INFLUENCE OF EXTENSION APPROACHES ON ON-FARM TREE PLANTING: A CASE OF FARMER FIELD SCHOOLS IN MBEERE DISTRICT, EMBU COUNTY, KENYA.

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DECLARATION

This research project is my original work and has never been presented in any other university.

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This research project has been submitted for examination with my approval as the university supervisor.

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DEDICATION

This project report is dedicated to my wife Agnes and daughters; Doreen, Caroline and Breda for giving me support during the period of study.

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I give special recognition of the enduring support and guidance I received from my supervisor, Madam Ruth Njora which forms the backbone of this study. A special mention goes to the University of Nairobi management particularly the Department of Extramural Studies for their support and guidance during the writing of this project proposal and also my report.

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ABREVIATIONS AND ACRONYMS

AESA	Agro Ecosystem Analysis
CBOs	Community Based Organizations
CBS	Central Bureau of Statistics
DI	Deficit Irrigation
FAO	Food and Agricultural Organization
FFS	Farmer Field School
FI	Full Irrigation
GoK	Government of Kenya
ILRI	International Livestock Research Institute
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
JICA	Japanese International Corporation Agency
KARI	Kenya Agricultural Institute
KFS	Kenya Forest Service
LEIRP	Low External Input Rice Production
LEIRP	Low External Input Rice Production
MPTS	Multipurpose Trees and Shrubs
NGOs	Non- Governmental Organization
PRA	Participatory Rural Appraisal
PTD	Participatory Technology Development
SPSS	Statistical Package for Social Sciences
UN	United Nations
USAID	United States Aid for International Development
WP	Water Productivity

ABSTRACT

The objectives of the study were : To establish the influence of participatory technology development as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District ; To assess the influence of farmers training as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere district and To determine the influence of adoption of suitable tree planting systems as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District. . The study was carried out using descriptive survey design. The sample size for the study was 300 farmers who were drawn from the four divisions in Mbeere District. The data was obtained from the respondents by the use of questionnaires which were structure based on the objectives of the study and were composed of both closed and open ended questions. The final data was entered into a computer by the use of SPSS and Excel softwares for analysis, presented and interpreted based on the study objectives. The study found that participatory technology development has made the farmers adopted new skills and techniques in tree production and management in their farms. It also found that training as FFS extension approach have provided tree farmers with hands on experience on how to carrying out various experiments during the Farmer Field School (FFS) sessions, make observations, record and analyze their findings and come up with solutions for the problems affecting them. Lastly, the study found that tree farmers in Mbeere district have adopted suitable tree planting systems in their farms to meet their requirement in terms of wood based tree products and ensure agricultural sustainability that maximizes on farm productivity that improves their livelihood. However the farmers' ability to expand on their tree planting in the district to meet their requirement has been constrained by lack of enough land for expansions as most of them rely on their family lands which can hardly allow massive investment in tree planting.The study recommends that Kenya Forest Service should find ways of encouraging more participation of farmers in FFS training sessions so as to increase tree planting for agricultural land conservation, climatic conditions improvement and ensuring sustainable food security in the district and country as a whole. The trees planted in the farms should not only cater for domestic use but also for commercial needs. The tree farmers should consider acquiring more land outside their ancestral boundaries in order to provide more spaces for tree planting. Finally the government should find better ways of providing incentives to farmers to invest more on tree planting.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Agricultural education, extension, and advisory services are a critical means of addressing rural poverty, because such institutions have a mandate to adopt technology, support learning, assist farmers in problem solving, and enable farmers to become more actively embedded in the agricultural knowledge and information system (Braun, Graham and Fernández (2000). Extension approaches of farming are practiced by almost one billion small-scale farmers worldwide. It is thus urgent to seek the best ways to support such farmers in terms of information, technology, advice, and empowerment. Finding an extension approach is a special challenge in the African context, as poverty is growing and productivity is declining on the continent. 24 African countries have listed extension as one of the top agricultural priorities for a poverty reduction strategy (Inter-Academy Council, 2004).

One very popular extension and education program worldwide is the Farmer Field School (FFS) approach, now in place in at least 78 countries (Braun and Duveskog, 2011). Farmer Field Schools (FFS) is described as a Platform and "School without walls" for improving decision making capacity of farming communities and stimulating local innovation for sustainable agriculture. It is a participatory approach to extension, whereby farmers are given opportunity to make a choice in the methods of production through discovery based approach. The FFS approach was developed by Food and Agriculture Organization (FAO) project in South East Asia in 1989 as a way for small-scale rice farmers to investigate, and learn, for themselves the skills required for, and benefits to be obtained from, adopting on practices in their paddy fields.

The term "Farmers' Field School" comes from the Indonesian Sekolah Lampangan simply meaning "field school". The first Field Schools were established in 1989 in Central Java during the pilot phase of the FAO-assisted National Integrated Pest Management (IPM) Programme. This Programme was prompted by the devastating insecticide-induced outbreaks of brown plant hoppers (Nilaparvata lugens) that are estimated to have in 1986 destroyed 20,000 hectares of rice in Java alone. Since then, it has expanded through many parts of Sub-Saharan Africa. In Africa the FFS approach is implemented in Kenya, Uganda, Tanzania, Zimbabwe, Zambia, Malawi, Ethiopia, Ghana, Nigeria, Gambia, Egypt, Lesotho, Swaziland and Mozambique. The farmer field schools approach was introduced in Kenya in 1995 on a pilot basis under FAO's Special Programme on Food Security for Low Income Countries. Its introduction was in response to the acceptance of the Ministry of Agriculture that the approach was an appropriate extension method for Kenya. The pilot phase was implemented in Western Kenya by Villa Maria Enterprises (NGO) in collaboration with the Ministry of Agriculture and the Kenya Agricultural Research Institute (KARI) in 1995 (Matata and Okech, 1998). In Kenya there are over 5000 FFSs that have been implemented in Kenya with over 150, 000 farmers under the coordination and funding of various agencies (/KARI/ILRI, 2003). Many donors, governments, and non-governmental organizations (NGOs) enthusiastically promote FFSs in Sub-Saharan Africa today. As a result of their popularity concern has been raised as whether the FFS approach should be scaled up and incorporated into mainstream farming practices like in on-farm tree planting, (Anandajayasekeram, Davis and Workneh, 2007).

On on-farm tree planting is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy, and sustainable land-use systems, (Paul, 2002). A narrow definition of on-farm tree planting is trees on farms. On-farm tree planting is the deliberate incorporation of trees and other woody species of plants into other types of agricultural activities. By definition the use of woody species must result in the enhancement of either the biological productivity or the economic return of the system, or both. There are many types of on-farm tree planting, which are usually defined by what type of agricultural activity is involved, but this can be a very broad definition and includes what we normally think of as agriculture (on-farm tree planting), but also other combinations such as livestock production (sylvo-pastoral on-farm tree planting) and even aquaculture (sylvo-aqua on-farm tree planting). Even more complicated versions are possible such as agricultural systems that incorporate livestock, trees and aquaculture (sylvo-pastoral-aqua on-farm tree planting), (Paul, 2002).

Biodiversity in on-farm tree planting systems is typically higher than in conventional agricultural systems. With two or more interacting plant species in a given land area, it creates a more complex habitat that can support a wider variety of birds, insects, and other animals. Depending upon the application, potential impacts of on-farm tree planting can include reducing poverty through increased production of wood and other tree products for home consumption and sale, contributing to food security by restoring the soil fertility for food crops, cleaner water through reduced nutrient and soil runoff, countering global warming and the risk of hunger by increasing the number of drought-resistant trees and the subsequent production of fruits, nuts and edible oils, reducing deforestation and pressure on woodlands by providing farm-grown fuel wood, reducing or eliminating the need for toxic chemicals (insecticides, herbicides), through more diverse farm outputs, improved human nutrition, in situations where people have limited access to mainstream medicines and providing growing space for medicinal plants, (Muschler, 1999).

Since time in memorial forests and trees have provided humankind with numerous services and benefits. Such benefits can be economic, social, cultural and of course environmental. In fact for a developing country like Kenya, forests are key to the nation’s very survival and touch on all spheres of our lives. There is no argument on the environmental importance of forests and trees, trees are of great socio-economic and biophysical importance to the national economy of Kenya. Trees are an essential part of diversified farm production, providing both subsistence products and incomes while contributing to soil fertility, soil and water conservation, carbon sequestration and other environmental services roles. Products such as fuel wood and fodder from trees and shrubs on farmlands contribute significantly to sustainability of rural households and livelihoods, (Braun, Graham and Fernández, 2000)

On-farm tree planting plays a significant role in the provision of forest goods and services while supplementing wood supply from state forests. It is estimated that 24 million cubic meters of fuel wood materials worth Ksh.4.8 billion is sourced from farmlands annually (Kamfor, 2000). Some of the economic benefits derived from forests include provision of building materials, paper and food. Others are utility products such as timber, pulp, poles, posts, wood fuel for industrial and domestic use. Forests offer employment through opportunities in processing and trade of forest products and energy. Recreation and tourism are other ventures that Kenyan investors need to harness. Although 60% of all wood harvested from forests and trees are used for fuel, forests also contain trees that have natural oils, gums and resins which are used to manufacture insecticides, rubber products, fuel, paint, varnish and wood finishing products, cosmetics, soaps, shampoos, perfumes, disinfectants, and detergents, (Wakhusama and Kanyi, 2003).

Culturally, forest have been said to ground us spiritually and connect us to our primal past. Long before modern religions came to our shores, the forests around many communities were sacred places of worship, meditation and commune with the gods & ancestors. Even today with dwindling forests around the country, we still have numerous sacred sites that communities use to uphold their traditional beliefs like the Kaya forests of the Mijikenda. Forests also offer a wide range of non-wood forest products e.g. herbs, trees of medicinal value, hosting and protection of sites and landscapes of high cultural, spiritual or recreational value, (Wakhusama and Kanyi, 2002)

The other importance of environmental services offered by forests include carbon sequestration, conservation of biological diversity, regulation of water supplies, providing habitat for wildlife, soil conservation, mist rain, wildlife habitats amongst others. According to Kenya Census of 2009, the population was estimated at 38.6 million (CBS). Considering the current population growth rate of 2.5% per annum, the pressure on wood based resources from the state forests continues to intensify. 67.7% of the population in the country is in rural areas which is heavily dependent on wood based resources for domestic requirements. Rural households' consumption of fuel wood is estimated at 35.1 million tons per year against annual supply of 15.02 million tons (Mugo, 2001). It is in this context of heavy reliance on state forests and inadequate supply of tree based resources from farms that the government has been involved in on-farm tree planting tree planting support in the country, (Muschler, 2001).

1.2 Statement of the Research Problem

Trees are of great socio-economic and biophysical importance to the national economy of Kenya. Trees are an essential part of diversified farm production, providing both subsistence products and incomes while contributing to soil fertility, soil and water conservation, carbon sequestration and other environmental services roles. Products such as fuel wood and fodder from trees and shrubs on farmlands contribute significantly to sustainability of rural households and livelihoods. On-farm tree planting plays a significant role in the provision of forest goods and services while supplementing wood supply from state forests, (Kamweti, 1981).

According to Kenya Census of 2009, the population was estimated at 38.6 million (CBS). Out of this total population, 67.7% is in rural areas which are heavily dependent on wood based resources for their domestic requirements. Considering the current population growth rate of 2.5% per annum, the demand on wood based resources from the state forests and on farms will continue to intensify.

Since 1971, the Kenya government has supported a total of thirteen different forest extension approaches with the aim of supporting the rural farming population to be self reliant in terms of wood based resources, (GOK, 2009).There is inadequate supply of tree based resources from on-farms to meet the requirements of the rural farming communities despite the fact that the government has been involved in supporting on-farm tree planting in the country since 1971, (Muschler, 2001).

In an attempt to promote extension practices in the country, the government introduced the Farmers Field School as an extension approach in the forestry sector through the Kenya Forest Service in 1998 and piloted under the funding of Japanese International Corporation Agency (JICA). However despite its existence for the last fourteen (14) years, there is little information on it, especially on its influence on on-farm tree planting to meet the requirement of rural farming communities in terms of tree products.

This study therefore intended to investigate the influence of Farmer Field School as extension approach on on-farm tree planting by farmers in Mbeere District, Embu County. The study examined the influence of participatory technology development, training and adoption of suitable tree planting systems as an FFS extension approach by farmers on on-farm tree planting in Mbeere District.

1.3 Purpose of the Study

The purpose of this study was to examine the influence of farmer field schools as an extension approach on on-farm tree planting by farmers in Mbeere District, Embu County.

1.4 Objectives of the Study

The study was guided by the following objectives:

1. To establish the influence of participatory technology development as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District.
2. To assess the influence of farmers training as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere district.
3. To determine the influence of adoption of suitable tree planting systems as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District.

1.5 Research Questions

The study was guided by the following research questions**:**

1. What is the influence of participatory technology development as a Farmer Field School extension approach on on-farm tree planting in Mbeere district?

2. To what extent does farmers' training as a Farmer Field School extension approach influence on-farm tree planting in Mbeere district?

3. How does adoption of suitable tree planting systems as a Farmer Field School extension approach influence on-farm tree planting in Mbeere district?

1.6 Significance of the Study

The study may be of great importance to the tree farmers in Mbeere District for guidance on the appropriate application of the techniques, knowledge and skills acquired through FFS approach in enhancing their farming activities in forestry for better returns and utilization of the available land. To the coordinators of the FFS approach, this study may be very important as it would point to the most relevant and sustainable curriculum development for training farmers in Mbeere District and other parts of the country. To the Government which is the main agent behind the FFS project in the country, the study may assist in refining the application of FFS programs across the country depending on the specific needs and climatic conditions that are favorable in different parts of the country. Finally, to the academician and future researchers, the study may add onto the existing literature on Farmers Fields School and the various methodologies relevant for their application.

1.7 Assumptions of the Study

The study was based on the assumption that the FFS as an extension approach is supportive to the farming community. Further triangulation by use of several instruments to collect the data can yield richer data for on-farm tree planting. It was also assumed that the community adopted the approach to reap the benefits associated with on-farm tree planting.

1.8 Limitations of the Study

Due to limitation of time and budget, a sample of the population was taken as opposed to carrying out a census which would have been the most ideal method of carrying out the study. Due to time and financial constraints, the study employed the use of structured questionnaires as the only data collection tools.

1.9 Delimitation of the Study

The study focused on on-farm tree planting techniques as an FFS extension approach which is currently in use in Kenya which aims at improving environmental sustainability and community development through empowerment of the participating communities.

1.10 Definition of Significant Terms

Alley cropping : Alley cropping is a form of on-farm tree planting practice in which perennial, preferably leguminous trees or shrubs are grown in rows simultaneously with an arable crop.

Boundary planting : This is a tree planting method where trees are planted along the boundaries at pre-determined intervals for the purpose of marking boundaries. Extension Approach: This defined as Extension approaches: These are methods used by the technical officers to pass technical information to farmers for adoption to improve their farming practices.

Farmer Field School : Farmer Field School is a participatory approach to extension whereby farmers are given opportunity to make a choice in the methods of production through discovery based approach.

Homestead planting : This is tree planting within the homesteads for the Purpose of provision of shade and other aesthetic values.

On farm tree planting: On-farm tree planting is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock.

Farmers training: This is the farmers' capacity to make well-informed crop management decisions through increased knowledge and understanding of the on-farm tree planting as an extension approach.

Participatory Technology Development : Participatory technology development is an approach that promotes farmer driven technology innovation through participatory processes and skills building involving experimentation to allow small scale farmers to make better choices about available technologies.

Adoption of suitable tree planting practices: This is the farmers' ability to plant trees that are sustainable, acceptable and productive within their environment by assessing the weather conditions, available land and considering other crops that are planted in the farms to maximize on their benefits

1.11 Organization of the study

This research report is organized into five main chapters. Chapter one is the introduction of the study and it includes background to the study; statement of the research problem; purpose of the study; objectives of the study; research questions; rationale of the study; significance of the study; assumption of the study; limitations of the study; delimitations of the study; definition of the terms used; and organization of the study. Chapters two forms the literature review of the report and it includes the following sub-sections: introduction; literature review based on the objectives i.e. participatory technology development; the influence of farmers' training through FFS on on-farm tree planting; and adoption of suitable tree planting systems. Summary of literature review; and conceptual framework constitutes the last part of this chapter.

Research methodology constitutes chapter three of the research report and contains the study design; target population; sample size and sampling procedure; research instruments; validity and reliability of the instruments; data collection procedures, data analysis techniques; and operationalization of variables. Data analysis, presentation and interpretation forms chapter four or the report and it includes the response rate, demographic data analysis; analysis of the findings based on the study objectives i.e. participatory technology development; the influence of training as on on-farm tree planting extension approach; and adoption of suitable tree planting systems. Discussion of findings, conclusion and recommendation forms chapter five of the report and it includes the following sub-sections: introduction; discussions of findings based on the objectives of the study; conclusion; recommendations; and recommendations for further studies. The research report ends with a list of references and appendices.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature reviewed on the influence of extension approached on 0n-farm tree planting. The extension approach considered in this section is the Farmer Field School which entails participatory technology development adoption, training and adoption of suitable tree planting systems involved in on-farm tree planting and their influence on on-farm tree planting. The study winds up by summarizing the literature review and presenting the researcher conceptualization of the relationship between the variables

2.2 Participatory Technology Development

2.2.1 Fruit Trees Grafting

Fruit tree grafting describes any of a number of techniques in which a section of a stem with leaf buds is inserted into the stock of a fruit tree. The upper part of the graft (the scion) becomes the top of the plant; the lower portion (the understock) becomes the root system or part of the trunk (Garner, 2008). Hottes (2005) defines grafting as a horticultural technique whereby tissues from one plant are inserted into those of another so that the two sets of vascular tissues may join together to form inosculation. The technique is most commonly used in asexual propagation of commercially grown plants for the horticultural and agricultural trades like fruits. Although grafting usually refers to joining only two plants, it may be a combination of several. A third plant added between two others becomes the trunk or a portion of it. This is called an interstem, (Core, 2005).

Some cultivars (varieties) of plants do not come true from seeds. The seed from a Haralson apple will produce an apple tree, but it will not produce a Haralson apple tree. In other words, fruit trees cannot be reproduced "true" to the original cultivar from seed. They can only be reproduced by grafting. Grafting (top working), is a way to change a large tree from old to a new variety. It is also a method of using a root system better adapted to soil or climate than that produced naturally by an ungrafted plant. By using special under stocks or interstems grafting is a way to produce dwarf plants, (Core, 2005).

Most varieties of a particular fruit species are interchangeable and can be grafted. Because of differences in vigor, some are better able to support others as understocks. Plants of the same genus and species can usually be grafted even though they are a different variety, (Garner, 2008). Plants with the same genus but of a different species may often be grafted. But the result may be weak, short-lived, or they may not unite at all. Plants of different genera are less successfully grafted although there are some cases where this is possible. Plants of different families cannot be grafted successfully, (Cooper and Chapot, 2007).

Agricultural research that yields improved production is recognised as an effective approach to enhance the agricultural productive capacity, and lead to both economic growth, and poverty reduction (Lusting and Stern, 2006). As such young, vigorous fruit trees up to 5 years old are best for top working. Older apple and pear trees of almost any age can be top worked but the operation is more severe and those over 10 years old must be worked at a higher point. Young trees should have 1 to 2 feet of branch between the trunk and the graft. Otherwise the good crotch formation of the understock will be lost by the trunk expanding past the union. Trees up to 5 years old can be grafted at one time. On older trees about half--the upper and center part only should be worked at one time. The remainder should be worked a year later, (Hottes, 2005).

A key issue in tree production is how to target agricultural research in a way that its productivity gains in domestic levels can be implemented successfully in a wider range of socio-economic settings at the regional level. Well-targeted agricultural research on a regional basis can potentially reduce the production cost per unit of output, increase the output of marketable produce especially in nutrient deficient soils, increase supply of better quality wood for local processing, increase rural households demands for farm and non-farm products, increase on-farm employment opportunities, increase foreign exchange income at the country level, and generate savings for smallholders, (Rogers, 1995). Therefore grafting or inarching is used to join together plants that are otherwise difficult to reproduce. The plants are grown close together, and then joined so that each plant has roots below and growth above the point of union. Both scion and stock retain their respective parents that may or may not be removed after joining, (Cooper and Chapot, 2007).

Grafting with a single eye or bud is most commonly used for citrus trees. Normally performed at the height of the growing season by inserting a dormant bud into a shallow slice under the rind of the tree where the bud is sealed from drying and bound in place. There are many styles of budding depending on the cutting and fitting methods, the most popular being shield budding. Other budding styles include the inverted T, patch budding, double shield, flute budding and chip budding, (Garner, 2008).

The most common form of grafting is cleft grafting. This is best done in the spring and is useful for joining a thin scion about 1 cm (0.39 in) diameter to a thicker branch or stock. It is best if the latter is 2–7 cm (0.79–2.8 in) in diameter and has 3-5 buds. The branch or stock should be split carefully down the middle to form a cleft about 3 cm (1.2 in) deep. If it is a branch that is not vertical then the cleft should be cut horizontally. The end of the scion should be cut cleanly to a long shallow wedge, preferably with a single cut for each wedge surface, and not whittled. A third cut may be made across the end of the wedge to make it straight across, (Cooper and Chapot, 2007).

The whip and tongue graft, this is considered the most difficult to master but has the highest rate of success as it offers the most cambium contact between the 2 species. It is the most common graft used in top-dressing commercial fruit trees, (Core, 2005). It is generally used with stock less than $\frac{1}{2}$ in (1.3 cm) diameter, with the ideal diameter closer to $\frac{3}{8}$ in (0.95 cm) and the scion should be of roughly the same diameter as the stock. The stock is cut through on one side only at a shallow angle with a sharp knife. The scion is similarly sliced through at an equal angle starting just below a bud, so that the bud is at the top of the cut and on the other side than the cut face, (Hottes, 2005).

Agricultural research that yields improved production is recognised as an effective approach to enhance the agricultural productive capacity, and lead to both economic growth, and poverty reduction (Lusting and Stern, 2006). A key issue in tree production is how to target agricultural research in a way that its productivity gains in domestic levels can be implemented successfully in a wider range of socio-economic settings at the regional level. Well-targeted agricultural research on a regional basis can potentially reduce the production cost per unit of output, increase the output of marketable produce especially in nutrient deficient soils, increase supply of better quality wood for local processing, increase rural households demands for farm and non-farm products, increase on-farm employment opportunities, increase foreign exchange income at the country level, and generate savings for smallholders, (Rogers, 1995). Projects on homestead vegetable production promote vegetable cultivation through multistory cropping patterns homestead space planting and IPM, and fruit tree planting and improvement on an extremely limited land base the homestead, (TBP, 2000-2002).

In PTD, innovations emerge from interactive learning among different social actors of knowledge system operating together. The implementation of PTD aims at the development of technologies for improving the agro-ecological systems as well as the development of the capacity of the local community to sustain the technology development process. In Zimbamwe, participatory process was used successfully in promoting sustainable management of natural resources and food security in smallholders farming areas (Hagman, Chuma, and Murwira, 1996).

2.2.2 Tree Seeds Pre-treatment

Seeds are of importance for propagating seedling root-stocks on which to graft or bud varieties, and for obtaining hybrid plants in breeding studies. Whether or not a viable seed germinates and the time at which it does so depend on a number of factors, including factors in the seed’s environment (Bewley et al., 1994). Seed germination is influenced by internal factors controlling dormancy, including phytohormones (e.g., abscisic acid) inducing dormancy, and by seed coat factors (seed coat-enhanced dormancy). Dry seeds of most temperate trees and shrubs, even though mature, will not germinate and grow until they been imbibed to threshold moisture content under cold conditions (0–5 □C) (cold stratification) (Hartmann et al., 1997). The dormancy of dormant seeds must be broken to induce germination. Various methods are used for this, depending on the plant species and type of dormancy. Chilling plays an important role in pro-viding the stimulus required to overcome dormancy, increase germination, and produce normal seedlings for Prunus persica (Martinez et al., 2001).

Participatory technology development is an approach that promotes farmer driven technology innovation through participatory processes and skills building involving experimentation to allow small scale farmers to make better choices about available technologies. These innovations could be in improving local technologies or through introducing new technologies from elsewhere. It is also defined as a process of interaction between local people and outside facilitators to develop more sustainable farming systems. It begins with a joint analysis of the situation, an activity commonly known as Participatory Rural Appraisal (PRA). It continues by including participatory planning, implementation, monitoring and evaluation of local development activities (KFS, 2006). This is to develop and disseminate environmentally sound and productivity-enhancing technologies for use by smallholder tree crop farmers and other users. Policy options are developed to influence government policies and scientists, extension services, targeted farmer groups and development agents are pooled together in a multidisciplinary and participatory fashion to address key issues within a community focus.

A strategy for technology development is to increase and sustain on-farm tree productivity and quality in a wider range of socio-economic. The design principle surrounds the concept that such strategy can attain the full potential of tree planting to reduce poverty by improving the economic and social well-being of smallholders and the environmental sustainability of their tree crop systems, (Rogers, 1995). In many countries in Africa and Asia, encouraging experience has been reported with Participatory Technology Development (PTD) approach. Although this is a relatively new approach focusing on different aspects of technology development with participatory methods, it highly values the knowledge and experience of farmers and other relevant stakeholders. Three thematic areas of participation which are considered crucial in effective PTD includes farmer participation, participation by agricultural researchers and participation within a multidisciplinary team of scientists and practitioners involved in rural development (Sutherland, Martin, & Salmon, 2008).

Economic growth depends on the ability of agents to innovate. For FFS purposes, innovation is defined as anything new introduced into an economic or social process in the wood supply chain. According to OECD (1999) innovation is defined as the ability to use knowledge creatively in response to market opportunities or other social needs. Sustainable productivity improvements of tree planting smallholdings must be attained to increase farmer incomes, and achieve more efficient use of the land. One way forward is the dissemination and adoption of better production and post-harvest technological innovations; with emphasis on the rehabilitation of old forest farms, suitable soil fertility replenishment approaches, and the reclamation of deforested lands. Research must ensure a transformation of knowledge into innovations. The agents involved in the innovation process in the tree planting chain must interact in a positive manner to ensure that there is a clear understanding of both: scientific bases of the underlying phenomena and the singular characteristics of the dissemination process of the innovation itself. There is a clear need for more efficient institutional arrangements for research and the steady flow of innovations into farmer fields. Within the FFS vision to link producers and consumers throughout the whole chain, this approach provides the necessary backstopping for the effective dissemination of innovations within a community focus, for enhanced impact of research on their livelihoods, and on the natural resources managed by these groups. Productivity-enhancing technologies developed through research will yield such potential benefits in key tree producing countries only if these technologies are appropriate and profitable enough to be adopted by farmers. All of these supported by an appropriate policy context that will lead to technology adoption, increase participation of empowered smallholders in markets, and this will improve the efficiency of the tree crop sector in reducing poverty, (Ruthenberg, 1995).

2.2.3 Nursery Soil Improvement

Land degradation and soil nutrient depletion have become serious threats to agricultural productivity in sub-Saharan Africa. Most arable lands have been affected by degradation thereby reducing agricultural productivity, which in turn results in poor economic growth of countries (Bekele, 2003).Ultimately this results in abject poverty and high incidences of food insecurity among the population that depend on agriculture for livelihood. The continued threat to land resources is exacerbated by the need to reduce poverty and poor farming practices, especially among smallholder farmers. All fertilizers used in Malawi are imported and the government has been encouraging the use of high analysis fertilizer to save on transport and foreign exchange costs (Kherallah and Govindan, 1997). Use of inorganic fertilizers is one way of overcoming soil fertility depletion and increase crop yield. Biophysically there is nothing wrong with proper use of inorganic fertilizers, as they provide the same nutrients as organic sources. However, if no organic matter is applied, continuous application of inorganic fertilizers may lead to reduction in productivity of clay soils which dominates Africa (Akinnifesi and Kwesinga, 2002).

The use of mineral fertilisers is declining as they are increasingly beyond the means of most small-scale farmers (Larson and Frisvold, 1996). Erosion and severe run-off are further depleting existing soil nutrient reserves, while levels of soil organic matter are declining as land is subject to over-use. Sustaining soil fertility has become a major issue for agricultural research and development in SSA (Smaling and Oenema, 1997). In the past, most research consisted of trials to determine the appropriate amount and type of fertiliser needed to obtain the best yields for particular soil types and specific agro-ecological locations. This approach emphasised the use of external inputs and expensive technologies, and often disregarded farmers' knowledge and the resources at their disposal. Since then, research has gradually shifted towards an approach based on Integrated Soil Fertility Management (ISFM), which combines various existing soil fertility management techniques. This approach is based on a thorough scientific understanding of the underlying biological processes of ISFM and aims to promote options that make the best use of locally available inputs, and that are tailored to suit local agro-ecological conditions, and farmers' resources and interests. Improving farmers' knowledge, and their capacity to observe and experiment, is an essential element in the development of ISFM technologies. It is also important to build on local systems of knowledge, as they relate to specific locations and are based on experience and understanding of local conditions of production. Such systems are a source of site-specific ecological information, and provide the key to understanding peoples' socio-cultural conditions (Pawluk et al., 1992). Many development projects and policies have collapsed because of a failure to understand local knowledge, and how this influences the way farmers manage natural resources (Schoonmaker-Freudenberger, 1994).

Composting is the rotting down of plant and animal remains before it is applied to the soil. The compost is mixed with available manure and allowed to decompose together for a maximum of two months before applying to the soil. Composting is safer because the heat generated whilst the material breaks down kills diseases and weeds and seeds and the mixture has a better balance of all the soil needs (Sanchez et al., 1997).

2.3.4 Tree Watering Techniques

In arid and semi-arid regions, where rainfall is not sufficient to sustain a good seedling / tree growth, water harvesting for a forestation is applied. Water harvesting can significantly increase the rate of tree establishment in drought prone areas by concentrating the rainfall/runoff ('Run-off Irrigation'). Arid lands are among the world's most fragile ecosystems, made more so by periodic droughts and increasing overexploitation of meager resources. Arid and semi-arid lands cover around one-third of the world's land area and are inhabited by about one billion people, a large proportion of who are among the poorest in the world. Forests, trees and grasses are essential constituents of arid zone ecosystems and contribute to maintaining suitable conditions for agriculture, rangeland and human livelihoods. In providing goods (especially fuel wood and non-wood products) and environmental services to the rural poor and in contributing to the diversification of their household sources of income, forests and trees in arid zones boost poverty alleviation strategies and reduce food insecurity. Roughly 6 percent of the world's forest area (about 230 million hectares) is located in arid lands (FAO, 2001). Trees outside forests (scattered in the landscape, in arable lands, in grazing lands, in savannahs and steppes, in barren lands and in urban areas) have a vital role in arid lands, although it is difficult to assess their extent.

Irrigated agriculture is the main user of the available water resources. About 70% of the total water withdrawals and 60-80% of total consumptive water use are consumed in irrigation (Huffaker and Hamilton, 2007). There is a conflict in global increase in food demand and decrease in water resources that should be resolved. Food security can be achieved by irrigated agriculture since irrigation on average double the crop yield compared to that usually is produced in rain-fed conditions. The irrigated area should be increased by more than 20% and the irrigated crop yield should be increased by 40% by 2025 to secure the food for 8 billion people (Lascano and Sojka, 2007). Therefore, water resources should be used with a higher efficiency or productivity. To achieve this goal improvement in agricultural water management is a promising way.

Many investigations have been conducted to gain experiences in irrigation of crops to maximize performances, efficiency and profitability. However, investigations in watersaving irrigation still are continued (Sleper et al., 2007). Full irrigation (FI) is used by farmers in non-limited or even water-limited areas. In this method, crops receive full evapotranspiration requirements to result the maximum yield. Nowadays, full irrigation is considered a luxury use of water that can be reduced with minor or no effect on profitable yield (Kang and Zhang, 2004). Water-saving irrigations are used to improve the water productivity (WP) in recent years. Deficit irrigation (DI) and partial root-zone drying irrigation are the water-saving irrigation methods that cut down irrigation amounts of full irrigation to crops. The amounts of irrigation reduction is crop-dependent and generally accompanied by no or minor yield loss that increases the water productivity (Ahmadi et al., 2010).

2.3 The Influence of Farmers' Training through FFS on On-Farm Tree Planting

2.3.1 Experimentation

The history of adult education has shown that adults learn best through hands-on experience and exposure to subject matter that relates closely and relevantly to everyday experience. This is the fundamental principal underlying FFS: it provide the setting and the materials for Farmers to explore and discover for them on the basis that knowledge actively obtained in this way will be more easily internalized, retained and applied after the training has finished. Field schools typically consist of once-weekly or once-fort- nightly meetings of half a day that run throughout the agricultural season. The field school environment can offer an extended training ground for new skills and new potential sources of income (Rola, Velthuizen, Jamias, Fischer and Quizon, 2002). The FFS spans the full season of a particular crop precisely so that farmers and facilitators can explore problems and opportunities that arise at different moments, from issues of seed health, soil fertility to disease management and harvesting to knowledge of markets. A season-long school can help urban farmers really confront the shifting and perhaps unfamiliar difficulties in the urban environment. As fields of participatory learning, FFS are excellent arenas for experimenting with new technologies. FFS started on the subject of Integrated Pest Management, but experiments on other subjects are ongoing. The specific conditions of urban farming, such as limited space, insecurity of tenure, poor soils, competing labour demands and so on require assessment of the best-bet crop management options. A stable means of conducting experiments through which farmers will themselves select the technologies best adapted to the circumstances is extremely important. Possible limitations on this involve the willingness and capacity of urban dwellers to overcome competing demands (Richards, 1985).

FFS focuses on building farmers' capacity to make well-informed crop management decisions through increased knowledge and understanding of the agro-ecosystem. FFS participants make regular field observations and use their findings, combined with their own knowledge and experience, to judge for themselves, what, if any, action needs to be taken. FFS follow a set curriculum that is determined by the priority constraints identified during needs assessment. FFS curricula do not promote recommendations; farmers are encouraged to experiment on their own farms and make their own decisions based on their observations and knowledge. FFS therefore encourages farmer experimentation as part of discovery learning, (David, Agordorku, Bassanaga, Couloud, Kumi, Okuku, Wandji, 2006). A study by Rhoades and Bebbington, (1991) shows that farmers experiment differs from formal agricultural research in several respects as farmers sometimes evaluate the performance of different technological options in a similar environment by conducting controlled experiments that compare treatments. For example, they may plant small areas to different varieties, which Rhoades and Bebbington (1991) call 'adaptation experiments'. This type of experiment is similar to formal agricultural research practice. Farmers also experiment on the interaction between one or more crops, pests and the environment, often on the whole plot. These 'problem-solving experiments' (Rhoades and Bebbington, 1991) help farmers understand how the agro-ecosystem functions.

In Nigeria, some farmers have learnt how to control variegated grasshoppers – an important pest of cassava – through experiments which involve marking and digging up egg-laying sites (Richards, 1996). Another example of this type of experimentation is the long-term observation of the effect of changing crop rotations in the same field. Normally, farmers' data collection methods are qualitative rather than quantitative, in the sense that they do not normally measure inputs and production systematically. For example, farmers rarely weigh the harvest to prove that a disease lowers yield, although they perceive these effects (Bentley, 1994). Farmers do not usually control non-experimental variables nor do they use repetitions to control for the effect of spatial and temporal variation. Farmers evaluate differences contextually – rather than using blocking to control for differences in soil type, they evaluate how the variation of soil in a field affects plant development and yield (Soniia, 2000).

Better internalization and retention of knowledge, attributed to the discovery learning process, coupled with social benefits of FFS training, are key justifications for the relatively high time, human and cost investments required to implement farmer field schools. A number of studies show the effectiveness of FFS as a training method by comparing knowledge test scores of FFS and non-FFS farmers (Mutandwa & Mpangwa, 2004; Godtland, Sadoulet, de Janvry, Murgai, & Ortiz, 2003; Rola, Jamias, & Quizon, 2002), but few empirical studies compare the technical knowledge of FFS graduates and farmers trained through conventional methods (Godtland et al., 2003).

Farmers evaluate the performance of a new technology in different locations or in time (Prain et al., 1992; Ashby et al., 1995). Just as serendipity often plays a role in formal research, farmers' experiments are sometimes accidental or fortuitous discoveries (Richards, 1996). In general, farmers do not record their data, nor do they undertake formal analysis but they remember results and subject them to continuous comparison with new observations. Farmers experimentation (like that of formal researchers) is limited by gaps in their knowledge (Bentley, 1994). They may not know, for example, how the different animals that comprise the stages in an insect life cycle are related to one another. They may draw the wrong conclusion about how a system functions, especially when the phenomena involved are difficult to observe and not of direct interest to them (Bentley, 1994). Finally, in terms of scale, farmer experimentation is local. Farmers are concerned with developing solutions that work under their particular conditions, and not with identifying options that can be adapted to other situations.

2.3.2 Experiments' Observation, Recording and Analysis

Central to the popularity of FFS programmes is an appropriate topic and methodological training of the people who organise and facilitate farmer field schools. To be a successful FFS trainer/facilitator, one must have skills in managing participatory, discovery-based learning as well as technical knowledge to guide the groups' learning and action process. Without an adequate training of trainers (ToT) programme, the subsequent FFS programme will fall far of its potential (Luther et al., 2005). Season-long in-house (residential), and field-based, training-of-trainers courses in which all activities should follow an experiential learning approach have proven to be an effective model for building the required technical capacity of trainers and for changing their attutudes towards that of facilitators of bottom-up change, whereby previous extension methodologies and lecture-type approaches conflicting with the FFS approach had to be essentially 'unlearned'.

FFS seek to improve farmers' problem solving abilities by sharpening their observational skills and decision-making ability rather than promoting "one fits all" recommendations, yet, most research on FFS focuses on adoption of practices and technologies and few studies assess the impact of FFS training on farmer experimentation, observational skills and problem solving abilities. Proponents of the farmer field school approach propose that social benefits and related spin-offs mitigate the relatively high investment costs. Notably, the social benefits of FFS include better communication skills and increased social capital as a means to collective action. The few empirical studies of social impacts of FFS show mixed results, with some studies, particularly in Africa, documenting greater group cohesion and leadership skills (Khisa, 2004; Mwangi, Onyango, Mureithi, and Mungai, 2003).

2.3.3 Decision Making

Complementary platforms for integrated decision-making in sustainable agriculture by Braun, Graham and Fernández, (2000) to examine the nexus between farmer field schools and local agricultural research committees found that both focus on identifying concrete solutions for local problems, but they apply different styles of experimentation and analysis; both increase the capacity of individuals and local groups for critical analysis and decision-making; and both stimulate local innovation and emphasise principles and processes rather than recipes or technology packages. Whereas FFS fill gaps in local knowledge, conduct holistic research on agro-ecosystems and increase awareness and understanding of phenomena that are not obvious or easily observable, their strength lies in increasing farmers' skills as managers of agro-ecosystems.

According to David et al (2006) on developement of a manual for Farmers Field schools in the production of Cocoa in Accra Ghana, observed that in understanding the FFS approach the farmers need knowledge of biological processes and agro-ecosystem analysis to be able to make sound management decisions. Their argument was that unless farmers understand how a disease is transmitted, they will not be motivated to do certain practices to avoid disease transmission. In cocoa producing countries, institutions specializing in cocoa have typically been responsible for cocoa extension.

With the decline of many of these institutions, cocoa extension has been turned over to national extension systems that are overburdened with providing extension services for a wide range of crops. The result is that in most cocoa producing countries, cocoa extension is inadequate at two levels i.e. there are too few extension agents to take on the task of providing extension advice and moreover, few have specialized training on cocoa. On the other hand, the training and visit approach typically used in cocoa In conclusion, the authors agree that important goals of FFS are to sharpen farmers' abilities to make critical and informed decisions that make their farming activities more profitable and sustainable and to train them to become experts on their own farms. These goals are achieved through doing Agro-ecosystem analysis (AESA) a tool or method used to observe interactions in the agro-ecosystem and to make decisions about overcoming problems observed which involves five steps: observe to know what is happening to the crop, learn to understand problems affecting the crop, interactions between disease and environmental conditions, pests and natural enemies, decide to take the best option to overcome the problems observed and act to implement the management decision chosen to overcome the problem observed. FFS helps farmers to understand the cocoa ecosystem and how to best manage their farms. It also helps them to understand the concept of systematic experimentation. Extension is inadequate to change farmers' practices or impart new knowledge.

Many extension scientists are now convinced that it is no longer desirable to use a transfer of technology approach in which the extension administrators decide on the target and subject matter content to be realized by field level extension. The challenge for extension has been to develop strategies and approaches for optimum involvement of the eventual users of the technology in the entire process, starting from the identification of a field problem to the actual generation of the possible solution. It has been suggested that extension organizations should come up with client oriented approaches rather than doing a "bulk delivery" of agricultural practices. The chances of adoption of any new technology increase considerably if its potential users are involved in its development from the very beginning. The same logic applies to the academic institutions in terms of following a "participatory curriculum development" approach which is now being implemented in many post-graduate degree programmes at leading universities around the world (Quamar, 2000). Therefore, a more participatory approach is preferred, in which farmers decide which changes are desirable and what kind of supports are needed from extension to realize these changes (Van den Ban, 2000).

2.4 Adoption of Suitable Tree Planting Systems

2.4.1 Homestead Planting

On-farm tree planting is defined as a dynamic, ecological based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustain production for increased social economic and environmental benefits for land users at all levels (Leakey, 1996). On-farm tree planting has considerable potential to contribute towards solving some of these problems. Home gardens (also known as homestead and mixed gardens and as compound farms) are usually located, where they exist at all, close to the household as one of the more intensively cultivated parts of the overall farm. They are characterized by a mixture of several or many annual or perennial species grown in association, and commonly exhibiting a layered vertical structure of trees, shrubs and ground-cover plants, which recreates some of the properties of nutrient recycling, soil protection and effective use of space above and below the soil surface to be found in forests (Fernandes and Nair, 1986). Home gardens are widely used to supplement outputs from other parts of the farm through the cultivation of a variety of other subsistence and commercial crops (Ninez, 1984).

2.4.2 Boundary Planting

Farm boundaries provide one of the most favourable and non competitive niches for trees. Multipurpose trees can be planted in rows or strips around farms, pastures and compounds to delimit boundaries and protect areas from animals and human encroachment. These boundary plantings also provide fuel wood, timber, fodder and act as wind breaks (Ssekabembe 1987). Spatial arrangement, width and orientation depend on the site, climatic variables and major production goals. Leucaena has been planted extensively on farm boundaries and home gardens for demarcation and wood production in many parts of Africa. Due to the fast growth of leucaena and the low management input requirements, boundary and home garden planting of leucaena has become the most important technology among the majority of rural farmers in Africa.

Trees planted along contours help in erosion control and band stabilization thus playing a major pole in conserving the natural resource base for sustainable production. Trees on boundaries also act as boundary markers which help to reduce land related conflicts in society. Trees planted along boundaries are very helpful in reducing the speed of wind (wind breakers). By so doing they minimize devastating effects of strong winds. This technology has a potential to answer some of the global environmental concerns. It can be used to reduce the green house/global warming effect which is threatening the very existence of mankind (Van et al.,1985).

2.4.3 Alley Cropping

Alley cropping or hedgerow intercropping is a form of on-farm tree planting practice in which perennial, preferably leguminous trees or shrubs are grown simultaneously with an arable crop. The trees, managed as hedgerows, are grown in wide rows and the crop is planted in the interspaced or 'alley' between the tree rows. During the cropping phase the trees are pruned and the pruning used as green manure or mulch on the crop to improve the organic matter status of the soil and to provide nutrients, particularly nitrogen, to the crop. The hedgerows are allowed to grow freely to shade the inter-rows when there are no crops. Alley cropping retains the basic restorative attributes of the bush fallow through nutrient recycling, fertility regeneration and weeds suppression and combines these with arable cropping so that all processes occur concurrently on the same land, allowing the farmer to crop the land for an extended period. The incorporation of woody species into crop production systems is one option that has received significant attention in recent years (Kang *et al.* 1990).

Nitrogen fixing trees, as a suitable or complements for chemical fertilizer, can increase smallholders’ income and improve food security. By providing supply of fuel wood from the farms, on-farm tree planting can reduce pressure on forests and communal lands. Moreover on farm trees can supply farm households with wide range of other products, including food, medicine, livestock feeds and timber for home use and sale. Other services that trees provide such as boundary markers, windbreaks, soil erosion barriers, beauty and shade, are none the less of substantial importance to farm families and for natural resource protection. One of the greatest challenges facing agriculture in the tropics is the need to develop viable farming systems for the rain-fed uplands that are capable of ensuring increased and sustained crop production with minimum degradation of the non-renewable soil resource base. Much of the agricultural land in the humid tropics is currently used for traditional farming based on the bush fallow. This is a low productivity but biologically stable system with long fallow periods that can sustain agricultural production for many generations (Kang and Wilson 1997). However, in many regions, shortening or abolition of the fallow period has resulted in increased land degradation, invasion by weeds and substantial crop yield decline. The use of fertilizers inputs alone has largely been ineffective in overcoming these problems (Lal and Greenland 2006), and there is a need to develop an integrated soil fertility management approach to address these issues. Suitable tree planting practices can be carried out through alley cropping, mixed cropping, farm woodlots establishment, boundary planting and many others.

2.4.4 Woodlot Establishment

Farm woodlots are small plantations of less than 10 ha, often much less, that are established by the individual farmer for the production of poles, fuel, fodder and possibly other products; multi-purpose trees are thus desirable. The products supply the farmer's own needs with excess for sale and such woodlots may be established on unused or degraded land with a view to rehabilitating it. On-farm tree planting can also be done through boundary planting. Boundary planting involves planting of multipurpose trees and shrubs (MPTS) around the farm to provide protection, privacy, and valuable products to the farmers. Trees are planted within property line as fence, or as demarcation of farm lots (Lulanala 1988).

Leucaena and other multipurpose trees can be planted in pure stands or plantations for wood and pole production (Brewbaker 1987). Woodlots provide practical and cost effective ways of tree integration into African farming systems. High biomass and wood yields ranging from 12 to 35 m^3/ha have been reported from two year old woodlots in an arid environment in Tanzania Woodlots, however, require large amounts of land and thus take land out of production from food crops and thus limit crop production in areas where land availability is a serious constraint. Rotational woodlots which involve low densities of trees 400-500 trees/ha and allow continuous integration of crops and animals provide a more practical alternative. Recent studies in the semi-arid areas in Shinyanga, Tanzania have shown that leucaena woodlots planted at 4 x 4 m spacing could support up to three continuous years of cropping while maintaining an excellent stand of trees (Otsyina et al 1994). Due to high coppicing ability, leucaena woodlots can be harvested in one to four year rotations to provide sustainable supplies of domestic fuel wood and timber. Four year old rotational woodlots of *Leucaena leucocephala* and *Acacia polyacantha* produced 10-15 tons/ha of fuel wood and poles. The fallow phase between tree rotations provides valuable fodder for livestock.

2.5 Summary of the Literature Review

The literature above has covered the issues surrounding the application of the Farmers Field School as an extension approach on on-farm tree planting to enhance production and improve on the farmers' sustainability in the agricultural sector. The major areas in this section are the ability of on-farm tree farmers to be engaged in participation technology development, training and adoption of suitable tree planting systems. Engagement of tree farmers in participatory technology development provides a forum to acquire and adopt new skills and techniques in tree production and management in their farms and other agricultural activities.

Training during FFS programmes provides farmers with capacity to make well-informed crop management decisions, making of regular field visits, use of their findings, knowledge and experience to make judgements within the context of what they have observed and come up with possible solutions and suggestions that are relevant to their experiences. It also entails to discovery learning, methods of mitigating of the cost of investments and adoption of new technologies in order to improve in tree planting.

Adoption of suitable tree planting systems includes alley cropping, woodlots establishment, boundary planting, silvopastural, mixed planting and windbreaks planting. These systems make use of nitrogen fixing trees that complements for use of chemical fertilizers, increase smallholders' income, conserve soil/water and improve food security. By providing supply of fuel wood from farms, on farm tree planting can reduce pressure on forests and communal lands. Moreover on farm tree planting trees can supply farm households with wide range of other products like food, medicine, livestock feeds and timber for home use and sale. Trees also provide other services such as boundary markers, windbreakers and soil erosion control barriers.

2.6 Conceptual Framework

The figure 1 presents the researcher's conceptualization of the study variables. The researcher intended to examine the relationship between the independent variables i.e participatory technology development , training and adoption of suitable tree planting systems and the dependent variables which is on-farm tree planting. Government policies and legislations were considered as the moderating variables while the weather conditions, political instability and the farmer's ownership of the approach were treated as the intervening variables.

The researcher argues that tree farmers in Mbeere District have adopted Farmer Field School as an extension approach to improve tree production in the district. However effective on-farm tree planting is dependent up on participatory technology development , training and adoption of suitable tree planting systems. For the farmers to effectively apply these techniques they must be able to work with the unreliable weather conditions, the political situation and must be in a position to accept and own the programs. These can be achieved with provision of proper policies and legislations by the government authorities.

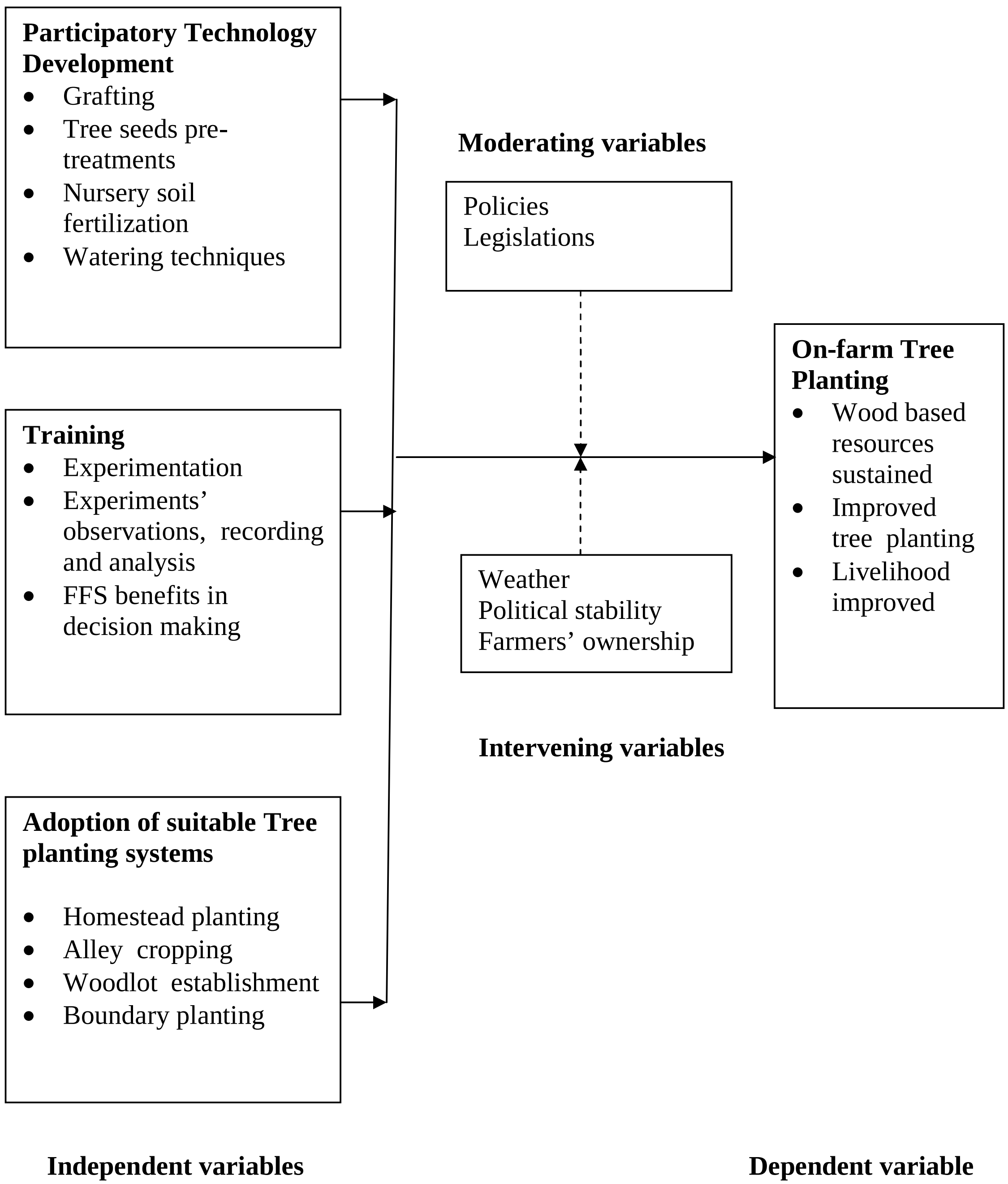

Figure 1: Conceptual Framework

CHAPTER THREE : RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology employed to achieve the study objective. It is broken into the study design, target population, sample size and sampling techniques used in the study. It also gives a brief description of the instrument used, its validity and reliability. Finally the chapter gives an insight on data collection procedures, data analysis techniques and presentation methods used.

3.2 Study Design

The study was carried out using descriptive survey design. This design was appropriate because it is relatively inexpensive and is useful in describing the characteristics of a large population (Grbich, 2007). This gives considerable flexibility to the analysis and standardization of questions and makes measurement precise by enforcing uniform definitions.

3.3 Target population

The study was carried out in Mbeere District and specifically targeted 1000 tree planting farmers according to the data obtained from the District Forest Officer. The data shows that 1000 tree farmers have been registered under various groups within the divisions in the district. There are 4 divisions within the district which are Gachoka, Siakago, Mwea and Everure with four registers bearing the names of registered tree planting farmers, (Mbeere District Forest Office, 2011).

3.4 Sample Size and Sampling Procedure

In addition to the purpose of the study and population size, the researcher was required to specify the sample size for the study from the target population. The sample size was drawn from the group registers which formed the sampling frame by employing stratified sampling technique. The farmers were stratified according to the Divisions in which the study adopted Grbich's (2007) recommendation of picking on sample of 10 % to 30 % for a study population of 1000 respondents and above by picking on 300 farmers to represent 30 % of the target population. The registered tree farmers from each division were divided based on their population representation (ratio) at the district level and therefore the sample was stratified as shown in table 3.1.

Table 3.1: Sampling Table

Division	Population Representation	Population Ratio	Sample Size	Percentage (%)
Gachoka	320	0.32	96	32
Mwea	285	0.285	85	28.5
Siakago	210	0.21	63	21
Everure	185	0.185	56	18.5
Total	**1000**	**1.00**	**300**	**100**

Simple random sampling technique was used to randomly select the respondents from the list of registered tree farmers (sampling frame) in each of the divisions which gave all the individuals in the defined sample size an equal chance of being picked as a respondent in the study (Orodho and Saleemi, 2009).

3.5 Research Instruments

The study employed the use of questionnaires as the research instrument. The questionnaires were used because they are convenient to use when handling a large group of respondents. The instrument consisted of both open and closed questions, (Scott, 2006). The questions in the instrument were of various types and included multiple choice, numeric open end and text open end, rating scales as well as agreement scales. The first section of the instrument carried questions on the demographic characteristics of the respondent involved in on-farm tree planting as a result of participating in FFS programmes in Mbeere District. This section contains data pertaining to level of education of the respondent, duration involved in tree planting, amount of land under tree planting and agricultural crops grown. The second section of the instrument focused on the study objectives which are participatory technology development, training and adoption of suitable tree planting systems.

3.6 Validity and Reliability of the Instrument

3.6.1 Validity

Validity is the appropriateness, meaningfulness and usefulness of the inferences a researcher makes. Validity therefore has to do with how accurate the data obtained in the study represents the variables of the study, (Cochran, 1993). To ascertain the content validity of the research instrument, the instruments were pre-tested in order to ensure that they yielded the required information during the survey through a pilot study by picking 3 respondents from each of the four divisions in the district.

The results of the pilot study were discussed with the respondents and the enumerators for correction of ambiguous and wrongly structured questions. This enabled the researcher to develop instruments that would yield valid, relevant and reliable data. After the pre-test, the questionnaires were revised to make it fully appropriate to collect the required data. The instruments were designed in a simple format to ensure ease of administration.

3.6.2 Reliability

Reliability refers to the consistency of scores or answers from one administration of an instrument to another and from one set of items to another, (Bishop, 2007) and the closer the value is to + 1.00, the stronger the congruence measure (Mugenda and Mugenda, 1999). The researcher employed the split half technique to ascertain the coefficient of internal consistency or reliability of the research instruments. To do this correction Spearman-Brown prophecy formula shown was used.

$$Pxx'' = 2Pxx'/1+Pxx'$$

Where: Pxx'' is the reliability coefficient for the whole test and Pxx' is the split-half correlation. Using the half-split method, the instrument was split into two tests by placing the even numbered and odd numbered ones into their sub-tests. The scores of all the odd and even numbered scores for all items were computed separately. Then the odd numbered scores for all items were correlated with the even numbered scores and a reliability coefficient of 0.8 was established which was above the recommended coefficient of 0.7 implying that the research instrument was reliable. This method is more practical in that it does not require two administrations of the same or an alternative form test.

3.7 Data Collection Procedures

After the approval of the proposal, the researcher obtained a research permit from the government to allow him collect the data. This was followed by making contacts with the forest extension officers in Mbeere District who were expected to guide the researcher on how to reach the respondents based on the 4 divisions in the district. At the divisional level the researcher was guided by the forest extension officers to the chiefs who were used to identify tree farmers in each of the division.

This was followed by identification of two young graduates as enumerators and trained them. The training of the enumerators and pre-testing of the research instrument took one week. After pre-testing various issues arising were incorporated into the instrument. Sampling was done and the data collection exercise commenced. The entire data collection exercise took approximately 3 weeks. After the data was collected, checking was done to check for obvious errors and inconsistencies. At the end of each day, the researcher would hold a brief meeting with the enumerators to review the day's experiences and also check the completeness and consistency of the data collected. At the same time all the questionnaires administered in a particular day were collected at the end of the day to avoid cases of alterations of the collected data.

3.8 Data Analysis Techniques

The collected data was both quantitative and qualitative in nature comprising of numeric and non-numeric types. Before the analysis, the data was prepared by checking the data for accuracy and entering the data into the computer. The raw data was appropriately coded in readiness for analysis in order to organize it and provide a means to introduce the interpretations into quantitative methods. It involved the researcher reading the data and demarcating segments within it. Each segment was labeled with a "code" – a word or short phrase that suggests how the associated data segments inform the research objectives. Descriptive statistics such as, frequencies, percentages, mode, means and standard deviations were used to analyze the data. This provided summaries about the sample and the measures. Statistical Package for Social Scientists (SPSS), Excel and Word computer packages were used in analyzing the data.

3.9 Operational Definition of Variables

Table 3.2: Operationalization of variables

Objective	Variable	Indicators	Measurement	Scale	Data Collection Method	Data Analysis
To establish the influence of participatory technology development as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere district.	Participatory Technology Development	Grafting method Tree seed pre-treatment Nursery soil fertilization method Watering techniques	No. of farmers adopting grafting method No. of farmers adopting the seed pre-treatment No. of farmers adopting nursery soil fertilization method No. of farmers using the watering techniques	Nominal Ordinal Nominal Ordinal	Questionnaire	Descriptive
To assess the influence of training as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere district.	Training	Experimentation Observations, records and analysis Participatory decisions	No. of farmers carrying out experiment No. of farmers making observations, recording and analyzing FFS benefits in decision making	Nominal Nominal ordinal	Questionnaire	Descriptive
To determine the influence of adoption of suitable tree planting systems as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District.	Tree planting systems	Tree planting systems Agreement levels Tree planting benefits	Methods of tree planting adopted Relevance of adoption of suitable planting trees systems Importance of tree farming to the farmers	Nominal Likert Ordinal	Questionnaire	Descriptive

CHAPTER FOUR :DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the research findings beginning with response rate and demographic information of the respondents. The other sub-sections were presented based on the study objectives. These were to establish the influence of participatory technology development, to assess the influence of farmers training through FFS and determine the influence of adoption of suitable tree planting systems as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District.

4.2 Response Rate

The first item on this section presented information on the response rate in table 4.1 per division

Table 4.1: Response Rate

Division	**Number of respondents**		**Non-response**	
	Frequency	**%**	**Frequency**	**%**
Gachoka	90	30	6	2
Mwea	83	28	2	0.7
Siakago	57	19	6	2
Everure	52	17	4	1.3
Total	**282**	**94**	**18**	**6**

The table 4.1 shows that after the data collection 282 questionnaires were filled and returned for analysis giving a response rate of 94 % and 6% non-response rate. These were distributed as 90 (30%) from Gachoka, 83 (28%) for Mwea, 57 (19%) from Siakago and 52 (17%) from Everure. This commendable response rate was realized as a result of the researcher's emphasis to the enumerators on maximizing on data collection and making follow ups to ensure that the data collection process was carried out as planned. Therefore for the purpose of analysis the sample size was taken as 282 (n).

4.3 Demographic Data Analysis

This section of the study sought information on the respondent's level of education, the duration of time they have been planting trees, the amount of land under tree planting and the other crops planted by the farmers other than trees. The responses were as follows.

4.3.1 Level of Education

The farmers' distribution based on their level of education was presented in table 4.2.

Table 4.2: Distribution of Farmers Based on Level of Education

Level of education	Frequency	Percentage (%)
Primary	174	61.4
Secondary	80	28.4
Tertiary	6	2.3
None	22	7.9
Total	**282**	**100**

There farmers' levels of education are very low with those who have basic primary education ranking highest at 61.4 %, followed by the secondary school category at 28.4 %. Those who have not gone to school at all were ranked at 7.9 % with the tertiary level being the lowest at 2.3 %. This implies that tree farmers are equipped with basic skills in agricultural management through elementary education and therefore on- farm techniques applied though FFS approach are quite appropriate and relevant to them at this stage as it goes a long way in empowering the farmers with knowledge and skills that are tailored towards tree farming though participation.

4.3.2 Duration in Tree Planting

The table presents information on the farmers' duration in tree planting.

Table 4.3: Farmers Duration in Tree Planting

No. of years	Frequency	Percentage (%)
< 1	99	35.2
1 - 5	85	30.7
5-10	71	25.2
10-15	24	8.0
0ver 15	3	0.9
Total	**282**	**100.0**

From the table 4.3, most of the farmers have been practicing tree planting for less than 1 year at a response rate of 35.2 %, they are followed by those who have been in the practice for 5 years at 30.7 %. Those who have been practicing tree planting for 10 years came third at a response rate of 25.2 % followed by the ones who have been in tree planting for 15 years at 8% while those who have been in the practice for over 15 years ranked lowest at 0.9 %. This implies that most of the farmers in the district have a relatively low experience in tree planting based on duration of the time they been in the practice.

4.3.3 Land Area Allocated for Tree Planting

Information on the land allocation by the farmers for tree planting was presented in table 4.4.

Table 4.4: Size of Land under Tree Planting

Amount of land in acres	Frequency	Percentage (%)
1-3	135	47.7
3-6	127	45.5
6-10	20	6.8
Total	**282**	**100.0**

A relatively high number of farmers have allocated a small piece of land for tree planting of 1-3 acres at a response of 47.7 %, this is closely followed by those who dedicated 3–6 acres of land for tree planting at a response rate of 45.5% with those who have allocated up to 10 acres of their land for tree planting ranking lowest at a response rating of 6.8%. This implies that most of the farmers do not have enough land for tree planting since the little they have they are mixing tree with agricultural crops like maize, beans, green grams, pigeon peas, cassava, bananas among others.

4.4 Participatory Technology Development

This section of the study sought information on the influence of participatory technology development on on-farm tree planting through tree nursery establishment, tree species raised methods of improving nursery soil fertility, seedlings production, seeds pre-treatment, grafting and watering techniques.

4.4.1 Tree Nurseries

The farmers were asked to indicate whether they have established tree nurseries. The response was presented in table 4.5.

Table 4.5: Establishment of Tree Nurseries

Response		Frequency	Percentage (%)
	Yes	149	53
	No	133	47
	Total	**282**	**100.0**

Most of the tree farmers Mbeere District have established their own tree nurseries at a response rating of 53 % while 47 % of the respondents have not. This is a clear indication that most of the farmers are directly applying the skills acquired through participation in FFS programmes by establishing tree nurseries in order to cut down on the costs incurred in the course of planting trees.

4.4.2 Tree species raised

Having indicated that they own tree nurseries, the next item sought to find out the tree species raised in the nurseries and the reason. The response was presented in table 4.6.

Table 4.6: Species of Trees Raised

Specie		Frequency	Percentage
Valid	Grevillea	88	31.2
	Eucaluptus	72	25.5
	Cassia siamea	42	14.8
	Mukau	80	28.5
Total		**282**	**100.0**

Grevillea seems to be the most preferred specie by the tree farmers in Mbeere District at a response rate of 31.2 %. This is because it can be pollarded and it has ability to coppice after cutting. During the dry season, the same tree species provide fodder for livestock.

Melia volkensii (Mukau) species comes second at a rate of 28.5%. It is preferred by farmers for its high quality timber production and it can be grown together with other agricultural crops. Eucalyptus is rated as the third preferred specie at a response rate of 25.5%. It is preferred by farmers for poles and timber production since it has the ability to coppice after cutting and its growth rate is quite high. Cassia siamea was the least preferred species at 14.8% but it is important for provision of shade since it is evergreen and its flowers are important for honey production.

4.4.3 Nursery Soil Improvement

The study then sought information on the methods used by the farmers to improve nursery soil fertility. The response was presented in table 4.7

Table 4.7: Methods of improving nursery soil fertility

Method	Frequency	Percentage (%)
Fertilizer	138	49
Compost manure	102	36
Livestock droppings	14	5
others	28	10
Total	**282**	**100**

Use of fertilizer for enriching nursery soils is the most preferred method at a response rate of 49%, this was followed by the use of compost manure at a rating of 36 %, 10 % of the farmers indicated that they use other methods while use of livestock dropping was ranked lowest at a response of 10%. This implies that most of the farmers in Mbeere District who are planting trees prefer to use fertilizer and compost manure for improving nursery soil fertility.

4.4.4 Tree Seedlings Production through Seeds

The study sought information on whether the respondents raised their seedlings through seeds. The response was presented in table 4.8.

Table 4.8: Raising of seedlings through seeds

Response	Frequency	Percentage (%)
Yes	264	94
No	18	6
Total	**282**	**100**

Most of the farmers observed that they raised seedling through seeds at a response rate of 94 % while 6 % of the farmers raised their seedlings through others means.

4.4.5 Fruit Tree Seedlings Production

The respondents were asked whether they raised fruit tree seedlings in their tree nurseries. The response was presented in table 4.9.

Table 4.9: Raising of Fruit Tree Seedling in the Nurseries

Response	Frequency	Percentage (%)
Yes	274	97
No	8	3
Total	**282**	**100.0**

The study found out that 97 % of the respondents are raising fruit tree seedlings while only 3% were not raising fruit tree seedlings in their nurseries. Fruit tree seedlings raised in the nurseries included mangoes, citrus and avocado.

4.4.6 Tree Seeds Pre-treatment

The respondents were asked whether they pre-treat tree seeds before sowing in the nursery. The response was presented in table 4.10.

Table 4.10: Pre-treatment of tree seeds

Response	Frequency	Percentage (%)
Yes	280	99.3
No	2	0.7
Total	**282**	**100.0**

The study found that 99.3 % of the respondents indicated that they pre-treat tree seeds before sowing while only 0.7 % were not pre-treating their seeds before sowing the in the nurseries.

4.4.7 Melia volkensii Seeds Pre-treatment

Based on the response above, the respondents were asked to indicate the methods they use to enhance Melia volkensii (Mukua) seeds germination. The response was presented in table 4.11

Table 4.11: Methods used to Enhance Mukua Seeds Germination

Methods	Frequency	Percentage (%)
Nipping and soaking in water	112	39.8
Soaking in water	93	33.0
Scarification	60	21.6
Partial burning	17	5.7
Total	**282**	**100.0**

Nipping and soaking of seeds in water is the most preferred methods of enhancing Mukau seeds germination at a response rating of 39.8%. This is followed by soaking of the seeds in water at a rating of 33%, scarification was third at a response rate of 21.6% and partial burning was the lowest at response rate of 5.7%.

4.4.8 Fruit Seedlings Grafting

The study sought information on whether the farmers grafted their seedlings in the nurseries. The response was presented in table 4.12.

Table 4.12: Fruit tree seedlings grafting

Fruit tree seedling grafting	Frequency	Percentage (%)
Yes	200	70.9
No	82	29.1
Total	**282**	**100.0**

The study found that 70.9 % of the respondents graft fruit tree seedling in their nurseries while 29.1 % do not practice this technology in their nurseries. Most of the farmers who are grafting their seedling in the nurseries got the expertise from FFS training sessions held in their areas.

4.4.9 Watering Techniques

The respondents were asked to indicate the methods they use for watering their out planted tree seedlings. The response was presented in table 4.13.

Table 4.13: Methods of Watering Out-planted Tree seedlings

Tree farming methods	Frequency	Percentage (%)
Bottle feeding	242	85.8
Dripping	36	12.8
Others	6	1.4
Total	**282**	**100.0**

From table 4.13, most of the farmers prefer bottle feeding method of watering their out planted tree seedlings at 85.8 % , dripping was rated second at a response rate of 12.8 % and 1.4 % of the farmers use other methods for watering .

4.5: The Influence of Training as on On-farm Tree Planting Extension Approach

This section of the study sought information on the influence of famers' training as an FFS extension approach on on-farm tree planting through experimentation, recording of observation, analysis, presentations and decision making.

4.5.1 Experimentation

The first item on training sought information on whether the farmers have participated in carrying out any experiments. The response was presented as shown in table 4.14.

Table 4.14: Farmers Participation in Experiments

Response	Frequency	Percentage (%)
Yes	274	97
No	8	3
Total	**282**	**100.0**

Most of the farmers agreed that they had participated in carrying out various experiments at 97 % while only 3% had not participated. The experiments were carried out at host's farm during the FFS training sessions to provide solutions affecting them in terms of the right species for firewood, timber, fodder, fruits, and poles among others.

4.5.2 Observations Recording, Analysis and Presentation

Further the farmers were asked to state whether they participated in recording the observation and analysis from the experiments carried out. They were also asked to state on how they present their findings. The response was presented as shown in table 4.15.

Table 4.15: Recording of Observations from the Experiments

Response	Frequency	Percentage (%)
Yes	282	100
No	0	0
Total	**282**	**100.0**

All the farmers indicated they make records of the observations obtained from the experiments carried out and analyze all the observation during the FFS trainings. Agro Ecosystem Analysis (AESA) involves observation of interaction between tree crop and other biotic / abiotic factors co-existing in the field. The observations are recorded in the AESA sheets whose findings are analyzed and presented to the farmers in form of bar charts, pie charts, graph and simple illustration to aid decision making.

4.5.3 Farmer Field School Training Benefits

To assess the benefits achieved by the farmers through FFS training in relation to participatory decision making, the researcher asked the respondents to rate their level of agreement with the benefits indentified in table 4.16 on an ordinal scale of 1 – strongly agree, 2- agree, 3- strongly disagree and 4- disagree.

Table 4.16: Benefits of FFS Training in Participatory Decision Making

Benefit in relation to participatory decision making	Modal choice	Frequency	Percentage
Take the right action to improve crop management	Strongly agree	280	99.1
Improve my understanding on on-farm tree planting	Agree	279	98.1
Make informed decisions based on the knowledge and experience acquired	Agree	281	99.6
Carry out experiments on my own and take action depending on observations made	Strongly agree	268	95.0
To improve my problem solving abilities through observation	Strongly agree	276	97.8
Develop a better internalization and retention of knowledge on tree planting	Strongly agree	279	98.9
Reduce the cost of investments since I can always make observations and come up with solutions without having to pay to get the solution	Strongly agree	277	98.2
improve on my ability to critically analyze a situation and develop social networks for consultations	Agree	278	98.5
Improved my skills in research on agricultural matters	Strongly agree	282	100
Been able to improve my understanding of agricultural phenomena that are not obvious and easily observable	Strongly agree	280	99.3

Through FFS training, the farmers indicated that they have been able to improve their decision making abilities by taking the right action to improve crop management at 99.1 % for those who strongly agreed, improving their understanding on on-farm tree planting at 98.1% for the ones who strongly agreed, making informed decisions based on the knowledge and experiences acquired at 99.6 %. Furthermore the farmers are able to carry out experiments on their own and take actions depending in the observations made at 95.0%, they have been able to improve problem solving abilities through observation at 98.9%, the farmers have been able to reduce on the cost of investments in tree planting at 98.2%, they have been able to develop social networks for consultation at 98.5% and improved the farmers skills carrying out research on agricultural matters and understanding on agricultural phenomena that are not obvious and easily observable at 100 and 99.3 % for those who strongly agreed.

4.6 Adoption of Suitable Tree Planting Systems

This section of the study sought information on the influence of adoption of suitable tree planting systems as an FFS extension approach on on-farm tree planting. The systems adopted included homestead planting, boundary planting, intercropping and woodlots establishment. Also the levels on agreements on adoption suitable planting systems and benefits associated were also sought.

4.6.1 Systems of Tree Planting

Table 4.17 presents information on the systems of combination of trees with other crops applied by the farmers.

Table 4.17: Systems of Tree Planting Employed

Tree Planting Systems	Frequency	Percentage (%)
Within the homestead	112	39.7
Along the boundaries	93	33.0
Intercropping with food crops	60	21.3
Woodlots	10	3.5
Others	7	2.5
Total	**282**	**100.0**

Planting of trees within homesteads seems to be the most preferred system by the farmers at a rating of 39.8 %, followed planting of tree along the boundaries at a response rate of 33 %, intercropping comes third at a response rating of 21.6 % and tree planting in woodlots came fourth at response rate of 3.5 %. Other tree planting systems was the least at response rate of 2.5%. Due to lack of enough land to dedicate for trees alone, farmers have resorted to utilizing the little land they have by planting trees mainly within their homesteads, along the boundaries and mixing trees with other crops**.**

4.6.2 Levels of Agreement with Adoption of Suitable Tree Planting Practices

The researcher created a series of statements reflecting on adoption of suitable tree planting practices as a result of participating on FFS programmes on a likert scale of 1 – completely disagree, 2- mostly disagree, 3- neither agree nor disagree, 4- completely agree, 5- mostly agree. The farmers were required to pick on one of the options on the scale to depict their level of agreement with the statements where these scores were summed to obtain the likert scores of each the farmers and an overall means score established for all the farmers depending on their response. The results were presented as shown in table 4.18.

Table 4.18: Adoption of Suitable Tree Planting Practices

Suitable tree planting systems	Mostly agree	Likert score	Mean	Stv. Dev
Adopt viable tree planting systems that are agreeable with climatic conditions in our areas	280	1400	4.9645	0.9923
Ensure increased practice in mixed farming	237	1185	4.2021	0.1245
Ensure minimum degradation of non-renewable soil resource base	278	1390	4.9297	0.8976
Sustain agricultural production for many generation	256	1280	4.53900	0.6754
Adopt methods of farming such as windbreaks, silvopasture, alley cropping and woodlots	281	1405	4.9823	0.3451

Adoption of tree planting systems such as windbreaks, silvopasture, alley cropping and woodlots establishment ranked highest which are adopted by the farmers at a means score of 4.9823 with a standard deviation of 0.3451, adoption of viable tree planting systems agreeable to climatic conditions in areas was ranked second at a mean rating of 4.9645 with a standard deviation of 0.9923, ensuring minimum degradation of non-renewable soil resource base was ranked third at a mean response rate of 4.9297 and a standard deviation of 0.8976, sustainability of agricultural production for various generations was ranked fourth at a mean of 4.53900 and a standard deviation of 0.6754 with increased practices in mixed farming ranking lowest at a mean score of 4.2021 and a standard deviation of 0.1245.

4.6.3 Benefits of Farmer Field School Extension Approach on On-farm Tree Planting

Asked to rank their responses based on the importance of FFS on on-farm tree planting systems in their farms, the farmers responded as shown in table 4.18.

Table 4.19: Importance of FFS on On-Farm Tree Planting Systems

Importance of on-farm tree planting systems	**1**	**2**	**3**	**4**	**5**	**Total**
Planting nitrogen fixing trees	3	8	12	25	234 (82.9%)	282
Forms a suitable compliment for chemical fertilizer	4	3	9	115	151 (53.5 %)	282
Acts a source of income for the farmers	0	3	0	23	256 (90.7 %)	282
Improves food security	0	0	0	0	282 (100 %)	282
Helps in conservation of soil and water	8	4	10	39	221 (78.3 %)	282
It is a source of fuel	0	0	0	35	247 (87.6 %)	282
Supplies the farmer with a wide range of other products	4	0	5	56	217 (77 %)	282
Acts as boundary markers, windbreaks, soil erosion barriers, beauty and shade	0	0	0	98	184 (65.2 %)	282

Key: 1- strongly disagree, 2- disagree, 3- neither agree nor disagree, 4- agree, 5- strongly agree

From table 4.18, most of the respondents strongly agreed that through FFS trainings there is improvement in food security in the district at 100 %, tree farming has increased the farmers’ sources of income at 90.7%, it is a source of fuel which is majorly firewood at 87.6 % and that trees are a good source of nitrogen for other plants at 82. 9%. Participation of the farmers in FFS programmes in the district has further help in understanding on conservation of soil and water at 78.3 % .Further the farmers strongly agreed that the trees harvested supplies them with a wide range of other products at 77%, it also act as a source of income for the farmers at a response rating of 67 % and boundary markers, windbreaks, soil erosion barriers, beauty and shade at 65.2 % with 53.5 % of the respondents strongly agreeing that trees form a very good compliment for fertilizer for the households.

CHAPTER FIVE:SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents discussion of the findings, conclusion and the recommendation for further research**.** This section presents the discussion of the findings of the study based on the three study objectives i.e. Influence of participatory technology development, farmer' training and adoption of suitable tree planting systems as Farmer Field School extension approaches on on-farm tree planting.

5.2 Summaryof the Findings

This section provides discussion of the findings of the study based on the three objectives i.e influence of participatory technology development, famers' training and adoption of suitable tree planting systems as FFS extension approaches on on-farm tree planting.

5.2.1: The Influence of Participatory Technology Development on On-Farm Tree Planting

The first objective of the study was to establish the influence of participatory technology development as a Farmer Field School extension approach technique on on-farm tree planting in Mbeere District. Results indicated that majority of tree farmers (61.4%) have basic primary education and they have been planting tree for a short period of less than 5 years (35.2%) with just a handful (30.7%) having participated in tree planting for up to 10 years. This shows that most of tree farmers in the district are new entrants in tree farming. The few (25.2%) who have been participating in tree planting for up to ten years were enrolled during the inception periods from 1998 when the extension approach was first piloted in the district through JICA. The results also indicates that most farmers (47.7%) have only allocated 1-3 acres of land for tree planting and a 45.5 % of farmers have allocated 3-6 acres for planting trees with crops implying that they do not have even enough land to dedicate for trees alone. The failure of farmers to put more land under tree planting can be attributed to inadequate land in the district. The other crops that are competing for space with the trees are maize, beans, green grams, pigeon peas, cassava, bananas. This means that although the farmers have embraced FFS to boost their tree planting techniques, contrary to the expectations tree planting has not gone up in the district.

The study found out that most of the tree farmers have adopted participatory technology development with 53% having established their own tree nurseries. Through this, they are able to reduce on the costs incurred in planting of the trees since they do not have to buy from other sources and can easily exchange with their colleagues in case they do not have certain species. The farmers who have own tree nurseries also provide markets for the others who are not engaged in the same business and at the same this acts as a source of income. This is in agreement with Rogers (1995) who argues that well-targeted agricultural research on a regional basis can potentially reduce the production cost per unit of output, increase the output of marketable produce especially in nutrient deficient soils, increase supply of better quality wood for local processing, increase rural households demands for farm and non-farm products, increase on-farm employment opportunities, increase foreign exchange income at the country level, and generate savings for smallholders.

Through use of technology, the farmers are raising Grevillea robusta (31.2 %) as the best tree species because of its ability to be pollarded, high growth rate, provision of fodder to livestock and it is a nitrogen fixer. Melia volkensii (Mukua) is the second (28.5%) major tree species for timber, eucalyptus for poles and Cassia siamea for shade. Generally, trees are mainly used for firewood and timber while others are meant for shades within the homesteads and fodders for their domestic animals. Trees are also used as building materials and seen as source of income for the farmer through the sale of their products within and outside the district.

To reduce the cost of tree seedlings production in the nurseries, the farmers are using innovation for nursery soil fertility improvement through use of composting (36%) beside use of chemical fertilizer (49%). To enhance tree seedlings production in the nurseries, majority of farmers (94%) are using seeds and pre-treating them to promote germination. To improve the quality of fruits production in the district and earn more returns from fruit orchards, most of the farmers (70.9%) are grafting their fruit tree seedlings.

Since the district doesn't receive adequate amount of annual rainfall, tree farmers are using bottle feeding (85.8%) and dripping (12.8%) as watering techniques to enhance survival of the out-planted tree and fruit seedling to realize good returns from the investment. This is in agreement with OECD (1999) who defines innovation as the ability to use knowledge creatively in response to market opportunities or other social needs.

FFS as an extension approach has provided farmers in Mbeere District with new skills and experiences on how to better manage agricultural products and how to improve on their socio-economic activities to improve their lives. This is in agreement with Van Den Ban's (2000) argument that innovations emerge from interactive learning among different social actors of knowledge system operating together.

5.2.2 The Influence Farmers' Training on On-Farm Tree Planting

The second objective of the study was to assess the influence of farmers training as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere district.FFS focuses on building farmers' capacity to make well-informed crop management decisions through increased knowledge and understanding of the agro-ecosystem.

The study found out that most of the farmers (97%) in the district were involved in carrying out various experiments during FFS sessions to come out with solutions for the problems affecting them. These experiment ranges from seeds germination test, tree species selection, soil fertility, growth rates and grafting. Through experimentation, the farmers have been able come out with solution for problems affecting them in terms of firewood, timber, poles, fodder, soil fertility, shade, fruits among others. According to David et al (2006) FFS curricula do not promote recommendations; farmers are encouraged to experiment on their own farms and make their own decisions based on their observations and knowledge. FFS therefore encourages farmer experimentation as part of discovery learning.

The study also found out that all the farmers (100%) had made records of observation, analysed finding and made presentation. According to the study, 97.8 % of the farmers are able to improve their problem solving ability through observation. This is in agreement with Prain *et al* (1992) that FFS seek to improve farmers' problem solving abilities by sharpening their observational skills and decision-making ability rather than promoting "one fits all" recommendations.. Furthermore 95% of the farmers are able to carry out experiment on their own and take actions depending on observations made.

Through the FFS training, 99.6 % of the tree farmers are able to make informed decisions based on the knowledge and experience acquire. FFS curricula provides for Agro Ecosystem Analysis (AESA) that involves observation of interaction between tree crop and other biotic/abiotic factors co-existing in the field. The observations are recorded in the AESA sheets whose findings are analyzed and presented to the farmers in form of bar charts, pie charts, graph and simple illustration to aid decision making. Prain *et al* (1992) argues that farmers are also able to carry out experiments on their own and take appropriate actions depending on the outcome of the experiments and observations made which has gone a long way in reducing on the costs incurred in the course of sourcing for such services from experts.

Participation of the farmers in FFS has been very beneficial and has enable farmers take the right actions on crop management, have more understanding of on-farm tree planting techniques and making of informed decisions as a result of the knowledge and experiences acquired during the training sessions. This agrees with Van *et al* (2004) that more participatory approach is preferred, in which farmers decide which changes are desirable and what kind of supports are needed from extension to realize these changes.

Through FFS as an extension approach, farmers are able to select tree species depending on the various uses in which they can utilize. For instance Grevillea robusta is suitable because of its high growth rate, ability to be pollarded beside other benefits, Eucalyptus is best used for poles because of its ability to coppice, straight bole and high growth rate. Melia volkensii (Mukau) is best known for its high quality timber while Cassia siamea is used for shade since it doesn't shade leaves and it grows fast. This is in agreement with Mutandwa & Mpangwa (2004) that better internalization and retention of knowledge, attributed to the discovery learning process, coupled with social benefits of FFS training, are key justifications for the relatively high time, human and cost investments required to implement farmer field schools.

5.2.3 The Influence of Adoption of Suitable Tree Planting Systems

The last objective of the study sought to determine the influence of adoption of suitable tree planting systems as a Farmer Field School extension approach technique on on-farm tree planting by farmers in Mbeere District**.** The study found out that majority (39.7%) of tree farmers in Mbeere District prefers planting the tree within their homesteads to provide shade and improve aesthetic value. The tree also acts as habitats for birds and insects which are very useful during crop pollination which enhances agricultural production.

Boundary planting was another suitable system of tree planting adopted by 33.0% of the farmers in the district where trees are planted in rows along farm boundaries thus acting as "live fences". They are very useful in protecting the farms against air erosion and protection of other crops within the farms since they act as wind breakers and prevent the farms from encroachment by neighbors. In addition the trees also provide the farmers with fodder, fuel wood and timber besides providing shade to the crops.

The study also found out that 21.3 % of the farmers plant trees together with agricultural crops in a mixed system. Through this system the trees provide nourishment for the crops by improving soil fertility through the natural processes and hold soil in place to control soil erosion and protection of crops from strong winds .Alley cropping is one of the mixed tree planting system adopted by the farmers where perennial leguminous trees or shrubs are grown simultaneously with arable crops. The benefits derived from this system include soil fertility improvement, shade to crops, and fodder for livestock among others. Lal & Greenland (2006) argues that there is a need to develop an integrated soil fertility management approach to address these issues.

Woodlots establishment as a form tree planting system was adopted by 3.5% farmers who had established small plantations of less than 10 ha for production of poles, fuel wood and timber. Very few farmers in the district had dedicated farms for woodlots establishment due to scarcity of land. Leakey (1996) defined on-farm tree planting as a dynamic, ecological based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustain production for increased social economic and environmental benefits for land users at all levels.

On suitable tree planting systems, statements reflecting the adoption of this system were put on a likert scale and tree farmers had adopted windbreak planting, alley copping, woodlot establishment and Silvopasture tree planting systems with mean of 4.9823. The tree farmers were in agreement that the planting systems adopted ensure minimum degradation of renewable soil resource base with mean of 4.9645. This shows that the farmers are embracing tree planting systems that promote tree on farm tree planting which contributes towards meeting their requirement in terms of various tree products and at the same time ensure soil and water is conserved for agricultural production sustainability.

In addition, the study found out that 82.9% of the farmers practiced various tree planting systems in the district and had benefited from nitrogen fixation into the soil to improve on soil fertility. Nitrogen fixing trees like Grevillea robusta is a suitable tree species that complements for chemical fertilizer, can increase smallholders’ income, and improve food security. The tree plantings systems adopted had improved 90.7% of farmers’ lifestyles through their increased income accrued from sale of seedlings, timber, building poles and firewood. This is in agreement with Kamfor (2000) that on-farm tree planting plays a significant role in the provision of forest goods and services while supplementing wood supply from state forests. It is estimated that 24 million cubic meters of fuel wood materials worth Ksh.4.8 billion is sourced from farmlands annually.

The study also found out that 100% of the farmers had their food security improved since tree planting practice improve soil fertility , conserve soil and water and in the overall increase crops production in their farms. Lastly, 87.6% of the farmers source their fuel wood from the various tree planting systems they had adopted which includes woodlot establishment, boundary planting, alley cropping, and homestead and mixed planting. This in agreement with Kamweti (1981) that on-farm tree planting plays a significant role in the provision of forest goods and services while supplementing wood supply from state forests.

5.3 Conclusions

From the findings, the study concludes that FFS an extensions approach has promoted the use skills and knowledge in on-farm tree production in Mbeere District. The farmers have been empowered in terms of technology uptake to aid enhancement of tree planting and management and other forms of agricultural techniques like grafting of fruit tree seedlings. Through training, the farmers have been provided with the necessary capacity to make participatory decisions and come up with solutions for the problems affecting them. By adopting suitable tree planting systems, the farmers have been able to be self sufficient in terms of tree products. Through sale of various tree products the farmers have been socio-economically empowered. The farmers have further been able to improve on soil and water conservation in the region which has led to increased food production. However the farmers' ability to expand on on-farm tree planting in the district has been constrained by lack of enough land for expansions as most of them rely on their family lands which can hardly allow massive investment in tree planting.

5.4 Recommendations

Based on the findings, the study recommends the following:

1. Kenya Forest Service and other line ministries should find ways of encouraging more participation of farmers in FFS training sessions so as to increase tree planting which is recommended as form of agricultural land conservation, improving on the climatic conditions and ensuring sustainable food security in the district and the country as a whole.
2. The tree farmers in the district should consider acquiring more land in order to provide more spaces for tree planting. This can be done by getting more land outside their ancestral boundaries. As such more trees will be planted to diversify on the benefits accrued from tree planting.
3. The government should find better ways of providing incentives to farmers to invest more on on-fam tree planting.
4. Key line ministries should provide the farmers with more training opportunities on other agricultural crops/livestock to assist the farmer in diversifying their efforts.

5.5 Recommendations for Further Studies

1. The effect on FFS methodology on the performance of food crops in Mbeere district.
2. The perception of farmers on FFS as an extension approach verses traditional farming.
3. A comparative analysis of agricultural production between FFS participants and non-FFS members.

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APPENDICES

Appendix 1: Letter of Transmission

David Ng'ang'a Kuria
C/o University of Nairobi,
School of Continuing and Distance Education,
Department of Extra-Mural Studies

Dear Respondent,

RE: REQUEST TO FILL QUESTIONNAIRES

I am a University of Nairobi student undertaking a Masters of Arts degree in Project Planning and Management. As part of the requirements for the course I am carrying out a study on influence of extension approaches on on-farm tree planting, a case of FFS in Mbeere district. I believe the study will go a long way in improving on-farm trees production so as to ensure maximum benefits to tree farming communities.

I am interested in your opinions and suggestions. Although I understand that your schedule is busy, I am hoping that you will take the little time required to respond to the questions contained in the questionnaire. I want you to know that your responses will be of great value to the completion of this study.

Please note that all the information provided will be treated with a lot of confidentiality and will only be used for the purposes of this study.

Yours sincerely,

David Ng'ang'a Kuria

Appendix 2: Questionnaire for the Tree Farmers

Serial No……………

Section 1: Bio Data

1. What is the level of your education?

a) Primary b) Secondary c) Tertiary d) University e) None

(Tick where applicable)

2. How long have you been planting trees?

a) Less than 1 year b) 1 – 5 years c) 5 – 10 years d) 10 – 15 years e) over 15 years

(Tick where applicable)

3. What is the amount land under tree planting?

a) Less than 1 acre b) 1 – 3 acres c) 3 – 6 acres d) 6 – 10 acres e) over 10 acres

(Tick where applicable)

4. Other than trees which other crops do you plant?

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

Section 2: Participatory Technology Development

1. Do you have a tree nursery? (a) Yes [ ] (b) No [ ]

(Tick where applicable)

If yes, what are tree species raised in the nursery and why?

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

2. What do you use to improve the nursery soil?

a) Fertilizer [ ] b) Compost manure [ ] c) Livestock droppings [ ]

d) Others [ ]

(Tick where applicable)

3. Do you raise your seedlings through seeds? (a) Yes [ ] (b) No [ ]

(Tick where applicable)

4. Do u pre-treat tree seeds before sowing in the nursery? (a) Yes [ ] (b) No [ ]

If yes, which method do you use to enhance Melia volkensii (Mukau) seeds germination?

a) Soaking in water [ ] b) Nipping and soaking in water [ ] c) Scarification d) Partial burning [ ]

(Tick where applicable)

5. Do you raise fruit tree seedlings in your nursery? a) Yes [ ] b) No [ ]

(Tick where applicable)

If yes, which types? Specify……………………………………………………………

6. Do you graft your fruit tree seedlings in the nursery a) Yes [ ] b) No [ ]

(Tick where applicable)

If yes, where did you have the expertise from? Specify………………………………

7. What is the best method that you use for watering out planted tree seedlings?

a) Bottle feeding [ ] b) Dripping [ ] c) Others [ ]

(Tick where applicable)

Section 3: Training

1. During the FFS training, did you participate in carrying out experiments?

Yes [ ] No [ ]

(Tick where applicable)

2. If yes, specify……………………………………………………………………….

…………………………………………………………………………………………….

3. During the FFS training, did you participate in recording of experiments' observations and analysis of the findings?

Yes [ ] No [ ]

(Tick where applicable)

If yes, on what records? Specify……………………………………………………………

4. If yes, how were the findings presented? ....

……………………………………………………………………………………………

………...

5. From the experiments you carried out during the fields sessions, are you able to

Key: 1 – strongly agrees, 2- agree, 3- disagree, 4 – strongly disagree

Participatory decision making as a result of FFS	**1**	**2**	**3**	**4**	**5**
Take the right action to improve crop management					
Improve my understanding on on-farm tree planting					
Make informed decisions based on the knowledge and experience acquired					
Carry out experiments on my own and take action depending on observations made					
To improve my problem solving abilities through observation					
Develop a better internalization and retention of knowledge on tree planting					
Reduce the cost of investments since I can always make observations and come up with solutions without having to pay to get the solution					
improve on my ability to critically analyze a situation and develop social networks for consultations					
Improved my skills in research on agricultural matters					
Been able to improve my understanding of agricultural phenomena that are not obvious and easily observable					

Section 4: Adoption of Suitable Tree Planting Systems

1. Which tree planting system do you use in your in your farm? a) Homestead planting [ ] b) mixed planting with other crops [ ] c) Boundary planting [ ] d) In woodlots establishment [ ] e) Others [ ] Specify………………………………………………..…… (Tick where applicable)

2. Through FFS programme, you are able to:

Key: 1 – completely disagree, 2- mostly disagree, 3- neither agree nor disagree, 4- completely agree, 5- mostly agree.

Suitable tree planting systems	**1**	**2**	**3**	**4**	**5**
Adopt viable tree planting systems that are agreeable with climatic conditions in our areas					
Ensure increased practice mixed farming					
Ensure minimum degradation of non-renewable soil resource base					
Sustain agricultural production for many generation					
Adopt methods of farming such as windbreaks, silvopasture, alley farming and woodlots					

3. On a likert scale of 1 – 5, rank the following items on the importance of FFs on on-farm tree practices:

Importance of FFS on On-tarm tree planting	**1**	**2**	**3**	**4**	**5**
Planting nitrogen fixing trees					
Forms a suitable compliment for chemical fertilizer					
Acts a source of income for the farmers					
Improves food security					
Helps in conservation of soil and water					
It is a source of fuel					
Acts as boundary markers, windbreaks, soil erosion barriers, beauty and shade					
Supplies the farmer with a wide range of other products					

Key: 1- strongly disagree, 2- disagree, 3- neither agree nor disagree, 4- agree, 5- strongly agree