

RATIONALITY IN RESOURCE ALLOCATION IN SEMI-SUBSISTENCE AGRICULTURE:  
A CASE STUDY OF SEMI-SUBSISTENCE FARMERS IN THE SIGATOKA VALLEY OF FIJI.

SUBMITTED BY

MOLOKWU CHRISTOPHER CHUKWUKA

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DECLARATION

Except where otherwise indicated,  
this subthesis is my own work.



MOLOKWU CHRISTOPHER CHUKWUKA.

March 1984.

## DEDICATION

Dedicated to

My parents, Mr. C.N. and Mrs. J.A. Molokwu,  
who know these facts better but are in want  
of refined means of communication.

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Australia.

Molokwu Christopher Chukwuka,

## ABSTRACT

This study examines the responsiveness of the semi-subsistence farmers to prices in the Sigatoka Valley of Fiji. Specifically, it verifies whether the semi-subsistence farmers are 'on the average' rational in the sense of equating the marginal value products of their inputs with the opportunity costs (farm gate prices) of the respective inputs. It also verifies the existence of racial differences and the stability over short period in time, of the techniques of production of the major subsistence and cash crops (cassava, rice, maize and watermelon) in the Sigatoka Valley of Fiji.

The study employed the production function approach to data collected over two cropping years (Nov.1970 to Oct.1972) in the Sigatoka Valley. The Cobb-Douglas production function was found to produce the 'best fit' input-output relationship for the crops studied. The relevant explanatory variables for the changes in the output of the respective crops included land, labour, capital and current expenses.

It was evident from the study that; (1) the semi-subsistence farmers in the Sigatoka Valley of Fiji are 'on the average' rational in allocating their resources in the cultivation of the respective crops; (ii) there exist stable techniques for producing the respective crops and the different farmers conform to the techniques irrespective of their racial origin. (iii) the techniques of cultivation of cassava, rice and watermelon were

found to be associated with constant returns to scale while the technique for cultivating maize is associated with decreasing returns to scale.

Changes in the techniques of production of the respective crops, adequate and timely provision of agricultural inputs allied to the establishment of a good communication network, commodity and input markets are recommended. These would encourage expansion in the scale of the farm operations, concomitantly generate increases in the output of the respective crops.

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## CHAPTER 1

### INTRODUCTION

#### 1.1.0. THE MAGNITUDE OF FOOD PROBLEM IN FIJI.

"The biggest disappointment of the plan period so far has been the slow growth of the agricultural sector. As a result food imports have grown rapidly -- by 22% in 1971 and 21% in 1972 -- following a period of several years when they were virtually static." (Review of Fiji's Sixth Development Plan 1971-1973) (1974).

Similar observations have been made in Fiji's Seventh Development Plan 1976-80 (1976) and Eighth Development Plan 1981-85 (1980).

In the last decade, Fiji's food imports have been increasing while local production has remained relatively static. Chandra (1976) observed that the local production of some imported food items such as dairy products, beef, poultry and other meats has remained steady while their importation increased two or three times as the population increased. In 1981, Fiji imported 21,597 tonnes of rice valued at 7.4 million Fijian dollars (Chandra, 1983). This quantity accounted for about 56% of the total rice consumption in Fiji in that year. In the same year about 20% of total imports in Fiji was for food items of which about half could be classed as import replaceable. Such imports have detrimental consequences on the nation's balance of payments. It is associated with a diversity of macro economic problems such as depletion of the country's foreign reserve and the inhibition of policies designed to promote domestic food production. To a very large extent, the import of those foods that could be produced locally is attributable to low agricultural productivity.

Presented in table 1.1 below is Fiji's population and its growth rate, the gross domestic product (GDP) at factor cost, the contribution of the agricultural sector to the GDP and food imports in Fiji for the period 1970 to 1982.

**TABLE 1.1 POPULATION, GROSS DOMESTIC PRODUCT(GDP), CONTRIBUTION OF THE AGRICULTURAL SECTOR AND FOOD IMPORTS FOR FIJI, 1970 TO 1982.**

MID YR	POPULATION IN '000	EST.ANNUAL GROWTH RATE IN %	GDP AT CURRENT FACTOR COST \$ MILLION	CONTRIBUTION OF AGRIC.TO GDP'N \$ MILL. (constant 1968 Prices)	FOOD IMPORTS BY VALUE \$'000
1970	521	+3.1	168.9	N.A	N.A
1971	533	+2.3	184.7	"	20643
1972	544	+2.1	230.5	37.9	25013
1973	556	+2.2	300.6	40.3	33909
1974	565	+1.6	410.5	38.9	41302
1975	576	+1.9	515.4	39.1	38504
1976	585	+1.7	570.6	40.6	43330
				At constant 1977 prices.	
1977	596	+1.9	605.7	85.1	53829
1978	607	+1.8	642.9	81.2	59965
1979	621	+2.0	7794	102.002	61838
1980	634	+2.1	894.9	89.5	64934
1981	646	+1.9	985.3	103.9	76589
1982	658	+1.8	1064.2(p)	107.5(r)	70764

p = provisional, r = revised, N.A. = not available.

Source: Bureau of Statistics, Suva, Fiji. October Issues of the Current Economic Statistics (various years).

From the sixth, seventh and eighth national development plans, it is evident that the Fiji government is not passive to the food problems. The documents emphasised the need to raise farm incomes, the reduction of income disparities between rural and urban dwellers and policies to check rural to urban migration. The actions proposed in the plans include revamping of the existing farming methods by:

- (a) improvements in intensification and crop diversification,
- (b) the application of research findings,
- (c) the provision of rural credit and
- (d) the improvement in the structure of rural marketing and distribution channels.

The Fiji Central Planning Office (1975) proposed 'maximum possible self sufficiency' in agricultural production as a basic objective in planning the development of the agricultural sector. However, Baxter (1980), noted that the parameters of the "possible" were not defined. Nevertheless, the Department of Agriculture has directed its attention to the technical aspects of production of a wide range of food and other agricultural products (Ministry of Agriculture and Fisheries, Annual Reports, various issues).

#### **1.2.0. POSSIBLE CAUSES OF THE LOW AGRICULTURAL PRODUCTIVITY IN FIJI.**

Low agricultural productivity in Fiji could be attributed to a number of factors which include:

- (a) Scarcity and wide dispersal of arable lands in an island archipelago.
- (b) Rigid land tenure system.
- (c) The semi-subsistence nature of agriculture.
- (d) Dietary preferences of the communities.



### 1.2.1. SCARCITY AND WIDE DISPERSAL OF ARABLE LANDS.

Fiji is a group of islands and islets (about 500 in number of which only 100 are permanently inhabited) straddling longitude 180 meridian and located between latitudes 15 and 22 degrees south of the equator. The wide dispersal of arable lands manifests itself in inter-island and international communication problems. The country has a total land area of 18272 square kilometres of which 11.6% or 2120 square kilometres are suitable for arable agriculture, and with moderate improvements 30% or 5482 square kilometres would be suitable for agriculture (Twyford and Wright, 1965)

### 1.2.2. LAND TENURE SYSTEM.

In Fiji there exists an imbalance between racial composition, population distribution and land ownership. There are two dominant races which are the indigenous Fijians comprising about 45% of the population and the Indian Fijians that comprise about 49% of the population. There are three main categories of land in Fiji viz, crown land, freehold land and native land. Crown land comprises about 9% of the total land area, freehold land comprises 3% and the native or mataqali class of land comprises 83% of the total land area in Fiji.

Of the 83% native land, 28% are native reserve land which cannot, by ordinance, be sold or leased to a non-Fijian, and the other 55% is native leased land which is available for leasing by anyone. The native land is managed by Native Land Trust Board (NLTB), a non-government organization.

The Indians own about 1.7% (which constitute about 11% of total Indian land holdings) of the freehold class of lands and cultivate

6% of the native (mataqali) class of land on lease. The share of the Indians in the native lease land constitutes approximately half of the total Indian land holdings. Table 1.2, shows the percentage of holders in each major race, by land tenure of holding, as at the 1968 agricultural census in Fiji.

**TABLE 1.2 PERCENTAGE OF LAND HOLDERS IN EACH MAJOR RACE BY LAND TENURE OF HOLDING AS AT 1968 AGRICULTURAL CENSUS.**

LAND TENURE OF HOLDING	FIJIAN	INDIAN	ALL HOLDERS INCLUDING THOSE OF OTHER RACES.
FREE HOLD	2	11	7
CROWN OR N.L.T.B LEASE	27	49	37
C.S.R.	1	25	12
MATAQALI	59	-	31
ALL OTHERS	11	15	13
TOTAL	100	100	100

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Source: Bureau of Statistics, Suva, Fiji.(1970-71) Annual Abstract of Statistics.

Since the mataqali class of land comprises 83% of the total land area in Fiji (1.2.2 above), it is apparent that agricultural land for use by those of Indian origin is in short supply while the Fijians own a large part of the total land area.

### 1.2.3. THE SEMI-SUBSISTENCE NATURE OF AGRICULTURE.

Semi-subsistence agriculture in Fiji is characterised by smallholdings of 2-4 ha, mixed-cropping, unpaid family labour and simple technology. The semi-subsistence farmers often deliberately plant crops for sale or plan a surplus in a crop planted primarily for household consumption. But whether the produce is actually marketed depends to a large extent on the producer's need for cash, and whether the efforts and cost of harvest, transport and sale

bring a return commensurate to his expectations. In the non-fully monetized economy of Fiji, the latter attitude tends to result in poor response to incentives and innovations.

#### 1.2.4. DIETARY PREFERENCES.

Strong dietary preferences for particular crops prevail among the racial groups in Fiji, such that not only the cropping patterns have been conditioned differently for the two racial groups but the cash crops on the farms have also been influenced. Apart from race, religion also has a significant influence on the dietary mode of the people. To the Hindus the cow is sacred, consequently they do not eat beef. The Muslims regard pigs as unclean therefore do not eat pork. The Seventh Day Adventists do not eat wild pigs, prawns or eels, which are a major source of protein in Fiji.

Each of the problems listed above deserves detailed multidisciplinary analysis to determine the feasible measures that would enable the mitigation of their adverse effects. Some of the desired studies involve different forms of analysis which cannot be met by this study. Mindful of these problems, this study restricts itself to a part of the total problem associated with semi-subsistence agriculture.

#### 1.3.0. DEFINITION OF THE RESEARCH PROBLEM.

" The sixth development plan was overambitious in two respects. It seriously underestimated the nature of the task ahead in developing agriculture. The constraints operating in agricultural development which impede the transition from traditional to monocultural patterns of agriculture are still effective and there is need for significant structural, attitudinal and motivational changes ..." (The Review of Fiji's Sixth Development Plan 1971-1973) (1974).

Amongst others, lack of adequate knowledge of the semi-subsistence farmers' response to prices and incentives in Fiji has hindered the effectiveness of the prices and incentive policies of the government which were intended to ameliorate the problems of increasing imports of food. Food imports, which are supposed to be a short run measure so as to close the gap between domestic requirements and the domestic production, have tended to increase in the last decade to the detriment of the economy. This is an alarming situation since the measures taken to combat the increase in food imports in the last three development plans have not succeeded. The lack of the relevant coefficients and elasticities with respect to the responsiveness of the semi-subsistence farmers in Fiji to prices has hindered decision making and the planning and projections on prices and the requisite incentives in the staple food production sector. The review of Fiji's sixth development plan (1974) listed the following, among others, as the major problems hindering agricultural development in Fiji;

- (a) Lack of local leadership and entrepreneurship,
- (b) Problems of credit and capital investment,
- (c) Lack of input services,
- (d) Unsatisfactory prices and poor marketing,
- (d) Resistance to change in farming techniques and attitudes.

Lack of proper incentives and relevant price information may have scared-off investors from investing in the food sector and could have accentuated the problems listed above.

**1.4.0. JUSTIFICATION FOR THE STUDY.**

It is evident that the steps taken hitherto by the Fiji government to alleviate the food problems and improve the farm output of the Fiji farmers have not yielded optimum results. To complement the government efforts and achieve the expected results, studies need to be carried out with respect to the objective function of the farmers in Fiji, their technology in food production and their responsiveness to incentives and prices. Fiji's sixth development plan directed that special attention be paid to the relationship between prices of inputs and the prices of products. It also recommended subsidies to the farmers.

A knowledge of the behaviour and objective function of the semi-subsistence farmers in Fiji is necessary in formulating policies relevant in the current task facing the country which involve, inter alia, the mobilization and integration into the the total economic system of the largely rural population who are mainly occupied in semi-subsistence agriculture. This knowledge is also important in formulating policies against the economic menace of food importation especially with respect to those food items which could be produced locally.

Policy formulation for the semi-subsistence farmers in Fiji has been clouded with confusion. The farmers and the advisers are ignorant of the farmers' opportunity functions such as production, marketing and price possibilities. The farmers also have a variety of preference functions such as welfare and objective functions.

It is the contention of this study that what the semi-subsistence farmer does in the pursuit of his occupation would largely depend on the nature of the crops, the purposes for which he cultivates

the different crops (whether for cash or food ), the degree of monetization in the economy, the availability of the inputs, relative knowledge of his environment through past records etc. Adequate knowledge of his behaviour therefore could neither be adequately gauged through the study of an aggregate production function nor in the study of small farms at the extremes of either subsistence or commercialization. This study is directed to individual crops. It aims to present a clear picture of the farm level production analysis for the respective crops.

The farm level production analysis for different crops in this study would derive estimates of optimal rates of inputs and outputs that would serve as a guide to future allocation of resources and investigate the economic rationality of farmers. The coefficients and elasticities obtained from this would help to make price formulations, decision making, incentive planning and projections more meaningful.

The study assumes more importance when associated with the racial differences between the indigenous Fijians and Indians in the use of various inputs and modes of production. Chandra (1979) focused on these differences and recommended softer land leases to the Indians as one way of increasing agricultural productivity. The results obtained from this study would serve as a guide in improving the welfare of the rural dwellers and would provide some basis for policy formulation in Fiji agriculture.

**1.5.0. OBJECTIVES.**

The main objective of this study is to verify whether price incentives are likely to be an effective measure for alleviating the problems of low agricultural productivity in Fiji. Specifically I wish to verify whether semi-subsistence farmers in Fiji do behave "rationally" as implied by the neo-classical theory.

On the secular level, in the context of allocative efficiency defined in terms of profit maximization, Shultz (1964), hypothesised that there are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture. This view is supported by a legion of contemporary writers in the field among which include Chennareddy (1967), Hopper (1965), Massel and Johnson (1968), Sahota (1968), Welsh, Wise and Yotopoulos (1969). Dillion and Anderson (1971) reappraised some of the evidence using economic (decision theory) rather than statistical (significance testing) criterion of profit maximizing efficiency and observed only mixed support to the hypothesis of profit maximizing behaviour by farmers in traditional agriculture. They found Yotopoulos's data relatively consistent with the hypothesis, Hopper's data inconclusive and Chennareddy's data relatively inconsistent. They concluded that traditional farmers maximize their expected utility (implying active consideration of subjective risk).

These differing and inconclusive opinions invite further investigation into the behaviour and the objective functions of the traditional farmer. Given the situation in Fiji, it may be that

- there would be variations along certain lines such as;
- (a) Racial differences (Indians and Fijians)
  - (b) Different crops (subsistence vs commercial).

(b) Different crops (subsistence vs commercial).

**1.6.0. HYPOTHESIS.**

I hypothesize that there exists a pattern of technological relationship (which rarely changes over short periods in time) between the inputs and outputs in the various crops cultivated by the semi-subsistence farmers in the Sigatoka Valley of Fiji; that the cultivators conform to this pattern irrespective of their race; that it is possible to identify the parameters of this relationship and that the semi-subsistence farmer in the Sigatoka Valley of Fiji, optimizes within his resource constraints and subject to his surrounding economic environment.



## CHAPTER 2

### REVIEW OF LITERATURE.

The literature review for this study is decomposed into four classes viz,

- (1) The eclectic views on production function studies,
- (2) Production function analyses and types,
- (3) Production function studies in Fiji,
- (4) Other related studies in Fiji.

#### 2.1.0. ECLECTIC VIEWS ON PRODUCTION FUNCTION STUDIES.

A plethora of studies exist in the fields of specification and estimation of production functions in both industry and agriculture. Some of them are reviewed below as they are related to semi-subsistence agriculture, and from where some of the analytical procedures employed in this study are derived.

Yotopoulos (1968), stated that there are two conceptual alternatives to increase output per unit of input; that one is by changing the production surface and the other is by re-organizing the productive inputs within a given production possibility curve i.e. technological change or reshuffling the combination ratios of the resources employed. To ascertain whether allocative efficiency is hindered in the less developed countries by institutional rigidities such as irrationality, wastefulness or ignorance, he studied a random sample of farms in Epirus, Greece by fitting Cobb-Douglas production function.

He computed the marginal products of each factor of production and compared them with the farmer's opportunity cost for the factor. He

based his comparison on the premise that a significant difference between the marginal product and the opportunity cost of a factor is an indicative evidence of inefficient resource utilization while correspondence between each factor's marginal product and its opportunity cost is accepted as evidence against the hypothesis that farms in the less developed countries are largely inefficient due to irrationality, ignorance, wastefulness or other factors. The computed marginal products of each input of production is regarded as that of the 'average' farm.

His results were consistent with allocative efficiency of the type labelled poor but efficient by Schultz (1964). He concluded that poverty in Epirius is not due to misallocation of existing agricultural resources and that mere reshuffling of factors of production could not be expected to contribute significantly to agricultural development in Epirius. Agricultural improvement required an outward push of the production function into a new equilibrium.

Yotopoulos however, noted that the farms studied were efficient 'on the average', since if all farms had been individually efficient they should have been of the same size, have identical input-output ratios and have the same input combinations, and therefore would have been on the same point on the eight (he used eight variables in his study) dimensional space of inputs and output. Therefore, there would have been no regression. The underlying reasoning is that if "on the average" they succeed in being efficient, then a high probability value will be assigned to the extent that individually they attempt to be efficient. This reasoning is

analogous to shots in a shooting event. The closer the distribution of shots around the bull's eye (stochos), the higher the probability that the individual shooters were aiming at the target.

This study would adopt Yotopoulos' analytical methodology to investigate whether the semi-subsistence farmers in Fiji are "rational" in the sense of equating the marginal value products of their factor inputs with the opportunity cost of the inputs.

Etherington (1973), noted that the estimation of the production function is an important aspect of the attempt to explain "what is" in agricultural production. In other words the estimation of the production function is an attempt to explain what produced the observed data so that structural conclusions could be derived therefrom.

It is therefore pertinent that the production function approach employed in this study for the analysis of the available data is to derive structural and behavioural conclusions.

Woodworth (1977), in his studies of agricultural production functions concluded that: (1) although linear programming has become the dominant methodology for obtaining the most profitable farming systems, partial analysis based on production function studies have merit in analysing numerous policy and farm level decisions when interrelationships with other aspects of the farm organization are of secondary importance; (2) the results of the production function studies are useful in selecting data for linear programming studies.

He noted that production function studies do provide useful

insights to such issues as how much inputs to use or how to minimize input costs. He observed that: (1) the developing countries have more need for the production function studies than the developed countries like U.S.A. because there is a critical need to improve food production in the developing countries and the cost of fertilizer to farmers may be high as there is limited foreign exchange to import fertilizers; (2) the policy issues in the less developed countries involve the provision of adequate incentives for more efficient use of fertilizers.

Therefore he concluded that economic studies that determine optimal rates of fertilizer usage will be of major contribution under the above circumstances. He also advocated that:

- (1) crop production research be carried out on the farms rather than experimental stations;
- (2) there is need for greater understanding of the response relationship and non-treatment variations in crop production, because it would lead to improved criteria for selecting the functional relationships.

The foregoing also lends support to the adequacy of the application of the production function technique in the current study.

Upton (1979) dealt with problems surrounding the estimation of production functions. He noted that farm level production function analysis is generally aimed at developing estimates of optimal rates of inputs and outputs in order to;

- (1) guide the future allocation of resources;
- (2) investigate the economic rationality of farmers;
- (3) derive normative supply functions.

He observed that: (1) a farm is a highly complex and dynamic system and any attempt to represent such a system by a single equation is unlikely to be operationally meaningful; (2) in prediction, prescription or hypothesis testing, difficulties arise with unproven assumptions underlying the production function such as (i) that factor supplies and product demands are infinitely elastic to the individual producer and (ii) that farmer's objective is to maximize profits.

Upton concluded that various causes of differences between farms include: (i) environmental factors, location, soils and markets; (ii) objectives; (iii) knowledge; (iv) inherent managerial or entrepreneurial ability; (v) luck or random differences; and that some of these factors could be influenced by government policies while others cannot.

Hence hypotheses, predictions or prescriptions which are appropriate for one farmer may not be appropriate for another. Hence severe problems arise in arguing from general to singular.

Apart from justifying the production function approach for a study related to the economic rationality in resource allocation by semi-subsistence farmers, Upton's findings highlighted some of the major "caveat emptor" surrounding the interpretation and the application of the production function studies' results.

Muller (1974), in his studies of technical efficiency, attempted answers to why all the observations do not lie on a single unit isoquant. Some of the answers included:

- (i) the production technology may differ from farm to farm,
- (ii) the production technology may be the same

between farms but observed differences are due to random disturbances or luck, (iii) all farms have the same available technology but some are more successful than others in using it efficiently, i.e. implying real differences in technical efficiency.

He concluded that the neoclassical concept of the production function (given that the significant inputs and outputs are correctly accounted for) is perfectly able to account for technical efficiency differences which was not possible before.

From the above studies, it is evident that neither the study of rationality in resource allocation nor the production function analysis is new. It is only the location and the data that are new and the best approach to the current study involves the application of the production function analysis.

#### **2.2.0. THE PRODUCTION FUNCTION ANALYSIS.**

A production function is a mathematical expression describing the functional relationship between the output of a single commodity and a set of inputs. Technically the function indicates the maximum output obtainable from any given combination of inputs and it is assumed that the inputs are continuously variable and substitutable in the production process. The relationship could be expressed as a graph, a table, or in the following algebraic formulation:

$$Y = f(X_1 \dots X_n),$$

where Y = single valued output,

f = the technical relationship,

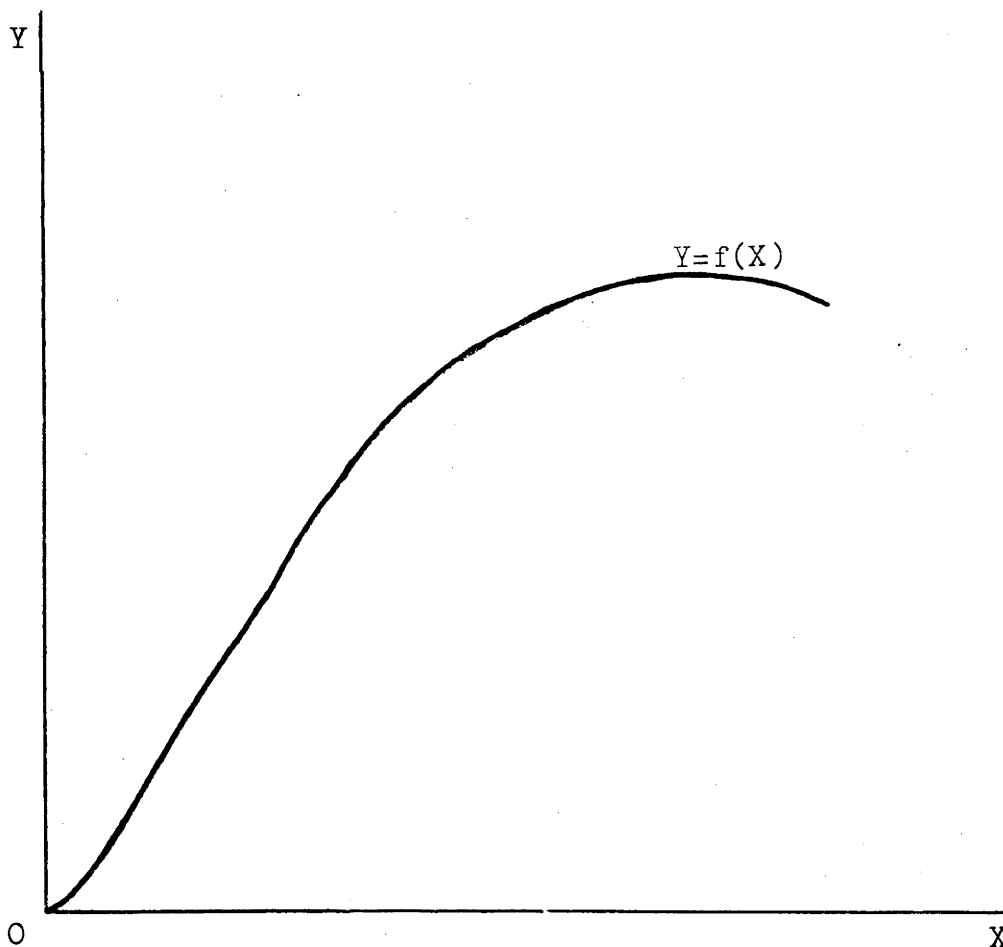
$X_i$  = input i,

i = 1, 2, ..., n.

This expression indicates that the output  $Y$  is some unspecified mathematical function of the quantity of inputs  $X_i$ . In semi-subsistence agriculture,  $Y$  is the crop or livestock output and the  $X_s$  are the factor inputs of land, labour, capital, management and other factors. The function summarizes the efficient production possibilities open to the farmer on the assumption that he is technically efficient.

The response function for the five factors would require a diagram spanning six geometric planes and such a diagram is not possible to draw. Presented in figure 2.1 below, is a diagram of a crop response to a single input.

FIG. 2.1 A DIAGRAMMATIC REPRESENTATION OF A CROP RESPONSE TO A SINGLE INPUT.



The simplified diagram suggests that the production response function for a crop in the Sigatoka Valley is a 'sigmoid' curve with varying slopes and a turning point. The single crop could be any of the crops in table 3.1 and the single input could be any of the  $X_1, X_2, \dots, X_5$  above. It is supposed in so doing that the nature of the response of the crop to one input will be similar and will adequately illustrate the response (except for scalar differences) when five inputs are applied.

The characteristics of the function include:

(1) the existence of a continuous causal relationship between the inputs ( $X_s$ ) and the output ( $Y$ ). This implies the existence of the first derivative of the function, that is, that  $dY/dX$  exists.

(2) the prevalence of diminishing returns with respect to each of the input factors, ie. the additional output for succeeding units of the input  $X_i$  becomes less and less, indeed beyond a certain peak of the output the additional use of the input  $X_i$  would result in the decrease of the output eg. some crop plants will die if fertilizer is excessively applied. Mathematically the prevalence of diminishing returns implies that the first derivative ( $dY/dX$ ) of the response function be positive

and the second derivative ( $d^2 Y/dX^2$ ) exists and be negative.

(3) certain inputs such as land, seeds or seedlings and planting labour are essential while others such as fertilizers and weeding labour are non essential inputs.



### 2.2.1. TYPES OF PRODUCTION FUNCTIONS.

An exhaustive review of the production functions currently in existence is beyond the scope of this study. It would suffice to mention a few and highlight some of their characteristics. Heady and Dillon (1961) provide a comprehensive review of the existing types of production functions.

### 2.2.2. POLYNOMIAL PRODUCTION FUNCTIONS.

Originating from Liebig's (1855) "law of minimum", in his studies of the fundamental relationship between fertilizer inputs and crop yield, are two forms of linear (polynomial of the first degree) production functions.

Bondorff (1924) and Plessing (1943) proposed the form:

$Y = A \prod X_i$ , (where all the inputs are essential) and Boresch (1928)

proposed the form  $Y = C + A \prod X_i$ , where

$Y$  = output,

$A$  = constant coefficient that defines the transformation ratios,

$\prod$  = indicates a multiplicative relationship,

$X$  = quantity of nutrients,

$C$  = yield level without the application of  $X$ ,

$i = 1, 2, \dots, n$ .

These linear forms do not satisfy the requirements of diminishing marginal returns. The application of the linear forms in the study of agricultural production would not be very fruitful because of their inherent assumption of constant marginal returns to inputs while diminishing marginal returns is an indispensable property of the agricultural production process. Although the second and the higher order polynomials allow for diminishing marginal returns,

declining and negative marginal productivities, they are seldom employed in agricultural studies because of the loss of degrees of freedom associated with them when working with small samples which is often the case.

### 2.2.3. THE SPILLMAN PRODUCTION FUNCTION.

Although Mitscherlich (1909) was the first researcher to suggest a non-linear production function with respect to inputs' usage and crop yields, Spillman(1933) working independently and without knowledge of Mitscherlich's studies proposed a similar exponential yield equation of the form:

$$Y = M - AR^x, \quad \text{which he later modified to:}$$

$$Y = A(1 - R^{x_1})(1 - R^{x_2}), \quad \text{where}$$

$Y$  = output,

$M$  = maximum total yield attainable by increasing the input  $X$ ,

$A$  = constant, defining the maximum response (sum of marginal yields) attainable from the use of  $X$ ,

$R$  = the coefficient defining the ratio by which marginal productivity of the inputs decline,

$X_i$  = quantities of variable inputs used.

Unlike Mitscherlich's equation, the constant in Spillman's equation varies with differences in the environment. In the Spillman function, the inputs are not essential i.e. it allows for outputs when input usage is zero. The input-output curve is asymptotic to  $A$  (the maximum output attainable from the use of inputs). It allows for change in the elasticity of production and diminishing marginal productivity to the inputs used but does not

allow for negative marginal products i.e. declining output.

In Spillman function all responses are diminishing in nature and successive changes are proportional to each other. As Heady and Dillon (1961) noted, constant rates of change is a rarity in the real world particularly in agriculture consequently the Spillman function found limited application in farm management survey data.

#### 2.2.4. THE CONSTANT ELASTICITY OF SUBSTITUTION (CES) PRODUCTION FUNCTION.

The CES function was developed and applied by Arrow, Chenery, Minhas and Solow(1963) to the United States industrial data in the form,

$$Y = A [dK^{-p} + (1-d)L^{-p}]^{-1/p}$$

where Y = output,

A = efficiency parameter with a neutral effect,

d = distribution parameter which determines the functional distribution of the dependent variable,

p = the substitution parameter.

By transformation the elasticity of substitution is obtained as  $e = 1/(1+p)$ . As the name implies this class of production function is characterised by constant elasticity of substitution, the values of which could range from minus one to positive infinity. When the elasticity of substitution is one the equation will precipitate to the case of the Cobb-Douglas production function.

The function allows for positive marginal productivity of inputs and diminishing marginal returns to factor inputs.

Though this function produced useful results in the industrial production analysis, it cannot do the same in agricultural production analysis because apart from assuming homogeneity,

additivity and constant returns to scale, when more than two inputs are involved, the multifactor CES function becomes mathematically extremely cumbersome.

#### 2.2.5. THE COBB-DOUGLAS PRODUCTION FUNCTION.

This function was first specified by Wicksell (1916) but was made famous by Cobb and Douglas(1928) who applied it to time series data for American manufacturing industries. The form in which it is extensively used is:

$$Y = AX_1^{B_1} X_2^{B_2}, \quad \text{expressed in logarithm as}$$

$$\ln Y = \ln A + B_1 \ln X_1 + B_2 \ln X_2, \quad \text{where,}$$

Y = output,

A = the efficiency parameter,

$X_i$  = input  $i$ ,

$B_i$  = elasticities of output with respect to the input  $i$ ,

$i = 1, 2, \dots, n$ .

It is mathematically simple in comprehension and estimation and satisfies the conditions for diminishing marginal returns to factor inputs and variable proportions. The function is linear and homogenous in the logarithm and assumes that all inputs are essential. It is characterised by constant elasticity of substitution of unity.

#### 2.2.6. THE TRANSCENDENTAL PRODUCTION FUNCTION.

The transcendental production function, which is a hybrid of the power and the exponential equations, was proposed by Halter et al. (1957). The general form is:

$$Y = cX^a e^{bX}, \quad \text{where}$$

Y = output,

X = input,

a, b, c, = coefficients to be estimated,

e = base of natural logarithms.

The function could handle data with stages of increasing and decreasing marginal productivities and the resultant curve could take a variety of shapes. With the transcendental production function distinction could be made between essential and non-essential inputs. The essential inputs appear in both the log and the semi-log form while the non-essential inputs appear only in the semi-log form.

Irrespective of the flexibility, the transcendental production function has found limited application in empirical studies (but see Sepien 1978).

### 2.2.7. THE TRANSCENDENTAL LOGARITHM (TRANSLOG) PRODUCTION FUNCTION.

The development of the translog production function by Christensen, Jorgensen and Lau (1970) ushered in an era of handling more than two inputs and yet being able to calculate the estimates of the partial elasticities of substitution between the inputs in production function studies. The translog form for one output and two inputs is thus:

$$Y = AX^{A_1} [B_1 + (a_{11}/2)\ln X_1 + (a_{12}/2)\ln X_2]^{A_2} [B_2 + (a_{12}/2)\ln X_1 + (a_{22}/2)\ln X_2]^{A_3}$$

On taking logarithms of both sides the equation reduces to:

$$\ln Y = \ln A + B_1 \ln X_1 + B_2 \ln X_2 + \frac{1}{2} a_{11} (\ln X_1)^2 + a_{12} \ln X_1 \ln X_2 + \frac{1}{2} a_{22} (\ln X_2)^2$$

where  $Y$  = output,  
 $X_1, X_2$  = the inputs,  
 $A$  = the efficiency parameter,  
 $B_i, a_i$  = the coefficients to be estimated.

The translog function is a quadratic function in the logarithm of the inputs. It satisfies the conditions for diminishing returns to factor inputs and variable proportions. Empirical studies by Humphrey et al.(1975) indicated that the translog function is more appropriate and fruitful in the analysis of the production process where natural resources (minerals) play major roles. In such studies it proved superior to the Cobb-Douglas function which is restricted to the elasticity measure of unity and also to the multi-factor CES function which requires that the elasticity of substitution between inputs stand in fixed ratios to one another.

It is apparent from the above review that since this study analyses agricultural data, the production function types characterised by constant marginal productivity of inputs cannot be adequate for the analysis because constant marginal productivity of inputs do not prevail in agriculture.

To ensure ease of computation and comprehension, the production function types that involve complicated and iterative computations are not tried in this study. The functional trials in this study are confined to those production function types characterised by variable marginal productivities of the inputs and that have been widely applied in agricultural studies, particularly the translog and the Cobb-Douglas production functions.

### 2.3.0. PRODUCTION FUNCTION STUDIES IN FIJI.

Currently, there is only one study by Chandra (1979) that employed the production function analysis in the study of semi-subsistence agriculture in the Sigatoka Valley, Fiji. Other studies in this Valley have been carried out by geographers, soil scientists, anthropologists, government initiated commissions of inquiry and local research personnel of the Fiji Department of Agriculture. These groups of scholars did not employ the production function analysis and they investigated specific and ad-hoc problems other than rationality in semi-subsistence agriculture.

Chandra (1979) studied the productive efficiency of Fijian and Indian farming systems in the Sigatoka Valley, Fiji. He fitted an aggregate production function employing the Cobb-Douglas formulation, and concluded that:

- (1) there was little difference in the technical efficiency between the Fijian and the Indian farms, although the Fijians tended to be slightly more efficient.
- (2) the most important factors on Fijian farms were labour and capital whereas on the Indian farms they were land and capital.
- (3) the gains from reallocation of resources in both farming systems would be relatively low because the allocative efficiency was comparatively high, especially in the case of the Indians.
- (4) increasing the productivity of the land and labour would require greater capital investment, technological innovations such as small tractors, improved varieties of crops, improved fertilizer regimes, use of pesticides and irrigation.

Although the above study was carried out on an aggregate crop basis, it would serve as a reference point for the current study. The extent to which the above conclusions apply on a crop-by-crop basis may be apparent from this study.

#### **2.4.0. OTHER RELATED STUDIES IN FIJI.**

In the area of semi-subsistence agriculture in Fiji, only very few literature exist. The handful of agricultural studies in Fiji are dominated by the study of the export crops, mainly sugar and coconut, which together account for 81.5% of Fiji's export.

Ward (1965), in his study of land use and population in Fiji, concentrated on the history of land settlement and the development of land use from the pre-European times to the present. He also described the climate, soil resources and land tenure in Fiji.

Frazer (1961) dwelt on the land use and population in the Ra province of Fiji. He observed that although many Indian sugar cane farms had relatively high levels of productivity, many farms had large debts which were attributable to fluctuations in prices of cane and high interest rates charged by money lenders.

Anderson (1971), in his study of Indian small farming, described the growth, structure and organization of Indian small farming in Fiji from 1879 to the present decade. He also gave a historical perspective of Fiji agriculture.

Watters (1969), in his studies of economic development and social change in Fiji, dealt with the implications of social change and economic development of farm productivity in four villages.



Twyford and Wright (1965) evaluated the soil resources and classified the agricultural lands on the basis of fertility, drainage, slopes and other factors that limit land use and recommended certain crops for various land classes.

Shaw (1973), investigated the economic problems surrounding rural credit on Indian sugar cane farms in Cuvu and Olosara sectors of south west Viti Levu. He noted that a high level of rural indebtedness affected household organizations and farm productivity.

Belshaw (1964) studied some of the economic problems and social order in several villages including Keiyasi village in the upper Sigatoka Valley.

Mayer (1973) in his study of peasants in the Pacific concentrated on farm credit, culture and kinship in three Indian agricultural settlements.

Fisk (1970) formulated an approach for rural development in Fiji and recommended the channelling of resources towards the provision of infrastructure such as roads, communication networks and schools in the remote villages. He advocated the intensification of food production by dissemination of the research results through extension staff of the Department of Agriculture. He stressed that efficient management has no substitute for a successful promotion of agricultural production.

De Boer and Chandra (1978) studied crop selection in semi-subsistence agriculture in Fiji. They observed that a vast majority of the world's farmers operate as semi-subsistence producers. They concluded that there exists a high degree of efficiency in semi-subsistence agricultural production in Fiji

farms. They recommended that additional incremental application of labour in Fijian farms be devoted almost exclusively to cash crops. In the Indian farms they observed that the productivity of labour is already low and recommended increased access to complementary inputs with particular reference to land.

## CHAPTER 3

### THE STUDY AREA AND THE DATA.

In this chapter, the semi-subsistence agriculture in the Sigatoka Valley of Fiji, the source of data, methods of collection and analysis are discussed.

#### 3.1.0. SEMI-SUBSISTENCE AGRICULTURE IN THE SIGATOKA VALLEY OF FIJI.

In Fiji, semi-subsistence agriculture is a broad link between the pure commercial farms at one extreme and the pure subsistence farms at the other extreme of the production continuum. It is characterised by multiple and inter-cropping of root crops, vegetables, grains and cereals grown for domestic consumption and for cash. Some of the crops are grown all the year round and some are seasonal. In table 3.1, the subsistence and cash crops cultivated in the Sigatoka Valley of Fiji are presented.

TABLE 3.1 THE SUBSISTENCE AND CASH CROPS ON FIJIAN AND INDIAN FARMS.

CROPS	FIJIANS		INDIANS	
	MAJOR	MINOR *	MAJOR	MINOR *
SUBSISTENCE	Cassava	Taro	Rice	Pulses
	Sweet potatoes	Yams		Egg plants
		Bananas		Green beans
COMMERCIAL	Maize	Tomatoes	Maize	Chinese cabbage
	Watermelon	Irish potatoes	Watermelon	Chillies
		English cabbage	Tomatoes	Broom corn
		Twist tobacco	English cabbage	Cucumber
		Virginia-	Irish potatoes	Peanuts
		tobacco	Twist tobacco	Pumpkins
		Broom corn		Passion fruit
		Passion fruit		

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\* Less than 10% of the total cropped area.

Adapted from Chandrá S.(1979) Productive efficiency of Fijian and Indian farming systems in Semi-subsistence Agriculture: Sigatoka Valley, Fiji.

From the table it is evident that cassava is a major subsistence crop while maize and watermelon are the major commercial crops for the Fijians. For the Indians rice is the major subsistence crop while maize and watermelon, among others, are the major cash crops.

This study does not deal with all the crops cultivated in the Sigatoka Valley of Fiji. Four crops, namely cassava, rice, maize and watermelon are chosen for study. The justification for selecting them lies with their economic importance to the different ethnic groups in the Sigatoka Valley as stated earlier and evident from table 3.1.

The description of the habit and cultivation processes of these

crops is beyond the scope of this study. Suffice to mention that:

(a) Cassava is a biennial root crop that is very rich in the supply of carbohydrates. In Fiji, it is planted all the year round.

(b) Rice is a cereal that matures after 3 to 4 months from planting and is usually planted in February.

(c) Maize is a seasonal grain crop that matures after 3 to 4 months from planting. It is usually planted in February in the area.

(d) Watermelon belongs to the family curcurbitacea and has an edible mesocarp. It is usually planted in the months of September and October in the Sigatoka Valley and it matures after 3 months from planting.

For any of the crops cultivated in the Sigatoka Valley the quantity of the crop output obtained by a farmer is determined by a variety of factors which include; land area, soil type, fertilizer application, management, labour application, weather conditions and a myriad of other non-quantifiable environmental factors. Many of the factors are correlated and as such could be grouped into classes, e.g. management and labour could be classed under a general heading of labour. By applying such broad classifications, the crop output could be said to be determined by land, labour, capital, current expenses and other non-quantifiable factors used. This could be expressed algebraically as;

$Y_i$  depends on  $X_1, X_2, X_3, X_4, X_5$  or more briefly,

$Y_i = f(X_1, X_2, X_3, X_4, X_5)$ , where

$Y_i$  = the output,

$X_1$  = land area cultivated,

$X_2$  = labour applied,

X3 = capital used,

X4 = current expenses used,

X5 = all other non-quantifiable factors involved  
in the production.

### 3.2.0. SOURCE OF DATA.

The data employed in this study is obtained from the Sigatoka Valley, Fiji. The Sigatoka area consists of 34,885 hectares of land including the 8,135 hectares of the Sigatoka Valley. The land tenure of the area is 3.3% crown land, 10.3% freehold land and 86.4% native land. Most of the sample observations in this study were generated from native lease land, native reserve land and some from freehold lease land but none of the observations is from crown land. The Sigatoka Valley is of prime importance in Fiji agricultural activities. It is inhabited by the various racial groups and has one of the most important agricultural research stations in Fiji -- the Sigatoka Research Station. As well a regional office of the Extension Division of the Department of Agriculture is located in the Valley. Not only is the area sufficiently characterised by all the features and problems of agriculture in Fiji, but it is also very accessible and amenable to research work.

The data is cross-sectional, secondary data, primarily collected by Chandra (1979) involving a farm management survey of the Sigatoka Valley. The survey was carried out in an attempt to study the efficiencies of the Fijian and Indian farming systems on an aggregate output base. The data on per crop basis was not analysed in the collector's studies and it was collected without any intention of a study of the present nature.

### 3.2.1. METHOD OF COLLECTION.

The farm management survey covered a period of two years from November 1970 to October 1972. Data was collected weekly from the sampled farms. The data collection procedure has been described in detail by Chandra (1979). November was chosen as the starting point because it is the beginning of the rainy season in Fiji, consequently the beginning of the farming calendar and cropping activities since crop husbandry in the area is rain-fed.

### 3.2.2. MEASUREMENT OF THE FARM AREA.

The data on farm area was obtained from the inventory taken at the beginning and the end of the cropping years. Land area was measured using the chain and compass survey method. The unit of measurement was hectares.

The farm sizes are comparatively small. They range between 0.81 to 5.26 hectares with a mean of 2.64 Ha. for an indigenous Fijian and between 1.21 to 8.09 Ha. with a mean of 3.54 Ha. for an Indian Fijian. Land was assumed homogenous within the area occupied by each crop.

### 3.2.3. MEASUREMENT OF LABOUR.

Actual labour hours used in crop production by task and by month were measured. From the structure of farming operations and cultural differentiation of duties in farming in Sigatoka Valley, woman hour was regarded as equivalent to manhour. Since no specialization was evident in any of the farming operations the implied assumptions of homogeneity and additivity of labour is justified. Table 3.2, shows the mean labour usage in manhours by month on Fijian and Indian farms.

TABLE 3.2, MEAN LABOUR USAGE IN MANHOURS BY MONTH ON FIJIAN AND INDIAN FARMS.

MONTH	FIJIAN(n=26)	INDIANS(n=35)
JANUARY	73	82
FEBRUARY	26	22
MARCH	29	18
APRIL	51	124
MAY	98	167
JUNE	142	257
JULY	97	217
AUGUST	69	121
SEPTEMBER	127	210
OCTOBER	101	148
NOVEMBER	46	86
DECEMBER	56	163
TOTAL	915	1615

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Adapted from Chandra S.(1979).

From the above table it is evident that the Indians apply more labour than the Fijians and most of the labour usage occurs during the winter months which is the peak of the agricultural calendar. The use of hired labour is limited, as most of the labour is supplied by the family.



#### 3.2.4. MEASUREMENT OF CAPITAL.

The data on capital was obtained from the farm inventories taken at the beginning and the end of the cropping years. The capital items included farm buildings as storage sheds, drying sheds, equipment sheds, tractors, bullocks, horses, ploughs, wooden sledges, knapsack sprayers, sickles, machetes and maize shellers. Items such as tractors and maize shellers were owned by very few farmers, in fact in the whole sample studied under the survey, only seven farmers possessed tractors and these were mainly used on sugar cane farms which are purely commercial enterprises.

Chandra (1979) observed that more capital items are present on Indian farms than on the indigenous Fijian farms. The Indians preponderate in owning oxen, tractors, maize shellers, storage sheds for maize, knapsack sprayers and wooden treadles while the indigenous Fijians have the pre-eminence in the possession of wooden sledges, storage sheds for maize, forks and spades. However a large number of farmers in both groups own horses.

The unit employed in the measurement and aggregation of capital is the Fijian dollar. The technique of measurement applied was Yutopoulos' (1967b) capital flow method of evaluating capital items. For details on the methods of derivation see Chandra (1979). Capital in the original survey was, however, measured on a household basis. In order to apportion capital to specific crops, this study multiplies the total capital employed by the farmer by the ratio of the particular crop area to the total land area cultivated by the farmer.

### 3.2.5. MEASUREMENT OF CURRENT EXPENSES.

The current expenses comprise all farm cash costs for the purchase of such items as fertilizers, pesticides, seeds, hired labour and hired implements. The data was obtained from weekly interviews with the farmers. The unit of measurement is the Fijian dollar. As in capital, the original measurements were recorded on per farmer basis therefore, to allocate to individual crops, the total current expenses incurred by the farmer is multiplied by the ratio of the particular crop area to the total land area cultivated by the farmer. No other method is possible given the available data.

### 3.2.6. THE MEASUREMENT OF CROP YIELDS.

Rice, maize and watermelon are multi-point input and point output crops while cassava is a multi-point input and multi-point output crop. The yields of rice, maize and watermelon were recorded at a point in time of harvest while cassava yields were taken periodically as harvested. The actual yield was recorded in kilogrammes.

### 3.3.0. METHODOLOGY.

This study investigates the nature of the relationship between the yields and inputs for the selected crops by applying some of the existing production functions to the data. The selection of the 'suitable' relationship is based on the satisfaction of 'a priori' agricultural production requirements and statistical significance tests.

Statistical significance tests are used to verify; (a) the extent of intertemporal differences in the techniques of producing the

selected crops; (b) the existence of variations due to race in the production technology of the selected crops and (c) the extent of intercrop differences in resource allocation and the ability of the semi-subsistence farmers in Sigatoka Valley of Fiji to equate the marginal value products of the inputs with the input prices.

#### 3.4.0. LIMITATIONS OF THE DATA.

Labour was restricted to men and women above the age of 15 years since children of less than 15 years of age are obliged to attend school as required by the compulsory free primary education scheme and their contribution after school hours was assumed to be very low. On the other hand it is evident that children do contribute significantly to the farm operations especially during the peak labour demand periods of planting and harvesting.

The manipulation applied in order to apportion capital and current expenses to specific crops in this study is an approximation, albeit the best available, consequently a possible source of error. The above and the other inherent measurement errors in the data could have 'carry-over effects' which may tend to lower the precision of the resultant estimates.

## CHAPTER 4

### PRODUCTION FUNCTION MODELS AND STATISTICAL ESTIMATION PROCEDURES.

#### 4.1.0. THE SELECTION OF THE FUNCTIONAL FORM.

Ferguson (1975) noted that the variety of equations that may validly represent a production function is virtually limitless. Economic theory per se has no clear cut approach for choosing between the various possible forms of production functions. The functional form employed in this study was selected on three considerations, namely (1) conformity to the logic of economic theory, (2) statistical manageability and (3) statistical fitness.

#### 4.1.1. CONFORMITY TO THE LOGIC OF ECONOMIC THEORY.

Conformity to the basic tenets of economic theory particularly to the law of variable proportions is given a pre-eminence in the selection of the functional form.

Functional forms linear in variables,

$$Y = a + b_i X_i \quad i=1,2,\dots,n,$$

which gives constant marginal productivity to a variable input but varying elasticity of output with respect to that input was contrasted with functional forms linear in the logarithms ;

$$\ln Y = \ln A + b_i \ln X_i \quad 0 < b_i < 1,$$

which gives varying marginal productivity to inputs but constant elasticity. Because this study is interested in the variations of the marginal productivities between groups, it is considered worthwhile to restrict the exercise to functional forms characterised by variable marginal productivities of inputs.

#### 4.1.2. STATISTICAL MANAGEABILITY.

Heady and Dillon(1961) observed that an infinite number of functional forms are possible in productivity studies and that some of the equations have parameters or coefficients that are difficult to derive in the statistical treatment of data. Some of the equations have terms which cannot be transformed or are not readily transformed into linear regression equations and hence are estimated only by iterative processes.

In this study, amongst the equations characterised by variable marginal productivities, only some of the forms which can be handled using conventional least square method and which has had wide application are tried to ensure ease of comprehension and computation.

#### 4.1.3. STATISTICAL FITNESS

Statistical and econometric techniques are used to test the validity and reliability of estimates. Heady and Dillon (1961) stated, "A procedure sometimes preferred is to select initially a simple polynomial form and add terms one at a time, retaining those which account for a significant incremental proportion of variance in output". The stepwise approach is adapted in the current study. For all the crops selected, the trans-log production function with all the interactive terms was specified (2.2.7). The resultant regression equations had high coefficients (and adjusted coefficients) of determination and the overall equations were statistically significant but most of the variables were wrongly signed and were statistically insignificant regressors. This anomaly was mitigated by applying "stepwise regression procedure"

(White 1982), whereby regressors were 'stepped-in' one variable at a time at the significant level (F-test) of five percent level of probability.

Constrained by the size of this study, the results of the stepwise regressions are not presented. Suffice it to report that for all the crops under study, all the logarithmically interactive terms of the specified trans-log equation were statistically not significant and the resultant form is the Cobb-Douglas production function.

Relying on this empirical evidence, this study assumes that even if any other algebraic form, for instance the transcendental form, is specified, the 'stepwise regression procedure' would filter out the interactive terms as was the case with the experimented trans-log production function.

#### 4.2.0. CHOICE AND JUSTIFICATION OF VARIABLES USED.

The choice of variables to depict a production process for semi subsistence agriculture is a delicate operation because as Heady and Dillon(1961) noted,"...should any relevant variables be omitted, the fitted model will be biased in an economic sense either structurally or predictively, likewise the unwarranted inclusion of variables will lead to bias".

Ideally, the choice of variables should be made in terms of the underlying mechanics of the production process yet the economic, physical and biological logic of the production process is to a large degree unknown. Some of the relevant variables are unknown and may be discovered only through fundamental research and some of the variables known to be relevant may be unobservable or nonquantifiable.

The imperfection in the knowledge of the underlying logic of production is also exacerbated by the dependence of semi-subsistence agriculture on unpredictable factors as climate and edaphic variables. Consequently the number of separate variables considered is determined in terms of data availability and also with regard to the resources available for estimation.

Heady and Dillon(1961), stated that a given algebraic form of the production may be tried with a variety of combination of variables. That combination which best accounts for the observed output may be selected provided that the influence of the included variables is not contrary to any of the physical, biological or economic logic known to underlie the production process.

From the theory of the semi-subsistence agricultural production, land and labour are included in the equations in the forms they were measured viz; land in hectares and labour in manhours.

An attempt was made to combine capital and current expenses as one variable because of their inter-relatedness and the sameness of their units of measurement, but the resultant regression equations wrongly signed the coefficient of the combined regressors. The combined variable was also statistically insignificant.

These occurrences were contrary to 'a priori' expectation and attributable to misspecification of variables. Consequently, they (capital and current expenses) were separated and the resultant coefficients for capital assumed the correct signs and were statistically significant. The signs for the coefficients of current expenses remained negative and insignificant in some cases. The latter observation is not however unexpected as it reflects the

insignificant role of current expenses in semi-subsistence agriculture.

#### 4.3.0. THE MODEL APPLIED TO THE DATA.

In this study, the conventional unrestricted Cobb-Douglas production function is specified and applied as the basic functional form to the data for the various crops.

The form is defined thus:

$$Y = B_0 X_1^{B_1} X_2^{B_2} X_3^{B_3} X_4^{B_4} U$$

where Y = The output of the crop measured in kilogrammes.

$B_0$  = The efficiency (scalar) parameter.

$X_1$  = Farm area measured in hectares.

$X_2$  = Labour applied, measured in manhours.

$X_3$  = Capital flow measured in dollars.

$X_4$  = Current expenses measured in dollars.

$B_i$  ( $i=1,2,3,4$ ) = The elasticities of the output with respect to the corresponding inputs.

U = The stochastic error term.

Subsequent modifications involve the inclusion of the shifts and slope dummy variables for time and race where they are statistically considered relevant. These are discussed in the following sections.

#### 4.4.0. THE SAMPLE SIZE.

The farm management survey conducted by Chandra provided data for two years namely 1970/71 and 1971/72. In 1970/71 the number of observations available ranged from 35 in water melon and maize to



38 in rice while for 1971/72 it ranged from 25 for cassava to 35 for maize, and it was not in all cases that a farmer who planted a particular crop in 1970/71 planted the same crops in 1971/72.

In order to improve the precision of the estimates and the degrees of freedom this study pooled together the data obtained during the 2 years after testing and ensuring that the equations for the periods are not significantly different for the respective crops.

#### 4.5.0. TESTING THE EQUALITY OF TWO REGRESSION EQUATIONS.

This involved testing that the parameters of the production function for the respective crops had not changed during the two years for which the data was collected.

The null hypothesis is,

$$H_0: B_1=A_1, B_2=A_2, \dots, B_k=A_k,$$

where  $B_i(i=1,2,\dots,k)$  are the estimated elasticities for the regression equations applying only 1970/71 data and  $A_i(i=1,2,\dots,k)$  are the estimated elasticities for the regression equations applying only 1971/72 data for the respective crops. The null hypothesis was tested against the alternative hypothesis that the null hypothesis is not true.

As described by Kmenta (1971) p.373, the relevant test statistics(F-test)is obtained by applying the least square estimation method to the 1970/71 set of observations, to the 1971/72 set of observations and to the two sets of observations combined. The sum of the least square residuals are employed to compute the statistic;

$$\frac{[SSEc - SSE1 - SSE2]/K}{[SSE1 + SSE2]/(n+m-2k)} \quad F_{k, n+m-2k}.$$

where,

SSEc = The least square residuals for the estimated equation applying all the observations combined.

SSE1 = The least square residuals for the estimated equation applying 1970/71 observations only.

SSE2 = The least square residuals for the estimated equation applying 1971/72 observations only.

n = The number of observations available in 1970/71.

m = The number of observations available in 1971/72.

k = The number of regressors used including the intercept term.

The derivation of the test is described in Johnston (1963) P.136.

The table showing the least square residuals, the number of observations, the calculated and the tabulated values of the F-statistics for the various crops are presented below in table 4.1.

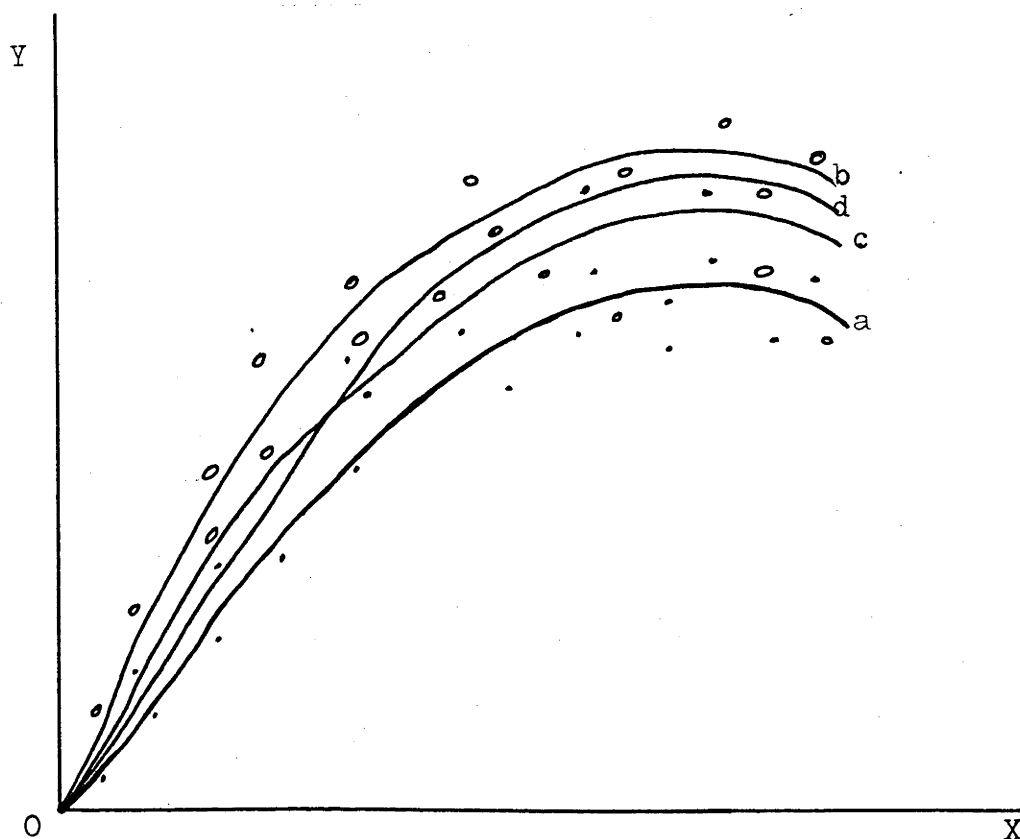
**TABLE 4.1 TABLE OF LEAST SQUARE RESIDUALS, CALCULATED AND TABULATED F-VALUES AT 1 PERCENT LEVEL OF SIGNIFICANCE FOR THE TEST OF EQUALITY BETWEEN TWO REGRESSION EQUATIONS.**

CROP	SSE1	SSE2	SSEc	K	n	m	Cal.F	Tab.F at 1%
Cassava	1.0536	2.6670	4.6838	5	35	25	2.588	3.42
Rice	2.5696	3.8419	7.8816	5	38	31	2.706	3.34
Maize	3.3736	9.6134	14.307	5	36	35	1.240	3.34
Watermelon	7.9068	8.8046	19.035	5	35	26	1.418	3.43

It is apparent from the table that at 1% level of probability, the regression equations for the different years are not statistically different for the four crops under study. In the light of this evidence the study pools the observations for the two years together.

Fig.4.1 below is an exaggerated hypothetical two dimensional (one homogenous output against one input) representation of the scatter of points for the two years for any of the four crops under study. The curves a, b and c, represent any of the regression equations that could be fitted by applying 1970/71, 1971/72 or the combination of the two respectively, while the curve d represents the "average" production function which is the target of this study. The concept of "on the average" is adequately elucidated by Yotopoulos (1968).

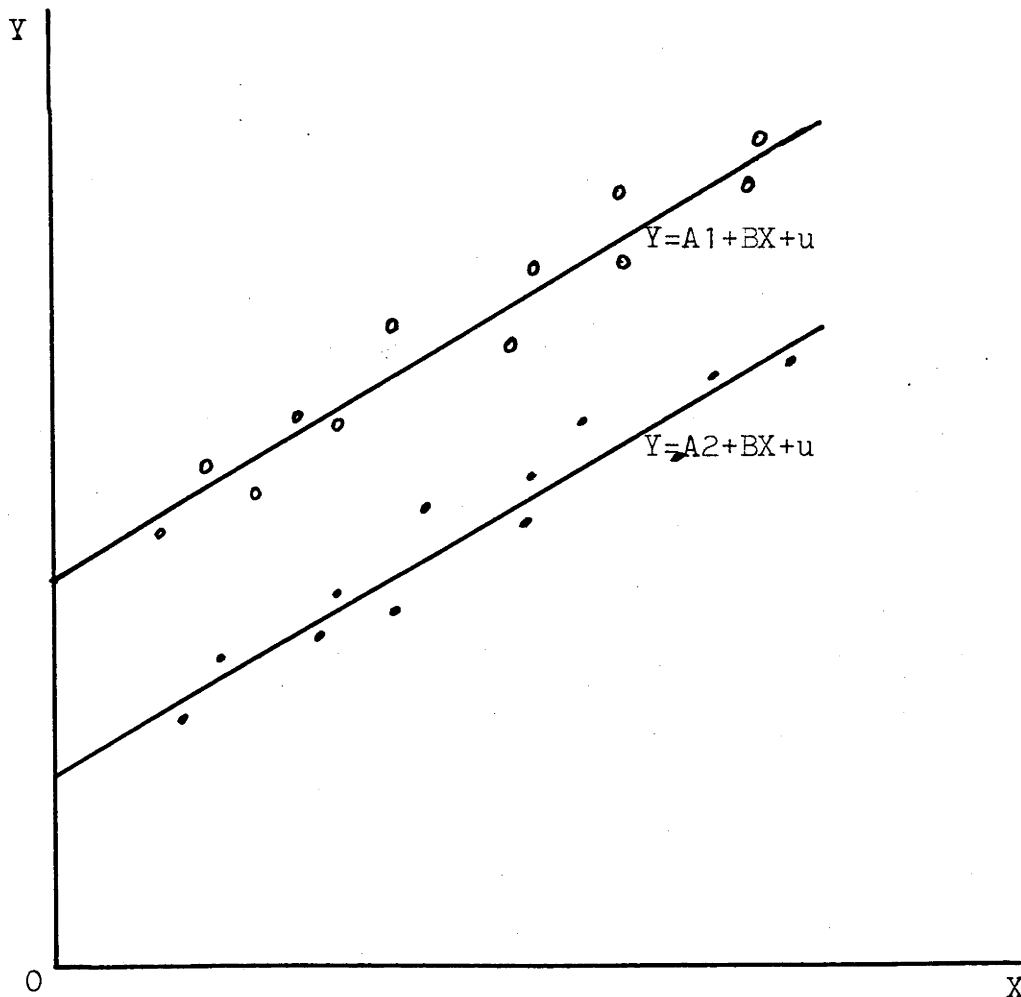
**FIG.4.1 HYPOTHETICAL REPRESENTATION OF THE SCATTER FOR THE TWO YEARS.**



**4.6.0. THE IMPLICATIONS OF A 'SHIFT' DUMMY VARIABLE.**

When the slopes of two regression equation lines obtained as relationships between the output Y and input X for a particular crop using different sets of observations, are roughly the same but possess different intercepts, as in the fig 4.2 below, then these equations could be combined into a single equation by employing an intercept (shift) dummy variable. Detailed exposition of the use of intercept dummy variables is found in Maddala (1977) pp.132-135.

**FIG.4.2 A DIAGRAMMATIC ILLUSTRATION OF TWO REGRESSION LINES WITH A COMMON SLOPE BUT DIFFERENT INTERCEPTS.**



In fig.4.2, the first equation is,  $Y = A_1 + BX + u$

and the second equation is,  $Y = A_2 + BX + u$ .

The combination would be,  $Y = A_1 + (A_2 - A_1)D + BX + u$ ,

where  $Y = \text{Output}$ ,

$A_1$  and  $A_2$  are intercepts,

$B$  = the coefficient of the slope,

$X$  = the explanatory variable,

$u$  = the stochastic error term,

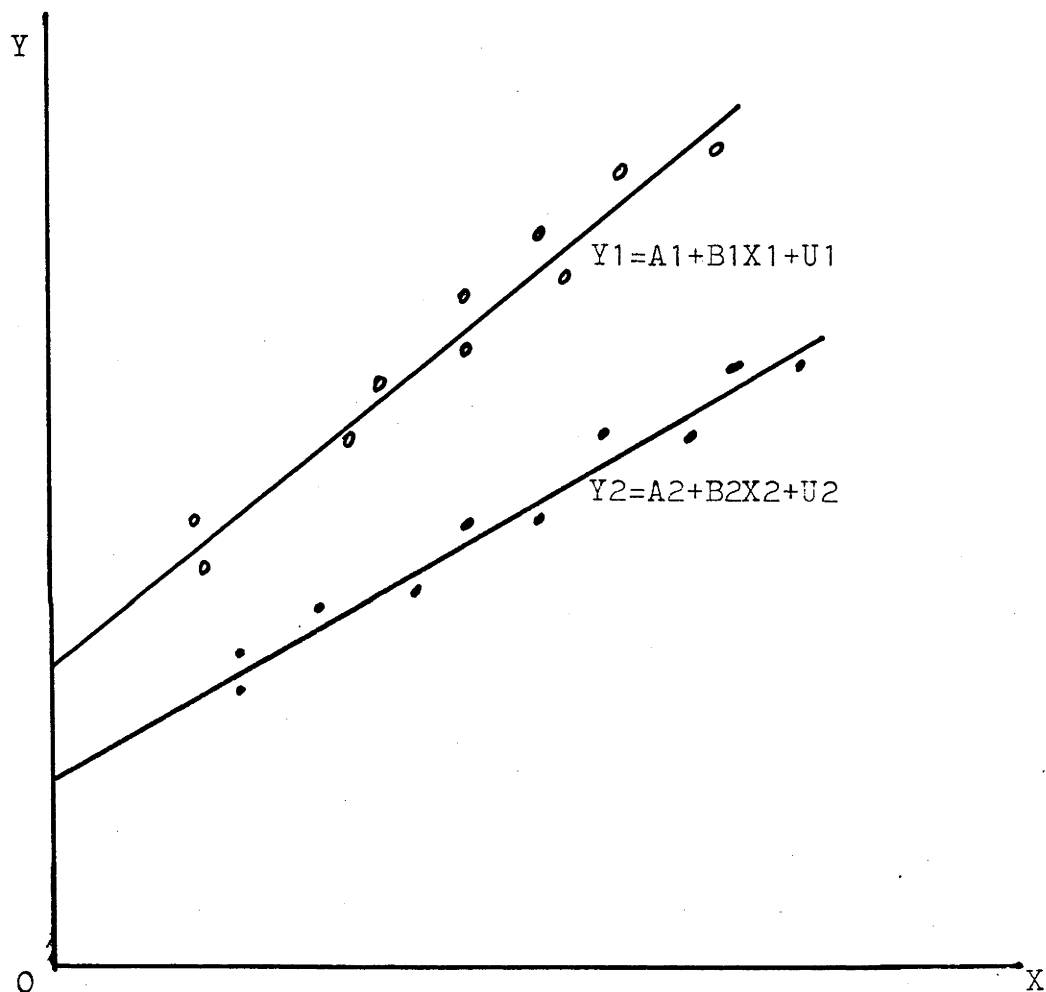
$D$  = the shift dummy (binary) variable and in this example takes the value of 0 for the observations associated with the first equation but takes the value of 1 for observations associated with the second equation.

The coefficient of the dummy variable measures the differences in the two intercept terms.

#### 4.7.0. THE IMPLICATIONS OF SLOPE DUMMY VARIABLES.

When two equations as in fig.4.3, below possess the same or different intercepts but have different slopes, dummy variables can also be used to allow for the differences in the slope coefficients (Maddala, 1977, pp.136-140).

**FIG.4.3 A DIAGRAMMATIC ILLUSTRATION OF TWO REGRESSION LINES WITH DIFFERENT SLOPES AND DIFFERENT INTERCEPTS.**



In fig.4.3, the first equation is,  $Y_1 = A_1 + B_1X_1 + U_1$ ,

and the second equation is,  $Y_2 = A_2 + B_2X_2 + U_2$ .

The two equations could be written together as,

$$Y = A_1 + (A_2 - A_1)D_1 + B_1X + (B_2 - B_1)D_2 + U.$$

where the subscripts 1 denote the fact that the attribute

is associated with the first equation. The subscript 2 denote the fact that the attribute is associated with the second equation, and where

Y = the regressand,

A = the intercept,

B = the coefficient of the slope,

X = the explanatory variable,

U = the stochastic error term,

D1 = the intercept dummy variable which takes the value of 0 for all observations associated with the first equation and takes the value of 1 for all observations associated with the second equation.

D2 = the slope dummy variable which takes the value of 0 for all observations associated with the first equation and takes the respective values of the observations for all the observations associated with the second equation.

The coefficient of the intercept dummy variable D1 measures the differences in the intercept terms while the coefficient of the slope dummy variable D2 measures the differences in the slopes. Apparent from the above is that the estimation of the combined equation amounts to estimating the two equations separately. If D2 is deleted from the combined equation, it would amount to allowing for different intercepts only and if D1 is deleted from the combined equation it would amount to allowing for different slopes only.

#### 4.8.0. THE EMPIRICAL DETERMINATION OF THE RELEVANCE OF THE INTERCEPT AND THE SLOPE DUMMY VARIABLES.

It was evident from the test for equality of two regression equations, that at 1% level of probability, the regression equations for the different years are not statistically different. However the same test carried out at 5% level of probability indicated that the regression equations for cassava and rice varied between the years. This observation is considered to be due to minor variations which could be filtered out through the application of shift and slope dummy variables for time.

It has been stated earlier in chapter two that this study is interested in the influence of racial differences on the production methodology of the various crops. Chandra (1983) pp. 43, stated, "...Fijians and Indians have marked differences in their farming systems." For these reasons race shift and slope dummy variables are introduced into the equations to extricate the variations attributable to differences in race (Indians and Fijians).

For each of the four crops under study, a Cobb-Douglas function was specified including time and race 'shift' dummy variables. The resultant regression equations revealed that neither the time nor the race 'shift' dummy variables were significant in the four crops. Consequently, the time and the race shift dummy variables were dropped.

This result in respect of race agreed well with the findings of Chandra (1979) p.48, that race was not a significant regressor wherefore he stated 'inter alia', "...no change occurred with the



introduction of the race dummy." However Chandra did not try the slope dummy variables.

Time and race slope dummy variables were incorporated into the equations by employing the technique of slope dummy variables as described in Maddala (1977) pp.136-140. The time and race dummy variables were applied with respect to land, labour, capital and current expenses in each of the four crops studied. A 'stepwise' regression procedure (White, 1982) was used to 'step-in' relevant regressors, one variable at a time at 5% level of probability.

The resultant regression equations indicated that:

for cassava, the time slope dummy variable for current expenses was relevant in explaining the changes in the output; for rice, the relevant time slope dummy variables were those of capital and labour; while for maize and watermelon, none of the time slope dummy variables was significant in explaining the changes in the outputs.

These results agreed well with the earlier conclusion that the equations for the different crops did not vary significantly over the two year period. The results also indicate that, on the individual crop basis, racial differences do not significantly influence the changes in the output of the crops (cassava, rice, maize and watermelon).

#### 4.9.0. THE ADOPTED FUNCTIONAL FORMS FOR THE CROPS.

Based on the theoretical knowledge of semi-subsistence agricultural production, and the fore mentioned empirical tests conducted, the equations selected for the crops under study are as follows;

The selected equation for cassava is,

$$\text{LnY} = \text{LnA} + \text{B1LnX1} + \text{B2LnX2} + \text{B3LnX3} + \text{B4LnX4} + \text{B6LnX6} + \text{B8LnX8}.$$

Although the time slope dummy variable for capital was not stepped-in in the 'stepwise' regression trial at 5% level of probability (section 4.8.0. above), it was found that the inclusion of the variable improved the statistical fitness of the regression equation. It is therefore included.

The selected equation for rice is,

$$\text{LnY} = \text{LnA} + \text{B1LnX1} + \text{B2LnX2} + \text{B3LnX3} + \text{B4LnX4} + \text{B5LnX5} + \text{B6LnX6} + \text{B7LnX7}.$$

The time slope dummy variable for land is included in the equation although it was not stepped-in during the 'stepwise' regression exercise at 5% level of significance (section 4.8.0. above). The inclusion is because the variable improved the statistical results of the regression equation.

The selected equation for maize is,

$$\text{LnY} = \text{LnA} + \text{B1LnX1} + \text{B2LnX2} + \text{B3LnX3} + \text{B4LnX4} + \text{B9LnX9}.$$

The race slope dummy variable for land is included in the selected form although it was not stepped-in in the 'stepwise' regression exercise (section 4.8.0. above). This is because the inclusion improved the statistical fitness of regression results.

The selected equation for watermelon is,

$$\text{LnY} = \text{LnA} + \text{B1LnX1} + \text{B2LnX2} + \text{B3LnX3} + \text{B4LnX4}.$$

In all the above equations,

Ln denotes logarithm,

Y = Output in Kilogrammes,

A = The intercept term,

$B_i(i=1,2,\dots,n)$  = The elasticities of output with respect to  
the associated inputs.

X1 = Area planted in hectares,

X2 = Labour applied in manhours,

X3 = Capital in dollars,

X4 = Current expenses in dollars,

X5 = The time slope dummy variable for land

X6 = The time slope dummy variable for capital,

X7 = The time slope dummy variable for labour,

X8 = The time slope dummy variable for current expenses.

X9 = The race slope dummy variable for land.

#### 4.10.0. LIMITATIONS OF THE PROCEDURES.

The preceding analysis and the subsequent ones assumed the existence of perfectly competitive market economic environment (Hirshleifer, 1980, pp.232-236). It is the closest approximation to the prevalent economic conditions in the semi-subsistence agriculture as in Sigatoka Valley. But being an approximation, it cannot be error-proof.

## CHAPTER 5

### RESULTS AND DISCUSSION.

#### 5.1.0. RESULTS OF THE EMPIRICAL STUDY.

It is evident from chapter 4 that for all the crops studied, the regression equations for the two cropping years (1970/71 and 1971/72) were not found statistically different at 1% level of significance (F-test). Consequently the data for the two years are pooled together. The minor differences observable in the regression equations of cassava and rice at 5% level of significance are filtered out by the slope dummy variables. Also for all the crops studied, racial differences are not found significant in explaining the variations in the output.

The functional forms chosen as most appropriate based on economic and statistical criteria (section 4.9.0.) were applied to estimate the average production functions for the sample data of the respective crops for the two cropping years (1970/71 and 1971/72) combined.

Some variables that were not found statistically significant at 5% level of significance but were found (when included) to improve the statistical fitness of the regression equations or are justified by the production theory of the respective crops are included in the estimation of the regression equations.

The 'best fit' of the estimated coefficients and the related statistics are summarised in the following tables. In table 5.1 the statistics for the 'best fit' equation for cassava are summarized.

TABLE 5.1 THE SUMMARY OF STATISTICS FOR THE SELECTED EQUATION FOR CASSAVA.

	OUTPUT IN KG.	INTERCEPT IN KG.	LAND IN HA.	LABOUR IN MAN HR	CAPITAL IN \$	CURRENT EXPENSE IN \$	PERIOD DUMMY F CAPITAL IN \$	PERIOD DUMMY FOR CURRENT EXP. IN \$
EST. COEFFS. IN LOG.		6.237	.5732	.4551	.0305	.0131	.1519	-.2060
STD. ERROR		.8353	.1632	.1263	.1061	.0836	.1064	.1073
T-RATIO		7.4666	3.5115	3.6038	.2875	.1569	1.428	-1.9197
ARITH. MEAN	4627.3		.5177	221.49	12.968	13.404		
STD DEVN	4183.3		.377	165.8	11.324	15.595		
GEOM. MEAN.	3171.310		.3844	165.2236	8.4714	8.2334	2.4998	2.4354
R =	.9163							
R sq. =	.9068							
F =	96.641							
STD. ERROR OF THE ESTIMATE =	.2829							

THE CORRELATION MATRIX OF THE COEFFICIENTS.

	INTERCEPT	LAND	LABOUR	CAPITAL	CURRENT TIME DUM. EXPENSES	CAPITAL TIME DUM. CUR. EXPENSES
INTERCEPT	1					
LAND	.92924	1				
LABOUR	-.93535	-.75893	1			
CAPITAL	-.38065	-.51442	.16841	1		
CURRENT EXPENSES	-.00814	-.08636	-.09659	-.53698	1	
TIME DUM. FOR CAPITAL	.11708	.0846	-.12118	-.60033	.7001	1
TIME DUM. FOR CUR. EXP.	-.09543	-.07394	.0896	.58095	-.70254	-.95452

In the above and in all other regressions in this study "A General Computer Program for Econometric Methods--SHAZAM" (White 1978) was used.

The regression coefficients are correctly signed. The coefficients of multiple determination are high and indicate that more than 90% of the variations in the output of cassava are explained by the included independent variables. The F-statistic is significant at 5% level of significance. The t-statistics for capital, current

expenses and the time slope dummy variable for capital are not significant at 5% level of probability. The inclusion of capital and current expenses in the equation are justified by the production economics theory. And the time dummy variable with respect to capital is included because it improved the statistical fitness of the regression equation.

The time dummy variables for capital and current expenses provided a weak evidence that the marginal productivity of capital increased while that of current expenses decreased in the second cropping year (Nov.1971-Oct.1972). These observations are explained by the drought that prevailed in that year. Consequently, the cassava farmers employed more inputs in the form of current expenses. The increased use of current expenses tended to substitute for the use of capital. Neither the race shift nor the race slope dummy variables were found important for explaining the variations in the output. In table 5.2 below the statistics for the 'best fit' equation for rice are summarised.

**TABLE 5.2 THE SUMMARY OF STATISTICS FOR THE SELECTED EQUATION FOR RICE .**

	OUTPUT IN KG.	INTERCEPT	LAND IN HA.	LABOUR IN MAN HRS.	CAPITAL IN \$	CURRENT EXPENSE IN \$	PERIOD DUMMY FOR LAND	PERIOD DUMMY F CAPITAL	PERIOD DUMMY FOR LABOUR
EST. COEF IN LOG.		3.7539	.23	.354	.3623	.0667	.1632	-.4527	.2118
STD. ERROR		.9352	.1881	.1408	.1316	.0726	.1556	.1614	.0889
T-RATIO		4.0142	1.2225	2.5135	2.7543	.9187	1.0488	-2.8045	2.3818
ARITH. MEAN	1085		.7784	297.48	20.991	28.594			
STD. DEVN	733.81		.4132	161.92	14.632	19.725			
GEOMETRIC MEAN	863.5916		.6513	250.7359	15.9507	21.1259	.744	3.1415	11.115
R =	.8033								
R sq. =	.7804								
F =	35.014								
STD. ERROR OF THE ESTIMATE =	.3319								

## THE CORRELATION MATRIX OF THE COEFFICIENTS.

	INTERCEPT	LAND	LABOUR	CAPITAL	CURR. EXPENSE	TIMEDUM FOR LAND	TIME DUM. FOR LAB	TIME DUM. FOR CAP.
INTERCEPT	1							
LAND	.79592	1						
LABOUR	-.86443	-.50479	1					
CAPITAL	-.40378	-.55283	-.02455	1				
CURR. EXPENSES	-.18409	-.33402	-.0433	-.08824	1			
TIME DUM. FOR LAND	.10161	-.37891	-.32742	.22435	.29407	1		
TIME DUM. FOR LAB.	-.14252	-.38162	-.25338	.66845	.23329	.61806	1	
TIME DUM. FOR CAP.	.14226	.37176	.25699	.67894	-.25399	-.56334	-.98102	1

The regression coefficients are correctly signed. More than 78% of the variations in output is explained by the independent variables. The F-ratio is significant at 5% level of probability. Except for land and current expenses, the t-statistics for all the independent variables are statistically significant at 5% level of probability. However land and current expenses are included in the estimation because the production theory of rice justified their inclusion. Also including them in the estimation improved the statistical fitness of the regression equation. The nonsignificance of land is attributable to the fact that there is not much variation in the size of the rice fields cultivated by different farmers in the area. The nonsignificance of current expenses reflects the limited application of cash expenditures and hired

labour (which is the major component of current expenses) in the semi-subsistence cultivation of rice in the Sigatoka Valley of Fiji.

The time dummy variables for land and labour indicated increases in the marginal productivities of land and labour while that of capital indicated a decrease in the marginal productivity of capital, in the second cropping year (Nov.1971-Oct.1972). This is not unexpected mindful of the fact that rice cultivation is a capital intensive enterprise; and with the drought that prevailed in the second cropping year, the rice farmers increased the use of capital items. The latter substituted for land and current expenses.

The race dummy variables were not found relevant in explaining the variations in the output. This observation is not unexpected since rice is predominantly cultivated by the Indians. Out of the 69 observations made for rice in the two cropping years, only 4 cases are Fijians (which is relatively too small to manifest any racial variations) while the rest are Indians.

In table 5.3 below, the statistics for the 'best fit' equation for maize are summarized.



TABLE 5.3 THE SUMMARY OF STATISTICS FOR THE SELECTED EQUATION FOR MAIZE.

	OUTPUT IN KG.	INTERCEPT IN KG.	LAND IN HA.	LABOUR IN MANHRS.	CAPITAL IN \$	CURRENT EXPENSE IN \$	RACE DUMMY FOR LAND IN HA.
EST. COEFFS. IN LOG.		4.8102	.4763	.2982	.1914	-.0314	-.1504
STD. ERROR		1.0153	.2647	.1421	.149	.0958	.1419
T-RATIO		4.7376	1.7995	2.0984	1.2847	-.3281	-1.059
ARITH. MEAN	842.64		.6206	225.96	16.777	22.584	
STD DEVN	630.76		.4123	178.34	12.869	21.722	
GEOM. MEAN	646.194		.4817	169.22	11.946	14.4935	.5565
R =	.6544						
R sq. =	.6278						
F =	24.612						
STD. ERROR OF THE ESTIMATE =	.465						

THE CORRELATION MATRIX OF THE COEFFICIENTS.

	INTERCEPT	LAND	LABOUR	CAPITAL	CURRENT EXPENSES	RACE DUM. FOR LAND
INTERCEPT	1					
LAND	.84494	1				
LABOUR	-.87827	-.61531	1			
CAPITAL	-.38908	-.40475	.02241	1		
CURR. EXPENSES	-.31326	-.44132	.18766	-.32897	1	
RACE DUM. FOR LAND	-.18548	-.56116	.1531	-.18281	.46438	1

All the regression coefficients but that of current expenses are correctly signed. The coefficients of multiple determination indicate that at least 62% of the variations in the output is explained by the independent variables. The F-ratio is high and significant at 5% level of significance.

The t-statistics for capital, current expenses and race dummy with respect to land are not significant at 5% level of probability. The inclusion of capital and current expenses are justified by the production theory of maize as well as the observation that including them improved the statistical fitness of the regression equation. The inclusion of race dummy for land was found to improve the regression results. It indicated that the marginal productivity of land for the Fijians was higher than that of the Indians. This observation simply reflects the fact that the size of the Fijian farms are smaller relative to those of the Indians (section 3.2.2.). And since the race dummy variable is statistically non-significant in the equation (t-ratios above) it does not deserve further rigorous interpretation.

None of the time dummy variables was found statistically important for explaining the variations in the output.

In table 5.4 below, the statistics for the 'best fit' equation for watermelon are summarized.

TABLE 5.4 THE SUMMARY OF STATISTICS FOR THE SELECTED EQUATION FOR WATERMELON.

	OUTPUT IN KG.	INTERCEPT IN KG.	LAND IN HA.	LABOUR IN MAN HRS.	CAPITAL IN \$	CURRENT EXPENSES IN \$
EST. COEFFS. IN LOG.		6.9561	.529	.0133	.6298	-.1194
STD. ERROR		1.5932	.332	.2659	.1897	.1326
T-RATIO		4.366	1.5932	.05	3.3207	-.9005
ARITH. MEAN	2635.6		.4361	79.548	10.613	15.339
STD DEVN	2570		.383	64.104	8.0463	15.924
GEOM. MEAN	1598.467		.3092	59.2046	7.3353	9.4074
R =	.7525					
R sq. =	.7349					
F =	42.577					
STD. ERROR OF THE ESTIMATE		=	.583			

## THE CORRELATION MATRIX OF THE COEFFICIENTS.

	INTERCEPT	LAND	LABOUR	CAPITAL	CURRENT EXPENSES
INTERCEPT	1				
LAND	.95718	1			
LABOUR	-.92424	-.79632	1		
CAPITAL	-.35802	-.48764	.09959	1	
CURRENT EXPENSES	-.26455	-.29278	.1332	-.3554	1

All the estimated elasticities except that for current expenses are correctly signed. The negative sign of current expenses could be explained by the fact that watermelon is a cover crop. The habit is such that the application of much labour, which is a major

component of current expenditure, after the shoots have established, tends to cause damages to the crop. Also Massel and Johnson (1968) suggested that unexpected signs of estimated elasticities could be attributed to imperfect measure of the inputs involved.

The coefficients of multiple determination are high and indicate that more than 73% of the variations in the output of watermelon are explained by the included independent variables. The F-ratio is high and significant at 5 percent level of probability. The t-statistics for land and capital are significant while those of labour and current expenses are not.

The non-significance of labour and current expenses is attributable to the fact that in semi-subsistence cultivation of watermelon in the Sigatoka Valley of Fiji, limited application of these inputs is made after the shoots have established.

Neither the race dummies nor the time dummies are found relevant in explaining the variations in the output of the crop.

#### 5.2.0. RETURNS TO SCALE.

Returns to scale expresses the direction of change in the total output when all the inputs are increased simultaneously by the same proportion. It could be used as an index to measure the incentive for expansion of a firm as well as distribution of income among the factors of production.

Increasing returns to scale, for example, imply that when all the inputs are increased by a certain proportion, the output would increase by a higher proportion. There would therefore be a strong motivation to increase the size of the firm. Constant returns to scale on the other hand imply that the output is exhausted in

payment to the factors of production.

In the Cobb-Douglas production;

(1) Returns to scale is estimated as the sum of elasticities of all the inputs involved in the production function and does not depend on the level of inputs at the point under examination;

(2) The estimated coefficients equal the elasticities of production for the respective inputs, consequently there exists unchanging elasticities of production over the whole production surface;

(3) With a decreasing, constant or increasing returns to scale, the sum of the elasticities of the production is less than, equal to or greater than unity, respectively.

In a semi-subsistence agriculture as practised in Sigatoka Valley of Fiji, there are no significant indivisibilities that would provide a basis for "a priori" expectation of increasing returns to scale. Constant returns to scale is therefore proposed. This proposal is tested with a two-tailed t-test at 5% level of significance. The procedure is fully detailed in Kmenta (1971).

The null hypothesis that the elasticities sum to unity is tested against the alternative hypothesis that they do not, for each crop studied.

That is;

$$H_0: \sum B_i - 1 = 0,$$

$$H_a: \sum B_i - 1 \neq 0,$$

$$t = \frac{\sum B_i - 1}{\text{std. error of the sum of the coefficients.}}$$

where  $B_i$  = estimated elasticity for the  $i$ th input.

$i = 1, 2, \dots, k,$

$k$  = the number of the explanatory variables.

In table 5.5 below, is presented the sum of; the estimated coefficients, the variance, the covariance of the coefficients; and the estimated and the tabulated values of t-statistic for the crops studied.

**TABLE 5.5 THE SUM OF; COEFFICIENTS, VARIANCE, AND COVARIANCE OF THE COEFFICIENTS; THE ESTIMATED AND TABULATED T-VALUES FOR THE DIFFERENT CROPS.**

CROPS	SUM OF THE COEFFS.OF	SUM OF THE VARIANCE OF	SUM OF THE COV.	ESTIMATED T-STAT.	TABULATED T-STAT.
CASSAVA	1.01773	0.083673	-0.081262	0.36071	2.0086
RICE	0.935234	0.135969	-0.127759	-0.71473	2.0003
MAIZE	0.783984	0.141743	-0.134999	-2.630	1.9974
WATERMELON	1.052703	0.23443	-0.22622	0.581553	2.0045

From table 5.5, it is evident that cassava, rice and watermelon are associated with constant returns to scale while in the cultivation of maize, diminishing returns to scale prevails.

### 5.3.0. MARGINAL PRODUCTS.

The marginal product of an input indicates the expected increase in the output due to the use of an additional unit of the input given that the level of the other inputs remains unchanged. It therefore

depends on the level of the input already used and the levels of the other inputs applied.

For the Cobb-Douglas production function, the marginal productivities of the various inputs are obtained from the estimated elasticities as follows;

$$MPX_i = E_{X_i} \times \frac{\bar{Y}_i}{\bar{X}_i}$$

where  $MPX_i$  = The marginal product of the input  $X_i$ ,

$E_{X_i}$  = The elasticity of the input  $X_i$ ,

$\bar{Y}_i$  = The geometric mean of the output of the crop  $i$ ,

$\bar{X}_i$  = The geometric mean of the input  $x_i$  used in producing the crop  $i$ .

In this study, the marginal products of the inputs are estimated as at the geometric mean of the outputs and the inputs, consequently they relate to the average farm. Heady and Dillon (1961) p.571, wrote, "the most accurate estimate of the marginal product from Cobb-Douglas functions is obtained with all the inputs held at their geometric mean level".

The estimates of the marginal products for the inputs applied in the different crops are presented in table 5.6 below.

#### 5.4.0. THE STANDARD ERROR OF THE MARGINAL PRODUCTS.

The standard error of the marginal product is a measure of the dispersion of the estimate (marginal product) about the mean level and it is obtained as the square root of the variance of the marginal product.

Carter and Hartley (1958) have shown that the variance of the marginal productivity estimated from a Cobb-Douglas function is calculated as follows;

$$\text{Var}(MP_i) = \left[ \frac{Y_i}{X_i} \right]^2 \times \left[ \text{var.} B_i + S_i^2 \times \frac{B_i^2}{n} \right],$$

where  $MP_i$  = the marginal product of the  $i$ th input,

$\bar{Y}_i$  = the geometric mean level of the output,

$\bar{X}_i$  = the geometric mean level of the  $i$ th input,

$B_i$  = the estimated elasticity coefficient of the  $i$ th input,

$S_i^2$  = the unexplained variance in  $\log(Y_i)$ ,

$n$  = the number of observations.

The estimated variances and standard errors for the marginal products are also tabulated in table 5.6 below.

**TABLE 5.6 THE CALCULATED MARGINAL PRODUCTS, THEIR VARIANCES AND STD.ERRORS**

	CASSAVA	RICE	MAIZE	WATERMELON
MPP.FOR LAND IN 1970/71.	4728.915	304.9686		2734.763
VARIANCE.	9519864.	122021.5		47368932
STD. ERROR.	2918.831	349.3157		6882.509
MPP. FOR LAND IN 1971/72.		521.3638		
VARIANCE.		217356.7		
STD. ERROR.		466.2153		
MPP. FOR LAND (FIJIANS).			638.95	
VARIANCE.			1263408.	
STD. ERROR.			1124.014	
MPP. FOR LAND (INDIANS).			437.19	
VARIANCE.			568720.4	
STD. ERROR.			754.1355	
MPP. FOR LABOUR 1970/71.	8.7352	1.2193	1.1387	.3591
VARIANCE.	28.7572	1.1911	3.9068	52.2879
STD. ERROR.	5.3626	1.0914	1.9766	7.23104
MPP. FOR LABOUR 1971/72.		1.9487		
VARIANCE.		2.5355		
STD. ERROR.		1.59234		
MPP. FOR CAPITAL 1970/71	11.4178	19.6154	10.3534	137.2424
VARIANCE.	1617.087	289.1057	363.5525	113588.1
STD. ERROR.	40.213	17.26574	19.0671	337.0284
MPP. FOR CAPITAL 1971/72.	68.2823	-4.8944		
VARIANCE.	2556.043	93.521		
STD. ERROR.	5.05573	9.67063		
MPP. FOR CUR. EXP. 1970/71.	5.0458	2.7266	-1.3999	-20.2879
VARIANCE.	1044.379	13.59479	23.69443	2952.41
STD. ERROR.	32.3168	3.6871	4.8677	54.336
MPP. FOR CUR. EXP. 1971/72.	-74.3			
VARIANCE.	3364.548			
STD. ERROR.	58.0047			



### 5.5.0. RATIONALITY IN THE USE OF INPUTS.

Rational input usage requires that the values of the marginal products of the respective inputs equate their opportunity costs (farm gate prices), ie;  $MVP_{Xi} = PX_i$ ,

where  $MVP_{Xi}$  = the marginal value product of the input  $X_i$ ,

$PX_i$  = the opportunity cost (farm gate price) of the input  $X_i$ .

In this study, the equality is tested by applying a two tailed t-test at 5% level of probability. The null hypothesis that there is no difference between the marginal value products and the respective prices of the inputs is tested against the alternative that the null hypothesis is not true, that is;

$$H_0: MVP_{Xi} - PX_i = 0$$

$$H_a: MVP_{Xi} - PX_i \neq 0$$

$$t = \frac{MVP_{Xi} - PX_i}{\text{Std Error of the MVP}}$$

The farm gate prices of the various crops and the inputs are obtained from Chandra (1979). The author collected the existing farm gate prices for several crops and inputs in Sigatoka Valley of Fiji during the farm management survey conducted from 1970 to 1972. The details of the collection and collation of prices were published in the above paper. The extracted summary is presented in table 5.7 below.

**TABLE 5.7, TABULATED EXTRACT OF THE AVERAGE FARM GATE PRICES FOR THE CROPS AND THE INPUTS FOR THE PERIOD 1970-1972.**

ITEM	AVERAGE PRICE	UNIT
CASSAVA	0.055	\$/KG.
RICE (PADDY)	0.1848	\$/KG.
MAIZE (GRAIN)	0.097	\$/KG.
WATERMELON	0.055	\$/KG.
LAND (RENTAL AVERAGE)	19.10	\$/Ha./YR.
LABOUR (HIRING RATE)	0.187	\$/Manhour
CAPITAL	0.12	per dollar
CURRENT EXPENSES	0.12	per dollar

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Extracted from Chandra (1979), Productive Efficiency of Fijian and Indian Farming Systems in Semi-subsistence Agriculture: Sigatoka Valley, Fiji.

Presented in table 5.8 below are the marginal value products of the inputs, the price of the inputs, the standard errors of the marginal value products, the calculated and the tabulated t-statistics for the various crops.

**TABLE 5.8 THE MARGINAL VALUE PRODUCTS OF THE INPUTS, INPUT PRICES, THE STANDARD ERRORS OF THE MARGINAL VALUE PRODUCTS, CALCULATED AND THE TABULATED T-STATISTICS FOR THE CROPS.**

CROP	MVP.OF LAND	PRICE OF LAND	S.E.OF MVP.	CAL.T-STAT.	TAB.T-STA.
CASSAVA	260.0903	19.1	160.5384	1.5011	2.0086
RICE (1970/71)	56.3582	19.1	64.5536	0.5772	2.0003
RICE (1971/72)	96.3480	19.1	56.3038	1.3720	2.0003
MAIZE (FIJIANS)	61.9732	19.1	109.0294	0.3933	1.9974
MAIZE (INDIANS)	42.4074	19.1	76.3108	0.3054	1.9974
WATERMELON	150.4120	19.1	378.538	0.3469	2.0045
	MVP.OF LAB.	PRICE OF LAB.			
CASSAVA	0.4804	0.187	0.2949	0.9949	2.0086
RICE (1970/71)	0.2253	0.187	0.2017	0.1899	2.0003
RICE (1971/72)	0.3601	0.187	0.0866	0.5882	2.0003
MAIZE	0.1105	0.187	0.1917	-0.3991	1.9974
WATERMELON	0.0198	0.187	0.3977	-0.4204	2.0045
	MVP.OF CAP.	PRICE OF CAP.			
CASS.(1970/71)	0.6280	0.12	2.2117	0.2297	2.0086
CASS.(1971/72)	3.7555	0.12	2.5999	1.3983	2.0086
RICE (1970/71)	3.6249	0.12	3.1422	1.1154	2.0003
RICE (1971/72)	-0.9045	0.12	1.4066	-0.7284	2.0003
MAIZE	1.0043	0.12	1.8495	0.4781	1.9974
WATERMELON	7.5483	0.12	18.5366	0.4007	2.0045
	MVP.OF CUR.	PRICE OF CUR.			
	EXPENSES	EXPENSES			
CASS.(1970/71)	0.2775	0.12	1.7774	0.0886	2.0086
CASS.(1971/72)	-4.0865	0.12	2.7668	-1.5204	2.0086
RICE	0.5039	0.12	0.6814	0.5634	2.0003
MAIZE	-0.1358	0.12	0.4722	-0.5417	1.9974
WATERMELON	-1.1158	0.12	2.9885	-0.4135	2.0045

From table 5.8 above, it is evident that in all the crops studied, the marginal value product of the inputs are not statistically different from the respective input prices. This implies that the semi-subsistence farmers of the Sigatoka Valley of Fiji are not 'on the average' irrational in allocating inputs in the cultivation of the various crops.

The above results and the implications cannot be presented without some cautionary qualifications, considering the unexpectedly high values of the standard errors of the estimated marginal value product. Unfortunately the high standard errors are inherent and unavoidable in a data set of this nature. Visual inspection of the results indicate that the marginal value products are higher than the associated factor prices especially with the subsistence crops cassava and rice. This observation is not statistically evident due to the masking (bias) effect associated with the high standard errors of the estimated marginal value products.

If the statistical evidence of marginal value product equalization (MVPE) above is accepted, irrespective of the magnitudes of the standard errors of the estimates, then the semi-subsistence farmers in the Sigatoka Valley of Fiji, could 'on the average' be described as neo-classical perfect competition optimizers (NCPC) and consequently their objective function would be profit maximization (Lipton 1968). The latter is, however, difficult to assert considering the risky and uncertain environment surrounding the semi-subsistence farmers, coupled with the market imperfections, the rigid land tenure system and the restrictions in the mobility of some resources in Fiji.

The rationality of the semi-subsistence farmers could be accepted to the extent that the marginal value products of the factors are never less than the respective factor prices, such that the objective function of the farmers would be regarded as utility maximization.

The salient inferences from the above results and discussions are that the semi-subsistence farmers in the Sigatoka Valley of Fiji respond positively to commercial possibilities reflected in the market prices and they are allocatively efficient in resource utilization. Consequently, their farm output cannot be significantly improved by mere reshuffling of resources from one use to another. Significant improvement in the output requires changes in the techniques of the production of the various crops.

The high standard errors of the estimates also, reinforce the fact that the conclusions emerging from this study are strictly 'on the average' conclusions. It suggests that probably the farmers are trying to be rational but are not equally successful, ie. real differences in technical efficiency attributable to the presence or absence of additional resources. In lieu of the latter observations, it would be suggested that further studies of the semi-subsistence farmers of the Sigatoka Valley may be directed to a 'frontier production function analysis' (Muller 1974), so as to discriminate between the farmers whose efficiency is above 'the average' from those below 'the average'.

The fact that the marginal value products are consistently greater than the price of the respective inputs provides a base for recommending increased use of inputs by the semi-subsistence farmers of the Sigatoka Valley.

**5.6.0. THE SCOPE AND LIMITATIONS OF THE STUDY.**

This study employed data collected between 1970 and 1972. There isn't a sufficient reason to believe that there hasn't been any intertemporal changes in farm operations and the techniques of cultivating the various crops. The conditions that prevailed then may be different from those prevailing currently.

Discrepancies in the data and the methodology of the study may have introduced bias in the results and the inferences derived from the study.

Perfectly competitive market situation was assumed to prevail all through the study. This assumption is based on the existence of innumerable buyers and sellers and the relatively free entrance and exit prevalent in the semi-subsistence agriculture in the Sigatoka Valley of Fiji. Given the imperfections in knowledge, inadequate communication systems, risky and uncertain weather conditions, etc. surrounding the semi-subsistence farmers in Fiji, a perfectly competitive market is merely the closest approximation of the economic environment.

Hence, one has to exercise caution in the interpretation of the results and be judicious and careful in the application of the conclusions derived from this study.

## CHAPTER 6

### SUMMARY AND CONCLUSIONS

In this chapter, the summary of the study, the conclusions and the policy guidelines apparent from the study are presented.

#### 6.1.0. SUMMARY OF THE STUDY.

Amongst other factors, the semi-subsistence nature of agriculture contributes to the low agricultural productivity in Fiji. The latter factor leads to a wide gap between the domestic food requirements and the domestic food production. The import of import replaceable foods (a short run measure employed to bridge the food demand gap) has grown in time while the local food production has remained stagnant. Food imports are attended by a diversity of macro-economic problems which have also tended to inhibit the policies designed to promote the domestic food production.

The literature review of agriculture in Fiji indicated that a study of rationality in resource allocation in semi-subsistence agriculture has not been carried out in the study area. Similar studies elsewhere indicated that semi-subsistence farmers are rational and are allocatively efficient subject to their surrounding economic environment. In terms of efficiency, the existing literature in Fiji indicated that there was little difference in the technical efficiency between the Fijian and the Indian farming systems in the Sigatoka Valley. However the

Fijians tended to be slightly more efficient and the most important factor that could lead to increased productivity on the Fijian farms was labour whereas on the Indian farms it was land and capital.

The study employed the production function approach to data collected over two cropping years (Nov.1970 to Oct.1972). On the basis of conformity to the tenets of economic theory, statistical fitness and computational manageability, the Cobb-Douglas production function was found to produce the 'best fit' equation (expression of the input-output relationship) for the crops studied. The relevant explanatory variables for the changes in the output of the respective crops included land, labour, capital and current expenses.

The responsiveness of the semi-subsistence farmers to prices in the Sigatoka Valley of Fiji was studied by verifying whether the semi-subsistence farmers are rational in the sense of equating the marginal value products of their inputs with the opportunity costs (farm gate prices) of the respective inputs.

The existence of racial differences and the stability over a short period in time, of the techniques of production of the major subsistence and cash crops (cassava, rice, maize and watermelon) in the Sigatoka Valley of Fiji, were verified.

#### **6.2.0. CONCLUSIONS FROM THE STUDY.**

From this exploratory study it is concluded that;

(1) There was no significant change (1% level of probability), in the techniques of producing the respective crops during the two



cropping years of the study and there were no significant variations attributable to race in the techniques of producing the respective crops. In other words, in the Sigatoka Valley of Fiji, there exists stable techniques for producing the various crops, and the different farmers conform to the techniques irrespective of their racial origin.

(2) The techniques of cultivation of cassava, rice and watermelon in the Sigatoka Valley, are associated with constant returns to scale while the technique for the cultivation of maize is associated with diminishing returns to scale. Hence for cassava, rice and watermelon the techniques of production are such that the outputs are just sufficient to pay the factors of production while for maize the production technique is such that equi-proportionate increases in all the factors, would result in less than proportionate increase in the output.

(3) The semi-subsistence farmers of the Sigatoka Valley of Fiji are rational in their resource allocation in the cultivation of the various crops.

#### 6.3.0. POLICY GUIDELINES DEDUCED FROM THE STUDY.

(1) The production techniques of the studied subsistence and cash crops in Fiji should not be expected to change significantly in a period of less than two cropping years. Consequently, the formulation and execution of agricultural development policies in the Valley could be spread over a number of production years.

(2) There need not be any differentiation in formulating policies related to the production technology of the subsistence and cash crops based on the racial origin of the individual farmers.

(3) Since it is evident from this study that the semi-subsistence farmers in the Sigatoka Valley of Fiji are 'on the average' rational in their resource allocation in the cultivation of the various crops, then increases in the average output would be achieved by an outwards push of the 'average' production possibility curve (involving changes in the techniques of production) and/or the price line. The following suggestions are possible ways of doing so, however they necessitate further studies (not concerned with in this study) to evaluate their costs and benefits and to determine the practicable administration procedures.

(i) The introduction of improved implements and other inputs associated with indivisibilities is necessary to generate increasing returns in the production process. The latter would strongly motivate the semi-subsistence farmers to expand their productive capacity.

(ii) Adequate and timely provision of agricultural inputs is necessary to encourage the expansion in the scale of the farm operations.

(iii) Increased and stabilized prices of agricultural products are possible incentives that could generate increased output as they directly improve the agricultural incomes.

(iv) Finally, complementary to the provision of the above price incentives, is the provision of adequate information on the available markets and the prevalent prices. These would have to be allied to the establishment of a good communication network, as well as commodity and input markets, in Fiji.

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