon New York.

Nyangi, F.O. (1999). Household Energy demand and Environmental Management in Kenya. Thesis University of Amsterdam. Netherlands.

Nyerere, J. (1988). The Role of Women in Development. In Environment in the Developing World. UNEP Nairobi, Kenya.

Ong'ayo, M. (1993). Manual for Training Field Extension Workers: Extension Methods. Moto Mwaka, KWAP and ETC. Nairobi, Kenya.

Ongugo, P.O. (1992). Social-cultural Issues in Social Forestry. KEFRI, Nairobi, Kenya.

Panayotou, T. (1993). Green Markets; The economics of Sustainable Development, International Centre for Economic Growth, San Francisco.

Ragland, J. and Lal, R. (1993). Technologies for Sustainable Agriculture in the Tropics. American Society of Agronomy. Winsconsin, U.S.A

Rees, D.G. (1995). Essential Statistics (Third Edition). Chapman and Hall, New York.

Republic of Kenya. (1999). Environmental Management and Co-ordination Act (EMCA). Government Press, Nairobi, Kenya.

Republic of Kenya. (2002). Lugari District(2002– 2008) Development Plan Government Press, Nairobi Kenya.

Republic of Kenya. (2005). Forest Act. Government Press, Nairobi Kenya.

Salam, M.A., Noguchi, T. Koike, M. (2000). Understanding why farmers plant trees in their homestead, Agroforestry in Bangladeshi.Journal of Agroforestry Systems. **50(1)**. 77 – 93.

Scherrs, S. (1995). Economic Factors in Farmer Adoption of Agroforestry. Patterns Observed in Western Kenya. World Development, Vol. 23. Elsevier Science Ltd. Great Britain.

Sharma, P. (1988). Research Methods in Education, Macmillan Publishers. London, UK.

Shiverly, Gerald, E. (1999). Prices and Tree Planting on Hillside Farms in Palawan. In World Development Journal **(6)** 337 – 349.

Tengnas, B. (1994). Agroforestry Extension Manual for Kenya. ICRAF, Nairobi, Kenya.

Warner, K. (1993). Patterns of farmer tree growing in eastern Africa: a socioeconomic analysis. Oxford Forestry Institute and International Centre for Research in Agroforestry, Oxford, 270 p.

Waswa, S.I. (2000). Factors Related to Adoption of selected Agroforestry Technologies by Small Scale Farmers as a Response to Environmental Degradation: The case of Rongai and Njoro Divisions of Nakuru District. Unpublished MSc. Thesis. Egerton University Njoro Kenya.

World Bank. (1992). Managing the World Forests. Kendall/Hunt Publishing Company. Washington DC, U.S.A.

Young, A. (1989). Agroforestry for Soil Conservation. ICRAF. Nairobi, Kenya.

APPENDIX

Appendix I: Questionnaire for Farmers

Socio-economic and cultural Factors Influencing Agro forestry Technologies in Nzoia Location, Likuyani Division, Lugari District (These questions are for research only and not for any other purpose. Your cooperation in answering questions will be highly appreciated).

Sub-location …… village…….. Date of visit ……...

Interviewee's Name ……

Sex …… (1) Male (2) Female, Age ……...

Marital Status:

Marital status: (1) Married, (2) Single, (3) Widowed/widowered,

(4) Divorced/ separated.

Does this status affect your tree-planting activities? (1) Yes (2) No

If yes, explain ……..

……..

……..

Family Size:

What is the total number of people in your family?

2, (2) 3 and 4, (3) 5 and 6, (4) 7, (5) 8 and more

Does your family size affect your tree planting options: (1) No (2) Yes

If yes, how …….

……

What is your total annual income from the farm produce? (1) <10,000 (2) > 100,000 (3) More that one million (1M)

How much do you realize annually from the sell of trees and tree products?

Education and Occupation:

Education level – (1) None (2) Primary level, (3) Secondary level, (4) College (5) University level

Has this been useful in your tree-planting activities (1) Yes (2) No

If yes, how? …….

……..

If no, why? ……..

…….

Occupation? (1) Employed (2) Farmer (3) Civil Servant/Teacher (4) Business Man/Woman (5) Other, Specify.

Does your occupation affect your tree planting activities in any way (1) Yes (2) No.

If yes, how …….

Farm Size:

Size of your farm ……. Acres.

Does size of farm influence your decision to plant/not to plant trees?

(1) No (2) Yes

If yes how?

Farm too small to accommodate trees,

Farm too big and trees are Naturally growing,

Utilized for cereals production and grazing

Trees interfere with mechanized farming

Farm small hence trees supplement income

Others, specify, ……

What do you use in your land preparation? (1) Tractor (2) Ox plough (3) Human labour

(5) Others, Specify…….

Land and Tree Tenure:

Who owns this land? (1) Husband (2) Wife (3) Daughter/Son (5) Leased (6) Others, Specify ……

Do you have a title deed for the farm? (1) No (2) Yes

If no, does it affect your tree planting activities …….

Who plants trees on the farm? (1) Wife (2) Husband (3) Both wife and husband (4) Children (5) Whole family

Who tends the trees (1) husband (2) Wife (3) Children (4) Husband and wife

Who owns the trees (1) Family (2) Husband (3) Wife (4) Children (5) Husband and Wife

Who decides when and how to harvest them? (1) Husband (2) Wife (3) Husband and wife (4) Children

Benefits:

Of what value are the trees on your farm:

i.
ii.
iii.
iv.
v.

Extension Services:

Extension Services: How often are you visited by extension staff at your farm (1) Not at all, (2) Rarely, (3) Yearly, (4) Once in a month, (5) Quite often

How often do you visit the extension officers/offices?

Not at all, (2) Rarely, (3) Yearly, (4) Once after several months, (5) Often Why? …….

Do extension officers provide seedlings (1) No, (2) Yes

If no, what is the source of your tree seedlings? (1) From on-farm nurseries (2) Bought from private nurseries (3) Borrow from friends (4) Others, specify ……

Traditional Believes and Taboos

Do you believe?

Some trees should not be planted by women (1) Yes (2) No

Some trees should not be cut for any purpose by women (1) Yes (2) No

Women should not own land and should not have a right to use any of the trees they plant and tend. (1) Yes (2) No

Women should not plant trees or

Do not belief at all

Do you have any traditional beliefs concerning trees and tree growing? (1) No (2) Yes

If yes, give examples of trees and associated beliefs

Tree Species	Belief

Have your own tree planting activities been affected by such beliefs (1) No (2) Yes

Other Land Use Activities

What are the different land use activities you practice on your farm?

Crop production

Livestock keeping/Dairy for milk

Others specify ……...……

Does crop production from your farm meet your household food requirements (i) Yes (ii) No

If No, where do you get the supplements:-

From selling milk and buying food

Selling fruits

Sell of timber

Work for neighbours to get food

Others specify ……

You practice Dairy farming (1) Yes (2) No.

Do the trees on your farm act as feeds for the animals you keep?

(1) Yes (2) No

If yes, which ones (tree species for fodder) …… …….

……

What do you see as major constraints to tree planting in Agro forestry production systems? …….

……

……

Personal Observations

Absent or presence of trees on the farm (1) Present (2) Absent

Trees present on the farm

Species Most Common	Common	Not Common

Farm machinery, observe and record.

Domestic animals, Observe and list.

Conservation measures practiced on the farm, if any?

Different Agro forestry technologies practiced by the farmer observe and list.

Appendix II: Questionnaire to Extension Staff

Are you aware that this location is experiencing high wood demand?

……

……

You are a Forest/Agricultural Extension Officer, how does your extension work influence Agro forestry technologies in this Area?

……

……

What resistance do you encounter when trying to promote Agro forestry extension?……

……

How often do you meet farmers in groups or individuals?.....

What incentives do you give to farmers to promote Agro forestry production?

……

What Government policies do you implement at the grass root level regarding on-farm tree planting that has an influence on Agro forestry production systems?……

……

Appendix III: Community Leaders

How often are you visited by extension officers during your barazas?

……

Are you aware of forest policy?.....

Are you satisfied, there is enough trees in your area? (1) Yes (2) No

If No, what is the cause of low attention to on-farm tree production ……..

……

……

How are you as a leader encouraging people in your area to plant trees?

……

……

5. (a). In your own opinion; is the acreage under crop production expanding (1) Yes (2) No.

……

……

(b). under grazing expanding? (1) Yes (2) No.

……

6. What do you think the government should do to encourage Agro forestry production in your area? ……..……

……

Appendix IV: Summary Statistics for General Variables

Frequencies for the variables used in the model

Variable	Categories	Frequency	Percentage
SEX	male	118	58.7
	Female	83	41.3
Awareness (extension services) on tree planting?	Yes	80	40.0
	No	120	60.0
Title deed for land ownership	Yes	103	51.2
	No	98	48.8
Do you believe women should not own land and should not have a right to use any of the trees they plant and tend	Yes	93	46.3
	No	106	52.7
Agricultural activity (land preparation methods)	tractor	121	60.5
	Ox plough/Human labour	78	39.0
	Human labour	1	0.5

Case summaries for categorical variables

		Marginal Percentage
Level of adoption for agroforestry practices	Low adopter	13.1%
	Moderate adopter	25.1%
	High adopter	61.7%
Sex	male	57.9%
	Female	42.1%
are you aware of any government policy on tree planting	Yes	41.5%
	No	58.5%
Do you have a title deed for this farm	Yes	52.5%
	No	47.5%
Do you believe women should not own land and should not have a right to use any of the trees they plant and tend	Yes	48.6%
	No	51.4%
Farm preparation method1	tractor	63.4%
	ox plough	36.1%
	Human labor	.5%

MNL estimates M -1 equation. Where M is the number of categories in the dependent variable. The reference category will be the comparison category.

Odds ratio of the category in consideration e.g. male is given by the Odd ratio (Exp (B)) column. The odds ratio for females in this case would be the reciprocal of the odds ratio for the male category.

The sign will indicate the likeliness of the subject category as compared to the reference category.

For quantitative variables, parameters with significant positive (negative) coefficients increase (decrease) the likelihood of that response category with respect to the reference category.

Coefficient interpretations

Moderate adopters relative to low adopters:

Age: This is the multinomial logic estimate for one unit increase in age for moderate level of adoption relative to Low level of adoption given all other variables in the model are held constant. If the age of the farmer was to increase by one year, the likelihood of that farmer to be a moderate adopter relative to being a low adopter would decrease by 1.2 % holding all other factors in the model constant. In other words, as the age increases the level of adoption increases-aged farmers are more likely to be adopters of agro forestry. This is because advance in age is considered as long experience in life and they can be able to reflect on the past and present ecological changes more accurately than the young generations and hence take appropriate conservation measures. Older farmers are also the owners of land title deeds and therefore make decisions on the best uses of their land.

Male gender: This is the multinomial logic estimate comparing males to females for moderate adopters relative to Low adopters given all other variables in the model are held constant. Given the positive coefficient, the Males are more likely to be moderate adopters relative to low adopters. (See B=1.51, Odds ratio (OR) = 4.526 and p=0.028). Conversely, we can conclude that females are less likely to be moderate adopters hence more likely to be low adopters. The male gender is in most cases the head of a household and also ownership of land rights are vested in him. He makes decisions on what type of use should be put on the land and these puts him in a good position to influence land use activities such as agro forestry.

Mechanized land preparation: Both tractor and oxen land preparation had a negative influence on the adoption of agro forestry. The likelihood of a farmer being a moderate adopter relative to low adopter would decrease by 17.3% and 16.5% if a farmer uses tractor and oxen for land preparation respectively. Mechanized ploughing needs less tree populations and especially for tractors, which need movement space. Ploughing by use of oxen can be used in fields where there are small populations of trees without compromising the quality of the ploughing. This could explain the smaller effect of the likelihood of adoption for farmers using oxen for

ploughing at 16.5% as opposed to those who use tractors for ploughing at 17.3% High adopters relative to low adopters

Male gender: This is the multinomial logic estimate comparing males to females for high adopters relative to Low adopters given all other variables in the model are held constant. Given the positive coefficient, the Males are more likely to be high adopters relative to low adopters. The likelihood of the males (compared to women) being high adopters increases by 0.4%. Conversely, we can conclude that females are less likely to be high adopters hence more likely to be low adopters.

Believe on land and tree ownership/use: Beliefs can also influence the level of adoption. Results indicate that people who believe that women should not own land and should not have a right to use any of the trees they plant and tend are less likely to be high adopters relative to low adopters. Since women are mostly resident on the farm, success or high adoption of agro forestry will depend on the extent to which women are involved in the technology. Farmers who have overcome this believe are more likely to be high adopters of agro forestry.

Mechanized land preparations: The likelihood of a farmer being a high adopter relative to low adopter decreases when the farmer is using oxen for land preparation. See explanation in the interpretation for moderate adopter relative to low adopters.

The following summery statistics – frequencies and descriptive were generated. These are the variables which were thought to be important in the work hence could help in the write up.

Do you believe some trees should not be cut for any purpose by women?

	Frequency	**Valid Percent**
Yes	172	86.0
No	28	14.0
Total	200	100.0
System	1	

Do you believe women should not own land and should not have a right to use any of the trees they plant and tend?

	Frequency	Valid Percent
Yes	93	46.7
No	106	53.3
Total	199	100.0

Have your own tree planting activities been affected by such beliefs

	Frequency	Valid Percent
Yes	86	43.0
No	114	57.0
Total	200	100.0

Farmer practicing woodlot technology or not

	Frequency	Valid Percent
No	72	35.8
Yes	129	64.2
Total	201	100.0

Farmer practicing hedge technology or not

	Frequency	Valid Percent
No	37	18.4
Yes	164	81.6
Total	201	100.0

Farmer practicing homestead tree planting technology or not

	Frequency	Valid Percent
No	47	23.4
Yes	154	76.6
Total	201	100.0

Farmer practicing home garden technology or not

	Frequency	Valid Percent
No	49	24.4
Yes	152	75.6
Total	201	100.0

Farmer practicing boundary tree planting technology or not

	Frequency	Valid Percent
No	16	8.0
Yes	185	92.0
Total	201	100.0

Who plants trees on the farm?

	Frequency	Valid Percent
Wife	24	12.1
Husband	14	7.0
Both wife and husband	72	36.2
children	3	.5
whole family	88	44.2
Total	201	100.0

Do you believe some trees should not be planted by women?

	Frequency	Valid Percent
Yes	164	82.0
No	37	18.0
Total	201	100.0

Do you believe some trees should not be cut for any purpose by women?

	Frequency	Valid Percent
Yes	172	86.0
No	29	14.0
Total	201	100.0

Do you believe women should not own land and should not have a right to use any of the trees they plant and tend?

	Frequency	Valid Percent
Yes	93	46.7
No	106	53.3
Total	199	100.0

Age of Farmers

Age group	Sex of respondents		Total Respondents	Percent
	Male	Female		
<30 Years	22 (11%)	14 (7%)	35	18.0
31-40 Years	39 (19.4%)	29 (14.4%)	68	33.8
41-50 Years	26 (13%)	17 (8.5%)	44	21.5
51 years and above	31 (15.4%)	23 (11.4%)	54	26.8
Total	118 (59%)	83(41%)	201	100.0

Source: Nzoia sample survey 2008.

Marital status

		Frequency	Valid Percent
Valid	Married	165	82.1
	Single	3	1.5
	Widowed/widowered	33	16.4
	Total	201	100.0

What is the total number of people in your family?

No. of dependants		Frequency	Valid Percent
Valid	2	13	6.4
	3-4	71	35.3
	5-6	69	34.3
	7	26	12.9
	8 and more	22	10.9
	Total	201	100.0

Education level

Valid	Frequency	Valid Percent
No education at all	108	54.0
Primary level	9	5.0
Secondary level	33	16.0
College Level	23	11.0
University level	28	14.0
Total	201	100.0

Source: Nzoia sample survey 2008

Occupation

		Frequency	Valid Percent
Valid	Employed	27	13.0
	Farmer	108	54.0
	Civil servant/teacher	31	15.0
	Business man/woman	32	16.0
	Squarter	3	2.0
	Total	201	100.0

Approximate levels of gross annual income

Valid acres	**Frequency**	**Valid Percent**
<10,000	11	5.5
11,000-30,000	24	12.
31,000-50,000	19	9.5
51,000-70,000	53	26.0
71,000 and above	94	46.8
Total	201	100.0

Source: Nzoia sample survey 2008.

Farm holdings

Valid Acres	Vinyenya	Moi Bridge	Musemwa	Matunda	Percet
<1	9	5	16	42	35.8
2-5	19	13	21	56	54.2
6-10	3	6	1	1	5.5
11-15	0	9	0	0	4.5
Total	31	33	38	99	100

Source: Nzoia sample survey 2008

Who owns this land?

		Frequency	Valid Percent
Valid	Husband	164	81.6
	Wife	32	15.9
	Daughter/son	1	.5
	Family	3	1.5
	Government	1	.5
	Total	201	100.0

Who tends the trees?

		Frequency	Valid Percent
Valid	Wife	29	14.0
	Children	126	63.0
	Both wife and husband	9	5.0
	Husband	4	2.0
	whole family	33	16.0
	Total	201	100.0

How often are you visited by extension staff at your farm?

		Frequency	Percent	Valid Percent
Valid	Not at all	152	75.6	75.6
	Rarely	47	23.4	23.4
	Yearly	2	1.0	1.0
	Total	201	100.0	100.0

How often do you visit extension offices or officers?

		Frequency	Valid Percent
Valid	Not at all	158	78.6
	Rarely	41	20.4
	once after several months	2	1.0
	Total	201	100.0

Do extension officers provide you with seedlings?

		Frequency	Valid Percent
Valid	Yes	19	9.5
	No	182	90.5
	Total	201	100.0

If no, what is the source of your tree seedlings?

		Frequency	Valid Percent
Valid	from on-farm nurseries	54	26.9
	Bought from private nurseries	143	71,0
	Borrow from friends	4	2.0
	Total	201	100.0

Do you have any traditional bellives concerning tree growing?

		Frequency	Valid Percent
Valid	Yes	161	80.0
	No	40	20.0
	Total	201	100.0

Different land use activity you practice on your farm?

		Frequency	Valid Percent
Valid	crop production	148	73.6
	Livestock keeping/dairy milk	35	17.4
	Poultry	12	6.0
	Apiculture	6	3.0
Total		201	100.0

Do the trees on your farm act as feeds for the animals you keep

		Frequency	Valid Percent
Valid	Yes	157	78.9
	No	42	21.1
	Total	199	100.0

What do you see as the major constraint to the tree planting in agro forestry production systems?

		Frequency	Valid Percent
Valid	Cost of seedlings	49	24.4
	Farm labour	55	27.4
	Extension services	52	25.9
	Traditional believes	44	21.9
	System	1	100.0
	Total	201	

Absence or presence of trees on the farm

		Frequency	Valid Percent
Valid	Present	198	99.5
	Absent	1	.5
	Total	199	100.0
Missing	System	2	
Total		201	

Conservation measures practiced

	Frequency	Valid Percent
Terraces	106	80.9
trees in rows	19	14.5
woodlots to rehabilitate eroded areas	6	4.6
Total	131	100.0
System	70	
	201	