AN ANALYSIS OF TECHNICAL AND SOCIO-ECONOMIC FACTORS IN ADOPTION AND ADAPTATION OF ALLEY-CROPPING IN THE HIGH RAINFALL ZONE OF SIAYA DISTRICT, KENYA.

By

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ÅS - JUNE 1992

DECLARATION

I, Collins Jared Amwatta Mullah do hereby declare that this thesis is my original work and has not been submitted for a degree in any other university. All sources of other materials have been duly acknowledged.

Signature..............................

Date ....

LIST OF ACRONYMS

AFRENA - Agroforestry Research Network for Africa

CARE - Cooperative American Relief Everywhere

KEFRI - Kenya Forestry Research Institute

LM - Lower Midland

MOA - Ministry of Agriculture

SAS - Statitical analysis systems

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DEDICATION

The work is dedicated to my wife Pamella Otieno for her unfailing love and support during the long study period. Our Children Ismael, Elizabeth and Joan for having missed my parental love during the long study period.

And

To my late father Ismael Mullah and my mother Agnes Odiero for having materially and morally supported my yearn for knowledge.

SUMMARY

One of the main lessons from the past studies on adoption of alley-cropping in Siaya district is that farmers have used highly variable design and management practices to adapt the technology to their farm and socio-economic conditions. It has also been shown that the technology is partially adopted by the farmers. This study attempted to identify the key technical and socio-economic factors underlying the adoption and adaptation of the technology in the high rainfall zone of the district.

The main objectives of the study were to:-

a) assess the relationship between socio-economic characteristics of households and the adoption of alley-cropping technology.

b) describe the range of current modified designs and management strategies used by adopters.

c) identify the main technical and socio-economic reasons behind these management strategies.

d) look at the implications of these technical and socio-economic factors on the improvement of adoption.

Information was collected on the socio-economic characteristics of the households on a total of 62 farmers (**adopters and non-adopters**) through formal survey. The adapted designs and management practices of the technology were investigated on 31 farmers (**adopters**) and technical and socio-economic reasons for these adaptations sought through both formal and informal surveys. Descriptive statistics and students t-test were used to analyze the quantitative data. The chi-square and logistic regression analysis were used to test the maximum likelihood of adoption using the parameters which had only binary answers.

No significant differences were found between adopters and non-adopters with respect to average landholding size, household size and available land at 0.1% level. However, the fact that only 27% of the household members were economically active had serious constraint on timeliness of field operations. There was a significant difference in the

average ages of adopters and non-adopters at 0.1% level. Younger and more able-bodied farmers were not adopting the technology and this was seen as a big hindrance to alley-cropping development in the area. Level of education, sex of the farmer, use of hired labour and land tenure had positive correlation with adoption but not significant at 0.05% level. Non-farm income of the male head of the household had negative correlation with adoption although it was not significant at 0.05% level. Only non-farm income of the respondent farmer and cultivation of crops for sale had significant negative correlation with adoption at 0.05% level. Cultivation of kales, tomatoes and beans for sale on the local markets was found among 68% of the non-adopters as opposed to only 22% of the adopters. The higher relative advantage of raising crops or tree seedlings for sale was also mentioned by the non-adopters as the main reason for discontinuation of managing the technology. This study therefore, found that only these two variables explained non-adoption of the technology in the high rainfall zone of Siaya district.

The most common tree species managed through cutting back (pruning) in alley-cropping technology was *Leucaena leucocephala* (91% of adopters). However, the hard stem of leucaena was a constraint to cutting back management by female adopters (77%). The adopters expressed a need for shrubs/trees with softer stems and manageable through pollarding a practice with which most farmers in the area are conversant. All the adopters except three had no experience with other trees like *Calliandra calothyrsus*, *Gliricidia sepium*, *Leucaena diversifolia* and the *Sesbanias*. Some of these multipurpose tree species have shown better potential for alley-cropping than *Leucaena leucocephala* and should now be extended to farmers to test their potentials in solving the cutting back problem.

The within row spacings used by the farmers ranged from 0.5 to 2.0 m with a mean of 1.2 m. The most frequent ranges were 0.5-1.0 m (11 out of 31) and 1.1-1.5 m (9 out of 31). The adopters attributed these variabilities mainly to repeated termite infestation of planted seedlings. The between row spacing variation was mainly due to use of different paces by different household members during tree establishment. However, these spacing ranges were reasonably close to the recommended ranges.

The adopters were found to prefer cutting heights below 45 cm because of convenience and reduction of shading of the inter-crop. However, all the adopters were still trying different cutting heights depending on the farm production goals. Cutting back operation was mainly done by men firstly because *leucaena* tree was hard and secondly due to traditional specialization of family labour. This situation contributed to delay of field operations as most of the adopters were females (77%) whose husbands had migrated to urban centres. Whereas all the cutting height ranges used by the adopters could give adequate green leafy mulch (using on- station results), the tree densities on most plots were too low to have any positive effect. Eighty four percent (84%) of the adopters had below 2000 $treesha^{-1}$. This suggested inadequate mulch production from only one cutting back per season used by the adopters. No adopter did second cutting back because it coincided with the time for first weeding. Only side pruning was done during that period instead of the second cutting back due to shortage of labour. Generally the adopters expressed satisfaction with adapted frequency since it enabled generation of more woody sticks for fuelwood and it also reduced labour requirement.

The adopters did cut back at different times mainly to enable practice of staggering planting and to reduce labour input. 74% of the adopters had cut back after land preparation, 16% before land preparation and 9% during first weeding period. However, none of the observed strategies seemed to synchronize time of mulch application with the crop nutrient requirement regimes. It was found that more than half of the nutrient released from the already inadequate green leafy mulch was lost through leaching before the inter-crop reaches critical time for nutrient need. The adopters generally lacked understanding of the underlying principle behind timing of mulch application and the need for supplementing green leafy mulch with manure or fertilizer. There was also unawareness about tree root management to reduce below ground competition despite the fact that most adopters had observed some below ground competition on their plots. On the overall, the major constraint to adopters receiving benefits from the present design and management strategies appeared to be the low tree densities (**1348 $treesha^{-1}$**) and poor timing of green leafy mulch application. There was a need for more inter-personal contact between the adopters and the extension personnel to enable easy understanding of their needs and constraints to adaptation of the current management

strategies.

Using the Ruthenberg,s farming systems progression model, it was found that the current farming systems in the study area will fall over to farming systems with trees as the major component. However, the current generation of adopters were unlikely to adopt intensive alley-cropping management since they still had less labour requiring systems. This concept explained the observation that the adopters used only an average of 3.5% of their total available land for practising the technology. The adoption of the technology could be enhanced by considering the current needs, constraints and production goals of the adopters in the generation of design and management recommendations. The need for incorporation of the design and management practices used more frequently by adopters into the on-going research and/or demonstration for further development and fine tuning was suggested. It was also recommended that long term research should involve a phased approach to design and management intensification of both alley-cropping and border planting systems to facilitate smooth fall over to the future systems. The scope of this study could not unravel all the mystery why some farmers adopted and others in apparently similar comparable situation did not. More studies on constraints to adaptation process, evaluation of the effectiveness of the current communication channels and the social impacts of the technology were also recommended.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information.

As a concept Agroforestry refers to sustainable land management systems which combine crop, woody perennials and/or animals simultaneously on the same unit of land. Such land management systems are specifically designed in full articulation of the components interaction and the benefits over and above those that are obtainable from the constituent separately. Given the very high pressure on limited arable land, severe fuelwood shortage in many areas in Kenya and the prevalence of poor fragile soils, agroforestry has a great potential role to play in the country's socio-economic development. It is for this reason that the Kenyan Government development agenda for the next fifteen years (**Sessional paper No.1 of 1986**), specifically addresses and gives prominence to agroforestry development.

The extension of agroforestry technologies in Siaya district started in a period when Kenya was in the fore front of agroforestry development. The revival of the International Council for Research in Agroforestry (**ICRAF**) in 1981, the International Conference on renewable and non-renewable energy sources in Nairobi (1981), the 1981 Kenya Agroforestry workshop, the Kenya Renewable Energy Development Project (**K.R.E.D.P**), the study carried out by Beijer Institute (1979-1982) on energy situation in Kenya, the Swiss financed Rural Afforestation Extension Scheme (**R.A.E.S**) through the Forest Department and the **CARE** International in Kenya Agroforestry Extension Project in 1983 were all activities that took place between 1981 and 1983, which made this a very dynamic period for development of agroforestry. Unlike in agriculture, where technology interventions have been developed based on the results of extensive research, there was very little locally validated information on agroforestry in Kenya. Most agroforestry literature in those days referred to the lowland humid tropics (**Nigeria, Philippines, Hawaii, Indonesia**). Yet all these projects were in the sub-humid to semi arid medium high lands to highlands. The initial extension recommendations were thus, limited mainly to identification of appropriate multipurpose tree species and general guidelines on spacing and configurations.

ICRAF developed a methodology for planning and design of agroforestry technologies called **Diagnosis** and **Design** (**D&D**) which uses rapid appraisal techniques. This methodology helped multidisciplinary team of researchers to identify research goals and arrive at sound agroforestry design recommendations. The diagnosis consists of the identification of land use problems, constraints and intervention points. In the light of information gained through feedback from farmers or research stations, rediagnosis and design may be carried out to improve initial technology design (**Raintree, 1987**). Various scales of the methodology were developed viz, the micro Diagnosis and Design, which is carried out at the household or farm level to develop farm specific agroforestry solutions, meso Diagnosis and Design, which focus on larger units of analysis such as ecosystems, and macro Diagnosis and Design, which serves as a basis for decision making on resource allocation at regional level. The Diagnosis and Design methodology was also adapted to the needs of extension projects by a more participatory approach involving farmers in farm and community level Diagnosis and Design as a prelude to decision-making about the species, sites and configuration.

In the food based systems of western Kenya broad based Diagnosis and Design exercise identified the major land use constraints as, declining soil fertility, shortage of fuelwood, fodder and cash (**Minae and Akyeampong eds., 1988**). Alley-cropping was recognized as an agroforestry technology that could assist in the maintenance of soil fertility, the prevention of physical soil loss through run-off and the provision of fuelwood and fodder. Alley-cropping involves the growing of food crops in alleys formed by hedges of Nitrogen-fixing trees or shrubs. The trees are periodically pruned to provide green manure or mulch to the crops grown in the alleys (**Kang *et al.*, 1985**). The fundamental assumption is that by inter-planting the trees (fallow) with the crops and by producing a fairly constant supply of nutrient-rich mulch, continuous cropping at a reasonable yield level can be sustained.

Alley-cropping also tends to inhibit weed growth through shading, physical and/or chemical effects of green leaf mulch (**Bashir, Amare & Ngugi, 1991**). In traditional alley cropping design, trees normally occupy 15-20% of land as compared to rotational fallow systems where trees occupy 50% of the rotation cycle (**Young, 1989**). The optimal ''mix'' of trees arranged in hedges and food crops depends on soil fertility, slope, seasonal precipitation, sensitivity of food crops to competition by trees for light, soil moisture and nutrients.

1.2 Problem Statement.

In the last eight years or so, farmers have tried alley-cropping in Siaya district. The adoption of the technology has varied with the agro-ecological zones with high rainfall zone showing a medium rate (**Scherr & Oduol, 1988**). There is also considerable diversity in tree arrangement and management practices. The performance of alley-cropping at the present levels of management by farmers is too low to have any economic impact on the general farm production. However, the on-going research in alley cropping in the area is beginning to yield information on the growth, management and interaction across the environmental conditions of multipurpose tree species. Results from the **KEFRI/CARE** experiments, for instance, have shown maize yields which were 1.5-2.0 times higher in the plots with alley-cropping than in the control plots (**Nyamai & Amwatta, 1989**). As **Richards (1985)** has argued for West African agriculture, the Siaya case shows that these conscious changes made by farmers are a basis for further scientific research. Therefore, there is a need to look at technical and socio-economic reasons which prompted these diverse modified design and management practices currently used by the farmers. The redesign of alley-cropping technology based on the vast experience accumulated over these years will also require identification of the modified designs and management practices which seem to work for most adopters. The general hypothesis is that, if a significant number of adopters are using a particular range of practice, they have good reasons for doing that. This is because in choosing to use these practices, the adopters are naturally reacting to the elements of their biophysical and socio-economic environments.

This study is more or less a follow up of the **Scherr** and **Oduol's** study on adoption and adaptation of alley-cropping and border plantings in Siaya (**1988**). However, as **Gupta** (in **Chambers, 1889**) put it, mere description of farmers practices as was done in that study is not enough. We have to identify the reasons behind such practices and link them with their scientific rationality. This study therefore besides description of the various farmer adapted practices, will attempt to understand reasons for the adaptation of alley-cropping through an integrated analysis of technical and socio-economic parameters.

1.2.1 Objectives of the study.

1. Assess the relationship between socio-economic characteristics of households and the adoption of the technology
2. Describe the range of current modified design and management practices used by the adopters.
3. Identify the main technical and socio-economic reasons behind these designs and management strategies.
4. Look at the implications of these technical and socio-economic factors on the improvement of adoption.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Adoption of Technology.

Rogers (**1983**), defined the adoption process as the mental process an individual passes from hearing about an innovation to final adoption. In agriculture adoption only occurs when a technology becomes part of the farming system on a permanent basis without extension. There are two levels of adoption of agricultural innovations namely adoption at farm level and at whole community level. Adoption at the farmer's level refers to the degree of use of a new technology in long-run equilibrium when the farmer has full information about the new technology and its potential. Aggregate adoption, on the other hand, is the level of use of a specific new technology within a given geographical area or within a given population. At the farmers level, introduction of a new technology results in a period of disequilibrium behaviour where resources are not utilized efficiently by the individual farmer (**Schultz, 1975 cited by Rogers, 1883**). New equilibria are attained through a process of learning and experimentation and thus making adoption a dynamic process.

While an innovation may be designed for a given ecological zone, it will be adopted to varying degrees. As past experience shows, immediate and uniform adoption of innovations in agriculture is quite rare. In most cases, adoption behaviour differs a cross socio-economic groups and over time. One innovation may therefore experience different adoption patterns in different ecological zones and by different groups of farmers. Farmers also conduct adaptation trials after acquiring a new technology. These adoption and adaptation processes may only be understood in the light of technical, economic and social factors that affect the farmers perception of the risks involved.

One of the first and still reasonably appropriate model for describing adoption process includes five stages that an adopter goes through. These are the awareness, interest, evaluation, trial, and adoption stages. Simply stated, at the awareness stage, a farmer becomes aware of a new innovation for the first time. A farmer therefore develops an interest in the new innovation and seeks additional information. At the evaluation stage, the prospective adopter accumulates information and weighs pros and cons of the new innovation as relates to his/her own situation. The farmer tries a little at first and more later if everything works out well. At the adoption stage, a farmer will have made full decision to adopt the innovation. Also these five stages may be somewhat culture-bound. In some socio-cultural settings, the awareness-adoption sequences may frequently occur, at least for certain innovations. The choice available to a potential adopter are not just adoption or rejection, adaptation and selective rejection of some components of the innovation may also occur. It is important to remember that the innovation process can just as logically lead to a rejection decision as to adoption. Two types of rejection can be distinguished:-

a) Active rejection which consists of considering adoption of an innovation (including even trial), but then deciding not to adopt it.

b) Passive rejection which is also called non-adoption consist of never really considering use of the innovation.

The two types of rejection represent quite different types of behaviour. Unfortunately they often have not been distinguished in the previous adoption studies. For the purpose of this study the term non-adoption means both active and passive rejections. Farmers in Siaya district seem to have undergone the stages of awareness, interest and evaluation after interacting with extension agencies for over eight years. These farmers have expressed their willingness by adoption and unwillingness by non-adoption of alley-cropping technology due to reasons still unknown.

2.2 Review of Methodologies.

Agricultural technologies can be categorized into two types. The technologies which are divisible such as high yielding varieties or new variable inputs and the technologies which apply to whole farm and are not divisible, at least at practical level such as combine harvesters. The adoption of the divisible technologies can be measured at the farm level in a given time period by the amount or share of the farm area utilizing it. For the non-divisible technologies, the extent of adoption at the farm level in a given period is necessarily dichotomous (use/no use).

In most previous studies, adoption variables are categorized simply as adoption or non-adoption. However, knowledge that a farmer is using a technology may not provide much information about a farmer's behaviour because he may be using 1 percent or 100 percent of his acreage. The extent and intensity of use of a technology at the individual farm level seem to be more relevant than the initial decision to adopt a new technology (**Van der Veen, 1975 cited by Feder, 1984**). Thus, adoption apparently cannot be represented adequately by a dichotomous qualitative variable in many cases. For instance, use of chi-square contingency tables in adoption studies to perform nonparametric hypothesis tests of the importance of certain explanatory variables may suggest a significant effect in statistical terms. But there is no way of knowing from this type of analysis whether the economic importance of the effect is worth considering (**Feder *et al.*, 1984**). More so, use of correlation or ordinary least square regression analysis also produces only qualitative information regarding effects of various explanatory factors; no information regarding quantitative importance of various factors is obtained. The simple correlation between some variables may also include the spurious effects of the other variables.

Econometric methodologies like logit models, probit models and discriminant analysis, have been developed for investigating the effects of explanatory variables on dichotomous dependant variables. These models specify a functional relation between the probability of adoption and various explanatory variables. The most commonly used qualitative response models are the logit and probit models.

2.3 Adoption and Resource Base.

Differences in resource endowment, such as the power to command traditional land rights or supplies, availability of family labour, farm size, education and others, may imply a great difference among households in their capacities to benefit from innovations. According to **Pieri (1985)**, technology will be adopted if it promises significant increase in profit at acceptable levels of risk, even though cultural factors may momentarily delay the acceptance. Non-adoption of a technology by farmers occurs because farmers rationally weigh the likely changes in incomes and risks associated with the new technology under their natural, social and economic circumstances. The differential degrees of innovativeness or risk aversion may also depend on interaction between the technology and local agrosocio-economic conditions which determine the suitability of a new technology in the farmers environment (**Ashby, 1983**).

2.3.1 Land

Farm size probably is the most obvious indicator of available economic resources and the ability to take risk involved in the adoption of a new technology (**Feder & O'Mara, 1981**). Specifically, the relationship of farm size to adoption depends on such factors as fixed adoption costs, risk preferences, human capital, credit constraints, labour requirements and tenurial arrangement. Previous studies have often found farm size to be related to adoption behaviour. **Parthasaranthy** and **Prasad** (**1978**), found a significant positive relationship between farm size and high yielding variety seed adoption in an Andhra- Pradesh village about seven years after the introduction of the varieties. **Scherr *et al.*** (**1988**), found significant impact on adoption by land size among **CARE** assisted farmers in Siaya. Land quality differences combined with farm size differences also affect adoption.

Ownership or secure use of land is a precondition for adoption of a technology. In rural Kenya, the tenure issue has less to do with the formal laws and regulations than with the customary rights of various groups and individual members of the group to make use of the land and of different products growing on the land. Strategies of land management based on the usufruct rights of lineage members to the land or particular resource on the land is a basic feature of the traditional tenure.

2.3.2 Capital constraints.

Access to capital in the form of either accumulated savings or capital market is necessary in financing the adoption of a new technology. Thus differential access to capital is often cited as a factor affecting adoption. A majority of small scale farmers have often reported shortage of funds as a major constraint on adoption (**Mohmood, 1975 cited by Feder, 1984**). **Young** (**1987**), argued that agroforestry has such a highly practicable management at the farm level that it requires no substantial capital. **Von Pischke (1987 cited by Feder,1984)**, argues that lack of credit is not crucial factor inhibiting adoption of innovations which are scale neutral e.g High yielding varieties since the profitability of adoption will induce resource mobilization for necessary inputs. External off-farm income sources are of relevance as well since they enable a farmer to undertake agricultural practices which may otherwise jeopardise his subsistence income. Off-farm income can also help to overcome a working capital constraint or may even finance the purchase of a fixed investment type of innovation. **Scherr *et al.*** found no significant impact of the level of wealth and off-farm employment of head of household on the level of adoption of alley-cropping and border planting technologies.

2.3.3 Human capital.

Previous work indicate that adoption of recommended farming practices requires certain managerial skills which are often gained through education. **Huffman (1977 cited by Feder, 1984)**, showed that farmers with higher education posses higher allocative ability i.e ability to adjust to change. Such farmers, for instance would adjust faster to reduction in nitrogenous fertilizer prices by adopting nitrogen-intensive technologies. He further noted that education is particularly important when extension activities are less. **Evenson (1974 cited by Feder, 1984)**, also found that education plays a strong role in determining rates of adoption of a new technology in agriculture. On the other hand, **Rogers** (1983), found no relationship between education and adoption. For agroforestry, **Young** stated that it easily understood even with limited formal education.

Labour availability is another often mentioned variable which affects adoption. **Hicks** and **Johnson (1974 cited by Rogers, 1983)**, found that higher rural labour supply leads to greater adoption of labour intensive rice varieties in Taiwan. **Swinkels (1991)** working in the study area found an increase in total labour input of 3-4.5% due to hedge management (assumed full tree density of 50,000 trees/ha). But under on-station conditions (**AFRENA-Maseno**) a similar study showed between 9 and 13% labour increase. **Balasubramanian** (1983), also reported that in a three cuttings per season regime, cutting back formed 20% of the total labour input. Labour shortage therefore may prevent the adoption of alley-cropping by those with limited family labour or those operating in areas with less access to labour markets.

2.4 Farmer adaptation of alley-cropping in Siaya district.

Previous exploratory surveys have indicated the striking scope and variability of management practices on alley-cropping resulting from farmers' endeavour to adapt the technology. **Scherr** and **Oduol** conducted adoption survey on 126 **CARE** assisted farmers in Siaya district. Out of these 126, 29 farmers were interviewed in the high rainfall zone, 49 in the medium rainfall zone and 48 in the low rainfall zone. Only 15 farmers out of these 29 had adopted alley-cropping technology in the high rainfall zone.

The results of this survey showed that the average between row spacing was 3.7 m and an average in row of 1.3 m in the high rainfall zone. These were close to recommended spacings in Table 2.0. Whatever alley cropping design an adopter uses, it always means fitting a higher total plant population on the same unit of land or replacing part of the food crop plant population with introduced trees. This usually involves sacrificing about 20% of the arable land to tree for production of green manure for soil fertility. The loss of food crop plant population would have to be compensated for by 20% higher food crop yields in the alley cropping and once that is achieved, the technology would have to show yield increase in the order of 20-50% (above the annual system) in order to satisfy the extra labour for managing the trees.

The recommended spacings give tree density range between 25,000 and 50,000 $treesha^{-1}$ They found between less than 500 and 17,000 $treeha^{-1}$ from these 15 **CARE** assisted farmers. Farmers have two possible ways by which these tree densities could be increased. One is to have more tree rows or simply have few double rows in their plots. Use of double rows was not observed on any of the farms visited. This could have been due to the fact that it was not included in the extension package. However, experiments have shown that doubling the in row tree spacing does not lead to proportional increase in biomass production (**AFRENA, 1989**). More so, land loss resulting from establishing wider hedge design are not compensated for by proportional food crop yield increase associated with higher amounts of *leucaena* mulch applied. The minimum level of biomass that should be applied to significantly raise crop yield without any biological or artificial inputs is still unknown.

The average cutting height reported was 34 cm for *Leucaena leucocephala* which was below recommended height (**Table 2.0**). Two years study on cutting heights at Maseno-Kenya showed that increase in leafy biomass production increased with cutting height and that there were minimal differences in leafy biomass production between 0.3 m and 0.7 m height (**AFRENA, 1989**). A cutting height range of 45-90 cm. was also found to be optimal for maximum dry matter yield in Hawaii (**Osman 1981**). **Field** and **Oematan** (**1990**), working in Hawaii, reported that 100 cm cutting height yielded more biomass than 10 cm. The reported frequency of cutting back hedges was low, as only 10% of the 126 farmers cut back at least two times each growing season. That indicated very little biomass which is insufficient to increase crop production. However, the study did not address the issue of side pruning which could be a very important management practice of generating more biomass and also reducing shading of inter-crops since most farmers cut back only once.

The study gave a lot of insight into the adoption pattern of alley-cropping technology a cross the agro-ecological zones in Siaya district. It also indicated a general range of management practices used by farmers at that point in time. However, it would have been better to have a fixed sample for each stratum so that more ecozone-specific conclusion could be drawn. Because the sample size was sufficiently large in the low and medium rainfall zones, analysis by ecozone was possible. But, estimates for the high rainfall zone were much less reliable due to low sample size. This shortcoming has been noted by the two Researchers. More over, there is a need to understand the reasons behind the diverse design and management practices reported in the study. This study aims at filling these information gaps.

Table 2.0. Recommended guidelines for alley-cropping-Humid Zone.

Component	Functions	Arrangement	Management
L. leucocephala & *C. calothyrsus*	soil fertility fuelwood fodder	4 x 0.5 m 4 x 1 m	-establish after sowing crop. -cutback at knee-height twice every season side prune during weeding
S. sesban bispinosa grandiflora	soil fertility fuelwood	4 x 1 m 5 x 1 m	-plant crops where trees are established -pollard branches during cropping. -fallow for 1-2 years
M. platycalyx	soil fertility fuelwood	4 x 1 m 5 x 1 m	-establish at the same time as crops. -prune the side branches during cropping.

Source: Scherr, 1988a eds.

CHAPTER THREE

3.0 THE STUDY AREA: HIGH RAINFALL ZONE OF SIAYA DISTRICT

3.1 Location And Size.

Siaya district is located in Nyanza province of Kenya (**Fig.3.0**). It extends from latitude 0^0 13 South to 0^0 18 North and from longitude 33^0 58 East to 34^0 33 East. It has an area of 3,528 Km^2 of which 765 Km^2 lies in the high rainfall zone. The district is bordered by Busia and Kakamega districts in the North and North-East respectively. It also forms boundaries with Kisumu district in the south-East and South Nyanza across Lake Victoria to the South.

3.2 Physical Characteristics.

The district has about 2,650 Km^2 arable land. The rest is covered by water, swamps and roads. The altitude ranges from about 1,140 m above sea level on the shore of Lake Victoria to about 1,300 m in the North and East. The study area lies in the North and North-East parts of the district, which have rough terrain of sloping ridges and hills which rise to 1,430 m. The land surface is crossed by two main rivers of Yala and Nzoia. Both flow south-westwards through the Kakamega district and enter the Lake Victoria through Yala swamp. Other water systems are mainly streams and tributaries of the two main rivers which start from the inland and flow over short stretch into the lake.

3.3 Soils

The district is mainly a peneplain and slopes gently from East to West. Some of the upland soils are moderately deep. Inselbergs have shallow soils, while soils on the hills and minor scarps are developed on undifferentiated tertiary volcanic rock. These are well-drained, dark-red to brown shallow sandy-clay-loam to clay. About 75% of the area has strongly leached tropical soils of low natural fertility (**Acrisols & Ferralsols**) and only a small section has soils of natural fertility (**Phaoezems & Nitisols**).

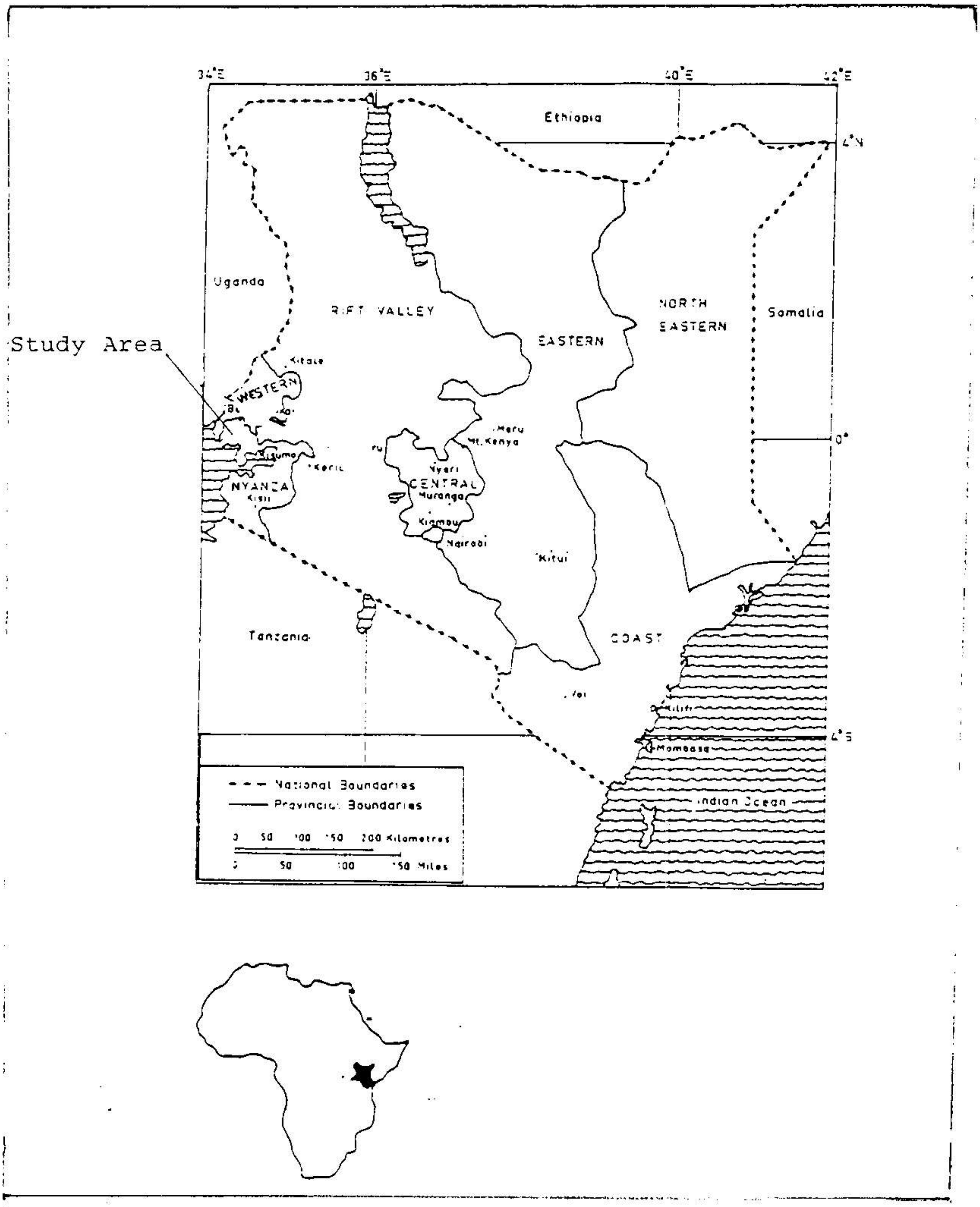


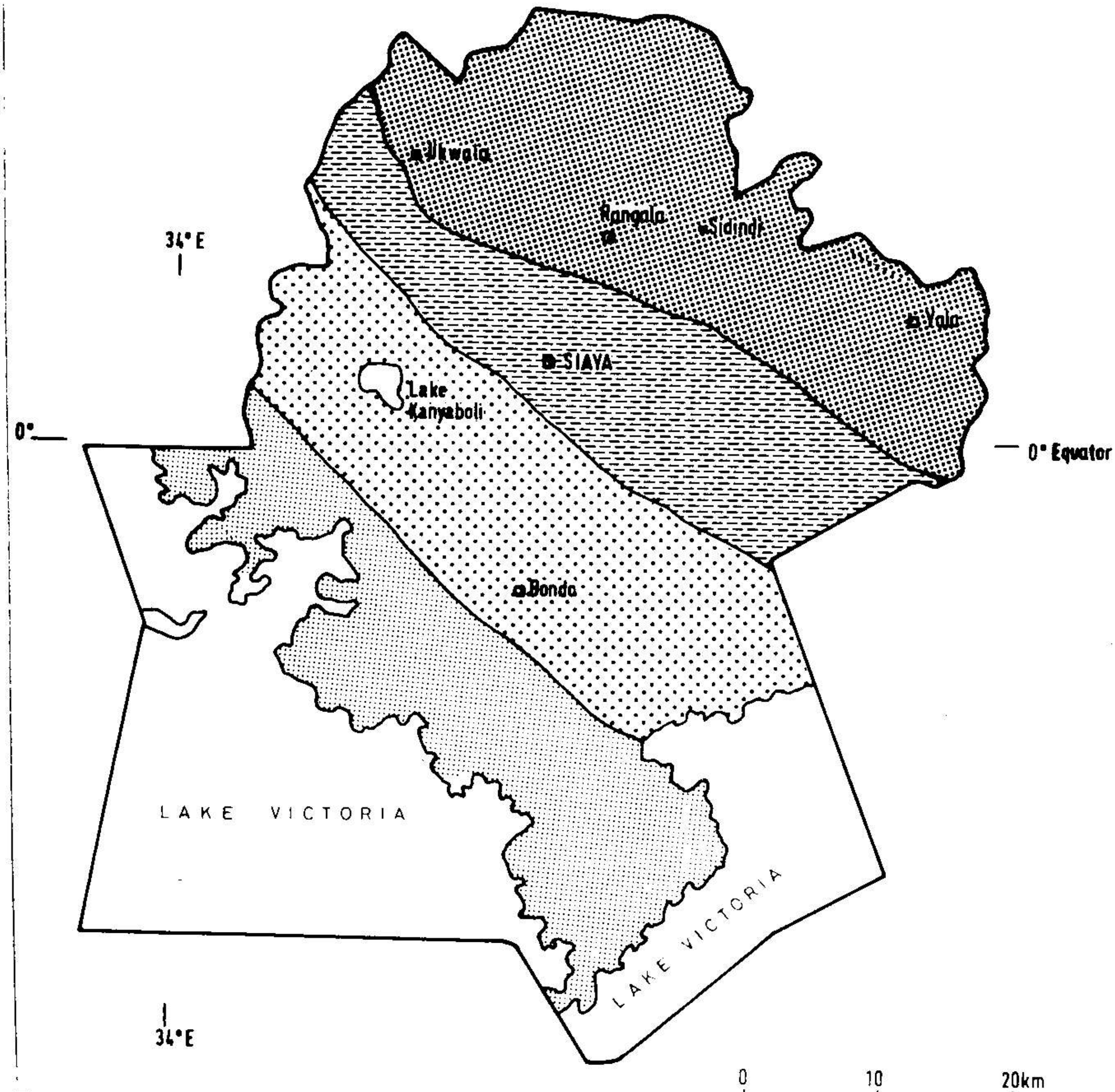
Figure 3.0. Map of Kenya showing location of Siaya District.
Source: Kenya Soil Survey 1980

Parent materials range from acid rocks with a low mineral content to basic igneous rocks rich in weatherable minerals. The soils are often strongly acidic with pH in water less than 5.2 (**Ministry of Agriculture, 1987**). The natural infertile soils have a low level of many major and minor plant nutrients and a low to moderate capacity to retain applied nutrients. Nitrogen and phosphorus deficiencies are widespread. Poor aeration and a high erosion risk pose major management constraints.

3.4 Agro-ecological Zones.

The total agricultural area of the district is 164,200 ha which are classified into four agro-ecological zones (**Fig.3.1**) These include the high rainfall zone measuring about 52,275 ha. This is mainly in Yala and Ukwala as well as upper part of Boro divisions. This is a humid zone with high moisture availability. It receives 1600-2000 mm of annual rainfall (**Fig.3.2**). The long rains occur between March and June with the peak period being April/May with 140-200 mm per month. The short rains occur from September to December with peaks during October/November with 85-130 mm per month. Average temperature is 21 ^{0}c with a minimum of 15 ^{0}c and a maximum of 30 ^{0}c. Humidity is relatively high with mean evaporation of 1800 mm. per. annum.

The other area is the medium potential zone with a size of 82,220 ha. This is spread across all the four divisions (**Yala, Bondo, Boro and Rarieda**). Only the long rains are reliable and the zone can only yield one crop season. The third zone is the marginal area of 25,980 ha. This is found mainly in Bondo, Southern parts of Yala and to a small extent, in Boro and Ukwala divisions. Finally there is the Range and Desert zone which covers about 3,788 ha in Boro division. Agriculture production in this zone can only be possible through irrigation.



ZONE	AREA [km²]	CLASSIFICATION	AVERAGE ANNUAL RAINFALL (mm)	AVERAGE ANNUAL POTENTIAL EVERPORATION (mm)	POTENTIAL FOR PLANT GROWTH	ZONE
I	765	Humid	1100 - 2700	1200 - 2000	Very high	
II	507.5	Sub-humid	1000-1600	1300 - 2100	High	
III	690	Semi-humid	800 - 1400	1450 - 2200	High to medium	
IV	507.5	Semi humid	600 - 1100	1550 - 2200	Medium	

Figure 3.1. Agro-ecological zones of Siaya District (Source: Kenya Soil Survey 1980)

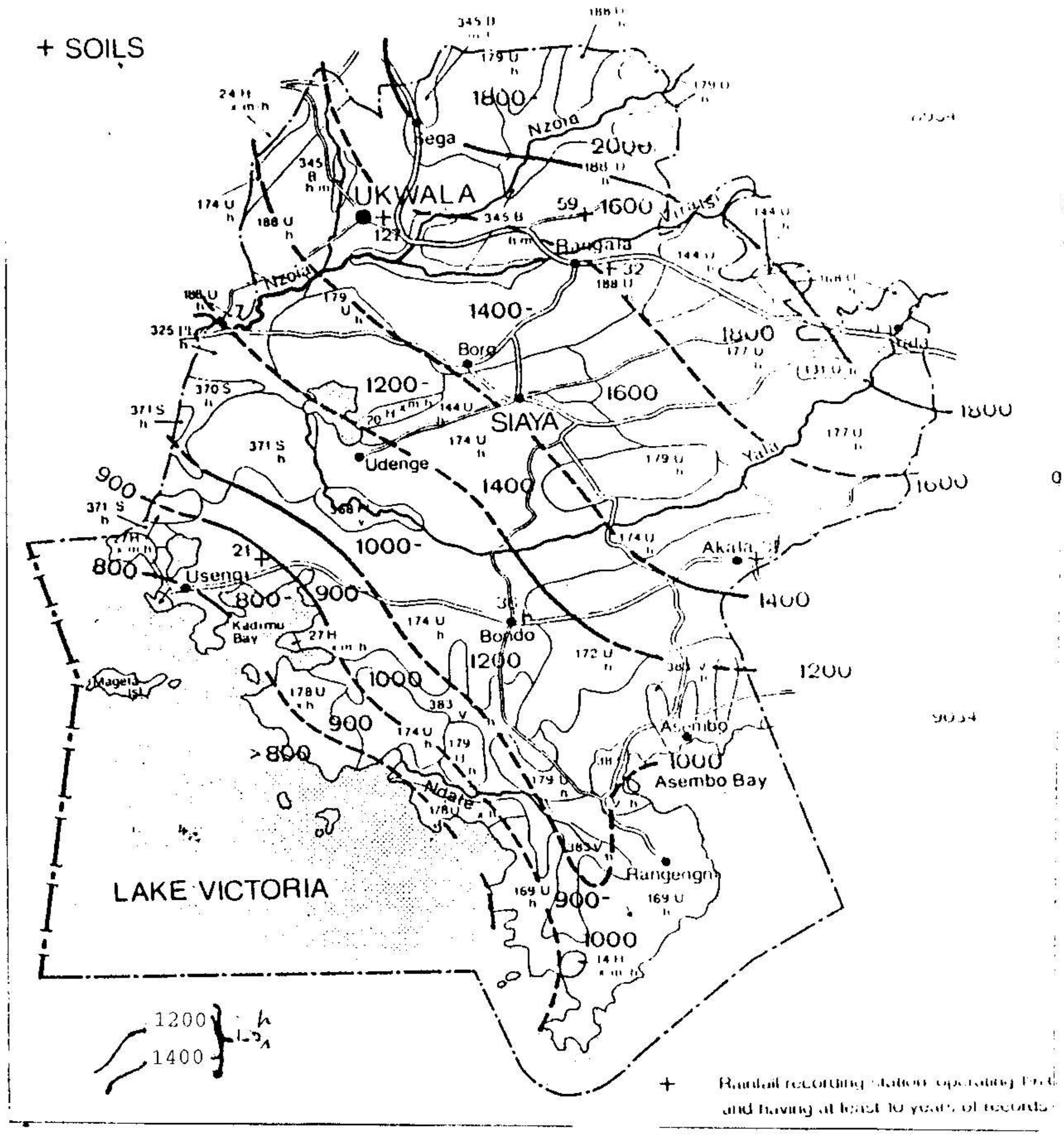


Figure 3.2. Average annual rainfall (mm) for Siaya District, 1972-1982.
Source: Jaetzold *et al.* 1982.

3.5 Administration

The entire district is divided into 5 divisions namely; Ukwala, Yala, Boro, Bondo, and Rarieda. These are further subdivided into 24 locations and 135 sublocations (**Fig.3.3**). The sublocations are the basic administrative units in the country. In each location, there is a chief and there is an assistant chief in each sublocation. The study area mainly covers bigger parts of Yala, Ukwala and a small part of Boro division. These include, East Ugenya, North Ugenya, Buholo, South Ugenya, North Gem, East Gem, North-East Gem, and East Alego locations.

3.6 Population

According to 1979 census, the population of Siaya district was 474,516. The annual population growth rate was estimated at 3.12% between 1979 and 1988. In 1988, the population of the district was estimated at 721,450 people, assuming constant mortality and birth rate. 45% of this population live in the high rainfall zone. The average population density is 188 persons/km^2. The study area has the highest population density of 202 to 277 persons/km^2. The present land use problems in this area have developed as a result of land use pressure in response to the increasing population density.

The district is dominated by one ethnic group, the Luo or Locustrine Nilotes. There are, however, a few pockets of non-luo people in the area inhabited by Luyia-speaking people. The district shows the lowest sex-ratio in Kenya which indicates a scarcity of males and a prepondence of females. The hardest hit is the study area, where there are less than 80 males per 100 females (**Table 3.0**). The reason for this, is hypothesized to be that education and improved transport network connecting the area with larger centres of economic activity play an important part in inducing out-migration.

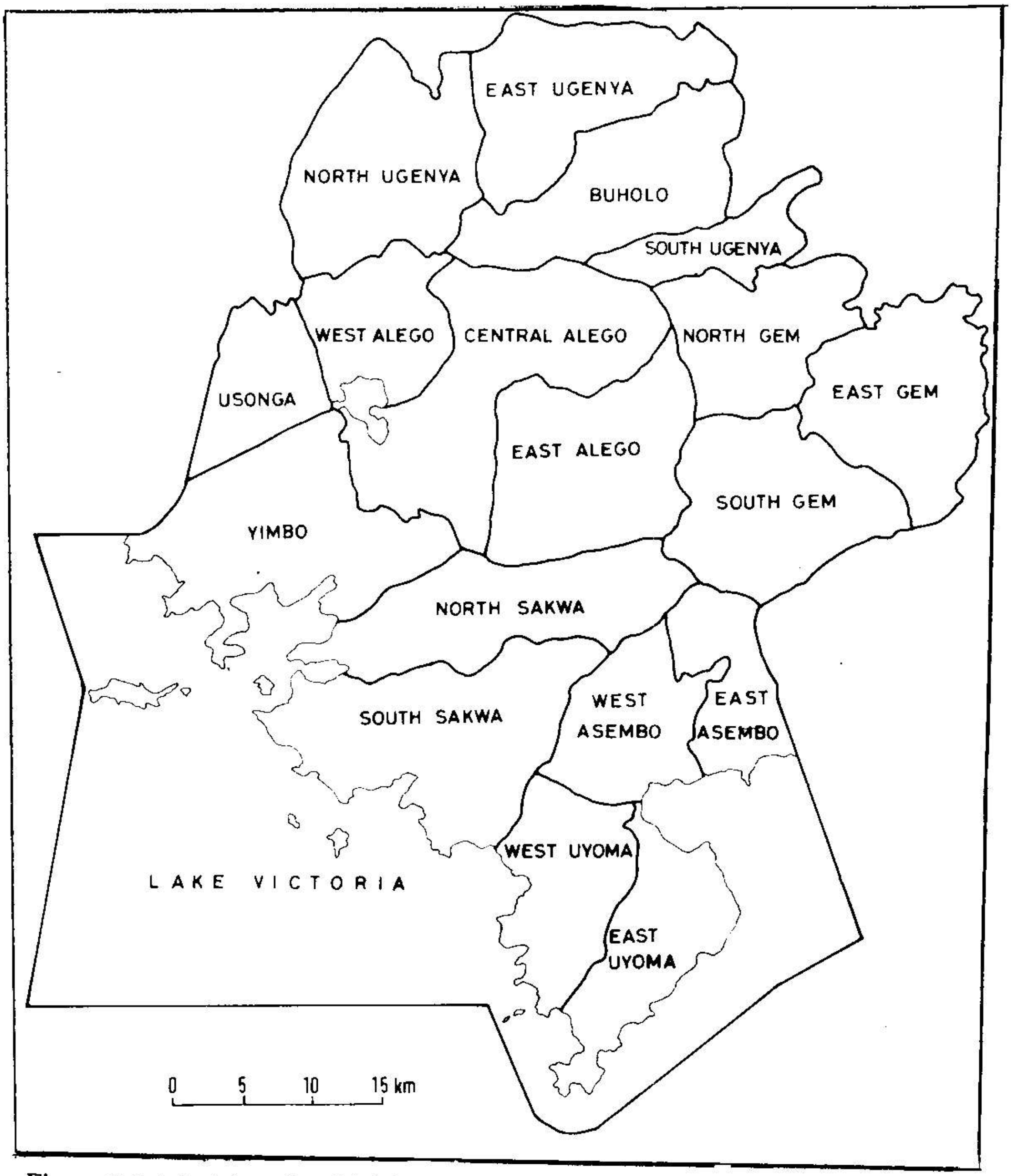


Figure 3.3. Administrative Divisions (locations) of Siaya District.
Source: <u>Ottichilo</u> 1986

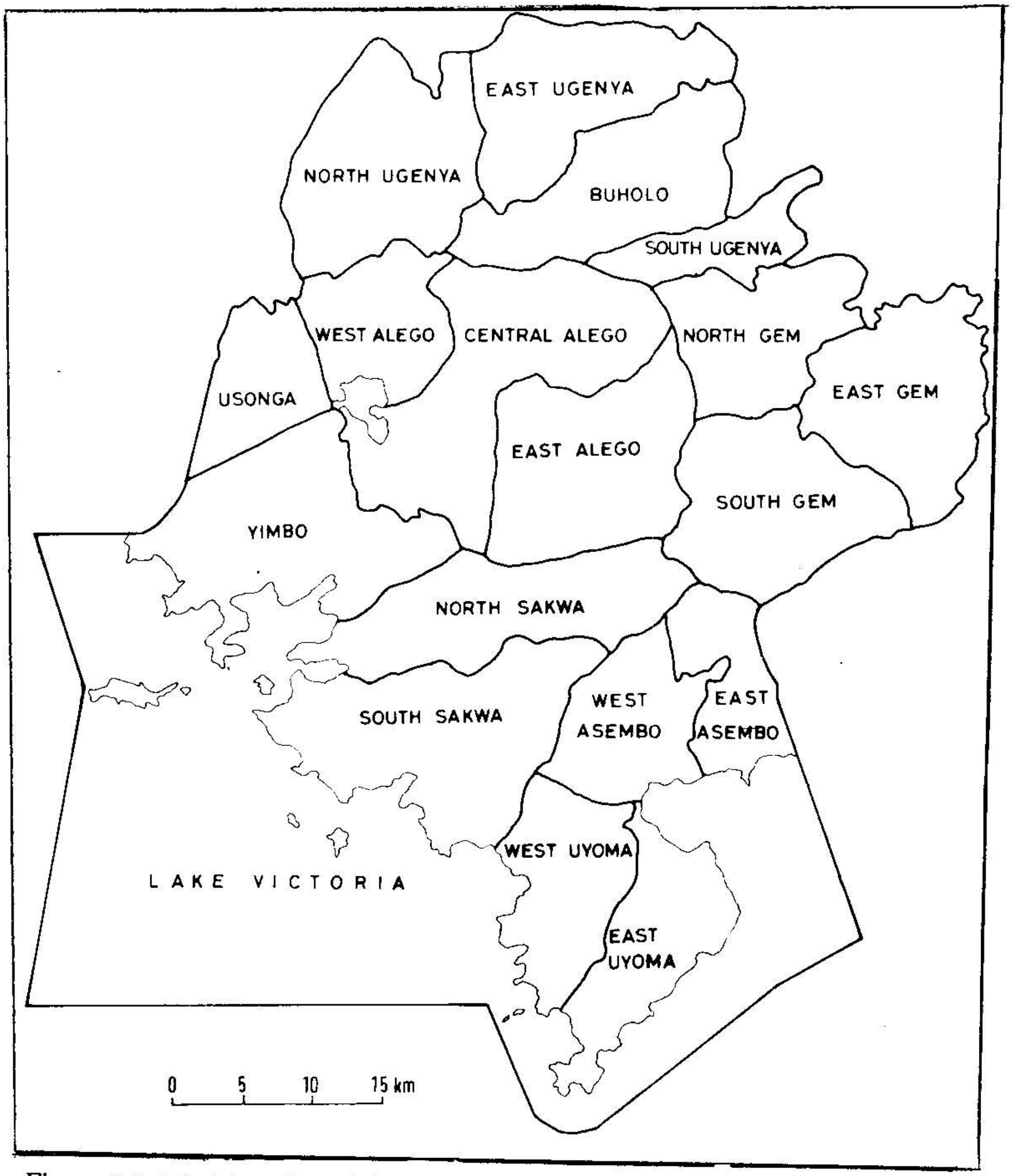


Figure 3.3. Administrative Divisions (locations) of Siaya District.
Source: Ottichilo 1986

A striking feature is the dramatic drop in the percentages of age group 20-24 onwards. The sex-ratio also indicates that the area loses males at all age groups except for the group 0-14 and from 65 years onwards, presumably due to return migration of males to the area.

Table 3.0. Age-structure of Siaya district, 1979.

Age	Males		Females		Sex Ratio
group	Number	Percent	Number	Percent	(M/F)100
0-4	40,314	18.7	41,024	15.8	98
5-9	37,164	17.3	37,283	14.4	97
10-14	34,331	16.0	32,469	12.5	106
15-19	25,057	16.6	26,802	10.3	93
40-24	11,735	5.5	19,244	7.4	61
25-29	8,865	4.1	16,972	6.5	52
30-34	7,868	3.7	14,468	5.6	54
35-39	5,939	2.8	12,536	4.8	47
40-44	6,736	3.1	13,209	5.1	51
45-49	6,899	3.2	12,675	4.9	54
50-54	6,685	3.1	9,609	3.7	70
55-59	5,763	2.7	7,273	2.6	79
60-64	5,368	2.6	5,953	2.3	90
65-69	5,319	2.5	4,133	1.6	129
70-74	3,490	1.6	2,786	1.1	125
75+	7,863	1.3	2,071	0.8	138
Not stated	702	0.3	951	0.4	74
Total	215,058	100.0	259,458	100.0	83

Source: Republic of Kenya 1981. Population census Vol.1

3.6.1 Household characteristics.

The household size varies across the district. The smallest household sizes are found in the high rainfall zone. This varies from 2 to 5 people with an average of 4.7 persons (**Table 3.1**). Out- migration rate of men is the highest in the country ie 45 percent of the households are female headed as compared to a national figure of 25 to 30 percent. The day to day agricultural management decisions are made by the woman. Typically, a high proportion of children are at school and only about one quarter of the farm family are economically active (14- 60 age). Labour shortages are therefore common.

Table 3.1. Demographic characteristics of the study area.

Location[1]	Sex Ratio	Number of Households	Households Size
South Ugenya	79	5,399	5
East Ugenya	78	6,258	4
North Ugenya	79	8,275	5
Uholo	79	5,489	5
North Gem	85	6,350	4
East Gem	86	8,118	5
Zone	81	39,889	4.7

Notes: 1 - some locations have been further subdivided since the 1979 census.

- parts of South Gem and Boro division falling in the zone are not included.

Source: Republic of Kenya, 1981. 1979 Population census, Vol.1. Nairobi : Central Bureau of Statistics.

3.7 Land Tenure.

Land ownership in Siaya is based on strong paternal kinship. At the family level land is owned individually by the male head of the household. Land inheritance is from father to son. Where there is no son, the next closest male relative takes over. A woman has no right to land at her place of birth. Once married, she is assigned a piece of land by her husband for cultivation and subsequent inheritance by her sons. Since trees are considered to establish permanent rights to land, tree planting has been traditionally considered as a 'taboo' for women. This has been used over the years to rule out the possibility of women claiming ownership of land through tree plating activities. The strength of the taboo varies across the district and between households according to such factors as religion, literacy etc. As long as the father is still alive, a son cannot claim ownership of any of his fathers land until he is married. In a polygamous home, the husband may sometimes shift pieces of land from one wife to a newly married son of the wife or to his own newly married wife. This land tenure system based on subdivision of land among the sons, has led to endless fragmentation into uneconomic land units. The degree of land fragmentation is illustrated by the 1983 aerial survey (**Ecosystem, 1985**) which reported a mean field size of 0.6 ha.

For practical purposes, land ownership in the study area can be said to exist on a private tenure basis supported by both legal and traditional provisions of land sales. The right of allocation of use is still entrusted to the male head of the household. He will usually make consultation with other members of the household before taking final decision. However, much of the agricultural land is still under communal land tenure rights, designated as either trust land or county council lands. Individual households are granted usufruct rights to a specific land unit on a continuous basis.

Trees are considered as permanent features of the land. Trees are therefore culturally interpreted as evidence of intuition to lay claim to the land. Land disputes have traditionally been resolved in favour of the party claiming ancestral ownership of the most mature trees on land. Both the land and tree tenure will affect tree planting depending on household's traditional beliefs.

3.8 Social Organizations.

The cooperative movements and self-help groups are strategies used in the district for mobilizing people in rural development. There are about sixteen registered cooperative societies of which 7 are cotton, 7 fisheries, 1 coffee and 1 sugar-cane cooperative societies. Most of these have not been economically viable mainly due to poor pricing and marketing policies.

The majority of enduring self-help groups in the district are the Womens' groups. These are both social and income-generating groups. Their sizes range from 10 to 30 members. They engage in array of activities e.g tree planting, poultry, goat and bee keeping, cultivation of crops for sale etc. The groups have mainly elderly, respected women as chairladies. The secretaries and treasurers on the other hand, are usually middle-aged literate women. These groups also have male members but they are not allowed to hold any office except being coordinators.

3.9 Agriculture

The study area is within the food crop land use system of western Kenya. This is one of the poorest land use systems in the East African Highlands (**Hoekstra, 1988, Minae *et al.*, 1988**). The farming system is a subsistence mixed farming (crop/livestock) economy. The main crops are maize, beans, sorghum, cassava and sweet potatoes. Bananas, vegetables, sugar cane, tobacco, coffee and eucalyptus trees are grown both for domestic use and for sale. Typically, 50 to 70% of the farm is planted to food crops in the long rains and short rains. On average, 20% of small scale households cash in-flow is generated from sales of food crops and 5% from cash crops in the area (**Mukhabi, 1986**). Overall, crops generate only 25% of the total household cash receipts.

Though maize is the most important food crop, its yields is far from optimum. For instance potential maize yields with good management and moderate fertilizer inputs are 4.0 ton/ha. But the actual maize yield vary between 1-2 tons/ha. This is mainly because maize is currently grown on small fields under traditional husbandry. These production levels often do not meet household needs and maize deficits are often felt.

Estimated maize production in the district for 1987 showed a deficit of 47%. Thus farmers are forced to purchase maize for food before harvest periods. The use of fertilizers has not taken off well as the cost is above the financial capability of majority of farmers. The primary soil fertility improvement practices include; animal manure, compost, rotation and natural fallow. But animal manure, the cheapest source of soil nutrient input is not available in sufficient quantities due to decrease in livestock activities. The occurrence of weeds especially *Striga hermontheca* (parasitic) and *Digitaria Scalarum* have increased, outcompeting most cereals for scanty soil nutrients. The only soil conservation practices currently in use are physical structures, grass strips and trash lines. The agroforestry research and development focuses mainly on alley-cropping as an adoptable solution to the declining soil fertility in the area.

Hiring of labour is common in particular for land preparation and weeding of crops. On large farm plots, land preparation is commonly done with oxen-plough. Lack of oxen and ploughs seriously constraint timely land preparation and it has become a commercial service for which cash has to be paid. Provision of formal credit to finance farm investment is only limited and linked to growing of cash crops or raising of dairy cows.

Sugar cane and arabic coffee are the main cash crops in the area. Currently sugar cane is grown mainly in Uholo location due to its close proximity to Mumias sugar factory and the outgrowers scheme. Due to lack of markets and the collapse of the Unilever white sugar factory in Yala, sugar cane growing in the other parts of the area has fallen drastically. The only available sugar cane markets are the jaggery factories which are few and offer poor prices to farmers. Sugar cane production can contribute a lot to the social and economic development of the area. According to the Siaya development plan (1984/88), in 1982 sugar cane had the highest income per capital in the district. There is therefore a need for establishment of more sugar factories and better pricing to boast its production.

Only arabic coffee is grown in this area. The area has good potential for coffee but this will not be realised until proper extension services, credit facilities and formation of well-managed coffee cooperative society are made.

The study area also has high potential for the growing of fruits and vegetables especially citrus fruits, mangoes, pawpaw, cabbages, tomatoes and onions. There is especially good prospects for producing vegetables in the river valleys. Lack of formal credit, shortage of extension staff and lack of profit motivation have been noted in the previous studies to play a big part in limiting production of these crops .

3.9.1 Livestock

Majority of the people in the district have a pastoral history and close association with animals particularly cattle. Other animals traditionally kept are sheep, goats and chicken. There has been a lot of changes in livestock keeping in the high rainfall area due to changes in land ownership, out-migration of males, increase in population density and changes in social values. Women were not traditionally prepared to manage cattle and therefore could not manage large herds in the absence of males. In some cases, women have followed their husbands to towns and livestock had to be disposed of. The increase in the population has necessitated the cultivation of more land leaving little land for grazing. Trendwise, livestock activities have therefore been on a steady decrease in the area. **Sands (1985)**, found poultry on 83% of farms, ruminants on 61% of farms. These are kept as a source of liquid capital, manure and traction power. The principal feed source is grazing of unimproved land and the use of crop residues as feed is rare. The seasonality of fodder in quantity and quality is a major constraint to livestock production. Labour for herding is the main household input to the livestock system. Animals and dipping are the only purchased inputs. Milk production is as low as 1-4 litres per lactation. Introduction and development of improved cattle breeds has been slow. This is due to lack of initial capital and presence of ticks in the district. The cost of buying improved breed is generally beyond the reach of most small scale farmers.

3.9.2 Agroforestry

Siaya district is one of the least forested districts in the country. A survey by **Ottichilo (1986)**, estimated that only 800 ha, (0.3% cover), was under woodlot- its equivalent to a forest. Bush and hedges covered 22,500, (12.3% cover), and 12,000ha, (4.9% cover), respectively. The intensity of tree growing in the district is related to population density and agro-ecological zone. In the study area, traditional forms of agroforestry involves purposefully allowing naturally established trees especially, *Markhamia platycalyx* and *Sesbania sesban* to grow in the field with crops and/ or animals. Farmers' management of trees has intensified over the years and the importance of naturally-growing trees has diminished markedly (**Scherr, 1990**). Farmers have on average around 500 trees growing on their farms plus about 900 tree hedges per farm (**Scherr & Alitsi, 1990**). Most trees are planted on unused or underused space. More intensive practices, such as mixed intercropping, linear intercropping and multi-strata homegardens are also emerging. There is considerable diversity in tree species, plant arrangements and uses, and the management intensities. Market trends in western Kenya suggest continuing incentives for trees on farms. This is because of the limited scope of increasing productivity and income from annual crops and the weakening of the cattle economy. Trees for commercial pole and timber production offer one of the few wealth accumulating investments available in the area.

Much of the credit for diversification of agroforestry practices, increased tree planting and wide spread public commitment to tree growing is due to many government supported (public and collaborative non-governmental organization-NGO) programmes of publicity, extension, tree nursery development, self-help group promotions and seed supply. Less obvious has been the changes in legislations and regulations which have encouraged agroforestry (**Getahun, 1987**). However, more systematic review of the these legislation and the regulations are still needed to harmonize the actual enforcement on the ground. This is because the competing land users and land use regulations in general are growing ever sensitive to changes as competing uses rise for a land base shrinking rapidly relative to population and economic demands for primary products.

3.9.3 Peoples'perspective about agriculture.

As regards attitude, previous studies have indicated that there is a feeling among young and educated people that farming is not a good form of employment. For example, **Nyabundi (1987)**, found that teachers who are probably the most educated and the best paid group in the rural areas, were more ready to buy food than engage in farming. The same appeared to hold for the local leaders. A number of farmers were also found to depend largely on monetary gifts from relatives mainly sons and daughters working elsewhere in urban centres. He advanced two hypotheses for these trends. One was that this attitude is based on the impression that farm work is unnecessary drudgery and anybody who has well-placed kin should not engage in it. Secondly, because the colonial settlers never established farms in the district, there is a general impression among the populace that the district is not a farming area. Well-funded people from the district who have the inclination to engage in agriculture, have therefore tended to move out of the district to buy land in the former white settler areas. Thus the district is deprived of enterprising farmers who would serve as good examples. Most of the current good farmers in the district are retired people who have invested their financial retirement benefits in farming.

CHAPTER FOUR

4.0 RESEARCH METHODOLOGY

4.1 Justification of choosing the study area.

The high rainfall zone, otherwise known as the high potential zone (**LM.** 1), of Siaya district was chosen for three main reasons namely;

1. general lack of more reliable information on reasons for the current alley-cropping management practices by farmers.
2. lack of information on reasons for non-adoption or rejection of the technology by a section of the farmers.
3. the zone was the easiest to work in terms of transport, time, accessibility and logistics due to presence of **AFRENA** research activities in the area.

4.2 Formal Survey.

The purpose of the formal survey was to generate both qualitative and quantitative information on technical and socio-economic aspects through a written questionnaire. Preparation of the questionnaire begun in March 1991 with a series of literature review and discussions with teaching staff in the University. The skeleton body of the questionnaire was developed as a result of these efforts. A second phase of review on published and grey literature was done at **ICRAF** headquarters and **AFRENA** research station-Maseno. This research proposal was also presented at the training/workshop on Socio-economic Research for Agroforestry Technology Development at **ICRAF** Headquarters, September 2 - 6, 1991. Improvement on the questionnaire draft was done in the light of all these sources of information.

The questions included in the questionnaire focused on farmers' knowledge and opinion on the technology in order to identify critical factors that influenced adoption or non-adoption of the technology. In order to facilitate use of the questionnaire, it was divided into two sections. The first section dealt with general socio-economic matters. The questions included in this section were based on two main criteria; their value to describing the household and their possible value to explaining adoption. The other section addressed the technical issues pertinent to management of alley- cropping.

4.2.1 Selection of enumerators.

Two enumerators were employed based on their past experiences with field surveys. Both are field technicians with the **KEFRI/CARE** agroforestry extension research project. A one week training session in the use of the questionnaire was held.

The questionnaire was field-tested by the enumerators and the researcher with 10 farmers. This session was also meant to train enumerators on field observations and measurement of tree rows, plot sizes and cutting height. The information gathered through the exercise was used to substantially modify the questionnaire and development of the final version (see **Appendix I**).

4.2.2 Criteria for farmer and field sampling.

Before the beginning of the survey, a decision was made about the population of farmers to be covered. Generally, the researcher was interested in farmers currently managing alley-cropping (**adopters**) despite withdrawal of extension inputs. Of equal interest were also those farmers who had the same duration of interaction as the adopters with the extension agents but decided not to adopt alley-cropping or dropped it after trying (non-adopters). A three stage sampling procedure was used for selecting adopters and two stage sampling for non-adopters. At the first stage, a list of 52 womens' groups who started tree planting since 1985 was made out of the master list of all groups in the high rainfall zone. These groups had received both technical and material assistance from the **CARE**/Forest department agroforestry extension project. However, 30 of these selected groups were no longer receiving both technical and material assistance. A random sample of 13 groups was made out of the 30. On average each group had 10 members active in agroforestry. At the second stage a list of 130 active members of these selected groups was made. From every group list, 4 adopters and 4 non-adopters were randomly selected. Stage three involved the selection of the adopters based on whether their plots had met the set criteria or not. This was necessary because, farmers' alley cropping plots are generally different from the conventional rectangular plots with consistent spacing and easily observable boundaries as is often found in the experimental plots. There is therefore no standard description of farmers alley-cropping plots. For the purpose of this study, alley-cropping plot was described as a plot with more than 2 rows of trees in which farmers said they had planted those trees for green mulch production. Each tree row must have had at least 5 living trees. The said trees were supposed to be at least 4 years old and must have been intercropped for two consecutive seasons. Only 2 out of the 4 in each category were aligned for interview. The names of the remaining 2 farmers were used to draw up a list of replacement farmers to be used to substitute those whose plots would not meet the set criteria or a farmer who would not be available for the interview. In both categories, the unit of interest was the member of the household who made day to day decisions on plot management.

4.2.3 Interviewing farmers.

The survey interviews were undertaken by the researcher and the two enumerators. Each farmer had to be contacted the day before the interview to arrange a suitable time. On average, interviews lasted one and a half hours. Each person interviewed two farmers per day since farmers could only spare us two hours in the morning or in the afternoon. Six of the farmers initially selected had to be replaced because of plots not meeting the set criteria or because of funerals. A total of 62 farmers were interviewed and these consisted of 31 adopters and 31 non-adopters.

4.3 Group Meetings.

The farmers' attitudes concerning alley cropping could be assessed more efficiently through an informal meeting than through questionnaire survey. The researcher felt that group interviews was valuable in obtaining a general description of the farmers' practices and reasons for their practices. The farmers knowledge and opinion on the recommendations are useful in identifying those critical factors that have been most important in their practices (**Kumar, 1987**). Two out of 13 womens'groups whose members were selected at random for the formal survey were used for these meetings. The two groups were selected at random and all the adopters in each invited to the meeting. The purpose of the intended meeting was explained to them. We met with each group for two hours. A lot of informalities was maintained all through the meetings so that the farmers were free of tension. Both the meetings were arranged after completion of the formal survey. All the topics were discussed at a time with occasional notes taken by the two enumerators while the researcher guided the discussions. The frame work of note taking was to identify the main views expressed and differences in opinion. Consensus and dissent within the group were considered highly productive in highlighting farmers main problems and constraints and different strategies for coping with these problems. In one group 12 adopters turned up for the meeting while only 8 attended from the other group. The main objectives of the meetings were;

1. for farmers to give reasons for their management strategies.
2. for farmers to reach a consensus on their priorities.
3. for farmers to identify possible action for alleviating the problems associated with the technology.

Two broad questions were asked to address these objectives:-

a) We have observed a great diversity of tree density, cutting heights, cutting frequencies, and mulch treatments on your farms.
   - what are your reasons for these ?
   - which among these reasons are more important?
   - are there any things you still do not understand about the technology ?

b) considering these diversities on your management, are there other changes you would like to make in order to improve the system ?

At the end of every meeting, we briefly reviewed the conclusions on the main themes discussed and also highlighted where differences of opinion occurred.

4.4 Data Analysis.

Before entering the formal data into the computer, a coding system for the questions (variable) and answers (value) was developed. The code for the questions was a combination of a letter and a number. All the coded answers were hand tabulated to allow entry into lotus 1-2-3 for preliminary analysis at AFRENA-Maseno. This included cross tabulations and frequency calculations. The lotus 1-2-3 spread sheet was later converted in Minitab and SAS spread sheets due to non availability of this programme at the University. Due to the nature of the study which addresses mainly opinion, perception, and judgement related questions, the data collected was mainly qualitative.

The use of chi-square, and logistic regression analysis were thought as more appropriate to allow testing of the binary responses. The quantitative data was subjected to simple descriptve statistics and comparison of means of each group by utilizing a t-test.

4.4.1 The chi-square tests.

When using variables which are categorical like qualitative variables with only binary responces, calculating the means does not reveal much valuable information and a T-test does not apply. Because of this, the Chi-square test was used to perform hypothesis testing of the importance of certain explanatory variables. The use of chi-square helps to decide whether two variables, independent or dependent, are related in a population. The test also determines if a conspicuous discrepancy exists between observed and expected counts. This is expressed as:-

$$X^2 = \frac{\textbf{Summation Cell. (observed frequencies - expected frequencies)}^2}{\textbf{Expected frequencies}}$$

Because a large value of the overall discrepancy indicates a disagreement between the data and the null hypothesis, the upper tail of the chi-square distribution constitutes the rejection area. This was employed in the analysis to test the hypothesis that the explanatory variables were related or not related between adopters and non-adopters.

4.4.2 The logit model.

Yapa and **Mayfield** (**1987**), through literature review, found that most empirical adoption studies used ordinary least-squares regression of a 0-1 adoption variable (say, use of high yielding varieties) on explanatory variables such as farm size, tenure, education etc. However, normality of disturbance is obviously inappropriate for such regression. Thus estimated standard errors and t-ratios produced by such analyses are not suitable for hypothesis testing. More so, ordinary linear-regression estimates produce predictions other than zero or one for dependent variable. If such predictions are considered as probabilities, then predictions less than zero or greater than one are nonsensical. The use of logit and probit models have recently become common in studies on the effects of explanatory variables on adoption. Both models specify a functional relation between the probability of adoption and various explanatory variables. **Gerhart (1978 cited by MOA, 1986)**, for instance, used probit model to explain adoption rates of hybrid maize in three different regions in Kenya. However, logit will be used in this study due to its robustness. The logit model specifies a functional relation between the probability of the adoption and various explanatory variables. The model has been used frequently only in cases in which the dependent variable is binary (taking only two values, say 0 and 1). It is based on the cumulative logistic probability factor expressed as:-

$$P_i = F(Z_i) = F(\acute{o} + \beta X_i) = \frac{1}{1 + e^{-(\acute{o} + \beta X_i)}}$$

where;

e = the base of the natural logarithm (= 2.718).

$\mathbf{P_i}$ = probability that an individual will adopt, given a resource base **Xi**.

Z = estimated variables or index.

Xi = resource base

Ó and **ß** = Constants

Cox (1970), noted that if we assume a given model, the corresponding likelihood ratio is valid as long as the sample size is large. The maximum likelihood estimation procedure has one desirable statistical property. That is, in addition, all parameter estimators are known to be (asymptotically) normal so that the analog of the regression t-test can be applied. In this case, the ratio of the estimated coefficient to its estimated standard error follows a normal distribution. If we wish therefore to test the significance of the all or a subset of the coefficients in the model when maximum likelihood is used, a test using chi-square distribution replaces the usual F-test. Using the Proc Catmod procedure in SAS gives the prediction of how an individual will make a certain choice ie adopt or not adopt. The adoption is the limited dependent variable (**adoption = 1, non-adoption = 0**). It was hypothesised that the independent variables may influence the dependent variable. The model therefore takes the form of:-

$$\log \frac{\text{prob.(adoption)}}{1 - \text{Prob(adoption)}} = ß_1 + ß_2 Z_2 + \ldots\ldots\ldots + ßkZk$$

where, **Z** = the independent variables (see table 4.0)

Prob. = the probability of adoption

The logit model is then estimated using a linear maximum likelihood estimation procedure. The logit model in practical use and interpretation is quite similar to the multiple-regression.

Table 4.0. Independent variables.

1. Sex of respondent (male = 1, female = 0)
2. Education (yes = 1, no = 0)
3. Has non-farm income (yes = 1, no = 0)
4. Land ownership (yes = 1, no = 0)
5. Head of household's income (job/trade = 1, no job/trade = 0)
6. Growing cash crop (yes = 1, no = 0)
7. Position in the womens'group (official = 1, ordinary member = 0)
8. Use hired labour (yes = 1, no = 0)

CHAPTER FIVE

5.0 RESULTS AND DISCUSSION

5.1 Background Information.

The chapter starts by looking at the relationship between the socio-economic characteristics of the households and adoption of alley-cropping technology. Households parameters which were hypothesized to be important in adoption are briefly presented. The results and the discussion are organized according to these key explanatory independent variables which affect adoption under three levels of analysis namely:-

1. General descriptions and t-test of quantitative variables.
2. Chi-square test on the main qualitative explanatory variables.
3. Logit test of maximum likelihood of adoption.

A general description of the range of current management practices by the adopters is given. This is followed by an attempt to explain some of the technical/socio-economic factors underlying these management strategies. Lastly a brief look at the implication of these factors on future adoption of the technology is made.

5.2 Comparison between Adopters and Non-adopters.

Table 5.0. shows the results of a t-test on the mean values of five parameters between the adopters and non-adopters. These were the only parameters which were quantified through the farmers estimations. An attempt was also made by the research team to cross check these values through visual observations.

5.2.1 Age of the respondent.

The age of the member of the household who manages the farm indicates his/her capacity to work. It also affects the will to accept innovations and changes. There was significant difference between the mean ages of adopters and non-adopters at 0.1% level (**Table 5.0**). This suggested that younger farmers among the farmers interviewed were not keen on alley-cropping. The hypothesis advanced earlier that younger farmers would be adopters was therefore not supported by the results. However, in both cases, about seventy percent (70%) of farmers were above 41 years old (**Table 5.1**). At such advanced ages, these farmers may be less able and less motivated towards dealing with heavy farm labour like is required in alley-cropping.

Table 5.0. T-test results.

Variable		Mean	Std.dev.	Min	Max	T-test	Result
Age	*	48.65	12.60	24.00	86.0	1.42	S**
	#	43.94	13.45	28.00	77.0	''	'
HH/size	*	4.81	2.44	1.00	9.0	0.48	NS**
	#	5.07	1.65	2.00	11.0	''	''
Ac/member	*	2.22	0.76	1.00	4.0	0.31	NS**
	#	2.23	1.19	1.00	6.0	''	''
Land size	*	1.80	0.83	0.58	4.0	0.5	NS**
	#	1.68	1.15	0.20	4.0	''	''
Ava/land	*	1.58	0.58	0.58	2.8	-0.49	NS**
	#	1.52	0.94	0.20	3.4	''	''
Fallowland	*	0.22	0.31	0.00	1.2	-0.38	NS**
	#	0.18	0.34	0.00	1.2	''	''

* = Adopter

= Non-adopter

*S = Significant at 0.1% level.

**NS = Not significant at 0.1% level.

HH = Household

Ac/member = Active member

Available land = Land size - fallow land

Table 5.1. Percentage age distribution among the farmers.

	Less/equal 30	31-40	41-50	Over 50	Total
Adopters	9.7	19.4	22.6	48.3	100
Non-adopters	3.2	22.8	42.0	32.0	100

5.2.2 Household size and active members.

The average household size was 5 persons for both adopters and non-adopters. However the values of the standard deviations in this study indicated high variability within the household sizes in both categories. As the production units are households, access to labour varies with the household development cycle and the prevailing consumer/producer ratio. In this study those members of the household below 15 and above 60 years were regarded as consumers. Only ages falling in between were considered economically active producers. About twenty seven percent (27%) of the household members were economically active in all the households surveyed (see table 5.2). This reflected the seriousness of labour shortage experienced by the households in the area.

Table 5.2. Mean household size and age distribution.

	Household Size	Under 15	Over 15-60	Over 60
Adopters	4.81	2.68	1.29	0.84
Non-adopters	5.07	3.13	1.44	0.50

In a comprehensive review of technologies for small scale farmers in Sub-Saharan Africa in five major agricultural zones, **Carr(1989)**, found that labour constraint was the major reason for low level adoption of high labour demanding technologies in much of Africa. It has also been noted that peak labour scarcity is the most operative constraint in African farming systems. Previous studies on labour, indicates that hedge management increases total farm labour requirement by at least 4%. Thus management of alley-cropping increases the seasonal demand of labour especially during the peak season. For the study area the situation may be aggravated by the fact that the neighbouring areas also peak at the same time hence discouraging labour migration. The labour bottleneck and the supply uncertainty possibly explain high non-adoption of the technology in the study area.

5.2.3 Land size.

Other factors remaining constant, size of land holding determines the extent of any agricultural production. Farmers in this area mainly depend on the land they own for raising both food and cash crops, and hence for their survival. No significant differences were found between mean land size of the adopters and non-adopters. The hypothesis advanced earlier that farmers with bigger landholding sizes would be better adopters was not supported by the results. The differences in land sizes among the adopters and non-adopters therefore did not explain adoption decision in the study area at 0.1% level. Land size, however, can have different effects on the rate of adoption depending on the characteristics of the technology and institutional settings. This is because land size is a surrogate for a large number of potentially important factors. Such factors are fixed adoption costs, risk preference, human capital, credit constraints, labour requirements and tenure arrangements. Since the confounding effect of these factors varies in different areas and over time so does the relationship between landholding size and adoption. However, the confounding effects of such factors was not considered in this study. Others studies have also shown that biological technologies are essentially neutral with respect to farm size or land tenure **(Ruttan & Binswanger, 1978 cited by Ruthenberg,1985)**. This is because, within a short time after introduction of the innovation, lags in adoption rates owing to land size or tenure typically disappear **(Fig.5.0)**. It is difficult to deduce from the results of this study whether adoption of alley -croppnig would follow that trend.

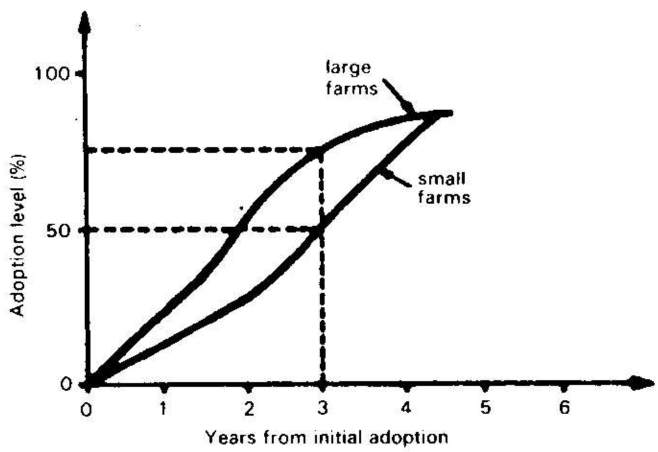


Figure 5.0. Stylized adoption curve for an agricultural innovation.
Source: Ibid

The mean size of available land was not significantly different between the adopters and the non-adopters at 0.1% level. Both adopters and non-adopters had fallow lands for reasons given in Table.5.3. Interpretation of the results is a bit difficult due to their qualitative nature. However, it seems that the adopters wanted to give the impression that they were more aware of and more concerned about the soil fertility problem. Unavailability of resources seemed to have been more pressing for the non-adopters.

Table 5.3. Percentage of respondents with various reasons for non-cultivation of the whole land.

	Adopters	Non-adopters
Lack of resources	36	59
Regain fertility	45	31
Pasture/thatching grass	19	10
Total	100	100

On the overall the main reason for fallowing was to let land regain fertility and implicitly to reduce weed population in about 52% for all households. However, the fallow period barely exceeds two cropping seasons due to small land holding sizes. These short fallows coupled with the labour bottlenecks can not effectively reduce the build up of especially parasitic weeds like *Striga species*. Alley-cropping is advocated for this area because studies have shown that tree fallow reduces weed population by almost 93% (**Bashir *et al.*,1991**).

5.3 Maximum likelihood of adoption.

Nine independent variables which had only binary answers were examined to see whether significant differences existed between the two sub samples using chi-square. The chi-square results are shown in Table 5.4. The logit model used is based on the maximum likelihood method. It allows the prediction of how each and every individual will make a certain choice, for instance, accepting to adopt or not to adopt alley-cropping technology. Only independent variables which showed high likelihood of explaining adoption were finally used in the logit model (see **Table 5.5**)

Table 5.4. Chi-square test results.

Variable	Percentage §Adopt.	Non-adop.	Chi-sq.	Result
Education of the respondent	51	35	2.345	NS*
Sex of the respondent	77	70	0.337	NS**
Non-farm income of respondent	32	77	12.765	S*
#HOH's non-farm income.	71	68	2.640	NS**
Land entitlement	55	36	2.345	NS**
Cash crop	22	68	14.762	S*
Position of respondent in the Womens' group	55	35	0.076	NS**
Use of hired labour	55	42	1.645	NS**

§adopt = adopters Non-adop. = Non-adopters
HOH = Head of household
** NS = Not significant at 0.05% level
* S = Significant at 0.05% level

Table 5.5. Analysis of maximum likelihood estimates for adoption.

Independent Variables	Parameter Estimates	Standard Error	Chi-Square	Pro.
Intercept	2.7820	0.9957	7.81	0.0052
Education	1.2591	0.7403	2.89	0.0890
Non-farm income	-2.6203	0.8598	9.29	0.0023
HOH's income	-1.2602	0.7225	3.04	0.0811
Cash crop	-3.1755	0.8776	13.09	0.0003

Likelihood Ratio DF = 10 Chi-square = 6.16 Pro. = 0.8

5.3.1 Education of the respondent.

No significant difference was found between the level of literacy between the adopters and the non-adopters at 0.05% level. The logit model indicated a positive relationship between adoption and education. This accords with the information found in the literature which also indicate high correlation between the level of education and innovations. However, the hypothesis advanced that literate farmers would be adopters was not supported by the results. But majority of the farmers had below secondary level of education. Only four in the whole sample had post secondary training. All the males interviewed were literate in both subsamples. The loss of people with most initiative and education through out-migration could be a serious constraint to adoption of any agricultural innovation in this area.

5.3.2 Sex of the respondent.

There was a positive relationship between adoption and sex of the farmer. However, this was not significant at 0.05% level. Therefore, the results did not support the hypothesis that men were better adopters than females in the study area. Only 6 out of the total sample were widows. There was one male widower among the adopters.

These results also showed that in this area, women still take complete charge of the family farm while able-bodied male adults seek outside employment. This is because the average wage in urban areas is two to three times the average agricultural income. This, however, does not reflect a high level of urban wages but just the low productivity of agricultural labour. Because of the high proportion of men who seek work a long distance from the rural area, major decision on land use and marketing commonly remain with the absent husbands. His permission must be sought before new practices are introduced to the farm. This gives limited scope for experimentation and couple with the relative shortage of labour is likely to constraint the adoption of alley-cropping. Cases of husbands or even economically influential relatives ordering the uprooting of trees on the cropping plots have been observed in the study area.

5.3.3 Non-farm income.

Although estimating income was beyond the scope of this study, it was apparent that non-farm income sources varied greatly. Non-farm income of the respondent farmers was significantly different at 0.05% level. The logit model indicated a significant negative correlation between the non-farm income and adoption of alley-cropping. These results indicated that the more a farmer depended on trade/job the less the likelihood of adoption of alley-cropping. The results did not support previous findings that engagement in non-farm activities positively influence adoption of alley-cropping.

The priority of most farmers in this area was to diversify away from food crop production. They did this by minimizing inputs in food cropping in order to maximize investment in off-farm enterprises. As **Nyaribo (1984)**, indicated, the households in this area are highly market dependent since they obtain less than 50% of all the 'food' from own production. **Reardon *et al.* (1989)**, also found that rural households do not necessarily perceive the need for cropping *per se* in order to meet food security objective. They invest in local non-cropping activities, such as commerce and food sales.

The farmers experienced cash constraints during non cropping seasons after depletion of the previous season's crop. None of the farmers interviewed mentioned casual work as source of income or as a means of solving cash problem. However, both adopters and non-adopters mentioned monetary help from the relatives as one of the reliable sources of income (**Table 5.6**). However, monetary gifts from relatives did feature more strongly among the adopters than non-adopters. **Nyabundi (1987)**, also found that a large number of families in Siaya largely depended on monetary gifts from relatives. Having a working kin is a social prestige among the Luos. The fact that such farmers have working kin could be hypothesized to have been an incentive for adoption so that the status remains. This is because, alley-cropping as an innovation must have some degree of status conferral although this could not be proved from the results of this study.

Table 5.6. Percentage of respondents by alternative household income sources.

Source	Adopters	Non-adopters
Petty trade	56	61
Relatives	25	13
Horticultural crops	11	23
Credit	8	3
Total	100	100

5.3.4 Head of household's non-farm income.

Logit model indicated a negative relationship between the adoption and head of the household's non-farm income. This was not significant at 0.05% level and did not support the hypothesis made earlier that households with the head having an off-farm income were more likely to adopt the technology. The results showed that head of households' non-farm income did not have significant impact on adoption decision. Most of the farmers surveyed had their male head of households stay away from home most of the time. As is the trend in the study area, they were involved in non-farm employments in the neighbouring towns. In households where the male head was actively involved in farming, the wife was in most cases found to be engaged in petty business. Interestingly enough, even retired males in most cases were not directly involved in farming, but were still employed mainly in rural development programmes run by the local churches or in the rural institutions. The negative correlation between head of household's income and adoption is explained more by **Gulliver's** findings (**1985**). He asserted that the income of out-migrated labour are so low that there is relatively little effect upon the economic conditions of the home area especially in East africa. He adds that even if income is remunerative enough, it is extremely rare for it to be used in improving agriculture in the home area. More often such incomes are invested in building or improving house, operating small business and buying land (**FAO,1986**).

5.3.5 Land entitlement.

The logit results indicated a positive relationship between land entitlement and adoption of alley-cropping. But this was not significant at 0.05% level. Seventy percent (70%) of the 62 farmers surveyed were both traditionally and legally entitled to their lands. The remaining 30% still had only the traditional land rights. The study indicated a substantial sense of security about land entitlement. The hypothesis advanced that only those farmers with secure land entitlement would be adopters was not supported by these results at 0.05% level. This could also be due to non-encounter of polygamy which could pose some threat. This was an evidence of a general decline in polygamy due to economic pressures and change in social values.

Several previous researchers in adoption have argued that tenurial arrangements may play an important role in the adoption decision. However, views have not been unanimous and the subject remains of considerable controversy. This is because innovations have been introduced in environments with different economic, social and political institutions. These underlying factors obviously operate differently in different socio-cultural environments. It is therefore sufficing that the findings of this study should be supported by a brief mention of the prevailing land use regulations governing tree planting in the area. The use of trees and shrubs is governed by a wide range of legislation and regulations in Kenya. There are regulations specific to soil conservation, protection of indigenous trees, district landuse management, public forest management, cash crop management and range lands management. Many of these regulations date back to the days of the colonial rule, when land use planning promoted specific land users for specific types of land. These regulations still generally discourage intercropping with trees. As such these regulations may affect not only whether trees will be planted and when, but also the type of agroforestry technology which is used. Of even more relevance is how such regulations are enforced. In Kenya, decision-making power regarding policy and government programmes are concentrated at the district level through the District Focus for Rural Development Strategy (**Office of the President, 1983**). But enforcement of the existing land use regulations has become a bit difficult to agriculture and forest departments due to the uncertainty of legal status of particular activity under existing acts. An increasing share of the actual enforcement and definition of land use is being done through the local Chiefs. The Chiefs are legally empowered through an act of parliament (**the Chiefs' Authority Act, 1970**) to regulate both public and private land uses. Given the current strong political support at the level of the presidency, the chiefs have in recent years tended to pursue group agroforestry activities. However, a chief who is not supportive of the agroforestry, can be a serious stumbling block for other land users. This can happen through restriction of large-scale nursery activities, withdrawal of approval for tree planting, management and/or harvest. As such, although this study indicated secure land tenure among all the farmers interviewed, the manner in which the existing regulations are enforced at the local level can still affect adoption of alley-cropping.

5.3.6 Cultivation of cash crops.

The cultivation of the traditional cash crops ie coffee, sugar cane and tobacco was encountered on few farms. Out of the 61 farmers only 2 had coffee and 3 had sugar cane. One farmer had tried tobacco but later had to abandon it due to high input costs. Cultivation of kales, tomatoes and fruits for sale was common in most farms. Since these vegetables find ready market either locally or on the inland markets, they were the main cash crops for most farmers. Production of beans for sale was also mentioned by most farmers. Sixty eight percent (68%) of the non-adopters were engaged in horticultural production as compared to only twenty two percent (22%) of the adopters. Two of the non-adopters had actually uprooted leucaena trees in alley-cropping plot to give room for more cabbage production.

There was a significant negative correlation between adoption of alley-cropping and cultivation of these crops at 0.05% level. This showed that cultivation of horticultural crops for sale led to non-adoption of the technology in the area. This agrees with previous finding that adoption of labour intensive agricultural technology is higher among the subsitence oriented farmers than among the commercial producers (**Ruthenberg, 1985**).

The promotion of the horticulture crops falls under the jurisdiction of the Ministry of agriculture. The Ministry has series of rules with regard to the types of trees to include in different types of nurseries mainly for phytosanitary reasons. More over intercropping of horticultural crops with trees is strongly disrecommended. All these factors, depending on the attitude of the district and local agricultural officers, may contribute to non-adoption among horticultural farmers.

5.3.7 Position in the womens'group.

It has been mentioned in other previous related studies that one of the important motivation for almost any individual to adopt an innovation is the desire to gain social status. Elective posts in the women groups are usually held by women who hold high social status either due to their age or education. It was hypothesized that the officials would be adopters. Logit model showed that there was positive relation between position in the womens' group and adoption. However, there was no significant difference between the adopters and non-adopters with respect to their position in their respective womens'groups. But, our questionnaire did not directly seek the status motivation of alley-cropping. This is because, such direct questioning about the motivation was likely to underestimate its real importance in the adoption decision. More so, farmers particularly in this area, would have been reluctant to admit that they adopted a new idea in order to secure the status aspects.

5.3.8 Other sources of labour.

In the study area, labour was mainly supplied by the family supplemented by hired labour during peak periods by some households. Both the adopters and non-adopters were equally accessible to group communal labour. Use of hired labour was found to be positively related to adoption of alley-cropping, but it was not significant. Table 5.7 shows that quite a good number of the households also never use hired labour. This could have been due to lack of finance with which to hire labour and/or due to uncertainty of labour supply during peak periods.

Table 5.7. Use of hired labour among the respondents.

	Permanent	Regular	Never	Total
Adopters	6	39	55	100
Non-adopters	3	49	48	100

5.4 Reasons for Non-adoption.

A simple classification system was used for non-adopters. Two sub classes of active rejectors and passive rejectors were created. Active rejectors were those who considered adoption and even tried the technology but later decided to discontinue. Passive rejectors on the other hand were those who never really considered use of the technology. Among the 31 non-adopters, there were 18 passive rejectors and 13 active rejectors. These two sub classes looked different in their decision not to adopt the technology as shown in Table.5.8. Landholding size is a surrogate for a large number of potentially important factors, one of which is the farmer's capacity to bear risk. In the case of passive rejectors, low capacity to bear risk probably lied at the root of negative relationship between land size and non-adoption. The fear of experimentation expressed by the passive rejectors could have been due to subjective/objective uncertainty of the expected utility in alley-cropping technology. For them alley-cropping practices looked on the spot to conflict with their routinized farming practices and probably of less relative advantage than the other systems. Active rejectors made decision to discontinue using the technology in order to adopt systems with higher relative advantages. These other systems included raising of cash crops and/or concentrating on small scale business. On the overall the combined results showed that the main reasons for non-adoption were land scarcity and preference for other systems. They therefore would only go for a system they were sure would give better response given the vagaries of climate in the tropics. Farmers had keen interest mainly in any crop that could find ready market to generate cash. Raising of commercial tree seedlings like *Eucalyptus species*, *Grevillea robusta* and *Cupressus lusitanica* which are highly demanded in the area were also actively persued in the tree nurseries.

Table 5.8. Main reasons given for non-adoption.

	Active		Passive		Combined	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Competition	5	38.5	0	0.0	5	16.0
Labour/cutting	2	15.4	2	11.0	4	13.0
Land scarcity	2	15.4	6	32.0	8	26.0
Experimenting	0	0.0	5	28.0	5	16.0
Tree mortality	3	23.0	0	0.0	3	10.0
Other systems	1	8.0	5	29.0	6	19.0
Total	13	100.0	18	100.0	31	100.0

In the high potentials zones in the country, for a long time, use of the fore mentioned commercial tree species for boundary plantings has been a preferred agroforestry system. Farmers as such are more used to these trees and hence the high demand for them. The pricing and market regulations for the inputs and the outputs will play a major impact on the incentives to pursue commercial tree seedlings production. The main inputs for agroforestry system are seed and seedlings. The price of both is subject to the Forest Department regulations, operationalized through fixed nursery stock prices to promote tree production. But this promotion of subsidy strategy conflicts with the cost of seedling production in private nurseries. Active and viable large group commercial tree nurseries will only be realized after liberation of these policies.

5.5 The current design, management practices and the underlying reasons.

Management is coordinating resources, provided by the farmer him/herself. He/She works within the natural and economic circumstances of the area and within the constraints of the resources to satisfy the household needs and priorities. Evaluation of the management practices was done with these two factors in mind. The main management practices which were included in the study were:-

- the establishment of the alley-cropping plot

- the tree spacings
- cutting back of the tree hedges
- frequency of cutting back per season
- time of cutting back
- cutting height
- treatment of harvested green leafy mulch
- side pruning
- the use of inputs

The resolutions passed in the meetings are also discussed. The meetings were attended by 14 females and 6 males.

5.5.1 Alley-cropping plot establishment.

The adopters interviewed established their plots between 1985 and 1987 long rains. Only one farmer had established her plot during the short rains 1986. All the plots were established using seedlings raised in the group tree nurseries. It should be noted that in the early part of the agroforestry extension, only the use of seedlings was recommended for alley-cropping establishment. The practice of establishing plots through direct seeding became a recommendation later in 1988. All the alley-cropping plots in this survey had *Leucaena lucocephala* (91%), *Leucaena diversifolia* (6%) and *Gliricidia sepium* and *Calliandra calothyrsus* (3%). *Markhamia platycalyx* and *Sesbania sesban* were also observed scattered in the fields.

Fifty two percent (52%) of these plots were established on degraded soils, forty two percent (42%) on average fertile soils and three percent (3%) on land which had been under fallow. This observation accords well with previous findings that all alley-cropping plots are mostly established on below average or degraded sites. This reflects the experimental behaviour of the farmers. Being a new innovation, the opportunity cost of trying it on poor sites was lower than on a fertile soil.

5.5.2. Choice of tree species.

The adopters never decided the tree species to be planted on their plots. They depended on what was recommended by the extension personnel. But all the adopters chose the plots for alley-cropping establishment. Among the adopters who attended the meetings, all except 3 had planted *Leucaena leucocephala* trees. Among the three, two had planted *Leucaena diversifolia*, and one had *Gliricidia sepium* and *Calliandra calothyrsus*. The adopter managing both *Leucaena leucocephala* and *Leucaena diversifolia* actually claimed that the latter was softer than the former. The general need the adopters expressed was for introduction of softer tree species to reduce the cutting back load. There was also general desire for an alley-cropping system with only pollarding of the branches during cropping season. This is similar to the traditional agroforestry using *markhamia* and *sesbania* with which the farmers are well conversant. The current research programmes on alley-cropping and multipurpose tree germplasm improvement at **AFRENA-Maseno** should look into development of such trees/shrub suiting these management regimes.

5.5.3. Purpose for establishing alley-cropping.

Eighty one percent (81%) of the adopters established their plots for both soil conservation and to increase crop production. Most of them mentioned fuelwood as the main by-product of the technology. Only three mentioned fodder as the main by-product. No adopter was managing the technology for pole production.

5.5.4. Tree spacings.

The parameters examined in regard to tree spacings were the number of tree rows in the plot, number of trees in a tree row, length of rows, between row spacings and the plot size. Full paces were taken on the length of three or four full tree rows, depending on the total number of tree rows. Physical count of all the surviving trees on each of the three or four rows was then taken. The average of the total length of the tree rows divided by the mean of the total surviving trees was used as the estimate for within row spacing. Again paces were taken across all the three or four alleys and an average calculated to give an estimate of between row spacing.

The spacings used by farmers varied a great deal as shown in Figures. 5.1 and 5.2. The average within tree row spacing was 1.2 metre while between row was 4.4 metre. These figures were close to 1.3 m and 3.7 m reported by **Scherr *et al.* (1988)**. Fifty six percent (56%) of the plots had within row spacing lying above the recommended range. The between row spacing also varied both on one plot and among different plots. However, the actual within row spacing was difficult to estimate due to high mortality of trees in most plots. These figures should therefore be interpreted with some degree of caution.

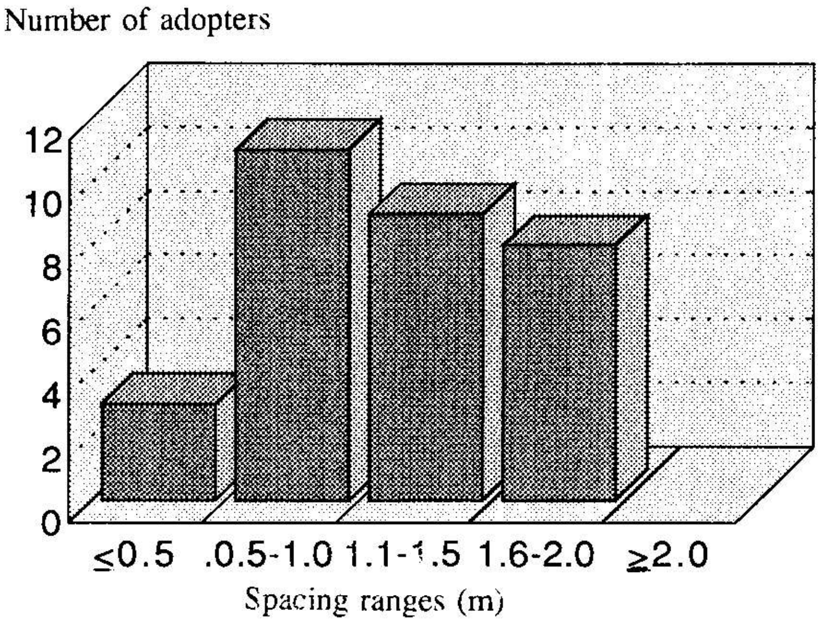


Figure 5.1 Distribution of the within tree row spacing ranges used by the adopters.
Source: Present work

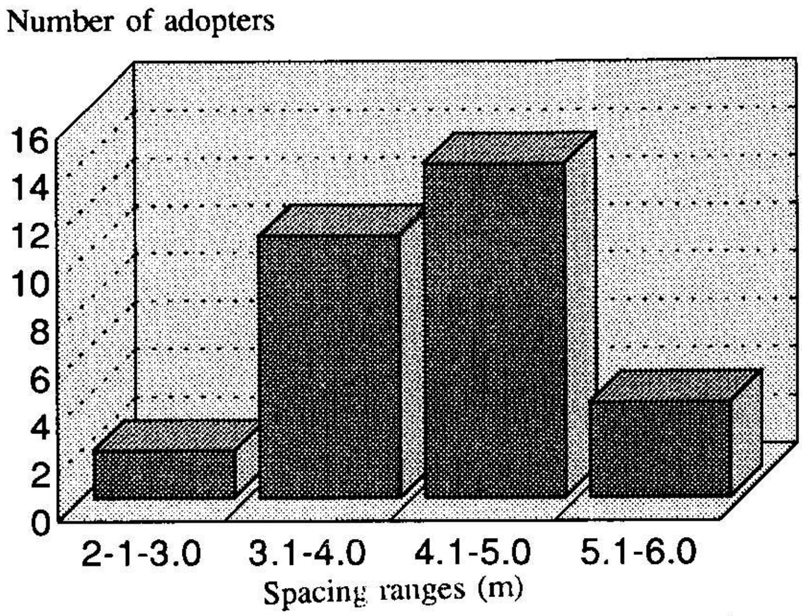


Figure 5.2. Distribution of the between tree row spacing ranges used by the adopters.
Source: Present work

Adopters did not agree that they had used spacings different from what the extension personnel demonstrated to them. They claimed that the gaps observed on their plots was just due to tree mortalities. But for the between row spacing, they claimed that establishment of the plots involved more than one person in most cases. And since this involved merely pacing the rows, members of the household used different spacing sizes. However, some adopters mentioned having used one pace for within row spacing since it was easier to do than 0.5 m (half pace). There was also fear that the current spacings might not be good because they had encountered tree roots within the 20-50 cm crop root zone and also observed signs of competition especially during droughts. Suprisingly, most adopters were not aware of the root pruning as a management pratice. **Singh (1987)**, working in India, reported that elimination of *Dalbergia sissoo* roots from the crop root zones, increased the yields of cotton from 965 $Kgha^{-1}$ to 1056 $Kgha^{-1}$. Tree root pruning as a management, is very critical especially to adopters with shallow soils. Thus the need for farmers to be aware of and practice such crucial management is very much overdue .

The tree survival rate was below 50% on eighty percent of the plots. The adopters claimed that most of the trees died at the seedling/sapling stages due to termite attack. Termite infestation has been noted by some previous studies, to be the major biotic factor affecting tree survival in Siaya district. The farmers reported having tried to gap up but gave up due to shortage of labour (55%), repeated termite attack (32%) and due to lack of seedlings (13%). When asked whether they had used the seedlings immediately after getting them from the nursery, very few could remember what actually happened since it was long time ago. However, farmers are known to take seedlings with intention of planting them but due to high labour demand, they keep the seedlings and only use them later. Since farmers also did plant the seedlings with little or no supervision of the extension personnel, it could not be guaranteed that the farmers followed the demonstrated techniques. Cases where farmers had planted trees with the polythene bags have been observed in some previous studies. All these conditions render planted seedlings vulnerable to severe termite attack.

All the adopters reported that *leucaena* tree was very hard and it cracked a lot during cutting back. The severely cracked stool die in most cases due to termite attack. Adopters reported having tried various method recommended by the extension personnel to rid the plots of the termite but they failed. The extension projects encouraged use of environmentally safe methods like use of wood ash. The use of chemicals is against the policies of both the Government and the agroforestry extension projects. However, neither the extension nor the research projects in the area have come up with alternative termite resistant species.

5.5.5. Tree density.

The mean number of tree rows was 4.8 with an average of 18 trees per row (**Fig.5.3**). This gave a total of 86 trees per plot which was higher than a figure of 35 trees per plot found by **Scherr *et al.***. The mean row length was 30.4 m and the between row spacing was 4.4 m. The average width of the plot was therefore (4.8 X 4.4) 21 m. That gave an estimated plot size of 638.4 m^2. The adopters, therefore, were practicing alley-cropping on only 3.5% of their total landholding size. This prompts the question of whether this qualifies to be called adoption. However, the percent area that an agroforestry system like alley-cropping should occupy for it to constitute adoption is still unknown (**Lynam, 1991**).

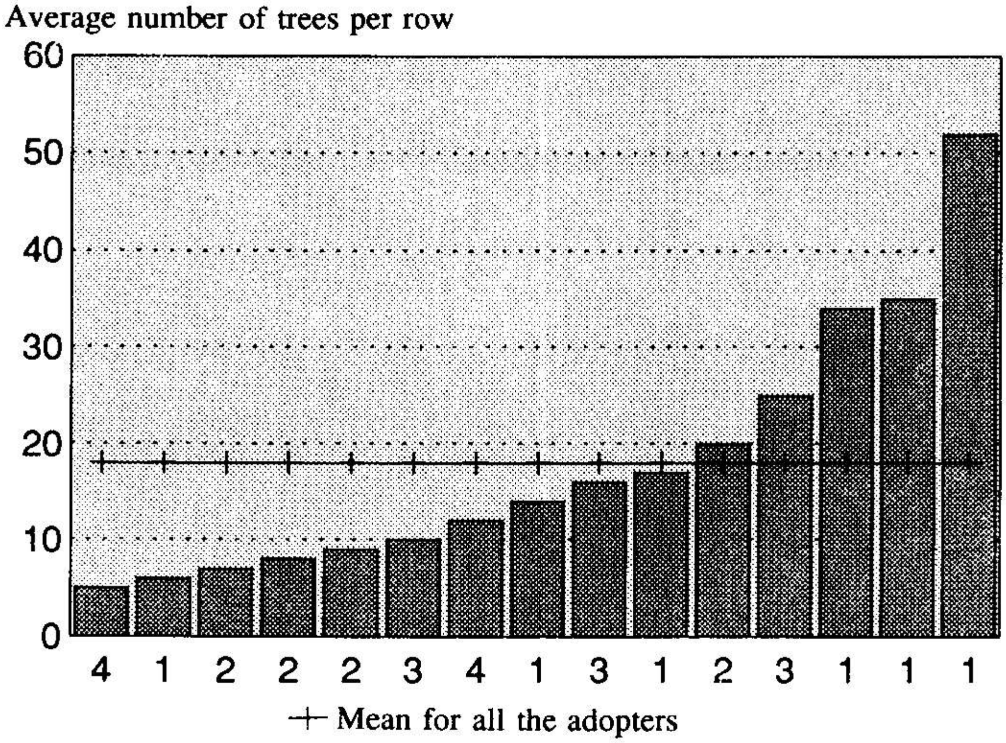


Figure 5.3. Distribution of the mean number of trees per row per plot.
Source: Present work

The average tree density was 1348 trees per hectare. This indicated an alley-cropping design of 1 x 5 m. Eighty four percent (84%) of the plots had tree densities below one third of the recommended density range of 2100-4440 trees/ha. These results differed from the 48% reported by **Scherr *et al.*** However both findings highlight the fact that most farmers were still managing very few trees (**Table 5.9**). Whether such tree density planted in lines constitute an alley-cropping technology or just a mixed intercroping system can be questioned. Only 5 adopters had more than 2000 trees/ha

Table 5.9. Distribution of current tree densities.

Tree density range	Number of plots Present study	Number of plots Scherr *et al.*
Less/equal 500	3	0
501-1000	5	0
1001-1500	7	1
1501-2000	11	6
2001-2500	2	1
2501-3000	0	0
3001-3500	2	1
3501-4000	1	3
4001-4500	0	0
Total	31	12

5.5.6 Cutting height and green leafy mulch management.

The use of prunings from leguminous trees and shrubs as mulch or green manure can be invaluable for building up soil nitrogen and organic matter. This is the rationale behind the cutting back management. Large and regular applications of prunings are needed to effect any significant increase in the soil nitrogen and organic carbon levels. In order to produce sufficient and sustainable quantities, cutting height and the cutting frequencies are important aspects of the management. This is because these practices influence the ability of the stool to withstand drought and to coppice vigorously.

The mean height of cutting back reported by the 30 adopters who had cut back their trees during the previous season was 37 cm. This figure was very near an average of 34 cm from 32 farmers from the whole district (**ibid**). One adopter did not cutback because her son who used to do the cutting back got employment away from home. The most frequent cutting height was 20-39 cm (30%), followed by 30-39 and 50-59 cm (20% each) as shown in Table 5.10. The two adopters who used above 100 cm height had special reasons for their decision. One was cutting at 1.5 m so that the high stool could be used to support passion fruit vines. Long stickwoods were used to connect the stool tops so that vines run along them as shown in figure 5.4.

Table 5.10. Different cutting height ranges used by the adopters.

Cutting height ranges (cm)	Number of plots
Less/equal 9	0
10-19	0
20-29	9
30-39	6
40-49	1
50-59	6
60-69	4
70-79	1
80-89	1
90-99	0
100-199	2
Total	30

The other adopter claimed that he chose that height after realising that lower cutting heights were making stool easily attacked by termites. One notable fact was that adopters had been trying different cutting heights as shown in Figure 5.4. As such it was difficult for the adopters to state whether they had finally decided on the observed heights or not.

Figure 5.4. An alley-cropping of *Leucaena* showing a change of cutting height from 55 cm to 150 cm. (Photo : The author)

Looking at the previous studies, we find that most adopters were using acceptable range of cutting heights. For instance, **Osman (1981c)**, using cutting heights 15 to 150 cm found that a cutting range of 45 to 90 cm gave adequate biomass production. The greatest biomass yield was at 90 cm which was higher than 75 cm found by **Karim, Rhodes and Savil (1985)**, in Sierra Leone. **Catchpole** and **Blaire (1990)**, also found that leaf production was unaffected by cutting at heights from 150 to 250 cm. A two year study at the **AFRENA** station indicated minimal difference between 30 and 70 cm in leafy biomass production. Looking at the cutting height *per se* we can conclude that most adopters had used acceptable cutting height ranges. But as **Karim *et al.*** stated, cutting height may not influence biomass yield as much as cutting frequency. So the next question is what cutting frequencies were adopters using? All the adopters were aware of the recommendation that cutting back should be done twice every cropping season. However, they said the recommendation was not easy to follow because the second cutting back coincided with the first weeding. They also expressed satisfaction with one cutting back and side pruning during weeding time since that enabled them to get more stick woods during the next cutting back. The strategy the adopters were using was meant to reduce labour input into the system and to enable production of fuelwood. **Karim *et al.*** found that average dry matter yields of the trees cut back at monthly interval were not significantly affected by the cutting height. However, at three months interval, the 75 cm cutting height was significantly superior to both 25 and 50 cm. While 100 cm was only significantly better than 25 cm. The dry matter yields resulting from monthly cuttings were significantly lower than three months cutting. Most of the additional yield realised from three months cutting was woody material.

Other studies have also indicated that the severe check in the growth caused by frequent cuttings result in mobilization of sugar and amino acids from roots to support development of new leaves, thus severely suppressing root nodule formation and further limiting the production of subsequent foliage. **Osman (1980)**, further observed that frequent cuttings often lead to stool death. In the light of above findings, it seems that too frequent cuttings (one month) especially on short stool may lead to low dry matter, decline in tree vigour with time and eventual death of the trees. A frequency of one cutting back per season (about 5 months) most of the adopters had used seemed acceptable. However, the fact that 50 percent of them still used cutting heights below 50 cm pose a problem. My experience in the study area shows that farmers use poor cutting tools and poor cutting techniques which lead to severe splitting of the stool. Consequently the cracked portions of the stool die and the dry matter attracts termite attack. The high tree mortality observed on most of these plots were partly due to termite infestation. A cutting height of above 40 cm would be safer especially in termite prone sites. The second problem is the low tree density mentioned earlier. A cutting frequency currently used cannot give adequate sustainable green leafy mulch given the low tree populations the adopters were managing. The adopters had various reasons for decicing on cutting heights. Fifty four percent (54%) of these them had used a particular height to reduce shading of the inter-crop. It should be noted that this was the main reason which farmers were told by the extension personnel. Forty percent (40%) said the height they were using was the easiest to work. This latter reason agrees with the conclusion made by **Karim *et al.* (1985)**, that the cutting height used in any alley-cropping system is a matter of convenience since it is the cutting frequency that matters more.

The time of cutting back the trees is also important since it affects the availability of the released nutrients to the inter-crop. Seventy four percent (74%) of the adopters had cut back after land preparation. Sixteen percent (16%) did cut back before land preparation and about nine percent (9%) had cut back during the first weeding. The main reasons behind these practices are given in Table 5.11.

There was also considerable variation in the treatment of green leafy mulch harvested from the trees. Out of the 30 farmers, sixty two percent (62%) had scattered the fresh leafy mulch on the surface of the soil without incorporating. Thirteen percent (13%) had hoed in after scattering and seventeen percent (17%) had lined the leafy mulch along the tree rows. Only eight percent (8%) used portion of the mulch for feeding livestock.

Table 5.11. Main reasons for different green leafy mulch treatment.

Reasons	Number of Farmers
To incorporate during weeding	15
To suppress weeds	7
Easier to work	4
Facilitate land preparation	3
Oxen do not browse trees	1
Total	30

Looking at the strategy used by most adopters, it shows that syncronisation of nutrients release with inter-crop growth demands may be lacking. With most crops , the greatest nutrient demand are in the first five weeks of growth (**Yamoah *et al.* 1986**), and demand lessens after this. The first and the only pruning reported by most adopters was done at the onset of the rains after land preparation. The cropping calender for the study area shows that first weeding starts one and half to two months after land preparation (**Fig.5.5**). This is because most farmers do stagger planting over two months due to frequent false starts of the rains. **Buldermi (1988)**, indicated that *Leucaena* green leafy mulch decomposes within about 45 days in the humid tropics. This shows that by the time weeding starts more than half of the nutrients would have been released. More so by this time the young maize plants have not developed efficient photosynthetic capability. Thus more than half of the nitrogen from the already inadequate leafy mulch is likely to be lost through leaching by the heavy rainfall at this time. The maize inter-crop probably does not receive all the released nutrients at the critical growth period. Although the trees will finally recover the leached nutrients due to their extensive root network, the cycle will just be repeated as long as the timing of mulch application remains the same.

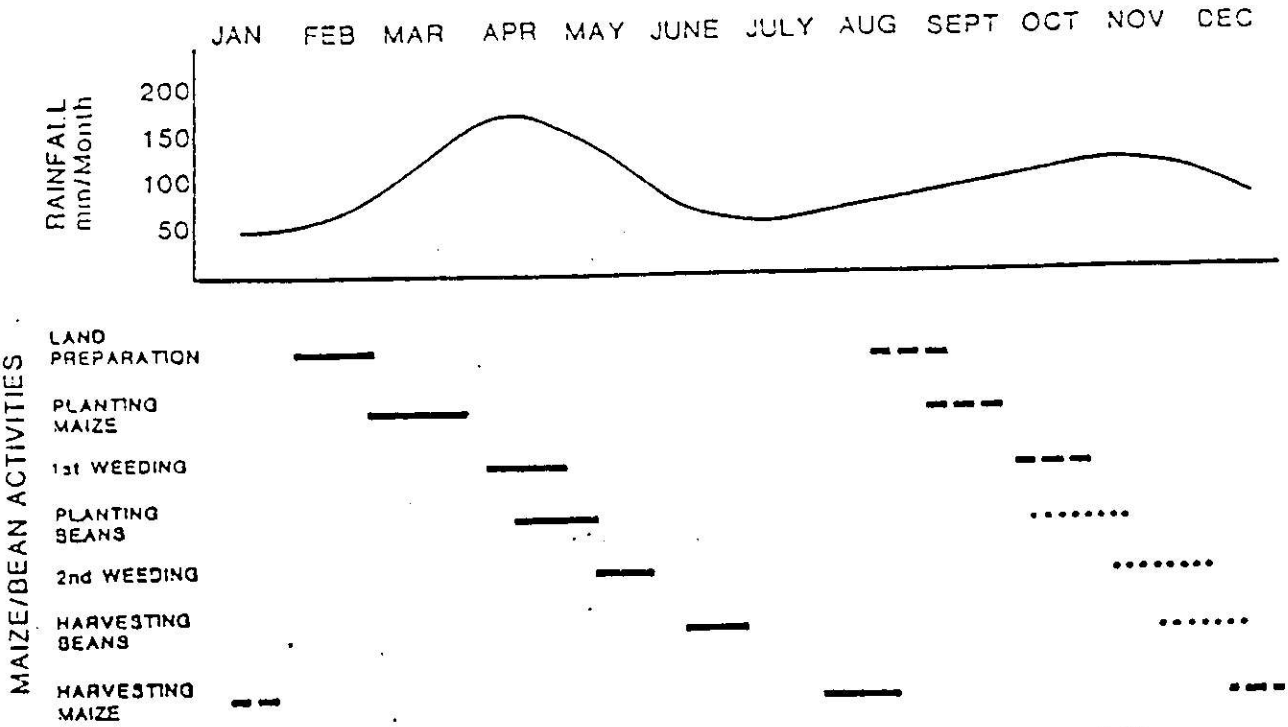


Figure 5.5. Distribution of rainfall and maize/beans cropping activities in the **LM.I** zone. Source: **Sands *et al.* (1985)**

5.5.7 The use of inputs.

By raising output per unit area, animal manure and fertilizers are proxies for land area expansion. They may also contribute to reducing erosion and thus saving land by helping to build up soil fertility, structure and improving its water-holding capacity. In the absence of the two, farmers may use land fallowing or improved tree fallow. Only thirty two percent (32%) of the adopters had left their alley-cropping plots fallow for at most one season. During these short fallows, no adopter had imposed any intensive management on the trees. They only harvested seeds (**Fig.5.6**), stick woods, fodder and allowed grazing in the plot.

Figure 5.6. Profusely seeding *Leucaena* tree during fallow
(Photo: The author)

The use of manure was found among these adopters (about 43%). Only 2 adopters used manure and fertilizer but not in alley-cropping plots. Forty five percent (45%) had used only green leafy mulch for soil fertility improvement in their plots. However, eighty four percent had used manure on non alley-cropping plots. Risk aversion may be associated with use of less land and less inputs in the alley-cropping plots. How much inputs an adopter applied in the plot depended on whether relative risk aversion was increasing or decreasing. These observations accord well with previous results in the study of use of fertilizers in Africa. For instance, **Oram (1988)**, reported that, only 5 out of 38 African countries for which data was available used more than 20 Kg N.P.K fertilizers per hectare and these was mainly used on cash crops.

Only thirty percent (30%) of the adopters had used hired labour during the previous season. Seventy two percent (72%) of hired labour was used for weeding. This supported the finding that farmers rated weeding as the most difficult task during cropping seasons. The hypothesis made earlier that cutting back could be the most difficult operation in alley-cropping system was therefore not supported by the results. Only three adopters reported having used hired labour for cutting back.

5.5.8 Farmers' evaluation of the performance.

Farmers were asked to evaluate the performance of the alley-cropping plots since their establishment with respect to crop yields. Fifty four percent (54%) said crop yield had remained same, sixteen percent (16%) had observed some yield improvement and twenty one percent (21%) had observed decline in crop yields. Nine percent (9%) had no opinion. Because of the qualitative nature of the question, it was not possible to evaluate the preference according to the adopters' objectives. It was assumed that answers of same yield indicated that there was no negative impact on the crops yields. Having no opinion and observed decline on crop yields were both interpreted to mean noticeabe low crop yields from the technology.

As concerns the current alley-cropping package, sixty eight percent (68%) of the adopters were not satisfied with the current technology package. Twenty three percent (23%) expressed satisfaction with the package. Three were non-committal. The main reasons given by the adopters who were disatisfied were that, the alley-cropping had not shown the potential indicated by the extension personnel (about 46%), the *leucaena* was very hard to cut leading to splitting (32%) and that the *leucaena* had high mortatility (22%). However, these results must be interpreted with caution since both the researcher and the enumerators had been associated with agroforestry activities in the district. This could make the farmers to exaggerate their responses. More so, such results are difficult to interprate without the considering contribution of the site characteristics and management practices. However, that does not reduce the indicative value of these findings. But according to **Ruthenberg (1985)**, in smallholder farming it may not suffice to ask whether innovations are paying propositions. It has to be determined whether culturally determined threshold value of additional net benefits exist. With fertilizer programmes, for instance, he argued that a valid rule of thumb is that- in order to expect adoption - additional returns should surpass additional costs by about 100 per cent. Another argument is that in subsistence where production is diversified, even significant improvement in the technology of one crop may have no conspicuous impact on total household situation. Even with all these facts taken into consideration, alley-cropping seems to have benefited very few farmers in the area due to low tree densities and suboptimal management levels.

5.5.9 Other agroforestry systems.

Sixty six percent (66%) of the adopters had tree border plantings besides alley-cropping. These was mainly composed of *Grevillea robusta*, *Cupressus lusitanica* and *Eucalyptus species*. Other common systems were live hedges and fruit trees. A woodlot was only observed on one farm and this was sited on a very rocky portion of the land. One adopter was also managing a fish pond.

5.6 Implications of these factors on the future Adoption.

This section of the discussion examines the implications of the technical and household socio-economic factors on the design of alley-cropping to facilitate adoption. This will be done on the basis of the present management practices, determinants of the present practices and their relevance to the research/extension and development programmes.

5.6.1 Socio-economic factors.

Most households have the same objectives in production activities; family welfare comes first, then the cash income; initially to meet 'necessary' purchase and subsequently to give command over an ever widening horizon of semi-luxury and luxury goods. The households in the study area are low on the income scale and so family welfare dominates their production objectives. Family welfare takes the form of an assured reliable supply of food and enough cash to buy necessities. The t-test results showed no significant differences between adopters and non-adopters with respect to average land size and household's size which were hypothesized to be the key determinants in adoption decision. The logit model also indicated that off-farm activities and production of crops for sale were the only variables that significantly explained the non-adoption decision. Adopters were generally geared towards subsistence production and non-adopters were more of "cash croppers".

The off-farm activities mainly involved the sale of crops. Dominance of the basic starch staples in the economic activity of the households was also demonstrated by the number of farmers who were selling these crops, mainly in the local markets (about 54% of the 62 farmers interviewed). Trends of supplementing farm income with off-farm employment are evident in this study among both adopter and non-adopters. This seems to suggest that this is the only viable alternative to abandoning the farming activity. As **Scherr (1990)**, explained, the fact that there is limited scope of increasing productivity and income from annual crops and the weakening of the cattle economy, leaves raising of tree crops and sale of crops as the only available means of accumulating investment. As long as the trend for higher demand of commercial trees and vegetables in the local markets continue, rejection of alley-cropping is likely to remain.

Only two out of the average family size of 5 were economically active. Constraints on land preparation, planting and weeding was therefore so widespread among the adopters that it became a stumbling block to timely application of green leafy mulch. As has been discussed in section 5.5.7. the evidence, both the subjective response of the farmers and their actions in supplementing family labour by hired labour, indicate a labour peak at a time when the weeding and second cutting back overlap. The coincidence between the peak weeding periods and the second cutting back makes its implementation impossible. Therefore, the effects of asking the adopters to use the two or three cutting back frequency (as suggested by **Scherr and Oduol**) as part of the recommendation for improved alley-cropping management are likely to be counter productive. The fact that land, labour for weeding and cash for hiring supplementing labour for weeding are in short supply in the area has important implication for adoption of alley-cropping. For households who can not mobilize other sources of labour, poor husbandry practices especially as concerns synchronization of mulch application and inter-crop nutrient demand will prevail. Again and again such households will run into lower crop yields which will finally lead to rejection. A good number of adopters were depended on family labour (45%) and for them suboptimal management practices are likely to continue which may finally lead to rejection. The picture this result is painting predicts that the number of rejections is likely to continue at the expense of adoption.
There was a significant difference in the average ages between adopters and non-adopters. Generally the adopters were older than non-adopters. The fact that alley-cropping was on average adopted by older farmers can be an hindrance to use of near optimal management practices. This is because such older farmers may have the interest but are less able to cope up with the extra labour needed for cutting back. Thus the fact that younger and more able- bodied farmers are not keen on alley-cropping could be a big hindrance to adoption.

Females constituted 76% of the 62 farmers interviewed. This has implications on the labour input in alley-cropping. Farming is not the only work that has to be done in small holdings. Besides the farming and petty trade activities, females have the household work. A further important aspect is the traditional specialization of family labour.

Previous studies have indicated that most households are still stuck to these traditional practices where seedbed preparation and general clearing are male responsibility whereas weeding and harvesting remains for the females. All these show that women are already overloaded with responsibilties. Management of alley-cropping would implies addition of at least 4.5% more labour for cutting hedges and that could make the technology not very appealing to females.

The priority of most farmers was to diversify away from food crop production. Thus, surplus food crops being a major source of cash income, adopters concentrate most of their resources in the non alley-cropping plots in order to realise larger cash surpluses. For instance, only three adopters had used hired labour in the alley-cropping plot and none used manure or fertilizer in the plot. A large number of adopters seemed to be using the presence of the trees in the technology to substitute for rather than supplement manure/fertilizer. The potential impact of the technology on the crop yield is not very likely to be realised in the near future given that most of the plots were already infertile. More so the current tree density and untimely application of the inadequate green leafy mulch may make the crop yields deteriorate further with time. For example, **Lal (1989)**, in a comprehensive study in Nigeria, found that maize yields declined over 6 years by 340 $Kgha^{-1}$. He concluded that maize yield could not be sustained by green leafy mulch alone. There is therefore an urgent need for the adopters to supplement the green leafy mulch with manure in order to enhance the improvement of crop yields and general fertility level of the plots in the long run.

There is much evidence that cash oriented extension may be utilized effectively to improve subsistence in the area. This is because production for sale often leads to household surpluses. For instance, promotion major cash earners like dairy cattle, coffee, vegetables etc can be used as 'ice-breaker' in a strategy of rural change to organize subsistence-oriented extension in its wake. These cash generating activities if used as an extension theme that is in sequential complementarity to alley-cropping may boost the adoption. This is because the regular supply of surplus cash may lead to initial use of more inputs in cash crop and later in the subsistence production. These are potential avenues for improving the cash flow which be explored for possible funding through the current rural development programmes.

The adoption of alley-cropping may also be constrained by the Government policies and other externalities which the extension personnel are unable to overcome. In particular the current inadequate land use regulations and the limitation on the access to input and credit are big constraints. The existence of gaps in the legislative context for tree production on-farm makes integration of alley-cropping into current agricultural development planning difficult. Legal and *de facto* responsibility for supporting and promoting rural tree growing activities are still spread across an unusually large number of institutions. This leads to lack of coordinated activities on the ground and lack of more effective service to farmers.

Provision of formal credit to finance farm investment has potentials of improving both food and cash crop production in the area. But this is not possible to achieve with the current shortage of government extension staff. Recruitment of more extension personnel or more training of the current extension personnel are two possible ways of improving the situation. More training of the current forest and agricultural personnel to increase their efficiency may be easier to achieve than recruiting more.

5.6.2 Technical factors.

It was found that the variability of within row spacing observed on most plots was due to failure by the adopters to gap up. The observed variation in between row spacings in individual plots was due to use of different paces by members of the household during tree establishment. However, both within and between row spacings used by the adopters were reasonably close to the recommended ranges on both upper and lower sides with very few extremes. But the management of alley-cropping was still primarily in the experimental realm since most adopters still used only 3.5% of their total landholding with a tree density of 1348 per hectare. On average adopters had only 4.8 tree rows per plot. Effort should be made to help the adopters gap up the plots since these rows are so few that gapping up should not be a big task if adopters are really interested.

The adopters were using such small plots as a means to cope up with inherent uncertainty about consequences of the technology. However, this partial trial is a very important step in adoption process and if supported decreases the perceived uncertainty. The current agroforestry extension projects in the area seem to overlook this requirement. They have concentrated their efforts and support mainly to achieving awareness creation and adoption decisionat group level. The assumption here is that once adoption is achieved it will continue automatically. The extension support is severed when the adopters may still be lacking proper understanding and drive to carry out the management adaptation they are trying to do. Thus adopters attention is likely to drop after withdrawal of this initial extension push. I believe that the change agents still have an additional responsibility of providing support message to individual adopters after the initial push. This should be a challenge to Non-Governmental Organizations development agencies, Donors and the local Government extension personnel. This is because when the underlying principle knowledge about alley-cropping or any other agroforestry technology management is still lacking, weaning out some farmers merely to recruit more new adopters does not fulfil the long run task of such extension programmes. It is possible that this premature withdrawal of support partly underlies the relatively high rate of discontinuance of the technology observed in the area. Alley-cropping is new to the adopters and being also a complex system it requires inter-personal contact between adopters and the extension personnel especially at the present stage of adaptation. Timing and frequent contacts between the extension personnel as well as researchers and the adopters will enable easy understanding of the adopters needs and constraints on management practices. The planning and financial horizon of these projects should take this need into account. Increasing the local extension personnel capacity to continue the support after phasing out of the projects through training may help to improve the situation.

In any evaluation of farmer's trials, the most central outcome variables are crop yield, labour, crop quality and farmers' interest. Previous studies have attempted to address the first three and generally results have not been impressive. Appreciation and understanding of the farmer's interest is very important in adoption. This can be assessed via questions like;

- is the alley-cropping plot being enlarged ?
- are the neighbouring farmers adopting alley-cropping ?
- are the farmers developing new ways of using the technology ?

The adopters were deliberately asked these questions in the questionnaire. The responses indicated that none had ever increased the area of the alley-cropping plot due to scarcity of land. Adopters were surrounded by fellow adopters, and non-adopters although the latter were the majority. The only positive finding was the attempts by most adopters to come up with some management options that suited their socio-economic conditions. This is the only finding that point at the fact that the adopters are interested in the technology. They only used the parts of the initial recommendation guide that did not conflict with their practices. For instance, they did cutting back at heights that were most convenient to them, which minimized shading on the inter-crop and which were in harmony with their production goals. Many of these management strategies were related to assurance of even spread of tree products and staggering of labour across all farm activities. In particular the adoption of only one cutting back per season reflected the farmers' own balance of labour distribution and harvesting of stick woods. But the splitting of the *leucaena* stool which induces termite attacks makes low cutting heights not suitable for stool survival. The synchronization of mulch application and inter-crop nutrient requirements was also still a major problem on most plots. Most adopters were spreading the green leafy mulch on the soil surface which is effective for weed suppression and should be encouraged. A potential improvement in the timing of the pruning may be to shift the cutting back to the end of the sowing in order to enable incorporation of green leafy mulch into the soil when the inter-crop's nutrient demand is highest. The whole tree coppices cut back should be spread between the inter-crop rows and then left to dry. After the dry foliage has fallen off the branches, the branches can be removed to be used as fuelwood or stakes.

Leucaena leucocephala was still the major alley-cropping species in the area. It was the only tree most farmers were managing as a continuously pruned alley-cropping system. The hard *leucaena* stem remains a constraint to management of the technology by females and also made use of good cutting techniques difficult. All these made cutting back of even 4 tree rows (as observed in most plots) difficult for female adopters. The potentials of *Leucaena diversifolia, Calliandra calothyrsus, Gliricidia sepium* and the *Sesbanias* are now known in the area. Use of these trees on demonstration plots and testing them together with willing farmers in the area is highly needed.

5.6.3 Progression of the current land use system.

Given the need and the potential of alley-cropping to address the present as well as the future problems, a look at the dynamics of the present farming systems is necessary. Farming systems are highly dynamic in countries of rapid population growth like Kenya. In the context of the progression from shifting cultivation to multistorey permanent intercropping developed by **Ruthenburg (1980)**, traditional cropping system in the area falls in the permanent upland cultivation. Using this model the next systems that the farmers are likely to fall over to are;-

- perennial crops for food,eg banana.
- various tree crops for cash as population density rises and commercialization increases.
- dairy production based on either permanent pasture or cut and carry system.

It is unlikely that the present generation of farmers will adopt intensive alley-cropping management before population pressure compels them to do so. This is because it is argued that population pressure is the main driving variable behind the adoption of more labour intensive agricultural technologies (**Boserup 1965 cited by Raintree 1983**). The farmers economize on the use of their labour and will tend to resist such technologies as long as less labour requiring systems are available which are capable of satisfying their basic needs. The management of border plantings which requires less labour input is more attractive to the present generation ot farmers than alley-cropping. The extension programmes should give a push for intensification of this system to enable the farmers benefit. The current adopters interest and capability to manage the alley-cropping should be used in developing new designs and management guidelines to increase adoptability of the technology. Both alley-cropping and border plantings emphasize the tree component and thus play role in this progression. This is because as population pressure forces the next generations of farmers toward more land and labour intensive technologies, trees will be a major component in the final system ie multistorey intercropping. There is therefore a need for a phased approach to design and management intensification of both systems to smoothen the fall over into the next systems and to make them suitable to the present and gradually the future farming generations.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Adopters versus Non-adopters.

This study found no significant differences between adopters and non-adopters with respect to landholding size, household size, education, use of hired labour, sex and income of the head of the household at 0.05% level. However, there was significant difference in off-farm activities and cultivation of crops for sale (p= 0.05%) between the two groups of farmers. These two variables were negatively correlated to adoption of the technology. The higher relative advantage of raising crops/tree seedlings for sale was also mentioned by the non-adopters as one of the main reasons for rejecting the technology.

6.2 The current farmers' design and management practices.

The various spacing ranges used by the adopters were reasonably close to the recommendations. All the cutting height ranges were within acceptable limits with respect to green leafy mulch production which was the main purpose in 88% of the plots. However, the most frequent range was 20-29 cm which was found to make stool more prone to termite attack. This was especially likely when there was severe damage on the stool due to use of blunt cutlers and poor cutting techniques. All the adopters did one cutting back and one side pruning per season. The cutting back was done after land preparation (74%) and this was found not to synchronize with the time when nutrient need of the inter-crop was highest. The other strategy of cutting back before land preparation (16%) was even worse off. A potential improvement in timing of the cutting back may be to shift it to the end of the planting time. There was general lack of awareness about tree root pruning as a management practice in alley-cropping despite many adopters having noticed tree roots in the crop root zone. On the overall, the major constraints to the adopters receiving benefits from the present designs appears to be the low tree density (**1348 trees ha^{-1}**) and poor timing of green leafy mulch application.

6.3 The reasons for the current design and management practices.

The adopters preferences for the observed spacings and cutting heights were mainly to meet their production goals and for convenience. They used one cutting back because the time for second cutting back coincided with the weeding time. Since weeding was the most demanding task (37%) after land preparation, the adopters could only manage to do side pruning during the weeding time. Another reason was to enable production of more stick woods which was the main by-product in 81% of the plots. Those adopters who used manual land preparation method preferred cutting back after the land preparation so that time for mulching was close to planting time. This was because of staggering of the planting over 1-2 months in order to minimize labour and to minimize crop failure due to false start of rainy seasons. The others did cut back before land preparation so that oxen were not attracted by the palatable *leucaena* foliage during land preparation. Since the main by-product from the system was stick wood most adopters preferred to scatter the whole cut branch on the soil surface so that the sticks were collected after the leaves had dried and fallen off.

6.4 Implications for future adoption.

The adoption of the alley-cropping in the study could be possible if the current needs, constraints and production goals of the farmers were considered in the future design and management recommendations. The following recommendations are potential avenues for such improvements:-

1.Incorporate the design and management practices ranges used by the majority of adopters to test the appropriateness of the various trees currently used in the on-going alley-cropping research at **AFRENA** in order to fine tune them to improve the efficiency of the technology. More emphasis need to be put on the following:-

- timing of cutting back taking staggering planting practice into consideration.
- effect of different levels of combined manure and leafy mulch on crop yields
- suiatbility of pollarding versus cutting back operation for females.

2. The adopters should be encouraged to shift the cutting back time to the end of planting time. More efforts should still be made to ensure the small plots farmers are

currently managing have near full tree density. All these call for active resumption of extension support to the adopters.

3. There is a need to support the raising of trees for sale through streamlining of the current unfavourable pricing and marketing policies. More so the farmers investment on the farming activities will only be possible if the unevenness of cash flow is solved. Expenditures of these farmers cannot be become modern while their income remain primitive. The present rural development projects in the area should give promotion of income generating activities more priority than is the case at present.

4. Updating of the initial recommendation guidelines based on the both **Scherr *et al.*'s** work and the present findings.

Proposed Recommendation Guidelines.

Acceptable design ranges:- 4.5 m x 0.5 - 1.0 m

Management options:-

- Cut back once every season immediately after sowing the inter-crop.
- Cut back heights
  - at the knee height
  - slightly below knee height
  - any height above knee height but not exceeding shoulder height.
  - do severe all the tree roots observed in the crop root zone.

5. There is a wide area of disagreement among researchers as to the optimum approach to understanding adoption. Why some adopt and others in apparently comparable situation do not is often a mystery. The scope of this study was not wide enough to unravel the mystery. This calls for devotion of more resources to adoption research and more so on the understanding effectiveness of the present communication channels and effective and timely evaluation of social impacts ie farmers attitudes, problems and constraints imposed on their acceptance of the technology.

6.5 Limitations of the study.

Ideally, surveys should include a good coverage of the households in all of the district and changes over time. This is because of dynamic nature of adoption process as a result of changes in resource endowment, family development cycles and other social factors. Due to time and financial constraints, only one agro-ecological zone was covered. Therefore, the concepts presented may not be related to what is happening in the other agro-ecological zones. Reliability of the data is limited due to the fact that the information gathered relied on the farmers' recall. More over, as **Barrow (1987)** rightly put it, care is needed in interpreting what was discussed/resolved in the meetings. Some issues might have been mentioned merely because they were topical and "real " issues could only emerge after we had been accepted by the adopters. Therefore the degree to which the findings of this survey can be generalized is limited. In spite of this limitation, with the information available, it is anticipated that the objectives were met. Possibly, the prodigious value of this study is first to show if at all there has been any change in the farmers' management strategies since the last adoption study by **Scherr *et al*.** Secondly, is to show the present farmers technical needs in the area.

a) **Problem of defining a household.**

Households were the basic unit of gathering information used in this study. There are several criteria used for defining a household two of which are:-

i) a group of two or more persons who dwell under one roof and eat meals together. Normally this unit is an individual family consisting of the father, mother and children. Under extended family traditions, relatives and servants are included.

ii) a group of several household members performing economic activities together, such as cultivating their fields and share the output among themselves.

For the purpose of this study, the first criterion was used to define a household. Fortunately in this study, no polygamous households were encountered.

b) **Tree density**.

The farmers' alley-cropping plots are irregular, have several tree spacings and a lot of gaps due to high tree mortalities. This situation made adopters not to be sure of what spacing to tell. However, in all the cases, visual observation and measurements of the alley-cropping plots and on the spacing was done by the researcher and the enumerators.

c) **Statistical analysis.**

The use of the chi-square is limited by the fact that its values depend on the sample size and the a mount of departure from independence for the variables. Comparison of chi-square values from several studies with different sample sizes is therefore not possible. Different types of relationships between two variables can also result in the same chi-square value. However, these limitations were minimized through combined use of chi-square and the logistic regression analysis.

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APPENDIX I

QUESTIONNAIRE

NOTE. Both Adopters and NON-adopters.

DATE______________

BASELINE SOCIO-ECONOMIC

CODE______________ W/GROUP______________

1. Name____

2. Sex 1. Male 2. Female

3. Age __________________

4. Position in the women group 1. official
   2. ordinary member

5. Level completed 1. literacy
   2. primary
   3. secondary
   4. none

6. Do you have off-farm job\trade ? 1. yes
   2. no

7. If yes, how much do you earn annually ? ______________

8. Marital status 1. single 2. married
   3. separated 4. widowed

9. Consider members of the household plus dependants living at home only.

*	Less/equal 15 years	16-50	>50
Children		*	*
Men	*		
Men	*		

10. Do you hire labour ?
    1. permanent throughout the year
    2. temporary for a particular work (specify___________)
    3. temporary for a particular period (specify___________)
    4. no

11. Do you sometimes get help on your plot from a work group ? 1. yes 2. no

12. Is this plot registered in your or your hushbands name ? 1. yes 2. no

13. If no, who owns it ?
    1. father
    2. motherin-law
    3. husband
    4. other___________

14. What is the size of your land ____________________

15. Do you practice fallow ? 1. yes 2. no

16. If yes, on how many hectares did yo have fallow during the last short rain ?.______________

17. Is the whole land under cultivation ?
    1. yes
    2. no

18. Give reasons for not cultivating______________
____
____

19. Does the head of house (HOH) do other paid work besides farming ?
    1. yes, specify________________
    2. no

20. Do you have cash crop ?
    1. yes (coffee, sugarcan, tobacco, other________)
    2. no

21. In which part of the year do you experience urgent need for cash
    1. cropping season
    2 . off-season
    3. neither

22. How do you solve this cash proble ?
   1. sell food crop
   2. seek employment
   3 sell livestock
   4. sell tree (specify ________________)
   5. sell cash crop (specify________________)
   6. borrow cash

23. Do you have livestock ?

*	yes	no
cattle		
sheep		
goats		

24. **NOTE. This question is for non-adopters only.**

Why did you not establish alley-cropping ?
____
____
____
____

NOTE. For Adopters only

<u>TECHNICAL</u>

Tree species______________________

25. When were the trees established ? 1. long rains 19---
   2. short rains 19---

26. After this did you ever increase the area under alley-crooping ?
   1. yes
   2. no

27. If no, why ? ______________________________

28a. Did you do any gapping ? 1. yes
   2. no

28b. If no, why ?______________________________

29. What planting material did you use ? 1. seedlings
2. seeds
3. wildlings
4. cuttings

30. Site 1. top of hill 2. mid slope
3. valley bottom 4. flat area

31. At the time you established alley-cropping, how fertile was plot ?
1. newly cleared land
2. several years of fallow
3. average fertility
4. degraded

32. Who decided where to plant the trees ? 1. extensionist
2. HOH
3. adopter
4. other_____

33. Alley-cropping can be for many purposes, what did you plant the trees for ?
1. soil conservation
2. increase crop production
3. supplemental fodder
4. fuelwood
5. poles

34. Are these trees dense enough ? 1. yes
2. no

35. If no, why dont you increase the number ?
____
____

36. Why do you like this particular tree spacing ?
____
____

37. Do you know the recommended spacing ? 1. yes
2. no

38. If yes, how many (Paces) ? ________________

39a. How high did you last cut back ? 1. above knee height
2. at knee height
3. below knee height

39b. What is the recommended height ? (use options in 43)_____

40. Why did you use that particular height instead of recommended height ?________________
____

41a. How many times did cut back last season ?____________

41b. Do you know recommended frequency ? 1. yes
2. no

42. At what time was the cut back done ?
1. before land preparation
2. after land preparation
3. during first weeding
4. after first weeding

43. Why did you cutback at that time ?
____
____

44. How did you use leafy mulch ?
1. scatter on surface without incorporation
2. hoed/ploughed in after scattering
3. lined along tree rows
4. other ____________________

45. If incorporated, why not scattered ?__
____
____

If scattered, why not incorporated ?________
____
____

46a. Did you side pruning last season ? 1. yes
2. no

46b. If yes at what time ? 1. during first weeding
2. after first weeding
3. other____________

47. Since you planted the trees, have you left the plot fallow ? 1. yes
2. no

48. How did you manage the trees during the fallow ?
1. harvested fodder
2. , , fuelwood
3. , , seeds
4. other________________________

49. Have you used manure or fertilizer on the alley plot during the last two seasons ? 1. manure
2. fertilizer
3. both
4. neither

50. What methods for soil fertility improvement, did you use in the other plots during the last two seasons ?

1. manure
2. fertilizer
3. both
4. neither

51. Why did you use this method ? ____________________________

____

52. Did you hire labour last season in alley cropping plot ?

1. yes
2. no

53. If yes, for which operation ?

1. cut back
2. ploughing
3. weeding
4. other__________

54. When do you find work in the alley cropping plot heavier than in the non alley-cropping one ?________________

____

____

55. During this month, what farm activity do you do ?

1. land preparation
2. weeding
3. sowing
4. cutting back

56. For which crop do you use hired labour ?

* *	yes	no
cash crop		
food crop		
food crop in alley-cropping		
other		

57. Do you use oxe plough for land preparation ? 1. yes
2. no

58. How has alley-cropping affected crop production ?

1. improved
2. remained the same
3. declined
4. cant tell

59. Do you get enough crop yield to last upto next year ?

1. yes
2. no

60. Is your household now self sufficient in fuelwood ?
    1. yes 2. no

61. The present design and management was chosen to meet your conditions, is it satisfactory ?
    1. yes
    2. no

62. If no, what are the present management problems ?
____
____

63. Do you have other agroforestry interventions ?
    1. border planting
    2. woodlot
    3. fruit trees
    4. other________

MEASUREMENTS

64. Tree spacings(metre) - within row ______________

- between row ______________

65. last cutting height (metre)________________

66. number of tree per row ________________

67. total number of tree rows______________

68. row lenght(metre)_______________

69. plot size (paces) (a) length______________________

b) width____________________

70. Total trees/plot_________________________________

APPENDIX II

SPECIFIC OBJECTIVES AND HYPOTHESES

1. Objective: Associate strength of adoption with sex.

   Hypothesis: males are better adopters than females.**(Q. 2, 66, 67, 70)**

2. Objective: Associate strength of adoption with age

   Hypothesis: younger farmers are better adopters than older ones.**(Q. 3, 66, 67, 70)**

3. Objective: Establish position of adopters in the group.

   Hypothesis: officials in a women group are adopters. **(Q. 4, 66, 67, 70)**

4. Objective: Assess extent to which literacy is associated with adoption.

   Hypothesis: literate farmers are adopters **(Q. 5, 66, 67, 70)**

5. Objective: Test impact off-farm income on adoption.

   Hypothesis: farmers with off-farm income are non- adopters,**(Q. 6, 7, 66, 67, 70,)**

6. Objective: Assess the relationship between family size and adoption.

   Hypothesis: small families are non-adopters.**(Q. 8, 9, 66, 67, 70)**

7. Objective: Associate strength of adoption with land entitlement.

   Hypothesis: land entitlement is an incentive for adoption.**(Q. 12, 66, 67, 70)**

8. Objective: Relate total land size and adoption.

   Hypothesis: farmers with small land parcel are poor adopters.**(Q. 14, 66, 67, 70)**

9. Objective: Assess the relationship between available land and adoption.

   Hypothesis: a. adopters with bigger available lands have higher tree density.**(Q. 14, 66, 67,70)**

   b. farmers with bigger available land practice fallowing.**(Q. 15, 16)**

10. Objective: Assess the influence of HOH paid work on the adoption.

    Hypothesis: households with HOH having paid work\trade are non-adopters.**(Q. 19, 66, 67, 70)**

11. Object: Find out the effect of cash crop on adoption.

    Hypothesis: farmers with cash crop (coffee, sugar cane,tobacco, horticultural crops) are non-adopters because of high labour demand for these crops.**(Q. 20, 66, 67, 70)**

12.Objective: Find out the period during which cash is needed and how farmers solve the problem.

Hypothesis: a. farmers experience cash constraint during cropping season **(Q. 21)**.

b. farmers solve cash problem by seeking employment.**(Q. 22)**.

13.Objective: Find out if adopters increased the area under alley-cropping.

Hypothesis: adopters did not increase the area under alley-cropping.**(Q. 26, 27)**

14.Objective: Find out if adopters did any gapping at all on alley-cropping plots.

Hypothesis: most adopters never did gapping due to shortage of labour, browsing and to a lesser extent availability of seedlings in time **(Q. 28a, 28b)**

15.Objective: Find out who decided where to plant trees and why.

Hypothesis: a. the adopter decided on the plot.**(Q. 32)**

b. adopters planted for several reasons **(Q. 33)**

16.Objective: Find out the reason for not increasing tree density.

Hypothesis: a. adopters know the recommended density.**(Q. 34)**

b. adopters'reason for not increasing tree density is awareness of trees competitiveness with crops for nutrients. **(Q. 34, 35)**

17.Objective: Establish reason for deciding the tree spacing.

Hypothesis: adopters choose spacing that suits land preparation method and implements.**(Q. 36, 37, 38)**

18.Objective: Find out how many times and why adopters cut back at the mentioned height.

Hypothesis: a. adopters cut back only once and they also choose the most convenient height to reduce labour input.**(Q.39a, 39b, 40, 41a, 41b)**

19.Objective: Ask adopters why they do not cutback at the right time.

Hypothesis: adopters do not cutback in time due to heavy workload during peak labour periods.**(Q. 42, 43)**

20.Objective: Find out how adopters use cuttings.

Hypothesis: most adopters scatter cuttings since incorporating require more labour.**(Q. 44, 45)**

21.Objective: Establish if the adopters do side pruning and when.

Hypothesis: most adopters do side prune during the first weeding.**(Q. 46a, 46b)**

22.Objective: Find out if adopters use other soil fertility practices on alley-cropping plots.

Hypothesis: Few adopters supplement alley-cropping capabilities to maintain soil fertility.**(Q. 49)**

23.Objective: Establish if adopters use other inputs (hired labour, fertilizer/manure) in non alley-cropping plots and why.

Hypothesis: adopters use other inputs in the non alley-cropping plots since they get higher returns than from the alley-cropping plots.**(Q. 50, 51, 52)**

24.Objective: Find out the most difficult operation in management of alley cropping and when it is done.

Hypothesis: cutting back is the most demanding task.**(Q. 54, 55)**

25.Objective: Solicits adopters evaluation of the technology.

Hypothesis: farmers are not yet satisfied with the performance of the technology.(Q. **58, 59, 61, 62)**

APPENDIX III

General Descriptive Statistics

	N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
AGE	31	48.65	50.00	49.04	12.60	2.260
C2	31	43.94	42.00	42.85	13.45	2.420
AVL	31	1.58	1.60	1.57	0.58	0.104
C4	31	1.52	1.20	1.48	0.94	0.169
FAL	31	0.23	0.02	0.18	0.31	0.056
C6	31	0.19	0.01	0.13	0.34	0.061
LAS	31	1.80	1.60	1.76	0.83	0.149
C8	31	1.68	1.60	1.61	1.15	0.207
AHM	31	2.23	2.00	2.19	0.76	0.137
C10	31	2.32	2.00	2.19	1.19	0.214
HHS	31	4.81	5.00	4.63	2.44	0.439
C12	31	5.07	5.00	5.04	1.65	0.297

	MIN	MAX	Q1	Q3
AGE	24.00	68.00	40.00	58.00
C2	28.00	77.00	32.00	53.00
AVL	0.58	2.80	1.00	2.00
C4	0.20	3.40	0.78	2.00
FAL	0.00	1.20	0.00	0.40
C6	0.00	1.20	0.00	0.08
LAS	0.58	4.00	1.00	2.40
C8	0.20	4.00	0.80	2.40
AHM	1.00	4.00	2.00	2.00
C10	1.00	6.00	2.00	3.00
HHS	1.00	11.00	3.00	6.00
C12	2.00	9.00	4.00	6.00

	N	MEAN	STDEV	SE MEAN	95.0 PERCENT C.I.	
AGE	31	48.65	12.60	2.26	(44.02,	53.27)
C2	31	43.94	13.45	2.42	(39.00,	48.87)
AVL	31	1.578	0.581	0.104	(1.364,	1.791)
C4	31	1.517	0.940	0.169	(1.172,	1.862)
FAL	31	0.2248	0.3111	0.0559	(0.1107,	0.3390)
C6	31	0.1835	0.3419	0.0614	(0.0581,	0.3090)
LAS	31	1.803	0.832	0.149	(1.498,	2.108)
C8	31	1.681	1.153	0.207	(1.258,	2.103)
AHM	31	2.226	0.762	0.137	(1.946,	2.505)
C10	31	2.323	1.194	0.214	(1.884,	2.761)
HHS	31	4.806	2.442	0.439	(3.911,	5.702)
C12	31	5.065	1.652	0.297	(4.458,	5.671)

The T-test Analysis

TWO SAMPLE T FOR AGE VS C2

	N	MEAN	STDEV	SE MEAN
AGE	31	48.6	12.6	2.3
C2	31	43.9	13.4	2.4

95 PCT CI FOR MU AGE - MU C2: (-1.9, 11.3)

TTEST MU AGE = MU C2 (VS NE): T= 1.42 P=0.16 DF= 59

TWO SAMPLE T FOR AVL VS C4

	N	MEAN	STDEV	SE MEAN
AVL	31	1.578	0.581	0.10
C4	31	1.517	0.940	0.17

95 PCT CI FOR MU AVL - MU C4: (-0.34, 0.46)

TTEST MU AVL = MU C4 (VS NE): T= 0.31 P=0.76 DF= 50

TWO SAMPLE T FOR FAL VS C6

	N	MEAN	STDEV	SE MEAN
FAL	31	0.225	0.311	0.056
C6	31	0.184	0.342	0.061

95 PCT CI FOR MU FAL - MU C6: (-0.125, 0.207)

TTEST MU FAL = MU C6 (VS NE): T= 0.50 P=0.62 DF= 59

TWO SAMPLE T FOR LAS VS C8

	N	MEAN	STDEV	SE MEAN
LAS	31	1.803	0.832	0.15
C8	31	1.68	1.15	0.21

95 PCT CI FOR MU LAS - MU C8: (-0.39, 0.63)

TTEST MU LAS = MU C8 (VS NE): T= 0.48 P=0.63 DF= 54

TWO SAMPLE T FOR AHM VS C10

	N	MEAN	STDEV	SE MEAN
AHM	31	2.226	0.762	0.14
C10	31	2.32	1.19	0.21

95 PCT CI FOR MU AHM - MU C10: (-0.61, 0.41)

TTEST MU AHM = MU C10 (VS NE): T= -0.38 P=0.71 DF= 50

TWO SAMPLE T FOR HHS VS C12

	N	MEAN	STDEV	SE MEAN
HHS	31	4.81	2.44	0.44
C12	31	5.06	1.65	0.30

95 PCT CI FOR MU HHS - MU C12: (-1.32, 0.80)

TTEST MU HHS = MU C12 (VS NE): T= -0.49 P=0.63 DF= 52

NOTE: C1 - C12 REFER TO CORRESPONDING VALUES FOR THE NON-ADOPTERS.
: AVL = AVAILABLE LAND
: FAL = FALLOW LAND
: LAS = LAND SIZE
: HHS = HOUSEHOLD SIZE
: AHM = ACTIVE HOUSEHOLD MEMBERS

APPENDIX IV

LOGIT MODEL RESULTS

CATMOD PROCEDURE

Response: Y
Weight Variable: None
Data Set: LOGIT

Response Levels (R) = 2
Populations (S) = 15
Total Frequency (N) = 62
Observations (Obs) = 62

Parameter Estimates

Iteration	1	2	3	4	5
0	0	0	0	0	0
1	1.6203	0.8219	-1.5249	-0.8346	-1.9743
2	2.3923	1.1541	-2.2585	-1.1528	-2.7931
3	2.7301	1.2505	-2.5724	-1.2500	-3.1263
4	2.7811	1.2590	-2.6194	-1.2601	-3.1746
5	2.7820	1.2591	-2.6203	-1.2602	-3.1755
6	2.7820	1.2591	-2.620	-1.2602	-3.1755

MAXIMUM LIKELIHOOD ANALYSIS OF VARIANCE TABLE

Source	DF	Chi-Square	Prob
INTERCEPT	1	7.81	0.0052
EDU	1	2.89	0.0890
OFF	1	9.29	0.0023
HOH	1	3.04	0.0811
CASC	1	13.09	0.0003
LIKELIHOOD RATIO	10	6.16	0.8013

ANALYSIS OF MAXIMUM LIKELIHOOD ESTIMATES

Effect	Parameter	Estimate	Standard Error	Chi-Square	Prob
INTERCEPT	1	2.7820	0.9957	7.81	0.0052
EDU	2	1.2591	0.7403	2.89	0.0890
OFF	3	-2.6203	0.8598	9.29	0.0023
HOH	4	-1.2602	0.7225	3.04	0.0811
CASC	5	-3.1755	0.8776	13.09	0.0003

COVARIANCE MATRIX OF THE MAXIMUM LIKELIHOOD ESTIMATES

	1	2	3	4	5
1	0.99136788	-.17689403	_.61441992	-.30385618	-.54402121
2	-.17689403	0.54806637	-.05817409	-.08161914	-.15171504
3	-.61441992	-.05817409	0.73925823	0.04726578	0.40678412
4	-.30385618	-.08161914	0.04726578	0.52200418	0.11453750
5	-.54402121	-.15171504	0.40678412	0.11453750	0.77024945

CORRELATION MATRIX OF THE MAXIMUM LIKELIHOOD ESTIMATES

	1	2	3	4	5
1	1.0000000	-0.2399823	-0.7177113	-0.4223900	-0.6225621
2	-0.2399823	1.0000000	-0.0913934	-0.1525943	-0.2335051
3	-0.7177113	-0.0913934	1.0000000	0.0760872	0.5390763
4	-0.4223900	-0.1525943	0.0760872	1.0000000	0.1806321
5	-0.6225621	-0.2335051	0.5390763	0.1806321	1.0000000