IMPACT OF AGROFORESTRY ON FARM PRODUCTION AND HOUSEHOLD FARM INCOME: CASE STUDY OF KAKAMEGA DISTRICT, KENYA.

KORIR, HILLARY K.

A Thesis submitted to the Graduate School in partial fulfilment for the requirements of the degree of Master of Science in Natural Resource Management in the Department of Natural Resources of Egerton University.

EGERTON UNIVERSITY

July 2002

EGERTON UNIVERSITY LIBRARY

Eger242916

APPROVAL PAGE

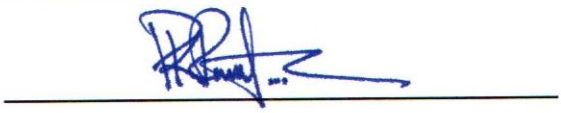
Approval by Supervisors

This thesis was submitted for examination with our approval as University supervisors.



Prof. A.A. Aboud

Date: 12-8-2002

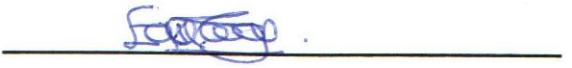


Dr. P. K. Rono

Date: 12/8/2002

DECLARATION

This thesis is my original work and has not been submitted to any university for award of a degree or diploma.



Korir Hillary, K.

Date: 22-08-2002

COPYRIGHT

No part of this thesis may be produced, reproduced, stored in any retrieval system, or transmitted in any form or means; electronic, mechanical, photocopying, recording or otherwise without prior written permission from the author or Egerton University.

DEDICATION

This thesis is dedicated to my parents.

ACKNOWLEDGEMENT

I am highly indebted to Egerton University for having given me the opportunity to undertake masters studies in Natural Resources at the institution. Special thanks go to the Graduate School for their guidance, patience and support throughout the study period.

Secondly, my gratitude goes to Professor A.A. Aboud of the Faculty of Environmental Studies and Natural Resources, Egerton University, and Dr. P.K. Rono of the Department of Sociology, Moi University for providing the necessary guidance and supervision right from the initiation of the study to its completion. Special thanks go to Dr. Philip K. Rono for his financial support through a Rockefeller funded project, without which the study would not have been possible.

I am thankful to the following members of staff in the Department of Natural Resources who sacrificed their time and offered constructive ideas and criticism to the research idea: Dr. M. Karachi, Mr. B.J.M. Ngoda, Mr. S.K. Inoti, and Mr. G.O. Obwoyere. I am also grateful to Dr. F.N. Wegulo of Department of Geography and Director, School of Continuing Education for his guidance and unlimited support in providing the logistics that ensured success in data collection.

Last but not least, I would like to extend my special thanks to my elder brother Dr. T.K. Serrem and his family for their continuous encouragement and material support that has made this study a success.

ABSTRACT

Agroforestry holds an enormous potential for augmenting critical development and ameliorating environmental problems in Kenya. As a land use system that combines the production of food, livestock, and forest products, preferably on the same piece of land on a sustained yield basis, agroforestry offers potential for enhancing farm production and household farm income, while at the same time reducing the increasing conflicts between arable farming, livestock keeping, and forestry interests, especially in the high-potential areas that are facing intense population pressure. Most research and analysis of agroforestry systems have dealt with biophysical aspects, with little attention given to farmer utilization of agroforestry technologies to improve farm production and household farm income leading to enhanced household socioeconomic status. The study examined the impact of adoption of agroforestry technologies on farm production, household farm income, and as intermediaries the constraints to adoption of agroforestry technologies by farmers in Navakholo and Shinyalu Divisions of Kakamega District. Data was collected using a questionnaire survey of 241 randomly sampled households. The data was subjected to statistical analysis using the statistical package for the social sciences (SPSS) computer programme. Qualitative treatment of data involved the use of frequency distributions, measures of central tendency, and dispersion. Correlation and regression analyses were run to determine any significant relationships between the study variables, namely; the adoption of agroforestry technologies, farm production, household use of multipurpose trees and shrubs (MPTs), household farm income, and constraints to adoption of agroforestry technologies by rural farmers. The results showed significant relationships between adoption of agroforestry technologies and farm production (β = 0.152, $p < 0.05$), adoption of agroforestry technologies and household farm income (β = 0.250, $p<0.001$), household use of MPTs and household farm income (β = 0.532, $p<0.001$), and a negative but not significant relationship between constraints to adoption of agroforestry technologies and adoption of agroforestry technologies (β = -0.22, $p>0.05$). It was concluded that agroforestry is an important variable in enhancing farm production and household farm income through increased household use of MPTs, and thus improved household socioeconomic status in Kenya.

TABLE OF CONTENTS

APPROVAL PAGE ii
DECLARATION iii
COPYRIGHT iv
DEDICATION v
ACKNOWLEDGEMENT vi
ABSTRACT vii
TABLE OF CONTENTS viii
LIST OF TABLES xi
LIST OF FIGURES xii
LIST OF ACRONYMS AND ABBREVIATIONS xiii
CHAPTER ONE: INTRODUCTION 1
1.0 BACKGROUND TO THE PROBLEM 1
1.1 STATEMENT OF THE PROBLEM 2
1.2 RESEARCH OBJECTIVES 4
1.3 RESEARCH HYPOTHESES 4
1.4 STUDY JUSTIFICATION 5
1.5 DEFINITIONS 7
CHAPTER TWO: LITERATURE REVIEW 9
2.0 INTRODUCTION 9
2.1 TYPES OF AGROFORESTRY PRACTICES AND FARMER ADOPTION 12
2.1.1 Dispersed Trees on Cropland: 12
2.1.2 Contour Vegetation Strips: 13
2.1.3 Alley Cropping: 13
2.1.4 Trees in Home Gardens: 14
2.1.5 Improved Fallows: 15
2.2 FACTORS THAT DETERMINE FARMER ADOPTION OF AGROFORESTRY PRACTICES 16
2.3 SOCIOECONOMIC BENEFITS OF AGROFORESTRY 18
2.4 USE OF MULTIPURPOSE TREES AND SHRUBS IN AGROFORESTRY 21

2.5 CONSTRAINTS TO AGROFORESTRY TECHNOLOGY ADOPTION ..21
2.5.1 Socioeconomic Constraints ..22
2.5.2 Socio-cultural Constraints..23
2.5.3 Technological Constraints ..26
CHAPTER THREE: RESEARCH METHODOLOGY ..27
3.0 INTRODUCTION..27
3.1 LOCATION AND SIZE OF THE STUDY AREA..27
3.2 KAKAMEGA DISTRICT AGRO-ECOLOGICAL ZONES..31
3.3 PHYSICAL ASPECTS OF THE STUDY AREA..33
3.3.1 Climate ..33
3.3.1.1 Rainfall..33
3.3.1.2 Temperature ..34
3.3.2 Soils..35
3.3.3 Topography..37
3.4 POPULATION PROFILES ..38
3.4.1 Population Size ..38
3.4.2 Population Distribution and Density ..39
3.4.3 Population Structure..41
3.5 RESOURCE EXPLOITATION..42
3.5.1 Forestry and Agroforestry ..42
3.6 THEORETICAL /CONCEPTUAL FRAMEWORK..44
3.7 DEFINITION AND MEASUREMENT OF VARIABLES ..46
3.7.1 Adoption of Agroforestry Technologies..46
3.7.2 Household Farm Income ..47
3.7.3 Household Use of MPTs..48
3.7.4 Constraints to Adoption of Agroforestry Technologies..50
3.7.5 Farm Production ..52
3.8 RESEARCH DESIGN, SAMPLE FRAME AND SAMPLE SIZE..53
3.9 SOURCES OF DATA AND DATA COLLECTION ..54
3.9.1 Limitations in Data Collection ..55
3.10 METHODS OF DATA ANALYSIS ..56
CHAPTER FOUR: RESULTS..59
4.0 DESCRIPTIVE ANALYSES ..59
4.0.1 Socioeconomic Characteristics of the Households..59

4.0.2 Agroforestry Activity 62
4.0.3 Adoption of Agroforestry Technologies 69
4.0.4 Farm Production 69
4.0.5 Household Farm Income 70
4.0.6 Household Use of MPTs 71
4.0.7 Constraints to Adoption of Agroforestry Technologies 71
4.1 ANALYTICAL RESULTS AND HYPOTHESES TESTING 72
4.1.1 Measurement of Direction and Strength of Relationships 72
4.1.2 Prediction of Direction of Relationships 74
4.1.2.1 Relationship between Adoption of Agroforestry Technologies and Farm Production 74
4.1.2.2 Relationship between Adoption of Agroforestry Technologies and Household Farm Income 75
4.1.2.3 Relationship between Household Use of MPTs and Household Farm Income 76
4.1.2.4 Relationship between Constraints to Adoption of Agroforestry Technologies and Adoption of Agroforestry Technologies 77
4.1.3 Contribution of Independent Variables on the Dependent Variable 78
CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS 81
5.1 DISCUSSION 81
5.1.1 Adoption of Agroforestry Technologies 81
5.1.2 Household Use of MPTs 84
5.1.3 Farm Production 85
5.1.4 Household Farm Income 89
5.1.5 Constraints to Adoption of Agroforestry Technologies 91
5.2 CONCLUSION 93
5.3 RECOMMENDATIONS 94
5.4 FUTURE RESEARCH 96
REFERENCES: 97
APPENDICES 106
APPENDIX 1 RESULTS OF BI-VARIATE REGRESSION ANALYSIS 106
APPENDIX 2 RESULTS OF STEPWISE REGRESSION ANALYSIS 110
APPENDIX 3 SURVEY QUESTIONNAIRE 112

LIST OF TABLES

Table 1 Area of the District by Division 28
Table 2 District Population by Divisions 39
Table 3 Navakholo Population by Location and Sub-Location 40
Table 4 Shinyalu Population by Location and Sub-Location 41
Table 5 Scores for Degree of Use of MPTs 48
Table 6 Scores for Economic Contribution of MPTs 49
Table 7 Scores for Annual Cash Income from MPTs 49
Table 8 Scores Used for Technological, Socioeconomic, and Socio-cultural Constraints 51
Table 9 Respondents by Sex 59
Table 10 Categories of Respondents by Marital Status 59
Table 11 Categories of Respondents by Occupation 60
Table 12 Categories of Respondents by Land Ownership 61
Table 13 Education Level of Respondents 61
Table 14 Major Types of Agroforestry Technologies Utilized by Respondents 62
Table 15 Uses of MPTs by the Respondents 63
Table 16 Negative effects of MPTs on farms 63
Table 17 MPTs Utilized by the Respondents on Their Farms 64
Table 18 Crop Production in Navakholo and Shinyalu Divisions 65
Table 19 Tree Production in Navakholo and Shinyalu Divisions 65
Table 20 Use of Excess Tree Products by the Households 66
Table 21 Household Income from Crops 67
Table 22 Household Income from MPTs Products 67
Table 23 Technological Constraints 68
Table 24 Socioeconomic Constraints 68
Table 25 Socio-cultural Constraints 69
Table 26 Adoption of Agroforestry Technologies in Navakholo and Shinyalu Divisions 69
Table 27 Farm Production in Navakholo and Shinyalu Divisions 70
Table 28 Household Farm Income in Navakholo and Shinyalu Divisions 70
Table 29 Extent of Household Use of MPTs in Navakholo and Shinyalu Divisions 71
Table 30 Degree of Constraints to Agroforestry Adoption in Navakholo and Shinyalu Divisions 71
Table 31 Variables Entered for Correlation Analysis 72
Table 32 Matrix for Pearson Correlation Coefficients (r), 1-Tailed Sig. ... 73
Table 33 Results of Bi-variate Regression Analysis 74
Table 34 Results of Multiple Regression Analysis 79

LIST OF FIGURES

Figure 1 Location of Kakamega District in Kenya..... 29
Figure 2 Kakamega District. 30
Figure 3 Kakamega District Agro-ecological Zones. 32
Figure 4 Theoretical Path Model for the Study. 44

LIST OF ACRONYMS AND ABBREVIATIONS

ACTS	-African Centre for Technology Studies
FAO	-Food and Agricultural Organization of the United Nations
GoK	-Government of the Republic of Kenya
ICRAF	-International Centre for Research in Agroforestry
KEFRI	-Kenya Forestry Research Institute
KENGO	-Kenya Energy Non-Governmental Organizations Association
Kshs	-Kenya shillings
MPTs	-Multipurpose Trees and Shrubs
p.a.	-Per Annum
REAFADOP	-Agroforestry Technology Adoption Index
RECOAFAD	-Constraints To Agroforestry Adoption Index
REFARMIN	-Household Farm Income Index
REFARPRO	-Farm Production Index
REUSEMPT	-Household Use of MPTs Index
SPSS	-Statistical Package for the Social Sciences
UNEP	-United Nations Environmental Programme

CHAPTER ONE: INTRODUCTION

1.0 BACKGROUND TO THE PROBLEM

There has been an increase in population density in Kenya and in Kakamega District in particular, which has exerted great pressure on land. The population of the district according to the 1989 census was 1,005,878 and is projected to be 1,514,698 in 2001. Thus, giving the district's population growth rate to be 2.98% annually. It is expected that the population between 1989 and the year 2001 will have increased by 50%. (Republic of Kenya, 1997). This tremendous demographic leap has potentially serious implications on environment, agricultural production, and the Kenyan rural economy as a whole. There is an urgent need therefore, to develop land-use systems that promote conservation of the natural resources for improved and sustainable productivity.

It has been well documented that population pressures are responsible for people's movement into ecologically non-viable and unsuitable areas to cultivate land on which to provide for basic family needs (Repetto and Holmes, 1983). As productive arable lands come under increased population pressure, they tend to become degraded and/or scarcer. The result is that farmers move onto the marginal and forested lands, which are consequently degraded due to their fragility (Bilsborrow, 1987).

Environmental degradation coupled with increased household size and higher man-land ratios translates into poverty, land fragmentation and in some cases retrenchment into subsistence agriculture (Aboud, 1992).

Thus, use of agroforestry technologies for the production of multiple products appears a feasible approach that could be used to combine production of food, livestock, and forest products on the same unit of land on a sustained yield basis to improve farmers socioeconomic status. However, such an approach is not always the case in the District.

1.1 STATEMENT OF THE PROBLEM

The high population in Kakamega District has created pressure on land as the average farm size by households is becoming smaller and smaller due to sub-division of land. This implies that employment opportunities and incomes from agricultural activities are gradually reducing, a situation which is contributing to the increase in the depth of poverty in the district (Republic of Kenya, 1997).

Despite the fact that agroforestry offers various benefits that are important in enhancing production and reducing the increasing conflicts between arable farming, livestock keeping and forestry interests especially in the high potential areas like Kakamega district, few farmers adopt agroforestry practices, so as to enhance their household incomes.

Because of the ever-increasing population pressures each year, thousands of hectares undergo land use changes in Kenya. Forests have been greatly excised through conversion to agricultural land and harvesting of tree products for various uses. Thus, it has become harder to obtain forest products such as fuelwood, which is necessary in the day to day running of the rural households. Furthermore, the small farms are undergoing intensive cultivation to meet the demand for food by members of the household.

This has led to reduced soil fertility levels on the farms and in turn, reduced food production consequently confining farmers to subsistence farming with no surplus for sale. The instability of land use practices has put further pressure on the current land use systems such that they do not allow the society to develop and meet its needs essentially in perpetuity. The implication of this is that less income is being generated from the farms, with ensuing lower household socioeconomic levels.

A number of questions thus remain unanswered such as: does agroforestry have any impact on farm production and household income? Does the use of MPTs have any impact on household farm income? And if so, what is hindering farmers from utilizing agroforestry practices on their farms? It is from these questions that the research hypotheses for the study were formulated.

1.2 RESEARCH OBJECTIVES

Broad objective

To determine the impact of agroforestry on farm production and household income, and as intermediaries, the constraints to adoption of agroforestry technologies by farmers in Kakamega District.

Specific objectives

1. To determine the impact of adoption of agroforestry technologies on farm production.

2. To determine the impact of adoption of agroforestry technologies on household farm income.

3. To determine the impact of the use of multipurpose trees and shrubs (MPTs) on household farm income.

4. To determine the constraints farmers encounter in adoption of agroforestry technologies.

1.3 RESEARCH HYPOTHESES

1. There is a significant, positive relationship between adoption of agroforestry technologies and farm production.

2. There is a significant, positive relationship between adoption of agroforestry technologies and household farm income.

3. There is a significant, positive relationship between household use of MPTs and household farm income.

4. There is a significant, negative relationship between constraints to adoption of agroforestry technologies and adoption of agroforestry technologies.

1.4 STUDY JUSTIFICATION

The increasing population pressure is responsible for the ever-increasing deforestation as more land is sought for cultivation or fuelwood. Such unmanaged expansions are not only depleting the forests as valuable watersheds and fuel reservoirs, but are also gradually eliminating the most effective protection against water erosion on steep slopes. The threat to forest lands is accentuated by the growing need of subsistence farmers to expand the land under crops to meet their demand for food and cash from sale of excess products. But land in which to expand to for this purpose is no longer available.

Over the last decades, agroforestry has emerged as one of the principal responses to the problems caused by the widespread loss of trees and forest cover in the developing world. Its aim is to help people solve their

own wood supply problems, meet their own needs, and preserve the environment in which they live by planting trees on their farms (Foley and Bernard, 1984).

This study aims to help provide a better understanding of the impact of adopting agroforestry technologies on farm production, household income, and the constraints to adoption of agroforestry practices by farmers in Kakamega District.

It is hoped that the data availed by this study on the benefits of agroforestry technology adoption as an alternative farming system and its potential contribution in enhancing productivity and the sustainability of agroecosystems, can play a major role in the process of economic development of the rural people in Kakamega district, and in Kenya as a whole. Information from this study will also be useful to extension workers in the implementation and dissemination of agroforestry practices to farmers elsewhere in the district.

The research outputs may be useful to the agroforestry project sponsors (Rockefeller foundation), government departments, non governmental organizations, community based organizations, and change agents involved in rural based development activities that are concerned with agroforestry system in the tropics.

1.5 DEFINITIONS

Agroforestry. Is a collective name for all land use systems and technologies in which woody perennials (trees, shrubs, bamboo) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement and temporal sequence. In agroforestry there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1983). In this study, agroforestry system addressed is agrisilvicultural, i.e. the management of trees and crops.

Agroforestry System. This is a type of agroforestry land use that is specific to a locality and described according to its biological composition and arrangement, level of technical management or socioeconomic features (Nair, 1989).

Agroforestry Practice. Denotes a specific land management operation of an agroforestry nature on a farm or any other management unit, and usually consists of arrangement of agroforestry components (Nair, 1989). Such arrangements constitute practices such as dispersed trees on cropland, home gardens, or even alley cropping.

Agroforestry Technology. This indicates an innovation or improvement, usually through scientific intervention, that can be applied with advantage

in the management of the system or practice under consideration (Nair, 1989). They include scientific agroforestry technologies such as alley cropping, and traditional agroforestry technologies such as dispersed trees on cropland, or trees in home gardens.

Household. It is a group of individuals who eat together and live under one roof performing and sharing domestic responsibilities as a means of survival (Ellis, 1992). It is the basic unit of study composed of a family, whose members include household head (husband or wife), children and relatives living together.

Adoption. It is the degree of utilization of scientific or traditional agroforestry technologies by the farmers. Such technologies include alley cropping, dispersed trees on cropland, improved fallows, wind breaks, and home gardens.

CHAPTER TWO: LITERATURE REVIEW

2.0 INTRODUCTION

Agroforestry has been defined as a collective name for land–use systems and technologies in which woody perennials (trees, shrubs, palms, bamboo, etc) are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence (Lundgren and Raintree., 1983, Raintree, 1987; ICRAF, 1989). The foregoing definition of agroforestry has the word "deliberately" as a key word that automatically eliminates many naturally occurring mixes of trees, crops and/or animals from the current concept of agroforestry that are not managed by man (Gholz, 1987).

In agroforestry land-use system there are three basic sets of elements or components that are managed by man, namely, the tree (woody perennial), the herb (agricultural crops including pasture) and the animal. In order for a land-use system to be designated as an agroforestry system, it should always have a woody perennial. Thus an agroforestry system can be classified as Agrisilvicultural (crops and trees including shrubs/vines/and trees), Silvopastoral (pasture/animals and trees), and Agrosilvopastoral (crops, pasture/animals and trees) (Nair, 1989).

The practice of agroforestry makes trees a component of the total farming system. Agroforestry is frequently invoked as a solution to problems of land and water degradation as well as an answer to shortages of food, fuelwood, cash income, animal fodder and building materials in sub-Saharan Africa (Rocheleau *et al.*, 1988). This is attributed to the beneficial effects of agroforestry in enhancing soil fertility and environmental protection and the potential to produce multiple products.

Agroforestry has come to be associated with a possibility of improving food security and the potential to overcome problems of seasonality of food and fodder availability by greatly extending the season when green fodder and food supplies are available (Hoskins, 1987).

The significance of the various attributes associated with agroforestry cannot be overemphasized. This is especially so in the face of increasing human and livestock populations in parts of the developing world that can only be sustained through better management of the natural resources, including forests and land. There is also ample evidence that growing landlessness among many rural populations continues to rise in much of the developing world (Fortmann and Riddel, 1985; Ngoda, 1988). This is coupled with deterioration of the tropical forests and increasing rates of desertification. Hence, the scope of trees and shrubs that can be produced under agroforestry systems in meeting man's needs for trees

and their associated products, and in enhancing and sustaining soil productivity, is becoming increasingly recognized (Burley, 1982). Farmers and livestock owners need alternatives to the modern agricultural technologies and simplified cropping systems that have been promoted over the last few decades as part of the development efforts.

There is a general consensus that future land-use systems and technologies must provide people with more flexibility to respond to rapid shifts in economic and ecological conditions due to population pressure. In addition, new production systems must maintain, or in most cases restore the soil and water resources upon which rural life depends (Rocheleau *et al.*, 1988).

Kenya's cultivable land (10% of the total land area) is under pressure due to rising population growth. The population of Kenya was approximately seven million at the 1962 census. It is estimated that in the 38 years since then the population has increased more than four-fold to about 28 million in the late 1990s (Republic of Kenya, 1997). Compared to the previous density levels, this is a tremendous demographic leap that has potentially serious implications on the environment, agricultural production, development, and the Kenyan rural economy.

2.1 TYPES OF AGROFORESTRY PRACTICES AND FARMER ADOPTION

Research has shown that farmer adoption of agroforestry practices varies with the types of technologies, farmer's economic ability, and environmental constraints. There are a number of technologies that have been identified by researchers and agroforesters, which have developed traditionally or scientifically and can be adopted and utilized in agroforestry practice by farmers (Baumer & Wood, 1986). The most common ones include: dispersed trees on cropland, contour vegetation strips, alley cropping, Trees in home gardens, and improved fallows.

2.1.1 Dispersed Trees on Cropland:

Trees may be grown on farmers' fields while crops are grown as the understorey. The trees may be dispersed widely, either spaced systematically in a grid or scattered at random. This practice of raising trees dispersed on cropland is based on protection and management of selected mature trees already on the site.

Farmers have different reasons for adopting this technique. Some of these reasons include the need to increase crop production, extend the time that a particular field can be cropped, diversify products, and produce a particularly valuable product in a secure site, protected from animals. This technique allows for minimum competition with crops.

2.1.2 Contour Vegetation Strips:

The contour strip technique is also known as a barrier strip or hedge, horizontal vegetation strip, contour hedge or horizontal hedgerow. It is an erosion-control measure for sloping farmland, which, in addition, provides useful products and enriches the soil.

Many traditional African farming systems include this technique in form of living barriers of grasses, lines of stone or wood, leaves and other organic debris which are usually placed across hillsides to control storm runoff and soil erosion (Rocheleau *et al.*, 1988). The establishment and maintenance of horizontal strips of vegetation on sloping ground is one of the most direct, cost-effective and ecologically sound erosion control intervention. This technique is very useful to hill-slope farmers who are aware of erosion hazards and wish to keep more water and top soil on their fields without resorting to expensive structures.

2.1.3 Alley Cropping:

Alley cropping, also known as hedgerow intercropping, involves managing rows of woody plants with annual crops planted in alleys in between (Carter, 1996; Kang, 1993).

The woody plants are cut regularly and leaves and twigs are used as mulch on the cropped alleys in order to reduce evaporation from the soil surface, suppress weeds and/or add nutrients and organic matter to the

top soil. The primary purpose of alley cropping is to maintain or increase crop yields by improvement of the soil and microclimate and weed control.

The technique is designed to be a sustainable alternative to shifting cultivation or expansion into unproductive farmland. It retains the basic principles of traditional fallowing, but keeps all the land productive at the same time. Alley cropping particularly works best in cases where farmers feel a need to intensify crop production but at the same time, face soil fertility problems. However, this technology requires intensive management and is labour demanding. Therefore, it is appropriate mainly in areas with small farms and where labour is not a limiting factor (Tengnas, 1994).

2.1.4 Trees in Home Gardens:

Home garden technology includes trees and shrubs of diverse mixtures, such as medicinal plants, fruits, and often fodder grasses, in small intensively cultivated plots in and around home compounds. In Kenya, home gardens may be small vegetable plots with passion fruit, vine on the fence and a few guava and citrus trees in the overstorey. Home gardens increase productivity because they are labour intensive, yet, because they are near the home, the labour required can be combined with home and child-care responsibilities (Tengnas, 1994). In semi-arid areas of Kenya,

women are increasingly left to farm on their own due to the widespread migration of men to urban centres.

Therefore women are the key participants in agroforestry projects and the main stakeholders in the management of natural resources (Kamatari, 1996; Rocheleau *et al.*, 1988). The home garden has a valuable role in educating children about agroforestry as fruits can be picked even by small children who otherwise do not go very far away from their houses.

2.1.5 Improved Fallows:

This practice involves leaving cropped fields to lie fallow in order to allow soil to rest and recover some of its lost fertility. In agroforestry, woody species replace crops on the fallow fields in sequence (Nair, 1989). Trees are not grown with crops on the same plot at the same time. The fallow period may range from 1 to 20 years, though the classic bush-fallow systems of the West Central Africa were usually based on an 8 to 10 year period (Baxter, 1995).

However, the optimum duration depends on local criteria such as the immediate need for food or cash crops, or the importance of soil fertility improvement. In many parts of Africa, fallow periods are becoming shorter, due to the increasingly acute land shortage. But by using the right choice of fallow species and management, the duration of the fallow

can be significantly reduced and the nutrient quality of litter and biomas retention to soil ensure high productivity of subsequent food crop, improved soil stability and food security (Rocheleau *et al.*, 1988).

Other agroforestry practices that are very useful to rural farmers, include structural conservation measures (e.g. Trees and shrubs on terraces, microcatchments and water management, protection and stabilization of water ways and gullies, etc), and agroforestry for in-between places (e.g. living fences, wind breaks, trees and shrubs along roads and paths, etc.).

2.2 FACTORS THAT DETERMINE FARMER ADOPTION OF AGROFORESTRY PRACTICES

Adoption of agroforestry technologies appears to be determined by several factors. According to Cook and Grut (1989), economic value of trees appears to be the key factor in farmer adoption. In a study carried out in Siaya, it was found that although the CARE project implementers realized that fuel wood was a problem to local residents, it was not a priority (Tengnas, 1994). Farmers had other priority needs, which included food, fruit fodder, fencing, poles, timber, shade, soil fertility, and cash. The subject of environmental degradation has gained a lot of attention due to its impact on the survival of man (Tolba, 1992): the question of food being the prime factor. This is also the situation in present day Kenya.

Alongside the economic factor in adoption, is the type of trees available for planting. Farmers appear to accept multipurpose trees more than single purpose trees, and fast-growing trees that can yield early benefits (e.g. fruits) rather than trees that have a long maturity period (Sharma, 1995). The main consideration is the amount of time it takes to realize a return even for the most minimal investment. In the Sahel region, farmers responded to similar pressures by diversifying out of agriculture (Cook and Grut, 1989).

Another factor that determines farmer adoption is the availability of labour. Labour shortage has tended to discriminate against categories of farmers (Aboud *et al.*, 1996). In Western Nigeria for instance, adopters have only been farmers who own or have access to more than average amounts of land, adoption is undertaken more by men than women, and by older, wealthier farmers whose farming and off-farm activities are already diversified (Cook and Grut, 1989).

Initial adopters of agroforestry practices tend to be individuals or groups that can afford to take a risk. In Kenya, tree-seedling nurseries have proved to be appropriate for small, informal, women groups. This has been noted to be so because the risk involved in the activity can be shared by the group as a whole. Land belonging to a male relation of a member of the group can be used for the nursery (in exchange for a

portion of the seedlings produced), and labour requirements can be shared among the women members (Cook and Grut, 1989).

Land tenure has often been regarded as a major constraint in agriculture and as a limiting factor for farmers to make long term investments. The size of land has also been found to be a significant factor that determines environmental conservation practices (Aboud *et al.*, 1996). This also appears to be the case in agroforestry (Cook and Grut, 1989; Republic of Kenya, 1993).

Technologies are adapted to varying degrees by persons of different income levels, occupations, gender, age, and education. In addition, extension contacts with rural farmers are a significant factor in agroforestry technology adoption (Aboud *et al.*, 1996).

2.3 SOCIOECONOMIC BENEFITS OF AGROFORESTRY

Agroforestry has various functions and attributes, which have socioeconomic benefits, and thus directly or indirectly contribute to rural development. Trees may play one or more of the following functions in any economic system:

i) as a source of food for human beings;

ii) provision of fodder for livestock production;

iii) provision of fuelwood for the rural and, sometimes, the urban people;

iv) provision of building materials;

v) provision of fibre;

vi) provision of medicine for both human and animals;

vii) source of some other useful products such as latex, and

viii) may play a service function, e.g., soil conservation, microclimate amelioration, soil nitrogen-fixation, and provision of shade, etc.

Generally, it is difficult to work in the open fields in hot weather, and there is need for shade in and around fields in dry zones. Hence, provision of shade, which is associated with agroforestry, improves the working conditions for the farmers in dry zones and has been associated with increased productivity (Von Maydell, 1987). Trees also increase the stability of the farm system by adding to the diversity and seasonal spread of farm products (FAO, 1986).

In discussing the role of forestry in rural development, Steinlin (1979) noted that forestry has ordinarily been associated with timber production. However, he also noted that forestry has a role in contributing to nutrition of both human and livestock and that the combination of perennial trees

and shrubs with ephemeral food plants in one and the same area constitute the concept of agroforestry, with a changed emphasis on man-made rather than natural forests.

Nevertheless, timber production can still be enhanced through agroforestry production systems. With dwindling energy resources of the renewable nature, agroforestry may be expected to play an even bigger role in the provision of fuelwood for the rural people and most of the urban poor.

In Kenya, for instance, increased pressure for agricultural lands has reduced the number of easily available trees. Wood therefore has undergone a transition from being an abundant free good to a commodity of value, to be protected and perpetuated (Brokensha, 1983).

Energy resources from fossil fuels and electric and nuclear power are limited for most rural communities, whereas contributions of wind, solar, and biogas alternatives are almost negligible (Relwani, 1987). This factor singles out the importance of fuelwood in meeting the energy requirements of the vast majority of the rural and urban poor, notwithstanding the fact that wood has several alternative uses.

2.4 USE OF MULTIPURPOSE TREES AND SHRUBS IN AGROFORESTRY

Multipurpose trees and shrubs (MPTs) refer to all woody perennials that are purposefully grown to provide more than one significant contribution to the production and/or service functions of a land use system. They are also classified according to the attributes of the plant species as well as to the plants' functional role in the agroforestry technology under consideration. Such output may be in the form of productive or service role. Productive roles refer to tangible products that can accrue from such trees and shrubs, for example, fodder, timber, food, etc, while service roles of MPTs yield non tangible products such as nutrient cycling, microclimatic amelioration, shade, boundary delineation, etc (ICRAF, 1997).

Selection of a tree component in any agroforestry system will be largely restricted to high value species, which satisfy the existing consumer and market demands in any particular region. The trees provide high-value products for sale locally, regionally or internationally and useful services to the local people (Scherr, 1987).

2.5 CONSTRAINTS TO AGROFORESTRY TECHNOLOGY ADOPTION

There is abundant evidence that, almost everywhere, people appreciate the value and usefulness of trees, and know how to grow them. The

BER ON UNIVERSITY LIBRARY

assumption that major educational efforts are needed just to convince people that trees are beneficial is rarely justified. If farmers are not growing trees it does not mean that they are unaware of the problems of disappearing wood resources or are unconcerned about their own future.

It is far more likely that there are good local reasons why they are not able to grow them, or have other more urgent priorities. Establishing why growing of more trees is not taking place spontaneously is one of the most important steps in planning agroforestry programmes (FAO, 1986).

2.5.1 Socioeconomic Constraints

Economic considerations are among the most important factors that will determine the value of agroforestry to the land user (Chavangi, 1989). Most research on agroforestry that has been done to date has concentrated on the biological and physical factors that affect productivity. Inadequate attention has been paid to the economic value of directly quantifiable agroforestry outputs including fodder, green manure, fuelwood, timber, and significant indirect effects such as enhanced soil fertility and watershed protection (Burley, 1982). There is, therefore, a serious lack of reliable information base on actual farm and field conditions. Furthermore, whereas traditional agroforestry systems may have proved economically viable under the conditions in which they evolved, increasing land pressures, changing social perceptions and new

land-use options all call for new economic evaluations of many existing systems.

In general, however, economic and financial studies in agroforestry have been grossly inadequate in relation to their indicated potentials, and this is a serious constraint in agroforestry implementation and adoption.

2.5.2 Socio-cultural Constraints

The words "social" or "cultural" may be used to refer to the norms, rules and attitudes that govern the meaning of certain activities for individuals and groups; they also govern the organization of activities, and the behaviour of individuals in the course of participation in such groups (Ongugo, 1992). It therefore stands to reason that activities that are designed around existing cultural and social structures, taking fully into account local customs, beliefs, values and even taboos, are much more likely to be successful (Chavangi, 1992).

Customs and Traditions

According to Husch (1987), customs and traditions can be a major consideration, especially in rural areas with populations having long established cultures, traditions, and religious practices. Examples of customs and traditions of the populations that exist in some countries in the use of forests or trees that can influence forestry policies include:

- The customary use of forest fires to improve pasture for domestic animals.

- The accepted norm of open or uncontrolled grazing of forest and wildlands regardless of ownership.

- The unrestricted collection of fuelwood and other forest products by the public from state lands.

Chavangi in 1992 documented the following taboos in Western Kenya;

- If a woman plants a tree she will be barren.

- If a woman plants a tree her husband will die.

- If a woman carries seedlings of pine species the seedlings will die.

- If a woman plants a tree it is a challenge to her husband.

- Trees planted by women cannot be used for house construction.

Trees and Tenure

Land tenure refers to the possession or holding of the many rights associated with each parcel of land. Ownership or user rights are not static. Such rights can be subdivided or transferred by the holder. The same person also may not hold different kinds of rights to a certain piece of land. An example of such a situation is farmland, which is cultivated

and "owned" by an individual family but communally grazed after the harvest. In such cases, communal grazing may be regarded as a right that the neighbours have to the land in spite of formal individual ownership (Tengnas, 1994). Insecurity of tenure or unclear rights to land are strong disincentives to all forms of long-term investment, e.g. tree growing.

It is not only that it is unattractive to invest in tree planting if you are not sure of getting the benefits of the investment, but it may also be unacceptable to plant trees on land which has not legally been confirmed as belonging to the user.

Gender

The gender issues in relation to agroforestry covers the roles that male and female family members play in tree planting, tending and harvesting. In different societies there are differences in responsibilities, user rights, legal status, division of labour, decision-making, between men and women. It has been recognized that women in Kenya perform a large share of the farm work in addition to all the other duties that are traditionally their responsibility. Social changes such as most children now going to school and men being increasingly busy with off-farm work have added to women's workloads. In Kakamega, a lack of women's participation in tree planting is sustained through various taboos and

beliefs. Examples are beliefs that if a woman plants trees, her husband will die, or that she will be barren. Older women who already have the number of children they want can, however, plant trees and often do so (Chavangi, 1989). In general, it is important to get the whole family involved in discussions on agroforestry. All family members have ideas and knowledge to contribute and their individual needs and priorities should be taken into account in order to make the best use of available resources.

2.5.3 Technological Constraints

The technological constraints originate partly in the historically separate development of agriculture and forestry, and in the consequent research emphasis on monoculture.

Lack of a reliable set of agroforestry technologies seriously constrains agroforestry development (Burley, 1982). More research trials are needed on optimal (in biophysical, social, and economic terms) combinations of woody and non-woody components of land-use systems. Researchers need to apply scientific methods that are already being used in agriculture and forestry to improve agroforestry components and systems.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 INTRODUCTION

In this chapter an attempt is made to highlight the main physical and socio-economic aspects of Kakamega District, where the study was undertaken. In so doing, the chapter examines how these factors have influenced the pattern of development in the district as far as natural resources and income generation is concerned. The chapter also indicates the methodology used in data collection and data analysis.

3.1 LOCATION AND SIZE OF THE STUDY AREA

Kakamega district is located in western province of Kenya. It is bordered by Busia, Siaya, and Bungoma districts to the west, Nandi and Uasin-Gishu Districts to the east, Trans Nzoia district to the north and Vihiga District to the south. It is defined by longitudes $34^{0}20'$ and 35^{0} E and latitudes $0^{0}15'$ and 1^{0}N of the equator. (**Figures 1 and 2**)

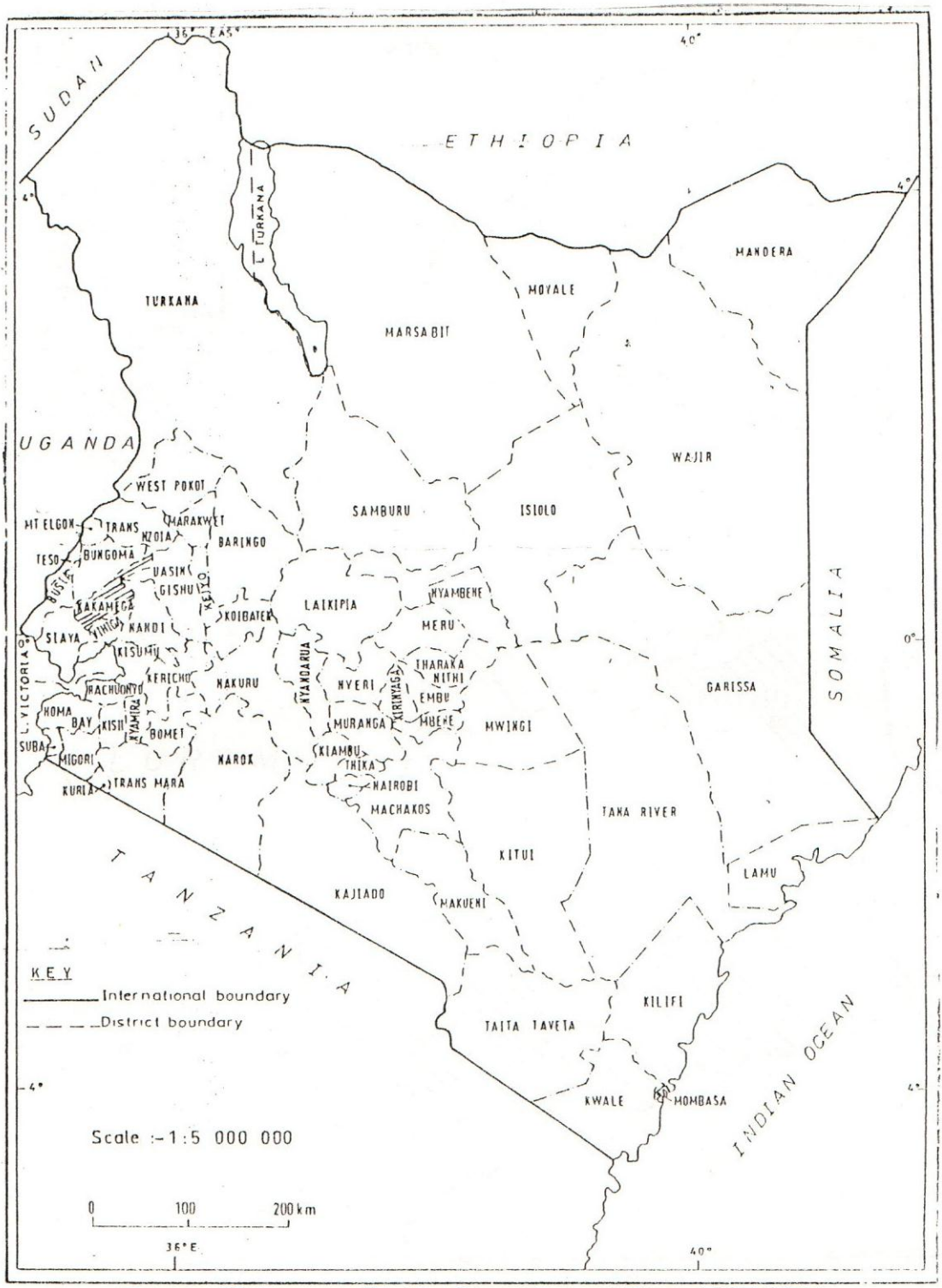
Kakamega district covers a total area of 1,421 square kilometres. The district is divided into seven administrative divisions: Ikolomani 140 square kilometres; Shinyalu 352 square kilometres; Ileho 75 square kilometres, Lurambi 193 square kilometres; Navakholo 187 square kilometres; Kabras 426 square kilometres; and Kakamega Municipality 48 square kilometres; (Republic of Kenya, 1993 and Table 1).

The smallest administrative division is Kakamega municipality, measuring 48 square Kilometres, followed by Ileho division, which is 75 square kilometres. Kabras and Shinyalu are the largest divisions in size measuring 426 square kilometres and 352 square kilometres respectively (**Table 1**).

Table 1 Area of the District by Division

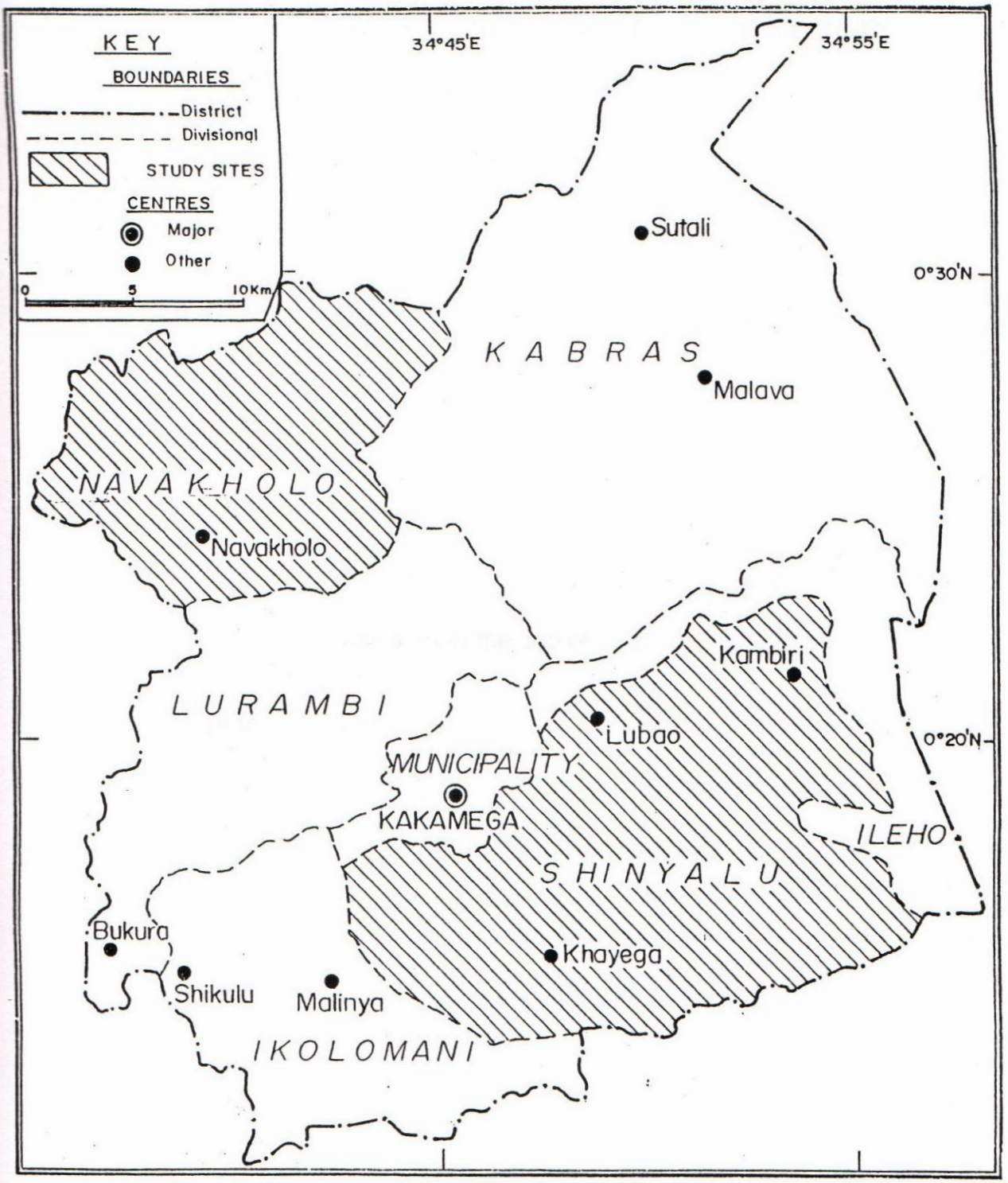
Division	Area (square kilometres
Kabras	426
Shinyalu	352
Lurambi	193
Navakholo	187
Ikolomani	140
Ileho	75
Kakamega Municipality	48
Total area	**1,421**

Source: Population Census report, 1999.



Source: Kakamega District Development Plan, 1997-2001

Figure 1 Location of Kakamega District in Kenya.



Source: Kakamega District Development Plan, 1997-2001

Figure 2 Kakamega District.

3.2 KAKAMEGA DISTRICT AGRO-ECOLOGICAL ZONES

The main agro-ecological zones in the district comprise Upper Midland (UM) and Lower Midland zones (LM) as indicated in **Figure 3**. These zones are:

UM0 Forest zone, which is too wet for good yields of most crops. The Kakamega forest in Shinyalu/Ileho divisions falls under this zone.

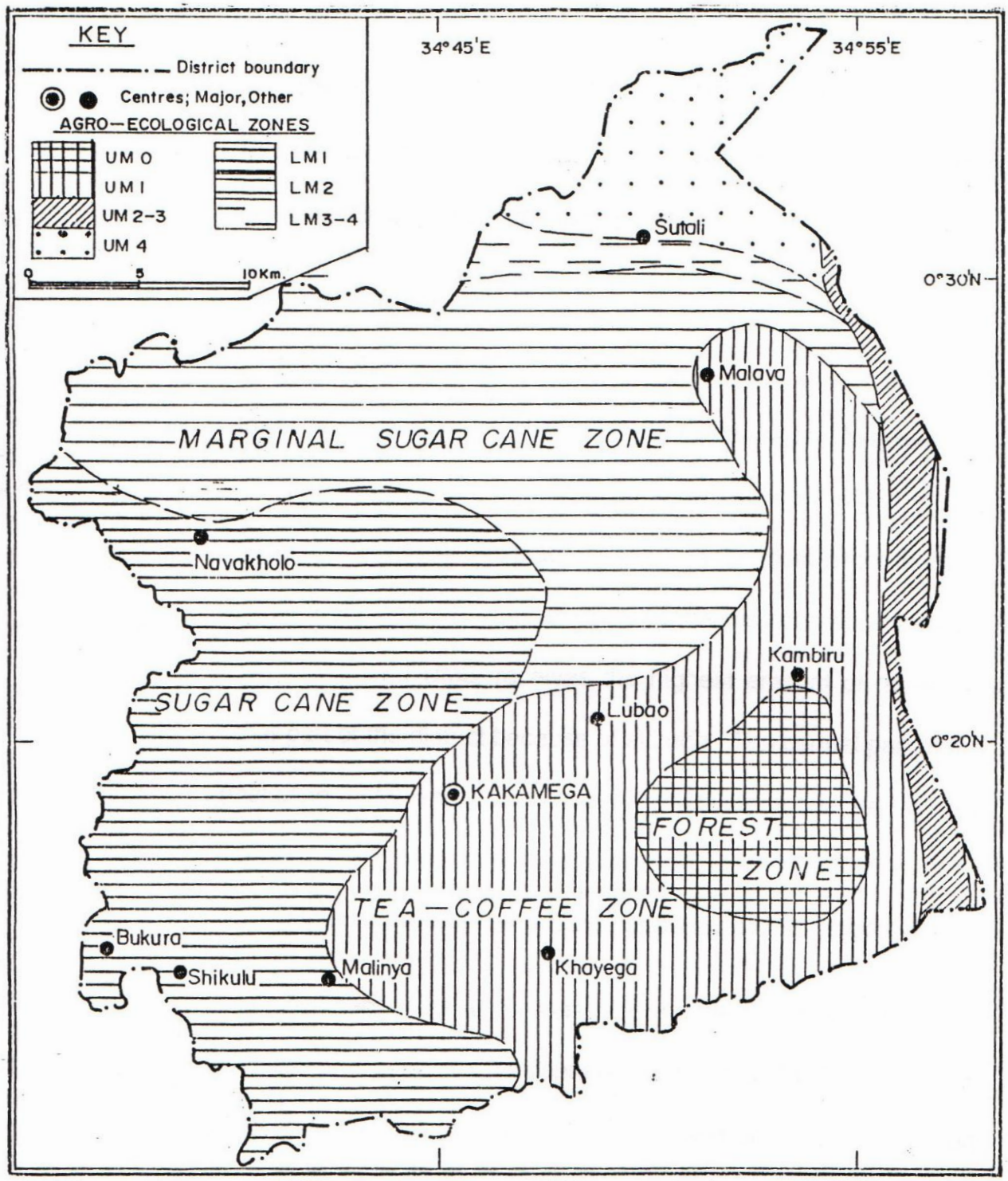
UM1 Tea-Coffee zone area, which has very good yield potential. Long rains in this zone start at the end of February and short rains start at the end of July.

UM4 Sunflower-Maize zone. Area has good yield potential and one long cropping season. Rains start in March.

LM1 Sugarcane zone. Has good yield potential and two rainy seasons. The long rains start at the end of February and short rains start at the end of July.

LM2 Marginal sugarcane zone. Area has good yield potential and two cropping seasons.

In addition to the above, there is a small section of LM3 and LM4 in Kabras division. The area is a marginal coffee zone.



Source: Kakamega District Development Plan, 1997-2001

Figure 3 Kakamega District Agro-ecological Zones.

3.3 PHYSICAL ASPECTS OF THE STUDY AREA

This section examines the physical characteristics of the study area including climate, soils, and topography.

3.3.1 Climate

3.3.1.1 Rainfall

Kakamega district has high annual rainfall averaging between 1000mm to 2400mm. Rainfall in the district as in other areas within the equatorial belt, varies from place to place. Altitude is the main factor that contributes to this variation. The eastern part of the district, which includes UMO, UM1, UM2, and UM3, receives the highest amount of rainfall than any other part of the district because of altitude. The central part of the district (including LM1 and LM2) receive relatively moderate rainfall. The northern part, UM4 zone, receives the least rainfall amount. This is because this zone lies in the rain shadow area of Mt. Elgon.

The movement of the air masses between the two temperature belts in the northern and southern hemispheres within the ITCZ provides two rainy seasons in the district, namely: the long and short rains. The long rains start in March and end in June with the peak in May. The short rains commence in July and end in September with the peak in August. Other months receive normal rainfall with drier months being December, January, and February (Jaetzold and Schimdt, 1982). The rainfall

expectation is high, at least 500-1100mm during long rains, and 450-850mm during short rains. While the central part of the district has no clear distribution between the two rainy seasons, the northern part has distinct dry and wet spells.

Most of the rainfall received in the district is to a large extent, of the conventional type, and often comes in form of heavy thunderstorms, which continue into the night. Relief rain is mainly received in the eastern part of the district where the altitude is distinctly higher.

3.3.1.2 Temperature

Temperatures in Kakamega district vary between mean maximum of 26^0 C and 32^0 C and mean minimum of 11^0 C and 16^0 C. In the eastern part of the district (in UM0 and UM1) the annual mean temperature is about 18^0 – 20.5^0 C.

The climate in Kakamega district is good for a variety of crops such as bananas, maize, beans, sweet potatoes, sugarcane, and horticultural crops, to mention a few. Adequate rainfall means that water availability is not a critical concern to the population (Republic of Kenya, 1997). However, this type of climate has adverse effects to the people, crops and animals as exemplified by incidence of diseases such as malaria, upper respiratory and tract ailments, and fungus diseases in plants and animals,

as a result of heavy showers. Also because of heavy downpours and run-off, soil nutrients are lost through leaching, and motor transport is crippled during wet seasons, especially on most of the earth –surfaced roads.

3.3.2 Soils

Kakamega District is characterized by a variety of soils. The soil units (121U, 139U, and 151U), which are dominant in the district are found on upper middle-level uplands and lower middle-level uplands respectively. Soil unit 121U has developed on tertiary or older basic igneous rocks. It is well drained, extremely deep, dark reddish brown, friable clay, with humic topsoil (Mollic Nitosols). Apart from soil unit 121U, soil units 168U and 179U also occur on uplands. Soil unit 168U is developed on various rocks (Kavirondian sediments, often mudstones). This soil is well drained, deep to very deep, dark reddish brown to strong brown, friable clay (rhodic to orthic ferrasols). Soil unit 179U is developed on granites. It is a complex of : (i) well drained, moderately deep to very deep, reddish brown to yellowish brown, friable clay, over petro-plinthite (orthic ferrasols, partly petroferric phase; with orthic acrisols); and (ii) moderately well drained, shallow, brown, brown to dark brown soils over petro-plinthite .

Apart from soil units 168U and 179U, other soil types found in sugarcane zone (LM1 and LM2) include: soil units 139U; 144U; 151U; and 188U.

Soil unit 139U is developed on various rocks. It is well-drained, very deep, dark red to yellowish red, friable to firm, and clay loam to clay; in places with acid humic top soils (ferralo-chromic/orthic acrisols. Soil unit 144U is developed on igneous rocks. It is well-drained, very deep, red to dark, friable to firm, clay; in places moderately deep over petro-plinthite (euric nitosols; with rhodic ferrasols, partly petro-ferric phase). Soil units developed on granites include 151U. This is well drained, deep to very deep, brown to dark brown, friable, and sandy clay to clay (ferralo-orthic acrisols). Soil unit developed on various rocks (Kavirondian sediments, often mudstones) include 188U. This soil unit is well drained, moderately deep to very deep, dark red to strong brown, friable clay; in places over petro-plinthite (orthic to rhodic ferrasols, partly petro ferric phase; with murrum cuirass soils (10-40%).

Soil units 139U, 144U, 151U, 168U, 179U, and 188U are found in the sugarcane zone. These soils comprise the acrisols and ferrasols. With adequate rainfall, sugarcane, maize, and beans perform better on such soils. However, because of continuous cultivation, fertility of these soils has dropped to the extent that regular application of fertilizer is required for better crop production. Other crops that grow on these soils include vegetables, sorghum, millet, yams, etc.

3.3.3 Topography

The altitude of the district ranges from 1250 to 2000 metres above sea level with the major parts of the district displaying a rather undulating topography. The physiography of the district has suffered little from tectonic disturbances. Earth movements including faulting and volcanicity have taken place in a few areas, giving rise to an upland environment. On the other hand, denudation has played a big role to the physiography of the district, producing a large peneplain, which is slightly undulating to the north, central and eastern parts of the district.

The district has two physiographic units: the southern hilly belt and the peneplain found in the central and western parts. The southern hilly part is made up of rugged and dissected granites rising in places to 1950 metres above sea level. Another prominent topographic feature is the Nandi escarpment. This is found in the eastern part of the district, with its main scarp rising from the general elevation of 1700-2000 metres within one kilometre. The north eastern corner where river Nzoia cuts the scarp, has an elevation of 1460 metres while downstream near Mimias, 45 kilometres from the scarp, elevation drops to 1260 metres.

The peneplain the covers most parts of the district has been produced by denudation process. This slightly undulating topography is evident in the central, western and northern parts of the district. There is a general tilt of

the peneplain towards Lake Victoria basin, the direction in which most rivers flow. The peneplain has been eroded and dissected in some places by several rivers. The major rivers include: the Nzoia, which originates from the Cherangani hills; and Yala river, flowing westwards from the Nandi escarpment.

Generally, the flat topography evident in the western and central parts of the district (which comprise the sugarcane zone) is good for mechanized farming and road construction. These two aspects have enabled the operationalization of large sugarcane farm units and construction of feeder roads within the sugarcane growing zones.

3.4 POPULATION PROFILES

The size and demographic features of the population are important variables in the equation of the development process; for they determine the pattern of resource utilization. Accordingly, this section of the chapter presents the population profile of Kakamega District. Among the demographic features discussed are size, distribution of population by division, and population structure.

3.4.1 Population Size

The total population of Kakamega District according to the 1999 population census was 603,422. The high population in Kakamega is

attributed to good physical environment which provides unlimited agricultural potential and hence sustenance to many people. However, it can be observed that variations occur in population densities between various divisions in the district (**Table 2**). Intra-divisional variation in population densities can be attributed partly to physical environment as reflected by the ecological zones in the district, and land tenure systems that were encouraged long ago after independence

Table 2 District Population by Divisions

Division	Population 1999	Households 1999	Population density
Navakholo	65,337	13,083	377
Kabras	149,510	29,226	352
Ileho	32,505	6,534	419
Shinyalu	103,948	21,460	313
Ikolomani	92,104	19,689	645
Lurambi	85,863	17,509	442
Kakamega Municipality	74,115	18,400	1,485
Total	603,422	125,901	433

Source: Population Census Report, 1999.

3.4.2 Population Distribution and Density

According to the population census of 1999, Kabras, Shinyalu, and Ikolomani divisions had the largest population in the district. The population of these divisions were 149,510, 103,948 and 92,104, respectively. In Kabras division, in-migration of people in search of arable land from other divisions causes the population to be comparatively high. Ileho, and Navakholo divisions had the smallest populations. Their

population figures were 32,505 and 65,337, respectively. The population by location and sub-location in the two divisions (Navakholo and Shinyalu) in which research was undertaken is shown in **Tables 3** and **4**.

Table 3 Navakholo Population by Location and Sub-Location

Location/sub-location	Population 1999	Households 1999
Bunyala west	27,904	5,584
Budonga	4,854	989
Kochwa	7,556	1,505
Sidikho	6,716	1,277
Lusumu	8,778	1,773
Nambacha	21,649	4,287
Buchangu	6,516	1,206
Nambacha	4,667	962
Sirigoi	6,407	1,302
Mukhweso	4,059	870
Bunyala east	15,784	3,212
Namirama	7,494	1,491
Sivilie	8,219	1,721
Total	**65,337**	**13,083**

Source: Population Census Report, 1999.

Table 4 Shinyalu Population by Location and Sub-Location

Location/sub-location	Population 1999	Households 1999
Ilesi	16,897	3,946
Malimili	4,366	887
Mukhonje	7,276	1,490
Magomari	5,255	1,119
Khayega	32,223	6,759
Shitochi	8,475	1,755
Shidodo	9,319	1,911
Luseno	5,208	1,144
Shirulu	3,913	837
Lugose	5,308	1,112
Murhanda	24,187	4,962
Shiswa	8,118	1,644
Kakamega forest	843	30
Mukulusu	7,058	1,446
Itenyi	4,239	892
Shisembe	4,688	950
Shibuye	30,641	6,243
Shing'odo	9,933	2,131
Mirembe	8,532	1,732
Mukango	5,802	1,123
Shiasaba	6,374	1,257
Total	**103,948**	**21,460**

Source: Population Census Report, 1999.

3.4.3 Population Structure

The population structure of Kakamega district shows that the proportion of young persons aged between 0-14 stands at nearly 51 percent of the entire population; suggesting that the district is predominantly composed of youthful population. About 63 percent of the total population is less than 20 years of age. By contrast, the most productive group of the population- those aged between 20-59 years- constitutes only about 32 percent of the population while only 4 percent of the population is above

60 years (Republic of Kenya, 1997). As the district has a large population of children and adolescents, young people greatly outnumber their parents. When the generation of these young peole reaches adulthood, the number of potential parents will inevitably be much larger in future than at present. The in-built demographic momentum will make the total population in the district to be increased by 15 percent between 1997 and the year 2000 (Republic of Kenya, 1997). The high growth of the youth population means that the rate of growth of the labour force will also be high and this will result in high demand for jobs. This will also affect the dependency ration, as the youthful population are mainly consumers and not producers.

3.5 RESOURCE EXPLOITATION

3.5.1 Forestry and Agroforestry

The land under gazetted forest covers an area of 28199.72 hectares. There are five forest stations viz: Lugari, Turbo, Nzoia, Malava, and Kakamega. The first three are mainly composed of industrial plantation of pine, cypress, and eucalyptus, which mainly supply pulpwood material to Pan African Paper Mills in Webuye. Malava and Kakamega are covered mainly with indigenous forests with *Croton megalocarpus, Caltis duradii, Ficus exaspersta, Fantumia clastica,* and *Bosquea phoberos* being the dominant species. *Croton macrostachyus* and *Olea welwithii* are of

special concern since though abundant in the past, they have been overexploited for timber used in construction.

The forests in Kakamega District are the source of woodfuel, timber, medicine, pasture, and in some areas cultural values. They also play a critical role in the prevention of soil erosion, protection of water catchment areas, wildlife habitat as well as the conservation of bio-diversity. But illegal felling of trees for domestic use and systematic exploitation by Pan African Paper Mills in Webuye without corresponding replanting programmes, has left the land susceptible to erosion and has led to environmental degradation and subsequent shortage of wood in the long-run (Republic of Kenya, 1997).

There is high potential for agroforestry activities in the district due to high rainfall and fertile soils. The promotion of agroforestry has therefore been gaining importance. The forest extension service officers have been targeting farmers who are encouraged to create their own woodlots for firewood, poles and timber for their domestic use. This is aimed at reducing dependency on the gazetted forests for these products. Schools are also targeted in the learning of agroforestry activities with a view of spreading this knowledge. Agroforestry has also been encouraged through the raising of tree nurseries in the district by private farmers, schools, women groups, and NGOs.

3.6 THEORETICAL /CONCEPTUAL FRAMEWORK

The theoretical/conceptual framework for the study is as depicted in the following path model (**Fig. 4**).

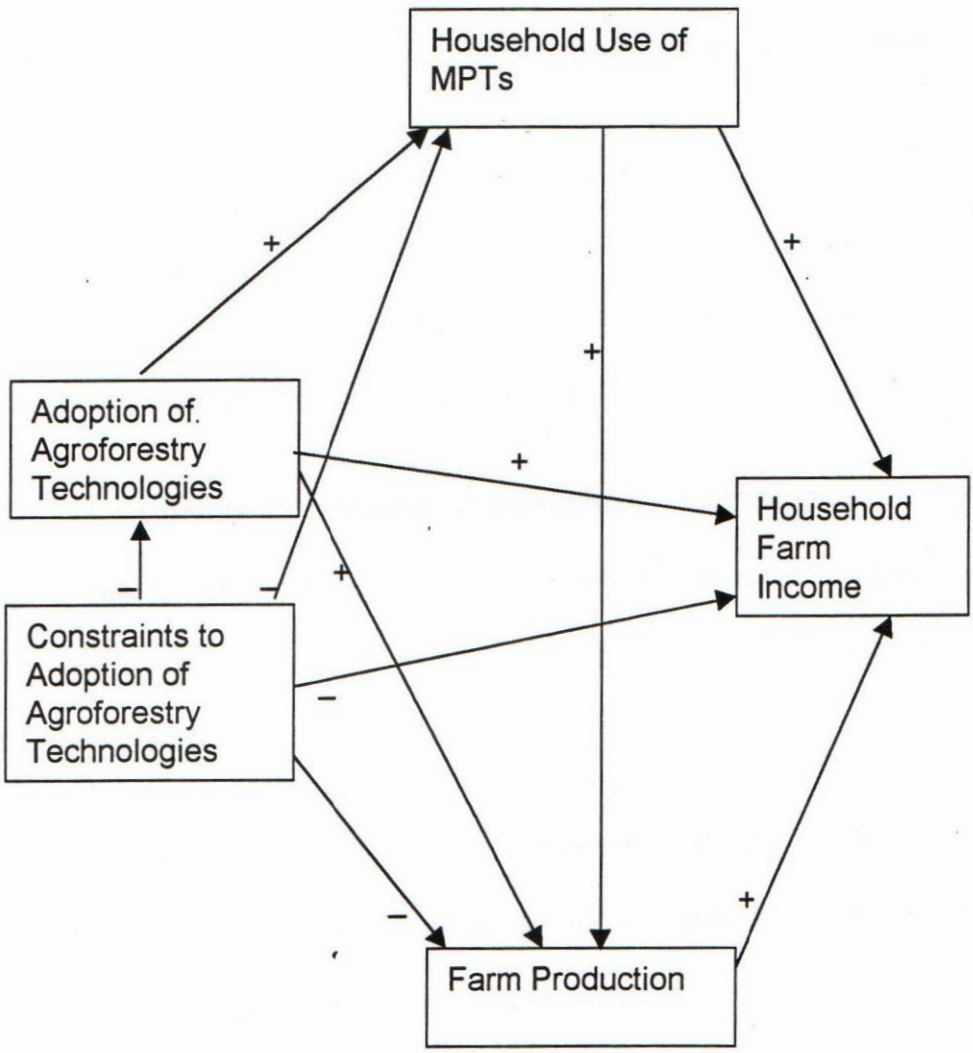


Figure 4 Theoretical Path Model for the Study.

The arrow head (→) indicates the direction of the effect, the positive (+) sign indicates an increase, improvement or positive impact on the other variables while the negative (-) sign indicates a decrease or a negative effect.

The theoretical/conceptual framework for the study, as suggested by the path model (**Fig. 4**) contends that:

1. Adoption of agroforestry technologies influences household farm income directly, and indirectly, through increased use of MPTs and through increased farm production.

2. Constraints to adoption of agroforestry technologies, on the other hand, influence household farm income directly and indirectly through decreased use of MPTs and through decreased farm production.

3. While farm production has intervening effects on household farm income as suggested in contentions 1 and 2 above, it also has a direct influence on household farm income.

4. While use of MPTs has intervening effects on household farm income as suggested in contentions 1 and 2 above, it also influences household farm income directly and indirectly through increased farm production.

3.7 DEFINITION AND MEASUREMENT OF VARIABLES

3.7.1 Adoption of Agroforestry Technologies

This is the integration of woody perennials on the farmers' farms through the adoption of agroforestry technologies. It was determined by the type of technologies utilized by the households on their farms. Examples of such technologies include alley cropping, dispersed trees on cropland, improved fallows, wind breaks, and home gardens. Each type of agroforestry technology practiced was accorded a score of five (5) in order to generate an index for the measurement of level of adoption of agroforestry technologies.

Adoption of Agroforestry technologies index = [Alley cropping scores + Dispersed trees on cropland scores + Improved fallows scores + Wind breaks scores + Home gardens scores]. The summed scores formed an index of adoption of agroforestry technologies with a range of 0-25 for use in regression analysis.

The constructed interval scale categories from adoption of agroforestry technologies index for use in descriptive analysis are as follows:

Category	Code	Description
0-5	1	Very little adoption
6-10	2	Little adoption
11-15	3	Moderate adoption
16-20	4	High adoption
21-25	5	Very high adoption

3.7.2 Household Farm Income

The household farm income was measured by level of total income from the farm per year. This included income from the sale of tree and crop products. These indicator variables were used to construct an index that ranged from 0-97,000 so as to measure the level of household farm income. This continuous variable was categorized into the following groups for use in descriptive analysis:

Category	Code	Description
0	1	No income
1-25,000	2	Low income
25,001-50,000	3	Moderate income
50,001-75,000	4	High income
>75,000	5	Very high income

3.7.3 Household Use of MPTs

Multipurpose trees and shrubs (MPTs) refers to all woody perennials that are purposefully grown to provide more than one contribution to the production and/or service functions of a land use system. Productive role refers to provision of tangible products such as fodder, firewood, food and service role refers to the yielding of non tangible products such as nutrient cycling or microclimate amelioration. Household use of MPTs was determined by the degree of use of MPTs for productive or service function, the degree of economic contribution of MPTs on the farm and income derived from MPTs on the farm. Scores assigned for these indicator variables are as shown in **Tables 5, 6,** and **7**.

Table 5 Scores for Degree of Use of MPTs

Score	Household use of MPTs
0	No use
1	Little use
2	Moderate use
3	High use
4	Very high use

Table 6 Scores for Economic Contribution of MPTs

Score	Degree of economic contribution of MPTs
0	No contribution
1	Little contribution
2	Moderate contribution
3	High contribution
4	Very high contribution

Table 7 Scores for Annual Cash Income from MPTs

Score	Annual income from MPTs (Kshs)
1	0
2	1-10,000
3	10,001-20,000
4	20,001-30,000
5	>30,000

Household use of MPTs index = [Degree of use of MPTs scores + Degree of economic contribution of MPTs scores + Cash income from MPTs scores]. The three items were summed as an index with a range of 1-13 to form a continuous variable for use in regression analysis.

The constructed interval scale categories from the household use of MPTs index, which were used in descriptive analysis, are as follows:

Category	Code	Description
1-4	1	Little use
5-7	2	Moderate use
8-10	3	High use
11-13	4	Very high use

3.7.4 Constraints to Adoption of Agroforestry Technologies

Constraints are the limiting factors to the adoption of agroforestry by farmers. These constraints were operationalized by determining the constraints experienced by households with regard to the adoption of agroforestry technologies. These constraints were classified into technological, socioeconomic and socio-cultural constraints. Scores used for these constraints are shown in **Table 8**.

Table 8 Scores Used for Technological, Socioeconomic, and Socio-cultural Constraints

Score	Nature of constraints
1	Least constraining
2	Moderately constraining
3	Constraining
4	Highly constraining
5	Very highly constraining

Constraints to adoption of Agroforestry technologies index = [Technological constraints scores + Socioeconomic constraints scores + Socio-cultural constraints scores]. These scores were summed to create an index of constraints to adoption of agroforestry technologies with a range of 7-16 for use in regression analysis.

The constructed interval scale categories for constraints to adoption of agroforestry technologies for use in descriptive analysis are indicated below:

Category	Code	Description
7-8	1	Least constraining
9-10	2	Moderately constraining
11-12	3	Constraining
13-14	4	Highly constraining
15-16	5	Very highly constraining

3.7.5 Farm Production

This is the output or the yield of farmers' farms in terms of combinations of tree and crop products. The yields of crop and tree products produced from the farms per year were determined. The amount of each product was multiplied by the average unit cost in order to get the economic values of tree and crop products produced from the farm per year. Household farm production was then computed from the total of economic value of crop and tree production. An index was then constructed to measure the level of farm production.

The constructed interval scale categories for farm production index used in descriptive analysis are indicated below:

Production per year (Kshs.)	Code	Description
1000-55,000	1	Low Production
55,001-110,000	2	Moderate production
110,001-165,000	3	High production
>165,001	4	Very high production

3.8 RESEARCH DESIGN, SAMPLE FRAME AND SAMPLE SIZE

Research method involved a cross-sectional survey by use of a structured questionnaire which was administered after being pre-tested to ensure it solicited reliable, valid and accurate data. Pre-testing of the questionnaire was done on forty respondents in Nambacha location. The household survey was conducted between February 2001 and May 2001 in two locations selected randomly in both Navakholo and Shinyalu divisions to elucidate the information and data required for the study. The locations were Bunyala West and Bunyala Central in Navakholo division and Khayega and Shibuye locations in Shinyalu division.

The household formed the unit of analysis while the total number of households in the four locations constituted the sample frame. A sample size of 241 households was used for this study. Systematic random sampling design was used where the sampling units were selected randomly along transects which were paths traversing the locations. Sampling begun from a central point in the sub-location and every fifth

household along the transect was then interviewed to obtain the data for the study. In case the interviewee was absent, the next immediate household was sampled.

3.9 SOURCES OF DATA AND DATA COLLECTION

Data for the study was collected from both primary and secondary sources. Primary data was obtained through the field survey which involved 241 randomly selected households in Navakholo and Shinyalu divisions. Farmers were asked questions regarding total land size and area under agroforestry, agroforestry adoption, benefits from use of MPTs, constraints to adoption of agroforestry technologies, farm production and income from sale of farm produce.

Survey through the use of a questionnaire (**Appendix 3**) containing open and closed-ended questions and direct observation were used to gather primary data for the study. The questionnaire was pre-tested to ensure that it elicited the responses that answered the study questions. Three enumerators were recruited from the study area to assist the researcher and were trained on how to administer the questionnaire. Their selection was based on familiarity with the area, and had to have a minimum of form four level of education. Enumerators assisted the researcher in administering the structured questionnaire through household visits. Single visit personal interviews were conducted whereby the respondent

was interviewed and the interviewer recorded the responses. Other members of the household were encouraged to participate especially in cases where the household head experienced difficulties in recalling events/data.

Secondary data was obtained from relevant books, District agricultural reports, forestry reports, journals, periodicals, theses and government publications. Specific information restricted to Forest officers, Agricultural officers, etc which could enhance the collected secondary data was solicited for. Secondary data was used for descriptive purposes so as to give an insight into the trend of agroforestry practice in Kakamega District as a whole. However, it is the primary data that was significant for the study as it was used for statistical analysis.

3.9.1 Limitations in Data Collection

An important limitation was the local language (Luhya) of the people in the area of study, while the author happens to come from a different ethnic group. As a result of this barrier, the author may not have had full advantage of some of the responses given by the respondents in Luhya. However, this limitation did not translate into a weakness of the study. The use of local personnel as enumerators and the translation of the questionnaire into Luhya and back to English ensured that the findings of the study were valid. It is possible that misunderstanding could have

arisen with translation from one language to another, but such errors were minimized by probe questions to ensure consistency on the answers given by the respondents.

Difficulty was encountered by the household heads in answering questions that required them to recall events, such as amount of income earned per year from the sale of crops of tree products. In such cases other members of the household who could recall were encouraged to participate during the questionnaire administration so as to get as accurate information as possible.

It is therefore worth to note that the data used in this thesis is not free from errors especially due to the above mentioned limitations. The use of results obtained in this study and my conclusions should be weighed against these limitations.

3.10 METHODS OF DATA ANALYSIS

Analysis of data collected was done by use of Statistical Package for the Social Sciences (SPSS) program. Data was coded and entered in to SPSS program, after which it was cleaned to remove the effect of the out-liers. Descriptive analysis of the data was done which involved the use of frequency distributions and measures of central tendency (mean). Bi-variate correlation and regression analysis was carried out to determine

the magnitude, strength and direction of the relationship between the dependent variable (household farm income) and independent variables (adoption of agroforestry technologies, farm production, household use of MPTs, and constraints to adoption of agroforestry technologies). Multiple regression analysis was used to determine the contribution of each independent variable on the dependent variable. The regression model used was adapted from the general multiple regression model as given by Bohrnstedt and Knoke (1985), Harvey and MacDonald (1993) and Mugenda and Mugenda (1999).

The general multiple regression model is of the form:

$$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots \beta_n X_n + \varepsilon$$

Where: Y – is the dependent variable

X_{1-n} – are the independent variables

β_0 – is the constant

β_{1-n} – are the regression coefficients or change induced in Y by each X

ε – is the error term

The multiple regression model modified to suit the study was of the from:

$$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where: Y – Household farm income index

β_0 – is the constant

X_1 – Farm production index

X_2 – Household use of MPTs index

X_3 – Adoption of agroforestry technologies index

X_4 – Constraints to adoption of agroforestry technologies index

$\beta_{1\text{-}n}$ – Beta regression coefficients

ε – Error term

Stepwise regression was used to choose the best set of independent variables that explained the variability of the dependent variable.

CHAPTER FOUR: RESULTS

4.0 DESCRIPTIVE ANALYSES

4.0.1 Socioeconomic Characteristics of the Households

Out of the 241 respondents interviewed, 141 were males while 100 were female (**Table 9**). The high number of females interviewed was attributed to them being representatives of the male heads of household who were engaged in other off-farm activities at the time of survey. The mean age of the respondents was found to be 46.3. The minimum and maximum ages of the respondents were 17 and 82 years, respectively.

Table 9 Respondents by Sex

Sex	Number of respondents	Percentage
Male	141	58.5
Female	100	41.5
Total	**241**	**100.0**

The respondent's marital status was grouped into four categories; married, divorced/ separated, widowed and single. Majority of the respondents were married while the minority were either divorced or separated (**Table 10**).

Table 10 Categories of Respondents by Marital Status

Category	Number of respondents	Percentage
married	196	81.3
widowed	26	10.8
single	12	5.0
divorced/separated	7	2.9
Total	**241**	**100.0**

The respondents were categorized into different groups based on their primary occupation; farming, business, civil service, domestic/housewife, non-farm full time employee, non-farm casual employee, unemployed, farming and business, and pastor. The majority respondents had farming as their occupation (**Table 11**).

Table 11 Categories of Respondents by Occupation

Occupation	Number of respondents	Percentage
Farming	149	61.8
Farming & Business	25	10.4
Business	19	7.9
Unemployed	19	7.9
Civil servant	17	7.1
Housewife	4	1.7
Non farm casual employee	4	1.7
Non farm full time employee	3	1.2
Pastor	1	0.4
Total	**241**	**100.0**

The mean land holding size was 4.5 acres. The minimum land holding size was 0.2 acres while the maximum was 35.0 acres. The main categories of land ownership that exist are shown in **Table 12**.

Table 12 Categories of Respondents by Land Ownership

Category	Number of respondents	Percentage
Own land with title deed	170	70.5
own land with no title deed	50	20.7
communal	18	7.5
rented	2	0.8
squatter status	1	0.4
Total	**241**	**100.0**

The education level attained by the respondents was categorized into five categories; No schooling, primary 1-4, primary 5-8, secondary 1-4, and post secondary. Most of the household heads were in the primary 5-8 category while few respondents attained post secondary education (**Table 13**).

Table 13 Education Level of Respondents

Category	Number of respondents	Percentage
Primary 5-8	86	35.7
Secondary 1-4	77	32.0
No schooling	46	19.1
Primary 1-4	25	10.4
Post secondary	7	2.9
Total	**241**	**100.0**

4.0.2 Agroforestry Activity

The types of agroforestry technologies/practices utilized by households included alley cropping, improved fallows, trees in home gardens, dispersed trees on cropland and wind breaks. The distribution of the agroforestry practices/technologies is shown in **Table 14.**

Table 14 Major Types of Agroforestry Technologies Utilized by Respondents

Type of technology	Number of respondents	Percentage
Home gardens	203	84.2
Dispersed trees on cropland	142	58.9
Wind breaks	31	12.9
Alley cropping	7	2.9
Improved fallows	3	1.2

The role played by MPTs on the respondent's farms was either productive such as provision of fodder, timber, firewood, or service function such as the provision of shade. **Table 15** summarizes the uses of MPTs on the farms.

Table 15 Uses of MPTs by the Respondents

Use	Number of respondents	Percentage
Firewood	212	88.0
Fruit	202	83.8
Timber	188	78.0
Shade	152	63.1
Fencing	149	61.8
Building material	119	49.4
Poles	115	47.7
Charcoal	99	41.1
Medicine	74	30.7
Soil fertility improvement	60	24.9
Windbreak	58	24.1
Soil & water conservation	39	16.2
Fodder	26	10.8
Aesthetic	24	10.0
Food	21	8.7

Sixty-six respondents (27.4%) reported experiencing various negative effects attributed to trees on their farms **(Table 16).**

Table 16 Negative effects of MPTs on farms

Negative effect	Frequency	Percent
None	184	76.4
Interference with crops	41	17.0
Falling tree branches damage crops	14	5.8
Attract lightning	2	0.8
Total	**241**	**100.0**

The tree and shrub species incorporated on the respondents' farms are shown in **Table 17**.

Table 17 MPTs Utilized by the Respondents on Their Farms

Species	Number of respondents	Percentage
Indigenous		
Markhamia lutea	139	57.7
Croton macrostachyus	100	41.5
Terminalia mentalis	42	17.4
Spathodea companulata	39	16.2
Fagara macrophyla	34	14.1
Cordia abyssinica	29	12.0
Ficus sycomorus	26	10.8
Acacia lahaii	25	10.4
Erythrina abyssinica	21	8.7
Indigoffera errecta	19	7.9
Syzygium quineense	18	7.5
Bredilia macrantha	18	7.5
Ficus vasta	17	7.1
Dombeya goetzenii	13	5.4
Combretum binderianum	12	5.0
Vitex doniana	10	4.1
Rhus natalensis	3	1.2
Exotic		
Eucalyptus saligna	186	77.2
Cupressus lusitanica	153	63.5
Grevillea robusta	58	24.1
Pinus patula	40	16.6
Jacaranda mimosifolia	34	14.1
Azadirachta indica	12	5.0
Calliandra callothysus	6	2.5
Fruit trees		
Mangifera indica	84	34.9
Persia americana	81	33.6
Psidium guajava	79	32.8
Carica papaya	71	29.5
Citrus lemon	5	2.1

Crops grown included maize, beans, sweet potatoes, vegetables, peanuts and cassava. Total value of crops produced was computed by adding the economic values of all crops harvested per year, and then summarized

into category groups **(Table 18)**. Majority of the households had production value of 10-55,000 Kshs. Only 1.2% had very high crop production value greater than 145,000 Kshs.

Table 18 Crop Production in Navakholo and Shinyalu Divisions

Production value (Kshs)	Number of respondents	Percentage
10-55,000	216	89.6
55,001-100,000	15	6.2
100,001-145,000	7	2.9
>145,000	3	1.2
Total	**241**	**100.0**

Source: Household Survey, 2001

Products from MPTs included timber, firewood, charcoal, poles, fruit, fodder, food and logs. Total MPTs product value was computed and summarized into groups **(Table 19)**. The majority of the households had tree production value ranging between 1000 and 23,000 Kshs. Only 0.8% had tree production value greater than 67,000 Kshs.

Table 19 Tree Production in Navakholo and Shinyalu Divisions

Production value (Kshs)	Number of respondents	Percentage
1000-23,000	208	86.3
23,001-45,000	25	10.4
45,001-67,000	6	2.5
>67,000	2	0.8
Total	**241**	**100.0**

Source: Household Survey, 2001

Few respondents (12.4%) reported production of tree products in excess of their average requirement while the majority (87.6%) indicated that no excess products were produced from their farms. The majority of those who produced excess tree products sold them while few respondents stored for future use. **Table 20** summarizes how the respondents used excess tree products.

Table 20 Use of Excess Tree Products by the Households

Use of products	Number of respondents	Percentage
No excess produced	211	87.6
Sale of excess products	28	11.6
Store for future use	2	0.8
Total	**241**	**100.0**

Income from sale of crops indicated that for the majority (45.2%) no income was earned as most of the produce was used for family consumption (**Table 21**). For those who sold some crop produce, (44.4%) were in the category of 1-16,000 Kshs per annum group whereas only 1.7% were grouped in the income category having greater than 48,000 Kshs per annum. The mean income from this source was computed to be Kshs 5,897.20. The maximum income earned per annum from the sale of crop produce was Kshs 59,600.00.

Table 21 Household Income from Crops

Income p.a. (Kshs)	Number of respondents	Percentage
0	109	45.2
1-16,000	107	44.4
16,001-32,000	16	6.6
32,001-48,000	5	2.1
>48,000	4	1.7
Total	**241**	**100.0**

Income from sale of MPTs was also determined. The majority (63.1%) of the households had income of between 1 and 10,000 Kshs per annum, while only 2.1% had income greater than 30,000 Kshs per annum (**Table 22**). The mean income from sale of MPTs products was computed to be Kshs 5,084.50. The maximum income earned per annum from this source was Kshs 40,000.00.

Table 22 Household Income from MPTs Products

Income p.a. (Kshs)	Number of respondents	Percentage
0	50	20.7
1-10,000	152	63.1
10,001-20,000	24	10.0
20,001-30,000	10	4.1
>30,000	5	2.1
Total	**241**	**100.0**

Constraints to the adoption of agroforestry technologies were classified into three categories; technological, socioeconomic and socio-cultural constraints. Technological constraints included constraints such as tree

interference with crops or prevention of mechanized land preparation. The distribution of technological constraints is shown in **Table 23**.

Table 23 Technological Constraints

Constraint	Frequency	Percent
Tree interference with crops	140	58.1
Lack of seedlings to plant	125	51.9
Lack of knowledge on trees to plant	78	32.4
Lack of knowledge on tree establishment	76	31.5
Inhibits mechanized land preparation	25	10.4

Socioeconomic constraints included constraints such as small land size or lack of income to invest in trees. The distribution of socioeconomic constraints is shown in **Table 24**.

Table 24 Socioeconomic Constraints

Constraint	Frequency	Percent
Small land size	131	54.4
Lack of income to invest in MPTs	77	32.0
Lack of immediate benefits from trees	54	22.4
None ownership of land	46	19.1
Too old to plant and tend trees	28	11.6

Socio-cultural constraints included constraints such as women not being allowed to plant trees by the clan or planting of trees being associated with barrenness. **Table 25** shows the distribution of these constraints.

Table 25 Socio-cultural Constraints

Constraint	Frequency	Percent
Not allowed by clan as a woman	20	8.3
May cause death in the family	18	7.5
Woman will be barren	7	2.9
Woman will not have a stable marriage	3	1.2
Woman won't give birth to normal children	2	0.8
Not allowed to plant trees used for traditional medicine	2	0.8
Not allowed to plant trees meant for shrines	2	0.8

4.0.3 Adoption of Agroforestry Technologies

Adoption of agroforestry technologies was categorized as non-adoption, little, moderate and high adoption. The majority of the respondents were grouped under moderate adoption category (**Table 26**).

Table 26 Adoption of Agroforestry Technologies in Navakholo and Shinyalu Divisions

Score	Category	Number of respondents	Percentage
1	Non adoption	21	8.7
2	Little	72	29.9
3	Moderate	130	53.9
4	High	18	7.5
	Total	**241**	**100.0**

4.0.4 Farm Production

Most of the households (73.9%) had low farm production, while 1.7% had very high farm production (**Table 27**).

Table 27 Farm Production in Navakholo and Shinyalu Divisions

Score	Category	Number of respondents	Percentage
1	Low farm production	178	73.9
2	Moderate farm production	47	19.5
3	High farm production	12	5.0
4	Very high farm production	4	1.7
	Total	**241**	**100.0**

4.0.5 Household Farm Income

Household farm income was divided into five categories; no income, low, moderate, high, and very high income. The majority of the households (72.6%) had low farm income (**Table 28**). The mean annual farm income was Kshs. 11,527.10. The maximum annual farm income was determined to be Kshs. 97,000.00.

Table 28 Household Farm Income in Navakholo and Shinyalu Divisions

Score	Category	Number of respondents	Percentage
1	No income	34	14.1
2	Low income	175	72.6
3	Moderate income	20	8.3
4	High income	10	4.1
5	Very high income	2	0.8
	Total	**241**	**100.0**

4.0.6 Household Use of MPTs

The majority of the households (45.6%) had moderate use of MPTs, while only 3.7% had very high use of MPTs (**Table 29**).

Table 29 Extent of Household Use of MPTs in Navakholo and Shinyalu Divisions

Score	Category	Number of respondents	Percentage
1	Little use	65	27.0
2	Moderate use	110	45.6
3	High use	57	23.7
4	Very high use	9	3.7
	Total	**241**	**100.0**

4.0.7 Constraints to Adoption of Agroforestry Technologies

Constraints to adoption of agroforestry technologies were divided into five categories: least constraining, moderately constraining, constraining, highly constraining and extremely constraining. Generally, a majority of households seem to have highly constraining constraints (**Table 30**).

Table 30 Degree of Constraints to Agroforestry Adoption in Navakholo and Shinyalu Divisions

Score	Category	Number of respondents	Percentage
1	Least constraining	13	5.4
2	Moderately constraining	55	22.8
3	Constraining	73	30.3
4	Highly constraining	99	41.1
5	Extremely constraining	1	0.4
	Total	**241**	**100.0**

4.1 ANALYTICAL RESULTS AND HYPOTHESES TESTING

4.1.1 Measurement of Direction and Strength of Relationships

Four hypotheses were investigated in the study. The Pearson Product-Moment correlation (r) was used to measure the level of association between the variables under study. **Table 31** shows the variables entered for correlation analysis.

Table 31 Variables Entered for Correlation Analysis

Variable	Label
REAFADOP	Agroforestry technologies adoption index
REFARPRO	Farm production index
REFARMIN	Household farm income index
REUSEMPT	Household use of MPTs index
RECOAFAD	Constraints to agroforestry adoption index

A one-tailed significance test was utilized in the analysis. **Table 32** summarizes results of Pearson Product-Moment correlation analysis.

Table 32 Matrix for Pearson Correlation Coefficients (r), 1-Tailed Sig.

	REAFADOP	REFARPRO	REFARMIN	REUSEMPT	RECOAFAD
REAFADOP	1.000				
REFARPRO	.152*	1.000			
REFARMIN	.250***	.533***	1.000		
REUSEMPT	.362***	.325***	.532***	1.000	
RECOAFAD	-.022	.205**	.092	-.122	1.000

* p< 0.05, ** p< 0.01, *** p< 0.001

The results of analysis indicate a positive significant relationship between adoption of agroforestry technologies and farm production, (r= .152, p<0.05), a significant, positive relationship between adoption of agroforestry technologies and household farm income (r= .250, p< 0.001), a significant, positive and strong association between household use of MPTs and household farm income (r= .532, p< 0.001), and a negative, insignificant relationship between constraints to adoption of agroforestry technologies and adoption of agroforestry technologies (r= -.022, p> 0.05).

4.1.2 Prediction of Direction of Relationships

Bi-variate regression analysis (**Appendix 1**) was used to establish whether an independent variable predicts a given dependent variable and hence test the postulated hypotheses. The results of bivariate regression analysis are summarized in **Table 33.**

Table 33 Results of Bi-variate Regression Analysis

N=241	R^2	Beta	t	Sig.
Dependent: *Farm production*				
Adoption of Agroforestry Technologies (REAFADOP)	.023	.152	2.379	.018
Dependent: *Household Farm Income*				
Adoption of Agroforestry Technologies (REAFADOP)	.063	.250	3.997	.000
Dependent: *Household Farm Income*				
Household Use of MPTs (REUSEMPT)	.283	.532	9.716	.000
Dependent: *Adoption of Agroforestry Technologies*				
Constraints to Adoption of Agroforestry Technologies (RECOAFAD)	.001	-.022	-.346	.729

4.1.2.1 Relationship between Adoption of Agroforestry Technologies and Farm Production

The first study hypothesis, based on the first specific objective, postulated that adoption of agroforestry technologies has an impact on farm

production. The assumption is that adoption of agroforestry technologies will lead to an increased farm production as a result of a combination of tree and crop products. In order to determine the impact of adoption of agroforestry technologies on farm production and test hypothesis one, farm production was regressed over adoption of agroforestry technologies. The results of the analysis as indicated in **Table 33** show a statistically significant regression coefficient between adoption of agroforestry technologies and farm production ($\beta = 0.152$, $p < 0.05$). The null hypothesis (H_o) that there is no relationship between adoption of agroforestry technologies and farm production is rejected. This implies that adoption of agroforestry technologies has a positive impact on farm production. The R^2 value indicates that 2.3% of the variation in farm production is explained by the adoption of agroforestry technologies.

4.1.2.2 Relationship between Adoption of Agroforestry Technologies and Household Farm Income

As postulated, based on the second objective, hypothesis two states that there is a significant, positive relationship between adoption of agroforestry technologies and household farm income. It was anticipated that adoption of agroforestry technologies creates diversification in sources of income, that is, income from crop and MPTs products, and thus positively influencing household farm income. To test this hypothesis and

therefore fulfil objective two, household farm income was regressed over adoption of agroforestry technologies. When bivariate regression was performed, the relationship between adoption of agroforestry technologies and household farm income was found to be significant at probability level 0.001 with a *beta* statistic of .250 ($\beta = 0.250$, $p < 0.001$). The results imply that the null hypothesis, which stated that there is no significant positive relationship between adoption of agroforestry technologies and household farm income is rejected since, the relationship has been proven positive and statistically significant. These results suggest that adoption of agroforestry technologies, which leads to a combined income from MPTs and crops has a positive influence on household farm income. The R^2 value shows that only 6.3% of the variation in household farm income is explained by the adoption of agroforestry technologies.

4.1.2.3 Relationship between Household Use of MPTs and Household Farm Income

The third hypothesis of the study, which is based on the third specific objective, postulates that there is a significant positive relationship between household use of MPTs on household farm income. The rationale here is that when MPTs are used to earn cash income in terms of timber, charcoal, fruit, or firewood there is likely to be increased economic returns and hence improved household farm income. To test

hypothesis three, household farm income was regressed over household use of MPTs. The results of this bivariate regression analysis are shown in **Table 33**. Regression results indicate that there is a significant positive relationship between household use of MPTs and household farm income, at probability level 0.001 with a *beta* statistic of .532 ($\beta = 0.532$, $p < 0.001$). The null hypothesis (H_o) that stated that there is no relationship between the two variables is therefore rejected. It can therefore be concluded that household use of MPTs has a significant contribution to household farm income. R^2 value of 0.283 obtained indicates that 28.3% of the variation in household farm income is explained by household use of MPTs.

4.1.2.4 Relationship between Constraints to Adoption of Agroforestry Technologies and Adoption of Agroforestry Technologies

The fourth hypothesis of the study derives from objective four and postulates that there is a significant negative relationship between constraints to adoption of agroforestry technologies and the adoption of agroforestry technologies. The assumption here is that various socioeconomic, socio-cultural, and technological constraints would significantly affect the adoption of agroforestry technologies. In testing hypothesis four, adoption of agroforestry technologies was regressed over constraints to adoption of agroforestry technologies. Results of bivariate

regression analysis as shown in **Table 33** indicate insignificant regression coefficient between the two variables (β = -0.022, $p > 0.05$). In this case, we fail to reject the null hypothesis (H_o) which stated that there is no significant relationship between constraints to adoption of agroforestry technologies and adoption of agroforestry technologies. This implies that the presence of various constraints do not significantly prevent individuals from adopting agroforestry technologies. This is true because as realized in the study, agroforestry has been a long time practice and farmers have incorporated trees on their farms in varying combinations with crops. The R^2 value given indicates that 0.1% of the variation in adoption of agroforestry technologies is explained by constraints to adoption of agroforestry technologies.

4.1.3 Contribution of Independent Variables on the Dependent Variable

Multiple regression analysis was used to determine the contribution of each independent variable (farm production index, household use of MPTs index, adoption of agroforestry technologies index, and constraints to adoption of agroforestry technologies index) on the dependent variable (household farm income index). **Table 34** shows the summary results of multiple regression analysis.

Table 34 Results of Multiple Regression Analysis

N=241	R^2	Beta	t	Sig.
Dependent: *Household Farm Income*				
(Constant)		.510	2.191	.029
1. Farm Production (REFARPRO)		.384	7.160	.000
2. Household Use of MPTs (REUSEMPT)		.397	7.089	.000
3. Adoption of Agroforestry Technologies (REAFADOP)		.049	0.940	.348
4. Constraints to Adoption of Agroforestry Technologies (RECOAFAD)	0.425	-.063	1.230	.220

The results indicate that 42.5% (R^2 = 0.425) of the variation in the dependent variable (household farm income) is explained by the independent variables in the equation. Testing for individual β coefficients (**Table 34**) was done and it was determined that the addition of constraints to adoption of agroforestry technologies index to the model given that the other independent variables are already in the model does not help to explain the variability of the dependent variable (β = 0.063, t = 1.230, p> 0.05). The addition of adoption of agroforestry technologies index to the model also does not help to explain the variability in the dependent variable (β = 0.049, t = 0.940, p> 0.05). However, the addition of household use of MPTs index (β = 0.397, t = 7.089, p< 0.001) and farm production index (β = 0.384, t = 7.160, p< 0.001) to the model given that

other independent variables are in the model helps to explain the variability of the household farm income index.

Stepwise regression was done to determine the best set of independent variables that explain the variation in household farm income. Of all the explanatory variables included in the model, only farm production index ($\beta = 0.403$, $t = 7.784$, $p < 0.001$), and Household use of MPTs ($\beta = 0.401$, $t = 7.744$, $p < 0.001$) were found to be significant (**Appendix 2**). The value of the coefficient of multiple determination, $R^2 = 0.424$, indicates that nearly 42% of household farm income can be explained by variables X_1 and X_2 only. The rest 58% can be attributed to factors not considered in this study. In case of the two independent variables coming into play, household farm income can be determined using the following model:

$$Y = 0.831 + 0.403\,X_1 + 0.401\,X_2 + \varepsilon$$

These results imply that for one to have an increase in farm income there should be increased household use of MPTs and increased farm production. Adoption of agroforestry technologies alone will not result in an improved household farm income unless there is utilization of MPTs on farms or harvesting of tree and crop products for various uses including for sale.

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 DISCUSSION

5.1.1 Adoption of Agroforestry Technologies

Results of analysis indicated that adoption of agroforestry technologies positively and significantly affects farm income ($r= 0.250$, $p< 0.001$), and farm production ($r= 0.152$, $p< 0.05$). Agroforestry systems have the potential to improve production and to enhance the agronomic and ecological sustainability of resource-poor farmers. Most of the respondents (84.2%) practiced traditional home gardens on their farms. This is because agroforestry is not a new concept and farmers have always incorporated trees in their crop farms (Nair, 1989). But due to increased human population and decreased land holding sizes, practices such as improved fallows are no longer a common feature. This agrees with the results of the study, which show that a small proportion (1.2%) of the households utilized this practice.

The potential benefits of agroforestry systems can be harnessed and maximized through skillful and labour-intensive management of compatible systems. There are no simple blue prints of a universally applicable system that can harness all potential benefits possible under

ideal conditions. Thus, a wide range of agroforestry systems have been designed to alleviate agronomic, ecological, or managerial constraints. It is a common feature therefore to find farmers incorporating different practices such as trees in home gardens, dispersed trees in cropland, wind breaks or alley cropping under their farms as witnessed in the study.

One technological constraint to adoption of agroforestry technologies presented by the farmers was mechanized land preparation. Rather than using a random and difficult to mechanize system of growing trees and annuals, mixtures can be grown in an improved spatial and temporal arrangement. In agrisilvicultural system for example, trees can be grown in alternate rows and strips as contour hedges to control erosion or in field boundaries. These orderly arrangements can facilitate the use of animal power and of mechanization of farm operations, save labour, and enhance economic and ecological benefits.

Alley cropping, though utilized by few respondents (2.9%) is a common example of a spatial arrangement. Food crops are grown in alleys formed by contour hedgerows of trees or shrubs (Kang *et al.*, 1981). Trees and shrubs can be pruned to prevent shading of the food crops and to provide nitrogen-rich mulch for crops and fodder for livestock. Shrubs and trees also act as windbreaks, facilitate nutrient recycling, suppress weed growth, decrease runoff, and reduce soil erosion (Ehui *et al.*, 1990).

The most common trees for alley cropping are fast growing, multipurpose, nitrogen-fixing trees. Tree species with the potential for use with non-acid tropical soils include *Gliricidia sepium* and *Leucaena leucocephala*. Species for acid soils include *Calliandra calothyrsus*, *Erythrina* spp., *Harungana madagascariensis*, and *Inga edulis.*

When successfully established, alley cropping systems can produce multiple products and can improve or maintain soil structure. However, the beneficial effects of these systems depend on many factors, such as the tree species, area of land allocated to trees, hedgerow management, crop management, soil type, and prevalent climate. In areas with non-acid soils, satisfactory yields of cereals can be attained with the added benefit of erosion control (Kang *et al.*, 1984; Lal, 1989). These systems are also labour intensive (Lal, 1986; 1991), therefore they are adapted primarily to areas of high population density and modest to low labour cost.

Adoption of agroforestry technologies could have a greater impact on farm production and income through the improvement of traditional agroforestry systems by enhancing productivity and ecological compatibility. Ways of improving these systems include using high value trees and woody shrubs and creating an orderly arrangement of trees and crops. This could be

achieved through effective extension contact with farmers so that they are aware of technologies suited for their farms.

5.1.2 Household Use of MPTs

There is a significant, positive relationship between household use of MPTs and household farm income ($r= 0.0532$, $p< 0.001$). Results of stepwise regression analysis (**Appendix 2**) indicate that household use of MPTs ($\beta= 0.401$, $p<0.001$) helps to explain the variability in household farm income. This is because when MPTs are used to earn cash income in terms of timber, fruit, charcoal, or firewood, there is increased economic returns hence improved household farm income. Similar observations have been made by Chavangi (1992), Pathak and Roy (1995), and Roy (1999).

MPTs are planted and managed by farmers for many purposes, including poles, timber for construction, split wood for sale, wood for making charcoal, or for use in rituals and ceremonies. This implies that the multipurpose nature of trees and shrubs is an important component in the selection of MPTs to be included in agroforestry systems so as to maximize benefits from trees.

Households have come to attach an economic value to trees, and now regard them as sources of cash (Bradley, 1991). There is a distinct

preference for exotic trees, such as *Eucalyptus, Cupressus* and *Pinus* species, which are regarded as cash earners, or as a form of investment that can be used to pay for domestic requirements. However, exotic MPTs such as *Leucaena leucocephala*, *Calliandra callothysus*, or *Grevillea robusta* are deliberately grown on agricultural land as plants that enhance soil fertility.

Tengnas (1994) reported that trees play an important role in providing cash for the household. Trees may also support agricultural and livestock production, which also contributes to greater income from the farm. It is argued that a standing stock of growing trees can also be an important investment, and to some extent a saving and that can help to bridge years when the harvest is poor, or help the family to manage in periods of financial crisis (Tengnas, 1994). That is the reason why MPTs tend to have a greater impact on household farm income, as reflected by the study. An important factor to note is that trees are not subject to inflation and may be a better kind of saving than keeping money in bank accounts.

5.1.3 Farm Production

There is a positive significant association between adoption of agroforestry technologies and farm production ($r= 0.152$, $p< 0.05$). This can be attributed to the positive effects associated with adoption of

agroforestry technologies, which can only be realized if there is a positive tree interaction with crops surrounding it.

Agroforestry is only beneficial to the farmer when there is increased farm production or if the net effect of all the factors involved in the interaction is positive. Trees planted with crops certainly do not always contribute to a higher output or to more sustainable land use. The benefits will only be obtained through a combination of the right tree species with the right crops in the right spatial arrangements and with the right management practices (Tengnas, 1994; Nair, 1989).

Most of the households had low crop and tree production, which can be attributed to poor management practices pertaining to the interaction between trees and crops. Some factors of importance in the relationship between crops and trees which farmers need to understand in order to improve crop production include: light demand, demand for moisture and nutrients, potential for bird damage, the distribution of roots in the soil profile and the potential for wind damage. A crop such as maize is light demanding, so shade may reduce crop yields. It is sensitive to competition for moisture; so intercropped trees must be of a non-competitive type in drier areas. Wind damage can be a problem in maize production; therefore trees can be useful as windbreaks. On the other

hand crops like beans prefer lower temperatures and they normally perform well under maize, bananas or trees.

Regarding the selection of the tree component, it is recognized that a farmer appreciates a tree that gives high net cash value, and low values for the negative factors. The major cost is competition with other components, and this should be as little as possible. Since land holdings are small, very competitive trees such as *Eucalyptus* spp. may not be recommended even though they are fast growing and have valuable production.

Most of the respondents (88.0%) used MPTs for the provision of fuelwood (**Table 15**). Since it is traditionally regarded as the duty of women to provide fuelwood, it is important to involve them in projects such as agroforestry that concern fuelwood production, provision, and use. Men and women almost always have vastly different views concerning the utility of community or farm forestry activities (Molanar and Schreiber, 1989). In Senegal, the men in the village councils planned to sell as poles the timber from community woodlots, which had in fact been established to provide fuelwood for local households and to reduce the workload of the women (Dankeknan and Davidson, 1988). Where women are actively involved, chances of success are high. In the Gambia, for example, the National Women's Bureau and the Forestry Department promoted the

establishment of woodlots cum-orchards managed by village women's groups; which produced locally significant quantities of fruits and vegetables as well as fuelwood (Marenha 1985; Dankeknan and Davidson 1988).

Several successful programs in Kenya are based on involvement of local women. One of the best known and most successful non-governmental afforestation program is the Green Belt Movement, started in 1977 by the National Council of Women of Kenya (Maathai, 1988). Another successful program is that of the Kenya Energy Non-Governmental Organization (KENGO), an association of over 200 NGOs dealing with energy issues, which include a number of women's groups and organizations. KENGO is active in the promotion of fuel-saving stoves as well as in reforestation with indigenous trees. Information on medical, cultural, ecological, and economic values of trees is collected from local women and passed on to women's groups through workshops, exhibitions, mass media, pamphlets, and posters. The Kenya Woodfuel Development Programme promotes a self- sustaining system of tree planting to supply fuelwood. Based on surveys of agroforestry practices and cultural background of local people, its approach accommodates indigenous expertise with traditional belief, and taboos. Women are especially encouraged to develop solutions that will not conflict with traditional

values (Chavangi, 1992; Engelhard and Jones, 1985; Leach and Robin, 1988). When all these factors are taken into consideration, there is likely to be increased and beneficial farm production.

5.1.4 Household Farm Income

Most of the households had low farm income. This can be attributed to low incomes earned from individual components that add in to total farm income (income from MPTs and income from crops). As a result of small farm sizes, the majority of the households grow crops for home consumption and rarely for sale.

Social trends and economic development forces of more recent times have placed a huge amount of importance on short-term products and profit maximization. Cash, rather than subsistence crops have understandably been the focus of more advanced societies. Economic rationale tells the farmer to maximize production of the crop that yield him/her the most money at the market. Agroforestry systems have often been replaced with crop monoculture where trees are seen to interfere with crop yield maximization. Intensive mono-cropping systems, though perhaps more profitable for a time, are much more risky and costly in the long run. Risky because crop prices are always changing and pest infestations can destroy entire harvests. Costly because these intensive

farming practices degrade most soils rapidly, and thus require expensive chemical and fertilizer inputs to sustain productivity.

Agroforestry systems could be improved and managed so as to increase subsistence and market produce from limited land areas over time. It is important to note that farmers will not invest in agroforestry unless there are adequate incentives at the farm level to produce trees for own use or for the market. The emergence of such incentives depends on a combination of factors such as climate, stage of deforestation institutional arrangements, land tenure conditions, effectiveness of forestry extension, along with pricing (Barnes, 1990). If trees are to be grown for sale as fuelwood or construction material the practice must be profitable.

The development of fuelwood markets; will be accelerated if: cutting in protected forest areas is restricted, farmers are not restricted or licensed/taxed in marketing fuelwood they produce on their farms; nurseries are established to produce appropriate species; research and extension services incorporate tree farming as a major theme; and land tenure reform provides ownership of forests to farmers and local communities so that they are more likely to invest in forests rather than merely mine them for fuel wood. If appropriate price signals are to be developed, fuelwood must not be obtainable as a free good. Provided the appropriate species are used, agroforestry techniques can be very

profitable in many areas because of their potential to generate a combination of benefits (fuelwood, poles, fodder, fruit, and associated crop yield increases). Given a compatible association of trees and annual crops, agroforestry systems are likely to sustain economic productivity without causing severe degradation of the environment. Because of the low fertility of most upland tropical soils, some degradation is inevitable with any cultivation system. But the rate and risks of such degradation are lower with agroforestry than with annual crop rotations (Lal, 1989).

5.1.5 Constraints to Adoption of Agroforestry Technologies

Constraints to adoption of agroforestry technologies do not have a profound effect on the adoption of agroforestry technologies. Results of analysis indicate a negative, insignificant association between the two variables. Because Kakamega district is dominated by strong cultural taboos that hinder women from planting trees (Bradley, 1991; Chavangi, 1992), it was expected that adoption of agroforestry technologies would be greatly hampered significantly.

The resultant insignificant relationship, however, can be attributed to the strength of socio-cultural constraints, which has been weakened in recent times through female contact with religion and education (Bradley, 1991). Some important taboos affecting women emerging from the study in

Kakamega District, and consistent with findings of Aloo (1985), and Chavangi (1992), include:

1. If a woman plants trees, she will be barren or will not give birth to normal children. Child bearing is the only quarantee of stability in marriage. Therefore because of the high value placed on marriage in any society, no woman would dare plant a tree lest she became barren and hence a social misfit.

2. If a woman plants a tree, her husband or a member of the family would die. The life of a widow is a miserable one, so no woman would dare take action that could pose a threat to her husband's life.

3. A woman is not allowed by the clan to plant trees. Certain trees are considered special for specific customary rituals such as for use in shrines and religious ceremonies or traditional medicine. Exclusively, men perform such functions. To sustain the male-only requirement, women are totally excluded from any tree planting activities.

Caveness and Kurtz (1993), argue that constraints to and motivations for adoption of agroforestry technologies do not necessarily remain constant. Current socioeconomic and technological constraints to an individual adopting agroforestry, such as land tenure issues or seedling availability,

may be eased through policy changes in land tenure, nursery establishment and credit subsidies. Further, motivations of current adopters often include income potential from tree products. With the reduction of technological, socioeconomic and socio-cultural constraints, it is anticipated that adoption of agroforestry technologies will increase leading to a higher farm production and income.

5.2 CONCLUSION

The results of the study show that adoption of agroforestry technologies significantly and positively affects farm production and household farm income. However, the results indicate that there is a negative but insignificant relationship between constraints to adoption of agroforestry technologies and the actual adoption of agroforestry technologies. This does not imply that the strength of the constraints should be underestimated. Of great importance is the involvement of women in developmental programs especially in the development of solutions that do not conflict with traditional values.

Agroforestry is arguably a more sustainable and optimal way of farming in most resource limited environments. Successful agroforestry though, requires careful planning and usually more labour. Trees and crops must be arranged and managed properly if overall total productivity is to be

increased and sustained. If left unmanaged, trees can out-compete crops, and reduce yields.

Farmers generally appreciate the worth and function of trees in agricultural systems. They did not traditionally, however, manipulate and manage the tree component to the degree that most modern agroforestry practices require. They must therefore, be informed that the products and benefits associated with agroforestry will justify their added time and labour inputs. The active promotion of agroforestry through information transfer, demonstration, and on-farm research, is a worthwhile timely task.

It is important to note that as more tree products become available in the future due to continued adoption, potential unrealized financial returns from tree products may prove a discouragement to continued participation in agroforestry. Promotion of alternative species may become advisable to diversify income as well as for environmental and ecological considerations.

5.3 RECOMMENDATIONS

From the results of the study, the following recommendations can be made:

The key to successful implementation of agroforestry projects will include building on traditional knowledge, involving farmers in the choice of tree

species, and providing economic incentives greater than those of traditional systems. This will encourage farmers to diversify and adopt scientific agroforestry practices that are beneficial and profitable.

Scientists and policy makers need to improve traditional agroforestry systems by enhancing productivity and ecological compatibility. Ways of improving these systems include using high value trees and woody shrubs and creating an orderly arrangement of trees and crops.

In addition to understanding the agronomic and biophysical aspects of agroforestry systems, the social, ecological, and economic elements require more attention. The economic feasibility of agroforestry systems needs to be assessed at the farm level. Human ecology and sociology play an important role in the acceptance and spread of technologies, as do the specific sociopolitical and institutional constraints.

Agroforestry can be a sustainable alternative to monocropping. However, systems suited to many major soils and ecological regions of the tropics need to be developed. Further research is needed to develop systems performance indicators and to document ecological viability of agroforestry systems across a range of biophysical conditions.

5.4 FUTURE RESEARCH

The study produced relevant information on the impact of adoption of agroforestry technologies on farm production and household farm income. Constraints to adoption of agroforestry technologies were also determined and their effect on adoption of agroforestry technologies measured. Important areas for further research include:

1. Inventory and evaluation of indigenous MPTs that are highly valued for a wide range of products.

2. Research is needed on the ways to improve current extension approaches that will lead to effective contact with farmers.

3. Research is also needed on the contribution of MPTs on livestock production.

4. Research is needed to establish the level of management of MPTs on farms and its effect on farm production.

REFERENCES:

Aboud, A.A., (1992): *Population Pressure, Environmental Degradation and Farmer's Adaptive Strategies in Nakuru District of Kenya.* A Ph.D. Dissertation. University of Illinoi at Urbana-Champaign, U.S.A.

Aboud Abdillahi, Andrew J. Sofranko and Serigne Ndiaye., (1996): *The Effects of Gender on Adoption of Conservation Practices by Heads of Households in Kenya. Society and Natural Resources*, 9: 447-463.

Aloo, T., (1985): *Forestry and the Untrained Kenyan Women in Women and the Environmental Crisis.* Report of the Proceedings of the Workshop on Women, Environment and Development, Nairobi, 10-20 July 1985. Environmental Liaison Center, Nairobi; pp. 26-28.

Barnes, D.F., (1990): *Population Growth, Wood Fuels, and Resource Problems in Sub-Saharan Africa.* Industry and Energy Department Working Paper. Energy Series, Paper No. 26. World Bank, Washington, D.C.

Baumer, M. & Wood, P., (1986): *Agroforestry Research and Development: Agroforestry Practices for the Solution of Food, Fodder and Fuel Shortages.* Paper presented at IUFRO Research Planning Workshop for Africa. Nairobi, 9th –15th January 1986.

Baxter, J., (1995): *Farmers Who Fallow With Trees. Agroforestry Today*, Vol 7.No. 3-4., ICRAF.

Bilsborrow, R.E., (1987): *Population Pressures and Agricultural Development in Developing Countries*: A Conceptual Framework and Recent Evidence. World Development, Vol. 15, No. 2, pp 183-203.

Bohrnstedt, G.W. & Knoke, D., (1985): *Statistics for Social Data Analysis.* F.E Peacock Publishers Inc, Ithaca Illinois.

Bradley, P.N., (1991): *Woodfuel, Women and Woodlots.* Macmillan Education LTD, London.

Brokensha, D.(1983): *Fuelwood Use in Rural Kenya. Impacts of Deforestation.* Revised draft report. Institute for Development Anthropology, New York.

Burley, J., (1982): *Obstacles to Tree Planting in Arid and Semi Arid Lands.* Comparative case studies from India and Kenya, Tokyo, United Nations University.

Carter, J., (1996): *Alley Farming: Have Resource-Poor Farmers Benefited*? Agroforestry Today. Vol. 8. No. 2, pp 5-7, ICRAF.

Caveness, F.A., & Kurtz, W.B., (1993): *Agroforestry Adoption and Risk perception by Farmers in Senegal.* Agroforestry Systems. 21:11-25.

Chavangi, N.A,. (1992): "*Household Based Tree Planting Activities for Fuelwood Supply in Rural Kenya*: The Role of the Kenya Woodfuel Development Programme". In Taylor and Mackenzie, (1992)., pp. 140-169.

Chavangi, N.A., (1989): *Socioeconomic Issues in Agroforestry.* A Paper presented at Agroforestry Seminar, Thuci River Lodge, November 1989. Nairobi, Ministry of Agriculture, pp 9.

Chavangi, N.A., (1992): *Socio-cultural Issues in Social Forestry.* A paper presented at the Social Forestry Extension officers course, 13th - 22nd January and 10th - 19th February, 1992 KEFRI Muguga, Nairobi..

Cook, C. and Grut, M., (1989): *Agroforestry in Sub-Sahara Africa; A Farmer's Perspective.* World Bank Technical Paper No. 112. The World Bank, Washington D.C, 20433 U.S.A.

Dankeknan, I., & Davidson, J., (1988): *Women and Environment in the Third World Alliance for the Future.* Earthscan Publications, International Union for Conservation of Nature, London.

Ehui, S. K., Kang, B. T., & Spencer, D. S. C., (1990): *Economic Analysis of Soil Erosion Effects in Alley Cropping, No-Till, and Bush Fallow Systems in Southwestern Nigeria.* Agricultural Systems. 34:349-368.

Ellis., (1992): *Agricultural Policies in Developing Countries.* John Wiley & Sons. New York, USA.

Engelhard, R.J., & Jones, V., (1985): *Culture as the Basis for Implementing Self-Sustaining Woodfuel Development Programs.* Beijer Institute, Nairobi.

Food and Agricultural Organization (FAO), (1986): *Tree Growing by Rural People.* FAO forestry paper 64, FAO, Rome.

Foley, G. & Bernard, G., (1984): *Farm and Community Forestry.* Earthscan Institute for Environment and Development. United Kingdom.

Fortmann, L. and Riddell, J., (1985): *Trees and Tenure*: An annotated Bibliography for Agroforesters and others. Madison, Wisconsin, U.S.A.

Gholz, H.L., (1987): *Agroforestry: Realities, Possibilities and Potentials.* Dordrecht, Netherlands.

Harvey, L. & MacDonald, M., (1993): *Doing Sociology, A Practical Introduction.* MacMillan Press Ltd.

Hoskins, M., (1987): *Agroforestry and the Social Milieu.* In H.A Steppler and P.K.R Nair, (Eds). *Agroforestry: A Decade of Development.* pp 192-203, ICRAF, Nairobi,

Husch, B., (1987): *Guidelines for Forest Policy Formulation.* FAO Forestry Paper 81 Rome.

International Council for Research in Agroforestry (ICRAF), (1989): *Agroforestry Development in Kenya.* Proceedings of the Second Kenya National Seminar on Agroforestry, held in Nairobi, Kenya, 7-16 November 1988. ICRAF, Nairobi, Kenya.

International Council for Research in Agroforestry (ICRAF), (1997): *ICRAF and Agroforestry: A vision and Plan of Action.* ICRAF, Nairobi, Kenya.

Jaetzold, R. & Schimdt, H., (1982): *Farm Management Handbook of Kenya, Vol. II.* Ministry of Agriculture, Nairobi.

Kamatari, B., (1996): *Women and Desertification.* In the circular on desertificaton:The International NGO Network on Desertification and Drought. No. 13, June 1996. Environment Liaison Centre International (ELCI), Nairobi, Kenya. pp. 15.

Kang, B.T., Wilson G.F., & Sipkens, L., (1981): *Alley Cropping Maize and Leucaena in Southern Nigeria.* Plant Soil, 63:165-179.

Kang, B.T., Wilson, G.F., & Lawson. T.L., (1984): *Alley Cropping: A Stable Alternative to Shifting Cultivation.* International Institute of Tropical Agriculture. Ibadan, Nigeria.

Kang, B.T., (1993): *Alley Cropping: Past Achievements and Future Direction.* In Agroforestry Today. Vol.8 No. 2, pp 5-7, ICRAF.

Lal, R., (1986): *Soil Surface Management in the Tropics for Intensive Land Use and High and Sustained Production.* Advanced Soil Science. 5:1-108.

Lal, R., (1989): *Agroforestry Systems and Soil Surface Management of a Tropical Alfisols*, I-V. Agroforestry Systems. 8:1-6.

Lal, R., (1991): *Myths and Scientific Realities of Agroforestry as a Strategy for Sustainable Management of Soils in the Tropics.* Advanced. Soil Science. 15:91-137.

Leach, M., & Robin, M., (1988): *Beyond the Woodfuel Crisis: People, and Trees in Africa*. Earthscan Publications,London.

Lundgren, B.O. & Raintree, J.B., (1983): *Sustained Agroforestry*. ICRAF. Nairobi, Kenya.

Maathai, W., (1988): *The Green Belt Movement: Sharing the Approach and the Experience*. Environment Liaison Centre International, Nairobi.

Marenha, C. (1985): *"Producing Food: The Gambian Women's Burden"*. In Environmental Liaison Center, Women and the Environmental Crisis. Report of the Proceedings of the Workshop on Women, Environment and Development, Nairobi,10-20 July 1985. Environmental Liaison Center, Nairobi; pp. 55-57.

Molanar, A., & Schreiber, G,. (1989): *Women and Forestry: Operational Issues*. PPR Working Paper WPS 184. World Bank, Washington, D.C.

Mugenda, O.M. & Mugenda, A.G., (1999): *Research Methods. Quantitative & Qualitative Approaches*. African Centre for Technology Studies (ACTS), Nairobi, Kenya.

Nair, P.K.R., (1989): *Agroforestry Systems in the Tropics*. Kluwer Academic Publishers, Netherlands.

Ngoda, B.J.M., (1988): *The Prospects of Smallholder Agroforestry Activities in Bungoma District, Kenya: A Socioeconomic and Ecological Assessment.* A Msc. Thesis. Agricultural University of Norway.

Ongugo, P.O., (1992): *Socio-cultural Issues in Social Forestry.* Paper Presented at Social Forestry Extension Officers Course. 31st August – 10th September, 1992.

Pathak, P.S.& Roy, M.M., (1995): *Silvopastoral System of Production.* Jhansi: Indian Grassland and Fodder Research Institute (IGFRI).

Raintree, J.B., (1987): *Land, Trees and Tenure.* Proceedings of an international workshop on tenure issues in agroforestry. Nairobi, ICRAF and the Land Tenure Centre.

Relwani, L.L., (1987): *Socioeconomic Scenario of Agroforestry.* In Hedge and Kelkar, V.D., (Eds). *Agroforestry: Selected readings.* Puru, India.

Repetto, R and Thomas, H., (1983): *The role of Population in Resource Depletion in Developing Countries.* Population and Development Review. Volume 9, No. 4.

Republic of Kenya, (1993): Office of the Vice-President and Ministry of Planning and National Development. *Kakamega District Development Plan 1993-1996.* Government Printer, Nairobi.

Republic of Kenya, (1997): Office of the Vice-President and Ministry of Planning and National Development. *Kakamega District Development Plan 1997-2001*. Government Printer, Nairobi.

Rocheleau, D., Weber, F., & Field-Juma, A., (1988): *Agroforestry in Dryland Africa*, ICRAF, Nairobi, Kenya.

Roy, M.M., (1999): *Silvopastoral Systems: There is Hope in Rehabilitating Degraded lands in Arid and Semi arid India.* In *Agroforestry Today.* January – June, 1999, pp. 24-26, ICRAF, Nairobi.

Sharma, R., (1995): *Learning from Experiences of Joint Forest Management in India*. Forests, Trees and Peoples Newsletter No. 24, June 1994. KENGO publication. pp. 36-41.

Scherr, S.J., (1987): *Guidelines for Land Use System Description.* Working Paper No. 48. ICRAF, Nairobi, Kenya.

Steinlin, H. (1979): *The Role of Forestry in Rural Development. Applied Science and Development.* 13: 7-26

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

Tolba, M., (1992): *UNEP Two Decades of Achievement and Challenge*. Nairobi. UNEP publication.

Von Maydell, H.J., (1987): *Agroforestry in the dry zones of Africa: Past, Present and Future*. In H.A Steppler and P.K.R Nair, (Eds). (1987). *Agroforestry: A decade of development*. pp 89-116, Nairobi, ICRAF.

APPENDICES

APPENDIX 1 RESULTS OF BI-VARIATE REGRESSION ANALYSIS

Dependent Variable:
REFARPRO Farm production index

Independent Variable:
REAFADOP Adoption of agroforestry technologies index

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.152	.023	.019	.7087

a Predictors: (Constant), REAFADOP

Analysis of Variance

Model		df	Sum of Squares	Mean Square	F	Sig.
1	Regression	1	2.843	2.843	5.661	.018
	Residual	239	120.036	.502		
	Total	**240**	**122.880**			

a Predictors: (Constant), REAFADOP
b Dependent Variable: REFARPRO

Coefficients

Model		Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.165		6.104	.000
	REAFADOP	.061	.152	2.379	.018

a Dependent Variable: REFARPRO

Dependent Variable:
REFARMIN Household farm income index

Independent Variable:
REAFADOP Adoption of agroforestry technologies index

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.250	.063	.059	.6610

a Predictors: (Constant), REAFADOP

Analysis of Variance

Model		df	Sum of Squares	Mean Square	F	Sig.
1	Regression	1	6.979	6.979	15.972	.000
	Residual	239	104.424	.437		
	Total	240	111.402			

a Predictors: (Constant), REAFADOP
b Dependent Variable: REFARMIN

Coefficients

Model		Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.154		9.504	.000
	REAFADOP	.057	.250	3.997	.000

a Dependent Variable: REFARMIN

Dependent Variable:
REFARMIN Household farm income index

Independent Variable:
REUSEMPT Household use of MPTs index

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.532	.283	.280	.5781

a Predictors: (Constant), REUSEMPT

Analysis of Variance

Model		df	Sum of Squares	Mean Square	F	Sig.
1	Regression	1	31.542	31.542	94.396	.000
	Residual	239	79.861	.334		
	Total	**240**	**111.402**			

a Predictors: (Constant), REUSEMPT
b Dependent Variable: REFARMIN

Coefficients

Model		Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.101		11.239	.000
	REUSEMPT	.046	.532	9.716	.000

a Dependent Variable: REFARMİN

Dependent Variable:
REAFADOP Adoption of Agroforestry technologies index

Independent Variable:
RECOAFAD Constraints to adoption of agroforestry technologies index

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.022	.001	-.004	.7535

a Predictors: (Constant), RECOAFAD

Analysis of Variance

Model		df	Sum of Squares	Mean Square	F	Sig.
1	Regression	1	6.807E-02	6.807E-02	.120	.729
	Residual	239	135.691	.568		
	Total	**240**	**135.759**			

a Predictors: (Constant), RECOAFAD
b Dependent Variable: REAFADOP

Coefficients

Model		Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.273		9.883	.000
	RECOAFAD	.064	-.022	-.346	.729

a Dependent Variable: REAFADOP

APPENDIX 2 RESULTS OF STEPWISE REGRESSION ANALYSIS

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	REFARPRO Farm production index	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	REUSEMPT Household use of MPTs index	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a Dependent Variable: REFARMIN Household farm income index

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.533	.285	.282	.5775
2	.655	.429	.424	.5172

a Predictors: (Constant), REFARPRO
b Predictors: (Constant), REFARPRO, REUSEMPT

Analysis of Variance

Model		df	Sum of Squares	Mean Square	F	Sig.
1	Regression	1	31.707	31.707	95.086	.000
	Residual	239	79.696	.333		
	Total	240	111.402			
2	Regression	2	47.746	23.873	89.257	.000
	Residual	238	63.656	.267		
	Total	**240**	**111.402**			

a Predictors: (Constant), REFARPRO
b Predictors: (Constant), REFARPRO, REUSEMPT
c Dependent Variable: REFARMIN

Coefficients

Model		Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.081	1.348	16.636	.000
	REFARPRO	.052	.533	9.751	.000
2	(Constant)	.099	.831	8.423	.000
	REFARPRO	.049	.403	7.784	.000
	REUSEMPT	.044	.401	7.744	.000

a Dependent Variable: REFARMIN

APPENDIX 3 SURVEY QUESTIONNAIRE

Household characteristics:

Division_____ Location_____
Name (Optional)_____Sex: [ ]. Male[ ]. Female.
Age_____ Marital Status: 1. Married 2. Divorced/Separated
3. Widowed 4. Single
Occupation_____ Size of land_____ acres.

Household size: _____

Land ownership:

		✓
1	Squatter status	
2	Rented	
3	Communal	
4	Own land with title deed	
5	Own land with no title deed	

Level of Education:

		✓
1.	Illiterate	
2.	Primary 1-4	
3.	Primary 5-8	
4.	Secondary 1-4	
5.	Secondary 5-6	
6.	Post secondary.	

AGROFORESTRY ACTIVITY.

1. Have you incorporated trees and shrubs in the farming system?
[ ]Yes[ ]No

2. If yes, when did you plant the trees? _____ years ago.

3. Which of the following technologies is practiced on your farm?

	Technology	✓
1	Alley cropping	
2	Trees in Home gardens	
3	Improved fallows	
4	Dispersed trees on cropland	
5	Wind breaks	
6	Others (specify)	

USE OF MPTs

1. Which tree species have you planted on your farm? (Can use vernacular name)

Tree species	Seedling Number	Mature Number	Planted (✓)	Natural (✓)	Uses of the tree

Key of uses: *1) Fodder. 2) Timber. 3) Firewood. 4) Fruits. 5) Poles. 6) Shade. 7) Aesthetic. 8) Wind break. 9) Fencing. 10) Soil and water conservation. 11) Medicine. 12) Soil fertility improvement. 13) Building material. 14) Charcoal. 15) Others (specify)*

_____

2. What is your degree of use of the above trees on your farm?
   1). Very high.2). High. 3). Moderate. 4) Little. 5.) No use

5. Are there negative effects that result from the trees on your farm?
   [ ]Yes[ ]No

6. If yes, which ones?

_____
_____
_____
_____
_____

7. How would you rate the economic contribution of trees and shrubs in your farming system?
1). Very high. 2). High. 3). Moderate. 4) Little. 5.) No contribution.

FARM PRODUCTION AND HOUSEHOLD FARM INCOME

1. Fill in the following table representing crop production in your farm.

Crop grown	Area grown (acres)	Quantity harvested Per year	Cost per unit	Income	
				1999	2000
Maize					
Beans					
Sweet potatoes					
Sugarcane					
Kales					
Cabbages					

2. Fill in the following table representing production of tree products from your farm.

Tree product	Total quantity harvested (p.m.)	Total quantity harvested (p.a.)	Price per unit	Income (Kshs)	
				1999	2000
Log					
Timber					
Firewood					
Poles					
Charcoal					
Fodder					
Food					
Others (specify)					

3. Does your farm produce excess tree products than you need?

[ ]Yes [ ]No

4. If yes, what do you do with the excess products?

_____

_____

_____

_____

CONSTRAINTS TO AGROFORESTRY TECHNOLOGY ADOPTION.

1. Technological and socio-economic constraints

a) What are the factors that limit the planting of trees on your farm? (Tick box where appropriate)

	✓
Lack of knowledge on tree establishment	
Lack of seedlings to plant	
Lack of knowledge on the trees to plant.	
Mechanized land preparation	
Tree interference with crops	
Size of land is small	
Lack of income to invest in trees	
Lack of ownership of land	
Too old to plant and tend trees	
No immediate benefits from trees	

b) What other constraint(s) affect tree planting on your farm?

_____

_____

_____

_____

_____

_____

2. Socio-cultural constraints.

i) Does your gender (being male or female) inhibit you from planting trees on your farm? [ ]Yes [ ]No

ii) If yes, how does it inhibit you?_____

_____

_____

_____

_____

iii) Are there traditional beliefs that hinder you from planting trees on your farm? [ ]Yes [ ]No

viii) If yes, do they discourage you from planting trees? [ ]Yes [ ]No

ix) What are these beliefs_____

_____

_____

_____

_____

x) What other socio-cultural constraints inhibit you from planting trees on your farm?

_____

_____

_____

_____

_____

_____

Name of interviewer

_____

Date of interview _____

Sign_____