AN ANALYSIS OF THE ECONOMIC POTENTIAL AND ADOPTION OF ALLEY CROPPING IN SIAYA DISTRICT

BY

COLLINS OTIENO OBONYO

A thesis submitted in partial fulfilment of the requirement for degree of Master of Science in Agricultural Economics, University of Nairobi, October 1993.

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

Collins Otieno Obonyo

(Candidate)

This thesis has been submitted for Examination with my approval as University Supervisor

26/10/93

Prof. C. Ackello-Ogutu

(University Supervisor)

Date:

Table of Contents

List of Tables

Abstract

Though alley cropping has been in use for about six years in Siaya District, no economic study to determine its impact on farm families' income in the district has been undertaken hitherto. This study was therefore an attempt to determine the impact by focusing on two divisions: namely Bondo and Yala. These two divisions represent medium and high potential regions of the district. The objectives of the study were to describe the factors that influence adoption of alley cropping and to determine the profitability of alley cropping. Data was generated by administering a questionnaire survey. This primary data was supplemented with secondary data obtained from Kenya Forestry Research Institute(KEFRI).

Through the use of appropriate statistical techniques and Cost-Benefit analysis(CBA), it was concluded that alley cropping has the potential of increasing farm families' income in both divisions. The potential has been realized to some extent in both divisions. The study established that labour availability, level of income and farm-size are important factors that influence adoption of alley cropping.

ACKNOWLEDGEMENT

To my supervisor, Prof Ackello-Ogutu who guided and supported me throughout the research work, I am most grateful. Mr. D. Hoekstra and Mr. R. Swinkels of ICRAF must also be thanked for their helpful comments. I am also grateful to Dr. Omwani who helped at the initial stages of my research proposal.

My sincere gratitude goes to the University of Nairobi for sponsoring me for the Masters program. I am also grateful to ICRAF for allowing me to make use of their library. My thanks also go to Dr. Nyamai of KEFRI for providing me with secondary data.

Finally, much thanks go to Ms R. Oloo and E. Akinyi for their help in typing the thesis. To my parents and other friends who helped in various ways, I am most thankful.

CHAPTER ONE

INTRODUCTION, RESEARCH PROBLEM AND OBJECTIVES

1.1 Background

The importance of the agricultural sector to the national economy of Kenya is well appreciated. Indeed the agricultural sector is expected to be the main tool through which economic development is to be achieved. According to Sessional Paper No.1 of 1986, the agricultural sector is expected to be able to achieve the following by the year 2000:

(a) provide food security,

(b) generate farm family income that grow by at least 5 percent annually,

(c) absorb new farm workers at the rate of over 3 percent per annum

(d) stimulate growth of productive off-farm activities in the rural areas, and

(e) supply export crops.

The sessional paper further recognizes that these goals can be achieved only if:

(a) farmers adopt better agronomic practices and other technologies,

(b) research to develop new technologies for agricultural development is enhanced, and

(c) production patterns are diversified to high value commodities that are labour-intensive.

Focusing on the strategies that Kenya expects to enable it to achieve the target economic goals by the year 2000, it is observed that they revolve around increasing and sustaining agricultural productivity. Agricultural productivity is affected by the following factors:

(a) natural and climatic factors
(b) technological factors
(c) government economic policies
(d) institutional factors

In most cases, it is the natural and climatic factors which seriously constrain agricultural productivity, especially in developing countries. The two factors which seriously constrain agricultural productivity in the Tropics are the amount of rainfall and the level of soil fertility. However, due to modern techniques, these two natural factors can be manipulated to some extent to allow for increases in agricultural productivity. These technologies include the use of irrigation, drought tolerant varieties and chemical fertilizers. Recently, the use of alley cropping as a means of improving the level of soil fertility has been suggested as a complimentary tool to the use of chemical fertilizers. Kenya has vast regions which have poor soil fertility. One of the districts in the country with extensive areas having low soil fertility is Siaya district (Jaetzold, 1982). Siaya district is one of the five districts that make up Nyanza province. It has a bimodal rainfall pattern with rainfall varying from 800 mm to 2000 mm per annum. The low lying plains near Lake Victoria receive less than 120 mm. The long rainy season is from March to May while the short rains season is from September to November. The Major soils of the district are orthicferasols and vertoluvic phaezones (black cotton soil) Due to the combination of low rainfall and low soil fertility, only 93, 000 hectares of land can be said to have high and medium agricultural productivity (Jaetzold, : 1982, Siaya District Development Plan 1989 - 1993).

Most of the small scale farmers in the district are subsistence oriented in production. Maize, Sorghum, Millet, Beans and Cassava are the important food crops while Cotton and Sugarcane are the major cash crops. However, there exists a potential for introducing coffee as a cash crop (Siaya District Development: 1989-1993). A small farm survey done in 1977 found that climatically achievable yields are not realized due to poor soil fertility. (Jaetzold, 1982, Pg 242). Jaetzold (1982) observes that "a lasting improvement in soil fertility requires the introduction of a proper mixed farming system and the use of increasing amounts of fertilizers".

The chemical fertilizers used in the district are applied almost exclusively on sugarcane and coffee and has thus resulted in low yields of important food crops (Siaya District Development plan; 1989-1993).

The productivity of maize which is the most important food crop in the District has remained at low levels of between 15 - 20 bags per hectare (Siaya district annual agricultural Reports 1979 - 1987). This low productivity level is caused by a combination of poor soil fertility and low usage of chemical fertilizers.

Due to the low level of agricultural productivity in the district, the level of per capita income per month has also been low. Between 1986 and 1987, it ranged between Kshs 141 to 269 (Siaya District Development Plan. 1989 - 1993). With the population density expected to increase to 330 persons per square kilometre by the year 1993, the per capita income level may worsen unless the level of agricultural productivity of the district increases. It is under such kind of background that CARE-Kenya in 1984 initiated an Agroforestry Extension Project (AEP) in the district. The hope of the project was to improve the well being of the participating communities (Otieno, 1989). Among the technologies extended by the project was Alley Cropping (Nagle; 1989).

The AEP worked with women groups and Primary Schools. As of 1989, it was estimated that it had established contract with 213 women groups and 190 schools in Siaya District (Otieno; 1989). CARE-Kenya encouraged and provided technical support for the establishment of tree nurseries by each women group and also employed Extension Agents who helped the farmers with advice on how to manage alley cropping and other agroforestry technologies. The number of CARE-supported tree nurseries grew rapidly between 1984 and 1987 from 9 to 275 (Nagle, 1989).

Alley cropping was promoted among the small scale farmers as a tool for soil improvement and maintenance. By 1989, 47 percent of the participating farmers had at least one alley cropping plot (Scherr et al, 1989) and 67 percent of the farmers who had an alley cropping plot were using it as a tool for soil fertility/improvement (Scherr and Oduol, 1989).

As a result of collaboration between CARE-Kenya and Kenya Forestry Research Institute (KEFRI), five research plots were established in different Agroecological zones of the district (Vonk, 1986): Nyabeda research plot located in high potential region, Nyasanga and Sigomere research plots located in medium potential region, Abayo research plot located in medium low potential region and Bondo research plot located in low potential region (Nyamai, 1989). In these plots, research was conducted on alley cropping, woodlot, border planting and fruit trees with the most important being alley cropping (Vonk, 1989). The research plots were on-farm researcher managed and executed, and thus similar to on-station research plot. The only difference was that they were located in a farm environment and therefore inevitably some level of involvement and participation of the farmer had to be there.

In laying out the experiments, complete randomized block design was used. Each replicate consisted of 3-4 treatments and replicated 3-4 times depending on the site. Maize was the annual crop being grown, while the following five tree species were used.

(1) Leucaena leucocephala

(2) Gliricidia sepium

(3) Calliandra calothyrsus

(4) Sesbania sesban

(5) Markhamia lutea.

Out of eighteen agroforestry practices and technologies this study focused only on the practice which is perhaps the best known but least understood of all agroforestry practices: alley cropping (hedgerow-intercropping). Alley cropping is a land-use system involving the management of rows of woody plants (preferably leguminous ones) with annual crops planted in alley between the woody trees; the woody plants are periodically pruned in order to prevent shading the companion crop and also to provide leaves which can be used as mulch (Rocheleau, Weber and Juma; 1988: pg 92).

The primary purpose of alley cropping is too maintain or increase crop yield by improvement of soil microclimate and weed control. Fuelwood, building poles, food and fodder may also be obtained as subsidiary output (Rocheleau et al; 1988). Alley cropping is a land-use system which is designed to be a sustainable alternative to shifting cultivation or for expansion into unproductive farmland. It works best in places where people need to intensify crop production but face soil fertility problems.

In field trials conducted by the International Institute for Tropical Agriculture (IITA) in the sub-humid zone of Nigeria, significant increases in maize y yields were observed when leucaena leucocephala (leucaena) pruning were added as green manure to he alleys. Ten tonnes of pruning dug into the soil at the time of maize seedling increased maize yield from 1.3 to 3.2 tonnes per hectare, equivalent to applying 100 kg of Nitrogen fertilizer per hectare (Rocheleau et al; 1988). In field trials conducted by KEFRI in different agroecological zones of Siaya District, it was demonstrated that for all alley cropping treatment, except Markhamai lutea treatment, maize yields were significantly higher than for the control (Nyamai, 1989).

It can therefore be argued that alley cropping through its expected contributions in enhancing crop productivity and productivity of agroecosystems has a major role to play in agricultural development. An assessment of the potential of alley cropping in raising farm income thus becomes very useful in the formulation of agricultural policies.

1.2 Research problem and objectives

1.2.1 Research problem and justification

As already indicated, the income per capita of Siaya District is quite low and as population density increases it will even become lower unless agricultural productivity, among other factors, increases. One way of increasing agricultural productivity of the district is by using technologies which can improve the level of soil fertility. The scope of improving soil fertility by use of animal manure is limited (Siaya District Development plan; 1989-1993). Further, the use of chemical fertilizers in the province as a whole is quite low. The farmers in the province use 3 percent or less of the recommended fertilizer levels (Schluter and Ruigu, 1984). An attempt was therefore made by CARE-Kenya to encourage the use of alley cropping as a soil maintenance/improvement tool (Vonk, 1986). It has already been stated that since the initiation of the AEP, 47 percent of the farmers have had at least an alley cropping plot (Scherr et al, 1989) and 67 percent of them were using it as a soil improvement tool (Scherr and Oduol, 1989). Moreover, the agronomic potential of alley cropping in siaya district has already been demonstrated. Though alley cropping appears to be a low cost sustainable agricultural technology and an attractive alternative of shifting cultivation and bush fallow system, it does increase the cost of labour (Ngambeki;

1983, Sumberg; 1985) thus suggesting the need for an analysis of its economic potential and viability.

Eicher(1988) quoted by Parafina 1989) argues that the prime movers of agricultural development include the following:

(a) favourable economic and policy environment,
(b) human capacity and managerial skill,
(c) diffusion of appropriate technology,
(d) rural capital formation and rural institutions.

Though all the above factors are important and worth investigating, one can not investigate all of them at the same time. The third factor (diffusion) of appropriate technology) formed the basis of this study. This study was therefore an attempt to answer two questions, namely is alley Cropping economically appropriate? and what factors should it be considered in its, diffusion and consequently its' adoption.

As a rule, alley cropping is complementary to chemical fertilizers and not competitive. This study therefore did not seek to compare the profitability of using chemical fertilizers as opposed to alley cropping but rather a comparison of the private profitability of alley cropping vis-a-vis the traditional production system which does not use any soil improvement technology.

Given the diversity of climate, farming systems and economic conditions in various regions of the country, it is important to try and find out whether alley cropping is a land-use systems which is economically viable, ecologically sound, and socially compatible in the various types of farming systems and ecozones. This study dealt with the question of economic viability. It is with this in mind that such a study concentrated in Siaya district; a similar study having been done in Machakos district (Lubega;1987). Moreover, since Siaya district has different ecological zones, the study chose two divisions: Yala division (high potential) and Bondo division (low potential). Two factors were considered in choosing the crops to work with, viz :

(a) the importance of the crop in the district, and

(b) the percentage of the crop in the alley cropping plots.

Maize is the most important food crop in the district and it is also the most widely grown crop in the alley cropping plots (Scherr and Oduol, 1989). This study thus focused on maize as the annual crop that can be grown using two technologies. The first technology involved growing maize traditionally without the use of chemical fertilizer or alley cropping, while in the second technology, alley cropping but not chemical fertilizer was used. In the alley cropping system leucaena was selected as the tree-crop since it is grown in about 82% of the alley cropping plots. The study also focused on determining whether certain socio-economic factors influence the adoption of alley cropping.

1.2.2 Objectives and Hypothesis of the study

The general objectives of the study were to describe some of the factors influencing the adoption of alley cropping and to estimate the value of alley cropping in helping to raise farm families' incomes in Siaya district. The study had the following specific objectives:

(1) to investigate the effect of a few socio-economic factors on the adoption of alley cropping,

(2) to investigate and estimate the economic potential of alley cropping in Siaya district.

The study tested the following hypothesis:

(1) Alley cropping can increase small scale farmer's income in Siaya district.

(2) Null hypothesis: Alley cropping has not increased farmer's income in Siaya district.

The basis of hypothesis testing was the gross margins earned from maize production. The performance of alley cropping was compared with the performance of traditional maize production. The hypothesis testing was done through the use of confidence intervals as explained in the methodology section.

CHAPTER TWO

LITERATURE REVIEW

The problem of poverty and low incomes that are common in developing countries is largely caused by low level of agricultural productivity (Mcpherson and Johnson, 1970; Shaw, 1973; Malassis, 1978; and Eicher and Staatz, 1985) Malassis argues that low productivity and low income are attributes of poverty which exacerbate each other. An increase in the productivity of agriculture is therefore necessary if one is to succeed in increasing incomes and fighting poverty. Mcpherson and Johnson argue that the low level of agricultural productivity in developing countries is a result of many interacting factors namely:

1) physical characteristics,
2) economic and institutional factors, and
3) state of the scientific knowledge and advanced technology applicable to agricultural production in the tropics.

The problem of low agricultural productivity can be tackled by using several approaches which can be classified into the following three strategies; expansion of area, technological progress, and institutional reforms.The first strategy does not result in an increase in agricultural productivity as such but seeks to ensure that no productive land is left idle. This strategy is only applicable where population density is still low. The situation in Kenya, for example does not allow this strategy as agricultural productivity has been falling largely due to population increase (Wisner, 1987). It is true that expansion of area can be achieved through irrigation, but irrigation is in reality a technological progress and not an expansion of area Kenyans thus have to use the other two strategies in order to increase the level of agricultural productivity.

By the year 2000 developing countries will require to increase their food production by at least 50-60% than in 1980 (Swaminathan, 1987). Swaminathan further argues that

> "any increase in food production has to come primarily by raising the food productivity of currently tilled soils rather than bringing new land resources into farming. Indeed, large portions of currently tilled marginal areas will have to be phased out of agriculture for economic and ecological reasons. Land is a shrinking resources for agriculture" (pg 20).

It is clear that the first strategy can only be used in areas where population densities are still low. Any country with a high population growth rate such as Kenya is likely to use only the second and third strategies. Technological progress can be achieved in two ways:

(a) biochemical advances; this involves the utilization of chemical inputs which include chemical fertilizers, herbicides and insecticides, as well as the use of improved varieties, and

(b) removing key constraints through use of mechanical power to speed up or better accomplish certain jobs in the agricultural season.

The role played by chemical fertilizers in increasing productivity cannot be over-looked. It can be argued that most crop yield increases throughout the world have been associated with chemical fertilizers (Pinstrup-Andersen, 1982; Evenson, 1985). The progress made in food production in Latin America and Asia has been due to new technologies that emphasize cultivation of strains that respond to irrigation and soil fertilization. One can therefore conclude that the level of soil fertility is quite critical in helping to increase productivity.

The third strategy consists of institutional reforms relating to land tenure, credit facilities, research and extension. It can be argued that credit has been one of the most important strategies for development of agriculture in developing countries(Gonzalez-Vega, 1985). Whereas access to credit is quite important, credit alone cannot create the other vital missing inputs, markets, or technologies that keep productivity low.

The factors that keep productivity low include some factors which the farmer can modify without waiting for government intervention. Among the physical factors, the level of soil fertility is one which an individual farmer can modify. Declining soil fertility and increased soil erosion have been identified as major problems in food crop based land use systems in the densely populated parts of Western Kenya as well as other parts of East and Central Africa highlands (Minae and Akyeampong, 1988). This situation has occurred because labour that might have been used to maintain fertility and conserve soil is often diverted to casual wage labour, and, in order to meet consumption needs, fallow periods have become shorter. Vegetation is also burnt for charcoal by rural dwellers due to immediate need of cash (Wisner, 1987).

In order to maintain/improve soil fertility, technologies are required that maintain/improve the fertility while at the same time being compatible with prevailing conditions. Such technologies should be cheap since small scale farmers' resources are so committed to meeting seasonal needs that long run considerations become secondary. In view of the fact that agriculture; in developing countries is becoming more dependent upon energy intensive inputs (oils, fuels and inorganic Nitrogenous fertilizers), it follows that any increase in the oil price will lead to higher agricultural prices in general, making the overall effect to be a reduction in food purchasing capacity unless there are compensating changes in incomes (Greeley, 1987). It is therefore to the advantage of developing countries to reduce their dependence on energy intensive agricultural inputs in order to enhance their food security. This implies that a technology that enhances soil fertility and is not affected by oil prices is a premium(Greeley, 1987).

Alley cropping is a technology which is not dependent on oil prices and is said to be cheap. The use of legumes such as leucaena which provide animal fodder and enhance soil fertility is an attractive method of maintaining/improving soil fertility (Collinson, 1987).

Alley cropping is made more attractive by the fact that it is environment friendly and has several other additional products such as fuelwood, fodder, timber and building poles. In Kenya, the struggle to secure biomass for domestic energy by women is well documented. In two studies it was found that rural women and their children spend between three to ten hours per week (in low population density areas) and twenty hours per week (in areas of severe scarcity) in collecting fuelwood (Hosier, 1982; Banes et al, 1984 as quoted in Wisner, 1987). If one considers the fact that energy needs of nearly 95% of households in rural Kenya is met through fuelwood and crop residues (Jama and Getahum, 1991), alley cropping becomes therefore a practical way of solving the problems of declining soil fertility and shortage of fuelwood simultaneously.

Siaya district has low agricultural productivity. the development plan (1988-1993) recognizes that for the small scale farmers to improve their livelihood, the level of agricultural productivity must be increased. It is appreciated that fertility of the soil is moderate to low in vast areas of the district (Jaetzold, 1982). The fuelwood used in the district is produced locally but there is an urgent need of planting more trees for fuelwood at a rate that is not less than two million trees annually (district development plan, 1888-1993). Alley cropping can therefore be used to enhance the level of agricultural productivity at the same time help to meet the fuelwood requirements of the district. The contributions of alley cropping can only be realized, if farmers adopt it, it is therefore important to try and describe some of the factors affecting it's adoption.

Several factors can affect the adoption of technology by farmers. These include among others; situational factors, personal factors and socio-cultural factors (Lionberger, 1968). Effective diffusion is an essential but not a sufficient condition for adoption (Pinstrup- Andersen, 1982).Effective diffusion can be defined as communicating useful ideas to as many members of the target group as possible, while adoption is the acceptance and application of the ideas (Pinstrup-Anderson, 1982). Once the technology has been effectively diffused and is available, the adoption decision will depend on four considerations;

1) will the farmer perceive the technology as suitable for his physical environment?
2) will the farmer perceive adoption as adding to the net return?
3) will the adoption enhance the achievement of other goals?
4) are there any factors that make it difficult to adopt or obtain the perceived benefits.

The factors that influence the answers to the last three consideration are therefore important in the adoption process. Farmers who have a high dependence on friends and relatives as sources of information are usually associated with low adoption rates (Lionberger, 1968). In Kenya, land size and level of income have been found to be positively related to adoption (Lipton and Longhurst, 1985; Sherr and Oduol, 1989). Lipton and Longhurst found land size to be strongly related to early adoption of hybrid maize. In studying the adoption of alley cropping in Siaya district, Scherr and Oduol found that farmers with more land or off-farm sources of income were more likely to adopt alley cropping.

Alley cropping is a recent innovation and thus the number of studies which have been done to determine its profitability, viability and sustainability is still small. The results of some relevant studies which touched on these issues are reviewed below.

In a study done by Raintree and Turay (1980), a Linear Programming model was used to evaluate the economic attractiveness of an experimental leucaena-rice alley cropping system. The model was used to explain the relative profitability of various rice growing activities at levels of 0, 20, 40, 60, 80, and 100 kg of elemental nitrogen (N) per hectare from three different sources: urea, ammonium sulphate and in situ leucaena.

The results of their study suggested that under conditions of small holder rice production in Nigeria, it was more profitable to grow rice with N from leucaena hedgerows than from either of the two mineral sources. Also relative profitability of luecaena increased overtime.

The first limitation of their study was that they relied solely on simulated data for the performance of leucaena. It is therefore possible that the yields of rice they simulated would occur in a rice-leucaena alley cropping and was either over-estimate or an under-estimate of the actual yield that would have been observed had the experiment been actually carried out. The second limitation was that in dealing with small scale farmers, they did not include a constraint to reflect the food requirement of the family.

In 1981 Verninumbe et al evaluated the economic potential of leguminous tree crops in a zero tillage system using 1977 - 1979 as a study period. The key questions they attempted to answer were: what is the most promising land management system and how would it perform under various farming conditions? Their work was done in the humid tropical zones of Nigeria and compared six alternative maize - zero tillage systems form which the use of chemical fertilizer was excluded.

The systems were as follows:

1) Maize - Pigeonpea
2) Maize - stylo
3) Maize - maize
5) Maize - Maize/Pigeonpea
6) Maize - leucaena alley cropping[1]

All other useful products of leucaena, stylo and pigeonpea were ignored in favour of effects of Nitrogen combination. They used a linear programming model as their analytical tool.

Verinumbe et al (1981) concluded that the incorporation of leucaena and stylo in the zero- tillage system enhanced the profitability of the system and made it more economically sustainable. Focusing on zero-tillage system made their study of limited applicability to the general farming conditions of the small scale farmers in Kenya. This is so since most small scale farmers in Kenya do not practice zero- tillage and thus the finding that leucaena increases profitability may not be true for Kenyan conditions.

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[1] the first crop indicates what was grown during the first season and the second crop what was grown during the second season

In the period 1981 - 1983, Ngambeki did two studies whose results were published in 1985.
The two studies involved (a) economic evaluation of leucaena with maize and maize-cowpea; (b) on-farm evaluation of leucaena - maize/yam intercrop. The first study compared the use of nitrogen fertilizer or herbicides or leucaena or any two combinations or a combination of all the three on the economic profitability of maize production. Ngambeki found that the introduction of leucaena on the cropping pattern increased labour input. Further, leucaena occupied 2 percent of the land and increased labour cost by 52 percent. However, by applying cost-benefit analysis, Ngambeki showed that it gave greater economic returns than from leucaena - Nitrogen or Nitrogen-herbicide or Nitrogen alone. The conclusion was that use of nitrogenous fertilizers at full rate with leucaena is an economic waste even at subsidized price. This study implied that the use of leucaena (alley cropping) should lead to a reduction in the amount of fertilizers used.

The on- farm evaluation was conducted in the West and Midbelts of Nigeria. The profits of farmers who got stakes for yams from the bushes was compared to the profits of farmers who got stakes from alley cropping system involving maize-leucaena. It was demonstrated that farmers who got stakes from leucaena earned an average marginal rate of return per unit additional cost of 5.13, while those who got them from the bush earned an average of -0.53. These two studies thus demonstrated that an alley cropping system involving leucaena-maize/yams is of definite benefit to a small scale farmer particulary those with soil fertility problems.

Hoekstra (1983) analyzed the potential of alley cropping in Machakos district by comparing different land-use systems. He considered three models:

Model 1 : traditional beans/maize system without use of fertilizers

Model 2 : maize/beans - leucaena alley cropping system

Model 3 : maize/beans - leucaena alley cropping system but now assuming only maize benefits and not beans.

He used MULBUD (a micro-computer program for the analysis of agroforestry land-use system) to calculate the net present value (NPV) for the various models at the following discount rates: 8%, 16%, 24% and 32%. Using data that was simulated for a ten year period, Hoekstra concluded that land, labour and animal draught power would be used more economically in the leucaena alley cropping system than the traditional system.

In 1985 Sumberg et al carried a study on the economic analysis of alley-farming' with small ruminants. Using both on-station and on-farm research data, cost-benefit analysis was done for a seven years period:four models were considered in this study.

Model 1 : traditional fallow system

Model 2 : maize-leucaena-alley cropping

Model 3 : maize-leucaena-alley farming[2] with sheep

Model 4 : maize-leucaena alley farming with goats.

It was found that models 2, 3 and 4 had a net present value which was greater than that of model 1 by 14 to 59 percent. Further, even though labour input increased by 50 percent due to the incorporation of mulch, alley farming was still 65 percent more profitable than a fallow system. Since the authors have not indicated which data was from On-farm, it is not possible to conclude that the farmers would make higher profits by practising alley cropping.

Using empirical data collected over fourteen months period and simulated data, Lubega in 1987 analyzed the economic feasibility of alley cropping in Machakos district. He considered two land-use systems:

(a) present system - traditional crop production system where neither alley cropping nor chemical fertilizers were used.

(b) alternative system - involving the use of alley cropping.

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[2] alley farming is alley cropping in which animal production component has been incorparated.

Considering a fifteen year period and production of maize, beans cowpeas and pigeon-peas, he formulated two linear programming models. The first model was for system (a) and the second model was similar to the first except that it contained maize-intercropped with leucaena as an activity.

The model enabled Lubega to carry out a multi-period analysis and he concluded that system (a) was not only economically superior during the first years but also the gains of alley cropping during the later years did not significantly off-set the losses during the first five years. Therefore alley cropping was not found to be economically profitable venture in Machakos district. However, it is not clear why Lubega included a biomass restriction in his model, since by stressing on the use of leguminous trees in alley cropping one would infer that the legume effect (Nitrogen fixation) is much more important that the green manure per se. It has been shown that leucaena can fix 96 to 133 kg of N per hectare in six months (Mulongoy and Sanginga ,1990). Moreover, the minimum amount of biomass in his model is left to the reader to guess how it was arrived at.

In 1989 Mittal and Singh gave the results of a study done from 1981 to 1986 on sandy loam of Northern India under rain fed condition.Their study had eight treatments, five of which included leucaena and were as follows:

Treatments 1 - Leucaena close spacing

Treatments 2 - Leucaena wide spacing

Treatments 3 - Leucaena widely spaced with Maize

Treatments 4 - Leucaena widely spaced with Backgram

Treatments 5 - Leucaena widely spaced with Clusterbeans

Treatments 6 - Maize monoculture

Treatments 7 - Blackgram monoculture

Treatments 8 - Clusterbeans monoculture

By calculating net return per hectare for each treatment from 1983 to 1986, they found that leucaena with clusterbeans was the most promising from a monetary point of view.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

In the studies that have been done to determine the economic viability of alley cropping, the following two methods have been used.

1) Linear programming-which was used by Raintree and Turay (1980), Verinumbe et al (1981) and Lubega (1987).
2) Cost-benefit analysis (CBA)-which was used by Ngambeki (1988), Hoekstra (1983), Sumberg et al (1985) Mittal and Singh (1989).

Though Stocking et al (1990) include Linear programming as a cost benefit method, it deals more with optimal allocation of resources. Indeed as Baumol (1978, pg 70 - 71) observes:

> "Programming is concerned with the determination of solution to problems. As a result, it is well suited to the analysis of rational behaviour. It has therefore been somewhat less successful in describing "what is" than in indicating "what ought to be" given some preassigned goals".

On the basis of the objectives of this study, it would appropriate to use cost-benefit analysis in the second objective (to investigate and estimate the economic potential of alley cropping in Siaya district).

3.2 ANALYTICAL MODEL

This section gives a detailed account of the economic and statistical models used in the study. In respect of the objectives of the study, various methods had to be employed to fulfil them. The first objective was achieved by calculating the percentage of farmers who used alley cropping and those who did not use alley cropping in terms of various socio-economic considerations. The second objective entailed calculating gross margins per hectare for the two models and thereafter Cost Benefit Analysis was done. The two models are shown below:

Model 1 - traditional production of maize is where neither alley cropping nor chemical fertilizers is used.

Model 2 - alley cropping system of maize and Leucaena.

The hypothesis that alley cropping earns a higher gross margin was then tested statistically. Using secondary data, cost benefit analysis was done for alley cropping. Gross margins rather than profits were used because of the difficulties involved in identifying and computing the fixed costs which are needed in the calculations of profits.

3.2.1 FACTORS INFLUENCING ADOPTION

Adoption of technology can be influenced by several factors (Lionberger, 1968). The investigation of all these factors was considered to be beyond the scope of this study. Therefore by going through a few selected relevant Literature (Lionberger, 1968; Lipton and Longhurst, 1985; Scherr and Oduol, 1989), it was possible to select a few factors for investigation. The factors selected included: the level of exposure to outside sources, the level of farm family income, labour availability, land size and amount of knowledge of alley cropping.

The level of family income was determined indirectly through considering the presence or absence of a permanent house in the homestead and the degree to which a farmer felt that cash was the most limiting input. In adoption studies, the surplus cash that remains is the one the is important and not the quantity generated as such (Scherr et al, 1990). Time and financial constraint did not allow the collection of such a detailed data that would have given an accurate indication of the revenue generated by all the farm enterprises and off-farm activities, as well as income got from other sources. Thus presence/absence of permanent house can be considered as a fairly accurate indicator of farm family income (Scherr et al, 1990). Visit to a Farmers' Training Centre was considered to be an exposure to outside information sources.

Using the data generated from the survey, farmers were divided according to level of family, income, exposure outside information sources, number of visits by the Agricultural Technical Assistant and whether cash is the most Limiting input. This was done for both model I and model 2. This allowed cross tabulation to be done for both divisions. The farmers who had heard about alley cropping, but had not adopted, were asked to give the reasons for not adopting. The percentages of farmers who gave level of Labour availability, land size and amount of knowledge, as reasons for not adopting were calculated for both division.

3.2.2 Hypothesis Testing

The hypothesis was tested using confidence interval approach. An assumption was made that the two populations (farmers with alley cropping and those without) had the same population variance and it was further assumed that the two populations were independent. The confidence interval was calculated using the following formula: $\Delta = (\bar{X}_1 - \bar{X}_2) \pm t_{.025}\ Sp\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$
where

Δ = difference in the gross margins of the two populations.

$\bar{X}_1$ = mean gross margin per hectare of farmers using alley cropping (Model 2)

$\bar{X}_2$ = mean gross margin per hectare of growing maize without chemical fertilizer or alley cropping. (model 1)

S_p = the squareroot of the estimate of the pooled population variance

n_1 = size of sample of population 1

n_2 = size of sample of population 2

$t_{.025}$ = value of t at 95% confidence level

Since the hypothesis to be tested was that Δ was greater than zero, it was not accepted if the confidence interval was found to include zero.

3.2.3. **Cost Benefit Analysis (CBA)**

There are several possible perspectives for a Cost-Benefit Analysis (CBA) of a project. The general cases may be classified into the following three groups (Stocking et al. pg 27, 1990):

a) Ex-ante appraisal (looking at a planned project in advance): to decide whether or not to implement a new enterprise

b) On-going (looking at an operational but not completed project): assessing the cost and benefits of an existing enterprises

c) Ex-post evaluation (looking at a completed project): judging the cost and benefits of a completed enterprise.

The steps that are followed as given by Bojo et al, (1988) quoted in Stocking et al, (1990) are as follows:

1) The establishment of decision criteria: Among the decision criteria most commonly used are:

   a) Net present value (NPV): The present value of all current and future benefits minus the present value of all current and future cost. This is the fundamental criterion and it is normally safe to use it. If it is positive, the project or enterprise is estimated to earn a surplus.

b) Internal Rate of Return (IRR): The maximum interest that a project can pay for the resources used while still recovering all investment and operating costs (It makes NPV = 0). It should be noted that using IRR to rank projects may give wrong results. This is because IRR only measures the rate of net benefits, but not their size.Thus, a small but high yielding project can take precedence over a competitor yielding greater net benefits but at a lower rate.

c) Benefit cost ratio (BCR): the present value of all benefits divided by the present value of all costs: If this is more than one the project/enterprise is estimated to a earn surplus. Using the BCR to rank projects of different sizes may give an incorrect signal to policy makers.

2) Identification of the costs and benefits

3) The quantification of costs and benefits: This usually presents problems due to inadequate knowledge of the underlying natural scientific relationships. By the use of sensitivity analysis one can test to what extent uncertainties matter for decision making purposes.

4) The valuation of costs and benefits

5) Setting an appropriate time horizon

6) Discounting using a real private or social discount rate to estimate the rate today of the stream of future costs and benefits.

7) Identification of the variable with the greatest uncertainty about future rate and the use of sensitivity analysis.

8) Policy conclusion.

The type of CBA used in this study was the one of an on-gong enterprise. As already stated earlier two models were considered namely, Model 1 (traditional maize production) and Model 2 (alley cropping of maize and leucaena).

The study used three types Cost ratio (BCR) and Internal Rate of Return (IRR). If one lets B_t to represent benefit in year t and C_t, cost in year t then

$$NPV = \sum_{t=o}^{n} \frac{B_t - C_t}{(1+i)^n} \quad \text{- equation 1}$$

Similarly BCR is given as:

$$BCR = \frac{\sum_{t=o}^{n} \frac{B_t}{(1+t)^n}}{\sum_{t=o}^{n} \frac{C_t}{(1+i)^n}} \quad \text{- equation 2}$$

While the internal rate of return is the interest rate at which

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^n} = 0 \quad - \quad \text{equation 3}$$

In order to use cost-benefit analysis in analyzing the financial impact of alley cropping to a farmer's income the following assumptions were made:

(a) A farmer can only use two benefits of alley cropping, namely improved soil fertility and fuelwood, hence all the other benefits were ignored.

(b) A market for fuelwood exits in the farmer's locality.

(c) Alley Cropping only causes marginal changes in the overall farm plan.

On the basis of the above assumptions, partial budget were constructed in order to analyze marginal changes that occur in receipts and costs due to introduction of alley cropping. These budgets were developed for each of the research plots (Abayo and Nyabeda) for the period 1985 to 1989. This analysis was done using compounded annual partial budgets and only the differences between the controls and the treatments were considered. The following was taken to be the extra cost incurred: the value of extra labour required due to alley cropping while the value of the incremental yield due to alley cropping was taken as the extra benefit. Even though by practising alley cropping a reduction occurs in the cost of seedling due to planting less rows of maize, this cost saved was ignored in the analysis due to the difficulties involved in computing it. The interest rate of 18% per annum that was charged on loans by commercial banks in 1989 was used as the compounding rate.

3.3 DATA AND DATA SOURCES

To enable the application of cost benefit analysis and data were required and derived on the following:

i) outputs and prices

ii) inputs and prices

iii) the technical coefficients

Data on the above were generated from both primary and secondary sources. Structured questionnaire was designed and pretested using ten farmers. Seventy farmers were selected form each division using multi-stage random sampling. The sampling frame in each division consisted of members of women groups who had been in contact with CARE-Kenya. This was facilitated by the existence of a record showing the groups that had been in contact with CARE-Kenya. Thus for the district as a whole a total of 140 farmers were interviewed. The interview was carried out using structured questionnaires to obtain information on inputs, outputs, labour availability and prices. From secondary data obtained from International Centre of Research in Agroforestry and Kenya Forestry Research Institute (KEFRI) it was possible to carry out Cost Benefit analysis.

For ease of analysis, farmers were divided on the basis of the technologies they were using. The first technology was the use of animal manure (or nothing) considered to be the traditional technology for maize production. The second technology was maize production using alley cropping. The third technology considered was one in which maize was grown using fertilizers and the fourth one in which the farmers produced maize under alley cropping but also used chemical fertilizers. These latter two technologies were not a part of this study. Moreover, only those who has been practising alley cropping for at least three years were considered for the comparison of profitability of their technologies.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

In Yala Division 90% of the farmers who had an alley cropping plot were growing leucaena with maize. The inter-row spacing of the tree rows varied from four metres to five metres while the intra-row spacing (spacing between trees) varied from 0.5 metre to one metre. About 73% of the farmers cut back their trees twice per year. Due to the above two factors (spacing and pruning frequency), a measure of uniformity in the management of alley cropping was assumed.

In Bondo Division, all the farmers with alley cropping at least had a plot of maize alley cropped with leucaena with inter-row spacing varying from 3.5 to 6 metres and intra-row spacing from 1 metre to 2 metres. Sixty eight percent of the farmers cut back their trees once per year. Due to the above two factors (spacing and frequency of pruning), an amount of uniformity in management of the alley cropping plot was assumed.

4.2 Effect of some socio-economic factors on adoption

As stated elsewhere, the first objective of this study involved the investigation of the effect a few selected socio-economic factors on the adoption of alley cropping by farmers in the district. As stated in the methodology section, a few factors were investigated. These factors included: the level of exposure to outside sources, the level of family income, labour availability, land size, and amount of knowledge of alley cropping.

The study showed that 47% of the group members in Yala division had at least an alley cropping, while the figure for Bondo Division was 54%. About 30% of the farmers with alley cropping plots in Yala division also used chemical fertilizers, whereas no farmer in Bondo division was found to use chemical fertilizer either in combination with alley cropping or alone.

From Table 1a it appears that the number of times a farmer was visited per month by the Agricultural Technical Assistant was not important in getting farmers to adopt alley cropping. In both divisions farmers reporting higher frequencies of visits were the ones without alley cropping. The most important source of information was CARE- Kenya. In Yala division 68% of the farmers surveyed knew about alley cropping through CARE and in Bondo division about 90% knew about alley cropping through CARE. In both divisions the number of farmers who had attended a course at a Farmers' Training Centre was higher among the farmers practising alley cropping suggesting that farmers with alley cropping plots were more exposed to information sources. Further, farmers practising alley romping appeared to be slightly financially better off than the non adopters, inferred from the finding that in both divisions the numbers of farmers with permanent houses was higher among the adopters. Also a lower percentage of farmers listed cash as the most limiting input.

Among the Yala division farmers who did not have alley cropping plot, 59% of them knew that alley cropping could be used to increase soil fertility but were not using it as they felt that the land was too small. In Bondo division 67% of the farmers knew about alley cropping as a soil improvement tool but were not using it because of two major reasons. Most of them thought that they did not have enough labour to manage an alley cropping system while the rest reported that they did not have enough knowledge about alley cropping management.

Table. 1a. Socio-economic factors affecting adoption of alley cropping in Yala.

Category of Farmers	% visited by T.A twice or more times/month	% attended a course at FTC	% of farmers with permanent houses	% cash is most limiting input
Farmers without alley-cropping	34.8%	11.8	14.8	56.0
Farmers with alley-cropping	28.3	42.4	38.5	33.2

Source: Author's Survey, 1990

Table. 1b: Socio-economic factors affecting adoption of alley cropping in Bondo.

Category of farmers	% visited by T.A. twice or more times/month	% attended a course at FTC	% of farmers with permanent houses	% thinking cash is most limiting input
Farmers without alley-cropping	30.6	10.0	2.4	88.8
Farmers with alley-cropping	21.2	57.1	20.3	62.4

Source:Author's Survey, 1990

It can be inferred from tables 1a and 1b that farmers who have attended a course at FTC are more likely to adopt alley cropping than hose who have not. Another inference that can be drawn is that farmers with relatively high incomes are more likely to adopt alley cropping. Small land size, shortage of labour and inadequate knowledge can impede the adoption of alley cropping.

4.3 Gross margin analysis of sample farmers

In order to compare the profitability of alley cropping, gross Margins were calculated for all the four models. In the calculation other benefits of alley cropping were ignored in favour of its yield improvement benefit. The first model was traditional maize production where neither chemical fertilizers nor alley cropping was used. The second model was maize-leucaena alley cropping. The third was maize production involving fertilizer use and the fourth involved using both alley cropping and chemical fertilizers in maize production. For Bondo Division, only the first and the second models were applicable whereas for Yala division all the models were applicable. In the calculation of the gross margins Lotus 1-2-3 was used. The Gross margins were compared on per hectare basis and were calculated using Kenyan shillings as a measure of monetary value. The Gross Margins (GM) are shown in Tables 2 and 3. All the values used are the means calculated from the samples.

Table 2: Gross Margins (Per hectare) of the four models in Yala

	Models			
	1	2	3	4
Revenue	3259	5958	13668	10985
Variable Cost	1775	3000	3662	3036
GM(Ksh/Ha)	1484	2958	10006	7949
Range	-248 -4728	395 -8299	7882 -11416	6177 -11416
Sample size	20	21	7	4

Source: Author's Survey; 1990

model 1 - traditional maize production
model 2 - maize production using alley cropping of leucaena
model 3 - maize production using chemical fertilizers
model 4 - maize production using both chemical fertilizers and alley cropping.

Table 2 shows that the farmers in Yala division who used chemical fertilizers with or without alley cropping in maize production earned as average gross margin that was greater than Kshs. 7,949 per hectare. The use of alley cropping results in lower gross Margin value as compared to chemical fertilizers but higher than the gross margin earned when practising traditional maize production. Farmers using model 2 earned an average gross margin of Ksh 2,957.6 per hectare as compared to Ksh.1,483.7 per hectare earned from traditional maize production. However, the Gross Margins earned from these two models (alley cropping and traditional) was quite variable as seen from the wide magnitude of the range, and the value of standard deviations (1,526.9 and 2,299.6 for model 1 and model 2 respectively)

Table 3: Gross Margins per hectare of the models in Bondo Division (in Kshs/ha)

	MODEL 1	MODEL 2
Revenue	3748	5312
Variable cost	2518	2732
Gross margin	1230	2580
Range	-939 to 3952	98 to 8694
Sample size	18	30

Source: Author's survey; 1990

Table 3 shows how the models found in Bondo division performed. The farmers using traditional method of maize production in this division were found to earn an average gross margin that was lower than that earned by farmers using alley cropping. Farmers using Model 1, on average earned Kshs. 1,230 per hectare as compared to those using model 2 who earned an average of Ksh. 2,580 per hectare. The gross margins, however, varied widely from farm to farm in both models as shown by the wide magnitude of the range for each model (Table 3) and the value of the standard deviations (1,524.6 and 1,858.0 for model 1 and model 2 respectively).

4.4 Results of the hypothesis testing

The hypothesis that alley cropping can increase small scale farmers' income was tested for each of the divisions. The data used was generated from the small scale survey. The hypothesis was as follows:

Alley cropping increases farm incomes against the null hypothesis: alley cropping has not increased farm incomes.

The hypothesis was tested by use of confidence interval approach.

1. Bondo Division

The 95% confidence interval of the difference between model 2 (Alley Cropping) and model 1 (traditional production of maize) was calculated as shown below:

$$\Delta = (\bar{X}_1 - \bar{X}_2) \pm t_{.025} Sp\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$= (1045 - 496) \pm 2.016\ (701.110)(0.298)$$

$$= 549 \pm 2.016\ (208.932)$$

$$= 549 \pm 421 \text{ (in Ksh/acre)}$$

$$= 1359 \pm 1040 \text{ (in Ksh/ha)}$$

This difference thus varies between Ksh. 319 per hectare and kshs 2,399 per hectare. Since the interval does not include zero, it can be argued that the difference between the two Gross-Margins is statistically significant at 5% significance level. Thus we can accept the hypothesis that alley cropping increase small scale farmers' income.

2.Yala Division

The difference of the 95% confidence interval for the Gross Margin between model 2 and 1 was calculated as follows: $\Delta = (\bar{X}_1 - \bar{X}_2) \pm t_{025}\ Sp\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$

$$\Delta = (1200 - 601) \pm 2.022\ (794.199)(0.312)$$

$$= 599 \pm 2.022(247.79)$$

$$= 599 \pm 502 \text{ (in Ksh/acre)}$$

$$= 1479 \pm 1239 \text{ (in Ksh/ha)}$$

This difference thus varies between Kshs.240 per hectare and kshs 2,718 per hectare. Since this interval does not include zero, it can be argued that there is a difference between the two gross margins that is statistically significant at 5% significance level. Therefore we reject the null hypothesis and accept the alternative hypothesis that alley cropping significantly raises small-scale farmers' incomes as compared to traditional production.

4.5 Results of cost-benefit analysis

In this section, the findings which underline the analysis are presented.

Crop Yields

The maize yields with and without leucaena in the on-farm

Alley cropping experiments are presented in Tables 4 and 5 below.

TAble 4: Dry maize grain yields in plots with and without leucaena during 1986-1989: Abayo research plot.

Yields in kg/ha

Year	1986	1987	1988	1989
Leucaena:	6092	3562	3431	2969
Control:	5294	3382	3267	1629
Yield increment	798	180	164	1340

Source: Nyamai (1989)

The maize yields are form hybrid varieties.

Table 5: Dry maize grain in plots with and without Leucaena during 1986-1989: Nyabeda research plot

(yields in kg/ha)

Year	1986	1987	1988	1989
Leucaena:	2255	863	1294	1934
Control:	1941	470	588	904
Yield increment:	314	393	709	1034

Source: Nyamai (1989)

These maize yields are form hybrid varieties.

Fuelwood

The trees are pruned once a year just before planting time, around March of each year. The amount of fuelwood harvested each year from each research plot is presented in Table 6.

Table 6: Amount of leucaena fuelwood harvested in Abayo and Nyabeda research plots during the period 1986-1989

(in kg)

Year:	1986	1987	1988	1989
Abayo plot:	776	726	593	538.7
Nyabeda plot:	469	703	388	371.9

Source: KEFRI (1990)

The analysis of the maize and fuelwood yield

The economic analysis is carried out using compounded annual partial budgets or, in other words, the compounded values of annual extra costs and extra benefits of alley cropping are calculated. Only the differences in costs between the treatment and control are considered. The yields harvested in 1985 are not considered because it is assumed that the effects of alley cropping are only noticeable a year after the trees are planted. The partial budgets for the years 1986-1989 are presented in Tables 7 and 8. These tables form the basis of the Cost Benefit Analysis.

Table 7: Partial budgets for alley cropping of maize & leucaena (1985-1989) in Kshs/ha; Abayo research plot.

YEAR	ADDED COST	ADDED BENEFITS		BENEFITS-COSTS
1985				
seedlings	3088.00			
extra labour				
200 man hrs @ 4	800.00			
TOTAL	3888.00		0.00	-3888.00
1986:				
Extra labour	280.00	extra yield	1580.04	
		fuelwood	886.97	
TOTAL	280.00		2467.01	2187.01
1987:				
extra labour	280.00	extra yield	376.20	
		fuelwood	1033.18	
TOTAL	280.00		1409.38	1129.38
1988:				
extra labour	280.00	extra yield	-427.58	
		fuelwood	1102.98	
TOTAL	280.00		675.40	395.40
1989:				
extra labour	350.00	extra yield	2988.20	
		fuelwood	1231.33	
TOTAL	350.00		4219.53	3869.53

Source:Author (compiled from KEFRI research results, 1990).

Table 8: Partial budgets for alley cropping of maize & leucaena for (1985-1989): Nyabeda research plot

YEAR	ADDED COST	ADDED BENEFITS		BENEFITS-COSTS
1985:				
seedlings	3088.00			
extra labour				
200manhrs @ 4	800.00			
TOTAL	3888.00		0.00	-3888.00
1986:				
extra labour	280.00	extra Yield	675.18	
		fuelwood	670.67	
TOTAL	280.00		1345.85	1065.85
1987				
extra labour	280.00	extra Yield	821.37	
		fuelwood	1033.41	
TOTAL	280.00		1854.78	1574.78
1988				
extra labour	280.00	extra Yield	1510.84	
		fuelwood	492.48	
TOTAL	280.00		2003.32	1723.32
1989:				
extra labour	350.00	extra Yield	2296.90	
		fuelwood	766.11	
TOTAL	350.00		3063.01	2713.01

Source: Author (Compiled from KEFRI research results, 1990).

To compare costs and benefits occurring over a long time period, it is important to discount or compound the values. In this study, by compounding the values, it was possible to calculate Net Present Value(NPV), Benefit-Cost Ratio(BCR), and Internal Rate or Return (IRR) of alley cropping. These three choice indicators are important in determining the profitability of a project. Tables 9 and 10 show the calculation of the NPV,BCR, and IRR for Abayo and Nyabeda research plots respectively. The interest rate used was that charged by commercial banks on loans in 1989.

Table 9. The calculation of NPV or alley cropping: Abayo plot

YEAR	Benefit-Cost	Compounding factor	Compounded benefit
1985	-3,888.00	1.939	-7,538.8
1986	2,187.01	1.643	3,593.3
1987	1,134.38	1.392	1,579.1
1988	395.40	1.180	466.6
1989	3,869.53	1.000	3,869.5

NPV at 18% = Kshs 1,969.7; BCR = 1.22 ; IRR = 30%

Source: Author(1990).

Table 10. The calculation of NPV of alley cropping: Nyabeda plot

YEAR	Benefits-Costs(Kshs)	Compounding factor (18%)	Compounded benefit - cost
1985	-3,888.00	1.939	-7,538.8
1986	1,065.85	1.643	1,751.2
1987	1,574.78	1.392	2,192.1
1988	1,723.32	1.180	2,033.5
1989	2,713.01	1.000	2,713.0

NPV at 18% = Kshs 1,151 per Ha; BCR = 1.13;IRR = 24.6%

Source: Author(1990).

In both Abayo and Nyabeda research plots, the NPVs are Kshs 1,969.7 and Kshs 1,151 respectively. Abayo plot yields an IRR of 30 percent and a BCR of 1.22, while Nyabeda plot Yields an IRR of 24.6 percent and a BCR of 1.13. These results are an underestimation of the real values, since leucaena trees are expected to last beyond 1989 and continue to exercise their positive effect on crop yield. This analysis shows that alley cropping was more rewarding in medium potential regions (Abayo plot) than in high potential regions (Nyabeda plot). In the study, the emphasis was on the financial performance of alley cropping and all the decision criteria were of equal value.

Sensitivity Analysis

Sensitivity analysis was done in order to determine how the earning capacity of alley cropping would be affected by changes in the value of output, cost of labour and other variables. The advantage of BCR is that it can be used to calculate switching values. According to Gittinger(1983), a BCR of 1.48 implies that either the costs can rise by 48% or benefits can fall by 32% [3]and the project remains profitable.

The BCR of Abayo plot was 1.22, this means that for Abayo plot either costs can rise by a maximum 22% or benefits can fall by as much as 18% and alley cropping still be profitable than traditional maize production. For Nyabeda plot the BCR was 1.13 which implies that either costs can rise by as much as 13% or benefits can drop by as much as 13% and alley cropping would still be more profitable. It can be argued that alley cropping is more stable in Abayo plot than Nyabeda plot. This follows from the finding that the range of variability in which alley cropping remains profitable is wider for Abayo.

Sensitivity analysis was done for four situations and results are presented in tables 11 and 12. It is important to point out that the 5% figure was chosen arbitrarily. The impact of the change was considered to be more important than the magnitude.

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[3]the percentage fall in benefit is calculated substracting 1/1.48 from 1 and multiplying by 1

Table. 11: Sensitivity analysis for Abayo plot

Assumption	: IRR or effect on benefit
1. Labour cost 5% higher -	26.8%
2. Labour cost and fuelwood value 5% up -	28.4%
3. Labour cost and maize value 5% higher -	28.7%
4. No market for fuelwood, thus no return-benefit falls by	49.2% at interest rate = 18%

Source : Author(1990).

Table. 12: Sensitivity analysis for Nyabeda plot

Assumption	: IRR or effect on benefit
1. Labour cost 5% higher each year	21.8%
2. Labour cost and fuelwood value 5% higher	22.9%
3. Labour cost and maize value 5% higher	23.5%
4. No market for fuelwood, thus no return benefit falls by	38% at i = 18%

Source: Author(1990).

The contribution of fuelwood in the profitability of alley cropping is high. This is demonstrated by the finding that when the contribution of fuelwood is excluded, the value of benefit falls by percentages(49.2% and 38%) which exceed the permissible limits (18% and 12%) for Abayo and Nyabeda plots, respectively. Labour is quite important in both plots, since the IRR is more sensitive to cost of labour than to either the value of maize or the value of fuelwood.

In order to ensure the profitability of alley cropping, it is advisable to introduce it in areas with cheap and abundant labour. The extra yields attributable to alley cropping should be larger than was found in the study, if alley cropping is to be profitable in regions which do not have fuelwood market.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

5.1.1 Factors affecting adoption

Though the study revealed that in both Bondo and Yala divisions alley cropping was being practised by more than forty-five percent of the group members, it was not able to explain why a greater percentage of members in Bondo division had alley cropping plots than in Yala division. All the alley cropping plots in Bondo division had leucaena as the tree crop while in Yala, Calliandra spp and Sesbania sesban were also being used. For the low rainfall zone (Bondo division) it is recommended that Leucaena should be used for crop improvement (Scherr and Oduol, 1989). It was, however, not possible to establish the reason why the project (AEP) did not promote other tree species apart from leucaena in Bondo division.

The effect of income on adoption of alley cropping by farmers was that it tended to facilitate the adoption of alley cropping. This inference is suggested by the fact that the incidence of permanent houses was higher among farmers practising alley cropping than those who were not for both divisions (Table 1) It has been found that farmers with more land or off-farm sources of income are more likely to employ alley cropping (Scherr et Oduol, 1989) However, the frequency of visits by Agricultural Extension Agent did not seem to make it more likely for a farmer to adopt alley cropping which could be explained by the fact that the Agroforestry Extension Project worked with the Forest department rather than with Department of Agriculture. The study also suggested that most of the farmers viewed alley cropping as replacement for chemical fertilizers in Yala division. However, for Bondo division, it is not possible to say how alley cropping is viewed when compared with chemical fertilizers since no farmer in the sample was found to be using chemical fertilizers.

Land was found to influence adoption in Yala division but not in Bondo, about fifty-nine percent cited their small land size as the reason for not adopting alley cropping.This suggests that in regions where land is scarce, the adoption of alley cropping can be hindered by small land size, whereas alley cropping is infact meant for such land scarce regions (Rocheleau, et al, 1988). For Bondo division which has more land as compared to Yala division, labour and management knowledge were much more important than land in affecting adoption of alley cropping.

The overall conclusion that can be reached is that alley cropping is becoming popular among the farmers who are participating in the Agroforestry Extension Project. The probability of adoption is influenced by the farmers exposure to information sources, the level of farm income, Land size, amount of labour, and knowledge (management) level of alley cropping. The factors of production (Land, Capital, Labour and Management) vary on their importance on the adoption process depending on the region.

5.1.2: Profitability of alley cropping

The study revealed that Gross Margins earned by farmers using alley cropping for maize production was just slightly higher than those growing maize using traditional methods. For both Yala and Bondo divisions the difference was slightly above Kshs. 1000 per hectare demonstrating that alley cropping has a potential of raising farm incomes. However, when compared to farmers using chemical fertilizers, alley cropping had much lower earning (Table 2). This would appear to contradict the finding that using chemical fertilizer at full rate is an economic waste (Ngambeki, 1985).

Considering that most of the farmers practising alley cropping use traditional varieties, this contradiction can easily be explained. It has been found that forty-eight percent of alley cropping was done using local varieties while twenty-six percent was done using hybrid varieties (Scherr and Oduol, 1989). The response to inputs by local varieties is not usually the same as that of hybrids. Therefore since users of chemical fertilizers were the ones mostly using hybrid varieties (author's survey, 1990), the great difference in earning between alley cropping plots and chemical fertilizer plots can be attributed to this factor.

Results of hypothesis testing suggested that in Bondo division, alley cropping can enhance and has increased the income of the small-scale farmers in the division. For Yala division, it can be argued that alley cropping has increased the farm families incomes to a lesser degree than in Bondo. This follows from the fact that the Abayo plot has a greater NPV than Nyabeda plot. This finding conflicts with the opinion that most farmers in medium potential regions(such as Bondo) have achieved a marked improvement in maize yields as a result of using alley cropping, while in high potential regions (such as Yala), most farmers have achieved little or no improvement (Scherr and Oduol, 1989). In this study, improvement in financialy performance occured in both regions.

By doing Cost-Benefit analysis, it was demonstrated that alley cropping uses land and labour resources more economically than the traditional system when the value of fuelwood is included. This is especially so when one considers the fact that some of the effects of alley cropping such as reduced weeding (Jama et al, 1990), were not considered in the analysis. Moreover, the analysis only considered a five year period whereas leucaena can last for more than ten years. It is, however, clear that alley cropping was more profitable in Bondo division (IRR = 30%) than in Yala (IRR =24.6%)

which further supports the view that alley cropping works better in medium potential regions than high potential ones (Scherr and Oduol, 1990).

It can therefore be concluded that alley cropping as practised by farmers in both divisions can increase farm incomes. The increase is not substantial but it can be enhanced if farmers are encouraged to harvest and sell fuelwood from their alley plots. Also since the farmers got the initial supply of seedlings free, the cost of establishing the plot was thus very small.

The inferences made from the two methods used in determining financialy profitability of alley cropping are not quite consistent. In analyzing the gross margins, it was found that alley cropping causes a significant increase in the profit earning from maize production. This increase occurred without the inclusion of the value of fuelwood harvested. This finding does not agree with the one demonstrated by the use of cost benefit analysis which suggested that the exclusion of the value of fuelwood would make alley cropping less profitable than traditional production. A possible explanation for this inconsistency could be due to the fact that the data used come from two different sources and also in cost benefit analysis the initial cost of establishing an alley cropping plot was not included in the analysis.

Due to shortage of time, it was not possible to collect accurate information on all the variables. In order to get such accurate information, one would require a period of about one year in which the activities of the farmers would be closely monitored. The conclusions of the study must therefore be taken in the light of this data limitation.

Secondly, the data on labour utilization in alley cropping was very difficult to come by. It was obtained by asking the farmers to estimate the amount of labour they used. The estimates were then supplemented with existing research findings.

5.2 Recommendations

1) A more in-depth study, investigating the exact amount of labour requirement by alley cropping plots should be done so that one can calculate accurately the extra cost incurred by using alley cropping rather than the traditional method. This could not be done in this study due to financial and time constraints.

2) Since alley cropping is meant for land scarce regions, the implementing agency (CARE Kenya) should try to find out why farmers in Yala division find their small Land size a hindrance to adoption and take steps to convince them of the appropriateness of alley cropping for their small farms.

3) Without the inclusion of the environmental advantages of alley cropping, the study concluded that alley cropping can help to ;increase the small farm income significantly. It would therefore make sense to include alley romping in the extension package. So far the government through the Ministry of Agriculture only extends fertilizers as a tool for yield improvement. For regions with climatic conditions comparable to that of Siaya District and with low levels of fertilizers use, alley cropping can be extended to the farmers who find fertilizers unaffordable. Howeve,r given the findings from Cost-Benefit Analysis, alley cropping must be used judiciously.

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Apendix A (1)

YALA DIVISION

Model 1 - Traditional Maize Production - Long Rains-1990

Gross Margin per Acre of Maize Enterprise

Area	Gross Revenue	Total Variable Cost	Gross Margin	Gross Margin/Acre
(Acres)	(Ksh)	(Ksh)	(Ksh)	(Ksh)
3.00	7000.00	1500.00	5500.00	1833.30
1.00	950.00	700.00	250.00	250.00
1.50	800.00	900.00	-100.00	-66.70
2.00	1400.00	1200.00	200.00	100.00
0.25	350.00	150.00	200.00	800.00
2.50	7000.00	2215.00	4785.00	1914.00
1.00	700.00	800.00	-100.00	-100.00
2.00	4200.00	2275.00	1925.00	962.50
2.00	2100.00	1200.00	900.00	450.00
0.50	875.00	400.00	475.00	950.00
2.00	4200.00	1800.00	2400.00	1200.00
1.50	1050.00	600.00	450.00	300.00
2.00	1000.00	900.00	100.00	50.00
1.00	1000.00	600.00	400.00	400.00
1.00	700.00	600.00	100.00	100.00
1.50	1000.00	700.00	300.00	200.00
2.00	1200.00	800.00	400.00	200.00
1.00	1400.00	1200.00	200.00	200.00
2.5	6000.00	2200.00	3800.00	1520.00
2.00	4000.00	2500.00	1500.00	750.00

Source: Author's Survey, 1990

[4]

[4]Some of the farmers who were using traditional model are not included in the calculation of the Gross Margins since they could not recall the amounts of harvest - i.e. 12 farmers are not included.

Appendix A 2

YALA DIVISION

Model 2 - Maize-Leucaena Alley Cropping - Long Rains 1990

Gross Margin per Acre of Maize Enterprise

Area	Gross Revenue	Total variable Cost	Gross Margin	Gross Margin/Acre
(Acres)	(Ksh)	(Ksh)	(Ksh)	(Ksh)
0.75	900.00	300.00	600.00	800.00
0.36	360.00	150.00	210.00	583.30
0.08	540.00	300.00	240.00	3000.00
0.15	540.00	150.00	390.00	2600.00
0.30	360.00	150.00	210.00	700.00
0.30	300.00	100.00	100.00	333.30
0.20	540.00	200.00	100.00	1700.00
0.12	360.00	300.00	60.00	500.00
0.25	1080.00	240.00	840.00	3360.00
2.00	1700.00	600.00	1100.00	550.00
2.00	3000.00	1750.00	1250.00	625.00
2.00	1200.00	540.00	660.00	330.00
1.00	1050.00	800.00	250.00	250.00
0.50	700.00	620.00	80.00	160.00
0.50	1750.00	775.00	975.00	1950.00
0.25	700.00	320.00	380.00	1520.00
0.25	1190.00	945.00	245.00	980.00
0.50	1400.00	700.00	700.00	1400.00
0.13	350.00	200.00	150.00	1153.85
1.00	2800.00	800.00	2000.00	2000.00
2.00	2800.00	1500.00	1300.00	650.00

Source: Author's Survey, 1990

YALA DIVISION - Appendix A 3

Model 3 - Maize production using chemical fertilizers: Long rains 1990.

Area (acres)	Gross Revenue (Ksh)	Total variable cost (Ksh)	Gross Margin (Ksh)	Gross Margin/acre
2.50	1200.00	2450.00	9550.00	3820.00
1.50	7000.00	2810.00	4785.00	3190.00
4.00	18000.00	2810.00	15190.00	3797.50
3.00	15000.00	2000.00	13000.00	4333.30
2.00	11000.00	2675.00	8325.00	4162.00
2.50	14000.00	2450.00	11550.00	4620.00
1.50	8750.00	2100.00	6650.00	4433.30

Model 4 - Maize produc tion using both alley cropping anc chemical fertilizer

Area	Gross Revenue	Total Variable cost	Gross Margin	Gross Margin/acre
2.00	7000.00	2000.00	5000.00	2500.00
2.25	8750.00	2450.00	6300.00	2800.00
1.25	6000.00	2310.00	3690.00	2952.00
2.50	1400.00	2450.00	11550.00	4620.00

Source: Author's Survey, 1990

[5]

[5] -Some of the farmers could not recall amounts (three 6farmers)

Apendix B 1

BONDO DIVSION (Long Rains 1990)

Model - Traditional Maize production

Area	Gross Revenue	Total variable cost	Gross Margin	Gross Margin/Acre
(Acres)	(Ksh)	(Ksh)	(Ksh)	(Ksh)
0.50	450.00	580.00	-130.00	-260.00
0.50	600.00	720.00	-120.00	-240.00
1.00	1440.00	1584.00	-144.00	-144.00
2.00	2250.00	1000.00	1250.00	625.00
1.00	2040.00	1120.00	920.00	920.00
2.00	2250.00	2000.00	250.00	175.00
0.50	450.00	640.00	-190.00	-380.00
1.00	1800.00	760.00	1040.00	1040.00
2.00	2920.00	1475.00	1445.00	722.00
1.00	2320.00	720.00	1600.00	160.00
0.50	700.00	520.00	180.00	240.00
0.25	580.00	260.00	320.00	1280.00
0.50	700.00	600.00	100.00	200.00
0.50	580.00	266.00	314.00	628.00
1.00	1920.00	2212.00	-202.00	-202.00
1.00	1050.00	730.00	320.00	320.00
1.00	2200.00	910.00	1290.00	1290.00
2.00	3000.00	764.00	2236.00	118.00

Source: Author's Survey, 1990

[6]

[6]Not all farmers are included out of the total 32 farmers since the other 14 farmers could not give enough data that could assist in analysis.

Appendix B 2

BONDO DIVISION

Model 2 Maize Leucaena Alley Cropping - Long Rains 1990

Area (Acres)	Gross Revenue (Ksh)	Total Variable Cost (Ksh)	Gross Margin (Ksh)	Gross Margin/Acre (Ksh)
2.00	4940.00	848.00	4092.00	2046.00
0.25	600.00	580.00	20.00	80.00
0.50	600.00	580.00	20.00	40.00
1.00	2400.00	1612.00	788.00	788.00
2.00	4058.00	624.00	3434.00	1717.00
2.00	3000.00	1872.00	1128.00	564.00
1.00	2640.00	1095.00	1545.00	1545.00
1.00	2720.00	1620.00	1100.00	1100.00
1.00	3400.00	2112.00	1288.00	1288.00
1.00	2400.00	1375.00	1025.00	1025.00
1.00	1750.00	1620.00	130.00	130.00
0.50	720.00	635.00	85.00	170.00
0.25	525.00	240.00	255.00	1140.00
1.00	1935.00	532.00	1403.00	1403.00
1.00	2040.00	1120.00	920.00	920.00
1.00	2000.00	270.00	1730.00	1730.00
0.50	700.00	420.00	280.00	560.00
1.50	2200.00	270.00	1730.00	1730.00
0.50	700.00	420.00	280.00	560.00
1.50	2200.00	1360.00	840.00	560.00
1.00	1020.00	614.00	406.00	406.00
1.50	3300.00	793.00	2507.00	1671.30
1.00	2600.00	1614.00	896.00	986.00
1.00	1950.00	1915.00	935.00	935.00
1.00	1350.00	534.00	816.00	816.00
0.50	700.00	580.00	120.00	240.00
1.00	6000.00	2480.00	3520.00	3520.00
1.00	1350.00	484.00	866.00	866.00
0.5	1680.00	612.00	1068.00	2136.00
3.00	4500.00	2490.00	2010.00	670.00

Source: Author's Survey, 1990

A QUESTIONNAIRE ON ALLEY CROPPING IN SIAYA DISTRICT DESIGNED BY COLLINS OTIENO OBONYO

NAME OF THE FARMER...

WOMEN GROUP...

DIVISION...

INTERVIEWER.. DATE ....

A) PERSONAL DETAILS

1) Are you the head of the household? Yes/No ....

2.1 If No, Are you the only wife or there are other co-wives? Yes/No ....

2.2 Does the head of the household stay with you or he stays elsewhere? Yes/No ....

3) How old are you?...

4.1 How many children do you have?...

4.2 How many of them reside in the home with you?.....................

5) What is the size of your household?..

6) What is your educational background?.....................................

(i) upto primary

(ii) upto secondary level

(iii) upto form six and above

(iv) no formal schooling at all but attends adult classes

(v) illiterate.

7) Apart from farming, do you have any other employment? Yes/No ....

8) If Yes, what is your other employment? ....

....

B) IMPORTANCE OF THE FARM TO THE HOUSEHOLD ECONOMY

9) How long is the land available to you?..

10) Is it fragmented or consolidated?...

11) What proportion of the land do you use for the following activities?

(i) Crop production...

(ii) Grazing..

(iii) Fallow..indicate the length of fallow period...

12) What crops do you grow as cash crops (the two major ones)

(1) (2)

13) What crops do you grow as food crops (four major ones)

(1) (2)

(3) (4)

14) Other crops grown ....

15) Do you keep any livestock? Yes/No ....

16) If Yes, what types do you keep and for what purpose?

	Type	Number	purpose
i)	Cattle	....	....
ii)	Goat and sheep	....	....
iii)	Poultry	....	....
iv)	Donkey	....	....
v)	Others (specify).........................	....	....

17) How far are you from your market centre?..

18) Is the distance large enough to incur transportation cost?.........................

19) Are you able to get your inputs in adequate amounts from the market centre? Yes/No ....

20) If you want to sell your output, do you find it easy to do it? Yes/No ....

21) If No, specify for which input or output. ....

C) SOIL FERTILITY MAINTENANCE

22) Do you have any problem with the level of fertility of your farm? Yes/No ....

23) If Yes, which of the following methods are you using for solving the problem? ....

(a) Use of chemical fertilizers

(b) use of animal manure

(c) by the use of alley cropping

24) When you have such problems do you seek the advice of agricultural extension agent? Yes/No ....

25) How frequently does the extension agent visit you in your farm? ....

(a) once a month

(b) twice a month

(c) thrice a month

(d) four times a month

(e) rarely

26) Have you ever attended any course at the farmers training centre? Yes/No ....

27) What are the benefits of having trees in the farmland according to you?

a)

b)

c)

d)

e)

f)

28) Do you know hat alley cropping can be used to maintain or increase soil fertility? Yes/No ....

29) Are you using alley cropping for this purpose? Yes/No ....

30.1 If No, why are you not using it?

....

....

....

30.2 Do you think you will start using it sometime in the near future? Yes/No ....

D) ALLEY CROPPING

31) How did you get to know about alley cropping?..

....

32) For how long have you been practising alley cropping?

....

33) Which species of trees do you use for alley cropping (4 major)

(i) (ii)

(iii) (iv)

34) Which four major crops do you use for alley cropping?

(i) (ii)

(iii) (iv)

35) Have you had any problems with alley cropping? Yes/No ....

36) If Yes, what problems have you had? ....

(i) Not having enough knowledge about its management

(ii) Not having enough labour to manage

(iii) Increased incident of pest and insects attack.

37) Since you started using it has it increased your yields? Yes/No ....

38) How many times does the care extension agent visit you per month? ....

39) Are you enthusiastic about alley cropping? Yes/No ....

40) For what other purposes do you use alley cropping?

(i) Fuel wood (ii) Building Poles

(iii) Fodder (iv) Others (specify) ....

41) How frequently do you cut back the trees per year

(i) once (ii) twice (iii) thrice

42) What is the size of the alley cropping plot?...

43) What is the (i) Inter row spacing...........................metres, Number of rows ....

(ii) Intra row spacing...............................

44) Who decided on the size of the plot?

(i) The head of the household

(ii) The farmer herself

(iii) Extension agent from CARE

E) FARM INPUTS

45) Lobour supply profile

Month	March	April	May	June	July	Short rains season October	November	December
No. of people present								
No of days available								

46) How much labour do you have available for use?

(i) during the first season...

(ii) during the second season...

47) How much is available from

(i) home supply (give days and number of persons)

(ii) group supply

(iii) hired labour

48) Of the home supply, how many of them are children (less than 14 years)

....

49) Which equipment do you have ?

	Equipment	Quantity
1)	Plough	....
2)	Jembe/hoes	....
3)	Pangas	....
4)	Wheelbarrows	....
5)	Others	....

50) If you wanted to increase your production, which input would you want to be increased?

(i) Land

(ii) Labour

(iii) Cash

F) *(FOR THE INTERVIEWER)*

51) On the basis of the furniture and state of the house, rank the farm
(a) very poor (low income)
(b) poor
(c) average (middle income)
(d) high income

52) What is the state of the house with reference to time
(i) temporary
(ii) semi-permanent
(iii) permanent

DATA SHEET

SEASON ....

Price of labour/day was: KSH..

Crops Grown (7 major ones)	Area Grown	Labour Number of persons involved	Number of days worked	Cost of fertilizers used	Cost of seeds	Quantity harvested	Per unit price of Harvest	Remarks
(1) Alley Cropping of maize with								
(2)								
(3)								
(4)								
(5)								
(6)								
(7)								

On average how many hours/day does the farmer allocate to his farm work?. ....