ECONOMIC EFFICIENCY OF SMALLHOLDER COFFEE PRODUCTION IN MATHIRA DISTRICT, KENYA

BY

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DEDICATION

To my dear wife Jerusha Wanjiru whose support and encouragement is beyond words. Dedication also goes to my sons Frank Nginyangi and Jeff Kimawira and to my daughter Maryanne Wanjiru who had to bear with my absence especially in the evenings and during their school holidays as I pursued this course. Finally but not the least I also dedicate this study to my parents Francis Nginyangi and Mary Wanjiru whose moral support was indeed great.

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ACRONYMS

AE -Allocative Efficiency

AEZ – Agro-ecological zone

Agric. - Agriculture

CMAAE- Collaborative Masters in Agriculture and Applied Economics

DEA- Data Envelopment Analysis

DEAP- Data Envelopment Analysis Program

DIV - Division

EE- Economic Efficiency

FAO- Food and Agriculture Organization

FAOstat- Food and Agriculture Organization Statistics

GDP- Gross Domestic Product

ICO- International Coffee Organization

SE- Scale Efficiency

SFA- Stochastic Frontier Analysis

TE- Technical Efficiency

ABSTRACT

Coffee is the third most important agricultural commodity to the Kenyan economy after horticulture and tea in terms of contribution to Gross Domestic Product (GDP) and employment creation in the agricultural sector. The enterprise contributes about 10 percent of the total agricultural export earnings, and up to 30 percent of the total labor force employed in agriculture. It is an agricultural export commodity that employs about 250,000 people directly and an estimated 6 million people indirectly. The performance of the industry has been falling in the past two decades mainly due to deterioration of the world market. When the producer prices become consistently low, farmers uproot their coffee and replace it with other enterprises such as maize, beans, Irish potatoes and bananas or intercrop with the various crops. Since the small-scale farmers have small pieces of land, they usually intercrop coffee with the various subsistence crops as a strategic measure against food insecurity and reduced farm incomes.

Effects of other crops on the overall economic efficiency of coffee in the intercropping system are not known. The overall economic efficiency is a combination of the technical and allocative efficiency. Mathira district which has an area of about 254 square kilometers was purposefully selected for the research since no similar study had been carried out there in the past. Data was collected through structured questionnaires which were administered to farmers sampled through systematic sampling procedure. The Data Envelopment Approach model which computes economic efficiency indices was used in the first stage of the analysis while Tobit regression model was used in the second stage to analyze the factors that influence the level of economic efficiency.

The study established that overall mean technical efficiency for coffee farmers in Mathira district was 89 percent implying that farmers could reduce the current physical input use by about 11 percent on average and still realize the same output levels. The average allocative efficiency was 50 percent meaning that farmers could reduce input costs by about 50 percent without affecting the current production levels. Combination of technical and allocative efficiencies resulted in a mean overall economic efficiency of 45 percent for coffee production in the study area. This implies that there was potential for farmers to improve their economic gains by about 55 percent. The study also established that economic efficiency was significantly and positively influenced by the level of education, access to extension services and the age of the household head. This was consistent with the expectation since formal

education improves the capacity to learn and implement ideas. On the other hand, contact with extension services improves skills and information on good crop husbandry practices thereby influencing economic efficiency positively.

Age was observed to have a positive and significant influence on economic efficiency though the turning point was not established. To address this observation, the government may formulate policies that motivate the younger generation to be more actively involved in coffee production through selective strategies such as input subsidies for the youthful and middle aged farmers. The scenario of age influencing economic efficiency positively may however not be expected to continue indefinitely. To counter the tendency of the elderly generation holding on to coffee even when they are too old, the government may motivate them to progressively hand over coffee production enterprise to the younger generation through establishment of social schemes such as retirement benefits from farm enterprises.

The study also established that economic efficiency was significantly and negatively influenced by the household head attending off-farm activities. This implies that the forgone labor was not replaced by equivalent skills that would at least sustain economic efficiency at a level formerly realized by the household head. As a way of addressing this issue, the government through institutions that provide extension services may enhance provision of commercial agriculture so that farmers with opportunities for going for off-farm activities may make informed decision about whether to continue working as farmer managers in their farms or go for off-farm work. Farmers with knowledge on commercial agriculture are also more likely able to guide those who succeed them as farm managers when they go for off-farm activities thereby preventing decline in economic efficiency. Access to credit facilities from cooperative societies also significantly influenced economic efficiency negatively. This was an indication that credit funds acquired from the societies might have been diverted to other uses which were not promoting coffee production. Proper mechanisms for monitoring and evaluation of agricultural activities including utilization of credit may be institutionalized in extension services so as to address this problem. Intercropping coffee with other crops was also shown to have a significant negative influence on economic efficiency. This implies that economic viability of intercropped coffee was less than for non-intercropped coffee.

CHAPTER ONE

INTRODUCTION

1.1 Agriculture and Economic Development in Africa

Africa is profoundly an agrarian continent whereby two thirds of the people directly or indirectly derive their living from agriculture. Coffee is one of the key agricultural commodities in a number of sub-Sahara African countries including Kenya whereby it is highly depended upon for livelihoods by the poor people (Charveriat, 2001). At the global level, coffee is produced by about 25 million households, who solely rely on the crop as their source of income (Charis et al, 2002). Revenue from coffee is used to buy food items that cannot be produced on the farm, to pay for school fees and health care, and to meet other cash expenses, such as the purchase of agricultural inputs. Efficient coffee production may therefore result in higher farm incomes thereby safeguarding farmers against selling off their assets or cutting down on essential expenses such as education and consumption.

In Africa, agriculture contributes about 60 percent of the total labour force, 20 percent merchandize and 17 percent Gross Domestic Product (GDP). African agriculture is characterized by low profitability which is partly contributed by lack of appropriate technologies and poor utilization of available resources (FAO, 2010). The African governments are therefore faced with the fundamental question of what could be done to transform agriculture in the continent for it to be more profitable thereby contributing more to economic growth and development (Eicher, 2009). Technologies that promote efficiency in African agriculture would be more effective in economic development if they targeted the small-scale farmers since they are more than the large scale farmers. Hence, strengthening efficient participation of smallholder farmers in agricultural production would results in improved incomes and food security as envisioned in national policies of most African economies. Small-scale agriculture is also important since it leads to reduction in unemployment, provides a more equitable distribution of income as well as an effective supply of inputs demanded by other sectors of the economy (Bravo-Ureta et al, 1994).

Researchers and policymakers in the African continent need to focus their attention on the impact that the development and adoption of new technologies can have on increasing farm productivity, efficiency and farm income (Hayami et al, 1985). Similar sentiment were demonstrated by the Kenya's Minister of Economic Planning, Thomas Mboya, in 1967 while opening a meeting on Economic Commission for Africa by stating that; "No matter how successful our efforts are to industrialize, Africa will be for many generations, primarily a producer of agricultural and other primary products. We must learn to do it well and on a rapidly growing scale. This will require a massive frontal attack, not only on the research needs but also on the practical problems of production, storage, and marketing" (Eicher, 2009).

1.2 Overview of cash crops production in Kenya

The principal cash crops in Kenya are coffee, tea and horticulture. The crops are mainly grown by small-scale farmers owning about 2 to 5 acres of farm land. The small-scale farmers constitute about 65 percent of all Kenyan farmers. They account for over 75 percent of total agricultural output and about 50 percent of the marketed produce. The agricultural sector directly supports livelihoods of about 80 percent of Kenyan population (Agricultural Sector Development Strategy (ASDS), (2010-2020)). Therefore good performance of the agriculture sector may lead to economic growth in Kenya (Nyoro et al, 2004). The economic performance of Kenya since independence has been rooted in the growth of agricultural sector which has consistently accounted for a large share of employment, value addition, and exports (Nelson et al, 2007). The importance of agriculture in contributing to Kenya's development is exemplified in the Agricultural Sector Development Strategy (2010-2020) and the Comprehensive African Agriculture Development Programme (CAADP) policy documents. The policies identify agriculture sector as an important tool for employment creation and poverty reduction since it contributes directly to 24 percent of GDP. The sector also contributes indirectly a further 27 percent to the GDP through linkages with manufacturing and distribution sectors. Therefore agricultural sector is important for growth and development of the non-agricultural sector in Kenya.

The agricultural sector has a multiplier effect of about 1.64 through provision of raw materials for the agro-based manufacturing industries which constitute 70 percent of all industries in the country (Omiti et al, 2007). The sector also contributes 60 percent of the export earnings, 60 percent of employment and 45 percent of government revenue (Ministry of Agriculture, 2008). Thus, agriculture is the mainstay of the Kenyan economy. Growth of the agricultural sector has a direct link with higher incomes and poverty reduction for the rural poor (Otieno, 2007).

Coffee is the third most important agricultural commodity to the Kenyan economy after horticulture and tea. The enterprise contributes an average of about 5 percent export revenues in Kenya. The country mainly grows Arabica type of coffee which accounts for almost 100 percent of its national production. Robusta is also grown but accounts for less than 1 percent of the country's production (Republic of Kenya, 2008). Coffee farming in Kenya is done by both small-scale farmers organized into co-operative societies and by large scale farmers at plantation level. The small-scale production engages over 600,000 smallholder farmers (Economic Survey of Kenya, 2008). The crop contributes about 10 percent of the total agricultural export earnings, and up to 30 percent of the total labor force employed in agriculture. It employs about 250,000 people directly and an estimated 6 million people indirectly (Republic of Kenya, 2008). Coffee is therefore a major source of income and livelihood to many Kenyans.

Tea is also a major foreign exchange earner in Kenya. The country produces the best quality black tea in the world which is mainly contributed by hand-picking of only the upper two leaves and a bud followed by skillful manufacture under stringent conditions (Export Processing Authority, 2005). About 62 percent of the total tea crop in the Kenya is produced by the smallholder growers who process and market their crop through their own management agency, Kenya Tea Development Agency (KTDA) limited. The balance of 38 percent is produced by the large scale estates such as Unilever Tea (K) Ltd (Previously Brooke Bond), James Finlay (K) Ltd, Williamson's Tea (K) Ltd, which are managed by major multinational firms. The leading districts in tea production include Kericho, Bomet, Kiambu and Nyeri (Republic of Kenya, 2008).

The performance of coffee as compared to tea in the export market is graphically presented in Figure 1.1. The figure shows that while the amount of tea exported has been increasing for the last two decades, the amount of coffee exported has been decreasing within the same period. This is an indication of growth in tea industry and a decline of the coffee industry over the years. The progressive decline of the coffee industry was contributed by the collapse of the International Coffee agreement (ICA) in 1989, Fend (2005). This organization formally regulated the global coffee industry through setting export quotas that were agreed between the producing and consuming countries thereby keeping coffee prices stable.

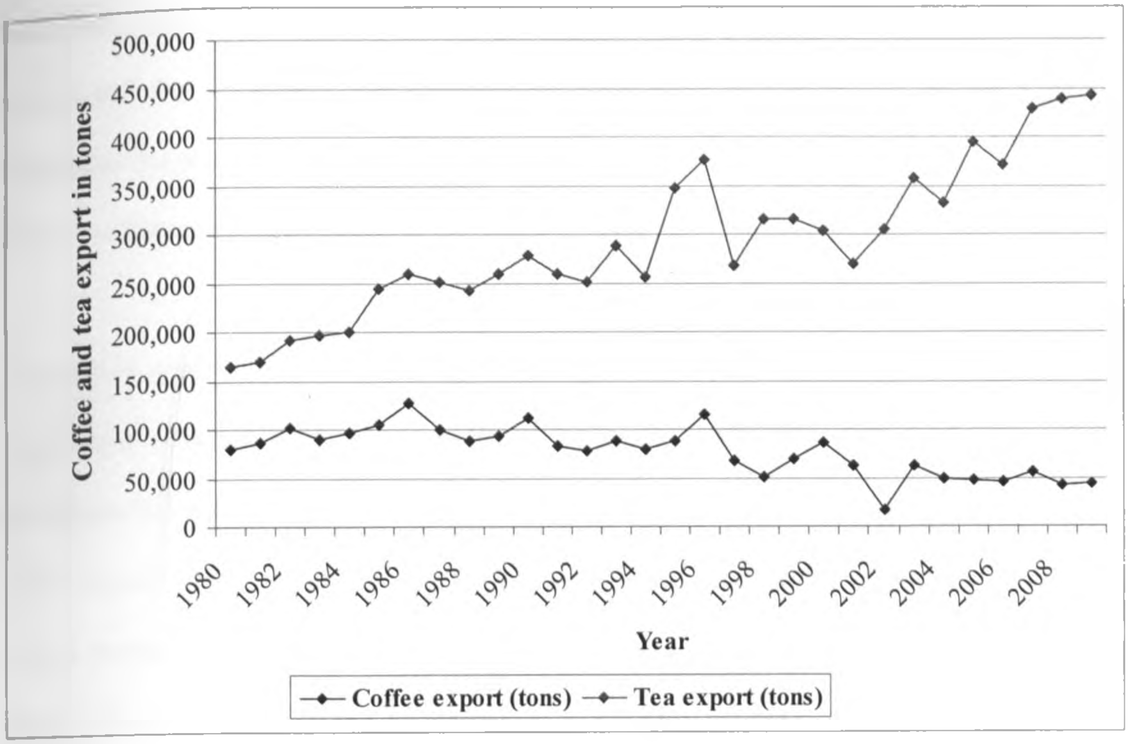


Figure 1. 1: Value of coffee and tea export in Kenya between 1980 and 2009
Source: FAOstat data base.

1.3 Performance of Coffee sector in Kenya

The performance of coffee sector has in the past 20 years been hampered by various constraints including: decline in production in response to high cost of inputs; increase in competition from other lucrative enterprises such as horticulture; global economic down-turn leading to low prices in the international market and collapse of International Coffee Organization leading to uncontrolled marketing (Coffee Board of Kenya, 2009). There has been an upward growth of 3.6 percent per annum of total coffee production in the world since 1980s compared to a lower consumption rate of 1.5 percent per annum (Karanja et al, 2002). This has led to an average price decline of 3 percent per annum in the world market in the last 20 years. The World Bank and other agencies contributed to the surplus coffee production by funding development of the coffee sector through programmes such as the Smallholder Coffee Improvement Programme (SCIP) in the 1990s. The programme was aimed at improving production and therefore contributed to the oversupply of coffee in the world market and the consequent low prices. The World Bank and other funding agencies also influenced the performance of the coffee sector through funding of macro-economic reforms such as coffee marketing liberalization (Oxfarm, 2001).

The dismal performance of the coffee sector is contributed by poor performance of the cooperative movement as was established by Mude (2006) in a study on cooperative movement in Kenya. The study also established that lack of formal regulatory structure with proper enforcement mechanisms for the by-laws and exploitive pricing by the cooperative society management are also key issues that contribute to the poor performance of coffee sector in Kenya. The study also indicated that cooperative societies may influence the level of technical efficiency among their members through capacity building on resource utilization. The poor performance of coffee industry in Kenya is depicted by Figure 1.2 which reveals a declining trend of its production. This is a reflection of inefficiencies in the coffee value chain including production. The scenario warrants a great concern for a country that heavily relies on agriculture for its economic development.

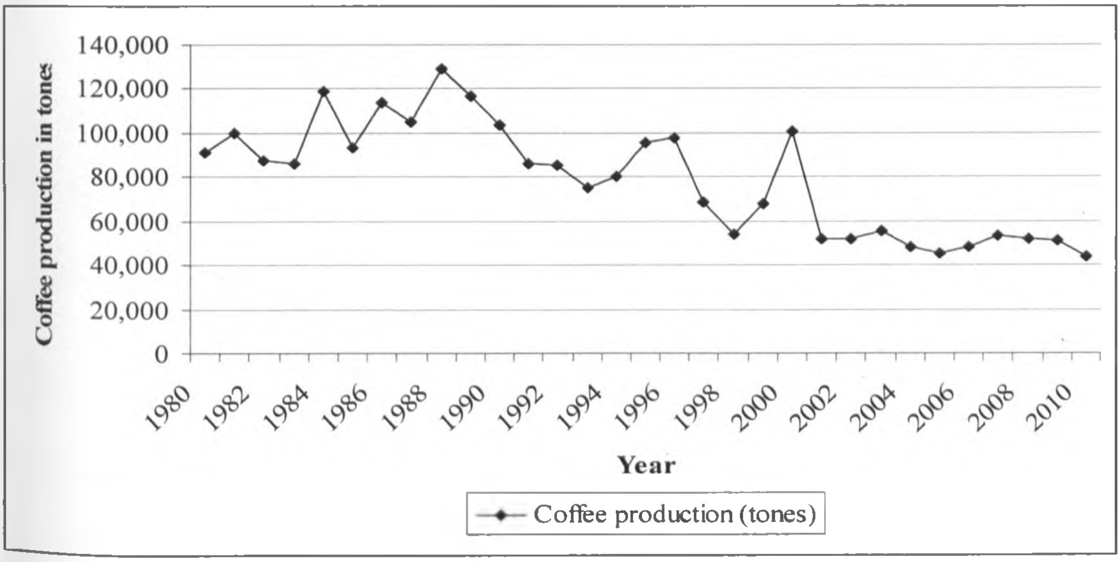


Figure 1. 2: Coffee production in Kenya between 1980 and 2010
Source: FAOstat data base.

The decline in production has been precipitated mainly by declining producer prices over the years which resulted to disincentives for proper husbandry practices (Karanja et al, 2002). Most of the coffee produced in Kenya goes to the export market since local consumption is very low. Consequently the world market heavily influences the producer prices of coffee in the country. Decline of the coffee sector in the last two decades in Kenya is therefore further demonstrated by the trend in world prices as shown in Figure 1.3

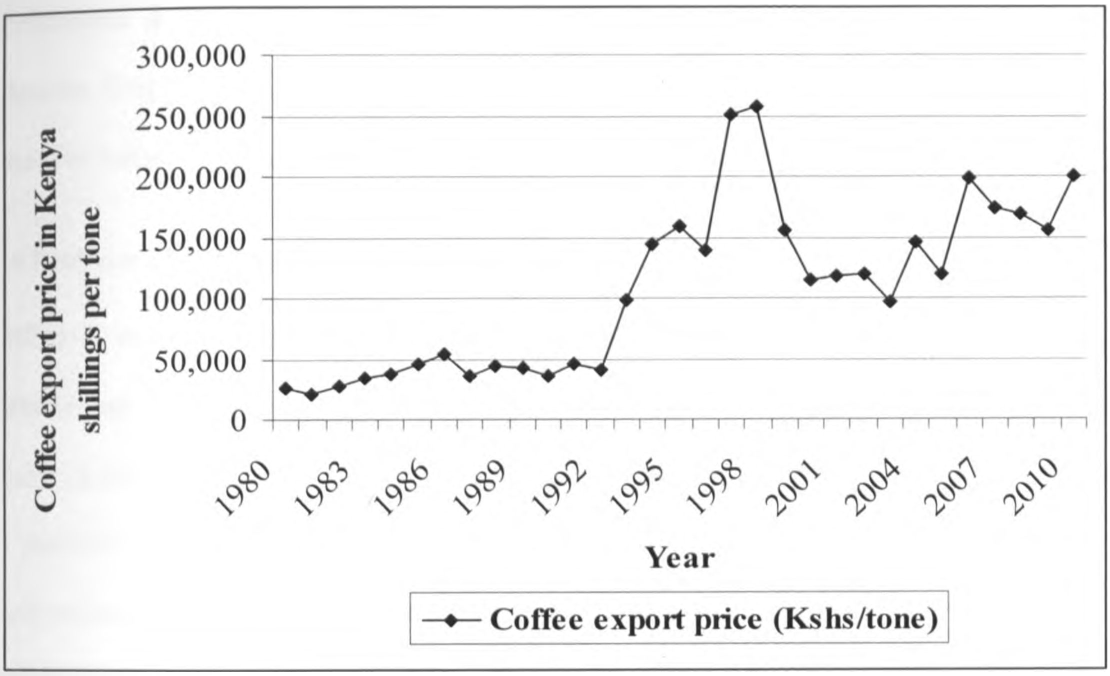


Figure 1. 3: Coffee export prices for Kenya between 1980 and 2010
Source: FAOstat data base.

The figure shows that coffee prices were low before mid 1990s but increased steadily thereafter up to the year 1998. The increase may be explained by liberalization which was recommended by the coffee Act after its first amendment in 1992. This was in line with the findings of Damianopoulos (2003) in a study on Coffee Liberalization in Kenya and Uganda. The study established that coffee liberalization reforms improved performance especially at smallholder level. In Kenya, coffee liberalization reforms changed coffee marketing from selling by auction to direct selling. Figure 1.3 shows that after 1998, coffee prices followed a drastic downward trend that persisted till the years of 2000.

The poor performance of the coffee sector has consequently led to decline in both quality and value of coffee export in the producing countries (Benin et al, 2007). This has prompted governments of these economies to give priority to technology development, dissemination and market reforms for speedy revival of the coffee industry. However, assessment of performance in the coffee value chain including production level has not received adequate attention. Empirical evidence on coffee production efficiencies was therefore lacking in these countries including Kenya. This study intended to make a contribution in this gap.

1.4 Problem Statement

Coffee is an important export crop in Kenya that supports 250,000 small-scale farmers directly and 6 million Kenyans indirectly (Ministry of Agriculture, 2008). This implies that about 16 percent of the Kenyan population depends on coffee for their livelihood. The need to maintain optimal performance of this crop can therefore not be overemphasized. The performance has in the past years been dwindling as depicted by the trend on amount of exported coffee in Kenya between 1980 and 2010 (Figure 1.1). Farmers in Kenya uproot their coffee and replace it with other enterprises such as maize, beans, Irish potatoes and bananas or intercrop with the various food crops when prices become consistently low. Since the small-scale farmers have small pieces of land, they usually intercrop coffee with the various subsistence crops as a strategic measure against food insecurity and reduced farm incomes. The current coffee Act of 2001 actually recognizes intercropping as a farming practice that may be adopted in coffee farming. One of the pertinent ways of measuring the level of performance of agricultural enterprises is through computation of the economic efficiency levels which may guide in choosing enterprises or practices that are more economically viable under *ceteris paribus* assumption. Economic efficiency of coffee under intercropping or monocropping practices in Kenya is not known. Therefore the economic research problem in this study is that there is no empirical evidence to guide coffee farmers on the more economically viable farming practices when faced with circumstances that may require them to choose between coffee monocropping and intercropping. Such empirical evidence may also give further guidance on the most economically viable practices among the various coffee intercropping practices such as; coffee-maize, coffee-beans, coffee-bananas and coffee- agroforestry.

1.5 Purpose and objectives

The purpose of this study was to analyze economic efficiency of coffee production and determine the factors influencing it in Mathira District, Kenya.

The specific objectives were:

1. To estimate the level of economic efficiency of coffee production in Mathira District, Kenya in the perspective of regions, gender, monocropping and intercropping practices.
2. To analyze the socioeconomic factors that influence the level of economic efficiency of coffee production in Mathira District, Kenya.

1.6 Hypotheses

1. There is no difference in economic efficiency for the different coffee growing regions, gender, monocropping and intercropping practices in Mathira District.
2. Socioeconomic factors do not have significant influence on economic efficiency of coffee production in Mathira District.

1.7 Justification

The persistent low trend of coffee producer prices in the past years has exposed small-scale farmers to various farming options that include: to continue farming the crop as a pure stand;

abandon the cash crop; uproot the crop and replacing it with other crops and especially subsistence crops or continue farming the crop but intercrop with other crops. However, there is no scientific evidence based on economic performance of the various options that may guide farmers in making their decisions about which option to undertake.

In Kenya, intercropping is very common and according to Coelli et al, (2004) in a study on farming systems, intercropping cash and food crops can influence productivity gains and technical efficiency in the farming operations. Further, the practice may buffer small-scale farmers against risks and uncertainties for food security and farm incomes. In the previous years, studies related to coffee production in Kenya focused on aspects such as prices and regulation (Karanja, et al, 2003); marketing and liberalization (Damianopoulos, 2003); coffee in relation to food security (Gitu, 2004); and distortions to agricultural incentives (Nelson, 2007). No studies have been done in the past specifically addressing generation of empirical evidence to guide farmers in choosing coffee farming practices that maximize output with the available resources at the existing market prices. This study intended to make a contribution in filling this gap on the understanding that coffee efficiency studies may lead to important policy interventions. Such interventions include policies related to development and dissemination of technologies relevant to coffee production and provision and management of agricultural credit.

CHAPTER TWO

LITERATURE REVIEW

This chapter gives an overview of the coffee industry in Kenyan. The aim was to give the reader an understanding of the history of the coffee industry in Kenya, policy reforms, coffee intercropping, efficiency measurement and socioeconomic factors that influence performance of coffee production.

2.1 History of coffee production in Kenya

The history of coffee production in Kenya dates way back to 1893, when missionaries of the Congregation of the Holy Spirit brought the first Arabica trees from Ethiopia and planted them in Kiambu district. In the 1950s Scott Laboratories, developed a number of coffee varieties numbered SL1 through SL40. The most successful and well-known of these are SL28 and SL34, and they account for majority of the coffee grown in Kenya (Kennedy, 2005). Little further development of coffee varieties has occurred since 1950s with the exception of 'Ruiru 11' and 'Batian varieties' (Coffee Research Foundation, 2008). These varieties differ from the SL types in that they are dwarf varieties which were aimed at disease resistance and increased yield. Results of Ruiru 11 which is the older of the two varieties have been poor as the variety constitutes only two to three percent of the coffee grown in Kenya (Ministry of Agriculture, 2008). Batian variety was officially launched on 8th September 2010.

During the early years, growing of coffee was restricted to white settler farmers only. Smallholder coffee production started in mid 1930s but the size of business was highly restricted. Smallholder production was expanded in 1954 through a policy intervention referred to as the Swynnerton plan. Since then, the area under coffee production has expanded progressively.

The crop is grown on rich volcanic soils in the highlands of Central, Eastern, Western and Nyanza provinces where altitudes are 3,600-6,300 feet above sea level. In the years before 1990, coffee was grown in more parts of the country, but as coffee started to decline in the 1990s, the crop died out in the marginal areas. What remains are eight primary regions namely: Nyeri, Murang'a, Kirinyaga, Embu and Meru in Mount Kenya region, Kiambu and Machakos to the south, and Nakuru to the west (Kennedy, 2005). The coffee mature cherries are picked by hand and then taken to cooperative societies for primary processing which produces coffee parchment. The parchment is taken to coffee mills for further processing which involves removal of husks. The de-husked parchment is also referred to as green coffee and it is sold through direct or auction market. Kenyan coffee is distinctive in that it has a unique, wine-like flavor which makes it suitable for blending other coffees. Traditionally the crop was grown as a monocrop but in the recent years, intercropping and especially with subsistence crops or agro-forestry has been widely practiced. It would be of great policy importance for researchers to establish the effects of these crops on the performance of coffee enterprise.

2.2 History of reforms in the Coffee sector in Kenya

Since the early 1980s dramatic changes in export commodity markets, shocks associated with resulting price declines and changing views on the role of the state have ushered in widespread reform agenda for agricultural commodity markets in Africa. The reforms have significantly reduced government participation in the marketing and pricing of agricultural commodities including coffee. The reforms have sought to present agricultural producers with the 'right prices', as a means of stimulating productivity and growth (Krueger et al., 1988). The agricultural commodity prices have important implications on decisions about amount of physical resources to be purchased and allocation of the same to crop enterprices hence technical, allocative and consequently economic efficiency in production. A shift in cropping practice from the traditional coffee monocropping to intercropping practice as has been witnessed since 1990s entails a paradigm shift in physical resource acquisition and allocation and therefore economic efficiency (Oi, 1961). Therefore reforms in the coffee sector are bound to have ultimate implicit impacts on economic efficiency in production.

The major reforms in the coffee sector in Kenya started in 1992. This was at the peak of the liberalization process under the banner of structural adjustment programme (SAPs). One of the key milestones of liberalization was the enactment of the new Coffee Act of 2001 which was meant to harmonize the policy reforms that had been implemented before that year and to complete the institutional reforms.

The new coffee Act removed the draconian and archaic rules in coffee production such as restriction of uprooting and intercropping (Coffee Act of 2001). The Act also retained the provision of illegality of farmers to trade in cherry at the farm-gate level. They were required to continue taking their produce to the co-operative societies for processing and marketing. This was meant to safeguard the investments made by farmers in cooperatives and enhance economies of scale in coffee processing. All these changes were aimed at stabilizing coffee producer prices though this goal has not been achieved prompting farmers to continue exploring other farming methods away from monocropping (Karanja et al, 2002). However, effects of the resultant farming methods (for instance intercropping) on coffee production efficiency have not been researched on in the past.

In 1993, coffee marketing was reformed by introduction of an alternative payment system referred to as 'direct payment'. Prior to this year, coffee payments were pooled together by the Coffee Board of Kenya, which made several interim payments based on the averaged price for the season. A final payment was made after reconciliation of accounts. The pool payment system served the purpose of pooling price risks and maintaining a steady flow of funds. In this new system, farmers started getting their payments that were pegged to prices that coffee fetched at the Nairobi coffee auction. The main advantage of the direct system was that farmers were paid much more quickly. However, the system coupled with the deregulation of exchange rates exposed coffee farmers to higher price risks.

In 1998, the government reformed the co-operative movement through enactment of a new cooperative Act which removed most of the government control of the co-operatives retaining only a minimal regulatory role while encouraging members of the organizations to run these entities as economic units. The cooperative movement reforms were aimed at improving marketing which in turn influences agricultural production trend. The reforms were also aimed at improving marketing through demand driven production and management practices. This was in line with the recommendations of Holmlud et al (1999) in a study on cooperatives, which highlighted that reforms were more effective when aimed at bringing rapid development of new niche markets for agricultural commodities. Such reforms would in the long run transform market structure into what Holmlud (1992) termed as "new agriculture" with better returns to farmers as a result of higher commodity prices. Reforms in cooperative movement were also aimed at improving opportunities for farmers to address their collective economic needs and aspirations more efficiently (Chambo, 2009). The aims of reforming cooperatives in Kenya was also in agreement with Mude (2006) who stated that "reforming the cooperative movement leads to amplified ability of farmers to control their resources thereby making them realize higher benefits from farm enterprises".

Reform process in the Kenyan agricultural sector has been very slow yielding minimal tangible benefits to farmers. Some of the major reasons for the non-realization of reform objectives was that the process was broad, far reaching, poorly sequenced and not synchronized with other policies (Gitu, 2004). According to Nelson (2007), reforms in the coffee industry have also been slow due to external factors that include the coffee crisis (sharp decline of coffee prices in the international market). Worse still, empirical knowledge on the effects of what has been recommended through policies is either lacking or very limited. Therefore the need for scientific research focusing on effects of reforms on the performance of agricultural commodities cannot be overemphasized. This is the area in which this study intended to make a contribution.

2.3 Diversification in Coffee production

Diversification means "inclusion of several species in a crop production plan" (Blade et al, 2002). One advantage of this type of cropping pattern is buffering against low prices in a specific crop. Diversification therefore allows producers to balance low prices in one or more crops. Intercropping on the other hand is defined as an agricultural practice of cultivating two or more crops in the same space at the same time, (Andrews et al, 1976). From these definitions diversification and intercropping may be viewed as synonyms and have been used interchangeably in this study.

Diversification in agriculture allows producers to shift among alternative crops (Vyas, 1996). It may be classified into three types namely: shifting from less profitable to more profitable crops (horizontal diversification), shifting from farm to non-farm activities (vertical diversification), and dividing the use of resources among diverse activities (horizontal and vertical diversification) (Davis et al, 1997). The latter is the most common practice in coffee growing areas in Kenya. Diversification may be conceptualized as a risk management strategy involving multiple enterprises. This is in agreement with Lyadres (2004) who in a study on diversification in coffee production established that multiple cropping reduces over-reliance on one particular crop by farmers. The conceptualization of diversification as a risk management tool is also in line with Renato (2008) who in a similar study summed up the phrase "one should not keep all the eggs in one basket" given the unpredictability of the world processes which includes agricultural commodity production process.

Studies on effects of diversification on economic efficiency of specific crops and especially where a cash crop is involved have not received adequate attention by scientists in the past in Kenya. For instance, Bryan Dorsey (not dated) in a coffee diversification study carried out in Kirinyaga district, Central Kenya, established that diversification in production provides smallholder farmers with an opportunity to increase food availability and farm-generated income. Scientific information about efficiency in coffee-foodcrops intercropping practices is limited even in other countries. For instance, Hayami et al (1994) and Maurizio B. et al (2006) in their farming diversification studies limited themselves to the effect of intercropping on poverty alleviation and protection of the environment. Katia et al (2006) also carried out a similar study in Veracruz, Mexico but limited the study to effects of diversification on revenue potential, price risks, producer income and rural development. It was therefore clear that information about efficiency in coffee diversification cropping practices was inadequate. This study's relevance could therefore not be overemphasized.

Previous studies about synergistic effects between crops in an intercropping system propagated sentiments of positive association. For instance, Ouma, (2009) in a study on bananas intercropping in East Africa established that some of the benefits of intercropping are: risk minimization, effective use of available resources, efficient use of labor, increased production per unit area of land, erosion control and food security. A similar study focusing on intercropping between coffee and subsistence crops by Omolaja et al (not dated) in Mambilla plateau, Nigeria established that coffee yields were lower in the monocropping practice as compared to intercropping practices. Govereh (2003) in a study on effects of planting cash crops and food crops together observed that contrary to the conventional view that intercrop farming is disadvantageous in bringing about competition for land and labor, there are benefits associated with cash crop schemes that avail inputs on credit, management training, and other resources that could benefits food crops thereby increasing productivity. The study also established that intercropping coffee with subsistence crops such as bananas may also lead to other advantages that include: provision of shade, mulch, nutrients, moisture and reduced soil erosion all of which may increase performance of the coffee enterprise. The subsistence crops in the intercrop farming do not only provide food but also income thereby providing a modest but continuous cash flow throughout the year. The above studies however have a common characteristic in that they did not given attention to efficiency aspects of crops in the intercropping patterns.

2.4 Understanding Economic Efficiency

A production process may be presented in a graphical way showing the relationship between inputs and outputs. According to Derbertin, (1996) a graphical presentation showing the level of outputs that can be derived from every level of inputs forms the production function. Therefore, a production function describes the technical relationship that transforms inputs (resources) into outputs. The production function may also be referred to as a production frontier if it describes the highest level of outputs achievable from every level of inputs. Production resources are usually limited implying that farmers need to make rational decisions not only on how much of the available resources to use, but also on how to allocate them. This forms the basis for technical, allocative and economic efficiency.

Economic efficiency is defined as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology (Kopp et al, 1982). According to Varian, (2003) a system is economically efficient if; no one can be made better off without making someone else worse off; more output can be obtained without increasing the amount of inputs or if production proceeds at the lowest possible per unit cost. Economic efficiency may be differentiated from technological efficiency in that it occurs when the cost of producing a given output is as low as possible while technological efficiency occurs when it is not possible to increase output without increasing inputs. On the other hand, allocative efficiency reflects the ability of a firm to use inputs in optimal proportions given their respective prices and the production technology.

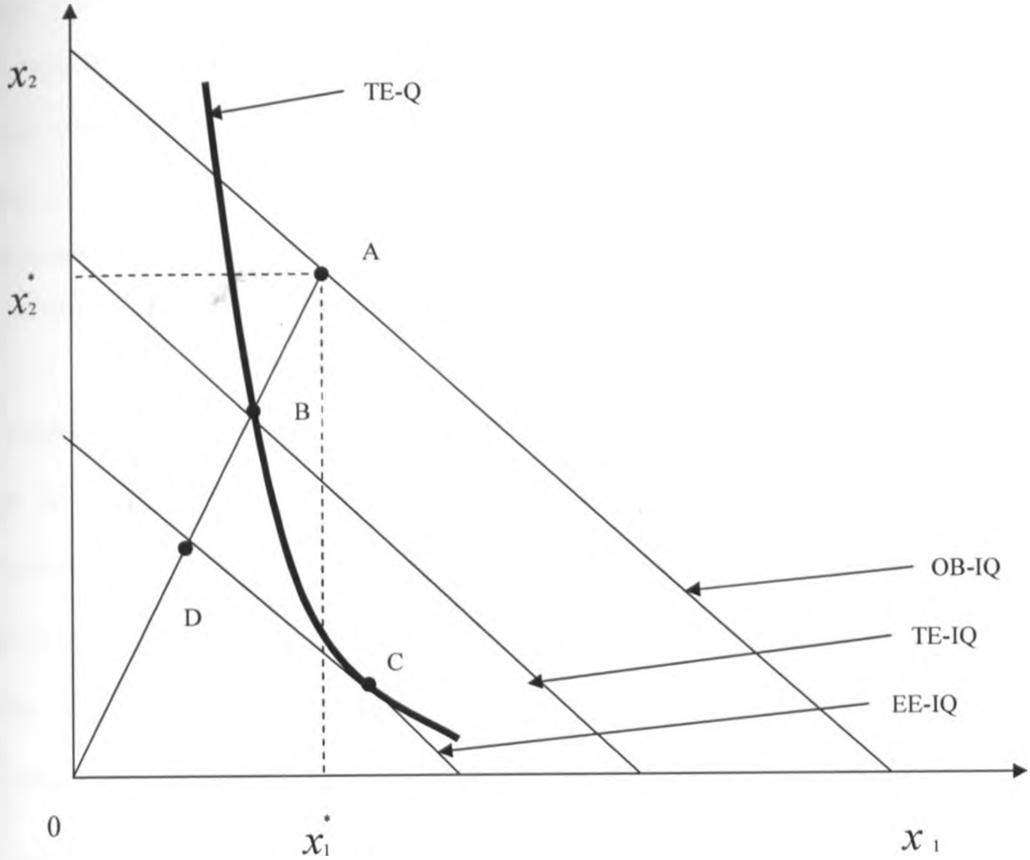
Efficiency forms the basis for understanding the neoclassical theory of production frontier which is defined as the maximum possible output attainable from a given vector of inputs (Coelli et al, 2001). However, the problem with the concept of 'maximum' is that it is not possible to recognize it simply by observing the actual level of output unless the observed output is assumed to be the maximum. Such an assumption is not realistic since different producers produce different levels of output even if they use the same level of each observed input. Ozkan et al, (2009) suggested that identical yields cannot be attained from two or more production units using equal amounts of inputs. The difference in performance of such two producers may be measured by their economic efficiency.

The existence of deficits in efficiency implies that there is room for increasing output without any additional inputs and without the need for new technological structure (Coelli, et al 2001). Empirical measures of efficiency are necessary in order to determine the magnitude of the gains that could be obtained by improving performance in agricultural production within a given technology. Determining the levels of economic efficiency has important policy implications (Shapiro et al, 1977). Koopmans (1951) suggested that economic efficiency forms the foundation of planning for a production unit. It is therefore imperative that researcher studies should focus not only on productivity but also on economic efficiency.

2.5 Efficiency Measurement

Efficiency measurement in production is a way of assessing performance. It is an indication of the performance of the farm in conversion of input(s) to output(s) (Coelli et al, 2001). The economic literature on efficiency normally distinguishes two types of efficiencies, namely: technical and allocative efficiencies. Combination of technical and allocative efficiency result in economic efficiency (Farrell et al, 1957). There are various methods of measuring efficiency of production systems. Most of these methods stem from the initial efficiency studies conducted by Debreu (1951) and Ferrell (1957).

Technical efficiency (TE) measures ability of a firm to produce on the production frontier isoquant. The latter is shown in figure 2.1 and denoted by TE-Q. Measurement of technical efficiency is based on obtaining maximum possible output from a set of production inputs. Therefore existence of technical efficiency means production of maximum amount of output by use of a certain level of inputs within a given production technology. On the other hand, allocative efficiency (AE) is associated with behavioural objectives that include cost minimization, revenue maximization or profit maximization (Papadas et al, 1991). It is the ability of a firm to produce at a given level of output using the cost-minimizing input ratios. This means production of optimal output set in response to given input prices. Allocative efficiency is said to occur if the producer equates the marginal rate of technical substitution between each pair of inputs with the respective input price ratio. Allocative efficiency is therefore dependent on prices and measures the firm's ability to make optimal decisions on product mix and resource allocation. Allocative inefficiency on the other hand reflects over-utilization or under-utilization of resources, hence failure to minimize costs or operating below potential. This implies operating at a loss or below optimal level .Technical and allocative efficiencies are illustrates graphically in Figure 2.1.



Key:

x_1 and x_2 = Two inputs used to produce output Y

$\overset{*}{x_1}$ and $\overset{*}{x_2}$ = Observed input combination at point A

TE-Q = Technically Efficient Isoquant

OB-IQ= Observed Isocost line for observed production at A

TE-IQ= Technically Efficient Isocost line

EE-IQ= Economically Efficient Isocost line

Figure 2. 1: Graphical presentation of Observed, Technically and Economically Efficient Cost Measures

Source: Bravo-Ureta, (1997) Page 51

Economic efficiency is also demonstrated graphically in Figure 2.1. Production at any point along TE-Q for instance point 'B' is technically efficient but not necessarily allocatively efficient. Production at a point outside TE-Q for example point 'A' by use of $x_1^{\bullet}$ and $x_2^{\bullet}$ inputs is technically inefficient. Point C satisfies the objective of cost minimization when using x_1 and x_2 inputs to produce along TE-Q. Therefore production at point C is both technically and allocatively efficient. In other words it is the point at which the firm is economically efficient.

As mentioned earlier, studies on measurement of economic efficiency for cash crops have not been done in Kenya in the past. Efficiency studies for other crops are also very few. Therefore to add value to the quality of this study, literature reviewed focused on studies carried out in Kenya and other countries as well. These studies informed in the identification of the most appropriate methods of analysis and also provided a basis for authentication of the results and discussion.

One of the key research work reviewed in this study was by Rios et al (2005) which examined efficiency of smallholder coffee farms in Dak Lak Province, Vietnam. The study used a two-step analysis. Data Envelopment Analysis (DEA) which is a linear programming technique of evaluating relative efficiency for Decision Making Units (DMUs) (Coelli, 2001) was used in the first stage to calculate technical and cost efficiency measures. Tobit regression was used in the second stage to identify factors that influence technical and cost inefficiencies. Since this study is also on coffee efficiency measurements for smallholder farmers, it was considered that the same tools may be appropriate for the study. In another related study, Helena (2005) examined technical, allocative and economic efficiency scores for dairy farming enterprise in Sweden by use of both the stochastic frontier approach (SFA) and DEA methods. SFA is a parametric model implying that it assumes a production function for the technology (Coelli, 2001). DEA and SFA are alternative methods for evaluating efficiencies and were used for purposes of comparison. The study indicated that DEA was a more appropriate tool since it does not require any function to be chosen for the technology.

Mulwa et al (2009) in a related study used a two-step estimation technique (DEA meta-frontier and Tobit Regression) to highlight inefficiencies in Maize cultivation in Western Kenya. Meta-frontier as defined by Hayami et al (1971) is one that envelops the commonly conceived classical production functions. In other words, a meta-frontier is the totality of regional technologies. Results of the study showed that maize producers in the study survey had between 20-30 percent technical inefficiency and about 50 percent allocative inefficiency. Since economic efficiency is a combination of both technical and allocative efficiencies, the study revealed that allocative efficiency is more limiting than technical efficiency in agriculture. The study also established that some of the socioeconomic factors that influence economic efficiency of maize production in Kenya are: farmer's education level, off-farm activities and contact with extension services. Since coffee is an agricultural commodity just like maize, the study provided an insight about farmers' specific attributes which were likely to influence economic efficiency for coffee production in Kenya.

A similar study by Paudel et al (2009) provided this study with information of socioeconomic factors that had a positive influence on adoption of fertilizer use in maize production in Nepal. The study used a sample of 117 farm households and used Tobit regression model to establish that the major factors that have influence on adoption of fertilizer use were: family size, farm size, credit use, off-farm activities, training and farm income. The study indicated that Tobit model was appropriate in the second stage of efficiency analysis.

Esmaeili et al (2007), estimated technical, allocative and economic efficiency of fishermen in Hamoon Lake, Iran by use of cross sectional data from 74 respondents. DEA technique was used to establishe that the average technical, allocative and economic efficiencies were 82.7 percent, 75.5 percent and 62.5 percent respectively. The study also showed that respondents who participated in extension classes and had high level of farm income were more efficient. Apart from informing this study about some of the socioeconomic factors that were likely to influence the level of efficiency in fishing, the study also showed that DEA could be used to evaluate performance of non-farming activities. Idiong (2007) estimated technical efficiency for 112 small-scale rice farmers in Cross River State, Nigeria by use of SFA method. The results indicated that rice farmers in the study area were 77 percent technically efficient meaning that there was a potential of 23 percent for improving efficiency. The mean technical efficiency was relatively high. Educational level, membership of cooperative society (farmer association) and access to credit had positive influence on efficiency. Apart from the study presenting SFA as an alternative approach to efficiency calculations, it also compares well with this study since both studies generated the sample frame from smallholder farmers who were also members of cooperative movement. The mean technical efficiency in this study was therefore expected to be high, all other factors held constant. The technical efficiency for members of cooperatives would rationally be expected to be high since these institutions capacity build their members on good husbandry practices.

Boris et al (1993), estimated the level of technical, allocative and economic efficiency for a sample of peasant farmers from Eastern Paraguay by use of SFA approach. The average economic efficiency was 40 percent for cotton and about 52 percent for cassava suggesting considerable room for productivity gains for the farms in the sample through better use of available resources given the technological structure. The study also established that improvements in educational and extension services would lead to more efficient production in Paraguay. The study also highlighted SFA as an alternative method to calculation of efficiency in agriculture though DEA was used in this study.

2.6 Socioeconomic Factors in relation Economic Efficiency.

The main path to development of smallholder farming is through improved technologies, appropriate field husbandry methods and management practices. This implies that farmers are required to have the ability to make the right decisions about acquisition and utilization of resources in a way that maximizes output at minimal cost. In other words farmers will be efficient both technically and allocatively and hence economically efficient.

The ability of farmers to make the appropriate decisions in farming activities is influenced by among other things the farmer specific characteristics that include: age of household head, gender, education level, household size, off-farm work, access to extension services, credit and attitude toward farming. This is in line with the findings of most studies dealing with agricultural production. For instance, Kalyebara (1999) in a study on factors that influence adoption of improved coffee management recommendations in Uganda established that education, farm size and contact with extension services were statistically significant at 10 percent level for smallholder farmers.

Pudasaini (1983) in another study on factors that influence performance of agriculture in Nepal established that education improves farmers' allocative ability, enabling them to select improved inputs and optimally allocate existing and new inputs among competing uses. Similarly, Paudel (2008) established that the level of formal education for household heads, contact with extension and availability of credit facility resulted to improved agricultural activities. Owens et al. (2001) while investigating the impact of agricultural extension services on farm productivity established that the ability of farmers to effectively diversify their farming system is influenced by their contact with agricultural extension officers. The study also showed that access to agricultural extension services, raises the value of crop production by about 15 percent. Herath et al (2003) while examining the variables that influence farmers' awareness and attitudes towards intercropping of immature rubber stands in Sri Lanka established that contact with extension, education level, and experience in farming positively influenced the probability of farmers to adopt new technologies.

The findings of the above studies showed that after establishment of the level economic efficiency (performance) of agricultural enterprises; it was important to analyze the factors that influenced this efficiency. This would add more value to such studies by giving guidance on formulation of policies that would alleviate the shortfalls in the efficiency. Credit is one of the critical non-land inputs that contribute to stabilization of agricultural production, improvement in food security and income generation (Republic of Vietnam, 2004). The demand for agricultural credit arises because realization of income happens at a different time from the time of expenditure. Farmers may also need to invest in expensive fixed capital such as purchase of land or machinery for instance pulping machines in coffee production. Accessibility of agricultural credit may be constrained by factors such as high transaction costs, lack of infrastructure in the rural areas, lack of collaterals and farmers being risk averse (Golait, 2007). On the other hand, effectiveness of agricultural loans may be constrained by diversion of the credit to non-farm activities. Diversion of agricultural credit may be curtailed by giving farmers basic training on efficient management of loans.

Holden, (2004) in a study on non-farm incomes in Ethiopia established that off-farm income may increase average income where seasonal labor demands differ across activities. Access to non-farm cash earnings may also ease credit constraints and smooth consumption, thereby increasing food security and enabling households to improve their livelihoods (Matshe et al, 2004 and Araujo, 2003). Off-farm work may also complement on-farm productivity by increasing the household capacity to purchase farm inputs and make on-farm investments that result to improved yield and labor productivity (Taylor et al, 2003). Matshe et al, (2004) examined the decision to participate in off-farm work and the amount of time devoted to this activity by individual household members in Zimbabwe. The study established that women were less likely to work off-farm as compared to men. Education was also identified as having a positive impact on the off-farm work implying that returns to education were higher for off-farm as compared to on-farm activities. Jolliffe (2004) estimated returns to education in off-farm earnings and on-farm profits at the household level and established that households with higher average education levels allocated more labor to off-farm work and also have higher off-farm earnings. The results also showed that the average level of household education has a negative effect on the household labor supply in smallholder farming.

Agricultural extension services provide farmers with important information, such as patterns in crop prices, new seed varieties, crop management, and marketing. Exposure to such activities is intended to increase farmers' ability to optimize the use of their resources (Muranya et al, 2006). Thus extension services may lead to improved efficiency in agricultural production thereby contributing to poverty reduction as envisaged in the Agriculture Sector Development Strategy (ASDS), (Republic of Kenya 2010). In addition, ideal extension system provides feedback from farmers to research centres and other actors in the economy.

Extension services in Kenya are provided through three different models or a combination of them: model 1 offers free public extension services, mostly to smallholder farmers including coffee farmers; model 2 is characterized by provision of extension services on partial cost shared basis and model 3 is signified by full commercialization of extension services involving private companies and Cooperatives among others (National Agricultural Sector Extension Policy (NASEP) - Republic of Kenya, 2007). Muranya (2006) in a study on

Agricultural Extension in Kenyan observed that private extension provision is generally skewed towards high potential regions and high value crops. This implies that potential of providing extension services through public-private partnership could be enhance in coffee growing areas since the crop is a high value export crop. However, this form of pluralistic extension system might be challenged by lack of regulatory system for coordinating the extension providers (NASEP, Republic of Kenya 2007).

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Conceptual Framework

The incentive structure presented in Figure 3.1, level B forms the basis under which socio-economic factors presented in level C collectively influence the decision making by farmers. It is envisaged that farmers' perception at level C depending on the availability and accessibility of the appropriate production technologies, gender, education level, age, cropping practices (monocropping or intercropping), opportunities off-farm activities and credit accessibility determine utilization of resources in a way that maximizes outputs (technical efficiency) at minimal cost (allocative efficiency). Level D presents the ultimate outcome of combining technical and allocative efficiency which is the economic efficiency. However, there are negative effects resulting from policies that favorably influence some socio-economic factors as presented by the downward facing dotted arrows in level A. Nevertheless, it is assumed that the positive effects indicated in the conceptual framework will outweigh the negative effects.

The figure visualizes that policies addressing provision of extension services, research, public-private sector partnership and private sector incentives may influence economic efficiency through adoption of cropping practices such as monocropping or intercropping among other things. It is also shown that policies on infrastructure in schools, personnel and sensitization campaigns may positively influence economic efficiency through acquisition of higher education. However, such policies may also have indirect negative influence on economic efficiency through overcrowding in schools thereby resulting to poor quality education. Policies on farm credit may positively influence economic efficiency if the farmers are capacitated to acquire credit and use it to procure farm inputs that they would otherwise not have been able to buy without credit. But if the credit is not used for that purpose, it may not positively influence economic efficiency as shown by the downward facing dotted arrow. The effects of off-farm activities will depend on whether the labour that would otherwise have been employed in coffee production is replaced by labour with equivalent skills or not.

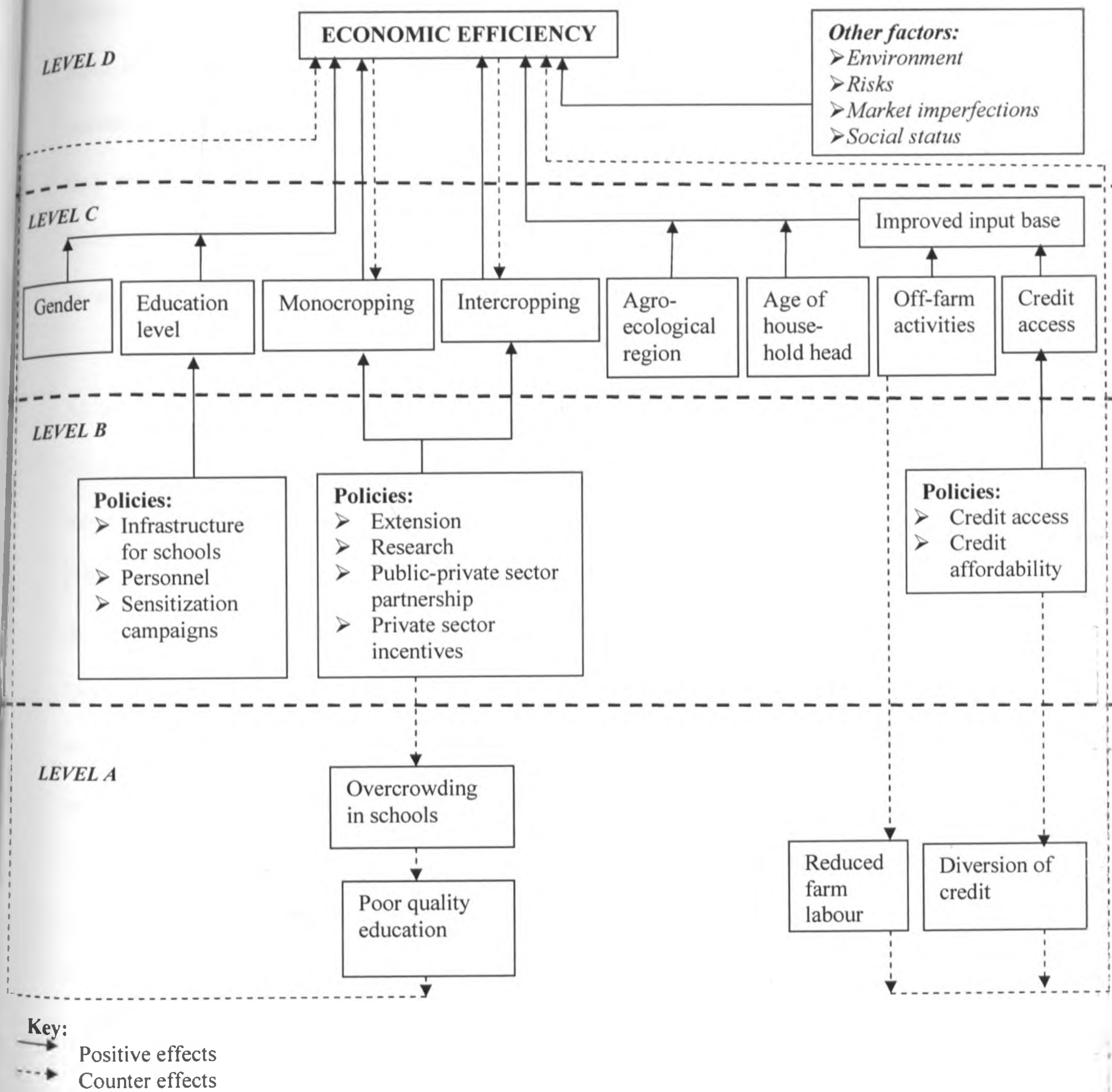


Figure 3. 1: Conceptual framework of economic efficiency for coffee production

Source: Adapted from Mutoko, (2008) page 40

3.2 Theoretical Framework in the Analysis of Economic Efficiency

Economics is defined as the study of allocation of resources among competing end uses (Nicholson, 1992). The definition stresses two important features which are that productive resources are scarce and that how these resources are allocated is a concern for economists. Firms which are operating on the production frontier (maximum output attainable from each input level) are said to be technically efficient. They are technically inefficient if they are operating beneath that frontier. On the other hand, firms are said to be allocatively efficient if they select that mix of inputs which produce a given quantity of output at minimum cost under the prevailing input prices. Combination of technical and allocative efficiency results in economic efficiency measure.

As mentioned earlier, the common types of models for measuring efficiency are SFA and DEA. The two approaches were derived from the methods of measuring efficiency introduced by Farrell (1957). SFA was initially independently proposed by Aigner et al (1977) and Meeusen et al (1977) and was later improved by Kopp et al in (1982) and by Bravo-Ureta et al in 1991. The SFA is composed of deterministic and stochastic models. Deterministic models are also referred to as 'full frontier' models. These production functions were the earlier method of estimating technical efficiency. They impose a limiting assumption that the entire deviation from the technically efficient frontier is due to inefficiency. The models envelope all the observations, identifying the distance between the observed production and the maximum production defined by the frontier and the available technology as technical inefficiency. The deterministic specification assumes that all deviations from the efficient frontier are under the control of the farmer (Kopp's, 1982). However, there are circumstances beyond the control of farmers which also determine the suboptimal performance. These are for instance the regulations by government; weather; socio-economic and demographic factors (such as age and gender); uncertainty and measurement errors. The deterministic models therefore do not have the assumed error term implying that they have limitation on the statistical inference (hypothesis testing) on the parameters (Ogundari et al, 2006). Deterministic models as proposed by Kopp's (1982) are demonstrated as follows:

$$Y_j = f(X_{ij}; \beta)$$

Whereby; Y_j = Output of the j^{th} farm

f = Production function

X_{ij} = i^{th} input vector used by farm j

β = Vector of unknown parameters

Due to the limitations of the deterministic methods, Bravo-Ureta et al (1991); Aigner et al (1992) and Meeusen et al (1997) independently developed the stochastic frontier in order to overcome the deficiency. The stochastic model was then presented as indicated below:

$$Y_j = f(X_{ij}; \beta) + \varepsilon$$

Whereby: Y_j, f, X_{ij} and β are as defined above,

ε = "Composed" error term

The "composed" error term can be written as ε = v - u (Aigner et al (1977) in order to separate the random element from the efficiency component. v denotes a two sided $(-\infty < v < \infty)$ normally distributed random error that captures the stochastic effects outside the farmer's control for instance; weather, natural disasters, and luck; measurement errors, and other statistical noises. The random error component (v) is assumed to follow a symmetric distribution in the traditional normal error term with zero mean and constant variance. On the other hand, the term u which is the technical inefficiency component is assumed to follow an asymmetric distribution and may be expressed as a half-normal, truncated normal, exponential or two-parameter gamma distribution. It is one-sided ($u \geq 0$)

and measures the shortfall in output Y from the achievable maximum given by the stochastic frontier. The two components (v and u) are however assumed to be independent of each other.

Deterministic frontier functions can be solved either by use of mathematical programming or by econometric techniques while stochastic specifications are estimated by means of econometric techniques only. Stochastic frontier approach has the advantage of making inference of the technical inefficiency possible since it incorporates the error term (Coelli et al, 2002). However, the method is sensitive to the choice of functional form.

This study employed the variable returns DEA approach to estimate the economic efficiency indices. The DEA model was introduced by Charnes et al (1978) to measure efficiency under the assumption of constant returns to scale. It was then extended by Banker et al (1984) to allow for variable returns to scale. The model is based on the notion that a production unit employing less input than another to produce the same amount of output can be considered as more efficient. The tool can be used to compute the perceptible best actors in a production process. Then other actors are compared with the best ones and relative efficiency scores allocated to them. The approach is non-parametric meaning that it does not require assumptions about the population distribution (Anderson, 1987). Unlike the parametric approach which assumes the existence of a specific transformation technology that determines the maximum amounts of outputs that can be produced from different combinations of inputs, the starting point for DEA is the construction, from the observed data, of a piecewise frontier surface. The surface is assembled by solving a sequence of linear programming problems, one for each farm and relating each farm to this frontier. The created frontier envelops the observed input and output data of each farm. Unlike the stochastic frontier techniques, DEA has no accommodation for noise, and therefore can be considered as a non-statistical technique whereby the inefficiency scores and the envelopment surface are 'calculated' rather than estimated.

DEA method produces relative efficiency measures since they are generated from actual observations for each farmer. The model can consider multiple inputs and outputs simultaneously. Inputs and outputs can also be quantified using different units of measurements. This study however, considered a relationship of two outputs (cherry and *mbuni*) with various inputs that included: fertilizers, manure, foliar feeds, fungicides, pesticides, family labor and hired labor. DEA method is advantageous in that it does not impose a functional form on the production function (Färe, 1985; Lovell, 1993 and Ray, 2004). This means that the danger of imposing a wrong functional form is avoided. However, the approach has the disadvantage in that it does not allow for direct hypothesis testing (Ray, 2004).

The DEA piece-wise frontier is illustrated in Figure 3.2. For simplicity purposes, the figure illustrates farmers using two inputs X_1 and X_2 to produce a single output Y under the assumption of constant returns to scale (Farrell, 1957). From the figure, points A, A', B, B', C and D may be presumed to represent farmers who produce various amounts of output Y by use of two inputs (X_1 and X_2) combination.

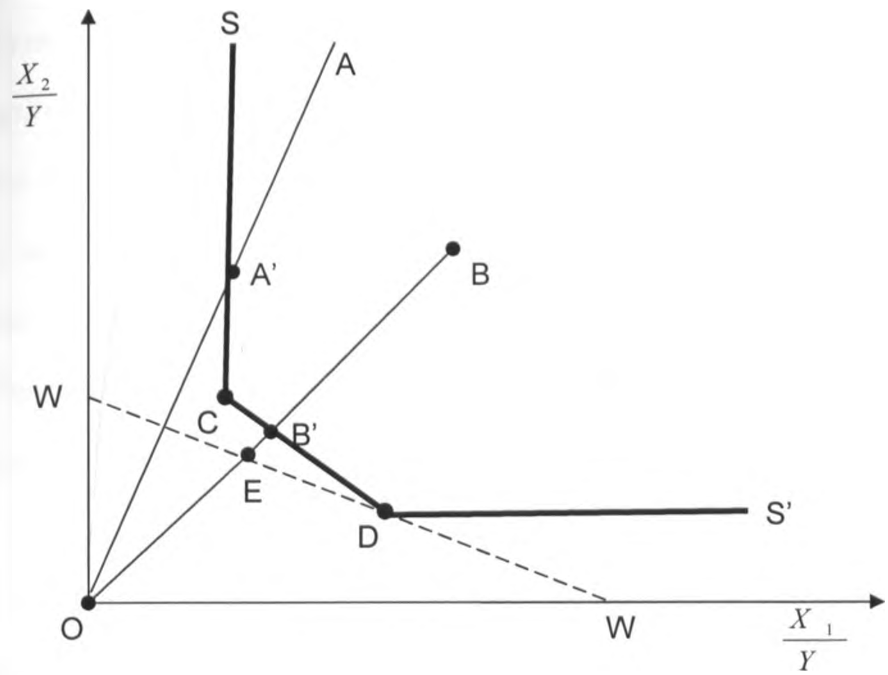


Figure 3. 2: Illustration of efficiency using input - oriented piecewise linear convex isoquant

Source: Coelli, (2001) page 143

The line SS' represents the full technical efficiency isoquant frontier derived by DEA technique. It illustrates the locus of farmers who are fully efficient. Efficiency measures for other farmers are then calculated relative to this frontier. For example a farmer in the sample survey who is operating at point B has technical efficiency given by OB'/OB. Point B' represents a producer who is fully technically efficient. Knowledge of the input price vector for this producer would help in the determination of allocative efficiency. If the line WW represents the isocost line for the farmer operating at point B with an input price vector of w, then, allocative efficiency for the producer is given by OE/OB'. Economic efficiency is given by the product of technical and allocative efficiency (that is, [TE X AE]) (Farrel, 1957). Hence for a farmer operating at point B economic efficiency is given as: [OB'/OB X OE/OB'] which is equal to OE/OB. D represents the point at which farmer B would be both technically and allocatively efficient hence, economically efficient.

Measurement of economic efficiency as mentioned earlier is mainly based on the parametric or on non-parametric methods. The choice of estimation method depends on the preference of the particular researcher though the end results are more or less equivalent (Berger, 1993) and (Seiford et al, 1990). It may be helpful to use both DEA and SFA methods and compare them on the same data set since both methods have advantages and disadvantages (Linh, 2005). But due to the limitedness of financial and time resources, only one method was employed in this study and since it involved multiple inputs and multiple outputs, DEA was considered as the most appropriate technique for empirical applications.

In the estimation of efficiency scores this study assumed variable returns to scale. Allowing for variable returns to scale is not a constraint on the model since the result would be the same as those calculated under constant returns to scale if the farms were operating at their optimal scale.

The second phase in the analysis entailed determining the factors that influence the economic efficiencies for the sampled farmers. The efficiency indices calculated in the first stage were regressed against farmer characteristics to determine whether there are special farmer characteristics that influence the level of economic efficiencies. Such information provides an opportunity for policy interventions that may improve the efficiency levels (Rios, 2005).

3.3 Empirical Analysis

3.3.1 Estimation of economic efficiency for coffee production in Mathira District

As mentioned earlier the DEA approach was used in the estimation of economic efficiency indices in this study. The model uses linear programming analysis to construct a frontier around the observed data. Efficiency is then measured relative to this frontier, and all deviations from the frontier are assumed to be inefficiencies. To estimate the economic efficiency, the first step is to calculate the technical efficiency. According to Murillo, (2001), DEA calculations of technical efficiencies must be in such a manner that they maximize the relative score of each farmer. The technical efficiencies may be calculated under the assumptions of constant returns to scale or variable returns to scale. The major challenge of estimating the technical efficiencies under constant returns to scale (CRS) is that they are only feasible if all farmers were operating at an optimal scale (Coelli, 2005). In reality this is not likely since the farmers are faced with many constraints such as unfavorable weather, lack of enough finances and imperfect competition. Therefore calculation of the efficiency scores under variable returns to scale (VRS) specification becomes the most appropriate option (Tsai et al, 2002). This was the reason behind opting to use variable returns to scale in this study. The study employed a multi-input-multi-output approach since two outputs (coffee cherry and *mbuni*) were produced by use of several inputs (fertilizer, manure, foliar feeds, fungicides, pesticides, family and hired labor).

3.3.2 Empirical model specification

The first stage of economic efficiency estimation was calculation of variable returns to scale technical efficiency. To do this, multi-input-multi-output model was used which considered a positive vector of inputs (**x**) which were used to produce a positive vector of outputs (**y**) for k coffee farmers.

k = 1,…, K. Since 126 farmers were sampled in this study, K = 126

x = {fertilizer, manure, foliar feeds, fungicides, pesticides, family and hired labour}. This vector is an input requirement set (IRS) that could be denoted by: $\mathbf{x} = (x_1,...,x_K) \in \Re^{N+}$

Whereby:

$x_1...x_k$ = inputs in coffee production

$\Re^{N+}$ = non-negative vector space of all possible combinations of inputs y = {coffee cherry and *mbuni*}. This vector is an output possibility set (OPS) that can be denoted by: $\mathbf{y} = (y_1,...,y_M) \in \Re^{M+}$

Whereby:

$y_1...y_m$ = coffee outputs

$\Re^{M+}$ = non-negative vector space of all possible combinations of outputs

From the available IRS and OPS, the producers may select any Production Possibility Set (PPS) which is a vector space ($\Re^{M+N}$) that could be denoted by **T**. According to Fare et al (2003), any producer may select any input-output combination $(\mathbf{x}, \mathbf{y}) \in \mathbf{T}$. The set **T** is a collection of all feasible input-output vectors that could be presented as: $\mathbf{T} = \{(\mathbf{y}, \mathbf{x}) : \mathbf{x} \in \Re^{N+} \ \textit{can produce} \ \ \mathbf{y} \in \Re^{M+}\}$. In other words, any combination of inputs (vector **x**) can produce an output possibility set (vector **y**) and **T** is the set of all possible input-output vectors (**x-y**).

With knowledge of the above variables, VRS technical efficiency indices are obtained by solving VRS DEA equations which finds the vectors of weights that maximize the efficiency score of the kth farmer subject to the constraint that none of the farmers has efficiency score greater than one at those weights. According to Banker et al ((1984), the DEA equations take the format given below:

$$DF^{L}{}_{(x,y)} = \min \phi_k^{VRS} \{\phi_k^{VRS} \geq 0\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$st: \sum_{k=1}^{k} \lambda^k y_m^k \geq y_m^* \qquad m = 1,...,M \ \ (Constraint\ a)$$

$$\sum_{k=1}^{k} \lambda^k x_n^k \leq \phi_k^{VRS} x_n^* \qquad n = 1,...,N \ \ (Constraint\ b)$$

$$\sum_{k=1}^{k} \lambda^k = 1, \ \ \lambda^K \geq 0, \ \ k = 1,..., K \ \ (Constraint\ c)$$

Whereby,

$DF^{I}{}_{(x,y)}$ = Debrue-Farrell input-oriented efficiency measure

k = coffee farmer

x = inputs used by farmer k

y = outputs (cherry and *mbuni*) achieved by farmer k

ϕ_k^{VRS} = Farrell technical efficiency for farmer k under variable returns to scale

Note:

The parameter ϕ_k^{VRS} scales down inputs of farmer k to the lowest possible level subject to the constraint that the minimized level must still be able to produce the original output bundle. The scaling down of inputs aim at constructing a virtual farmer whose outputs are the same as for the real (observed) farmer. The difference in input use between the two farmers (virtual and real one) denotes technical efficiency which is the proportionate reduction of inputs without reduction in outputs.

λ = (Kx1) vector of weights attached to each of the coffee farmers

x_n^{*} = the cost minimizing or economically efficient input vector for farmer k given the input price vector p_{xn}^{k}

y_n^{*} = output vector of farmer k at the economically efficient level

Constraints:

Constraint 'a' requires that the weighted average coffee outputs of all farmers $\left(\sum_{k=1}^{k} \lambda^k y_m^k\right)$ minus the outputs of the kth coffee farmer be greater than or equal to zero. This implies that the outputs of the virtual coffee farmer being constructed have to be at least y_m^{*} units.

Constraint 'b' requires that the virtual coffee farmer should not use more than x_n^{*} level of inputs.

Constraint 'c' ensures that an inefficient farmer is benchmarked against farmers of similar size. The projected point on the frontier for such a farmer is a convex virtual combination of observed farmers.

The second stage model for estimation of economic efficiency indices incorporates the input and output prices. The model assumed that the k[th] coffee farmer faced a set of input prices presented by the price vector $\mathbf{p_x}$ which can be denoted by $\mathbf{p_x} = (p_1,\ldots,p_n) \in \Re^{N+}$. On the other hand the model assumed that the k[th] farmer faced a set of output prices presented by the output price vector $\mathbf{p_y}$ which can be denoted by $\mathbf{p_y} = (p_1,\ldots,p_m) \in \Re^{M+}$.

Whereby:

$p_1 \ldots p_n$ = price of inputs used in coffee production

$p_1 \ldots p_m$ = price of coffee outputs

$\Re^{N+}$ = non-negative vector space of all possible prices of inputs

$\Re^{M+}$ = non-negative vector space of all possible prices of outputs

According to Coelli et al (2005), knowledge of the above variables enables the estimation of overall economic efficiency by solving the input-oriented cost minimizing DEA model. This model incorporates the input price vector $\mathbf{p_x} = (p_1,\ldots,p_n) \in \Re^{N+}$ and is presented in equation 2

$$C^L(y, p_x) = \min_{x_n^*} p_{xn}^k x_n^* \{p_{xn}^k, x_n^* > 0\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$st. \quad \sum_{k=1}^{k} \lambda^k y_m^k \geq y_m \qquad m = 1,\ldots, M$$

$$\sum_{k=1}^{k} \lambda^k x_n^k \leq x_n^* \qquad n = 1,\ldots, N$$

$$\sum_{k=1}^{k} \lambda^k = 1, \quad \lambda^k \geq 0, \quad k = 1,\ldots, K$$

Whereby

x_n^*, λ and k are as defined in equation 1

C^L = DEA model input-oriented overall economic efficiency

p_{xn}^k = input price vector for farmer k

The overall economic efficiency for a particular farmer k is defined as shown in equation 3:

$$EE = \frac{p_{xn}^k x_n^*}{p_{xn}^k x_n} \quad \text{...} (3)$$

Whereby;

p_{xn}^k = as defined in equation 2

$p_{xn}^k x_n^*$ = minimum cost

$p_{xn}^k x_n$ = observed cost

Since the economic efficiency is a product of the technical efficiency and the allocative efficiency [that is, EE = TE X AL], then, allocative efficiency will be derived as explained in equation 4:

$$AE = \frac{EE}{TE} \quad \text{..} (4)$$

Allocative efficiency measures relative ability of farmer k to allocate the input-bundle in the cost-minimizing way, given the estimated technology.

3.3.3 Analysis of factors that influence the level of economic efficiency of coffee farmers in Mathira District

This objective was achieved through the use of a second stage regression analysis to model farm specific attributes in explaining inefficiency in coffee production. Because efficiency measures range between 0 and 1, a two-tailed Tobit model is recommended in place of OLS regression (Ray, 2004). Tobit model is an extension of the probit model originally developed by Tobin (1958). The model is also referred to as the limited dependent variable regression model (Gujarati, 2007). The model is a censored normal regression which has wide application in statistics and econometrics. A model is said to be censored when some data on the dependent variable is lost (or is limited) but not data on the regressors. In this study, the economic efficiency indices were censored between zero and one.

The Tobit empirical model of the effects of a set of explanatory variables on the economic efficiency applying the maximum likelihood estimation (MLE) technique was specified using the following linear relationship:

$$y_k^* = X_k \beta \ \mu_k \quad \text{...} \quad (5)$$

Whereby,

y_k^* = the latent dependent variable for the k[th] farm. The variable is unobservable.

x_k = the vector of independent variables which have been postulated to affect efficiency.

They included:

x_1= Age of household head

x_2= Size of the household

x_3= Education level of the household head

x_4= Contact with extension services (number of demand-driven extension visits and follow- ups per year)

x_5= Off-farm activities

x_6= Intercropping

x_7= Access to credit facilities

x_8 = Region by agro-ecological zones

$\beta = (\beta_0, \beta_1, \ldots, \beta_n)$ represents the vector of unknown parameters associated with the independent variables for the k^{th} farm.

μ_i = an independently distributed error term assumed to be normally distributed with zero mean and constant variance σ^2.

Intercropping variable was further analyzed to establish how the various cropping practices affect economic efficiency by use of an AVOVA Tobit model which is illustrated in equation 6. This model assumes that all other things were held constant.

$$Y_i = \alpha_0 + \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 + \mu \quad \ldots\ldots\ldots\ldots\ldots 6$$

Whereby:

Y_i = economic efficiency variable

α_0 = intercept coefficient for the benchmark (coffee-monocropping) dummy variable

α_1 = differential intercept coefficient for coffee-agroforestry dummy variable

α_2 = differential intercept coefficient for coffee-bananas dummy variable

α_3 = differential intercept coefficient for coffee-beans dummy variable

α_4 = differential intercept coefficient for coffee-maize dummy variable

α_5 = differential intercept coefficient for coffee-maize-beans-bananas dummy variable

μ = error term

3.4 The Study Area

The study area covered Mathira district which was about 254 square kilometers. The district had two regions (eastern and western) with distinct agro-ecological zones. The eastern region had a total land area of 145.6 square kilometers. The agro-ecological zones from where survey data was collected in this region were UM_1 and LH_{1-2}. The western region on the other hand covered a total land area of about 108.8 square kilometers. The main agro-ecological zones in the western region from where data was collected were UM_4 and LH_2. The overall coffee growing area in the district was about 150 square kilometers which is approximately 60 percent of the total size of the district. Figure 3.3 shows the sketch map of Mathira district including the agro-ecological zones.

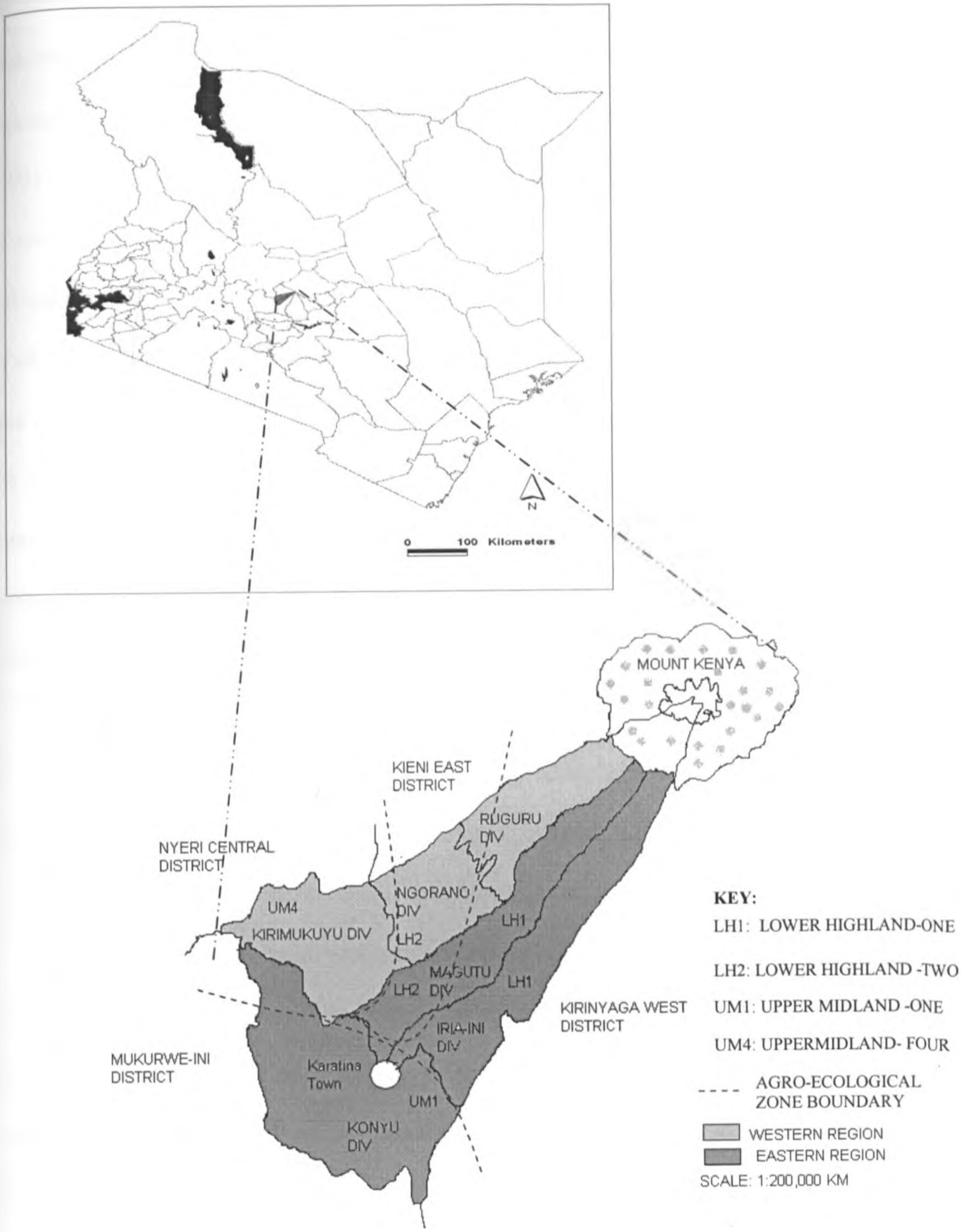


Figure 3. 3: Map of Mathira District, Kenya

Source: Sketch from District Commissioner's office

3.5 Sampling Procedure

Determination of the optimal sample size in research enables achievement of efficiency, representativeness, reliability and flexibility (Kathori, 2008). According to Bartlett et al (2001), inappropriate or inadequate sample sizes usually influence the quality and accuracy of research results. This study ensured correction of these anomalies by coming up with an unbiased sampling procedure that involved two stages. In the first stage purposeful selection of all factories in the study area was done. An up-to-date list of all small-scale coffee farmers was provided by each of the coffee society. Farmers were already numbered sequentially in the factory registers. A pre-determined number of respondents based on Cochran's (1977) sample size formula was allocated to each factory. The number allocated to each factory was based on the proportion of farmers for each factory to the total number of farmers in all the factories.

A critical component of sample size formulas including the one by Cochran (1977) is the estimation of variance in the primary variables of interest in the study. When estimating the variance of categorical or dichotomous variables it is recommended that researchers use 0.50 as an estimate of the population proportion (Krejcie et al, 1970). This proportion will result in the maximization of variance, which will also produce the maximum sample size. According to Krejcie (1970) squaring adopted population proportion gives the population variance. For example, if 0.50 is adopted as the population proportion the population variance becomes 0.25.

The Cochran's sample size formula is shown in equation 7.

$$n = \frac{z^2 (p)(q)}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Whereby:

$n=$ required return sample size

$z=$ value for selected alpha of 0.025 in each tail which equals 1.96 (from the statistical tables and for samples greater than 120)

$p=$ maximum possible population proportion (0.5 selected for this study) as mentioned earlier)

$q=$ 1- (maximum possible population proportion) = 1 - 0.5 = 0.5

$pq=$ estimate of variance or the maximum possible sample size = 0.5 x 0.5 = 0.25

$d=$ acceptable margin of error proportion or the error that the researcher is willing to accept (estimated at 0.05 for this study)

Therefore, $$n=\left(\frac{(1.96)^2(0.5)(0.5)}{(0.05)^2}\right)=384$$

According to Bartlett, 2001, this formula is suitable for both continuous data such as satisfaction and attitude as well as categorical data such as gender, education level and off-farm work. Bartlett, (2001) further identified the formula as being suitable for determining sample size for simple random and systematic random samples. Since the systematic random sampling procedure was employed in this study, the Cochran's (1977) formula was considered appropriate in determining the sample size. The formula employs two key factors. Firstly, the risk that the researcher is willing to accept in the study, and which is commonly referred to as the margin of error. The second factor is the alpha level which is the probability that Type I error will be committed.

In Cochran's formula, the alpha level is incorporated into the formula by utilizing the t-value for the alpha level selected; for example, t-value for alpha level of 0.05 is 1.96 for sample sizes above 120. According to Bartlett (2001), an alpha level of 0.05 and a margin error of 5 percent are generally acceptable for most educational and social research work. Hence, these values were adopted in this study. However, researchers may increase these values when a higher margin of error is acceptable or may decrease them when a higher degree of precision is needed, Bartlett (2001).

The table for determining sample size for a given population size for continuous and categorical data was referred for comparison purposes. For categorical data with a margin error-*d* of 0.05, *p*-value of 0.5 and *z*-value of 1.96, the minimum sample size for a population greater than 10,000 is 360 (Bartlett, 2001). Hence the calculated minimum sample size of 384 farmers was considered to be meaningful.

The total number of coffee farmers in the study area according to registers provided by the coffee society offices was 31,830. Knowledge of this figure was used in the second stage of sample size determination whereby systematic random sampling technique was used to select the k^{th} farmer from each factory. k was the sampling interval determined by dividing the population size (31,830) by the required sample size (384). The sampling interval, k was therefore 83 farmers. Due to budgetary and time constraints 80 percent (307 farmers) out of the 384 farmers (determined by Cochran formula) was considered for household data collection in this study. They were allocated to the specific coffee societies as shown in table 3.1

Table 3. 1: Number of coffee farmers interviewed in Mathira District in year 2009

Region	Name of society	Number of factories	Number of coffee growers	Proportion of coffee growers (%)	Number of questionnaires prepared for interviews
Eastern					
	Iria-ini	3	1,577	5	16
	Muguga	5	4,735	15	46
	Baricho	4	4,100	13	40
	Gikanda	3	2,168	7	21
	Kiama	5	3,558	11	34
	Gakuyu	2	1,503	5	16
Western					
	Mathira-North	5	5,000	16	49
	Rutuma	3	3,174	10	30
	Tekangu	7	6,015	18	55
Total		**37**	**31,830**	**100**	**307**

There was a general response rate of 74 percent hence 227 (that is, 0.74 x 307) filled questionnaires returned back. DEA version 2.1 method was used to estimate the efficiency indices. The tool was found to be irresponsive to the 227 farmers originally interviewed. To scale down the number that could be accommodated by the DEA version, a trial and error method was used each time randomly selecting the farmers by use of Excel program. Ultimately, the tool was able to accommodate 126 farmers whose economic efficiency levels were computed.

3.6 Data Collection

Coffee production in Mathira district is solely under small-scale production. The crop is marketed through nine cooperative societies and thirty seven coffee factories. All the factories were purposefully selected for primary data collection. The distribution of coffee societies based on regions (agro-ecological zones) in the study area was as indicated in Table 3.2.

Table 3. 2: Distribution of coffee growers in Mathira District in year 2009

Eastern region			Western region		
Name of society	Number of factories	Number of coffee growers	Name of society	No. of factories	No. of coffee growers
Iria-ini	3	1,577	Mathira-North	5	5,000
Muguga	5	4,735	Rutuma	3	3,174
Baricho	4	4,100	Tekangu	7	6,015
Gikanda	3	2,168			
Kiama	5	3,558			
Gakuyu	2	1,503			
Total	**22**	**17,641**		**15**	**14,189**

The nine society headquarters each of which is managed by a secretary/manager provided most of the vital secondary data. There was restructuring of coffee societies in the study area since 2005 aimed at promoting economic efficiency and the general welfare of members in accordance with the cooperative principles and values (Baricho Society Strategic Plan, 2009). As such, the available production and price data for all but one society (Iriai-ini) were limited to between three and seven years.

The survey data was collected between April and May 2010. Secondary data was solely provided by reports from the offices of local extension providers and society secretary/managers. Primary data was collected by use of semi-structured questionnaire during formal household survey of the sampled farmers in thirty seven coffee factories. Enumerators were recruited through vetting which was done with the assistance of district agricultural officer, Mathira district and secretary/managers for the respective coffee societies. They were then trained on objectives of the study, the meaning and implication of each question, interviewing skills, time management during interviews, recording of responses and ethical issues relating to interaction with the respondents and their family members during interviews.

The questionnaire was written in English language but the training was conducted in a mixture of vernacular, English and Kiswahili in order to clarify all the details properly. During the interviews, vernacular was the predominant language though the other two were also used. Ten farmers were interviewed during pre-testing exercise which was considered as part of the training. The necessary adjustments were made to the questionnaires in order to enhance correction of relevant data based on the specific objectives of the study.

The cross-sectional data collected for estimation of small-scale coffee economic efficiency included physical quantities of coffee output (cherry and *mbuni)* and inputs (fertilizers, manures, fungicides, pesticides, mulching, foliar feeds and labor) used in coffee. To identify the factors influencing the level of economic efficiency, data was also collected on the age of household head, gender of the household head, education level measured in number of years of formal schooling, size of the house hold, contact with extension services, off-farm income, coffee farming practices (intercropping and monocropping), access to credit and the agro-ecological zone where coffee was growing. The data was collected for the 2009/10 cropping season.

3.7 Problems encountered during data collection phase

The major constraint in the survey was that most farmers did not have farm records and those that had them were deficient and poorly kept. The data therefore depended on the capability of the respondents to recall. This was difficult and unreliable particularly for the elderly farmers. However enumerators were advised to counter-check some facts with other family members who were available in the farms and who were more knowledgeable about farming activities for the period under study.

There was also the problem of some farmers harboring the mentality of getting free goods either in financial or material form such as fertilizers and chemicals from the enumerators as a gesture to reciprocate the chance offered for interview. Other farmers were reluctant to give farming information and especially financial information on the basis of fear that it might lead to taxation by government. However the enumerators were able to overcome these problems through the implementation of skills learned during the training. Other problems that were encountered related to variability of units of measurement for the inputs. For instance, manure was reported in sacks, buckets, wheelbarrows, pickups or lorries. For fungicides and pesticides there were confusion between kilograms and litres in some instances since both chemicals were available in the two forms. This was overcome by cross-checking labels of used containers held by farmers or from containers of unsold stock in the shelves of agrochemical shops. Ultimately the measures were standardized into kilograms for manure and fungicides and litres for pesticides. Though the task was difficult and time consuming, it was necessary for harmonization of measurement units for the various inputs.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

The coffee societies in Mathira District did not provide production and price data for as many years as was available for the National data (see Figures 1.2 and 1.3 in chapter one). The production and price trends for Baricho society are shown in figures 4.1 and 4.2 respectively.

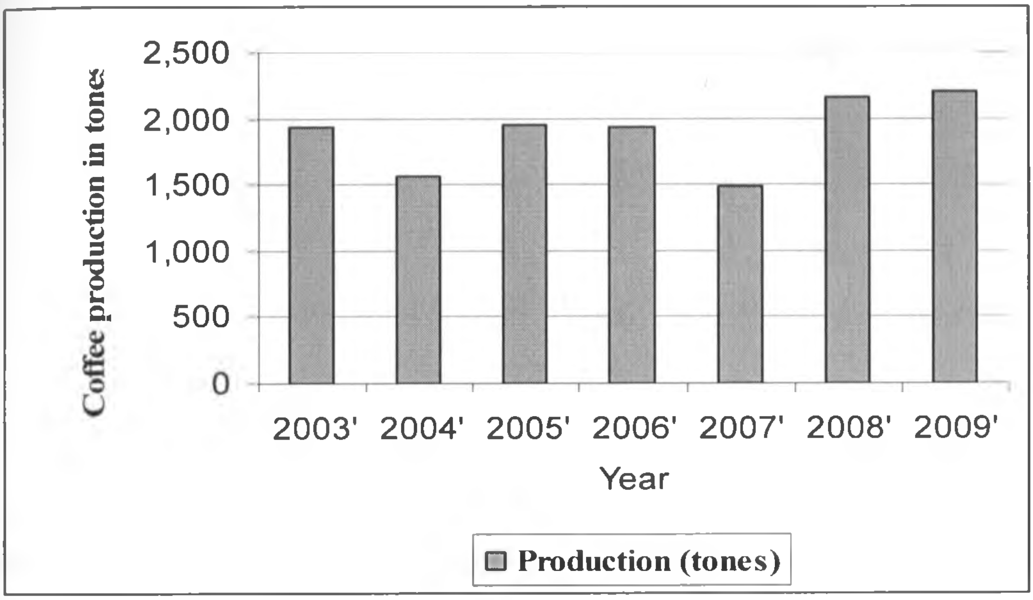


Figure 4. 1: Coffee production trend for Baricho society from 2003 – 2009
Source: Baricho coffee society status report 2009.

Figure 4.1 shows that in the seven years where production data was available, year 2007 had the lowest production level while year 2009 had the highest production level. The figure also shows that the difference in production level for year 2003, 2005 and 2006 was very small based on the height of respective bars. The difference in production level was also very small for year 2004 and 2007. The figure also reveals that production trend for the seven years had minimal fluctuations hence relatively stable.

The price trend for Baricho society is shown in Figure 4.2 covering a period of seven years as well from 2003 to 2009. The price was highest in year 2008 and lowest in year 2006. But the producer price trend just like the production trend did not have very big fluctuations within the given period. This might imply that though the data for this study was cross-sectional, collected in year 2009, the results were a reflection of the scenario for the past few years.

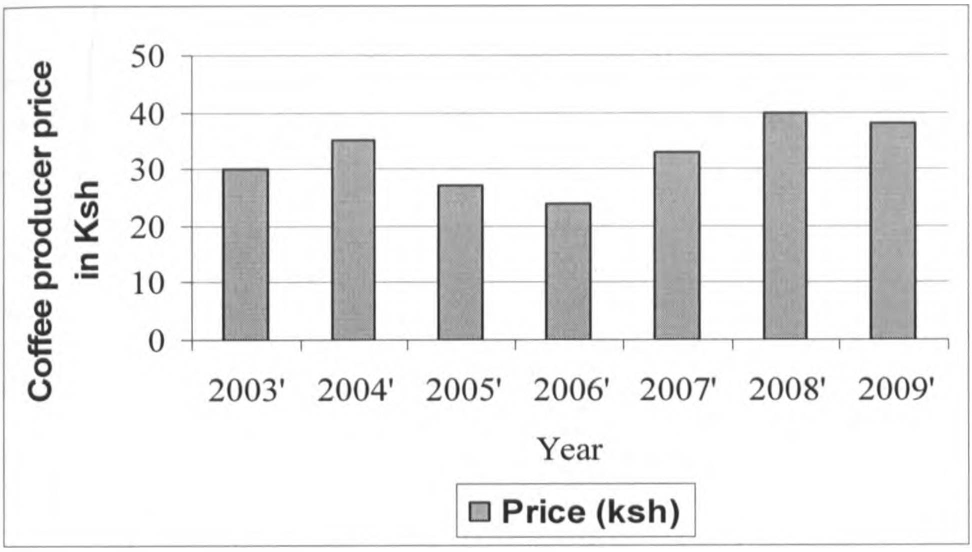


Figure 4. 2: Coffee price trend for Baricho society from 2005 – 2009
Source: Baricho coffee society status report 2009.

On the other hand Iria-ini society production data revealed more information because it covered a longer period (13 years). Production trends for the various factories are shown in Figure 4.3. They indicate that production was stable between 2001 and 2009. This was in line with the observations about Baricho Coffee society. The levels were however lower than what was realized in year 2000. This implied that the coffee enterprise was consistently performing at a level lower than this year (2000).

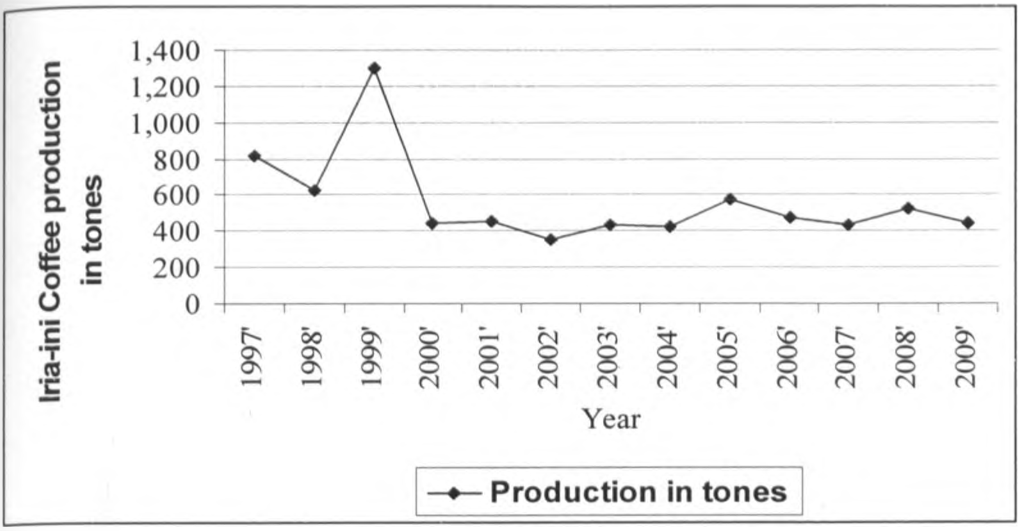


Figure 4. 3: Coffee production for factories in Iria-ini society from 1997 - 2009
Source: Iria-ini coffee society.

4.2 Descriptive Statistics

The analysis for this section is organized under: (i) correlation analysis; (ii) farm profile; (iii) household profile and (iv) outputs and variable costs in coffee production.

4.2.1 Correlation analysis of the main variables postulated to influence economic efficiency of coffee production in Mathira District

Table 4. 1: Correlation of the main variable that influenced economic efficiency of coffee production in Mathira District in 2009

	agehh	sizehh	educl	extvs	offarm	inter	accrd	region
agehh	1.00							
sizehh	-0.07	1.00						
educl	-0.13	-0.05	1.00					
extvs	0.05	-0.01	0.11	1.00				
offarm	-0.23	0.21	0.18	0.02	1.00			
inter	0.06	-0.02	-0.20	-0.07	-0.12	1.00		
accrd	-0.09	0.43	-0.07	0.06	0.13	0.04	1.00	
region	-0.17	0.33	0.14	-0.01	0.14	0.01	0.11	1.00

Key:

agehhh = age of household head

sizehh = size of the household

educl = education level of household head measured in number of years of formal schooling

extvs = number of demand-driven extension visits and follow-ups per year

offarm = off-farm activities dummy (1 = yes; 0 otherwise)

inter = intercropping dummy (1 = yes; 0 otherwise)

accrd = access to credit from cooperative societies dummy (1 = yes; 0 otherwise)

region = agro-ecological zone dummy (1= eastern; 0 otherwise)

The correlation matrix presented above indicates that both positive and negative relationships exist among variables. The least correlated variables were extension visit and size of the household with an absolute value of 0.01 while the most correlated variables were access to credit and size of the household with an absolute value of 0.43. Though all the correction values were less than 0.5 there could still be multicollinearity among the variables. Consequently the variance inflation factor (vif) was used to diagnose multicollinearity. The larger the vif, the bigger the multicollinearity problem. As a rule of thumb, if the value is 1, it means there is no multicollieарity and if the value ranges between 1 and 10, multicollinearity is not severe. If the vif is greater than 10, this is an indication of severe multicollinearity Gujarati (2007). Analysis in this study resulted in a mean vif of 1.16 indicating that multicolinearity is not a severe problem

The correlation matrix may be used to interpret relationships between each pair of variables. For instance the matrix indicated that there was a negative association between age and education implying that the higher the age of farmers in the survey data, the less educated they were. Assuming that education improves the capacity to learn new agronomic skills, it means that age is likely to affect economic efficiency negatively. On the other hand, education and off-farm activities had a positive relationship implying that the higher the education of farmers in the surveyed sample, the higher the likelihood for them to go for off-farm activities. This argument concurs with Linh (2005) who established that farmers with higher education tend to shift to non-farm activities, therefore their education do not contribute to improving farm technical efficiency and therefore economic efficiency.

4.2.2 Farm profile for coffee farmers in Mathira District

The average size of land owned by farmers in the study area was 2.24 acres. Land rented in was 0.033 acres (1.5 percent) and land rented out was 0.016 (0.7 percent) on average as shown in Table 4.2. This implies that about 98 percent of farm land in the study area was owned under individual tenure arrangements. Out of the privately owned land 69 percent have title deeds (that is formally owned) and 31 percent have no title deeds. This indicates that majority of the coffee farmers in the study area can access formal credit facilities that require land as collateral.

Table 4. 2: Land utilization profile in Mathira District in 2009

Characteristic	Mean	std dev
Total farm owned (acres)	2.240	1.857
Land ownership dummy; 1=formal; 0=informal	0.690	0.464
Area under coffee (acres)	0.656	0.759
Area under food crops (acres)	0.597	0.533
Area under livestock (acres)	0.484	1.210
Area under homestead (acres)	0.505	0.410
Land rented in (acres)	0.033	0.134
Land rented out (acres)	0.016	0.125

On average about 0.66 acres (29 percent) out of the mean size of land owned is used for coffee production, 0.6 (26 percent) is allocated to other crops, 0.48 acres (22 percent) is allocated to livestock and 0.5 acres (23 percent) is allocated for homestead as shown in Figure 4.4. Therefore coffee is a major crop in the study area that takes more than half of the land allocated to crops production. It is therefore imperative that economic efficiency of coffee production is improved since all other things held constant, this might improve its contribution to the economic well-being of farmers.

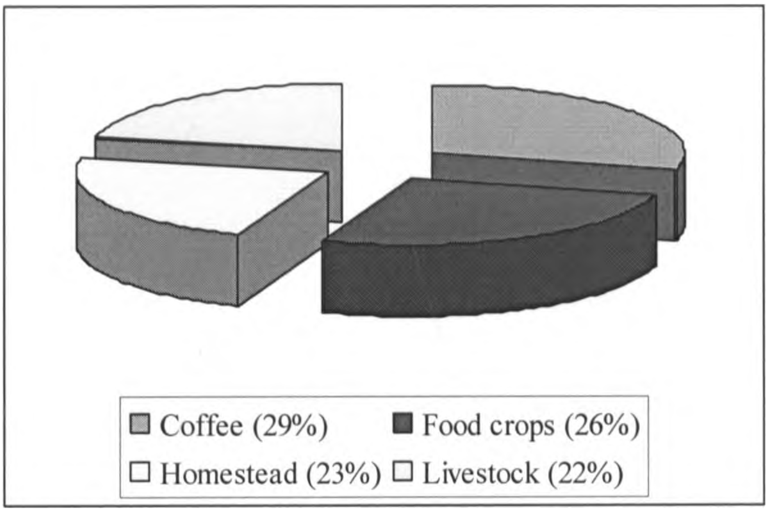


Figure 4. 4 Land allocation in acres to different uses in Mathira District in 2009

4.2.3 Household profiles compared between male and female headed households

The characteristics considered under this category for the sampled respondents included: age of the household head, size of household, level of education of household head measured in number of years of formal education, contact with extension services measured in number of visits and follow-ups on farmer-demanded extension per year. Descriptive statistics for the various characteristics were computed between male and female headed households as shown in Table 4.3. Paired sample t-test for comparing results based on male and female gender for each variable was carried out in order to establish the significance of the difference in means for each pair (male and female).

Table 4. 3: Household profile compared between male and female headed households and paired sample t-test

Characteristic	Mean		Paired difference of mean	95% C.I. of difference		t-ratio
	Male	Female		Lower	Upper	
1. Age of household head*	54.60	52.00	53.21	50.55	55.88	39.58[a]
2. Size of the household	4.86	3.43	-3.76	-4.23	-3.30	-16.0[a]
3. Education level of household head	8.22	7.18	-7.21	-7.92	-6.51	-20.37[a]
4. Extension visits and follow-ups on demanded extension	0.96	1.54	-0.31	-0.70	0.02	-1.58
5. Intercropping dummy; 1=yes, 2=no	0.60	0.68	0.19	0.02	0.31	3.15[a]
6. Experience in coffee farming*	25.48	27.03	-25.05	-27.41	-22.69	-21.02[a]
7. Off-farm activities dummy; 1=yes, 2=no	0.30	0.14	0.53	0.43	0.63	10.64[a]
8. Access to credit dummy; 1=yes, 2=no	0.58	0.50	0.21	0.10	0.32	3.83[a]

a' implies significance at 1% level, 'b' at 5% level and 'c' at 10% level

* Implies variables where null hypothesis (no statistical difference in values) was accepted

The survey data showed that seventy eight percent of coffee farmers in the study were men and twenty two percent were women. On average the male and female household heads were aged 54.6 and 52.0 years respectively as shown in Table 4.3. However, these values were not statistically different at 1 percent level. The average size of male headed households was 4.86 members while the average size of female headed households was 3.43 members. This difference was statistically significant at 1 percent level. Assuming that size of household was a proxy for the level of available household labor, the results indicate that male headed households were more endowed with family labor than female headed households. However, not all the available labor may be engaged in coffee production.

Table 4.3 also shows that male and female household heads had an average of 8.22 and 7.18 years of formal education respectively indicating that majority of the farmers had at least some level of primary education. The difference in education for both genders was statistically significant at 1 percent level. Rationally education would be expected to improve the capacity to learn and properly implement good agricultural practices from the available sources. The implication therefore is that all other things held constant there was likely to be a difference in economic efficiency between male and female headed households. The results also showed that there were significant disparities at 1 percent level in the mean number of male and female household heads who were attending off-farm activities and those that had access to credit facilities from cooperative societies. The above table also shows that 60 percent of male household heads were practicing intercropping while 68 percent of female household heads were intercropping coffee with other crops. The values were statistically different at 1 percent level.

Further analysis of cropping practices showed that the practice of intercropping coffee with food-crops takes a share of 49 percent of coffee farmers as compared to coffee-agroforestry which takes 10 percent and coffee monocropping which takes 41 percent as shown in Figure 4.5. Cumulatively intercropping took a share of 59%. It was also established that the main foodcrops intercropped with coffee were maize, beans and bananas. Since the prevalent intercropping practice was coffee and foodcrops it might be argued that all other things held constant, the main reason for intercropping in coffee farms was to increase food supplies. It might further be argued that since more female household heads engaged in intercropping as compared to male household heads, female gender was more sensitive to food security issues than male gender.

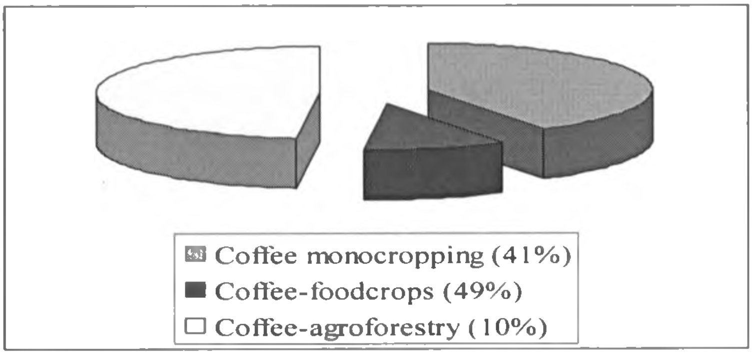


Figure 4. 5: Proportion of farmers practicing different coffee production systems

The number of farmers engaging in various types of intercrops in coffee farming is shown in Figure 4.6 which indicates that coffee-bananas was the most prevalent intercropping practice while coffee-maize was the least practiced.

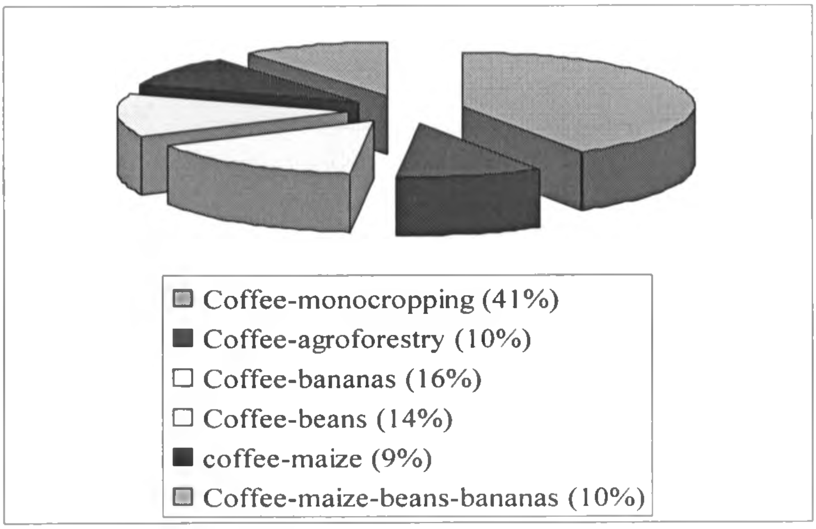


Figure 4. 6: Proportion of farmers engaging in different intercropping practices in Mathira District in year 2009

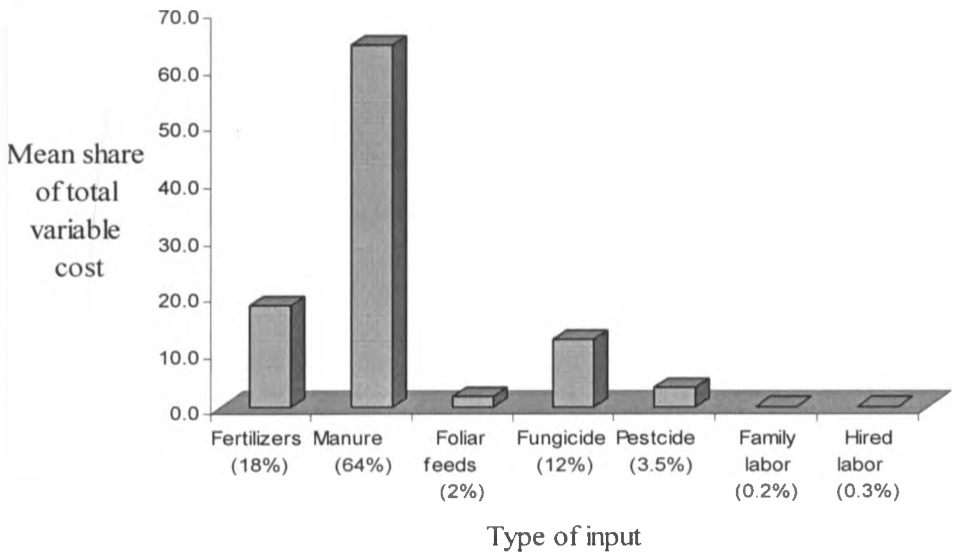
4.2.4 Outputs and variable costs in coffee production

This study as explained in the methodology used the DEA approach involving a multi-input-multi-output variables. Seven inputs (fertilizer, manure, foliar feeds, fungicides, pesticides, family and hired labor) and two outputs (mbuni and cherry) which are the major variables in coffee production were considered as shown in Table 4.4.

Table 4. 4 : Total revenue, variable cost and gross margin in coffee production valued in Kenya shillings per acre

Variable	Mean	Std. Dev.
Mbuni output (Kgs per acre)	117	130
Cherry output (Kgs per acre)	1,401	1,155
Revenue from mbuni (Ksh per acre) (117x45/=)	5,265	
Revenue from cherry (Ksh per acre) (1401x38/=)	53,238	
Total revenue (Ksh per acre)	**58,503**	**47,800**
Fertilizer cost (Ksh)	5,940	5,160
Manure cost (Ksh)	21,243	25,824
Foliar feed cost (Ksh)	529	694
Fungicide cost (Ksh)	3,746	5,183
Pesticide cost (Ksh)	847	1,230
Wage of family labor (Ksh)	59	86
Wage of hire labor (Ksh)	93	96
Total variable cost (Ksh)	**32,460**	**31,040**
Gross Margin (Ksh per acre)	**26,043**	**60,310**

The average output for mbuni and cherry were 117kgs and 1,401kgs per acre respectively while the average prices were Ksh 45.00 for mbuni and Ksh 38.00 for cherry. This resulted in revenue of Ksh 58,503per acre. A graphical presentation of the cost share of the various inputs was constructed in order to assist the reader have a better understanding of variable costs in coffee production as shown in Figure 4.7.



Source: Survey data

Figure 4. 7: Cost share of inputs for the average small-scale coffee producers in Mathira District in year 2009

Manure was the most expensive input followed by fertilizer and fungicides at the cost of Ksh 21,243.00 (64 percent), 5,940.00 (18 percent) and 3,746.00 (12 percent) per acre respectively. Pesticide cost was Ksh 847.00 (3.5 percent) per acre and foliar feed was the least expensive among material inputs at a cost of Ksh 529.00 per acre. The results indicate that promotion of less expensive own sources of manure such as farm yard, green or compost manure may improve returns in coffee production. Hired labor was more expensive at Ksh 93.00 per acre as compared to family labor which was costing Ksh 59.00 per acre. The mean total variable cost was Ksh 32,460.00 per acre. Consequently the average Gross Margin for small-scale coffee producers in the study area was Ksh 26,043 per acre (that is, total revenue less total variable cost). This gives an indication that on average small-scale coffee production in the study area was a profitable undertaking.

4.3 Economic Efficiency Estimates

The overall economic efficiency as mentioned in literature review and methodology chapters is a combination of the technical and allocative components. It was therefore considered appropriate for the discussion in this section to consider these efficiencies separately. They were analyzed by the non-parametric DEA model for multiple-inputs, multiple-product setting.

4.3.1 Discussion of technical efficiency results from DEA model

Technical efficiency as explained in the study methodology directly contributes to economic efficiency. It was therefore considered rational that the discussion in this section be pegged on three hypotheses {(a) there is no difference in technical efficiency between the eastern region (with AEZ: UM_1 and LH_{1-2}) and western region (with AEZ: UM_4 and LH_2); (b) there is no difference in technical efficiency between male and female headed household; and (c) there is no difference in technical efficiency between monocropping and intercropping in coffee farming} that are in tandem with the first null hypothesis for this study as given in Chapter one. The results of technical efficiency scores compared between the different scenarios and the corresponding paired sample t- test are shown in Table 4.5.

Table 4. 5: Technical efficiency compared between different scenarios and paired sample t-test results

Variable	Number of observations	Mean	Std dev	Paired difference	95% Confidence Interval of difference: Lower	Upper	t-value
Technical efficiency:	East = 83	0.90	0.18				
By region	West = 43	0.89	0.18	0.24	0.15	0.33	5.25[a]
Technical efficiency:	Male = 98	0.91	0.18				
By gender	Female = 28	0.86	0.21	0.12	0.02	0.19	3.01[a]
Technical efficiency:	Monocrop = 52	0.92	0.17				
By Cropping practice	Intercrop = 74	0.88	0.19	0.31	0.21	0.40	6.32[a]
Overall Technical efficiency	126	0.89	0.18				

'a' implies significance at 1% level, 'b' at 5% level and 'c' at 10% level

The paired t-test was used for testing the aforementioned null hypotheses; that is, (a) Ho: TE(eastern) equals TE(western) against Ha: TE(eastern) is not equal to TE(western); (b) Ho: TE(male) equals TE(female) against Ha: TE(male) is not equal to TE(female); and (c) Ho: TE(monocropping) equals TE(intercropping) against Ha: TE(monocropping) is not equal to TE (intercropping). The three null hypotheses were rejected at 1 percent level since their t-values fall outside the lower and upper critical values at 95 percent confidence interval.

The table shows that the mean technical efficiencies for eastern and western regions were 0.90 and 0.89 respectively. The values were statistically and significantly different at 1 percent level. This implies that if the average farmer in the eastern region of the district were to achieve the technical efficiency level of the most efficient counterpart, then the producer could realize a 10 percent cost savings (that is, 1- [0.90/1.00]). On the other hand, if the average farmer in the western region of the district were to achieve the technical efficiency level of the most efficient counterpart, then the producer could realize 11 percent cost savings (that is, 1- [0.89/1.00]). The results may also be interpreted that on average, about 10 percent of coffee outputs in eastern region and about 11 percent coffee outputs in western region are lost due to specific inefficiencies pertaining to farms.

The mean technical efficiencies were 0.91 and to 0.86 for male and female headed households respectively. Since the difference was statistically significant at 1 percent level, it was an indication that male household heads were less wasteful in utilization of available resources for coffee production as compared to female household heads. The previous section established that male household heads had attained more years of formal education than female household heads. It means therefore that all things held constant the technical efficiency results for the different gender may partly be explained by the disparity in the mean number of years of formal education for male (8.22 years) and female (7.18 years) household heads.

The results presented in Table 4.5 also indicate that the average technical efficiency for monocropping practice was 0.92 as compared to 0.88 for intercropping practice. The difference in values was also statistically significant at 1 percent level implying that farmers practicing monocropping can reduce their physical inputs outlays by 8 percent while those practicing intercropping can reduce their physical input outlays 12 percent and still obtain the same output levels.

Overall, farmers in Mathira district had a mean technical efficiency of 89 percent. Since the model used in this study employed multi-input-oriented approach, it implies that on average coffee farmers can reduce their inputs utilization by 11 percent and still get the same outputs. The distribution of overall technical efficiency is skewed to the left as shown if Figure 4.8 indicating that majority of the farmers in the study area operated at more than 50 percent efficiency level.

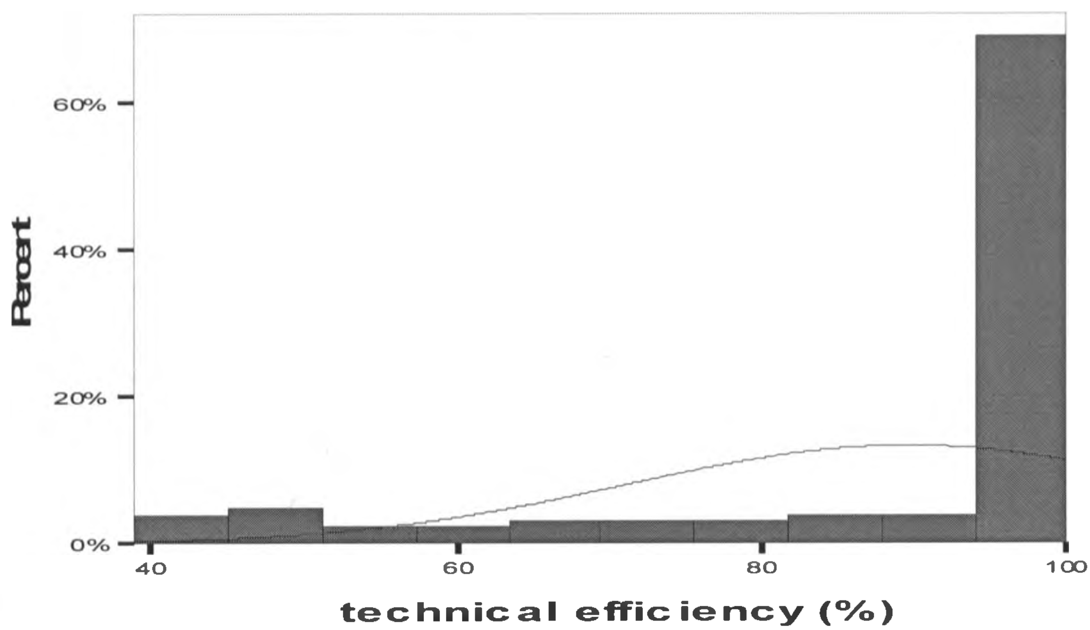


Figure 4. 8: Technical efficiency distribution

4.3.2 Discussion of allocative efficiency results from DEA model

Analyses for allocative efficiency also focused on descriptive statistics for the same characteristics that were considered for technical efficiency. The discussion was based on three null hypotheses namely; (a) Ho: AE(eastern) equals AE(western) against Ha: AE(eastern) is not equal to AE(western); (b) Ho: AE(male) equals AE(female) against Ha: AE(male) is not equal to AE(female); and (c) Ho: AE(monocropping) equals AE(intercropping) against Ha: AE(monocropping) is not equal to AE (intercropping). The paired sample t-test results are shown in Table 4.6. The results indicate that null hypothesis that mean allocative efficiency for eastern and western regions are the same is accepted at 1 percent level. But the null hypotheses for equality of mean allocative efficiency computed by gender and cropping practices are rejected at 1 percent level.

Table 4. 6: Allocative efficiency compared between different scenarios and paired sample t-test results

Variable	Number of observations	Mean	Std dev	Paired difference	95% C.I. of difference Lower	Upper	t-value
Allocative efficiency:	East =83	0.50	0.20				
By region	West = 43	0.50	0.22	-0.16	-0.25	-6.80	-3.45[a]
Allocative efficiency:	Male = 98	0.50	0.21				
By gender	Female = 28	0.48	0.18	-0.28	-0.36	-0.20	-6.87[a]
Allocative efficiency:	Monocrop = 52	0.54	0.22				
By cropping practice	Intercrop = 74	0.47	0.18	-8.80	-0.19	0.02	-1.75[c]
Overall allocative efficiency	126	0.50	0.20				

'a' implies significance at 1% level, 'b' at 5% level and 'c' at 10% level

The table shows that the average allocative efficiency for male and female headed households was 0.50 and 0.48 respectively. The difference was statistically significant at 1 percent level implying that all other things held constant, the male gender were making better decisions that reduce total variable costs in coffee production than the female gender. The table also shows that mean allocative efficiency for monocropping and intercropping practices were 0.54 and 0.47 respectively. The difference was statistically significant at 10 percent level indicating that there was better choice of input mix based on their prices in monocropping as compared to intercropping practice.

The overall mean allocative efficiency for coffee farmers in Mathira District was 0.50 implying that they could reduce input cost by about 50 percent and still get the same outputs. The frequency distribution analysis shown in Figure 4.9 reveals that allocative efficiency for farmers in the study sample is symmetrically skewed meaning that majority of the farmers in the study are centered around the mean value.

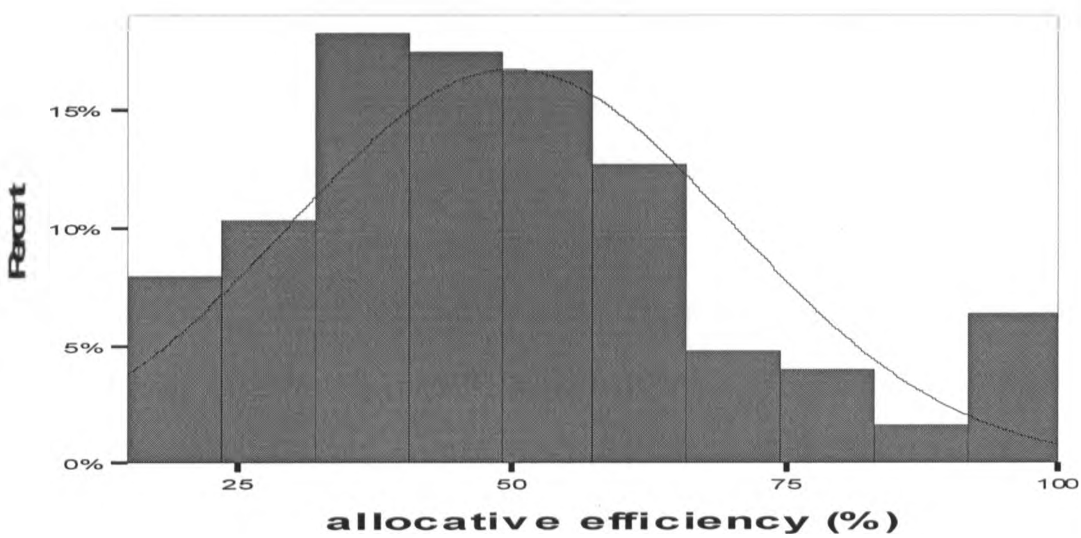


Figure 4. 9: Allocative efficiency distribution

4.3.3 Results and discussion of economic efficiency estimates

The neoclassical agricultural production economic theory denotes that rational farmers maximize farm profits by equating the ratio of marginal value products of all inputs costs to one in a competitive market environment. If the farmer is not at the point profit maximization, at least costs are minimized for the level of output if the ratio is equated to any other constant that could be denoted by K. This is the principle of equimarginal returns

(Derbertin, 1996). The producers will have maximized their output at the lowest possible cost if they are operating are at this point. This is a requirement for achieving technical and allocative efficiency respectively. Economic efficiency level is therefore determined by the combined effect of technical and allocative efficiencies in a production process. It is actually a product of technical and allocative efficiency as explained by equations 4 in the methodology.

This sub-section focuses on comparison of economic efficiency estimates between the three scenarios considered for technical and allocative efficiency, that is; region, gender and cropping practices. Consequently the three null hypotheses which were identified for analysis included; (a) Ho: EE(eastern) equals EE(western) against Ha: EE(eastern) is not equal to EE(western); (b) Ho: EE(male) equals EE(female) against Ha: EE(male) is not equal to EE(female); and (c) Ho: EE(monocropping) equals EE(intercropping) against Ha: EE(monocropping) is not equal to EE (intercropping). The paired sample t-test results as presented in Table 4.7 revealed that all the three null hypotheses were rejected at 1 percent level. This implies that the calculated levels of economic efficiency for the different scenarios were statistically different

Table 4.7 also shows that average economic efficiency for eastern and western regions was 0.446 and 0.451 respectively. On the other hand, the average economic efficiency for male and female headed households was 0.456 and 0.416 respectively. Since the difference in the values is significant at 1 percent level, it implies that *ceteris paribus*, the male gender were better than female gender in making decisions on physical input mix that were leading to higher profits in coffee production. The table also shows that mean economic efficiency for monocropping and intercropping practices were 0.51 and 0.48 respectively. This implies that though intercropping is practiced by a majority of coffee farmers (59 percent) and occupies a bigger coffee farming area (56 percent) than monocropping, it is less economically viable as compared to monocropping.

Table 4. 7: Economic efficiency compared between different scenarios and paired sample t-test results

	Number of observations	Mean	Std dev	Paired difference	95% C.I. of difference Lower	Upper	t-value
Economic efficiency:	Eastern = 83	0.45	0.21				
By region	Western = 43	0.45	0.23	-0.21	-0.30	-0.12	-4.51[a]
Economic efficiency:	Male = 98	0.46	0.22				
By gender	Female = 28	0.42	0.21	-0.33	-0.41	-0.25	-8.13[a]
Economic efficiency:	Monocrop = 52	0.51	0.24				
By cropping practice	Intercrop = 74	0.41	0.19	-0.14	-0.24	0.02	-2.69[a]
Overall Economic efficiency	126	0.45	0.22				

'a' implies significance at 1% level, 'b' at 5% level and 'c' at 10% level

The overall mean economic efficiency for coffee farmers in the study area was about 45 percent implying that on average farmers in the study area had the potential to improve their economic gains by 55 percent. The frequency distribution of economic efficiency in the district was also symmetrically skewed as shown in Figure 4.10 implying that majority of farmers had economic efficiency which was near the mean value.

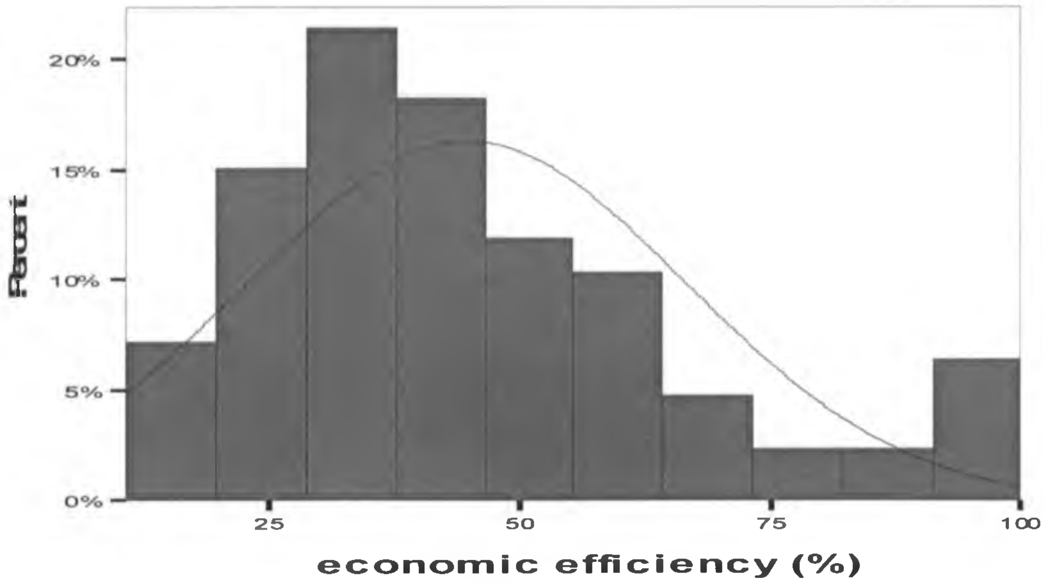


Figure 4. 10: Economic efficiency distribution

The results evidently show that economic efficiency in coffee production could be improved substantially. The average technical efficiency in coffee production is higher than allocative efficiency as was established in the previous sub-sections. This implies that allocative inefficiency constitutes a more serious problem than technical inefficiency in coffee production economic efficiency.

4.3.4 Summary of economic efficiency analysis

Distribution histograms showed that technical efficiency was skewed to the left while allocative and economic efficiencies were symmetrically skewed. This implies that if the current output levels were to be maintained, the level of physical inputs utilization should be reduced so that farmers could operate efficiently. The results also indicate that coffee farmers were allocatively inefficient. This means that cost reductions could be achieved by operating at allocativelly efficient inputs' combinations. This section also established that economic efficiency for coffee monocropping is higher than for intercropping practice.

4.4 Factors influencing Economic Efficiency

The discussion in this section was categorized into factors that influence technical, allocative and economic efficiency since the latter is a combination of the first two as mentioned earlier. The efficiency estimates obtained by DEA method were regressed on farmer specific attributes using the Tobit model to explain inefficiency in coffee production. Marginal effect analysis was carried out to explain the economic efficiency regression results. However, the marginal effect values are the same as regression coefficient values implying that the latter may also be used to interpret the results. The use of a second stage regression model of determining the farmer specific attributes in explaining inefficiency has been used in other studies including; Mulwa et al., (2009) and Rios et al., (2005). The studies established that technical and economic inefficiencies may be attributed to family size, farm size, credit use, off-farm activities, education level of the household head and contact with extension services. The results of Tobit regression in this study are presented in Table 4.8.

Table 4. 8: Factors influencing technical, allocative and economic efficiency of coffee production in the Mathira District in 2009.

	Technical efficiency		Allocative efficiency		Economic efficiency		
	Coef.	t-ratio	Coef.	t-ratio	Coef.	t- ratio	Marginal effect
Constant	1.112	4.48[a]	0.253	2.97[a]	0.208	2.43[b]	
Age of household head	0.002	0.50	0.003	2.95[a]	0.003	2.82[a]	0.003[a]
Size of household	-0.016	-0.78	-0.004	-0.60	-0.008	-1.140	-0.008
Education level of household head	0.019	1.44	0.020	4.6[a]	0.023	5.38[a]	0.023[a]
Demanded extension visits	0.059	1.54	0.012	1.56	0.017	2.11[b]	0.017[b]
Off-farm activities	-0.028	-0.24	-0.073	-1.85[c]	-0.067	-1.67[c]	-0.067[c]
Intercropping	-0.120	-1.18	-0.050	-1.51	-0.057	-1.7[c]	-0.057[c]
Access to credit from cooperatives	-0.207	-1.93[c]	-0.075	-2.13[b]	-0.109	-3.09[a]	-0.109[a]
Region	0.083	0.77	0.014	0.38	0.022	0.600	0.022

'a' implies significance at 1%; 'b' at 5% and 'c' at 10%

The regression results indicated that age of the household head positively influenced allocative and economic efficiency at 1 percent level. An extra year in age was shown to have improved economic efficiency by 0.3 percent. This is in line with the findings of Coelli et al (1986) and Dhungana et al (2004) who established that age has a positive significant influence on economic efficiency through the technical efficiency in agricultural production. A similar study by Bravo-Ureta et al (1997) also established the existence of positive relationship between age and economic efficiency for younger farmers but a negative relationship for older farmers. Furthermore, younger farmers are likely to have more formal education and therefore might be more successful in gathering and understanding new practices which in turn will improve their economic efficiency levels. Though their study did not give the threshold beyond which age reverses the influence of economic efficiency, it gave an indication that the trend cannot go on indefinitely. The mean age for farmers surveyed in this study was 53 years implying that all other things held constant, the threshold was likely to be above this age. Nevertheless there still exists a gap about the turning point for influence of age on economic efficiency and this could be addressed in future research.

Education level measured in the number of years of formal schooling was also established to have a significant positive influence on economic efficiency at 1 percent level. An extra year in school improved economic efficiency by 2.3 percent. This was in agreement with the findings of Belbase et al., (1985) and Kalirajan et al., (1986) who established that in agricultural production, there exists a significant positive influence of education on economic efficiency through the technical efficiency. Rationally it would be expected that farmers with higher levels of education are more likely to have higher capacity to learn and properly implement good husbandry practices from the various sources such as public and private agricultural extension personnel, other farmers, media or internet.

The extension variable represented the number of extension visits made by extension agents to individual farmers depending on their specific demand. The results showed that provision of demanded agricultural extension services had a significant positive influence on economic efficiency at 5 percent level. It was established that a single visit within the cropping season under study (2009/10) improved economic efficiency by 1.7 percent. The finding concurred with the expectation since agricultural extension imparts skills and information about good husbandry practices which in turn improves economic efficiency in farming. This finding agrees with Linh (2005) in a similar study on smallholder rice farming in Vietnam.

On the other hand, off-farm activities were observed to have a significant negative influence on economic efficiency at 10 percent level. Farmers who went for off-farm work were found to have reduced their economic efficiency by 6.7 percent. This finding disagrees with Mutoko (2008) who established a positive influence of off-farm activities on economic efficiency of smallholder maize production in Northwestern Kenya. However, it may be argued that a positive sign for the coefficient may be expected if some or all of the financial resources acquired from off-farm activities were used to purchase coffee inputs that would otherwise have not been bought due to lack of enough money. A negative sign would have been expected for the coefficient if the household head is not replaced by an equivalently skilled labor.

Coffee societies provide credit to farmers in material and/or financial form depending on their individual requirements. Application for financial credit is disaggregated into the various uses such as acquisition of inputs that are not available in the society stores for example manure, specifically preferred pesticides, foliar feeds; payment of school fees or purchase of assets of their choice. However the loan is disbursed as a single package and could be diverted once acquired. On the other hand the material credit could also be used in other crops or sold out thereby denying coffee the necessary nutrient for proper growth and therefore affecting economic efficiency. All the farmers sampled in this study who acquired credit from the societies intended to use part or whole of it to procure coffee inputs. Therefore the credit would have been expected to improve coffee production economic efficiency in the study area on the assumption that inputs would be procured in the right combinations. This expectation was consistent with study findings by Lingard et al., (1983); Kaliragan et al., (1986); and Bravo-Ureta et al., (1994) that farming credits positively influence efficiencies if they are used to enhance timely purchase of farm inputs where producers do not have enough money to buy those inputs. But on the contrary, the regression results showed that access to credit negatively influenced economic efficiency at 1 percent level. Farmers who acquired credit reduced their economic efficiency by 10.9 percent. This implies that most of the farmers diverted the input credit from the originally intended purpose.

Intercropping had a significant negative influence on economic efficiency at 10 percent level. Table 4.8 shows that on average farmers who engaged in intercropping reduced their economic efficiency by 5.7 percent. The farmers who practiced intercropping did not add extra inputs to the food crops other than the inputs meant for coffee. The food crops were therefore eating on the available inputs for coffee, a situation that may have contributed to lower economic efficiency for the intercropping system. But to get deeper insight about intercropping, the common intercropping practices were isolated and analyzed as shown in Table 4.9. The analysis was done under the assumption of holding all factors constant other than intercropping.

Table 4. 9: Analysis of the various Intercropping methods in Coffee production in Mathira District

Variable	Coefficient	Std. error	t-value
intercept	0.51	0.03	17.3[a]
Coffee-agroforestry intercrop dummy	-0.16	0.07	-2.43[b]
Coffee-bananas intercrop dummy	0.02	0.06	0.34
Coffee-beans intercrop dummy	-0.06	0.06	-1.02
Coffee-maize intercrop dummy	-0.21	0.07	-3.14[a]
Coffee-bananas-beans-maize mixture dummy	-0.19	0.07	-2.91[a]

'a' implies significance at 1%; 'b' at 5% and 'c' at 10%

The results showed that intercept coefficient (α_0) for the benchmark variable (monocropping) was 0.51 and statistically significant at 1 percent level. This value represents the mean economic efficiency for the monocropping practice. The value is the same as that obtained earlier while cross tabulating monocropping and intercropping as shown in Table 4.7. The differential coefficient for coffee-agroforestry practice (α_1) is shown to be -0.16 and it is statistically significant at 5 percent level. This implies that intercropping coffee with agroforestry reduces economic efficiency by 16 percent from the mean value of monocropping practice. Similarly, Table 4.8 also shows that intercropping coffee with maize reduces economic efficiency by 21 percent at 1 percent level while intercropping with a mixture of maize, beans and bananas reduces the economic efficiency by 19 percent at 1 percent level from the mean value of monocropping. The table also shows that intercropping coffee with bananas has an insignificant positive influence on economic efficiency while intercropping with beans results to an insignificant negative influence on the economic efficiency.

4.4 Summary findings of factors influencing economic efficiency

This section established that economic efficiency was significantly and positively influenced by the level of education, access to extension services and the age of the household head. On the other hand, the section also established that economic efficiency was significantly and negatively influenced by the household head attending off-farm activities, access to credit facilities from cooperative societies and intercropping coffee with other crops. This implies that the labor forgone by the household attending off-farm activities was not equivalently replaced. The negative influence of access to credit on economic efficiency is an indication that credit funds acquired from the societies were diverted to other uses other than promotion of coffee production. On the other hand, the observed negative influence of intercropping on economic efficiency is an indication that the practice is inferior to monocropping in terms of economic viability.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Data Envelopment Analysis was used to determine technical, allocative and economic efficiency measures for coffee production in Mathira District. Subsequently, Tobit regression was used to determine the socioeconomic factors that influence technical, allocative and economic efficiency in the district. Results showed that mean technical efficiency for coffee farmers in Mathira District was 89 percent (reference: Table 4.5) implying that farmers could reduce the current physical input use by about 11 percent on average and still realize the same output levels.

The average allocative efficiency was 50 percent meaning that farmers could reduce input costs by about 50 percent without affecting the current production levels. A key government intervention in this regard might be capacity building of coffee cooperative societies so that they may fulfill their mandate of providing inputs at the lowest costs as expected due to collective purchase. This suggestion is in line with the findings by Mude, (2006) who established that more efficient running of the cooperative movement may promote effective mechanisms that benefit small-scale farmers including low input prices.

The overall economic efficiency for coffee production was 45 percent implying that there was potential to improve their economic performance by about 55 percent. The government may indirectly intervene through formulation of policies that improve performance of cooperative societies which in turn may result to improved performance of coffee enterprise and therefore higher economic efficiency. This suggestion though not part of analysis for this study was based on the findings of Chambo, (2009) who established that cooperatives improve farmers' opportunities pertaining to their economic wellbeing.

The male headed households were found to have a higher mean economic efficiency of 0.46 as compared to female headed households whose mean economic efficiency was 0.42. This difference was statistically significant at 1 percent level as shown in Table 4.7, and may be explained by the difference in the average number of years of formal education acquired by both gender. The male household heads had an average of 8.22 years of formal education while female household heads had an average of 7.18 years of formal education. The difference was statistically significant at 1 percent level as shown in Table 4.3. To address the disparity, policy guidelines that enhance provision of gender balanced capacity building programs in adult education and short-term courses for farmers may be formulated. Education measured in number of years of formal education had a significant and positive influence on economic efficiency. This implies that capacity building programs such as free primary and adult education that enhance acquisition of formal education may be strengthened through provision of adequate infrastructure, resource persons and intensive awareness campaigns.

Economic efficiency was positively and significantly influenced by access to agricultural extension services. In this regard, provision of these services by both public and private extension as recommended by the National Agricultural Sector Extension Policy (NASEP) should be enhanced. The government may encourage participation of private sector in provision of agricultural extension through incentives that reduce their transaction costs such as subsidization of license fees.

Age was observed to have a positive and significant influence on economic efficiency as well but the study did not establish the turning point as this may not be expected to continue indefinitely. This was in line with the findings by Bravo-Ureta et al (1997) who established the existence of positive relationship between age and economic efficiency for younger farmers but a negative relationship for older farmers. To address this observation, the government may formulate policies that motivate the younger generation to be more actively involved in coffee production through selective strategies such as input subsidies for the youthful and middle aged farmers. The scenario of age influencing economic efficiency positively may however not be expected to continue indefinitely. To counter the tendency of the elderly generation holding on to coffee even when they are too old, the government may motivate them to progressively hand over coffee production enterprise to the younger generation through establishment of social schemes such as retirement benefits from farm enterprises. Nevertheless, there exists a gap in knowledge pertaining to relationship of age and economic efficiency variables in coffee production.

This study further established that economic efficiency was significantly and negatively influenced by the household head attending off-farm activities, access to credit facilities from cooperative societies and intercropping coffee with other crops. The negative influence of off-farm activities on economic efficiency may imply that the forgone labor was not replaced by equivalent skills that would otherwise have at least maintained the level of economic efficiency formerly realized by the household head. To alleviate this situation, the government through institutions that provide extension services may enhance provision of commercial agriculture so that farmers with opportunities for going for off-farm activities may make informed decision about whether to continue working as farmer managers in their farms or go for off-farm work. Farmers with knowledge on commercial agriculture are also better placed to guide those who succeed them as farm managers when they go for off-farm activities thereby preventing decline in economic efficiency.

Access to credit as well had a significant and negative regression coefficient implying that credit funds acquired from cooperative societies were most likely diverted to other uses other than promotion of coffee production. The government may intervene by enhancing institutionalization of monitoring and evaluation in extension services. This would lead to enhanced monitoring of how credit is utilized in agriculture including coffee farming. Intercropping was equally observed to have a significant and negative influence on economic efficiency. This implies that economic viability of intercropped coffee was less than for non-intercropped coffee

This study was constrained by financial and time resources resulting to some factors such as environmental issues, risks, market imperfections, cash constraints, and social status that might influence economic efficiency being left out. Therefore further coffee economic efficiency studies incorporating these factors are recommended as this might result to more concrete deductions and more sound policy recommendations.

APPENDICES

Appendix 1: Data Collection questionnaire

1. LOCATION OF THE FARM:

District…………………………………………………..

Division…………………………………………………..

Location…………………………………………………..

2. FARM LEVEL DATA

• Name of the farmer	
• Age of the household head	
• Gender of the h/h	
• Education level-h/h (No. of years in school)	
• Size of the h/h (No. of persons)	

3. LAND

	Hectares	**Remarks**
Total Land owned		
Total homestead area		
Land rented in		
Land rented out		
Area under Crops		
Area under Livestock		

3. NATURAL CAPITAL

Capital	**Type**	**Remarks**
Housing		
Livestock shed		
Poultry shed		
Others (specify)		

4. SOCIAL CAPITAL

	Remarks
Does the farmer belong to any institution/group? e.g. CBO **Yes/No.**	
If yes what type of group?	
a.	
b.	
c.	
d.	

6. TYPES OF CROPS GROWN OTHER THAN COFFEE

Type of crop	Hectarage	Production(Kgs)	Price per unit
a.			
b.			
c.			
d.			
e.			
f.			
g.			
h.			
TOTAL			

7. INPUT USE IN CROPS OTHER THAN COFFEE

Crop	Type of input	Quantity	Price per unit	Total Cost
1. Maize	Fertilizer			
	Seeds			
	Manure			
	Pest control			
	Others (specify)			
2. Irish Potatoes	Fertilizer			
	Seeds			
	Manure			
	fungicides			
	Others (specify)			
3. Beans	Fertilizer			
	Seeds			
	Manure			
	Others (specify)			
4. Tomatoes	Fertilizer			
	Seeds			
	Manure			
	fungicides			
	pesticides			
	Others (specify)			
5. Bananas	Manure			
	Others (specify)			
Other crops (Specify)				
TOTAL				

8. LABOUR USE IN CROPS OTHER THAN COFFEE

Crop	Activity	Family labour (person-days)	Hired labour (person-days)	Price	Total Labour cost
1. Maize	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Pest control				
	Others (specify)				
2. Irish potatoes	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Pest control				
	Others (specify)				
3. Tomatoes	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Pest control				
	Others (specify)				
4. Beans	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Pest control				
	Others (specify)				
5. Bananas					
Others (specify)					
TOTAL					

9. COFFEE OUTPUT

	Production (Kgs)	Price	Total Income
1. Cherry			
2. Mbuni			
TOTAL			

10. INPUT USE IN COFFEE

Type of input	Quantity	Price per unit	Total
Fertilizers			
Manure			
Foliar feeds			
Fungicides			
Pesticides			
Mulching			
Others (specify)			

11. LABOUR USE IN COFFEE

Activity	Family labour	Hired labour	Price	Total
Fertilizer application				
Manure application				
Spraying				
Pruning				
Desuckering				
Harvesting				
Transportation				
Others (specify)				

12. TYPES OF LIVESTOCK KEPT

Type	No. Kept	Production (specify product and units)	Price per unit	Total income
1. Cows		Milk		
		Manure		
		Others (specify)		
2.Poultry: (Layers)		Eggs		
(Broilers)		Meat		
		Manure		
3. Sheep				
4. Goats				
5. Others (Specify)				

13. LABOUR USE IN LIVESTOCK

Livestock	Activity	Family labour (person-days)	Hired labour (person-days)	Price	Total
1. Dairy cows	Feeding				
	Milking				
	Tick control				
	Deworming				
	Others (specify)				
2. Poultry	Feeding				
	Others (specify)				
3. Sheep					
4. Goats					
5. Others (Specify)					
TOTAL					

14. OTHER INFORMATION:

(i) Extension Services

Do you receive extension services? **Yes/ No.**	
If yes, how often? (Number of times in a month)	
If no, How do you acquire extension information?	

(i) Off-farm work

Do you go for off-farm work? **Yes/No.**	
If yes, how much income does it give you?	

(iii) Coffee farming experience

No. of years in coffee farming?	

(iv) Intercropping	
Do you intercrop coffee with other crops? **Yes/No.**	
If yes what are these crops and what size of coffee land is intercropped?	
a.	
b.	
c.	
d.	
e.	
f.	
g.	

(v) Access to credit

Do you access credit?	
If yes how much did you access in 2008/09 and how did you utilize it?	
a.	
b.	
c.	
d.	
e.	
f.	
Total	

(vi) Attitude towards coffee farming

➢ Very important	
➢ Medium importance	
➢ Not important	

(vii) Any other relevant information

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