AN ECONOMIC ANALYSIS OF SMALL SCALE FRENCH BEAN PRODUCTION IN CENTRAL PROVINCE OF KENYA.

BY

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DECLARATION

I Mercy W. Wanjiru hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

(Candidate)

This thesis has been submitted for examination with my approval as a University Supervisor.

7/12/93

DR. K. MUNEI

(University Supervisor)

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A B S T R A C T

In this study small scale French bean production systems in the major growing areas in Kenya are analyzed. The main purpose being to identify the problems causing low yields and to suggest possible ways of overcomming them.

The approaches used for the analysis included descriptive analysis for describing and comparing the usage of resources and cultural practices in the areas of study and regression analysis to estimate the influence of fertilizers, pesticides, seed and manure on yields.

Although the French bean enterprise was ranked first by most farmers in terms of income generation, the acreage under this crop was found to be minimal. Irrigation of the crop was practiced by all, where manual methods of irrigation were the most commonly used. Fertilizer and pesticide application were practiced by all farmers interviewed, but deviations occurred with respect to recommended amounts. Labour use was quite high, with irrigation taking up 45% whilst harvesting and grading took 20% to 28.5% of total labour requirement. Yields in all the areas were found well below yields reported by researchers and other French bean growing countries.

Regression analysis showed that nitrogen fertilizer, pesticides, manure and certified seed significantly influenced French bean yields and amongst these inputs, only the nitrogen fertilizer was being used below the point of economic optimum.

The study has shown that there is a potential of increasing French bean yields obtained by small scale farmers by using increased amounts of nitrogenous fertilizers, manure and the use of improved certified seed. Provision of information on the correct usage of inputs and market availability for the French beans is important if constraints to yield improvement are to be successfully eliminated.

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CHAPTER ONE

INTRODUCTION

Background Information

1.1 Importance Of Agriculture

The agricultural sector remains the leading sector in stimulating economic growth and job creation in the Kenyan economy (Republic Of Kenya, 1990). In 1989, this sector contributed 29% of the country's Gross Domestic Product (GDP) and 29% of the wage employment in the private sector was from the agricultural and forestry sectors. In foreign exchange earnings, this sector earned the country 600 Million Kenya pounds in 1988 (Republic Of Kenya, 1989). This explains why the government attaches a lot of importance to this sector in its' development strategies. In the 6th development plan of 1988-1993, the government includes increasing food production, growth in employment, expansion of agricultural exports, resource conservation and poverty alleviation as its objectives for the agricultural sector (Republic Of Kenya, 1989).

1.2 Importance of Horticulture

In the agricultural sector, the horticultural sub-sector has the highest growth rate of 1.1% in terms of production, whereas the growth rate of coffee, tea, rice, milk, and beans production is 1.04%, 1.05%, 1.08%, 1.02%, and 1.05% respectively (Republic Of Kenya, 1989). This sector has made substantial contribution in the provision of food for domestic consumption, employment opportunities and foreign exchange. Horticulture lies fourth after coffee, tea and tourism in terms of foreign exchange earnings. Kenya's main horticultural crops for export are cutflowers, French beans, pineapples, mangoes and avocadoes (Horticultural Crops Development Authority (H.C.D.A)). These exports have risen from a mere 1,476 mt in 1968 to 49,147 mt in 1990 (HCDA). Table 1.1 shows that Kenyan production of horticultural crops has also shown a tremendous growth.

Table 1.1: Total Production Of Horticultural Crops In Kenya (1970-1988)

Year	mt	Year	mt
1970	444007	1980	1755174
1971	523282	1981	2021359
1972	623122	1982	2079065
1973	662374	1983	2572476
1974	1062051	1984	2519461
1975	1234432	1985	2970272
1976	1268854	1986	34321721
1977	1225665	1987	3483131
1978	1387020	1988	3566355
1979	1480645		

Source; MOA, Report compiled by the Crop Production Division, 1990.

Table 1.2: Estimated Proportion Of Total Agricultural Land and Value Per Hectare For Selected Commodities, 1983/84

Commodity	Area % Agric. Land	rank	Value Per Hectare k£	rank
milk	46.6	1	70	16
maize & beans	22.6	2	153	12
Rootcrops	7.9	3	205	9
Sorg & Millet	6.7	4	48	17
coffee	2.9	5	1489	1
Horti.crops*	2.8	6	1209	3
Wheat	2.2	7	191	10
Cotton	2.1	8	32	18
Tea	1.6	10	1325	2
Sisal	1.1	11	137	14
cashewnuts	0.5	13	162	11
G-nuts	0.4	14	84	15
Barley	0.3	15	249	8
Sunflower	0.2	16	141	13
Pyrethrum	0.2	16	419	6
Rice	0.2	16	519	5
Tobacco	0.1	17	885	4

* Fruits and Vegetables

Source; Republic Of Kenya, 1986.

The horticultural crops also offer high returns per unit area. Table 1.2 shows that fruits and vegetables together occupy only 2.8% of the total agricultural area of Kenya, and yet they offer higher returns per unit area when compared to enterprises like milk which occupy 46.6% of the area.

Horticultural crops are grown by both large and small scale farmers. There are no statistics showing the proportion that is grown by each sector, but general observation indicates that fruit and vegetable production has been shifting to small scale farmers (Min. Of Agric., 1984) Currently over 30 different horticultural crops are grown in Kenya (National Horticultural Research Centre (NHRC)) However, this study will focus on French beans only.

1.3 French Bean Production

French beans belong to the same species as dry beans (*Phaseolus vulgaris*). *Phaseolus vulgaris* is primarily consumed as dry bean in both developed and developing countries. However, it is also harvested in its' fresh green state, while in Africa the bean leaves are consumed as a vitamin A rich spinach (CIAT, 1992). Alternatively the green pods are commonly consumed in their immature, preferably fibreless state. Most characteristics that distinguish French beans from common beans have evolved as mutations

(CIAT,1992). These mutations have been selected, refined and recombined through hybridization in Europe, U.S.A. and China.

French beans are cultivated in different climatic zones, at varying altitudes and under a variety of management practices. In the developing countries the common thing among them is that they are produced mainly by small farmers as a high input-high output market oriented crop. Their cultivation is widespread throughout the world. Table 1.3 below shows area , production and yields of French Beans In different regions of the world.. The most important production areas are Europe and Asia which account for 76% of the world production.

Table 1.3: Surface Area, Production And Yield Of French Beans Around The World (1986)

Region	Surface Area(ha)	Production(t)	Ave.Yield(kg/ha)
World	445,000	2,991,000	6,724
Africa	39,000	269,000	6,895
N.America	35,000	203,000	5,781
S.America	23,000	79,000	3,375
Asia	189,000	1,248,000	6,602
Oceania	8,000	42,000	5,052
Europe	150,000	1,151,000	7,662

Source; CIAT, 1992.

Within the EEC, Italy, Spain and France are the largest producing countries based on the surface area cropped. However, the highest yields of 11,478 kg/ha, 11,474 kg/ha, and 9,845 kg/ha have been reported in Germany, Belgium, and the Netherlands respectively. Within the Asian countries, China is the largest producer in terms of total production and yields (15,000 kg/ha), and within Africa, Egypt is the largest producer whereas the highest yield of 10,200 kg/ha have been reported in Morocco. Kenya's total production is reported to be 10,000 tons with the yields ranging between 2,000-3,500 kg/ha.

French bean consumption in Kenya is insignificant compared to the consumption of dry beans, they are however a major horticultural export crop. For example, in 1986, they accounted for, 40% of the total export earnings of fresh fruits and vegetables and 20% of all fresh horticultural exports by volume and value (HCDA). The French bean are labour intensive in their production because approximately 3,285 manhours per hectare per crop are required. This figure is much higher than most other crops in Kenya. The production of hybrid maize requires 984 manhours, maize and bean intercropped requires 1579 manhours, while milk requires 380-482 manhours (Min.of Agric., 1979). The high labour requirement in French beans production has made them a major employer of labour.

The French beans are sold to the export market either in their fresh or processed form. Kenyan trade in French beans only concentrates on a few western European countries. For example in the last 10 years, United Kingdom, France and Belgium have held a share of over 80% in terms of volume (Salasya, 1989). European consumers, particularly those in France distinguish among three grades of the French bean. Fine and extra fine are seen as superior to bobby, this makes them to be more income elastic than the bobby (CIAT, 1992). Bobby beans are typically produced in France, Italy, Spain, Egypt and Morocco, whereas Kenya is the major producer of fine and extra fine beans.

French beans can be grown in a wide range of soil types, and optimum production of the beans is attained at elevations between 900-1500m above sea level. A constant supply of moisture is very essential, for it affects the yields, uniformity and quality of beans (Nat. Horti. Res. Centre, Thika). Picking of the green pods begin 6-8 weeks after planting depending on the agro-ecological zone and continues for 3-8 weeks depending on the management practices. The beans are then graded and packed according to the requirements of the export market. Although many areas are suitable for French bean production in Kenya, the main producing areas are Kirinyaga, Murang'a, Machakos, Nakuru and Meru districts.

1.4 Problem Statement

As stated earlier, the French bean industry is playing a vital role in the Kenyan economy. The beans have also become a very important enterprise to the small scale farmers to whom, the French beans are a profitable enterprise which provides the much needed source of income.

For the country to be able to satisfy the much needed foreign .exchange and also to increase farmers incomes and employment opportunities, it is important that we look into ways and means of increasing French bean production so that we are able to meet the expected growth in demand and to ensure sustainable production.

French bean production may be increased by either increasing the acreage under the beans or by increasing the yields. Studies done by CIAT in Latin America and Asia show that most French bean growers have limited access to land, the same phenomenon has been observed in Kenya (Min. of Agric. 1987). Another limitation to increasing area under French beans is the high input requirements for production of French beans. Currently, the average French bean yield per hectare is estimated to be 2-3.5 tons (Min. Of Agric. 1987). These are quite low when compared to the yields of 6-7 tons that have been reported by Research scientists from K.A.R.I., and yields of 10-15 tons reported by other French bean growing countries like Germany, Belgium, China and Morocco.

It is therefore important to identify the factors which significantly influence yield, so that we are able to determine the appropriate strategies to be adopted in order to increase the yields obtained by the farmers. It is also imperative that the problems or constraints encountered by the small scale French bean farmers are identified and prioritized. This will enable the policy makers to develop the strategies to be adopted in order to increase French bean yields and hence their production in Kenya.

1.5 Objectives of the Study

The general objective of this study is to describe the French bean production system in the Central Province of Kenya and to identify the constraints facing the small scale

French bean farmers in the area of study.

The specific objectives of the study are:

i) to describe the usage of resources in French bean production and to determine the resources which significantly influence French bean yields in the areas of study.

ii) to determine whether farmers use the resources efficiently in French bean production.

iii) to describe the factors limiting small scale French bean production in the area of study and suggest the appropriate measures to be adopted.

1.6 Hypotheses of the Study

In view of the objectives of this study, the following hypotheses were formulated and tested. These were:

i) That the Nitrogen fertilizer significantly influences French bean yields.

ii) That phosphate fertilizer significantly influences French bean yields.

ii) That protective chemicals significantly influences

French bean yields.

iii) That certified seed significantly influences French bean yields.

iv) That farm size significantly influences French bean yields.

v) That farm yard manure significantly influence French bean yields.

vi) That small scale French bean farmers in Central Province use fertilizers efficiently in French bean production.

vii) That the small scale farmers in Central Province use protective chemicals efficiently in French bean production.

1.7 Organization of the Study

Chapter one provides background information, problem statement, objectives and hypothesis of the study. Chapter two contains the literature review. Chapter three gives the methods of data collection and data analysis. Chapter four contains the results of the descriptive analysis and chapter five the results and discussion of the production function analysis. Chapter six the summary, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

Presented in this chapter is a review of the relevant literature pertaining to efficiency of resource use, the theoretical background on the meaning of efficiency in resource use, superseded by a review of studies which have attempted to measure the efficiency of resource use are given. Finally a few studies in the horticultural industry and in particular French beans, which show some relationship to this study have been reviewed.

Wolgin (1973) and Massell (1966) refer to technical efficiency as being the degree to which producers are achieving the maximum output given the available resources and techniques. It is particularly important for the less developed countries which are endowed with frequently low productive resources, to produce as much as possible with those few resources.

According to Yotopulous (1967), economic efficiency constitutes the important criterion for economic decision making. Economic efficiency is made up of two components, (Wolgin, 1973 and Yotopulous, 1967). These are technical and allocative efficiency.

Technical efficiency refers to whether firms are obtaining the maximum output given the inputs of production. Allocative efficiency concentrates on correcting disequilibrium that might appear in the utilization of existing factors of production with the given techniques and methods of organization.

Henderson and Quandt (1980) observed that an entrepreneur is able to use many different combinations of inputs for the production of a given level of output. His technology, is all the technical information on the combination of inputs necessary for the production of his output and this includes all physical possibilities. However they feel that the production function differs from the technology in that it presupposes technical efficiency and states the maximum output obtainable from every possible input combination. They continue to state that the selection of the best input combination for the production of a particular output level depends on the input and output prices and is the subject of economic analysis. This same assumption is held in this study whereby the focus is on determining whether there are possibilities of increasing bean production and subsequently farm incomes, by improving the allocative efficiency of the resources used in French bean production.

Allocative efficiency is investigated through the use of production function models. Heady and Dillon (1961) point out that within the limits of statistical reliability, the ratios of marginal value products (MVP's) to their factor opportunity cost (input's market price) provides a measure of the efficiency of resource use on average through-out the population of farms relevant to the sample studied. If the ratio is less or greater than one, it indicates that too much or too little of the particular resource is being used under the existing price conditions, given the levels at which other resources are operating. To them, maximum efficiency in resource use occurs when the revenue from using one additional unit of input is equal to the cost of that additional unit, or in other words, when the ratio of marginal product to opportunity cost ratio is equal to unity.

According to Massel, an efficient farmer is one who allocates resources so that each marketed resource is used upto the point where its' marginal value product is equal to it's price, and each resource that is shared among crops is allocated so as to equate its' marginal value product in each use. He also says that efficiency of resource use can be increased either by improving the level of technology or by allocating resources among the uses more optimally.

A number of studies have utilized the production function to investigate the allocative efficiency of resources used by farmers in different countries.

2.1 Empirical Studies On Efficiency Of Resource Use

Chennareddy's (1967) investigation in South Indian agriculture, revealed that farmers there were efficient in the use of inputs which they had. The study used a Cobb-Douglas production function specified in equation 2-1 fitted on farm business data. It was concluded that a rapid and mass development of agriculture in India can be achieved only by breaking through the traditional state of arts and introducing modern technology in a package consisting of new inputs, agricultural education, special skills and techniques, and guidance in farm planning.

$$Y=aX^{\beta}.U \quad \text{(2-1)}$$

A more complex analysis of a larger sample was carried out by Sahota (1968). He evaluated the efficiency of Indian farmers in allocating resources available to them among different production alternatives. He estimated a production function using secondary data. Marginal productivities for various agricultural inputs for different crops and farm sizes, across six different states in India were derived.

The variables that were included in the study were, output in physical quantities, value of all forms of human labour used, value of all bullock labour, fixed capital, land, value of seed planted, value of fertilizer and manure used, irrigation cost (depreciation, repairs, maintenance, fuel oil and lubricants). The dummy variables included were, wet farms against dry farms, eight farm size groups, six regions, and seasonal dummy.

Marginal products were derived from the fitted Cobb-Douglas function. In order to account for different dimensions of the sample, two regression models were formulated. One with the intercept shifting dummy variables which allowed different year intercepts and also for region and farm correlates. The second model had slope shifting dummy variables to allow for different slope coefficients in different seasons for the crops that were grown more than once in a year.

Sahota concluded that the bulk of the evidence provided by this study appears to support the hypothesis that the resources available to farmers in India have by large been efficiently allocated.

Massel and Johnson (1966), studied the factors responsible for low productivity and the problem of raising productivity in African agriculture. The data analyzed was obtained from two agricultural areas in Rhodesia (now Zimbabwe), namely Chiweshe reserve and Mt Darwin native purchase areas. The reserve area consisted of small farms held under communal tenure whereas the purchased area consisted of larger farms held under free hold tenure.

Using analysis of covariance, the Cobb-Douglas production functions were fitted. Three major crops in the areas were chosen to be corn, millet and peanuts. Production functions were fitted for each crop because each crop was treated as a separate activity. The factors that were observed and hypothesized to be arguments in the production functions were land, labour, fertilizer, manure, fixed capital, soil type and management. Output was measured in physical units of pounds harvested and weighted by its' price.

The land input was entered in the model as the acreage planted to each crop during the survey year. Soils were classified into four types and then entered as dummy variables. The fertilizer and manure were entered in the model as the amount of money spent on each and the fixed capital as the value of fixed capital that is owned.
A Cobb-Douglas function was used to relate the output of each crop to the set of observed inputs. The function in its' logarithmic form was;

$$Y_{ij}=b_{0i}+b_{ki}X_{kij}+V_{ij} \qquad (2-2)$$

where;

Y = log of output

X_1 = log of land

X_2 = log of labour

X_3 = a function of fertilizer

X_4 = a function of manure

X_5 = log of fixed capital

X_6 = soil type dummy

X_7 = farm management dummy.

i denotes the crop whereas j denotes the farm.

The results from the analysis indicated that in the reserve area, there was economic efficiency in resource allocation among crops. There was therefore, very limited scope for raising output in the reserve by varying any one input. In this area land was found to be the major bottleneck. This led to the pre-sumption that giving the farmers more land would lead to an increase in labour and other inputs. Return to the fixed capital was found to be low and returns to expenditure on fertilizer too small to justify greater fertilizer use.

In the purchased area the returns to all inputs were higher than in the reserve. Higher yields were obtained due to a more intensive cultivation of the soil, presumably due to better management and technology. This was an indication that resources can be more profitably used in the purchased area.

Matovu (1979) studied the efficiency of resource use in small holder maize and cotton farming in Machakos and Meru districts. He analyzed the data using a Cobb-Douglas production function to determine the productivity of the resources used in maize and cotton. He also determined the efficiency of resource use within and between the maize and cotton enterprises. He found out that farmers allocated most of the resources considered efficiently within and between the two enterprises. He observed that the existence of allocative efficiency implied that farmers are sensitive to economic incentives, a simple mechanism that may be relied on for technological progress. He concluded that improvement of technological efficiency was to remain the way for further increase in maize and cotton output, for example by improving the rate of adoption of the technologies, such as use of fertilizers and pesticides. He also suggested that maize and cotton output could be increased by introducing economic incentives to the farmers.

He suggested incentives like:

a) raising output prices of maize and cotton.

b) introducing a subsidy on purchased farm inputs.

c) introducing Guaranteed Minimum Returns (G.M.R.) Scheme to small scale farmers.

Murithi (1990) carried out a study in Meru district on the efficiency of resource use in small holder milk production. The case study was on Meru central dairy farmers. Using a Cobb-Douglas production function, he showed that dairy farmers were efficient in allocating most of their resources in milk production. However he noted that the farmers were feeding the cows with less than optimal amounts of concentrates. From the study he concluded that there could be substantial increase in milk output and consequently gains in farm profits if the amount of concentrates fed to the animals is increased above the current levels. The function used was as shown below.

$$Y=A.X_1^{b_1}.X_2^{b_2}.X_3^{b_3}.X_4^{b_4}.X_5^{b_5}............(2-3)$$

The equation was then estimated in its linearized log form using the ordinary least squares method. From the regression results, the coefficients of concentrates and farm by-products were significant at the 1% level of significance, whereas the farm grown forages, labour, and operating capital were not significant at the 5% level.

To test for efficiency in resource use of milk production, Murithi employed the test for average allocative efficiency. This test involved comparing the marginal value product (MVP) of the resource with the price of the resource. If equal, then the resource in question is said to be used efficiently, but if different the resource is said to be used inefficiently. He used the t-test to test whether the estimated MVP was equal to the factor price.

The t-test was calculated using the following relationship;

Fit eqn here

Where: $MVPx_i$ = the estimated marginal value product of X_i

Px_i = Price of input X_i

$S.E.(MVPx_i)$ = standard error of the estimated $MVPx_i$

The calculated t was then compared with the tabulated t at the relevant degrees of freedom. If the calculated t was less than the tabulated t value, this was assumed to imply that the resource in question is being used efficiently. If greater, then this implied inefficiency in use of that resource.

From the efficiency tests, he found that the labour and operating capital were being used efficiently in milk production but, the concentrates were being used below the point of economic optimum.

The author concludes that efforts to increase milk production should be directed at encouraging farmers to give supplement feeds to animals. This could be done by education or by being shown the benefits of feeding concentrates through demonstrations in research stations, FTC's on farm demonstration and field days. He suggested that dairy farmers be paid promptly for milk delivered, farmers to be assisted to acquire feeds on credit and making the roads more passable as the efforts which would help the availability of feeds to the farmers.

This study takes the same approach as Murithi's to test for efficiency in French bean growing.

2.2 General Horticultural Studies

Jaffe (1986), studied the variables that influence the expansion of horticultural exports from Kenya. He found that the possibility of expanding exports exist and that there is need for Kenya to diversify its exports to reduce the risks of price, weather and loss of market that are imminent in the coffee and tea industry which Kenya relies on heavily as major foreign exchange earners. He felt that horticulture provided a basis for such diversification.

Salasya (1989), studied the factors that were affecting French bean exports from Kenya. She felt that if horticulture is to effectively diversify the Kenyan exports, then it is important to look into the export prospects and also find ways and means of improving and increasing both quantity and quality of exports.

Studies on French bean economics have been carried out by the International Centre For Tropical Agriculture (CIAT) in various Latin American and Asian countries. To assess the economic importance of French beans, Pachico (1987) carried out a study in Colombia to compare the profitability of French beans to other crops. He showed that even though labor and other input requirements for French bean cultivation are higher than the requirements for maize and beans, potatoes, wheat or barley, their profitability is still higher. Economic value can also be attached to post harvest losses in vegetables (CIAT, 1992). French beans are considered to be highly perishable, but their post harvest losses have been shown to be 25-28% (CIAT, 1987-89) which is comparable to those of green tomatoes but lower than that for cabbage, cauliflower or sweet corn. Another source (CIAT, 1992) estimates post harvest losses of French beans as 5-10% lower than those of lettuce, spinach, green onions or ripe tomatoes. Lower post harvest losses translate into a lower marketing margin that benefits both the producer and the consumer.

A case study on production, marketing and consumption of French beans under lowland and highland conditions was carried out in the Philippines with a view to identify ways to increase production (CIAT, 1992). It was found that the average area devoted to French beans is 0.25ha in the highlands and o.33ha in the lowlands. The yields were found to be higher in the highlands (11 tons/ha) than in the lowlands (9 tons/ha), but lowland farmers realized a higher benefit to cost ratio because French bean cultivation is more labour intensive in the highlands. The yields at both altitudes were however well below experimental-site yields of 15-18 tons/ha. Major production constraints were found to be susceptibility to insects and diseases, insufficient water, lack of production capital and unpredictable prices.

He estimated a production function using a Cobb-Douglas equation. The dependent variable was yield per hectare, while the independent variables were, farm size, pre-harvest labour days, amount of seed, insecticides, fungicides, organic fertilizer, nitrogen, phosphate, potassium, foliar fertilizers, variety planted, frequency of fertilizer applications per cropping season, frequency of harvesting, distance between rows, depth of planting, age of farmer, number of years in French bean growing and education level. Three production functions were estimated, one for the highlands, one for the lowlands and one for the combined areas. The inputs that were affecting yields in the highlands were farm size, levels of nitrogen and phosphate fertilizers, age of farmer, and number of years in production. The labour and chemicals were not significantly affecting yields, and the interpretation was that these inputs were being used in excess of economically efficient levels and can be reduced without a detrimental effect on yield. Under lowland conditions farm size was the only physical input affecting yields, however cultural and management factors like frequency of harvesting, frequency of fertilizer application and number of years in French bean cultivation were significantly affecting yields. Efficiency tests were carried out for the inputs nitrogen and phosphate. Results of the analysis showed that these inputs are still below the efficient level as indicated by a ratio of marginal value product to marginal factor cost which is greater than one.

Economic studies on French beans production in Kenya are scanty. The Ministry of Agriculture's farm management division has estimated gross margins of a hectare of French beans to be ksh. 1,333.00-9,892.00. The Horticultural Research Station at Thika has also estimated the gross margins to be ksh. 16,963.00. Mbatia (1984) visited a few French bean farmers to enable him to assess the financial benefit in French bean production. He estimated the total variable costs to be ksh. 11,539.00 and the gross margin to be ksh. 41,325.00 His conclusions were that even though the initial capital was high, French bean farming was a profitable operation.

CHAPTER THREE

METHODOLOGY

3.1 Data Type And Sources

This study used primary and secondary data. The primary data were collected from small scale French bean growers, officials from the Horticultural Crops Development Authority, French bean traders and stockists of farm inputs. The secondary data were obtained from reports from the HCDA, the Ministry of Agriculture and the Central Bureau of Statistics.

3.2 Selection of locations

The major French bean growing areas in the central province were identified to be Mwea Division in Kirinyaga District, Kandara and Makuyu Divisions in Murang'a Districts. Lists of all the French bean growers were compiled by the extension staff from these divisions. The locations with majority of French bean growers were chosen.

3.3 Sampling of Farmers

The lists of French bean farmers were used for sampling. Forty farmers were selected from each of the three divisions using a simple random procedure.

3.4 Data Collection

The farmers selected were personally interviewed using a pre-tested structured questionnaire (see appendix 1) to get the required information. Few informal interviews were held with the agricultural extension staff, HCDA officials, French bean traders and suppliers of farm inputs. The field data collection took place between the months of January and February, 1991.

One week prior to the actual survey, the three enumerators were briefed on purposes and objectives of the study and taken through the questionnaire. Training in the translation of the questions was undertaken since all the respondents were fluent in Kikuyu.

The questionnaire was pre-tested using 10 farmers in the study area. This was done as part of the training exercise for the enumerators and also to check for the appropriateness of the questionnaire in getting the desired information. After this exercise the needed changes were made.

3.5 Limitations Of The Data

The farmers interviewed did not keep records, therefore the author depended on the farmers to remember the quantities and prices of all the inputs used and output obtained.

3.6 Methods of Analysis

In this section I have described the methodologies used in analysis of the data collected. Two methods of data analysis were used in this study, descriptive analysis and production function analysis.

3.6.1 Descriptive Analysis

The purpose of this analysis is to describe the socio-economic characteristics of the French bean farmers, French bean production systems and problems faced by farmers in French bean production.

3.6.2 Production Function Analysis

Production function analysis is the estimation and analysis of the quantitative relationship between inputs and outputs. Many studies have utilized the production function approach to appraise the allocative efficiency of resources in farms.

According to Clayton (1983), production function analysis at the farm level has mainly been used for the following purposes:-

(i) to improve on the present allocation of resources.

(ii) to investigate the economic rationality of farmers.

(iii) to derive farm supply functions.

Although production functions cannot be used to make specific recommendations, their results are useful for general diagnostic purposes in analyzing farm resource returns and capital productivity, from which suggestions to farmers on whether they are using too much or too little of a resource or whether re-allocation of resources from one enterprise to the other would be profitable can be made. They are also very important for extension and policy purposes, especially when combined with other micro and macro-analysis (Heady and Dillon, 1961).

The main focus in this study is to determine whether there are possibilities of increasing farm incomes and French bean yields through the improvement on the allocative efficiency of the resources used.

3.6.2.1 Choice of Model

No one particular algebraic form of production function has been identified as the best for all situations (Rukandema, 1977), since various different algebraic forms like the linear, quadratic, generalised power, square root translog and transcedental functions have been used in empirical studies to describe different production processes. On the same line Rukandema observes that choosing the appropriate mathematical specification of the production model to reflect the complex allocative decisions on small scale farms is a very difficult problem. The dilemma in choosing the appropriate function is that the standard mathematical formulations will most often simplify reality, while the more complex formulations will lead to problems of estimation of the function and interpretation of the results, (Murithi, 1990)

According to Heady and Dillon, (1961) the criteria in choosing the algebraic from is a combination of:-

(i) Considerations on the biological, economic or other environmental factors that relate to the process that is under study.

(ii) The 'best fit' which may be indicated by the coefficient of determination (R^2) or the F-ratio, statistical significance and the signs of the estimated coefficient.

(iii) Subjective judgements of different individuals.

(iv) Ease and simplicity of the computations.

The Cobb-Douglas function has shortcomings (Heady and Dillon, 1961) in that :-

a) it cannot be used satisfactorily where there are ranges of both increasing and decreasing marginal productivity, or where there are both positive and negative marginal productivities.

b) the function may over estimate the optimal level of input x which equates the marginal revenue (MR) to the marginal cost (MC).

c) it assumes unit elasticity of substitution between factors of production and,

d) it does not give a maximum level of output since the output increases indefinitely with an increase in the level of input.

However, the function has some very desirable properties which have tended to make it the most popular in farm-firm analysis. These are :-

a) computation feasibility: The regression coefficients immediately give the elasticities of production. And the elasticities from a Cobb-Douglas function are independent of the level of inputs.

b) adequate fit of data.

c) it allows for the phenomenon of diminishing marginal returns to be observed without loosing too many degrees of freedom. It is therefore said to be an efficient user of degrees of freedom (d.o.f), which is an important quality where research resources are limited and collection of data an expensive exercise.

After weighing the advantages against the disadvantages of the Cobb-Douglas production function, I decided to use it to estimate the French bean production function.

According to Wonnacot and Wonnacot (1977) the Cobb-Douglas function is specified as follows:-

$$Y=A.X_1^{\beta_1}.X_2^{\beta_2}....X_n^{\beta_n}U......................(3-1a)$$

where:

Y = Output

A = Constant

β_i's = regression coefficients (elasticities of production with respect to the factors.

X_i's = factors of production.

u = a multiplicative stochastic error term.

This function when linearized using the natural logarithms, is expressed as:

$$LnY=LnA+\sum_{i=1}^{n}\beta_i LnX_i+LnU.........................(3-1b)$$

In the log-form, this function is estimated using the least squares method, with the assumptions that the residual error term is independently distributed from farm to farm with a mean of zero and a finite variance (Wonnacot and Wonnacot, 1977).

In estimating the Cobb-Douglas function, problems do arise if some levels of certain variables are zero. These cases often do occur in survey data where some respondents may not have used a particular input. In this case, estimation of the Cobb-Douglas function is not feasible since the natural log of zero is minus infinity. Heady and Dillon suggest that in such cases, very small values could be taken to replace the zero, or a constant figures should be added to that variable and then make adjustments to the estimated coefficient. Norusis (1986) in a manual on procedures for operating the scientific package for social sciences (SPSS + TM) suggests that this problem can be overcome by eliminating the cases with missing values. This is termed as list wise missing value treatment. The case is eliminated if it has a missing value on any variable in the list. The last method was adopted in this study.

3.6.2.2 Variables included in the French Bean Production Function

The variables that the author thought were important in determining French bean yields are described in this section. Also included here is the method used in the estimation and in obtaining their prices.

Dependent variable

In this study, the dependent variable is French bean yield in kilograms per hectare. This variable is estimated by asking the farmer the number of marketable cartons of French beans that were obtained from a particular measured plot during a particular period. The number of cartons given was then multiplied with a factor to get the marketable yield per hectare. The average price of French beans was used to determine the marginal value products. According to Moock (1971), the researcher must decide on average values for the unit cost of inputs and outputs in research areas and also in the marketing period because of the variation in prices due to space and time.

To get the simple average price of French beans the following was done;

$$Av.P_{nov}=\frac{P_{ex.nov}+P_{fn.nov}}{2} \quad \text{(3-2a)}$$

$$Av.P_{dec}=\frac{P_{ex.dec}+P_{fn.dec}}{2} \quad \text{(3-2b)}$$

$$Av.P_{jan}=\frac{P_{ex.jan}+P_{fn.jan}}{2} \quad \text{(3-2c)}$$

$$Av.P_{fb}=\frac{Av.P_{nov}+Av.P_{dec}+Av.P_{jan}}{3} \quad \text{(3-2d)}$$

where:-

$Av.P_{Nov}$ = Average price of beans in november.

$Av.P_{Dec}$ = Average Price of the beans in december.

$Av.P_{Jan}$ = Average price of beans in january.

$P_{fn.Nov}$ = Price fine beans in november.

$P_{fn.Dec}$ = Price fine beans in december.

$P_{fn.Jan}$ = Price of fine beans in january.

$P_{ex.Nov}$ = Price of extra fine beans in november.

$P_{ex.Dec}$ = Price of extra fine beans in december.

$P_{ex.Jan}$ = Price of extra fine beans in january.

$Av.P_{fn}$ = Average Price of French beans.

The Independent Variables

The variables that were hypothesized to be important in explaining the variation in French bean yields were, organic and chemical fertilizers, crop protection chemicals, agro-ecological zones, type of seed and the plant population.

a) Chemical Fertilizers

They were included in the model as two separate variables namely:-

i) Nitrogen fertilizer

This was included in the model as the amount of Nitrogen (N_2) applied per hectare. Nitrogen is recommended by agronomists in the National Horticultural Research Centre as a planting and topdressing fertilizer. It enhances the growth of leaves and the flowering, thereby increasing yields. The coefficient for nitrogen is hypothesized to be significant and positive in this study.

ii) Phosphate fertilizer

This was included in the model as the amount of the Phosphate (P_2O_5) component applied in a hectare of French beans. This fertilizer is recommended by agronomists for planting because it enhances root and other tissue formation.

The coefficient is hypothesized to be significant and positive.

In order to get the unit prices for this fertilizers, the most commonly used fertilizers by the farmers who were included in the sample were identified. These were found to be diammonuim phosphate (DAP) and calsuim ammonium nitrate (CAN). By using the 50kg bag prices for both DAP and CAN, and the percentage composition of nitrogen and phosphate in DAP and CAN, the unit prices for N_2 and P_2O_5 were obtained.

b) Manure

The use of farm yard manure is recommended, especially where the soils are low in organic matter and also in heavy clay and sandy soils. Significant increase in French bean yields have been registered by researchers from K.A.R.I and CIAT. Therefore the coefficient is expected to be positive and significant.

c) Protective Chemicals

Diseases and insects cause severe damage to French beans and researchers recommend that the farmers should give serious attention to prevent losses from diseases and insects (Omunyin, 1989). Due to the high variation of the protective chemicals used by the French bean farmers, the quantity used would not have reflected the quality effect. Therefore, the price of pesticide was used so that it would bring out the quality effect and expenditure on the chemicals was assumed to be a good proxy for the chemical input in French bean production. The same approach was taken by Headley (1968) while estimating the productivity of agricultural pesticides, though he agrees that this has a limitation because productivity of the chemical would vary and depends on the pest attacked, amount and timing of the application.

The coefficients obtained from the analysis for both fungicides and insecticides were expected to be positive and significant. The price per shilling spent on chemicals was assumed to be the opportunity cost of the capital used in purchasing crop protection chemicals. This is the gain forgone in terms of the interest the farmer would have earned had he put the money in a commercial bank. The interest rate for savings accounts in 1991 was 13.5%.

d) <u>Seed Rate</u>

There is the recommended seed rate of French beans (75kg/ha) which gives optimal growth of the plant. If the seed rate is higher than the recommended, the yields obtained are expected to decrease due to competition for sunlight, water and nutrients. The variable was entered in the function as the kilograms of seed per hectare. The price per kilogram of seed was taken to be the average of the prices of seed obtained from various sources.

These sources of seed included;

1) The Kenya Grain Growers Co-operative Union
2) own seed or neighbours seed
3) local shopping centres
4) French bean traders

e) <u>Type Of Seed Planted</u>

The type of seed used does affect the yields obtained because of the cleanliness of seed in terms of weeds, disease and insects. Researchers recommend the usage of certified french bean seed. The variable was entered in the model as a dummy variable for use or non-use of certified french bean seed. The coefficient obtained is expected to be positive and significantly affecting the yields of French beans obtained by farmers.

f) Area Under French Beans

This refers to the acreage of land that was under French bean production per farm. The hectares under French beans was obtained by summing up all the areas or plots that had beans on them at the time that the survey was carried out.

g) Region

Three agro-ecological zones were identified in the study area. These were the main coffee zone (UM_2), the maize sunflower zone (UM_4) and the cotton zone (LM_3-LM_4).
The main difference between the regions was the rainfall amounts received. Only two region dummies were included in the model, leaving out one due to the problem of perfect collinearity.

3.6.2.3 Testing of Hypotheses

To test the hypothesis that each of the identified inputs significantly influence French bean yields, the following hypotheses were tested.

$$H_0: \beta_i = 0 \quad \text{..........} \quad (3\text{-}3a)$$

$$H_1: \beta_i \neq 0 \quad \text{..........} \quad (3\text{-}3b)$$

To test for the statistical significance of the individual coefficients the t-statistic was used at specified levels of significance, where:

$$t=\frac{\beta_i}{S.E.(\beta_i)} \qquad \text{(3-3c)}$$

The calculated t was compared to the tabulated t at specified levels of significance and d.o.f. The null hypothesis (H_o) was either accepted or rejected depending on whether the calculated t-value was lesser or greater than the tabulated one. Accepting the null hypothesis would suggest that the input in question did not influence the bean yields, whereas rejecting it would imply the input did influence the yields.

A further economic analysis was done to test for the efficiency of resource use by the French bean farmers.
Using the fitted C-D function, the following economic variables with respect to the inputs were determined from equation 3-1 using the Heady and Dillon approach;

a) Elasticity of production with respect to the input X_i:-

$$\beta_i=\frac{dy}{dx_i}\cdot\frac{X_i}{Y} \qquad \text{(3-4a)}$$

b) Marginal Physical Product (MPP) with respect to input X_i

$$MPP_i=\frac{dy}{dx_i}=\beta_i\cdot\frac{Y}{X_i} \qquad \text{(3-4b)}$$

Following the algebraic notation of Heady and Dillon (1961), profits are given by:

$$\Pi = PyY - \sum P_i X_i - K \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}5a)$$

where:-

π = profit

Px_i = market price or opportunity cost of input the Xi

X_i = amount of i^{th} factor

K = fixed costs if any

Py = unit price of output

Y = amount of physical output

The first order maximization condition is given as

$$\frac{d\pi}{dx_i} = Py\frac{dy}{dx_i} - Px_i = 0 \ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}5b)$$

or,

$$\frac{dy}{dx_i} = \frac{Px_i}{Py} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}5c)$$

ie. the MPP of the i^{th} input is equal to the factor product price ratio.

This reduces to $MVPx_i = Px_i$, for efficient allocation of resources. This means that for efficient allocation of resource, the marginal value product per shilling spent on X_i is unity.

To test for efficiency of resource allocation the following hypotheses were tested:-

$$H_o: MVPx_i = Px_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.6a)$$

$$H_1: MVPx_i \neq Px_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.6b)$$

Inorder to find any discrepancy between the estimated marginal productivity and the existing opportunity cost of the resource, the t-test was used where:-

$$t=\frac{MVPx_i-Px_i}{S.E.(MVPx_i)} \quad \ldots\ldots (3\text{-}6c)$$

Where :

$MVPx_i$ = estimated marginal product of input x_i

Px_i = price of input x_i

$S.E.(MVPx_i)$ = standard error of the estimated marginal value product of input x_i

The null hypothesis was accepted or rejected at a specified level of significance. Accepting H_o means the farmers are efficient in using that input, whereas rejecting it means that the farmers are not efficient.

CHAPTER FOUR

DESCRIPTIVE ANALYSIS

Presented in this chapter are the results of the descriptive analysis of the survey data and their interpretation. This analysis helps to describe the socio-economic and technical aspects of French bean production.

4.1 Socio-Economic Characteristics

In this section, the socio-economic characteristics of small-scale French bean farmers in the area of study are described. These include farm sizes, sex of respondents, land ownership, land use and experience in growing French beans.

4.1.1 Respondents

These were the people responsible for making the day to day decisions affecting the production and marketing of french bean enterprise in the farm. Table 4.1 shows that in both Mwea and Makuyu divisions, the French beans were seemingly a man's enterprise, whereas both male and females had an equal share in Kandara division.

Table 4.1:French Bean Survey Respondents By Sex

Division	Male %	Female %
Mwea	67.5	22.5
Makuyu	75.0	25.0
Kandara	44.6	41.4

Source; Author's survey, 1991.

4.1.2 Land Ownership

As a whole, 80% of the farmers surveyed owned the land on which they grow the French beans, and only 20% of the farmers rented the land. Mwea division had the largest percentage (25%) whereas Kandara division had the least number (13%) of farmers renting the land on which they grew French beans. This phenomenon could be well explained by the tenure system in the study area. In Mwea, most of the farmers interviewed belonged to the Mwea rice irrigation scheme, where the government has provided them with land on which they are supposed to grow rice. This would mean that any farmer in the scheme who would like to engage in other enterprises had to rent land elsewhere. Whereas in the other study areas, the free hold tenure system is prevalent.

4.1.3 Farm Size Around The Homestead

The farm sizes varied greatly amongst the three regions. The mean farm sizes were 0.37 ha in Makuyu division, 1.85 ha in Kandara division and 2.7 ha in Mwea. In Kandara and Makuyu divisions the farm sizes were as low as 0.05 ha (see table 4.2).

Table 4.2: The Distribution of Farm Sizes Around Homestead

	Kandara		Mwea		Makuyu	
Farm Size Category(Ha)	Simp. %	Cumm %	Simp. %	Cumm %	Simp. %	Cumm %
< 0.4	6.0	6.0	0.0	0.0	65.0	65.0
0.4 < 1.2	39.4	45.4	27.5	27.5	30.0	95.0
1.2 < 2.0	30.2	75.6	15.0	42.5	5.0	100.0
2.0 < 4.0	9.3	84.9	42.5	85.0	0.0	
4.0 < 6.0	12.1	97.0	2.5	87.5	0.0	
> 6.0	3.0	100	12.5	100	0.0	

Source; Author's survey, 1991.

4.1.4 Area of Land Under French Beans

This differed greatly between the regions. The least acreage under French beans was to be found in Kandara where, 25.7% of farmers had less than 0.04ha, 49% had less than 0.08ha and 24.7% had over 0.4ha under French beans. None of the farmers in Makuyu had less than 0.04ha or even more than 0.8ha under the beans. Most of them (90%) had acreage ranging between 0.04ha to 0.39ha. Mwea farmers had the largest acreage under French beans. All of them had over 0.08ha, while the majority had acreage between 0.2 ha to 1.59 ha (see table 4.3). When these results are compared to the average total farm sizes, it appears that Kandara, which had the lowest average farm sizes also has the least acreage under French beans.

Table 4.3: **Area Of Land Under French Bean Production**

Area (Ha)	Kandara Simp. %	Kandara Cumm %	Mwea Simp. %	Mwea Cumm %	Makuyu Simp. %	Makuyu Cumm %
< 0.04	25.7	25.7	0.0	0.0	0.0	0.0
0.04 < 0.08	23.3	49.0	0.0	0.0	30.0	30.0
0.08 < 0.2	15.4	64.4	15.0	15.0	37.5	67.5
0.2 < 0.4	12.9	77.3	25.0	40.0	22.5	90.0
0.4 < 0.8	6.2	83.3	37.0	77.0	10.0	100
0.8 < 1.6	10.3	93.8	20.5	97.5	0.0	
1.6 < 3.6	0.0	0.0	2.5	100	0.0	
> 3.6	6.2	100	0.0	0.0		
Total	100	100	100	100	100	100

Source; Author's survey, 1991.

Table 4.4: Percentage Of Farm Size Under French Bean Production

Percent of farm	Mwea simp. %	Mwea cumm. %	Makuyu simp. %	Makuyu cumm. %	Kandara simp. %	Kandara cumm %
< 5	5.4	5.4	0.0	0.0	26.8	26.8
5 < 10	16.2	21.6	2.1	2.1	11.4	38.2
10 < 20	16.2	37.8	12.6	14.7	15.3	53.5
20 < 30	13.5	51.3	18.8	33.5	11.4	64.9
30 < 50	13.5	64.8	2.1	35.6	11.4	76.3
50 < 75	18.9	83.7	35.5	71.1	7.6	83.9
75 < 100	10.8	95.5	6.3	77.4	0	
100	0.5	100	18.8	96.2	0	

Source; Author's survey, 1991.

Table 4.4 shows that as compared to other regions, farmers in Makuyu were dedicating higher percentages of their land to French bean production. Only 35% of them had less than half their land under beans whereas majority of farmers had 50 to 100% of their total land under French bean production. In Mwea and Kandara, majority (64.8%, 76.3% respectively) of the farmers had less than 50% of their total land under French beans. The small fractions and percentages of area under the beans is an indication of the high risks that the farmers associate with the French beans in terms of price and market instability. Although the enterprise is such a lucrative one, the farmers are not willing to commit more of their resources on a risky enterprise like the French beans.

Another explanation is the high water requirements of the crop. Most of the farmers were using manual methods (bucket irrigation) to irrigate their French beans. Therefore the small pieces of land under the beans would also be an indication of the labour the farmers are willing to allocate to the French beans.

4.1.5 **Farmers Reasons for Engaging in French Bean Cultivation**

Table 4.5 shows the various reasons the farmers gave for engaging in French bean growing. Most farmers interviewed were in French bean production because of the quick cash generation. Even then, most of them reported that French bean production was not very profitable. They also reported that it wasn't an easy crop to grow, except in Mwea where a few of the respondents thought they were easy to grow when compared to rice growing.

Table 4.5: Reasons Given By Farmers for Growing French Beans

Reason Given	Mwea No.	Mwea %	Kandara No.	Kandara %	Makuyu No.	Makuyu %
Gen. quick cash	34	85.0	31	79.5	29	72.5
profitable	1	2.5	5	12.9	9	22.5
Easy to grow	4	10.0	0	0.0	0	0.0
All	0	0.0	3	7.5	2	5.0
	39	100	39	100	40	100

NB: No. = Numbers of farmers

Source; Author's survey, 1991.

Table 4.6 shows the rank of French bean in terms of amount of income earned when compared to other enterprises in the farm. Majority of the farmers interviewed in Kandara and Makuyu ranked the French bean enterprise first (76% and 95%) respectively. Whereas in Mwea the French beans faced strong competition from the rice production, so that only 47% of those interviewed ranked it first. In Kandara, the farmers had been discouraged by late payments in coffee and they were concentrating more on the French beans.

Table 4.6: **Ranking of French Beans as an Income Generator When Compared to Other Enterprises in the Farm**

	Mwea		Kandara		Makuyu	
Rank	No.	%	No.	%	No.	%
First	19	47.5	30	76.9	38	95
Second	15	37.5	7	17.9	2	5
Third	4	10	1	2.6	0	0
Fourth	2	5	1	2.6	0	0
Total	40	100	39	100	40	100

NB: No. = Number of farmers.

Source; Author's survey, 1991.

4.1.6 Years In Growing French Beans

The number of years a farmer had been in French bean production was regarded as a measure of experience of the farmers in growing the beans, thus making one farmer a better or worse manager in French bean growing.

Table 4.7 shows that in Mwea, 4 of those interviewed had grown French beans for less than 2 years, 20 of them had grown them for 2-3 years and 16 of them had grown them for over 4 years. In Kandara, only 2 of the farmers interviewed had grown them for less than 2 years, 17 of them had grown the beans for 2-3 years, whereas 20 had grown them for over

4 years. In Makuyu, 12 of those interviewed had grown them for less than 2 years, 13 had grown them for 2-3 years and 14 had grown them for over 4 years. In all the three regions over half of farmers interviewed had grown the beans for over 2 years.

Table 4.7: Years in Growing French Beans

	Mwea			Kandara			Makuyu		
No. of yrs	No.	Simp. %	Cumm. %	No.	Simp. %	Cumm. %	No.	Simp. %	Cumm. %
< 1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
1	4	10.0	10.0	2	5.0	5.0	12	30.7	30.7
2	14	35.0	45.0	12	30.7	35.7	8	20.5	51.2
3	6	15.0	60.0	5	12.8	48.5	1	12.8	64.0
4	5	12.5	72.5	5	12.8	61.3	1	2.5	66.5
> 5	11	27.5	100.0	15	38.7	100.0	13	33.5	100.0
Total	40	100.0		39	100.0		39	100.0	

NB: No. = Number of farmers.

Source; Author's survey, 1991.

4.2 French Bean Production Practices

4.2.1 Period of French Bean Growing

French beans can be grown during any time of the year depending on the availability of water. In all the three regions, over eighty percent of the Farmers grew French beans throughout the year, the only variation was the area of French beans whereby less land was dedicated to them during the dry season due to the high water required to fulfil the plant's water requirements. In Mwea, 4 of the respondents said that they grow the beans only during the rains and only one respondent said that he times the off-season in the European market. In Kandara, only one person timed the off-season in the European market whereas in Makuyu none of the respondents tried to regulate their production to the export market.

4.2.2 Mode of Irrigation Used

As shown in the table 4.8 below, over 50% of the farmers interviewed used the furrow or bucket method to irrigate their French beans. In Mwea, all the farmers interviewed used the furrow method to irrigate their beans. In Kandara 53.8% of those interviewed used the bucket to draw water for irrigation, 43.5% of the farmers had pumps to pump water from the rivers and out of the 43.5% only 12.8% had sprinklers while the rest used pipes to distribute the water in the French bean field. In Makuyu, 47.5% of the respondents used bucket irrigation, 17.5% used furrow and 17.5% had a water pump. Out of those who had pumps, 12.5% use sprinkler irrigation.

Table 4.8: Mode of Irrigation Used To Irrigate French Beans

Method	Mwea No.	Mwea %	Kandara No.	Kandara %	Makuyu No.	Makuyu %
Sprinkler	0	0	5	12.8	5	12.5
Pipes	0	0	12	30.7	2	5
Bucket	0	0	21	53.8	19	47.5
Furrow	40	100	0	0	7	17.5
Total	40	100	38	100	33	100

NB: No. = Number of farmers.

Source; Author's survey, 1991.

4.2.3 Varieties and Sources of Seed Grown

Table 4.9 shows the varieties of French bean seed grown. Varieties grown in the three areas of study were found to be Monel, Supermonel and Bobby, these were all bush type of French beans. In all the three areas, the monel variety was found to be the most commonly grown. Farmers claimed that most French bean buyers preferred the monel beans. Few farmers grew the super monel (9.2%), they claimed that this variety required a lot of labour since it has to be picked every day as compared to monel variety which is picked on alternate days. The bobby variety was rarely grown and the few who grew it had a few specific buyers.

As shown in Table 4.10, eighty percent of the respondents in Mwea bought certified seeds while 20% either used their own seed or from neighbouring farms. In Kandara 46.2% of respondents bought certified seed, 53.9% bought from neighbours or they used their own seed. In Makuyu, 32.5% of the respondents bought certified seeds, while 67.5% used either their own seed or neighbour's seed.

The average seed-rate per hectare was found to be 56kg in Makuyu, 61kg in Kandara and 76kg in Mwea. This shows that it is only in Mwea that farmers followed the recommended rate of 75kg/ha while the others were using less than recommended rate. Seed prices fell between 20/- per kilo in Mwea to 70/- per kilo in Kandara, however the seed was mainly sold at a price between 40/- to 55/- per kilo.

Table 4.9: Variety of French Beans Grown

	Mwea	Makuyu	Kandara
Variety	No.	No.	No.
monel	35	35	26
super monel	5	4	2
bobby	0	0	1
don't know	0	1	10
Total	40	40	39

NB: No. = Number of farmers.
Source; Author's survey, 1991.

Table 4.10: Source of The French Bean Seed

	Mwea		Makuyu		Kandara	
	No.	%	No.	%	No.	%
Appointed dealer for certified seed	32	80.0	13	32.5	18	46.2
Own seed	5	12.5	5	12.5	2	5.1
Neighbour	3	7.5	22	55.0	19	48.8
Total	40	100	40	100	39	100

NB: No. = Number of farmers.

Source; Author's survey, 1991.

4.2.4 <u>Fertilizer Use in French Bean Production</u>

Fertilizer use in French bean production was widespread since all those interviewed used fertilizer of some sort to grow the beans. Table 4.11 shows that of all the farmers interviewed, 80% in Mwea, 79.4% in Kandara and 95% in Makuyu used fertilizer during planting. In all the divisions the most used fertilizer during planting was diammonium phosphate (DAP). Other fertilizers used during planting were single super phosphate(SSP), 20:20:10 and 20:10:10.

Most of the farmers interviewed (85% in Makuyu, 97.4% in Kandara and 97.5% in Mwea) region topdressed the French beans with a fertilizer. In Makuyu and Kandara Calsium Ammonium Nitrate (CAN) was the most preferred topdressing fertilizer (74.4 and 63.2% respectively), whilst in Mwea Diammonium Phosphate (DAP) and CAN had almost equal popularity as topdressing fertilizers (see table 4.12).

Table 4.11: Types Of Planting Fertilizers Used

Fertilizer used	Kandara %	Makuyu %	Mwea %
none	17.9	5.0	20.0
DAP	69.2	90	77.5
20:10:10	5.1	0.0	0.0
20:20:10	1.0	0.0	0.0
SSP	0.0	0.0	2.5
Total	79.4	95.0	80.0

Source; Author's survey, 1991.

Table 4.12: Types Of Topdressing Fertilizer

Fertilizer used	Kandara %	Makuyu %	Mwea %
none	2.6	15.0	2.5
CAN	61.5	72.5	40.0
DAP	17.9	7.5	47.0
urea	2.6	2.5	0.0
ASN	0.0	0.0	10.0
20:10:10	2.6	0.0	0.0
20:20:10	10.3	0.0	0.0
total	97.0	85.0	97.5

Source; Author's survey, 1991.

Table 4.13: **Rates Of Fertilizers Used**

		Mean kg/ha	Min kg/ha	Max kg/ha
1) Nitrogen Fert.	a) Mwea	48.7	14.8	138.5
	b) Kandara	137.4	11.6	1797.8
	c) Makuyu	70.0	9.0	233.6
2) Phosphate Fert.	a) Mwea	80.3	10.0	210.0
	b) Kandara	105.1	23.9	364.9
	c) Makuyu	81.1	8.5	298.3

Note:- Recommended rates are 88 kg/ha = Nitrogen
92 kg/ha = Phosphate

Source; Author's survey, 1991.

The recommended fertilizer rates are 200kg of DAP and 200kg of CAN per hectare of French beans (Nat. Hort. Res. Centre). These rates correspond to 88kg of the Nitrogen component(N_2) and 92kg of the Phosphate component(P_2O_5) per hectare. The average rates of fertilizer used by farmers in Mwea and Makuyu were found to be less than the recommended rates by 44.7% and 20.4% respectively in nitrogen and by 12.7% and 11.8% respectively in phosphate as shown in Table

4.13. In Kandara, the farmers were on the average found to be using more than the recommended rates of both nitrogen and phosphate by 55.7% and 14% respectively.

Manure usage was a common practice amongst the French bean growers. Kandara division had the highest percentage (84.6%) of the farmers using manure, followed by Makuyu Division (60.4%) and lastly Mwea Division (43.2%). Out of those who applied manure, only 8% of them purchased it while the rest used their own.

4.2.5 Weeding

All the farmers used hand weeding to control the weeds. At least two weedings are recommended in order to maintain a weed free French bean crop. In Mwea and Makuyu divisions 92.5 and 82.5 percent respectively, weeded each crop once . This may be taken as an indication of the labor constraints experienced by the farmers. In Kandara however, 56.4% weeded twice, 17.9% thrice and 25.6% are the ones who weeded only once. This may be due to the size of areas planted with French beans. In Kandara division, the plots with French beans were very small which the farmers could manage to weed at least two times. Whereas in Mwea, the plots under beans were much bigger as shown in table 4.3.

4.2.6 Pesticide Use

According to researchers working on French beans in CIAT and at the National Horticultural Research Centre, Thika, all the French bean varieties currently under production were developed for the temperate climates and frequently of poor adaptation to the Kenyan environment. The use of these varieties has led to heavy reliance on pesticides in French bean production. All farmers in the sample used a pesticide of some kind. All of them sprayed their crop with insecticides, while only four of those interviewed did not spray their crop with fungicides. The farmers in the sample sprayed the crop protection chemicals either on sight of the pest or on routine basis as shown on table 4.14 where the routine spraying was carried out either on a weekly or fortnightly basis.

Both spraying methods did not always effectively protect the farmer's beans due to the fact that most farmers were using an under dosage of the chemical due to either;

i) scarcity of money to purchase enough chemicals.

ii) not knowing which chemical to use and how to use it. As of the time when the survey was carried out, farmers in the sample were using twenty four different insecticides and eight different fungicides to protect the french beans. This has often confused the farmers who do not know which concentrations to mix for all these different chemicals.

Routine spraying is not recommended by the crop protection department in the National Horticultural Research Centre, K.A.R.I since it leads to a build up of pest resistance. Farmers are therefore advised to practice scouting so that they may be aware of infestation as soon as possible and then do the necessary spraying.

Table 4.14: Spraying Programme of Protective Chemicals

		Mwea%	Makuyu%	Kandara%
Insecticides	a) Routine	78.3	65.0	81.6
	b) Sight of Pest	21.7	35.0	18.4
Fungicide	a) Routine	83.3	73.7	80.0
	b) Sight of symptoms of fungal attack	16.7	26.3	20.0

Source; Author's survey, 1991.

Table 4.15: Number Of Different Insecticides Used By Each Farmer

No. Of Insecticides	Mwea%	Kandara%	Makuyu%
one	33.3	69.2	90
two	59.0	20.5	10
three	7.7	7.7	0
four	0	2.6	0

Source; Author's survey, 1991.

Most of the farmers in Kandara (69.2%) and Makuyu (90%) were found to be using one type of insecticide, while in Mwea, most (59%) of the farmers were found to be interchanging the spraying program between two insecticides (see table 4.15). Table 4.16 shows that the most commonly used insecticide in all the three regions was Ambush. The other common insecticides were Ripcord (23%), Kelthane (18%) and Brigade (18%) in Mwea, Malathion (13%), and Diazinon (10%) in Kandara and Rogor-E (15%) and Fentrothion (8%) in Makuyu.

Table 4.16: Types Of Insecticides Used In French Bean Production

Insecticides	Mwea % of farms	Kandara % of farms	Makuyu % of farms
Ambush	62	69	73
Fentrothion	5	3	8
Kelthane	18	8	0
Lebycide	0	5	3
Decis	0	8	5
Rogor	0	8	15
Diazinon	0	10	3
Karate	3	0	3
Sumithion	0	8	0
Malathion	3	13	0
Folimat	0	5	0
Ripcord	23	3	0
Thiodan	5	3	0
Sumicidin	3	0	0
Brigade	18	0	0
Azocord	8	0	0

Source; Author's survey, 1991.

Table 4.17: Number of Different Fungicides Used By Each Farmer

No. of Fungicides	Mwea(%)	Kandara(%)	Makuyu(%)
one	67	67	67
two	28	23	5
three	3	0	3

Source; Author's survey, 1991.

Table 4.17 shows that fungicide use seemed to be mainly of one kind in all three regions, although interchanging between two or three chemicals was practiced mainly in Mwea and Kandara and to a lesser extent in Makuyu.

Table 4.18 shows that Dithane was the most common fungicide in Makuyu, while Kocide 101 and Baycor were used but to a lesser extent. In Mwea and Kandara, Dithane, Antracol, Kocide 101, and Bayleton were common.

Table 4.18: Types Of Fungicides Used In French Bean Production

Fungicide	Mwea % of farms	Kandara % of farms	Makuyu % of farms
Antracol	35.9	20.5	0.0
Dithane	41.0	28.0	83.0
Bayleton	21.0	15.0	0.0
Kocide 101	33.0	39.0	15.0
Baycor	0.0	5.0	8.0
Benlate	0.0	0.0	3.0
Moduna	0.0	3.0	0.0

Source; Author's survey, 1991.

4.2.7 Labor Use in French Bean Production

French bean production was found to be a labor intensive enterprise, where the total average labour used for production of a hectare of French beans was 2700 manhours in Kandara, 2067 manhours in Makuyu and 643 manhours in Mwea. The labour requirements differed between regions and also between the various activities involved in French bean production as shown in table 4.19. In all the three regions, irrigation used the most labour hours followed by the harvesting and grading.

Table 4.19: <u>The Average Labour Use And The Percentage Share Of The Various Production Activities</u>

Activity	Mwea		Kandara		Makuyu	
	mhrs/ha	%	mhrs/ha	%	mhrs/ha	%
Land Prep.	30	4.7	259	9.6	177	8.6
Planting	20	3.1	132	4.9	76	3.7
Weeding	35	4.8	189	7.0	144	7.0
Fert. Appl.	25	3.9	45	1.7	49	2.4
Chem.Spray	70	10.8	92	3.4	137	6.6
Harvesting	169	26.2	770	28.5	435	21.0
Irrigation	294	45.7	1213	44.9	1049	50.7
Total	643	100.0	2700	100.0	2067	100.0

Source; Author's survey, 1991.

The farmers were found to use either family labor, hired labor or both kinds of labor for the different activities in French bean production. Table 4.20 shows that in Mwea, hired labor was most oftenly used while in Kandara and Makuyu, family labor was the most popular kind of labor.

All the farmers interviewed employed some people to do some work in French bean production. No farmer employed permanent labor to work on the French beans. They employed them on casual basis, whereby they were paid on a daily or weekly basis. The casual workers, worked for an average of 7 hrs per day, and the daily payment ranged from Ksh.25/- to

Ksh.30/- a day. Some farmers paid workers on the basis of task for some activities like land preparation, spraying chemicals and harvesting and grading.

Family child labor was used by most farmers. They were used mainly for the irrigation of the French beans in the evening after they arrived home from school. In this study children under 15 years have been given a rating of 0.5 hours for each hour spent on french bean production, the assumption being that these children's rate of work would be half that of the adults.

Table 4.20: Distribution of the Type Of Labour Used For Different Activities In French Bean Production

Activity	Labor type	Mwea % of farms	Kandara % of farms	Makuyu % of farms
1. Land Prep.	a) Family	12.5	66.7	65.0
	b) Hired	80.0	28.2	15.0
	c) Both	7.5	5.2	20.0
2. Plant	a) Family	17.5	74.4	82.5
	b) Hired	75.0	17.9	12.5
	c) Both	7.5	7.7	5.0
3. Weed.	a) Family	20.0	71.8	77.5
	b) Hired	70.0	15.4	17.5
	c) Both	10.0	12.9	5.0
4. Fert. applic.	a) Family	25.0	84.6	90.0
	b) Hired	65.0	10.3	5.0
	c) Both	10.0	5.1	5.0
5. Spraying chemical	a) Family	40.0	89.7	87.5
	b) Hired	55.0	7.7	12.5
	c) Both	5.0	2.6	0.0
6. Harvest & Grading	a) Family	5.0	53.8	60.0
	b) Hired	85.0	12.8	17.5
	c) Both	10.0	33.3	22.5
7. Irrigation	a) Family	57.5	84.6	65.0
	b) Hired	30.0	2.6	17.5
	c) Both	12.5	12.9	17.5

Source; Author's survey, 1991.

Table 4.21: Age Of French Bean Crop At First Picking

No. of Weeks	Kandara %	Makuyu %	Mwea %
4	2.6	0.0	0.0
5	2.6	0.0	2.6
5.5	0.0	5.0	0.0
6	53.8	42.5	76.9
6.5	15.4	5.0	0.0
7	20.5	35.0	20.5
7.5	2.6	2.5	0.0
8	2.6	0.0	0.0
10	0.0	2.5	0.0

Source; Author's survey, 1991.

4.2.8 Picking or Harvesting Period

The timing of onset of picking varied between the regions as shown in table 4.21. Picking for all the regions mainly started at six weeks, however it was also common for the farmers to start picking when the crop was older at six and a half to seven weeks. Table 4.22 shows that majority of farmers interviewed picked beans for four weeks. Over half of those interviewed in all the 3 regions picked for 2 to 4 weeks. In Mwea, only four of respondents picked for over 1½ months while the corresponding number of respondents was 14 in Kandara 14 and 17 in Makuyu 17.

The length of the picking period depends on the management skills of the farmer. The picking period for a well managed french bean plot is 8 weeks, while it is only 1.5-2 weeks for a badly managed plot. The length of the picking period may then be used as an indication of the cultural practices followed by the farmers in terms of seed type, weeding, spraying and the watering regime.

Table 4.22: Length of Period of Picking French Beans

	Mwea		Kandara		Makuyu	
No. of weeks	No (of farms)	%	No (of farms)	%	No (of Farms)	%
2	1	2.5	1	2.6	0	0.0
3	10	25.0	9	23.1	6	15.0
4	24	60.0	14	35.9	17	42.5
5	1	2.5	1	2.6	5	12.5
6	2	5.0	9	23.1	12	30.0
>6	2	5.0	5	12.9	0	0.0
Total	40	100	39	100	40	100

Source; Author's survey, 1991.

The length of the picking period can be viewed as an insight into the management skills of the farmers interviewed. Those who were picking for over 1½ months would be regarded as having good management skill in French bean production, those picked for 1 month as having satisfactory skills and those picking for less than 1 month as poorly equipped with knowledge on French bean production.

The average yields obtained from the three regions were 3.9 tons in Makuyu, 3.3 tons in Mwea and 5.3 tons in Kandara. However, the yields obtained were low because 75% of those interviewed in Mwea and Makuyu and 54% of those interviewed in Kandara had yields less than 5 tons per hectare.

4.2.9 Availability Of Credit

Out of the French bean farmers who needed credit to enable them to carry out the various production practices, only 30.8%, 10%, and 56.4% received it in Kandara, Makuyu and Mwea respectively. The credit was usually in the form of either seed, pesticides or both. In areas where credit services were available, buyers of the beans were found to be the sole providers of the credit. The buyers would then recover their money from the farmers once they delivered their produce.

4.2.10 Marketing French Beans

All the farmers interviewed in the three regions said that they grew the beans for commercial purposes. The farmers grew the crop, either for one specific buyer on contract, or sold to the buyer offering the highest price. Most farmers said they would prefer contract farming as it was a way of reducing market and price risks, however this system was not very common since most buyers were not willing to contract the farmers due to the high fluctuation of the prices of French beans in the export market.
The beans were bought from the farmer by the exporter themselves directly or by middlemen who were contracted by the exporters. The latter method was most common.

The beans were either graded and sold in the farm or they were taken to the collection centres in the local shopping centres. Most farmers took their produce to the collection centre for sale since their scale of production was not high enough to warrant collection from the farm gate. Taking the beans to the collection centres also enabled the farmers to sell their produce to the highest bidder.

Table 4.23: Point of Sale and Buyers of French Bean

	Mwea %	Makuyu %	Kandara %
Point of Sale			
Farm	40.0	37.5	17.9
Shopping centre	57.5	62.5	79.5
Airport	2.5	0.0	2.6
Buyer			
Middlemen	75.0	52.5	59.5
Exporter	25.0	47.5	27.0

Source; Author's survey, 1991.

TABLE 4.24: Average Price Of 3kg Carton Of French Beans (1991)

		Oct.	Nov.	Dec.	Jan.
Kandara	Min	10.0	10.0	7.5	15.0
	Max	40.0	35.0	45.0	50.0
	Av.	25.4	25.0	23.9	34.0
Makuyu	Min	15.0	12.5	12.5	20.0
	Max	30.0	35.0	37.5	37.5
	Av.	22.7	25.1	22.4	31.8
Mwea	Min	10.0	10.0	7.5	12.5
	Max	36.5	36.5	31.5	45.0
	Av.	22.4	22.4	16.0	27.6

Source; Author's survey, 1991.

Table 4.24 shows that the prices received for the French beans varied with the place and the month of sale. The lowest price received in all the three divisions was during the month of December, when the average prices received were KSh.16.00, Ksh.22.40, and Ksh.23.90 in Mwea, Makuyu and Kandara respectively. The highest price received per carton of French beans was in the month of January, when the average prices received was Ksh.27.60, Ksh.31.80 and Ksh.34.00 in Mwea, Makuyu and Kandara respectively. Mwea seemed to be receiving the lowest price and Kandara the highest at any one time. Prices as high as Ksh.45.00 to Ksh.50.00 were received for the extra fine grade.

Farmers were not able to meet the demand for the beans during the period when the demand was high in Europe. This was due to the fact that most of them used manual methods to irrigate the crop, this demands a high input in labor which the farmer is not able to supply. During the wet season however, farmers are able to produce the crop using the rains, this leads to high production at times when the demand is not very high. Consequently the prices are lowest (KSh.7.50 to Ksh.10.00). In addition there is wastage of the surplus French beans which do not get a buyer.

4.2.11 Costs of Production

The average total variable costs incurred by the farmers were ksh. 14,010.00 in Mwea, ksh. 28,710.00 in Kandara and ksh. 19,334.00 in Makuyu. However, they were still able to get substantial returns, since the average gross margins per hectare were ksh. 15,690.00 in Mwea, ksh. 28,710.00 in Kandara and ksh. 15,766.00 in Makuyu. The proportion of the total variable costs of production taken up by various activities were comparable in all the regions. On the average Pesticide costs took up the largest share of the total variable costs (36.8% in Kandara, 31% in Makuyu and 38% in Mwea) followed by labour costs (32% in Kandara, 36% in Makuyu). Fertilizer costs took 20%, 18% and 21% of the total variable costs in Mwea, Makuyu and Kandara respectively. Whereas expenditure on seed was highest in Mwea (25.8% of the total variable cost).

4.3 Problems Encountered by the Farmers in French Bean Production

Tables 4.18 and 4.19 show the problems encountered by farmers in production and marketing of French beans. The most cited problems in production of the beans were, high prices of fertilizer and pesticides lack of working capital, many pests and diseases, not knowing which chemicals are the right ones to be sprayed and high labor requirements. In marketing, the constraints most commonly mentioned were fluctuation of the beans prices, lack of a steady market due to market fluctuations and exploitation by the middlemen in terms of low prices that do not reflect the market situation.

In order to reduce revenue instabilities which are mainly brought about by price fluctuations, staggering of the planting dates was widely practiced in all the regions visited. This would increase the number of harvests and also even out the high and low prices, at the same time improving the farmers cash flow. The other tactics used by the farmers to reduce revenue instabilities included, signing contracts with either the exporters who paid on the average a lower but guaranteed price.

Table 4.25: **Marketing Constraints**

Problem	Mwea No.	%	Kandara No.	%	Makuyu No.	%
Fluctuation of Prices	23	57.5	17	44.7	25	64.0
Lack of steady market	14	35.0	6	15.7	6	15.0
Exploitation by m/men	5	12.5	8	21.0	10	25.6
Lack of storage facilities	1	2.5	0	0.0	0	0.0

Table 4.26: **French Bean Production Problems**

	Mwea No.	%	Kandara No.	%	Makuyu No.	%
1. High rent and chemical prices	20	50.0	6	15.7	15	38.4
2. Lack working capital	16	40.0	11	28.9	20	51.2
3. Do not know what chemical to spray	8	20.0	13	17.0	20	51.2
4. High labor required	23	57.5	4	10.5	10	25.6
5. Unavailability of seed, fertilize, chemical, labor	11	27.5	2	5.0	2	5.0
6. Lack loan facility	1	2.5	0	0.0	2	5.0
7. Land scarcity	2	5.0	0	0.0	1	2.5

NB: Farmers had more than one problem.

No. = Number of farmers.

Source; Author's survey, 1991.

CHAPTER FIVE

French Bean Production Function

In this chapter the French bean production funcion that was estimated is presented. The results from the analysis and the testing of hypotheses are also presented.

5.1 **Model Specification**

The estimated French bean production function was of the form stated below and already detailed in chapter three.

$$Y = A.X_1^{\beta_1}.X_2^{\beta_2}.X_3^{\beta_3}.X_4^{\beta_4}.e^{\alpha_1 D_1+\alpha_2 D_2+\alpha_3 D_3+\alpha_4 D_4+\alpha_5 D_5+\alpha_6 D_6+\alpha_7 D_7+\alpha_8 D_8 U} \quad \text{..........(5-1a)}$$

where:

Y = french bean yields (kg/ha)

X_1 = Nitrogen fertilizer (N_2kg/ha)

X_2 = Phosphate fertilizer (P_2O_5 kg/ha)

X_3 = Pesticides expenditure (ksh/ha)

X_4 = Amount of seed planted (Kg/ha)

D_1 = Dummy for seed type where:
1 = certified 0 = not certified

D_2 = Dummy for manure use where:
1 = Yes 0 = No

D_3 & D_4 = Dummies for region

D_5 to D_8 = Dummies for farm size

β_i's = coefficients to be estimated for the continuous variables

α_i's = coefficients to be estimated for the dummy variables

U = Stochastic error term

The equation was estimated in its linearized as shown in equation 5-1b and estimated using the least squares method.

$$lnY=lnA+B_1 lnX_1+B_2 lnX_2+B_3 lnX_3+B_4 lnX_4+B_5 lnX_5+B_6 lnX_6+B_7 lnX_7+B_8 lnX_8 \ldots\ldots$$

5.2 Regression Results

The estimated coefficients and their respective standard errors, t-values are shown in table 5.1.

Table 5.1: **Regression Results: The French Bean Production Function**

Independent Variable	Bi	S.E.(Bi)	t-value
lnX_1	0.406252	0.112373	3.615**
lnX_2	-0.169265	0.121821	-1.389
lnX_3	0.137463	0.064583	2.128**
lnX_4	0.071765	0.148988	0.482
D_1	-0.170413	0.058613	-2.907*
D_2	0.498592	0.150026	3.323**
D_3	0.305567	0.156773	1.949*
D_4	0.062158	0.168169	0.370
D_5	0.204887	0.315080	0.650
D_6	0.067023	0.299933	0.223
D_7	0.129272	0.317434	0.407
D_8	0.005510	0.316055	0.017
Constant	4.662234	1.698705	2.745**

Source; Author's survey, 1991.

* * coefficient is significant at 1% level.

* coefficient is significant at 5% level.

n = 108

degrees of freedom (d o f) = 95

Multiple R = 0.66646

R^2 = 0.44418

Adjusted R^2 = 0.37246 (adjusted for d.o.f.)

Standard error (S.E.) = 0.60767

F-value = 6.19**

The coefficient of multiple correlation R, indicates the degree of the linear relationship of the dependent variable with all the independent variable, whereas the coefficient of multiple determination shows the proportion of the total variation in the dependent variables explained by the independent variables in the regression equation (Heady & Dillon, 1961). The F-test provides an overall test of the significance of the fitted regression model. The results from the regression indicate that $R^2 = 0.44418$, which means that 44.4% of the total variation in french bean yields was explained by the variables considered. Even though the R^2 is not very high, the F-value indicates that the all the variables included in the equation are important, hence the overall regression is highly significant.

The B_i's are the coefficients that estimate elasticities of production of the continuous independent variables. These elasticities show the percentage change in the dependent variable when an independent variable is changed by one per cent, ceteris paribus. For example, if the amount of nitrogen fertilizer applied to the French beans is increased by one percent, the french bean yields would increase by 0.369 per cent on average with all other inputs being held constant.

The α_i's are the coefficients that estimate the magnitude of the shift of the intercept of the estimated production function curve caused by the dummy variables.
The intercept shifting dummy variable may either cause the intercept of the average slope to shift up or down. For example, the positive coefficient of the dummy for manure means that use of manure shifts the intercept to a higher level which implies that the manure has an elevating effect on the average French bean yields.

The results showed that at 5% level of significance and 95 degrees of freedom, the coefficients of nitrogen fertilizer, pesticides, certified seed, manure and Mwea region were significantly different from zero while the coefficients for seedrate, phosphate fertilizer, and farm sizes, were not significantly different from zero.
Amongst the coefficients which were significantly different from zero, the coefficient for the certified seed was found to be negative.

Marginal Physical Product (MPP)

Heady & Dillon, define the marginal physical product as the change in output resulting from a unit change in the relevant input, levels of all other inputs being held contant.

From the estimated C-D function in equation 3-1, the MPP of input X_i is :-

$$MPPx_i = \frac{dy}{dx} = \beta_I . \frac{Y}{X_i} \ldots\ldots\ldots\ldots\ldots (5-2)$$

The MPP of any resource depends on the quantity of it that is already being used and on the levels of the other resources with which it is being combined with in the production process. For this reason, the most accurate estimates from C-D functions are obtained with all inputs held at their geometric means, that is at the value where log X_i assumes its' arithmetic mean (Heady & Dillon). In this study, geometric means have bean used to calculate the MPP_i's.

Marginal Value Product (MVP)

The MVP of an input X_i is the value of the output resulting from a unit change in the level of input X_i. It is obtained by multiplying the $MPPx_i$ by the price of the output. The output in this case is French beans, and the average price for a kilo of French beans was Ksh. 9.00. Table 5.2 shows the geometric means, marginal physical product and marginal value product of the continuous variables.

Table 5.2: Geometric means, MPP and MVP

Variable	G.M.(n=111)	MPP(kg)	MVP (Ksh.)
X_1	3.99	0.810467	7.294
X_2	4.22	-0.319277	-2.873
X_3	8.31	0.131673	1.185
X_4	12.14	0.047055	0.423

Source; Author's calculations, 1991.

The table shows that the MPP of the nitrogen fertilizer (X_1) is 0.810467 which means that if the N_2 fertilizer applied to a hectare of French beans is increased by 1kg, then the bean yields would increase by 0.810467 kg and the MVP resulting from this increase would be ksh. 7.29. The MPP of pesticides is 0.131673, impling that if the expenditure on pesticides is increased by ksh.1.00, the french bean yields would increase by 0.131673 kg and the MVP resulting from this increase would be Ksh. 1.19. The MPP's and MVP's of other inputs are interpreted in a similar manner.

5.3 Efficiency Of Resource Use In French Bean Production

In this study, efficiency refers to allocative efficiency and the objective function is assumed to be that of profit maximization. The determination of efficiency of resource use involves comparing the MVP of an input with its' price, Px_i (Matovu, 1979). When there is efficiency in resource use, the $MVPx_i$ is equal to the marginal factor cost (i.e. Price) of the resource X_i, whereas when there is inefficiency in resource use, the two are not equal, or they are said to be significantly different. The t-statistic as discussed in chapter three is used to test whether the estimated MVP is equal to the factor price where:

$$t=\frac{M\hat{V}Px_i-Px_i}{S.E.(M\hat{V}Px_i)}\qquad(5-3)$$

The calculated t is compared with tabulated t. If it is greater, then this implies that the input in question is being used inefficiently, whereas if it is less, then the input is said to be being used efficiently. The comparison has to be done at the relevant degrees of freedom and significance level. The test for efficiency of resource use was done only for the inputs with significant regression coefficients.

Table 5.3: Calculated t-values for Testing Efficiency of Resource Use

Input	$MVPx_i$ (Ksh)	Px_i (Kshs)	t-value	dof
X_1	7.294	1.73	3.575*	95
X_3	1.185	0.135	1.657	95

Source; Author's calculations, 1991.

* indicates that the $MVPx_i$ is significantly different from the input price Px_i at 5% level of significance.

The t-test has shown that the MVP of nitrogen is significantly different from the unit factor price. This implies that nitrogen fertilizer was being used below the economic optimum becsuse farm profits could be increased by applying more nitrogeneous fertilizers to the french bean crop. However, the MVP of pesticides expenditure was found not to be significantly different from the price of capital. This implies that the small scale french bean farmers were allocating expenditure for the purchase of pesticides quite efficiently.

5.4 Test Of Hypotheses And Further Interpretation Of Results

The first set of hypotheses to be tested are those on the statistical significance of the coefficients of all the independent variables considered in the production function. From the regression results, it was found that only the coefficients of nitrogen fertilizer (X_1), expenditure on pesticides (X_3), dummy variable for certified seed (D_1), regional dummy for Mwea (D_3) and dummy variable for use of manure (D_2) were significantly different from zero.

Whereas the coefficients of phosphate fertilizer (X_2), seed-rate (X_4), dummies for area under French beans (D_5, D_6, D_7, D_8) and the region dummy for Kandara (D_4) were not significantly different from zero. This would imply that nitrogen fertilizers, pesticides, certified seed, manure and Mwea region significantly influenced french bean yields, whereas phosphate fertilizer, plant population, and area under French beans did not significantly influence the yields.

Significance of the coefficient for Mwea region dummy variable is an indication of the regions positive effect on the French bean yields due to enviromental conditions like soils, drainage, humidity and also the management conditions not captured in the production function.

The significant coefficient for manure use is an indication that farm yard manure increased the average yields of French yields. This may be due to the good effect that manure has on soil in terms of improvement of the workability, moisture retention and the nutrients released.

The coefficients of the type of seed planted, was found to be negative, this means that this variable depresses the average yields of French beans. This is contrary to the expected positive influence of uplifting the average yields. The use of disease-free seed by the French bean farmer has an important effect on the yields of the crop (Omunyin, 1983), this is due to the fact that many diseases are caused by seed borne pathogens. Poor seed has been identified as one of the major constraints to growth of French bean exports in Kenya (Salasya, 1989). The negative sign may therefore be attributed to bad data, in that majority of the farmers may have bought sealed packages of seed believing it to contain certified seed, while those seeds may not have passed through the seed certification channels. This would imply that the seed that the farmers bought may have been contaminated with pathogens, weeds, and seeds of poor germination.

The insignificance of the coefficients for seedrate, phosphate fertilizer and the area of land under French beans means that we cannot confidently conclude that the magnitude of their coefficients is their true effect on the French bean yield. This leads to the conclusion that the null hypotheses stating that the seedrate, phosphate, and area under French beans do not significantly influence French bean yields in the Central Province of Kenya cannot be rejected.
On the other hand, the null hypotheses that nitrogen fertilizer, expenditure on pesticides, manure, certified seed and Mwea region do not significantly influence French bean yields in the area of study is rejected and the alternate hypothesis that these variables do indeed significantly influence French bean yields in the area of study is adopted.

The second set of hypotheses to be tested are on the efficiency of resource use. This was performed on the use of nitrogen and pesticide expenditure only. From the efficiency test only the marginal value product of nitrogen fertilizer was found to be significantly different from its' unit price. This leads to the conclusion not to reject the null hypothesis which says that the marginal value product of the expenditure on pesticide is equal to the price of capital (interest rate on savings).

The results have also led to the rejection of the null hypothesis which says that the marginal value product of nitrogen fertilizer is equal to it's unit price and to the adoption of the alternate hypothesis that the marginal value product of nitrogen fertilizer is significantly different from its' price. The conclusion that can be drawn from this test is that of the two resources, nitrogen fertilizer is the only one which can be said to be used inefficiently, therefore farmers would achieve higher profits if they were to increase the use of nitrogeneous fertilizers in french bean production from the present levels. Below are some of the possible explanations as to why farmers are not on the average applying the optimal levels of nitrogen fertilizer.

1) The farmers may not be aware of the recommended levels of the fertilizers.

2) The actual farm situation was not taken into account when doing the analysis, there was an assumption of unconstrained conditions in the farm, while the lack of

working capital was one of the most frequently cited constraints, thereby being forced to use less than the recommended amounts.

3) The French bean market is very volatile with high fluctuations in the market and in the prices received. This being the case, farmers operate under a very risky situation where they risk producing French beans that may fetch prices that are too low to cover the production costs. Under such conditions the farmer may opt to use less than the recommended amounts of inputs so that he minimises the losses that he may suffer.

Although the amounts of pesticides seem to have been allocated efficiently, farmers have problems in deciding which chemicals are for which pests due to the wide variety of pests attacking French beans and the wide range of pesticides offered in the market.

It is notable that the labour component has been omitted in this analysis. Although this variable seems to play a major role in French bean production (see chapter 4, pg 69-72), its' coefficient and t-value were found to be extremely low. Therefore the labour component has been omitted from the function, although not entirely since its' effect is most probably camouflaged in the variables included.

CHAPTER SIX

Summary Conclusions And Policy Implications

6.1 Summary

The horticultural sector has been making a substantial contribution in the provision of food needs, foreign exchange earnings, employment and in increasing farm incomes. There has been some indications that vegetable production has been shifting to small farmers, and the french bean is becoming one of the major horticultural export crops grown by small scale farmers. There is therefore a need to look into ways of increasing french bean production, so that the sector can fully contribute to the country's economic development. This increase can only be achieved by increasing the yields which are currently low when compared to the yields reported by the researchers and other countries. An increase in production by increasing the area under the beans is limited by the scarcity of land and also by the risk averseness of the small scale french bean farmers. It is therefore important to identify the factors that limit the yields obtained and also to identify the problems that the small scale french bean farmers encounter. This will enable the policy makers and researchers to develop and adopt the appropriate strategies in order to increse french bean yields.

The objectives of this study were to determine whether there are possibilities of increasing french bean yields in the areas of study, through the re-allocation of resources. The study also investigated the problems encountered by farmers in production and marketing. The hypotheses that were formulated and tested were, that each of the resources identified significantly influence the french bean yields and that small scale french bean farmers use their resources efficiently in french bean production.

Two methods of analysis were employed in this study. Descriptive analysis was used to describe and compare the socio-economic characteristics of the farmers, aspects of french bean production and problems faced by the farmers. Production function analysis was used to estimate the relationship between the factors of production and the yields obtained. The data used in the study was collected mainly through personal interviews with farmers who were randomly selected from lists collected from the agricultural offices in the respective divisions. Data collection took place between January and February, 1991. Most of the information sort referred to the 1990 calender year. The data used presented some limitations because the study relied heavily on the farmers memory, since most of the farmers interviewed do not keep records.

The results from the analysis showed that over 85% of the farmers interviewed owned less than 4 hectares of land, ie they were small scale farmers. French bean growing was found to be mainly a man's enterprise in both Makuyu and Mwea divisions comprising 75% and 67.5% respectively, whereas in Kandara both the men and women were equally involved. French beans were found to be competing favourably with other enterprises in both Makuyu and Kandara. However, in Mwea they faced stiff competition from rice growing. The beans were mainly grown on land owned by the farmers (80%) but in a few cases the farmers had to rent the land on which they grew the crop. This was to be found mainly in Mwea where 25% of the farmers rented land to grow French beans.

The area of land that the farmers allocated to french bean growing differed between the regions. Kandara division was where farmers allocated the smallest portion of land (as low as 0.004 ha), with 49% allocating land of less than 0.08 ha to beans. In Makuyu division only 30% of the farmers had less than 0.08 ha under beans while in Mwea division all of the farmers had area over 0.08 ha under beans with 37% of the farmers having 0.4-0.8ha under the crop. Majority (over 72%) of those interviewed grew the crop because they were a source of quick cash. Makuyu had the highest number (25%) who thought that it was a highly profitable enterprise, whereas Mwea division had the least (10%). In Mwea only 47.5% of the interviewees ranked rench beans first in income generation. This was quite low when compared to Makuyu and Kandara where 95% and 76.9% respectively ranked it first.

Over 80% of those interviewed grew the crop throughout the year and only two of those interviewed tried to regulate their production to coincide with the off season market in Europe. 50% used manual methods to irrigate the crop, which they said consumed a lot of labour and time. The Monel variety of french beans was found to be the most commonly grown in all the three regions. In Mwea, Kandara and Makuyu 80%, 46.2% and 32.5% respectively said they grew certified seeds of french beans. Seed-rates in Makuyu and Kandara division were found to be less than the recommended rate. Majority of farmers in Mwea bought their seed from appointed dealers, while those in Makuyu and Kandara bought their seed from neighbouring farms.

Fertilizer application was found to be very popular since all of those interviewed applied them. Over 79% applied the planting fertilizer and the most common is DAP . Over 85% in all the three regions applied a top dressing fertilizer with CAN being the most popular in Kandara and Makuyu, whereas in Mwea 47.5% used DAP and 40% used CAN to top dress. Farmers in Mwea and Makuyu were found to be using less than the recommended rates of fertilizer while those in

Kandara were using more than the recommended rates. All of those interviewed used an insecticide of some kind on the beans while only four of them did not use fungicide at all. In all the regions over 65% sprayed the insecticides and over 73% sprayed the fungicide on a routine basis. The rest sprayed the pest on sight. Ambush was found to be the most popular insecticide while Antracol, Dithane and Green Copper were the popularly used fungicides.

In Mwea hired labour was most oftenly used while in Kandara and Makuyu family was the most popular. On the average labour use for a hectare of the beans was 2700 manhours in Kandara, 2067 manhours in Makuyu and 643 manhours in Mwea. Irrigation took up over 45% of the total labour used, while harvesting and grading took up 21% to 28% of the total labour.

Over half of the farmers picked the crop for 2-4 weeks. In Mwea only 10.5% picked for over 4 weeks whereas, in Kandara and Makuyu 38.6% and 32.5% picked for over 4 weeks respectively. All the farmers grew the crop for commercial purposes. Most of the farmers took their produce to the collection centers which were mainly in the local shopping centers for sale. Those who sold the produce at their farms were producing under contract arrangements with the buyers. Mwea had the majority of contract farmers (40%) followed by

Makuyu (37.5%) and Kandara (17.9%). Gross margins were highest in Kandara (Ksh.28,710.00), followed by Makuyu (Ksh.15,766.00) and Mwea (Ksh.15,690.00).

The farmers cited various problems in production and marketing of the beans. The most common were ;

- High fertilizer and protective chemical prices
- Lack of working capital
- Many pests and diseases and lack of knowledge on the right chemicals to spray
- High labour requirements
- Fluctuation of french bean prices
- Lack of a steady market for the beans and
- Exploitation by middle men.

In the production function analysis a Cobb-Douglas type of production function was estimated for French bean production. The results of the analysis showed that the nitrogen fertilizer, pesticides, seed-rate, certified seed and manure affected french bean yields significantly.

The efficiency test revealed that the nitrogen fertilizer was not being used efficiently in production of french beans. The marginal value product (MVP) of nitrogen fertilizer was found to be Ksh. 7.29 per Kilo while its' average price was only Ksh. 1.73 per kg. This is an indication that farm profits would be greatly increased if the application of the nitrogen fertilizer was increased.

6.2 Conclusion

French bean production in the country can be increased mainly by increasing the yields obtained from the area that is presently under the beans. It is, therefore, important to look into the reasons behind the low yields that are presently being obtained by the scale French bean farmers and also to identify the problems that they are faced with in producing French beans.

The major conclusion that can be drawn from this study is that there exists some unexploited potential of raising French bean yields in the small scale farms in the Central Province of Kenya. The study revealed that farm profits could be increased substantially by applying more of the nitrogenous fertilizer to the French bean crop, with all other factors remaining as they are currently. This would call for the removal of those factors which prevent farmers from fully utilizing optimal levels of nitrogenous fertilizers. Farm yard manure was found to be also increasing yields on the average and its' use should be encouraged where it is available.

The use of the various pesticides on different pests even though the pesticide expenditure was found to be efficiently utilized needs to be made clearer to the small scale French bean growers. This is because the farmers expressed the lack of knowledge on pests and diseases and the appropriate control methods as one of their constraints in production.

The use of certified seed even though found to be negative is important in the determination of the marketable yields obtained by the farmers, because any blemished pods are usually rejected in the market. Diseased seeds will also lead to heavy expenditures on pesticides, which if reduced would also increase the gross margins. Therefore the emphasis should be on the availability of the truly certified seed.

6.3 Recommendations

This study gives the general direction in which efforts to increase french bean yields in small scale farms should be directed. The farmers should be encouraged to step up the application of nitrogenous fertilizer to increase their profits at the prevailing prices of the fertilizer and the French beans, since most farmers thought that fertilizers and chemicals were rather expensive. The farmers should also be encouraged to use these inputs as per the directions given by the researchers and extention agents. This could be achieved through demonstrations in Farmers Training Centers (FTC), On-Farm demonstrations and also during the Field days in the research stations.

There is a need for a scheme where the French bean farmers could collect the inputs needed on credit and pay later on after sale of the harvested crop. This would alleviate the working capital problem expressed by most farmers and play a role in ensuring that the farmers are able to apply the right inputs in the right quantities and at the right time. This kind of scheme could be in the form of a farmers co-operative.

The risk factor that is due to the marketing problems may also be a cause of farmers using less than the optimal amounts of nitrogenous fertilizers. By removing the

marketing and price fluctuations, the risk factor may be removed. This may be achieved by informing the farmers through the extention service on how the French bean export market operates. This will help the farmer to make decisions about when to plant, how much to plant and who to produce for during different periods.
This will reduce the many instances when the farmer receives very low and unprofitable prices, or when he has to feed the beans to the cows or leave them to be harvested as seed. This is a role that the HCDA would effectively carry out.

There is need to emphasize to the farmers on the need to plant clean, certified seeds as a way of reducing the amounts of protective chemicals that are needed to be sprayed on the crop and also as a way of increasing their yields and hence farm incomes. This could be achieved through the various extension channnels that exist.

There appears to be a problem with the seeds that are sold to the farmers and branded as certified seed. The study revealed that apart from the registered seed companies there were various french bean exporting companies which were also selling seeds to the farmers. There is therefore a need to establish what kind of seeds the farmers are buying from these exporters. Certified seed from authorised companies should be made available at the local shops instead of only at the Kenya Grain Growers Cooperative Union (K.G.G.C.U.) stores. This will improve the availability of the certified seeds to the farmers.

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A P P E N D I C E S

APPENDIX 1

QUESTIONNAIRE USED IN THE FORMAL SURVEY

The interviewer greets farmers, introduces himself and informs the farmer that he is seeking information on french beans production in the area. He stresses the point that the information collected will be used only for the purpose of completing a masters degree at the University of Nairobi. The farmer is assured that the information he gives will be strictly confidential.

Date...........................

1. Enumerators Name
2. Farmers number
3. District
4. Division
5. Location
6. Sub-Location
7. Village
8. (a) Are you the owner of this farm?
    1. YES
    2. NO

   (b) If no, what is your relationship with the owner?
    1. wife
    2. Husband
    3. Son
    4. Daughter
    5. Employee
9. Do you have other occupation apart from farming?

1. Yes

2. No

10. What is the total size of this farm?.....Acres/Hectares

11. (a) Do you farm on some other parcel of land apart from this one?

1. Yes

2. No

(b) Is it your own or do you rent it?

1. own .... size(acre/ha).............

2. Rent .... size(acre/ha).............

12. What are the various enterprises in your farm. List according to which you believe generates most income.

Enterprise	Area Acres hectares	Rank (income generation
(i)		
(ii)		
(iii)		
(iv)		
(v)		

13. For what purpose do you grow french beans?

1. Commercial

2. Commercial and Subsistence

3. During the dry season

4. During the high season (October-April)

5. During the short rains

14. For how long have you been growing the french beans?

1. One season....................

2. 1-2 years.....................

3. 3 years......................

4. 4 years ....

5. > 5 years......................

15. What are the reasons that have made you to continue growing the french beans?

1. highly profitable
2. generate quick cash
3. Easy to grow
4. 1 and 2
5. 2 and 3
6. 1 and 3
7. 1, 2 and 3

16. What times of the year do you grow french beans?

1. Through out the year
2. During the rains
3. During the dry season
4. During the high season (Oct.-April)
5. During the short rains

17. What usually, is the interval between successive plantings of french beans?

1. One week
2. Two weeks
3. Three weeks
4. Four weeks
5. Wait until the previous crop is harvested
6. Six weeks

18. Were your french beans last season,

1. Rainfed
2. Irrigated

19. If irrigated, what mode of irrigation did you use?

1. Sprinkler
2. Pipe

3. Bucket

4. Pipe & bucket

20. What is the Irrigation interval?

Period	Interval(days)
0-2 weeks	
2.5 - 6 weeks	
6 - end of harvest	

21. What do you use to prepare the plot for french beans?

1. hand
2. Animal drawn implement
3. tractor

22. What variety of french beans do you grow?

1. Monel
2. Super Monel
3. Bobby
4. Does not know

23. Are the seeds that you planted last season,

1. Certified?
2. Not certified?

24. What was the area under french beans last season?.....acres

25. How many kilograms of french beans seed did you plant last season?

.............Kg

26. How many seeds do you palnt per hole?

1. one
2. two
3. 1 or 2

27. Did you apply fertilizers onthe plot of french beans last season?

1. Yes
2. No.

28. Which fertilizers did you apply?

	CAN	DAP	20:20	20:10:10	SSP	ASN	UREA	FOLIAN
Tick if used								
Time of application								
Split of single application								
Quantity apppli ed								
Source of fertilizer								

29. Do you apply manure on the french bean plot?

    1. Yes

    2. No

30. Did you apply any protective chemicals ony your plot of french beans last season?

    1. Yes

    2. No

Chemical	Stage of Crop when Spr. Started (days)	Spraying routine	Total No times sprayed	Total chemical used
Nematicide (i) (ii) (iii)				
Insecticides (i) (ii) (iii) (iv)				
Fungicide (i) (ii) (iii)				

31. How many times did you weed last reasons plot of french beans?

1. Once
2. Twice
3. Thrice

32. Labour Use

Operation	Kind of labour used	Mode of payment	No.involved in plot	No. of days to complete
Land Preparation				
Planting				
Weeding				
Fertilizer application				
spraying chemicals				
harvesting and grading				
Irrigation				

33. How old (wks) was the crop when you embarked on picking the pods?

1. 4 weeks
2. 5 weeks
3. 6 weeks
4. 7 weeks
5. 8 weeks

34. What was the inteval between each picking?

1. one day
2. Two days
3. Three days
4. Every day

35. How long did you pick from last seasons crop?

1. 2 weeks from onset
2. 2 weeks from onset
3. 3 weeks from onset
4. 4 weeks from onset
5. 5 weeks from onset
6. 6 weeks from onset

36. What was the yield (in cartons), from last seasons crop? .... cartons.

37. What is the point of sale of your produce?

1. farm
2. shopping centre
3. Airport or cannary

38. To whom do you sell your beans to?

1. Middlemen
2. Exporters
3. Cannary
4. 2 and 3

39. Do you ever need credit to enable you to grow french beans?

1. Yes
2. No.

40. Do you have credit facilities?

1. Yes
2. No

41. Do you ever harvest the beans as seed?

1. Yes
2. No

42. What are the main problems that you experience in,

(a) french bean production?

(i)..

(ii)...

(iii)..

(iv) ....

(b) french bean marketing?

(i)..

(ii)...

(iii)..

At the end of the interview the farmer is thanked for taking his time in answering the questions.

Appendix ii

Derivation of the standard error of marginal value product (S.E.MVP)

The t-statistic is used to test whether the estimated $MVPx_i$ is equal to the factor price.:-

$$t=\frac{M\hat{V}Px_i-Px_i}{S.E.(M\hat{V}Px_i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5-3)$$

According to Heady and Dillon (1961), the standard error of marginal physical product (S.E.MPP) is given by:-

$$S.E(MPP)=\frac{Y.[S.E.(\beta)]}{\bar{\bar{X}}} \ldots\ldots\ldots\ldots\ldots\ldots (5-4a)$$

Therefore, S.E.$MVPx_i$ becomes:-

$$S.E.(MVP)=\frac{[PyY][S.E.(\beta)]}{\bar{\bar{X}}} \ldots\ldots\ldots\ldots\ldots\ldots (5-4b)$$

Through manipulation of equations a,b, and c, the t-statistic is then given by the formulae:-

$$t=\frac{[\beta_i-(\frac{X_iPx_i}{PyY})]}{[S.E.(\beta_i)]} \ldots\ldots\ldots\ldots\ldots (5-4c)$$

Appendix iii

Gross Margin Analysis

The gross margin of a farming activity is the difference between the gross income earned and the variable costs incurred. ie:-

Gross Margin = Gross Income - Variable Costs

Gross Income = PyY

Variable Costs = Px_iX_i

Where:-

Y = Average French Bean Yield (kg/ha)

Py = Unit Price Of French Beans

X_i = Average Level Of Input

Px_i = Unit Price Of Input

Gross Margin Calculation For Kandara, Makuyu And Mwea Divisions

	Kandara	Makuyu	Mwea
Gross Income	47,700.00	35,100.00	29,700.00
Variable Costs			
Fertilizers	5,969.00	3,567.00	2,839.00
Pesticides	10,563.00	6,002.00	5,351.00
Seed	2,897.00	2,660.00	3,610.00
Labour	9,281.00	7,105.00	2,210.00
Total Costs	28,710.00	19,334.00	14,010.00
Gross Margin/Ha	18,990.00	15,766.00	15,690.00

Source; Author's Survey.