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FACTORS AFFECTING COCOA PRODUCTIVITY AMONG THE SMALLHOLDERS IN WEST MALAYSIA

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ABSTRACT

FACTORS AFFECTING COCOA PRODUCTIVITY AMONG THE SMALLHOLDERS IN WEST MALAYSIA.

The principal objectives of this study are to identify the production factors that influence cocoa productivity at the smallholder's level and to examine resource allocation and technical efficiency in cocoa production.

Cross-sectional data collected from 260 cocoa smallholders were used for the study. Both the average production function estimated by the Ordinary Least Squares techniques and the frontier production function estimated by the Linear Programming methodology were employed in the analysis.

The results indicated that the input factors which had a significant impact on the production of cocoa were land size, labour, living capital, farm implements and fertilisers. Among the management proxies, only farmer's age, extension contact, farmer's education and the practice of keeping farm records and accounts were important.

The data presented in this study lend support to the hypothesis that the cocoa smallholders were highly inefficient allocatively. Inputs comprising land, fertilisers, and farm implements were underused while labour and living capital were overused

Technical inefficiencies were also present in the study area. The study revealed that a large proportion of the farmers have output levels below their potential. Output could be increased between 18 to 52 per cent if all the least efficient farmers attained those levels of technical efficiency that were achieved by the best farmers in the sample.

The variations in technical efficiency in this area were explained by differences in land size, farmer's educational level, their age and the practice of keeping farm records and accounts.

This study emphasises the need that increasing efforts must be directed at the least efficient farmers through better and effective management practices and better organization of farm activity without major new investments, at least in the short-run.

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CHAPTER ONE

INTRODUCTION

1.1. STATEMENT OF THE PROBLEM

The interrelationship and complementarity of the agricultural sector and the non-agricultural sectors of an economy has long been recognised by economists. Many writers still assign agriculture a prominent place in the development process of a country and regard agriculture as a 'powerful engine of growth' (Schultz,1964). Johnston and Mellor (1961) also stressed the importance of agriculture as a motivating force in economic growth. They argued that, far from playing a passive role in development, agriculture could make four important contributions to the structural transformation of the economies of the less developing countries. These can be summarised in the following propositions: 1) by supplying foodstuffs and raw materials to other expanding sectors in the economy; 2) by expanding the exports of agricultural commodities as a means of increasing income and foreign exchange earnings; 3) by releasing the labour force for manufacturing and other expanding sectors of the economy; and 4) by increasing the net cash incomes of the farm population as a stimulus to industrial expansion.

The role of the agricultural sector is in fact of such key importance in the early stages of development that without it, nothing can be done or initiated. Excepting countries which can hope for large earnings from petroleum or mineral exports, the only source of investment for almost all less developed countries is agriculture. And the importance of this source of capital remains so long as the industrial sector remains small (Lecaillon *et al*, 1987).

In Malaysia, agriculture plays an important role in overall economic development through its contribution to the Gross Domestic Product, employment and foreign exchange earnings. The average growth rate of this sector was 4.2 per cent for the period 1975-1980; declined to 3.4 per cent for the period 1981-1985 and is expected to drop further to 2.6 per cent for the period 1986-1990. The decrease is attributed mainly to low commodity prices and the continued recession in the world economy. As a consequence its contribution to the Gross Domestic Product dropped from 22.8 per cent in 1980 to 20.3 per cent in 1985 (Fifth Malaysia Plan, 1986).

In terms of employment this sector employed 1,953 million people or 35.7 per cent of the total work force in 1985 compared with 39.7 per cent in 1980. Export earnings from the major agricultural commodities (rubber, palm oil, sawn log and timber, cocoa and pepper) accounted for 29 per cent of the value of total Malaysian exports of goods in 1985 as compared with 39.8 per cent in 1980. (Fifth Malaysia Plan, 1986). The overall performance of the sector in recent years was largely attributed to the strong sustained increase in the production of palm oil and cocoa as well as that of sawn logs during the early 1980's (see Appendices 1 through 2).

According to Nicholls, (1964) agriculture, especially the agriculture of less developed countries, can be turned into a potential engine of growth through agricultural surplus. The latter is defined as the amount by which agricultural production exceeds comsumption. One of the approaches that can be adopted to the development of agricultural surplus is through an increase in agricultural productivity. It has been revealed that the increase in agricultural productivity brought about by increased efficiency in production within the agricultural sector has in fact set the pace for economic development of most of the developed countries (Hayami and Yamada, 1970).

However, one of the problems faced by most of the less developed countries in their effort to produce agricultural surplus is that agricultural productivity, measured either in terms of output per worker or output per hectare, is relatively low in these countries (Lecaillon *et al*, 1987). In the case of rice (paddy), for instance, it was noted that the yield in Indonesia was 2608kg. per hectare compared to 4008kg per hectare for USA. As for wheat it was 1410kg in India and 2039kg. in USA (Agrawal, 1981). The problem is further aggravated by the rapid growth in the rural population which exerts a great pressure on the existing resources. In Asia, for example, too many people are crowded on too little land. Where expansion in the cultivated area is not feasible because of physical, technical, social, economic or institutional reasons, fragmentation of land already under cultivation takes place. As the holdings further decrease in size, production falls below subsistence level and poverty becomes a way of life. The problem of low agricultural productivity in these countries presents a major challenge to domestic policy makers and the international community alike.

In these countries, because the majority of the poor live in the rural areas and because food prices are a major determinant of the real income of both the rural and urban poor, the low productivity of agriculture was seen as a major cause of poverty (World Development Report, 1982).

These grim scenarios which are found in the less developed countries are also present in the context of

Malaysian agriculture. In this country the agricultural sector is characterised by the existence of non-commercial, commercial, small and large-scale production units. The non-commercial units grow crops mainly for domestic consumption while the commercial production units produce commodities such as rubber, oil palm, cocoa, pepper and coconuts which are meant for export.

Small-scale units of less than 40 hectares are considered as smallholdings, while those larger than the above size are referred to as estates. The average size of the smallholdings is approximately two hectares, while that of the estates is 550 hectares. The smallholdings mainly use family labour, traditional methods of cultivation and are more labour-intensive. This is in contrast with the estates which mainly employ hired labour, modern technology and are capital intensive (Zulkifli,1988).

The smallholdings can be further sub-divided into two distinct groups namely: 1) the independent and 2) organised smallholdings. The former are owned by individuals or families. On the other hand, the organised smallholdings are those in the land development schemes such as the Federal Land Development Authority (FELDA) and Federal Land Consolidation Authority (FELCRA) which are run by the government and handed over to the smallholders with specific conditions.

There is however, a sharp disparity in the levels of efficiency, productivity, competitiveness and hence income between the well-organised estate sub-sector and the unorganised individually farmed smallholders who are mostly living in poverty[1]. In 1984 there were 67,300 rubber smallholders out of a total of 155,200 living in poverty. In terms of percentage this constitutes about 43.4 per cent. The situation is even worst for paddy farmers and the coconut smallholders where the poverty rates were 57.7 and 46.9 per cents, respectively. (Fifth Malaysia Plan, 1986). Some of the reasons for this phenomenon are the small size of the holdings, traditional methods of cultivation, bad management practices, an ageing rural labour force and inadequate access to support services.

As far as the question of agricultural productivity is concerned, one of the crucial problems facing the government now is the problem of low cocoa productivity at

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1. In Malaysia, poverty is defined as the lack of income needed to acquire the minimum necessities of life. A monthly income of M$ 350 is used to demarcate between the poor and the non-poor groups. The poverty line drawn is based on the minimum food basket required to maintain a family in good nutritional health plus a figure for minimum conventional needs (Economic Planning Unit, 1978).

the smallholder level. This crop which is the third major export crop in the country, occupies an area of 258,000 hectares in 1985 (Fifth Malaysia Plan, 1986). In Peninsula Malaysia about 41 per cent of the area planted with cocoa is under estates, 47 per cent under smallholdings and the rest is under Government experimental stations. The situation is different in Sabah where 67 per cent is under estate and the remaining under private holdings and land schemes. It is only in Sarawak that cocoa is planted mainly in smallholdings. Area expansion is expected to increase at the rate of 5.9 per cent annually from 258,000 hectares in 1985 to 343,00 hectares in 1990 (Fifth Malaysia Plan, 1986).

In 1985 the production of this crop increased to 103,000 tonnes (see Table 1.1) and contributed about 4.7 per cent of the total agricultural production. It is expected to increase tremendously by 11.5 per cent per year as a result of expansion in area and increase in planting density. Production is envisaged to increase from 103,000 tonnes in 1985 to 204,000 tonnes in 1988, thus ranking Malaysia as the third largest producer in the world after Ivory coast and Brazil (Fifth Malaysia Plan, 1986).

TABLE 1.1 PRODUCTION AND EXPORT OF COCOA BEANS MALAYSIA (1980-1988)

Year	Production (Tonnes)	Export (Tonnes)	Export Values (US $)ª
1980	36,500	30,640	60.6
1981	45,200	42,237	64.2
1982	66,200	57,614	74.2
1983	69,000	57,268	85.6
1984	79,300	66,138	126.6
1985	103,000	81,500	153.4
1986	131,000	106,200	185.8
1987	185,000	157,300	256.2
1988*	204,000*	182,000*	252.8*

* = estimates
a - average exchange rate during the period was US$ 1.00 = M$ 2.47
Source: Lapoaran Ekonomi 1988/89.

In terms of revenue, the earnings from cocoa have increased from US$ 60.6 millions in 1980 to about US$ 153.4 millions in 1985. This was the result of an upsurge of the quantum being exported from 30,640 tonnes in 1980 to 81,500 tonnes in 1985 or an increase of 166 per cent (Fifth Malaysia Plan, 1986). In 1986, a total of 106,200 tonnes were exported and in 1987, the figure increased to 157,300 tonnes (Information Malaysia Yearbook, 1988 and Laporan Ekonomi 1988/89).

Cocoa is planted in all the states of Peninsula Malaysia as an intercrop with coconuts. The three major cocoa growing areas are as follows (see Table 1.2 and Appendix 3):

i) District of Hilir Perak in Perak;

ii) Districts of Sabak Bernam and Kuala Selangor in Selangor; and

iii) Districts of Muar and Batu Pahat in West Johore;

Until now the government has exercised only limited influence on the development of the cocoa industry. A uniform governmental policy towards the development of this particular crop is practically non-existing. The government's influence on the cocoa development is limited to the following areas:

i) the alienation and the disposal of the State land to plantation companies and smallholders for the purpose of cocoa cultivation;

ii) the formulation of planned targets in terms of area cultivated. As spelt out in the Fifth Malaysia Plan, the set target is to develop 20,000 hectares of land for cocoa cultivation annually until the end of 1990;

iii) the underaking of research relating to the development of cocoa and its product:

iv) the marketing of the cocoa beans; and

v) the provision of subsidised inputs such as planting material, fertilisers, weedicides and insecticides during the first three years of crop production.

TABLE 1.2
TOTAL PLANTED AREA BY STATE AS AT DECEMBER 1986

STATE	AREA (Hectare)
<u>PENINSULA MALAYSIA</u>	
Johore	21,991
Kedah/Perlis	283
Kelantan	1373
Malacca	5,443
Negeri Sembilan	2,448
Pahang	17,003
Penang	1,279
Perak	26,082
Selangor	23,883
Terengganu	5,398
<u>EAST MALAYSIA</u>	
Sabah	184,477
Sarawak	44,451
Total	334,111

Source: FEDERAL AGRICULTURAL MARKETING AUTHORITY, MAY, 1988.

There is however, no specific extension and credit policies as far as cocoa is concerned. The facilities that are provided by the government are the same as those extended to all groups of producers irrespective of the crops grown.

As stated earlier, the crucial problem facing the cocoa industry currently is low farm productivity. At the farm level, it is found that production per hectare from the smallholders is relatively low when compared to the potential yields which can be obtained if farmers were to follow the recommended practices both in terms of the management of the holdings and the utilisation of inputs such as fertilisers and other chemicals. Wide variations in yields occur not only between estates and smallholdings but also within the smallholding in the different states and districts depending on management of the inputs and cultural practices undertaken.

Shaaban (1980) reported that based on the survey in the district of Sabak Bernam, the average yield of the smallholders crop was only 330 kilogrammes of dry beans per hectare per year. In another survey carried out by the Department of Agriculture (1984) in three major cocoa growing States of Johore, Perak and Selangor, the average annual yield per hectare obtained varied from 217 kilogrammes to 245 kilogrammes of dry beans. The

Department of Agriculture also revealed that the smallholders in the largest cocoa growing area (Hilir Perak) only obtained an annual average yield of 360 kilogrammes of dry beans per hectare (Abdul Rahman, 1987). Nasuddin *et al.* (1987) discovered that, based on the socio-economic survey of cocoa smallholders in four major districts of Hilir Perak, Batu Pahat, Tanjong Karang and Sabak Bernam which are all located in the States of Perak, Johore and Selangor, the average annual yield obtained were 282 kilogrammes, 715 kilogrammes, 477 kilogrammes and 442 kilogrammes of dry beans per hectare, respectively.

Low productivity is associated with low farm income. It is found that, if a farm family were to work on the plot themselves, without incurring other labour costs, the net income would be M$ 174 per hectare per month (Abdul Rahman, 1987). In the districts of Hilir Perak, Batu Pahat, Tanjong Karang and Sabak Bernam, the cocoa smallholders only earned an average monthly gross income of M$89.26, M$226.34, M$141.62 and M$140 respectively (Nasuddin *et al.* 1987), all of which are far below the poverty line of M$ 350 monthly.

In spite of all the various efforts undertaken by the government such as the provision of extension and credit facilities, there seems to have been not much change in the productivity status of the smallholder for the past seven years as indicated by the yields obtained. The cocoa productivity per unit area for the smallholders and hence the income in fact is still relatively low.

It is essential therefore, that if agriculture was to play a more important role in the development programmes in Malaysia, increasing attention should also be given to the strategy of increasing cocoa productivity. Otherwise, its contribution to such key development objectives such as employment, poverty alleviation and the balance of payments will be jeopardised.

1.2. OBJECTIVES OF THE STUDY

This study is confined to the region of Hilir Perak which is one of the largest cocoa growing areas in the country. Given the problem of low productivity that prevails at the smallholder level, there is a need, therefore, to examine the production behaviour of this group of producers in terms of the present input utilisation.

More specifically, however, the objectives of this study are:

i) to identify the production factors that determine cocoa productivity at the farm level;

ii) to determine the relative importance of those inputs which affect total output;

iii) to examine whether the factors of production are used in an allocatively efficient manner;

v) to estimate the level of technical efficiency of individual producers; and

vi) to identify the factors which contribute to variations in technical efficiency.

All the above information is important in the formulation of the appropriate extension and development strategies for the smallholding sector. Should the government wish to increase output for example, it would have to facilitate and encourage the efficient use of those factors of production that have a considerable influence on the total product being considered. The information obtained will also provide guidelines in assisting the authority to make the best decisions regarding the use of the available resources.

1.3. SIGNIFICANCE OF THE STUDY

As stated earlier although approximately half of the total cocoa acreage in the country is under smallholder production, the average yield obtained is very low, averaging about 400 to 600 kg of dried beans per hectare as compared to about 1000 to 2500 kg per hectare from the estate sector (FAMA, 1988; Laporan Ekonomi, 1988/89).

Because of the prevalence of low productivity at the smallholder sector some positive steps have to be undertaken to identify the different problems facing this group of producers especially those pertaining to the management and the use of limited farm resources.

Persistent low productivity would be detrimental to the government's objective of eradicating poverty and achieving an equitable distribution of wealth among its population. The problem is further aggravated when, as now, cocoa prices are on a declining trend owing to the surplus of cocoa beans on the world market. Future prices are also uncertain and this has created worries not only among the producers but also among the local agricultural planners.

Furthermore, since cocoa is the number three export crop after rubber and oil palm and also one of the major export earners, poor performance at the farm level will have a serious repercussion on the economic growth of the country.

This study as such hopes to generate new information that could be utilised to improve the productive capacity of the existing farms as well as new cocoa areas which the government hopes to develop at the rate of 20,000 hectares annually.

1.4. SUMMARY

This chapter has outlined the research problem to be dealt with in the context of the present study. It has examined briefly the importance of agriculture in the economic development of the country with special attention being focussed on the issue of agricultural productivity which forms the crux of the study.

The question of the low farm productivity as indicated by the low cocoa yield obtained especially in all the major producing areas in Peninsula Malaysia is of a grave concern to the government.

This study therefore, attempts to examine the factors that affect cocoa productivity at the smallholders' level with the hope of providing some new information vital for policy considerations.

CHAPTER TWO

THEORETICAL FRAMEWORK

Production function estimation is the approach applied in order to analyse the problem of low productivity in this study. Through the use of this approach we can derive estimates concerning the optimal levels of output and input. The latter can be used to guide the farmers regarding the future allocation of farm resources, to investigate the farmer's economic rationality and to investigate whether or not the returns to scale exist.

In this chapter a brief review of production theory in both technical and economic terms is presented. In addition, this section will also discuss the specific and simplified production functions which have been much used in empirical work as well as the practical statistical constraints that arise in their application.

2.1. PHYSICAL PRODUCTION FUNCTION

The production function expresses the functional relationship between inputs and output. It defines a boundary in the input-output space, specifying the maximum amount of output obtainable from a specified quantity of inputs given the existing technology. This is based on the assumptions that the inputs and output are non-negative, it is continuous and twice differentiable and the marginal products are decreasing (Farrell, 1957; Ferguson, 1969).

As crop production involves the services of many specific factors of production such as seeds, fertilizer and other resources, a production function is generally expressed as:

$$Y = f(X_1, X_2, \ldots\ldots, X_n) \qquad (2-1)$$

where Y refers to the quantity of a single commodity which may be produced and X_1, X_2, ..., X_n denote the inputs. The technological relationship between a set of inputs and output is usually expressed in a physical production function of an engineering type. Depending on the number of inputs involved, the function can either be presented in algebraic, graphical or tabular forms. Graphical presentation, for example, is only feasible when there are restrictions in the number of variables so as to avoid the problem of dimensionality.

From equation (2-1) both the average and the marginal products can be derived. The average product (AP) of an input X_i can be defined as the ratio of the total product to the quantity of X_i used in producing the amount of the product, that is:

$$AP_{x_i} = Y/X_i = f(X_1, X_2, \ldots\ldots, X_n)/X_i \qquad (2\text{-}2)$$

The marginal product of an input X_i can be defined as the increase of production per unit increase of the input under consideration. It is the partial derivative of the output with respect to a particular input or:

$$MP_{x_i} = \frac{\delta Y}{\delta X_i} = f_i(X_1, X_2, \ldots\ldots\ldots, X_n) \qquad (2\text{-}3)$$

Marginal product in fact is the actual slope of the total product curve. The total increment of the output is equal to the sum of the increment of the inputs each multiplied by its marginal product or:

$$\delta y = \frac{\delta Y}{\delta X_1}\delta X_1 + \frac{\delta Y}{\delta X_2}\delta X_2 + \ldots\ldots + \frac{\delta Y}{\delta X_n}\delta X_n \qquad (2\text{-}4)$$

When the marginal product of X_i is zero, output will be at its maximum. Further increase in X_i, after this point, will result in a negative marginal product as each additional input will have an increasingly deleterious effect on output.

Analytically, the concept of the marginal product is more important than that of the average product. While Y/X_i is merely an average, $\delta Y/\delta X_i$ tells us the rate of change in Y if, at any given level of X_i, we increase X_i by an infinitely small amount. In other words it tells us what happens to Y at any level of X_i as marginal change occurs in X_i.

2.1.1. ELASTICITY OF PRODUCTION

From the production function, the elasticity of response can also be determined. This concept measures the proportionate change in output relative to a change in an input. For the production function in equation (2-1), the input elasticity, also known as the partial elasticity of output (Ep_i) with respect to the ith input is :

$$Ep_i = \frac{\delta Y}{\delta X_i} \div \frac{Y}{X_i} = \frac{\delta Y}{\delta X_i} \times \frac{X_i}{Y} \qquad (2-5)$$

Increasing, decreasing or constant returns will exist if $Ep_i > 1$, $Ep_i < 1$ or $Ep_i = 1$. If all inputs are varied at an equiproportional level, returns to scale can be estimated. This measures the proportional change in output relative to the proportional change in the whole inputs, for movement along a ray from the origin in input space. Thus it is the elasticity of production with respect to scale.

$$Ep = Ep_1 + Ep_2 + \ldots\ldots + Ep_n \qquad (2-6)$$

Substituting

$$Ep_i = \frac{\delta Y}{\delta X_i} \times \frac{X_i}{Y} \qquad (2-7)$$

into (2-6) will yield

$$Ep = \frac{\delta Y}{\delta X_1} \times \frac{X_1}{Y} + \frac{\delta Y}{\delta X_2} \times \frac{X_2}{Y} + \ldots + \frac{\delta Y}{\delta X_n} \times \frac{X_n}{Y} \qquad (2-8)$$

If Ep is constant for all levels of output and for any given factor proportions, the production function is said to be homogeneous. Thus if there are constant returns to scale everywhere, Ep is always equal to 1 so that the function is said to be homogeneous of degree 1 or linearly homogeneous.[1]

2.1.2. <u>REGIONS OF PRODUCTION</u>

The input - output relations showing total, average and marginal products can be divided into three regions (see Figure 1) in such a manner that we can isolate the portion

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[1] A detailed explanation of this type of function is given in C.E. Ferguson (1969), The Neoclassical Theory of Production and Distribution (Cambridge University Press), Chapter 5.

of the production in which production is the most profitable. Regions I and III are considered as the irrational areas and are often eliminated in the analysis of farm management decision making (Upton, 1976).

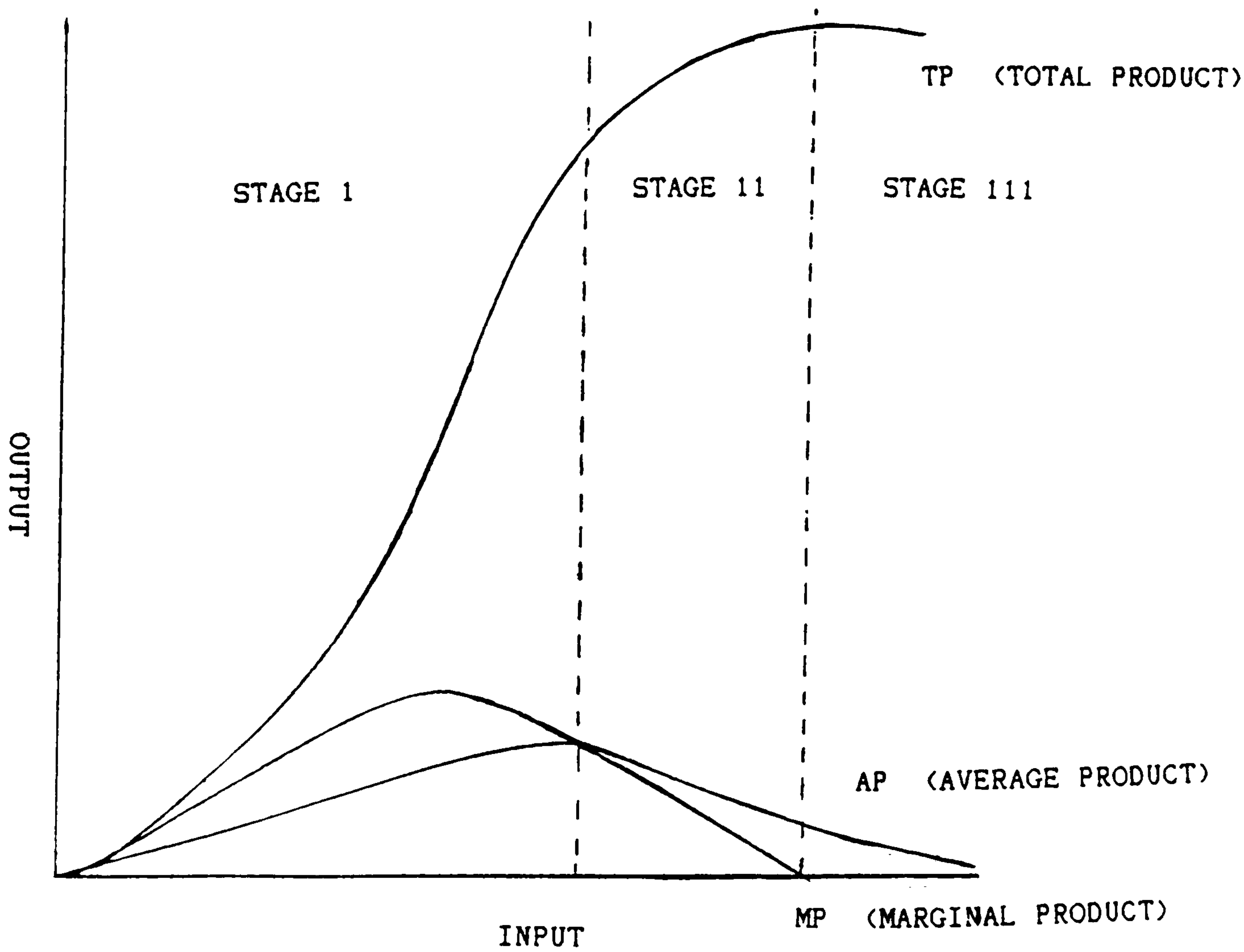

Fig. 1 A GENERAL PRODUCTION FUNCTION

In the production process as more of the variable inputs are added to the fixed inputs, production will increase from zero to the end of stage 1. At this stage the elasticity of output is greater than one. Thus, if it pays to produce, it is up to the end of stage I where the average product is maximum. However, if the farmer has limited resources which hinder him from producing at the end of stage one and moreover, no outside assistance either in the form of subsidies or farm credits is available, he should leave part of the farm idle rather than cultivate the whole area. For example, if he cannot afford to purchase fertilizers in order to reach maximum average product, it is advisable for him to concentrate their application on only part of the area. At least by doing so, an increase in the average returns from the input per unit of the area of land could be attained.

In region III where the elasticity of output is negative, the marginal product per unit of input is also negative. The total product starts to decrease as extra units of inputs are being applied. Thus if the farmer operates in this area, the productivity of variable inputs applied is negative.

Most farmers operate in region II where the elasticity of output lies between one and zero. It is the region in which farmers who seek to maximize profits will operate. From the physical data alone, it is impossible for the farmers to determine where production should fall within this region until the prices of inputs and output are known (Heady and Dillon, 1966).

In analyzing the relationship which involves more than one input, the implications that arise with great interest concern the isoquants, marginal rate of substitution and the elasticity of substitution.

Consider the general production function $Y = f(X_1, X_2, X_3, \ldots, X_n)$, where Y is the output, X_1 and X_2 are two types of fertilizers while $X_3, \ldots, X_n$ are fixed inputs. In this case the relationship can be shown either by a three - dimensional space with the Y, X_1 and X_2 axes or by a series of curve with two dimensions as shown in figure 2.

The output Y^* and Y^{**} represent the fixed level of Y which can be obtained from various combinations of X_1 and X_2. The curves Y^* and Y^{**} are called isoquants. Within the relevant range of operation an increase of both inputs will result an increased output. The further an isoquant lies from the origin, the greater the output level which it represents : $Y^{**} > Y^*$ (Heathfield, 1971).

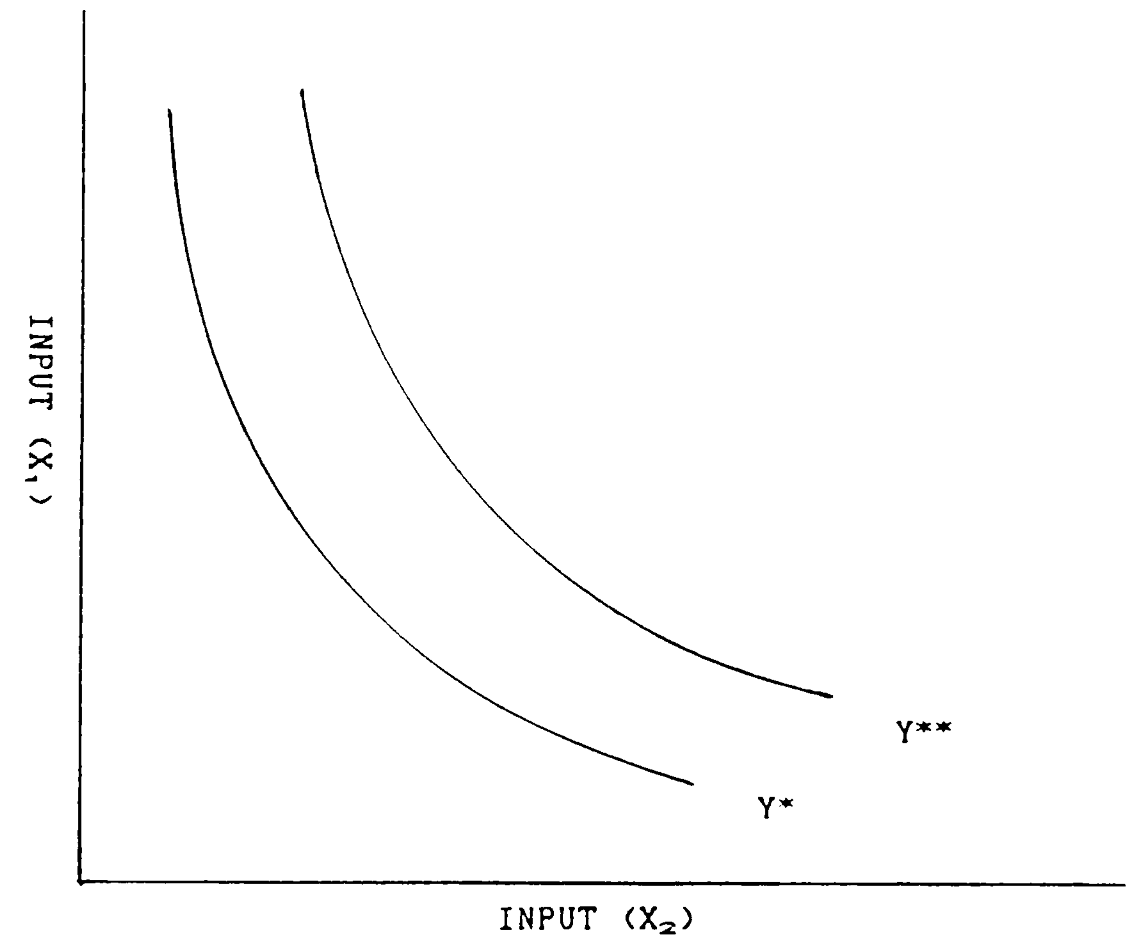

Fig. 2 THE ISOQUANT DIAGRAM

2.1.3. MARGINAL RATE OF TECHNICAL SUBSTITUTION (MRTS)

At any point on the isoquant, the marginal rate of technical substitution of X_1 for X_2 can be determined. This concept measures the rate at which one factor is substituted for another with the output held constant. It is obtained by differentiating one variable input with respect to another. Algebraically, the rate of substitution of X_1 for X_2 is written as:

$$MRTS_{12} = \frac{\delta X_1}{\delta X_2} \qquad (Y = Y^*) \qquad (2-9)$$

The marginal rate of technical substitution of X_1 for X_2 is given by the slope of the isoquant. Being a rate, $MRTS_{12}$ is measured in units of X_1 per unit of X_2, even though it is evaluated at a point on the isoquant.' It can range from minus to plus infinity.

Given an isoquant map and any stipulated value of the MRTS there exists on each isoquant one particular point at which the MRTS has that stipulated value. The line which connects such points is the isocline. It is actually a locus of points along which the marginal rate of technical substitution is constant. Isocline traces out the path of least-cost input combinations under the given price regime.

If we have a series of isoquants, substitution between two inputs occurs in the region which is bounded by the limiting isoclines which are sometimes called the ridge lines. In this area, since all isoquants are concave from above and throughout the region, there is a diminishing marginal rate of technical substitution.

2.1.4. ELASTICITY OF SUBSTITUTION

This measures the relative ease with which one input can be substituted for another while output remains constant. It is defined as the proportionate change in the ratio of the inputs divided by the proportionate change in the ratio of their marginal physical productivities. By definition, the elasticity of substitution of X_1 for X_2 is given as:

$$6 = \frac{\delta X_1}{X_1} \div \frac{\delta X_2}{X_2} \qquad (Y = Y^*) \qquad (2\text{-}10)$$

It is only restricted for measurement along an isoquant. Thus, this concept, however, only relates to the substitution of inputs with a constant level of output.

It is non-negative, and thus the elasticity of substitution of X_1 for X_2 is the same as the elasticity of substitution of X_2 for X_1.

2.2. PROFIT MAXIMIZATION CONCEPT

So far we have discussed only the technical features of the production function. No reference is made as regards to the prices of the inputs and output. If we assume that farmers are profit maximisers, we can determine the best operating conditions which will provide the maximum profit to the farm.

Assuming the production function is $Y = f(X_1, X_2, X_3, \ldots, X_n)$ with the Y held constant at a given level of Y^* and let

r_1 = price per unit of input X_1

r_2 = price per unit of input X_2

Then total cost $C = r_1X_1 + r_2X_2 + K$, where K is a fixed cost which is a constant.

Profit (π) is the difference between total revenue and total cost:

$$\pi = pY - r_1X_1 - r_2X_2 - K \qquad (2-11)$$

Profit is maximized where:

$$\frac{\delta\pi}{\delta X_1} = p\frac{\delta Y}{\delta X_1} - r_1 = 0 \qquad (2-12)$$

and

$$\frac{\delta\pi}{\delta X_2} = p\frac{\delta Y}{\delta X_2} - r_2 = 0 \qquad (2-13)$$

Moving the price of the inputs to the right,we have:

$$pf_1 = r_1 \quad \text{and } pf_2 = r_2 \qquad (2-14)$$

where both f_1 and f_2 are the first partial derivatives of π with respect to X_1 and X_2.

This is the first-order conditions for profit maximization which requires that each input be utilised up to a point at which the value of its MP equals its price. Profit can be increased as long as the addition to revenue from the employment of an additional unit of X exceeds its cost.

The second-order conditions[2] which are sufficient for a maximum to exist are:

$$\frac{\delta^2\pi}{\delta X^2_1} = pf_{11} < 0 \quad , \qquad \frac{\delta^2\pi}{\delta X^2_2} = pf_{22} < 0 \qquad (2-15)$$

and

$$\frac{\delta^2\pi}{\delta X_1{}^2} \times \frac{\delta^2\pi}{\delta X_2{}^2} - \left(\frac{\delta^2\pi}{\delta X_1\,\delta X_2}\right)^2$$

$$= \quad p^2 \begin{vmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{vmatrix} > 0 \qquad (2-16)$$

where f_{11} and f_{22} are the second partial derivatives of π with respect to X_1 and X_2 and f_{21} and f_{12}, their second cross partial derivatives.

Second-order conditions require that the production function be strictly concave in the neighbourhood of a point at which the first-order conditions are satisfied. This means that the marginal products of both inputs must be decreasing.

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2. For a detailed explanation, see A.C. Chiang (1984), Fundamental Methods of Mathematical Economics, McGraw-Hill International Book Company, pp. 247-249.

2.2.1. CONSTRAINED COST MINIMIZATION

Suppose in the production process the producer can spend only a fixed amount of working capital denoted by C. Subject to this constraint, he only operates efficiently if he maximizes the output attainable. To achieve this he must choose the proper input combination that can be purchased for the fixed amount of C that can result in the greatest level of output.

Assuming that the production function is

$$Y = f(K, L) \tag{2-17}$$

and the total cost is $C = rK + wL$, where r and w are the respective prices of input K and L. To maximize output subject to the cost constraint introduce the multiplier λ and construct the Lagrange function:

$$f(K,L) - \lambda(rK + wL - C)$$

Taking the first partial derivatives, we obtain

$$\frac{\delta f}{\delta L} - \lambda w = 0 \tag{2-18}$$

$$\frac{\delta f}{\delta K} - \lambda r = 0 \tag{2-19}$$

Through re-arrangement we obtain:

$$\frac{\delta f}{\delta L} = \lambda w, \tag{2-20}$$

$$\frac{\delta f}{\delta K} = \lambda r \qquad (2\text{-}21)$$

Alternatively we can obtain:

$$\lambda = \frac{\delta f/\delta L}{w} = \frac{\delta f/\delta K}{r} \qquad (2\text{-}22)$$

That is in equilibrium, the marginal product per dollar's worth of input must be the same for each input.

The second-order conditions[3] for a constrained maximum require that the quadratic form associated with the bordered determinant:

$$\begin{vmatrix} 0 & f_K & f_L \\ f_K & f_{KK} & f_{KL} \\ f_L & f_{KL} & f_{LL} \end{vmatrix}$$

be negative, where:

$$f_K = \delta f/\delta K, \quad f_{KL} = \delta^2 f/\delta K \delta L, \quad \text{etc.} \qquad (2\text{-}23)$$

Expanding, this requires that:

$$f_L^2 f_{KK} - 2 f_K f_L f_{KL} + f_K^2 f_{LL} < 0. \qquad (2\text{-}24)$$

This condition implies that the production function be regular srictly quasi-concave in the neighbourhood of a point at which the first-order conditions are satisfied.

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3. For a detailed explanation, see C.E. Ferguson (1969), pp. 136-38.

2.3. PRODUCT COMBINATION

So far we have considered choices relating to a single product. In practice most farmers grow more than one crop on their farms. Thus choices have to be made between alternative product combinations.

However, not all products are alternatives in the sense that if more of one is produced output of the other must be restricted. Some are joint products such as grain and straw. In some cases both of these joint products are important in their own right. In other instances one is subsidiary to the other.

Non-joint products usually compete for the use of scarce resources and as such a decision has to be made pertaining to the right combination of products.

As illustrated in Figure 3, there are two alternative products Y_1 and Y_2 being produced. Given a particular quantity of resources which can be used for either products, it is possible to produce either A units of Y_2 or B units of Y_1, or any combination of the two which falls along the curve AB. The curve AB is termed the production possibility curve which defines the quantities of each product that can be produced from the various allocations of resources between the two. The line R is the iso-revenue line which is defined as the locus of output combinations that will earn a specified revenue. Given the prices of the two products, optimum product combination is attained at the point P, where the production possibility curve is tangential to the iso-revenue line. At this point, the two slopes (that is, the slope of the iso-revenue line and the slope of the production possibility curve) are equal. This equality defines, the conditions necessary for attaining the optimum pattern of product combination.

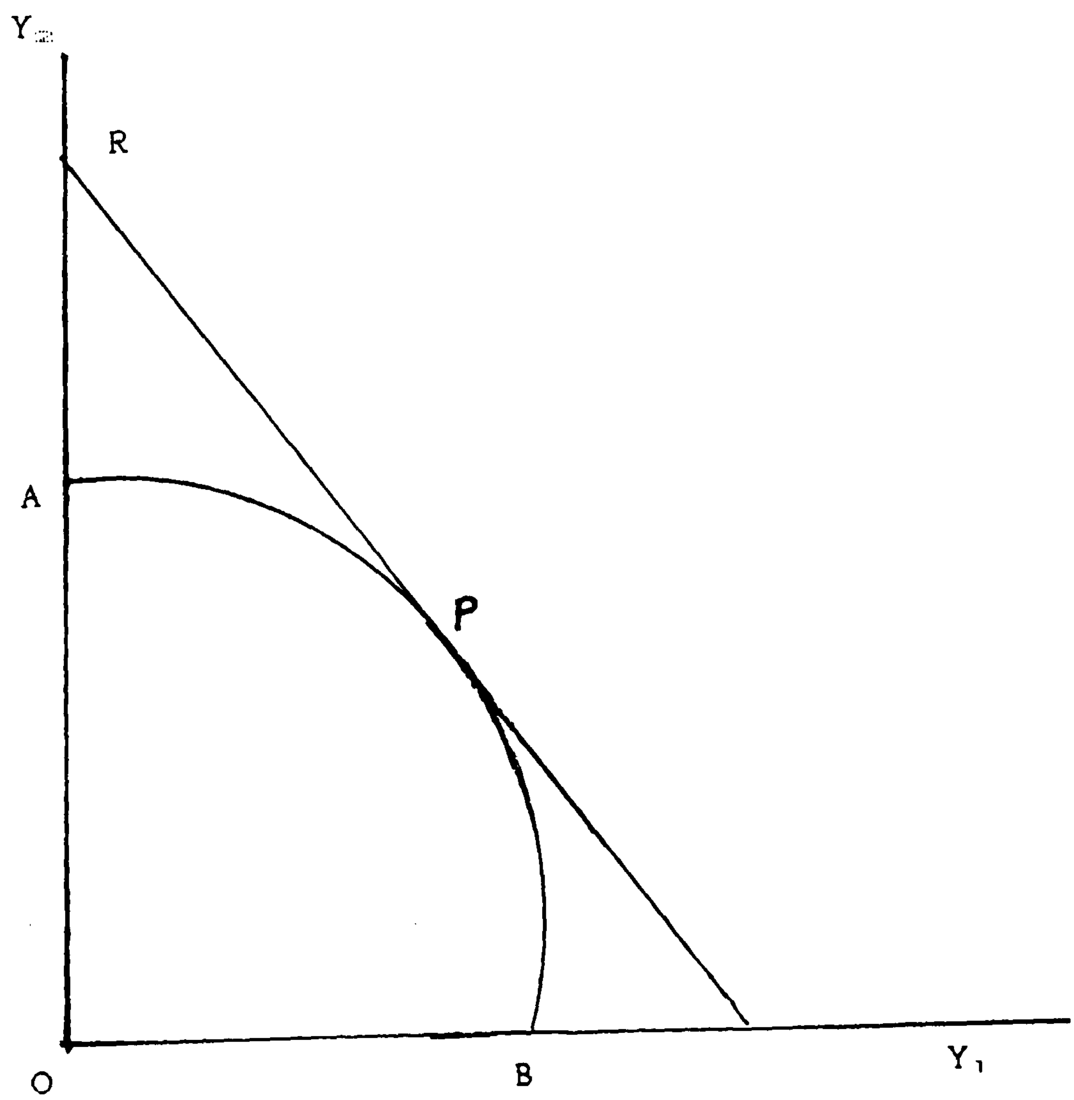

Figure 3. Diagram Showing The Optimum Product Combination.

The slope of the tangent to a point on a production possibility curve is the rate at which Y_2 must be sacrificed to obtain more of Y_1, without varying the input of X. The negative of the slope is defined as the rate of product transformation (RPT):

$$RPT = - \delta y_2 / \delta y_1 \qquad (2-25)$$

Assuming that a single input X is used for the production of both Y_1 and Y_2 then the function can be expressed as :

$$x = f(y_1, y_2) \qquad (2-26)$$

where y_1, y_2 and x are the respective quantities of Y_1, Y_2 and X.

Taking the differentials of (2-26),

$$\delta x = f_1 \delta y_1 + f_2 \delta y_2 \qquad (2-27)$$

Since $\delta x = 0$ for movements along a production possibility curve,

$$RPT = - \frac{\delta y_2}{\delta y_1} = \frac{f_1}{f_2} \qquad (2-28)$$

The RPT at a point on a production possibility curve equals the ratio of the marginal cost of Y_1 in terms of X to the marginal cost of Y_2 in terms of X at that point.

The RPT can also be expressed in terms of the MPs. The inverse-function rule applies in this case:

$$\frac{\delta y_1}{\delta x} = \frac{1}{f_1} \quad , \quad \frac{\delta y_2}{\delta x} = \frac{1}{f_2} \tag{2-29}$$

Substituting into (2-28),

$$RPT = - \frac{\delta y_2}{\delta y_1} = \frac{\delta y_2 \ / \ \delta x}{\delta y_1 \ / \ \delta x} \tag{2-30}$$

that is the RPT equals the ratio of the MPs of X in the production of Y_2 to the MPs of X in the production of Y_1.

Basically, there are three different relationships between two products:

i) They substitute for each other in the use of resources at a constant rate, irrespective of the amount of either product which is being produced. In this situation, the production possibility curve is a straight line. The two products have similar input requirements.

ii) Substitution is at an increasing rate. As more of one product is produced, and increasingly greater sacrifice has to be made on the other product. The production possibility curve will be concave downwards. This kind of substitution can arise out of the operation of the Law of Diminishing Returns.

iii) Substitution is at a decreasing rate. This might occur when the production function for the relevant factor is in the stage of increasing productivity. In this situation the rate at which the output of Y_1 is curtailed slows down with increasing of output Y_2. The production possibility curve is convex towards the origin.

2.3.1. INTER-PRODUCT RELATIONSHIPS

The examples stated earlier relate to cases where production was in the Regions 1 and 11. Another possibility is when production occurred in Region 111 where input application is excessive. In this situation if all the variable inputs are used in the production of Y_1, output will be less than what could be produced with fewer units of input. An alternative allocation, allowing maximum production of Y_1 and some output of Y_2 would clearly be preferable. Alternative allocations of resources, increasingly in favour of Y_2 would cause Y_1 to be produced at lower and lower levels, while the output of Y_2 would rise, but at a slower rate until it reached a maximum level. After this, if further units of resource were applied, output of Y_2 would fall. These alternative allocations give rise to a production possibility curve as shown in figure 4.

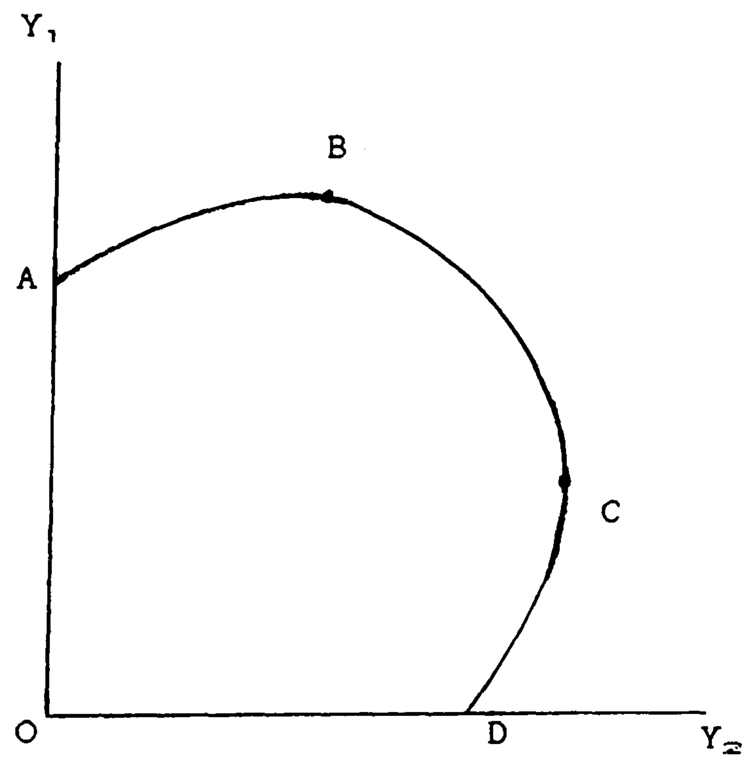

Figure 4. Production Possibility Curve For Complementary Relationship.

In the curve ABCD, B and C represent the maximum output levels of Y_1 and Y_2 respectively. Over the segments AB and DC, the products are complementary. Increased production of one product raises the output of the other product also. The same effect however, can also be observed with two products in region 11, provided one product contributes to the other in a physical sense. Legumes, for example, are usually grown in crop rotations for their properties of releasing nitrogen. If the inclusion of legumes leads to greater total output for other crops, then there is a complementary relationship.

Another form of relationship, supplementarity, has features somewhat similiar to complementarity. It has been observed that much of the work in crop production is seasonal. At times labour is fully occupied while in other periods it is under-employed. Usually other forms of subsidiary activities such as livestock are undertaken to take advantage of the slack labour available. Unless the amount of output and the timing of operation are carefully selected, these subsidiary products can be obtained with little or no adverse effect on the output of the main products. In some other cases there is a tendency for the farmers to be engaged with off-farm jobs which interfere little or not at all with the main farm work. In both the examples stated, the nature of relationships that exist is a supplementary one. This can be shown in Figure 5. The figure indicates that along the horizontal portion of the curve, production of livestock can be undertaken without causing a drop in the output of

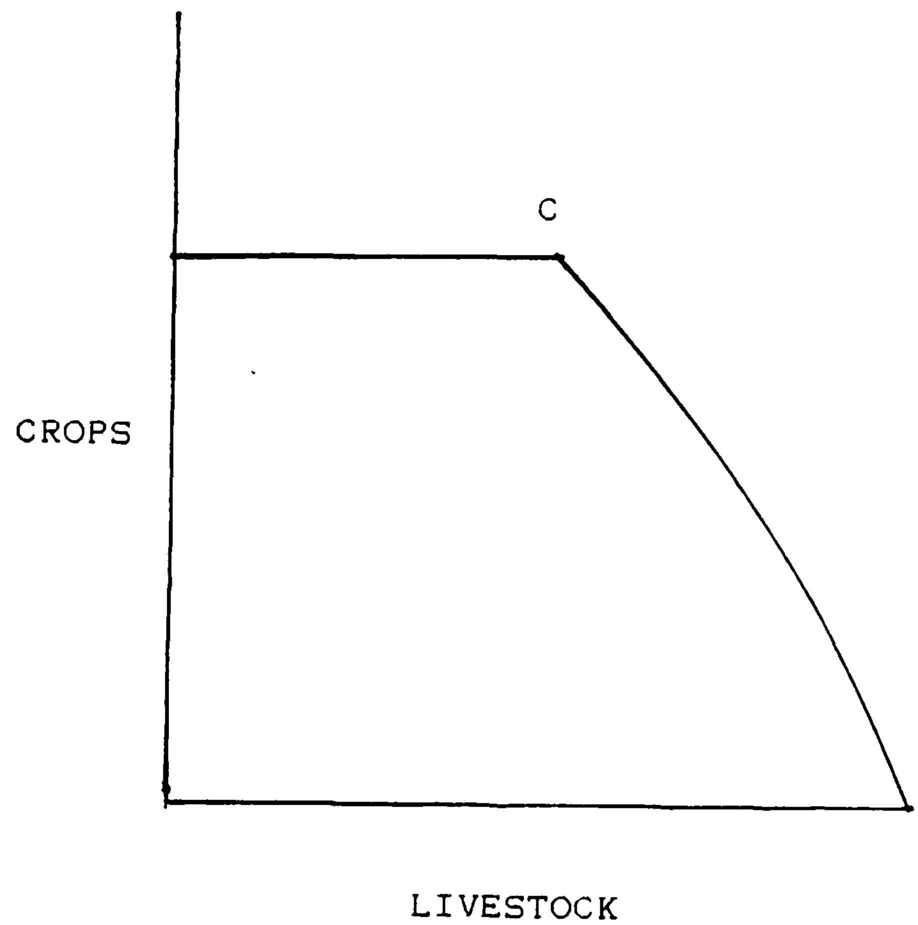

FIGURE 5. PRODUCTION POSSIBILITY CURVE: RELATIONSHIP BETWEEN CROPS AND LIVESTOCK.

the main crop. After the point C, different sources of income become competitive. The farm performance would be affected as additional time is spent on off-farm work. Similarly, at a certain scale of operation there will be competition for scarce resources like labour and capital between livestock and the main crop.

2.3.2. PROFIT MAXIMIZATION

The procedure employed to define a product combination that will give the highest possible level of revenue resembles to that used for the problem associated with the least-cost factor combination. Consider the case of two products Y_1 and Y_2 and with prices p_1 and p_2, profit can then be expressed as:

$$\pi = p_1 y_1 + p_2 y_2 - r f(y_1, y_2) \quad (2\text{-}31)$$

then by setting its first partial derivatives equal to zero, we have;

$$\frac{\delta \pi}{\delta y_1} = p_1 - r f_1 = 0 \quad (2\text{-}32)$$

$$\frac{\delta \pi}{\delta y_2} = p_2 - r f_2 = 0 \quad (2\text{-}33)$$

Moving the price terms to the right and dividing by the marginal costs in terms of X

$$r = \frac{p_1}{f_1} = \frac{p_2}{f_2}$$

or substituting from (2-29),

$$r = p_1 \frac{\delta y_1}{\delta x} = p_2 \frac{\delta y_2}{\delta x} \quad (2\text{-}34)$$

that is the value of the marginal product per unit of X in producing Y_1 should be equal to that of Y_2. The value of MP of X for producing each output must be equated to the price of X. Profit could be increased by increasing the use of X if its return in producing either product exceeded its cost.

The second-order conditions[4] however, requires that

$$-rf_{11} < 0 \qquad \begin{vmatrix} -rf_{11} & -rf_{12} \\ -rf_{21} & -rf_{22} \end{vmatrix} > 0$$

By expanding the second determinant,

$$r^2(f_{11}f_{22} - f^2_{12}) > 0$$

Since r>0, the second-order conditions can alternatively be stated as:

$$f_{11} > 0, \qquad f_{11}f_{22} - f^2_{12} > 0 \qquad (2\text{-}35)$$

Both imply that $f_{22} > 0$. The marginal cost of each output in terms of X must be increasing. Conditions (2-35) require that the production relation (2-26) be strictly convex in a neighbourhood about a point at which the first-order conditions (2-34) are satisfied.

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4. A detailed explanation is given in R.G.D. Allen (1963), Mathematical Economics, Macmillan and Co. Ltd. Second Edition, pp.613-17

2.3.3. CONSTRAINED REVENUE MAXIMIZATION

If a producer sells his outputs at fixed prices, his revenue is given by the equation:

$$R = p_1 Y_1 + p_2 Y_2 \qquad (2-36)$$

where p_1 and p_2 are the prices of Y_1 and Y_2, respectively. To maximize revenue from a given input of X_1 subject to the constraint $X_1 = K$, we thus write

$$R = p_1 Y_1 + p_2 Y_2 - \lambda (X_1 - K) \qquad (2-37)$$

then setting its partial derivatives equal to zero we have:

$$\frac{\delta R}{\delta Y_1} = p_1 - \lambda \frac{\delta X_1}{\delta Y_1} = 0 \qquad (2-38)$$

$$\frac{\delta R}{\delta Y_2} = p_2 - \lambda \frac{\delta X_1}{\delta Y_2} = 0 \qquad (2-39)$$

$$\frac{\delta R}{\delta \lambda} = - X_1 + K = 0 \qquad (2-40)$$

Solving from the first two equations we have:

$$\lambda = \frac{p_1}{\delta X_1 / \delta Y_1} = \frac{p_2}{\delta X_1 / \delta Y_2} \qquad (2-41)$$

Using the inverse function rule we obtain :

$$\frac{\delta X_1}{\delta Y_1} = \frac{1}{(MP_{Y_1})} \qquad (2-42)$$

and

$$\frac{\delta X_1}{\delta Y_2} = \frac{1}{(MP_{Y_2})} \tag{2-43}$$

therefore, $\lambda = p_1 \, (MP_{Y_1}) = p_2 \, (MP_{Y_2})$ (2-44)

that is, the value of the marginal product per unit of the variable factor should be equal.

The second-order conditions require that

$$\frac{\delta^2 Y_1}{\delta^2 Y_2} = \frac{\delta (RPT)}{\delta Y_2} > 0 \tag{2-45}$$

that is, the production possibility curve must have an increasing rate of product transformation at a point at which the first-order conditions are satisfied.

2.4. <u>OTHER POSSIBLE OBJECTIVE FUNCTIONS</u>

Given the diversity of circumstances that surround the farmers such as differences in abilities, ambitions, resource and asset availabilities, family circumstances and commitments, ecological, social and market conditions, it is quite difficult to generalise about their decision-making behaviour.

Generally, it has been recognised that besides aiming at maximising his profit, the farmer's decisions are also primarily aimed at satisficing and maximising utility.

In the case of satisficing the assumption made is that the objectives set can be expressed as targets or goals. For instance, the farmer's aim is to produce at least 100 kilogrammes of rice per season just to meet his family's basic food requirements. He may not be too concerned about finding a single, best combination or maximizing anything so long as he can meet this minimum target. Any point within the feasible target area is acceptable. Such behaviour is known as 'satisficing'. Should he finds that the current set of goals can be easily achieved, these goals may be adjusted upward. However, this process of adjustment is rather slow since it is not driven by the aim of maximizing anything. Although this may explain how decisions are made in practice, nevertheless, the analysis provides limited value as we cannot identify an economic optimum.

The second decision behaviour assumes the total welfare of the farmer or his satisfaction can be expressed as quantity of 'utility'. All the information regarding the satisfaction that he derives from the various quantities of commodities consumed is contained in his utility function. The locus of all commodity combinations from which he derives the same level of satisfaction forms an indifference curve. There is however, a different indifference curve for every different level of utility an individual might attain. Since the decisions at the farm level are normally joint decisions which involves other members of the family, the use of a single set of indifference curves to represent this joint decision-making is a simplification of reality.

Barnum and Squire (1976) however, proposed that the household but not the individual (unless the two coincide), is the relevant unit for the analysing of utility maximization. In this approach the household is seen as a production unit which converts purchased commodities and services, as well as domestic resources, into a set of final use values yielding utility in consumption[5].

Farmer's decision behaviour is also affected by risk and uncertainty. In any productive activity which a farmer embarks, there is bound to be uncertainty in outcome. This uncertainty may be attributed by the variations in the environment, market prices of output and inputs as

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5 A detailed explanation of this approach is given in Barnum and Squire (1976), A Model of Agricultural Household: Theory and Evidence, Occasional Paper No. 27 Washington DC: World Bank.

well as due to lack of information. Because of these conditions, a farmer therefore, cannot plan with certainty. The decisions taken are always subject to risk. The latter is a measure of the effect of uncertainty on the decision-maker.

Differences of opinion exists as regard to how risk should be measured. Some viewed it as a variation or instability in income, while others argue that it is the possibility of disaster or ruin.

It is generally assumed that poor farmers are risk averse. In order to survive, they must pursue a lower mean and a lower variance strategy which increases security and allocate farm inputs which allows them just tolerable level of profit, security and status. This 'optimal' strategy Lipton (1968) calls a 'survival algorithm'. Risk aversion however, declines as wealth or income rises. The higher the income or wealthier the farmers, the more capable they are of withstanding the losses which might crop up from taking risky decisions.

In general a consensus of opinion on the effect of risk and uncertainty on production appears to indicate that the presence of risk and uncertainty usually leads to lower output and a decrease in input usage. Under these conditions, the risk neutral producers will produce an optimum output when the marginal cost equals the expected price. On the other hand, the risk averse producer will produce an optimum output level for which his marginal cost is less than the expected price. This means that the output produced by the risk averse producer would be decreased under uncertainty, while the output produced by the risk neutral farmers would be reasonably said to be the same under uncertainty as under certainty if his expectations are correct.

In Malaysia, studies which have been undertaken by Abdullah (1978) and Tamin (1978) have shown that both the rubber smallholders and the rice farmers in the country are risk averse. As far as the cocoa smallholders are concerned no such information is available as regard to the farmers' attitudes towards risk. As such in the present study it is assumed that these farmers too, are also risk averse based on the outcomes of the above studies.

2.5. THE PRODUCTION FUNCTION IN PRACTICE

The characteristics of the physical quantities derived from the production function are varied with the forms of production functions used. There are two broad classes of production functions, namely; the fixed and variable-proportions production functions. A production process is characterised by fixed proportions if each level of output technologically requires a unique combination of inputs. All pairs of input ratios are constant for each output level, that is, the input-output ratio is independent of the scale of production. In this case, the fixed-proportions production function is homogeneous of degree one and the input coefficients are fixed along the isocline. On the other hand, if the input-output ratios are not independent of scale, but if all pairs of input ratios are constant, the production function will be homogeneous, but not of degree one. The returns to scale are not necessarily constant in this case.

The most widely used functional form in farm productivity studies is the homogeneous production function of degree one. As far as this production function is concerned, perhaps the two most commonly employed are the Cobb-Douglas and the Constant Elasticity of Substitution (CES) functions. In this context both functions are examined and in addition, other alternative functions are also discussed.

2.5.1 COBB-DOUGLAS FUNCTION

This is the most popular functional form that is most frequently used in empirical studies (Thomas, 1985; Gyimah-Brempong, 1987).

The Cobb-Douglas or power function is generally used in the form of:

$$Y = AX_1^{b_1} \ldots . X_i^{b_i} \ldots . X_w^{b_w} e^u \qquad (2-46)$$

where

Y = output

X_i = the ith input

A = the constant term or the efficiency parameter, since for fixed inputs, the larger that A is, the greater the level of output produced from such inputs.

b_i = parameter associated with ith factor.

u = random error term

In logarithmic form the above function can be written as:

$$\text{Log } Y = \log A + b_1 \log X_1 + \ldots . + b_i \log X_i + \ldots . + b_w \log X_w + u \qquad (2-47)$$

Differentiating equation (2-46) with respect to X_i, we can obtain the marginal product equation which is:

$$\frac{\delta Y}{\delta X_i} = AX_1^{b_1} \ldots X_i^{b_i - 1} \ldots X_w^{b_w} = bi \frac{Y}{X_i} \qquad (2-48)$$

That is, the marginal product is also equal to the product of b_i (the coefficient of X_i) and the average product. Since it is dependent upon the output-input ratio (Y/X_i), it declines as input is increased and vice versa.

The marginal product is used to derive the elasticity of production with respect to an input. By substitution from equation (2-48), the partial elasticity of production can be computed as:

$$\frac{\delta Y}{\delta Xi} \div \frac{Y}{X_i} = b_i \frac{Y}{X_i} \times \frac{X_i}{Y} = b_i \qquad (2\text{-}49)$$

It is estimated direct from the b_i coefficient or the input exponents. In this function the production elasticity of any factor is within the range of one and zero (i.e. $0 < b_i < 1$) which gives an indication that a one percent increase in any input will always increase output by a constant that is less than one percent.

The functional form allows substitutability between two inputs at any point on the isoquant. By setting Y = Y* (where Y* represents some arbitrary level of Y) and solving equation (2-46) for X_1 in terms of X_2, we can obtain the isoquant equation as follows.

$$X_1 = \left(\frac{Y^*}{X_2^{b_2} \; (AX_3^{b_3}, \ldots, X_w^{b_w})} \right)^{1/b_1} \qquad (2\text{-}50)$$

In this case, all the isoquants are downward sloping and convex to the origin since diminishing returns to scale prevails.

The marginal rate of technical substitution of X_1 for X_2 in the production of Y can be expressed as:

$$- \delta X_1 / \delta X_2 = - (\delta Y / \delta X_2) / (\delta dY / \delta X_1) = \frac{b_2}{b_1} \times \frac{X_1}{X_2} \qquad (2\text{-}51)$$

This describes the quantity of input X_1 required to compensate for a certain change in the quantity of X_2 so as to maintain output on the same isoquant. The marginal rate of technical substitution between two inputs in fact is a linear function of the ratio in which the two inputs are combined.

The Cobb-Douglas function, however, has a constant elasticity of substitution which is equal to unity. If two inputs X_1 and X_2 are increased in the same proportion, the elasticity of substitution remains constant at the ratio $-b_2/b_1$. The elasticity of substitution (6) is computed as follows:

$$6 = \frac{\delta (X_1 / X_2)}{\delta (P_2 / P_1)} \times \frac{(P_2 / P_1)}{(X_1 / X_2)} = 1 \qquad (2\text{-}52)$$

where P_1 and P_2 are the prices of X_1 and X_2, respectively. In this form, the elasticity of substitution shows the proportional change in the X_1-X_2 ratio induced by a given proportional change in the factor-price ratio.

However it should be noted that there are advantages as well as certain drawbacks in the use of this functional form in empirical research.

The advantages are that, it is computationally easy to handle (Dawson and Lingard, 1982) and can yield statistically significant estimates of the parameters without imposing excessive demands upon the accuracy of the data (Hebden, 1983). In addition to this, it is a relatively efficient user of the degrees of freedom. This is important especially when the resources for conducting the research are limited and the gathering of farm data is expensive (Heady and Dillon, 1966).

The assumption that the inputs are substitutable excludes the possibility of a production function in which the inputs are complementary. Since complementarity exists in the short-run, the Cobb-Douglas therefore, should only be used to define the long-run relation between the inputs (Heathfield, 1971).

Owing to the multiplicative nature of the function, no output can be produced if any of the independent variables are zero. This is not always a valid assumption. The use of the function is also criticised when the presence of multicollinearity between inputs is suspected. This can be a problem especially with cross-sectional data (Hebden, 1983). That the value of the elasticity of substitution should be unity further signifies the restrictive nature of the Cobb-Douglas function.

Notwithstanding these shortcomings, this function, however, has been widely used in studies dealing with diagnostic analyses, reflecting marginal productivities of the resources at the mean level of inputs (Heady and Dillon, 1966).

2.5.2. CONSTANT ELASTICITY OF SUBSTITUTION (CES) PRODUCTION FUNCTION

The CES function which is also a homogeneous function of degree one was popularised by Arrow, Chenery, Minhas and Solow in 1961 (Arrow *et al*, 1961). Using the cross-sectional data involving two main inputs, labour (L) and capital (K) for 24 industries across various countries, they found that this function provides an adequate description of the data.

The CES function can be written in the form of:

$$Y = A(\alpha L^{-\rho} + (1-\alpha)K^{-\rho})^{-1/\rho} \qquad (2\text{-}53)$$

where

$Y =$ output

$A =$ efficiency parameter which is a constant term

$p =$ substitution parameter $(-1 < p < \alpha)$

$\alpha =$ the distribution parameter $(0 < \alpha < 1)$

The marginal product of the inputs can be obtained by differentiating the above function:

$$\frac{\delta Y}{\delta L} = \frac{-A}{P} (\alpha L^{-p} + (1-\alpha)K^{-p})^{-1/p-1}(-p \alpha L^{-p-1}) \quad (2\text{-}54)$$

$$\frac{\delta Y}{\delta K} = \frac{-A}{P} (\alpha L^{-p} + (1-\alpha)K^{-p})^{-1/p-1}(-p(1- \alpha)K^{-p-1}) \quad (2\text{-}55)$$

Since the values of A and α are positive, the marginal product of any input will be positive for a positive value of the inputs and it decreases throughout its entire range.

Owing to the fact that the parameter α is constant, the slope of the isoquant as well as the marginal rate of technical substitution will also be a constant. The marginal rate of technical substitution (MRTS) can be expressed as follows:

$$MRTS = \frac{-\delta K}{\delta L} \div \frac{\delta Y}{\delta K} = \frac{\alpha}{1-\alpha} \left(\frac{K}{L}\right)^{1+p} \qquad (2\text{-}56)$$

The marginal rate of technical substitution should be equal to the ratio of the input prices, that is,

$$MRTS = \frac{-\delta K}{\delta L} = \frac{P_1}{P_2} \qquad (2\text{-}57)$$

where P_1 and P_2 are the prices of the inputs L and K, respectively. The elasticity of substitution (6) which measures the sensitivity of the input proportions to changes in marginal rate of technical substitution is given as :

$$6 = \delta\left(\frac{K}{L}\right) \div \frac{K}{L} \times \frac{\delta K}{\delta L} \div \delta\left(\frac{\delta K}{\delta L}\right) \qquad (2\text{-}58)$$

Since:

$$MRTS = \frac{-\delta K}{\delta L} = \frac{-\alpha}{1-\alpha} \left(\frac{K}{L}\right)^{1+p} \qquad (2\text{-}59)$$

Dividing by (K/L) we have

$$-\frac{\delta K}{\delta L} (K/L) = \frac{-\alpha}{1-\alpha} \left(\frac{K}{L}\right)^{p} \qquad (2\text{-}60)$$

By differentiating MRTS with respect to (K/L) will give

$$\frac{\delta \left(\frac{\delta K}{\delta L}\right)}{\delta (K/L)} = -(1+p) \frac{\alpha}{1-\alpha} \left(\frac{K}{L}\right)^{p} \qquad (2\text{-}61)$$

Thus

$$\sigma = \frac{\frac{-\alpha}{1-\alpha}\,(K/L)^{\rho}}{-(1+\rho)\,\frac{\alpha}{1-\alpha}\,(K/L)^{\rho}} \qquad (2\text{-}62)$$

$$= 1/1+\rho$$

The above equation shows that the elasticity of substitution is a constant and equal to $1/(1+\rho)$. The substitution parameter ρ specifies σ, since $\sigma = 1/1+\rho$. With the value of ρ taking the range of $-1 < \rho < \infty$; the elasticity of substitution then become $\infty > \sigma > 0$. Thus if $\rho = -1$, $\sigma = \infty$ and if $\rho = 0$, then $\sigma = 1$. In the latter situation, the CES is reduced to the Cobb-Douglas function. In fact the major difference between the CES and the Cobb-Douglas function lies in the treatment of the substitution effect. In the CES, the elasticity of substitution is not restricted to unity as is the case in the Cobb-Douglas function (Yotopoulos and Nugent, 1976).

The CES function discussed so far assumes constant returns to scale. This restriction according to Tsurumi (1970) can be removed by adding a returns to scale parameter to the original CES function. The function can then be rewritten as:

$$Y = A(\alpha L^{-\rho} + (1-\alpha)K^{-\rho})^{-u/\rho} \qquad (2\text{-}63)$$

where u represents the special returns to scale parameter and the rest as outlined earlier. The elasticity of substitution in this case still remains unchanged at $1/(1 + p)$. If the value of μ is less than unity, decreasing returns to scale exists and if $\mu > 1$, we have increasing returns to scale, while on the other hand if $\mu = 1$, constant returns to scale prevails and the function is reduced to its original form as discussed earlier.

Another point to be stressed here is that the CES function, unlike the Cobb-Douglas, allows the inputs used to be either substitutes or complements. Thus, it does not need to be restricted to long-run application.

The CES function however is difficult to interpret with more than two factors of production, and with six factors in the data set, the function becomes unmanageable (Timmer, 1970).

2.5.3. TRANSCENDENTAL LOGARITHMIC PRODUCTION FUNCTION

Dropping the restrictions of unitary elasticity of substitution in the case of Cobb-Douglas function and constant elasticity of substitution in the more general CES function, an explicit form of a general production function which allows for variation in input ratio as well as elasticity of substitution might be derived. Early notable examples were those developed by Sato and Hoffman (1968) who presented a series of forms in which the elasticity of substitution varied over time. However, it was Christensen, Jorgenson and Lau (1973) who finally presented a general form of the variable elasticity of substitution. The function developed by them is known as the transcendental logarithmic production function or the translog production function.

They argued that the use of the CES function involving one output and two factors of production which gives rise to constant elasticity of substitution and transformation is highly restrictive. They indicated that the CES assumptions of additivity and homogeneity are not always valid if several outputs and inputs are considered. Instead they introduce a new approach in which production is quadratic in the logarithms of the quantities of inputs and outputs in order to allow production to have a greater variety of substitution and transformation. Assuming two inputs K and L are used to produce output Y, then the function is represented as:

$$\ln Y = \beta_0 + \beta_K \ln K + \beta_L \ln L + \beta_{KK}(\ln K)^2 + \beta_{LL} (\ln L)^2 + \beta_{LK} \ln K \ln L \qquad (2\text{-}64)$$

This function is easy to estimate and since it can be regarded as a second-order Taylor approximation to any production function, it can be employed to test whether the elasticity of substitution is constant or not. The transcendental logarithmic function exhibits varying returns to scale, that is the nature of the returns to scale is not the same for all values of the inputs. A greater number of the degrees of freedom, however, is lost in the estimation of this function because the number of coefficients estimated is twice the number of regressors. This makes it less suitable for small data sets.

2.6. FRONTIER AND AVERAGE PRODUCTION FUNCTIONS

In theory the production function represents the boundary of the range of possible outputs that could be produced from a given set of inputs so that all observations should lie on or below it. This indicates that there is a frontier which sets a limit to the maximum possible output which could be produced. Thus a farm producing less than the maximum possible output may lie below the production frontier and is regarded as an inefficient farm. In fact this interest in the measurement of inefficiency has been the main idea behind the study of the frontiers.

The notion of the frontier production function, as will be fully discussed in Chapter 10, is not new and it was Farrell (1957) who first mooted the proposition that efficiency measurements should be made in a relative term and not in the absolute sense. It is relative since the measurement is made based on the deviation from the best performance in a representative peer group.

It is important to distinguish the basic difference between the frontier function and the so-called average function. While the former is associated with maximum possible output, the latter is basically associated with mean output for given input levels. The average function can be applied more meaningfully to a random coefficient model and has widespread application in empirical work because of the dominance of statistical theory in the analysis. Although the estimates obtained can be further subjected to all standard statistical tests of significance, this function however, does not fit well with traditional production theory.

As stated earlier the production function clearly expresses the maximum output obtainable from every possible input combination given the technology available to the farm. In this context the production function set the highest possible limit on the output which a farm can hope to obtain with a certain combination of inputs. As shown in figure 6, the function then represents the boundary or envelope of the feasible production set.

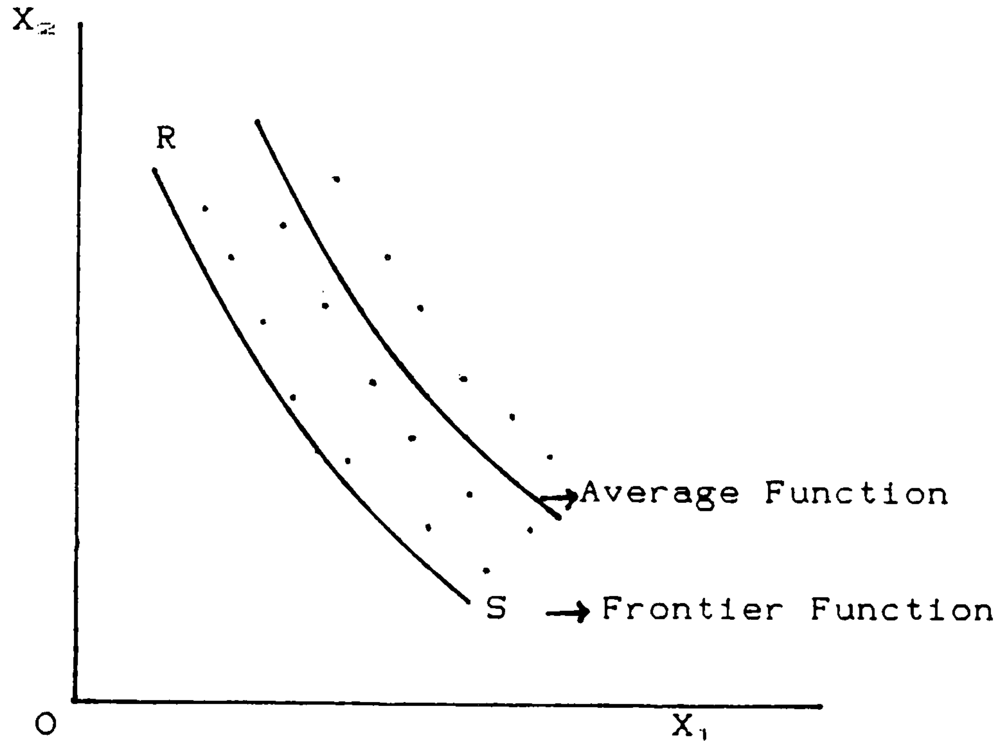

Figure 6: A cross-section of individual farm's observation in input space

Assuming that all the farms in the sample used two inputs X_1 and X_2 in the process of production, then each point represents the combination of inputs used to produce a unit of output. The efficient frontier in this case is represented by the surface RS. Given the present state of technology, it is clear that no farm is able to produce a unit of output to the southwest of the frontier RS since this space requires a new state of technology.

This indicates that only technically efficient farmers will actually operate on the production function while those who are not are located away from it. Since the use of the average production function only relates to mean output and not maximum possible output, as the frontier function does, this clearly indicates that the use of an average production function is not really consistent with the definition of the traditional production function theory.

From a practical point of view, the average concept is obviously the correct one to be employed if one is interested in estimating the maximum average product for the farm. On the other hand if the object is to measure the technical inefficiency of the individual farm the frontier concept is the most appropriate tool to be used.

2.7. PROBLEMS RELATED WITH ESTIMATION PROCEDURES

In this section emphasis is given to some of the problems encountered in the estimation of the production function especially those that are pertinent to the present study. Basically these problems can be classified into 2 groups:

1. conceptual problems; and
2. statistical problems.

2.7.1. CONCEPTUAL PROBLEMS

The most common problems associated with the use of non-experimental data in order to estimate the production are those related to the specification errors, aggregation of the inputs and simultaneous bias.

In estimating a production process, it is never possible to specify and fit the true production function. What is possible is to have a hybrid function to represent the true production function (Heady and Dillon; 1966; Yotopoulos 1967). Moreover, the complete range of inputs that the production process is supposed to have is also unknown. Some inputs that are thought to be relevant may be impossible to include in the analysis because of the problem of quantification or because data about them are unavailable. As a result we have to make approximations and these approximations as well as the omissions of the variables from the analysis lead to what is known as specification error.

The most commonly cited specification error is the omission of variables. The erroneous omission of one or more variables in a model may cause an upward bias in the estimates of the remaining parameters. That is to say, if the omitted variables are positively correlated with the included ones, there is a tendency of overestimating one or more of the coefficients of the included variables. On the other if the omitted variables are negatively correlated with the included ones, the parameters of the remaining variables may tend to be underestimated[6].

Apart from the above, failure to take into account the effects of a change in technology over time may also bias the estimates. This problem is crucial when time-series data are used for estimation purposes. Since the present study makes use of cross-sectional data, technological change over time does not have any significant effect on the estimates.

Another conceptual problem associated with the estimation of the production function for the farm concerns aggregation over inputs. This normally crops up when the number of input categories is large and quality differences in inputs are to be expected. To minimise this problem, input categories which are complements should be treated as a single input. Otherwise this would lead to

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[6] A more detailed discussion on these problems is given in Zvi Griliches (1957).

multicollinearity owing to the existence of high levels of correlation between the complementary inputs. In a similar manner inputs which are considered as close substitutes should also be treated as a single input category.

Although in practice, we cannot aggregate inputs perfectly an attempt should be made to go as far as we can in that direction.

The most common method employed in the estimation of the production function is ordinary least squares regression. The principle behind this method is the assumption of a linear relationship among the variables analysed. Through this means we select the sample regression, that is, those values for the estimated regression coefficients which minimise the sum of the squared residuals to yield good estimates of the parameters.

It has been demonstrated that any attempt to estimate the parameters of the production function by relating observed output to observed inputs through the use of ordinary least squares will be subject to simultaneous equation bias. The latter results when the equation is a member of a system of equations, where the independent as well as the dependent variables are functions of the disturbance in the given equation. Since the disturbances are correlated with observed values of all the variables, this makes the single equation estimates inconsistent (Hoch, 1958).

Consistency of the parameter estimates however, can be attained when the disturbance only affects the output and not the independent variables in the system. In this situation, there is no simultaneous equation bias.

Assuming that 2 factors of production are used in the production equation of the form below:

$$Y = AK^{a}L^{b} \tag{2-65}$$

Where

Y = output

A = efficiency parameter

K = capital

L = labour

In logarithmic form the above function can be rewritten as:

$$\text{Log } Y = \text{Log } A + a \text{ Log } K + b \text{ Log } L \tag{2-66}$$

This equation cannot be estimated statistically because of the absence of a stochastic term.

In real world situations production is affected by some random shocks and so the function is instead

$$Y = AK^{a}L^{b}e_{i} \tag{2-67}$$

Where e_i is lognormally distributed with zero mean. The equation in the log form becomes:

$$\text{Log } Y_i = \text{Log } A + a \text{ Log } K + b \text{ Log } L + \text{Log } e_i \qquad (2\text{-}68)$$

This function cannot be estimated directly by means of the ordinary least squares technique without bias and inconsistency in the parameters obtained since the profit maximisation impose additional constraints on equations (2-67) or (2-68).

Supposing that the rate of interest for capital is given as r, the wage rate as w and the price of output as P, then

$$P(\delta Y_i/\delta K) = P \frac{a}{K} AK^a L^b e_i = r, \text{ and} \qquad (2\text{-}69)$$

$$P(\delta Y_i/\delta L) = P \frac{b}{L} AK^a L^b e_i = w \qquad (2\text{-}70)$$

By rearranging and transforming into logs, equations (2-69) and (2-70) can be written as:

$$K = \text{Log } \frac{aP}{r} + \text{Log } A + a \text{ Log } K + b \text{ Log } L + \text{Log } e_i \qquad (2\text{-}71)$$

$$L = \text{Log } \frac{bP}{w} + \text{Log } A + a \text{ Log } K + b \text{ Log } L + \text{Log } e_i \qquad (2\text{-}72)$$

From equations (2-71) and (2-72) it is revealed that the use of inputs K and L are dependent both on the exogenous prices (i.e. r and w) and also on the error term (e_i). If the ordinary least squares is used to estimate equation (2-68), the results of a and b will be biased and inconsistent.

One of the methods used to overcome the problem of simultaneous bias is that of instrumental variable estimation. Consider the case of two-variable regression:

$$Y_i = \beta_1 + \beta_2 X_i + e_i \qquad (2\text{-}73)$$

Using the OLS, this equation can be reduced to

$$\sum Y_i = \beta_1 n + \beta_2 \sum X_i$$
$$\sum X_i Y_i = \beta_1 \sum X_i + \beta_2 \sum X_i^2 \qquad (2\text{-}74)$$

We can regard equation (2-74) as being obtained by summing (2-73) throughout by ignoring the term $\sum e_i$. Similarly, the second equation can be obtained by multiplying (2-73) throughout by X_i and again summing, this time ignoring the term $\sum X_i e_i$. Since $Ee_i = 0$, if the variable in (2-73) is uncorrelated with the disturbance, then ignoring the $\sum e_i$ and $\sum X_i e_i$ terms is justifiable provided we are dealing with large samples. For this reason, the OLS estimators obtained by solving the normal equations (2-74) are consistent. However, when correlation exists between X and the disturbance we can no longer ignore the $\sum X_i e_i$ term and the OLS estimators become inconsistent.

Suppose, however, we can find a so-called 'instrumental variable' Z which while correlated with X is uncorrelated with the disturbance. If in obtaining the second of the normal equations (as stated earlier) we multiplied (2-73) throughout by Z_i rather than X_i, then (this time ignoring the term $\sum Z_i e_i$) the normal equations would become

$$\sum Y_i = \beta_1^* n + \beta_2^* \sum Z_i X_i$$
$$\sum Z_i Y_i = \beta_1^* \sum Z_i + \beta_2 \sum Z_i X_i \qquad (2\text{-}75)$$

Since Z is by assumption not correlated with the disturbance we are justified in ignoring the $\sum Z_i e_i$ term for large samples. Hence the estimators of β_1 and β_2 obtained by solving (2-74) are consistent. The solution to the equation (2-75) is in fact (letting $z_i = Z_i - Z$):

$$\beta_2^* = \frac{\sum z_i y_i}{\sum z_i x_i} \quad \text{and} \quad \beta_1^* = Y - \beta_2^* X \qquad (2\text{-}76)$$

The expressions (2-76) are known as instrumental variable estimators of β_1 and β_2. In multiple regression, finding such consistent estimators involves finding 'instruments' for each explanatory variable that happens to be correlated with the disturbance. Such instruments must, in each case, be correlated with the relevant explanatory variable but uncorrelated with the disturbance.

Indirect Least Squares (ILS) is another way of deriving consistent estimates. This alternative method is introduced because it has a very useful economic and statistical interpretation.

The first step is to take the original set of equations, called the 'structural form' and transform it into its 'reduced form'. OLS estimation of the parameters of the reduced form is fully justified, and provides unbiased, consistent estimates. When these are transformed back into estimates of the structural parameters, the resulting estimates are consistent, despite small-sample bias.

In agriculture production, since inputs are applied first and the output is only obtained at the end of the production period the use of the ordinary least square estimation of the production function is appropriate. Hoch (1958) has shown that in order to avoid the simultaneous equation bias, the expected output should be used rather than the actual observed output. Since the disturbance only affects the output but not the rest of the variables in the system, he assumes that e_i is equal to zero and hence has no impact. The solution to this is as follows:

Let A(Yit) be the anticipated output for the farm i in year t, then from equations (2-69) and (2-70) we can derive.

$$p \frac{\delta A(Yit)}{\delta K} = P \frac{a}{K} (K^{a} L^{b}) = r \qquad (2\text{-}77)$$

$$p \frac{\delta A(Yit)}{\delta L} = P \frac{b}{L} (K^{a} L^{b}) = w \qquad (2\text{-}78)$$

The e_i does not enter in the equations and thus the use of single equation estimation is justified under such situation. This method will be adopted in the present study.

2.7.2. STATISTICAL PROBLEMS

The major statistical problem associated with the present study is the problem of multicollinearity.

Multicollinearity deals with the situation in which two or more independent variables in the single equation relationship are highly correlated with each other which leads to one or more other linear relationships between some or all of them (Heady and Dillon, 1966). When such a situation exists the estimates of the parameters become unreliable. The estimates will have a large variance and high standard errors so that the confidence interval for the parameter will be very wide. As such there is little confidence that the estimate will accurately reflect the impact of the variable on the production in the population (Lewis - Beck, 1980; Thomas, 1985).

However, it must be cautioned here that high standard errors not only reflect multicollinearity but also arise because the relevant variable may be genuinely unimportant in the production process.

The common symptom of high multicollinearity may be demonstrated through the overall high value of the R^2 in the model used. In this case, although the R^2 may be high, the coefficients of the independent variables may be highly imprecise and insignificant that is, with the wrong signs and/or large standard errors (Koutsoyiannis, 1973).

Another indication of the presence of multicollinearity is by looking at the bivariate correlations among the independent variables. If the value is about 0.8 or larger, then it indicates that multicollinearity is a problem (Heady and Dillon, 1966; Lewis-Beck 1980).

One of the measures that can be undertaken to reduce the problem is to increase the sample size since by this means the chances of obtaining statistical significance of the parameter will be greater, the bigger the sample size. However, if the sample size is fixed, one alternative is to combine the highly intercorrelated variables into an index provided it is logically sensible to combine them.

The researcher can also omit one of the highly correlated variables from the equation. However, in this case prior knowledge is required to determine the least important factors from the equation. Should such information is absent, some statistical tests could then be employed. The method of confluence analysis or t-statistic could be used as a guide to decide which particular factors are to be excluded from the analysis. Heady and Dillon (1966) state that, the decision to retain or remove the variables should be based on the physical, biological or economic relevance of the variable in the production process.

The degree of multicollinearity that arises can also be minimised without reducing the meaningfulness of the study by using principal component or factor analysis. This technique requires the rearrangement of the original variables into a new set of components. They can then be rotated to find their contribution to the explanation of the behaviour of the dependent variable.

In certain cases, where there exists high correlation between each two explanatory variables but low among all pairs of variables, input ratio between each two correlated variables can replace the original variable.

Generally speaking multicollinearity exists both in time series and cross-sectional data but the problem is more common in the former because of the tendency of the economic variables to move together over time. Apparently, there is no consensus yet as regards to the degree of multicollinearity that is tolerable in spite of the numerous methods available to diagnose it.

2.8. SUMMARY

This chapter has examined briefly the theory of production, the functions commonly used in agricultural production, and some of the problems involved with the estimation procedures. It seems that the choice of the algebraic form of production function could create some conflict between the realistic application of the theory, the statistical methods in hand, and the available information in practice. Nevertheless, numerous empirical investigations have shown that a simple functional form, often that of the Cobb-Douglas proves to be a useful tool in the agricultural production analysis. Given the situation at hand one should therefore, attempt to derive the best possible approximation that fits the actual situation.

CHAPTER THREE

COCOA: HABITAT AND CULTIVATION

Before any economic analysis is made on the production of cocoa at the smallholder's level it is important at this juncture to briefly outline first, some of the general features of this particular crop and the interrelationship that exists among the environmental factors as well as the standard cultivation practices that are considered vital for its growth. Such knowledge is important in order to familiarise the reader with some of the technical aspects associated with the production of this crop. The present chapter as such is devoted to a discussion on the ecology of the crop, its botanical features, varieties and the agricultural practices that have to be undertaken during crop production.

3.1. ECOLOGY

The cocoa tree, *Theobroma cocoa Linn*, is a tropical crop which belongs to the lower storey of the evergreen tropical forests of South America, where conditions are warm, shady and humid. It has been cultivated since prehistoric times by the Indians of South and Central

America. Its introduction to South-East Asia was mainly the efforts of the Spaniards and the Dutch in the 17th. Century (Urquhart, 1962).

It usually grows in groups along the river banks. The limits of cultivation are 20° North and South but the majority are grown within 10° North and South at low elevations, usually below 300 m. Good growing conditions of cocoa are associated with high humidity which is influenced heavily by rainfall and temperature. The optimum temperature suitable for cocoa planting varies from 21°C - 32.2°C with small seasonal and diurnal range. Rainfall requirement is between 1000mm - 2540mm and if irrigation is not available a rainfall above 1270mm is sufficient for its growth. However, an average of 100mm or over per month is preferable (Phang, 1978).

Hurricanes and gale of high velocity may cause considerable damage to the crop and if they blow from the sea, an accumulation of chlorides on the leaves may give rise to leaf scorch.

Soil required for cocoa cultivation should be well-drained, well aerated with good crumb structure and adequate supplies of water and nutrients. The best soils are aggregated clays and loams or sandy loams. Soil pH should be around 6.5 (Wood, 1975).

3.2. BOTANY

The trees are of variable height but are normally 6-8 meters. Seedlings form a single mainstem, 1-1.5 meter high at about 14 months. The terminal bud then breaks up into 3-5 meristems to give the so-called jorquette and grows out into lateral plagiotropic fan branches which may be almost horizontal. Further increase in height is made by an auxiliary bud just below the jorquette and this produces the orthotropic suckers or chupons which grow up vertically between the fan branches and then repeats the growth pattern by forming another jorquette and a second whorl of fan branches. In normal practice, unwanted chupons are removed by pruning.

Leaves of cocoa plants are large, simple, dark green when mature and have a petiole of 1-4 cm long. When young they are light green or of various shades of red, and very soft and limp.

Flowers and fruits are produced on the older leafless parts of the trunks and branches. Fruits are commonly called pods and are of variable sizes ranging from 10-32 cm long. The shapes of the fruits vary from nearly spherical to cylindrical, pointed or blunt, smooth or warty and with or without furrows. Young pods attain full size 4-5 months after fertilization and require another month for ripening.

Cocoa seeds are usually called beans and they number between 20-60 per pod. The size of the seeds varies from 2-4 cm and are ovoid or elliptic in shape. Fresh seeds are surrounded by mucilaginous, whitish, sugary, acid pulp which develops from the outer integument of the ovule. During fermentation and drying the pulp is removed. The seeds constitute about 25 per cent by weight of mature fruits; 250-450 dry fermented beans per pound.

3.3. VARIETIES

There are four main varieties cultivated in Malaysia (Phang, 1978):

(i) Criollo
(ii) West African Amelonado
(iii) Upper Amazon and
(iv) Trinitario

The Criollo variety produces the highest quality of all cocoas; only small quantities are now available on the world market. It is mainly used for the manufacture of chocolate. The pods are yellow or red when ripe and usually deeply furrowed, often markedly warty, and pointed. The seeds are large and almost round in section. Yield from this variety is low and the plant is prone to insect attacks.

The West African Amelonado was the first variety planted in Peninsula Malaysia during the early 1950s. The beans are normally used for the manufacturing of cocoa powder. The pods are yellow when ripe and consist of 40 pink seeds. Although yield from this variety is high, the plants, however, are not strong and easily susceptible to diseases and insect attacks.

The Upper Amazon variety grows faster and fruits earlier than the West African Amelonado. The yield is comparatively higher than the Amelonado variety. The pods are yellow when ripe and are of the same size as that of the Amelonado but with a rough outer layer. The seeds are violet and much smaller in size than that of the Amelonado. This variety is widely planted in Malaysia because of high yield and the plants are resistant to diseases and insects attacks.

The Trinitario is very heterogeneous and exhibits a wide range of morphological and physiological characters. The colour of the unripe pod may be whitish, green, red or purple and turns to yellow, orange or red when ripe. The pods are of various shapes with thick wall with the surface ranging from complete smoothness to heavy sculpturing. The seeds however are plump or flat. This variety is hardier and more productive than the Criollo. The Trinitario cocoas are of great importance for breeding and in the trade it is regarded as a 'fine' cocoa (Purseglove, 1968).

3.4. AGRICULTURAL PRACTICES

Agricultural practices in cocoa vary to some extent with the system of cultivation adopted, whether monoculture or dual culture. In monoculture, cocoa is planted in association with auxiliary shade trees, especially members of the Leguminosae. In dual culture, cocoa is planted mainly as an intercrop with coconuts.

3.4.1. PLANTING MATERIALS

Upper Amazon material, as well as some Upper Amazon x Amelonado and Upper Amazon x Trinitario hybrid progenies have proved more vigorous and rather more tolerant to dieback when compared with earlier Trinitario and Amelonado planting materials. For this reason, selected progenies have become preferred material and seeds of the chosen parental combinations are produced in specially designed seeds gardens.

3.4.2. GERMINATION

Seeds normally germinate immediately on reaching maturity and they remain viable only for a short duration. Before planting the mucilage surrounding the seeds must be removed either by using sand, wood ash or coconut fibre. They are usually planted 2.5-5 cm deep with hilum scar pointed downwards or horizontal and germinate in 2-3 weeks time. The first true leaves will appear 15-20 days after germination in the polythene bags. Seeds which do not germinate within 3 weeks after sowing should be discarded. Seeds may be planted at stake where 3 seeds per hole are planted and later thinned to one plant. This technique however, proves to be unreliable, agronomically. In general seedlings are retained in the nursery for 4-6 months. They are sown in soil mixtures consisting of 7 parts loam with a pH not higher than 6.5, 3 parts dried cattle manure, 2 parts sharp sand and 38 gm. double superphosphate per bag. Bag size varies according to the nursery period, 30 x 20 cm (lay/flat) polybags being commonly used where seedlings are grown for 4-5 months. If seedlings are to be retained longer in the nursery, larger polybags are needed. A small amount of fertilisers which consist of nitrogen or complete mixtures are applied. Seedlings may be grown with natural or artificial shade which should give 50 per cent sunlight. In coconut areas, the normal practice is to use palm fronds on a simple framework of posts and cross-pieces to provide shade and lateral protection. This shade is easily adjusted and is advantageous in that light penetration increases as the fronds decay. Initial shade intercepts about 80% full sunlight. When the seedlings are ready for transplanting the shade intensity should equal that in the field i.e. about 30% - 40%. In monoculture areas, nurseries have to be established under the natural shade of rubber, or Gliricidia maculata stands. At this stage spraying of insecticides is normally undertaken.

3.4.3. SHADE AND PLANTING DENSITY

There are two main shade systems involved in the planting of cocoa: (i) planted shade and, (ii) coconut shade. In areas where the land is cleared, a suitable shade must be created before the cultivation of cocoa. The initial desired shade level has to be attained within the shortest possible time so that the young cocoa can be planted without delay. This temporary shade can be provided by planting fast-growing, easily established shrubs such as the *Tephrosia* spp. For permament shade, slow growing tree species such as *Gliricidia maculata, Albizzia* and *Parkia* species can be planted earlier before cocoa is transplanted to the field.

To establish cocoa under existing coconuts is relatively easy because of a ready-made shade system. Coconuts are normally planted at 9 meters triangularly. The cocoa trees are then planted in double rows at a distance of

3-3.5 meters apart in the coconut avenues. Spacing within the cocoa row varies from 2-3 meters thus giving a planting density of 750 - 1000 trees per hectare.

Besides shade, cocoa requires good drainage and in many coconut areas, the coastal alluvial soil is poorly drained and as such drains are normally constructed in each or alternate avenues.

3.4.4. MANURING PROGRAMMES

The types and quantities of fertilizers to use in cocoa depend on edaphic and climatic conditions, age of planting and the shade intensity. On the coastal alluvial soils under coconuts, nitrogen and phosphorous are required for immature cocoa. When the plants come into bearing, nitrogen and phosphorous are still required and there is an increased need for potassium. Phosphorous is required in order to balance nitrogen uptake and stimulate bacterial multiplication for root development. Potassium is necessary in shade and it 'conditions' the plant against diseases and a deficiency of this mineral will cause wilting.

MARDI has given the general outline for the manuring of cocoa based on the age of the plants and types of soil involved (Table 3.1).

TABLE 3.1.
MANURING PROGRAMME FOR COCOA INTERCROPPED WITH COCONUT IN COASTAL AREAS OF PENINSULA MALAYSIA
(for Selangor, Kangkong and Briah soil series)

AGE OF PLANT (months)	TYPE OF FERTILIZER	DOSAGE PER TREE (grams)
2	Compound A	14
4	Compound A	28
6	Compound A	56
9	Compound A	185
10	Lime	227
12	Compound A	113
16	Compound A	142
20	Compound A	142
22	Lime	340
24	Compound A	170
30	Compound A	170
34	Lime	340
36	Compound B	170
42	Compound B	170
46	Lime	340
48	Compound B	198
54	Compound B	198
58	Lime	340
60	Compound B	227
66 and thereafter	Compound B	227

Source : MARDI (1984)

Remarks: Compound A fertilizer consists of more nitrogen with the ratio of 18N : 11P : 5K : Mg O 2.5
Compound B fertilizer consists of 14N : 14P : 14K

3.4.5. PRUNING

The main objects of pruning are to allow a development of a framework of branches which will give a tree in the shape of an inverted cone, to remove unwanted growth, and to obtain a closed canopy. Drastic pruning reduces early yields and should be kept to a minimum.

In pruning seedling trees, all basal chupons are removed as soon as they appear. The height of jorquetting is adjusted to a uniform height by pruning off jorquettes which form below 1.0-1.5 meter. Generally, development of a second jorquette is prevented by removing chupons at regular intervals; however, some organizations allow a second jorquette to form in Amelonado plantings and older hybrid plantings. When the jorquettes are formed usually only four fan branches are retained.

Maintenance pruning consists of periodic light pruning to enhance vigour of bearing branches and to facilitate access for spraying and harvesting. If the canopy is too dense, smaller branches are chopped to reduce the shade. Low branches which incline towards the ground are eliminated. If there is an outbreak of diseases or pests, more urgent and immediate pruning measures will usually be necessary to check its spread. In certain cases, it may be pertinent to carry out pruning in order to obtain well-ventilated canopies as a control or preventive measure against black pod.

3.4.6. WEED CONTROL

Manual weeding is commonly practised in young cocoa stands. This involves strip or circle-weeding, the interrows being regularly slashed or sprayed with herbicides. By the time the cocoa is 2 years old, a complete canopy should have formed; the shade provided by the combination of cocoa and the shade trees should thereafter be adequate to suppress most weeds. Only occasional spot spraying is needed in order to maintain satisfactory ground conditions.

3.4.7. PESTS AND DISEASES

Cocoa is normally subject to a number of pests and diseases and the incidence of which has at times given cause for alarm. Leaf-eating insects such as *Apogonia* sp. and *Valanga* sp. can seriously damage cocoa. An integrated programme of control is practised using natural predators to the extent possible and supplementing this with a programme of insecticide sprays. The incidences of diseases such as dieback and black pod may be countered by pruning and removal of affected tissues. Pod damage by mammalian pests is a serious problem. Regular shooting gives partial control of squirrels and monkey, while rats can be controlled to a large extent by using poisoned baits.

3.4.8. <u>HARVESTING</u>

Cocoa usually commences bearing in the second year after planting and harvesting consists of picking and breaking the ripe pods, removing the beans and transporting them to the fermentary. Most pods assume a distinctive colour when ripe. For example, green-podded Amelonado turns yellow, and red pods usually turn an orange or near-orange colour. These changes are slow and the pod will remain in a suitable state for harvesting for two or three weeks.

The fruits are borne on cushions on the stem of the tree. This may cease to bear if damaged, so it is most important that the harvesting tools should be sharp so that cushions cannot be injured, as a damage cushion can provide a point of entry for fungi. The pod stem should be cut close to the tree, the thickened jointed portion being left attached to the cushion. This stump drops off later, leaving a well-healed scar which is impervious to fungi.

The pods are usually harvested at fortnightly intervals. However, during peak seasons more frequent harvesting rounds are carried out. Harvested pods may be left in the field for up to 3 days. Pods are split in the field and husks left in small heaps. For each harvesting round, new sites for splitting are chosen. After pod splitting the wet beans are despatched with a minimum of delay for processing.

3.4.9. FERMENTATION

During fermentation, the mucilage surrounding the seeds is removed, the purple pigment diffuses through the cotyledons, the precursor of the chocolate flavour is produced and astringency disappears. Cocoa is fermented in heaps or in baskets and the beans are left for 4-7 days depending on the season. They may be left undisturbed or may be turned once or more times. Wooden sweat boxes are also commonly used for fermenting the cocoa beans. The dimension of the box varies and a good average size is 2 x 1.5 x 1 meter. The base is normally slatted to allow aeration and free drainage of the sweatings. The period for fermentation is between 6-7 days. During this process the beans are transferred to a second box after 2-3 days, then to a third box after a further 2-3 days and remain there for a further 2 days.

In the estates a method has been devised of fermenting in trays 92 cm x 122 cm and 10 cm deep with slatted bottoms and these are stacked to a depth of 10 trays and covered with sacking. With this method, Amelonado fermented in 3 days without any mixing and the same trays can be used for drying.

The temperature rises to about 96°F during the first 36 hours of fermentation. During the existence of very limited aeration, the yeasts that develop will convert the pulp sugar into alcohol and carbon dioxide. Subsequent enzymic reactions will lead to the hydrolysation of proteins present into amino-acids. The colour of the tissues becomes progressively paler and then pale brown. The brown colour deepens; the cotyledons shrink from the testa and separate. There is a gradual development of the aroma and flavour and loss in astringency.

3.4.10. DRYING

After fermentation, the beans are spread on mats, trays or drying floors and dried in the sun. In the estates, where bean production is high and weather does not favour sun drying of large quantities of beans, virtually the entire estate crop is artificially dried. During the process of drying, enzymic action continues and the moisture content is reduced from 56 to 6 per cent. During the whole process of fermentation and drying the loss in weight is 55 - 64 per cent.

When fully dried, beans are normally graded to remove flat, undersized and broken beans together with foreign matter and bean aggregates. This task has until recently been done manually but some estates have installed machinery to clean and grade the produce.

3.5. LABOUR REQUIREMENTS

The amount of labour required to undertake all those farming operations discussed earlier varies according to the system of cultivation adopted and also on the age of the cocoa trees. Generally speaking, when cocoa is still in its immature stage, more labour is needed to perform both the weeding as well as the crop pretection activities. On the contrary, when the plants are in full bearing, more time however, has to be spent on the harvesting operations and less on maintenance. As a guideline, the annual labour requirements for cocoa intercropped with coconuts on a per acre basis are as follows : 2.7 man-days for manuring, 2.5 man-days for crop protection while the corresponding figures for weeding, pruning, plucking, pod spliting and transporting are 2.5, 3.4, 16.3, 8.3 and 4.5 man-days, respectively (Shaaban and Mohammed, 1984).

These figures however, are computed based on the assumption that the farmers fully undertake all those recommended practices as discussed earlier.

3.6. SUMMARY

This chapter has examined briefly the complex set of relationships that exist among the environmental factors affecting the growth of cocoa. Many of these variables which are essential for the continued well-being of the crop are however, not yet fully understood. For instance, the light required for the establishment of cocoa has yet to be accurately measured. The chapter also touches on the basic agronomic practices as well as the processing techniques that have to be adopted by the producers in the process of cocoa production. These practices and techniques, nevertheless, differ from one operator to another depending upon the scale of operation and the financial means as well as the knowledge possessed.

CHAPTER FOUR

LITERATURE REVIEW

4.1 PRODUCTION EFFICIENCY STUDIES IN TRADITIONAL AGRICULTURE

The efficiency of resource use has long been an area of concern for economists and policy makers especially in the developing countries. Following the publication of Schultz's book in 1964, it has been observed that his hypothesis that 'there are comparatively few significant inefficencies in the allocation of the factors of production in traditional agriculture' (Schultz, 1964, p.37) has been a topic of substantial interest in recent years. Although he explicitly mentioned allocative efficiency it is clear that he also posited perfect technical efficiency when he stated that one implication of his 'efficient but poor hypothesis' is

> 'that the combination of crops grown, *the number of times and the depth of cultivation, the timing of planting, watering, and harvesting*, the combination of hand tools, ditches to carry water to the fields, draft animals and simple equipment - are all made with a fine regard for marginal costs' (Schultz,1964: 39).

In his influential study Schultz defined traditional agriculture as one that had attained a long-run equilibrium with respect to the allocation of the factors of production at the disposal of the farmers and to investment to increase the stocks of such factors. In this stationary state, all opportunities inherent in a given 'state of art' (an unchanging supply of productive factors and a constant technology) for increasing agricultural productivity had been exhausted. In support of this hypothesis, he had recourse to an empirical study by Hopper (1965). The latter in examining the factors affecting the productivity of barley, wheat, pea and gram in Uttar Pradesh, India, used the Cobb-Douglas production function in his analysis. The inputs examined comprised land area, bullock labour, human labour and irrigation water. Results of the analysis revealed that all these variables were important in affecting the production of these crops. It also emerged from this study that the sample farmers had achieved an optimal allocation of their resources (where the marginal value products (MVPs) equal the price of the factors), on the basis of which Schultz felt able to justify his general hypothesis as stated above.

Since the appearance of the Schultzian hypothesis, several studies have been undertaken in most of the developing countries in an attempt to test it and most researchers have concluded that their studies supported this hypothesis.

The study by Yotopoulos (1967) in the Empirus region of northern Greece is by far the most thoroughgoing of those so far addressed to the efficiency of traditional agriculture. In this study the crops examined comprised cereals, legumes and animal feeds, industrial crops, vegetables, vines, olives, citrus and deciduous fruits. By computing the marginal value product of each input of production for the 'average farm' and comparing it to the factor's opportunity cost, he found that land and labour were allocated very efficiently. The position with regard to the three capital input classes comprising equipment, plant and live capital (combination of livestock and different categories of trees) as well as the educational variable was not so clear. The difficulties in assessing capital use arose from the definitions of the service flows employed to measure capital inputs. As a consequence pricing of these production factors becomes somewhat ambiguous. Efficiency in the use of education could not be assessed because of the lack of data on its marginal cost. Overall he concluded that the traditional agriculture of Epirus is 'poor but efficient'.

In an attempt to evaluate the efficiency of Indian farmers in allocating resources available to them, Sahota (1968) incorporated input factors such as labour, fixed capital, land, seeds, fertiliser and irrigation in his analysis.

Average and marginal productivity differences were derived for these inputs in the production of nine different crops comprising wheat, jowar, bajri, gram, aus and aman paddy, pulses, potatoes and jute across different regions and over various farm sizes. The results, on the whole, did not lead to the rejection of the hypothesis that there were comparatively few inefficiencies in resource allocation in Indian agriculture.

Massell (1967) using the Cobb-Douglas production function estimated the marginal value productivity of land, weeding labour, fixed capital, soil type, fertiliser and manure in twenty peasant farms from the Mt. Darwin district of Rhodesia. Three crops were involved in this study, corn, peanuts and millet. He analysed the effects of different quantities of these resources on the value of the marginal products and made not only interfarm comparisons but also comparisons between marginal value productivities and factor prices. He concluded that the results obtained provided little evidence of potential gains from reallocation on the average farm but there might be considerable scope for gain to the individual farmers.

In a study conducted in Northwest Malaysia, Barnum and Squire (1976) illustrated that except for capital service, all other variables comprising area operated, labour, capital services and 'other variable inputs' have a significant influence in the production of paddy. In analysing the economic efficiency of the four inputs that were incorporated into the analysis, they found that by comparing the marginal value productivity of each of those inputs with their respective marginal factor costs, only labour, capital services and 'other variable inputs' were economically efficient while that of land size was not.

In an attempt to examine the production behaviour of the paddy cultivators in the MUDA Irrigation Region, Malaysia, Tamin (1978) incorporated six input factors in his analysis. The inputs involved were land size, labour, animal input, mechanical input, fertiliser and fixed assets. Using the Cobb-Douglas production function he found that all the variables except mechanical input were statistically significant. Among the inputs, land size was the most important factor followed by labour. From the test of allocative efficiency, he revealed that these farmers were allocatively efficient in the use of farm inputs.

Similiar studies on paddy conducted by Nasuddin (1976, 1983) in the states of Selangor and Perlis in Malaysia also tend to support the Schultzian hypothesis. In both the studies undertaken, the inputs analysed were the land size, labour, seeds, pesticides and the amount of urea used. Again using the Cobb-Douglas production function, it was demonstrated that land size and urea were significant contributors in the production of paddy while labour and the rest of the inputs were not statistically significant. When comparisons were made between the marginal value productivities and the marginal factor costs of the respective inputs, it was found that all the inputs analysed were allocatively efficient.

In the case of rubber an attempt has been made by Abdullah (1978) to examine the effects of some of the input factors used in the production of this particular crop at the smallholders level. In the state of Malacca, Malaysia, Abdullah (1978) reported that among the inputs analysed, the number of rubber trees planted, harvesting labour and fertilisers were the significant contributors that affect the crop yield. On the other hand, the use of chemicals, maintenance labour and age of the rubber trees seemed to have no significant impact. As for the sociological variables, he further demonstrated that farmer's age, farmer's education as well as the education of the family members were the only variables that have a significant influence on the yield. In this study a translog production function was used as the basis of analysis.

When an analysis of allocative efficiency was performed, he found that the number of rubber trees planted and the amount of fertilisers used were still not efficient. He therefore suggested that the number of trees as well as fertilisers should be increased in the production process as their quantities were still below the optimum level. Only harvesting labour was found to be efficient in relation to the ruling input and output prices in this study. In spite of the mixed results he, however, concluded that the study conducted supported the hypothesis that the smallholders were 'efficient but poor'.

Other studies conducted by Somel (1979) in the case of wheat in Turkey and paddy in the case of the study by Adulavidhaya *et al* (1979) in Thailand also supported the Schultzian hypothesis.

In examining the efficiency of the rice farms in the Philippines, Lingard *et al.* (1983) found that from the cross-sectional estimates of the pooled data, beside land area, inputs such as irrigation, mechanisation and fertiliser were also found to have a significant influence on the production of rice. When differences are allowed between farms, the outcomes demonstrated that the variations in efficiency that arise were mainly attributed to such factors as soil type, land tenure, education and access to credit. The study suggested that extension efforts should be stepped up in order to improve rice farming and to further investigate the reasons for the poor performance of the managerially 'worst' farms in this area.

The appearance of the Schultzian hypothesis however, has gave rise to substantial debate and criticisms by other researchers. A notable one came from Michael Lipton (1968). The latter, based on the observations arising from a survey of 62 peasant farmers in an Indian village rejected the hypothesis and responded with his own generalisation of the behaviour of the peasant farmers. He potrayed these farmers as one of maximising utility rather than maximising profits. His argument was based on the fact that the farm families were motivated by many things other than the quest for profit. In their decision making behaviour farmers have to face constraints which reduced profits. Of the many constraints he singled out risk and uncertainty arising from the variability of outcomes. He clearly stated that the high variance of rainfall and yields have a considerable influence on the decision making behaviour of the farmers and as a result they tend to be risk averters. In order to survive they must pursue a lower mean, lower variance strategy which increases their security. This however, requires the farmers to pay a high risk premium to insure against disaster. This 'optimal' strategy by which the farmers maximise their utilities is termed as the 'survival algorithm' in the words of Lipton. In the pursuit of this strategy they operate a group of practices and decisions for allocating the farm inputs which allow them just tolerable levels of profit, security and status. According to Lipton's decision algorithm allocative inefficiency is the consequence of risk aversion.

A considerable amount of research activity has been undertaken to test the Liptonian hypothesis. Michael *et al.* (1976) for instance, in their attempt to examine the cropping patterns chosen by a group of peasant farmers in Surat District, India, found that the farmers were willing to reduce their incomes substantially from the maximum obtainable to lower the risk. The study revealed that the farmers had struck a balance between two competing criteria, that is increasing income and decreasing risk, measured by the variability in income around its mean level. This study clearly supported the Liptonian hypothesis.

A study by Wolgin (1975) on smallholders in Kenya also provided strong evidence of risk averse behaviour. It was found that the marginal value products for most inputs were higher than their unit costs. This implied that the farmers used less than the economic optimum level of input and may be explained by their willingness to forego income in exchange for a reduction in risk. This was strongly supported by the fact that the ranking of crops by the marginal value product correlated closely with their marginal contributions to risk. In other words, the riskier the crop, the higher was the marginal value product, which implies that the farm resources used were further below their economic optimum.

Dillon and Anderson (1971), however, in examining the samples collected by Chennareddy (1967) for South India, Yotopoulos (1967) for nothern Greece and Hopper (1965) for North Central India found mixed results. They asserted that attitudes to risk varied both among farmers and, between one farmer and another. Although they acknowledged that quantitative information on risk attitudes is an important element in the understanding of the behaviour of the farmers in underdeveloped agriculture, nevertheless, to them risk is not a negative influence for all producers.

A more recent critic of the Schultz's efficiency hypothesis came from Shapiro (1974). In examining Hopper's data and those of Welsch (1965), Chennaredddy, (1967) and Sahota (1968), he argued that in most cases the claims that farmers are 'poor but efficient' were false. When a closer examination of the data was made, he found that approximately one third of the ratios (i.e. the ratios of marginal value productivity to marginal factor cost) differed significantly from one and hence contradicted the efficiency hypothesis. The remaining ratios ranged from 0.59 to 3.61 but all were not significantly different from one. He concluded that the data presented therefore, did not provide support for the Schultzian hypothesis that peasant agriculture is highly efficient. On the other hand, given the available inputs and technologies, sizeable deviations from optimal resource allocation and from the highest output-input ratio were revealed from the analysis of those data. According to him the hypothesis might not apply to all of traditional agriculture and that development policies might fruitfully place more emphasis on raising large numbers of farmers closer to the relatively high efficiency levels achieved by some of their neighbours.

4.2 PREVIOUS COCOA STUDIES IN MALAYSIA

Studies dealing with cocoa productivity at the farm level are limited. As a result little information is available on the productivity of cocoa production inputs either individually or jointly and also on the efficiency of input combinations. As a consequence it is impossible to ascertain the optimum size of the cocoa holding or the efficiency of the existing enterprise (Miranowski and Simmons, 1976).

In Malaysia, up till now major attention has been focussed on the study of the agronomic aspects of cocoa production which encompasses varietal improvements, soil suitability studies, fertiliser trials, weed control and crop protection. Although all these efforts are aimed at increasing cocoa productivity, it is surprising to note that applied economic research through the use of mathematical models has not been widely undertaken by the relevant agencies.

Most of the farm management studies that were conducted locally were not rigorous in their analytical approach. They only made use of simple linear models and descriptive statistics for estimation purposes. The use of descriptive statistics by Teoh *et al.* (1977), Nik Fuad and Mohd Sharif (1978), and Ministry of Agriculture (1984) poses severe drawback since they do not provide detailed information in terms of the statistical significance of the variables and the degree of correlation that exists. The data obtained from previous studies only furnish general background information as to the causes of the problem. In addition some of the more important variables were not incorporated in the analysis. As such the studies undertaken were not complete and conclusive.

Teoh *et al.* (1977) in their investigations on the problems faced by the cocoa smallholders in the region of Lower

Perak incorporated the following variables, namely; land size, weedicides, fertilisers, pesticides, planting density and related agronomic practices in their analyses. A total of 176 smallholdings were randomly selected according to the years when cocoa was being planted. Owing to time and resource constraints, the survey only covered cocoa planted between 1969 and 1974. For this purpose, a questionnaire was used to acquire the desired information.

The results of the analysis indicated that the majority of farms were of small size. It was also reported that the application of modern inputs such as herbicides, fertilisers and pesticides was minimal. In the third year of planting, approximately 38 per cent of the farmers had already stopped the application of fertilisers. This was mainly due to the lack of financial means to purchase the input. As for those who applied insecticides, varied success was obtained owing to the improper methods of spraying, the timing or selection of the suitable insecticides. Approximately, 37 per cent of the farmers sampled used herbicides for weed control while the rest either did it manually or a combination of both.

The undertaking of other agronomic practices such as drain maintenance and pruning of the cocoa trees was far from satisfactory. Poor maintenance of drains resulted in the flooding of the farms during the rainy season. Approximately 26 per cent of the farms were subjected to flooding during the study period. Many of the farmers did not know the proper methods of pruning their trees and as a consequence excessive shading was a problem.

Owing to improper agronomic practices that were being carried out by the farmers, yields obtained were low especially during the first two years of bearing. At this stage, they only managed to get about 47kg. of dry beans per acre annually.

Although productivity estimates were not part of the study, they suggested the use of high-yielding varieties and fertilizer subsidy in order to obtain higher yields. In addition, they emphasised the importance of extension services in an effort to educate the farmers regarding some basic aspects of cocoa agronomy.

In another study conducted in the same area Nik Fuad and Mohd Sharif (1978) pointed out that the cocoa yields obtained were rather low mainly due to inadequate fertilisation, non-optimal shade regimes and poor management. In their study inputs that were examined comprised mainly farm size, labour, fertilisers and planting density. Although the study was mainly undertaken to assess the socio-economic status of the coconut smallholders in Lower Perak, part of the analysis also covers the status of the cocoa farmers in the area.

A total of 194 farmers mainly from the participants and non-participants in the Coconut Replanting and Rehabilitation Scheme were selected from the regions of Bagan Datoh, Hutan Melintang and Teluk Baru. All the interviews were conducted in 1977 with the aid of questionnaires and the data were analysed by means of frequency distributions.

Results of this study also tend to confirm the findings of the earlier study conducted by Teoh *et al* (1977). As for labour utilisation, it was reported that the cocoa smallholders in Bagan Datoh utilised 110 man-days of labour per acre annually while the corresponding figures for Hutan Melintang and Teluk Baru were 114 man-days and 131 man-days, respectively. According to this investigation, there was underutilisation of the labour input during the study period.

The survey also revealed that the planting density of 61 palms per acre was above the recommended level and this tends to pose a problem to the cocoa that was being intercropped due to the heavy shade provided by the palms. It was found that the annual average gross income derived from cocoa was low at M$106.88 per acre for the region of Hutan Melintang, M$414.57 in the case of Bagan Datoh and M$336.44 for Teluk Baru. This was in spite of the high price of wet beans at M$2.10 per kilogramme during the reference period.

As with Teoh *et al.* (1977), the study conducted by Nik Fuad and Mohd Sharif (1978) also recommended the extension of the fertiliser subsidy, improvement in the extension services and the adoption of an intensive system of cultivation in order to increase cocoa productivity.

In 1984 another study was undertaken by the Ministry of Agriculture to examine the problems of low cocoa productivity in smallholders sector. A total of 161 farmers from 12 Kampung covering the states of Johore, Selangor and Perak were selected for this purpose. The variables selected were the age of the farmers, educational status, credit facilities, tractor and market services, soil, land size, planting material, modern inputs and labour.

The study demonstrated that one of the major problems encountered by the smallholders was the lack of cash for the purchase of modern inputs. The extension services were reported to be ineffective since the majority of the farmers still lack the knowledge to manage their holdings properly. The study results also showed that the low returns from cocoa were mainly due to poor management practices. Although quite a considerable number of farmers applied fertilisers to their plants, the majority applied them once a year. Insecticide application was minimal and those who undertook preventive measures, did it once a year, too. However, most of the sampled farmers realised the beneficial effects of pruning their cocoa trees in order to stimulate fruiting. Other findings reported were the smallness of farm size, low level of educational attainment on the part of the farmers, low planting density and low level of labour utilisation.

The study among other things suggested that there should be an improvement in the management of the farms, an effective extension system and the density of cocoa trees should be increased to its optimal level in order to increase farm income.

Shukri *et al* (1987) in their investigation of the production behaviour of the cocoa farmers in Tanjong Karang Selangor used a mathematical model to quantify the relationship between the gross income obtained from cocoa and coconut and the farm inputs used.

The variable studied were land size, labour, fertilisers, insecticides, planting density, credit, extension contact, age and level of educational attainment of the farmers.

For this study, 80 samples were selected from six Kampung in the district using a simple random sampling. The selection of the farmers to be surveyed was heavily influenced by the extension personnel in the study area, and this raises doubts about the representativeness of the whole samples collected.

Results obtained indicated that land size and planting density were the only inputs which were statistically significant. The study however, recommended that land size should be increased to enhance yield. The same goes to the use of the complementary inputs.

Nasuddin *et al.* (1987) used regression analysis in an attempt to examine the effects of some of the farm inputs on the production of cocoa. A total of 100 farmers were selected randomly from the District of Hilir Perak. The inputs selected comprised fertilisers, insecticides, land size, age of cocoa trees, planting density, labour, age and educational level of the farmers. The results of the analysis indicated that land size was the most important determinant of cocoa production. This variable explained 40% of the variation in the output received. They suggested that land size should be increased and more use of fertiliser and insecticides as well as the improvement in the extension services should be undertaken in an effort to increase the output of cocoa.

This study, however, is still far from complete since the majority of the most important inputs such as management, capital, and weedicides which were supposed to have a considerable contribution to the production of cocoa were omitted from the analysis. Land fertility differentials were also neglected.

The gross income used as a dependent variable was the income derived solely from the sales of cocoa products. The researchers did not take into account those income obtained from the sales of coconut products (nuts or copra). As a result the regression estimates obtained did not provide a true picture of the overall situation. This is because cocoa is planted under coconut on the same piece of land, thus any usage of input especially fertilisers will provide beneficial effects to both crops. The estimates would be meaningful only if the dependent variable used reflects the total gross income from both the crops.

4.3. PREVIOUS COCOA STUDIES ABROAD

In this section the related studies that had been undertaken in other major cocoa producing countries such as Brazil and Africa are presented.

De Carvalho (1972) in his study of the production factors employed for cocoa production in Bahia, Brazil, only concentrated on the use of the following inputs: land size, labour, pesticides, fertilisers, general expenses and management practices in his analysis.

The specific objective of the study was to examine the impact of these inputs on cocoa productivity and for this purpose, 122 samples were selected by means of a stratified random sampling.

Although the Cobb-Douglas production function was used for estimation purposes, however, the study did not reveal which particular inputs were statistically significant. From the analysis of allocative efficiency the results indicated that inputs such as labour, pesticides and general expenses were being used too much by the farmers while on the contrary, land and fertilisers were being too little used. He suggested that the re-organisation in the use of these inputs was essential in order to achieve maximum profit. He also stressed the need for the training of the labour force in order to improve their skills in the management of the cocoa farms.

In the study, no mention was made as to how the dependent variable was being measured. Furthermore, other relevant inputs were also not included in the analysis. However, the mathematical model used is similar to that of the present study.

In studying the economic aspects of cocoa production in Bahia, Brazil, De Souza Menezes *et al.* (1974) included input factors such land size, management, labour, fertilisers, lime, fungicides, miscellaneous expenditures and service flow for improvements, livestock and equipment in their production functions.

In this study the data were obtained from farm records kept by the farmers who were closely monitored by the agricultural body in charge of cocoa production. The Cobb-Douglas production function was estimated using the Ordinary Least Squares technique.

As far as the techniques of measurement were concerned the dependent variable was measured in physical units while that of the independent variables were in monetary values. Management input was measured by dividing the gross income by the total cost incurred. Results of the analysis revealed that all the inputs were statistically significant. They further discovered that although all the producers were operating in the rational areas of production, all the inputs used were not allocatively efficient. They suggested that the use of farm resources should be increased to achieve maximum profit.

The present study differs from that of De Souza Menezes *et al.* (1974) in the choice of the farm inputs and the techniques employed in measuring the management input and also land size. It is however, similar in terms of the production function model used.

Costa and Reis (1982) in an attempt to analyse the economic efficiency of the input factors used for cocoa production incorporated eight inputs in their analyses, namely; area of land cultivated, investment in working animals, total days used in the production process, fertilisers, insecticides, fungicides, capital and general cost. The dependent variable was measured in terms of dried cocoa beans on a per hectare basis and this also applies to that of the independent variables. Capital input comprised improvement in installation, equipment, building and repairs. General expenses were composed of insurance and medical cost. All the fertilisers, insecticides and fungicides were measured in physical units.

In this study a cross-sectional data from 76 estates were collected for the purpose. The method of estimation was by the use of Ordinary Least Squares technique with the Cobb-Douglas production function in its natural form being used as a basis of analysis.

The overall results indicated that the inputs that were statistically significant were mainly labour, fertiliser and capital while the rest were not. It was further indicated that from the analysis of economic efficiency, except for labour, all the resources were not being used to the optimum level. Marginal productivity of fungicides was found to be highest in the analysis made. The estates as a whole were operating the resources in the rational area with proportionately decreasing yield. The study suggested that the application of fertiliser, fungicides and insecticides should be increased in order to increase yield.

The present study differs from that of Costa and Reis (1982) in terms of the selection of the variables, methods of measurement for certain inputs and is similar with respect to the mathematical model used.

In the present analysis, labour is categorised as maintenance and harvesting labour, while that of capital inputs denote the living trees (cocoa & coconut) and farm tools used in the production process. Expected gross income is used as the dependent variable instead of the actual gross output in order to avoid simultaneous equation bias. Both education of the family members and the farmers, as well as the practice of keeping farm records, age of the farmers, working experience and extension contact are used as a proxy for the management ability in the present study. Nevertheless these inputs are omitted by Costa and Reis (1982). Inputs such as weedicides, the amount of credit were also omitted from their investigation.

In the study of cocoa production in Eastern Cameroon, Thirtle (1984) selected the input factors comprising land size, labour, age of the farmer, level of education, experience, extension contact and pesticides application in his analysis.

The objective of the study was to estimate the productivity parameters of the factors of production so as to furnish information for the formulation of appropriate policy measures. To this end about 830 households were surveyed in the Eastern Province of Cameroon and the data obtained were estimated by means of the Cobb-Douglas production function.

The results revealed that land and labour were the two major determinants of cocoa production. Labour alone accounted for about two thirds of the total output and the remaining was attributed to land size. However, the contribution from work teams, exposure to extension services, years of schooling and working experience were not statistically significant. The study suggested that there were few efficiency gains to be made from increasing the size of the holdings.

In this study planting density was used as a proxy for land size while the extension contact only took into account the exposure the farmers had with the extension service during the last three months prior to the start of the survey. The question of quality with respect to input used was not included in the analysis. Neither were relevant inputs such as management, capital and others. All these constitute the major differences with the present study. However, the similarity lies only in the mathematical model used.

In examining the problems of increasing cocoa production in Ghana, Boateng (1982) chose 20 input factors in his study. Three mathematical models comprising the linear, Cobb-Douglas and Translog production functions were used as the estimation procedures.

The results showed that cocoa farm size, age of cocoa trees, the use of chemicals, family size and expected income from cocoa were the important variables considered in the decision-making involving income from cocoa. Whereas age of the farmer, sex and agronomic practice were not statistically significant. From the analysis of allocative efficiency it was noted that all the technical inputs incorporated in the analysis were not efficient. The study emphasised the need for the subsidised inputs to reach the farmers in the required quantity and at the correct time and place and the introduction of a simple technology to aid the farmers in their labour problems.

The methods of measurement for some inputs like chemicals used differ from the present study. Another difference lies in the treatment of inputs in the analysis. Boateng (1982) treated expected income from cocoa as the independent variable whereas on the contrary the present study uses this input as its dependent variable in order to avoid simultaneous bias. In spite of the wide coverage made in selecting the input factors, this study is still considered far from complete especially with the omission of management and capital inputs.

4.4. CONCLUSION FROM VARIOUS COCOA STUDIES

Studies which had been undertaken by previous workers on cocoa are still considered deficient in many aspects. Many of the inputs which are thought to have a significant impact on cocoa production are omitted by the researchers either locally or abroad. A typical example is in the case of input factors such as management. This input which plays a considerable part in the process of production was not included in any of the studies discussed above except the one undertaken by De Carvalho (1972). As a result this may cause bias in the results obtained. De Carvalho (1972) however, used an auxiliary variable obtained by dividing the gross income by the total cost to capture the effect of management in production.

This measure however, is not very reliable since it reflects profits and losses due to factors which might be beyond the control of the farmers. Crop losses due to natural disaster, for example, may result in a great financial loss to the farmer. Similarly, a sudden drop in the price of the commodity as a result of the glut in the world market may also result in less profit to the farmer. This method of measurement adopted is an 'after the fact' measure; it can be used only after the activity has been completed and hence has have no prior predictive value; it measures the residual rather than management as an input. This measure also poses a lot of problems in the sense that there is bound to be errors of measurement owing to the lack of available records, knowledge and poor recall of the respondents in personal interviews.

Similarly, education of family members was also ignored in the previous studies. As the decision making process at the farm level is greatly influenced not only by the level of the farmer's education but also by that of other members of the family, it is felt that this input should be included in the analysis. Other omitted inputs comprised living capital, soil types, credit and the practice of farm bookkeeping. The consequence of not incorporating the relevant inputs into the analysis leads to incompleteness of the models used.

Furthermore in all the studies conducted, estimation of the production function model was made by the Ordinary Least Squares technique. No attempt however, was made by the researchers to solve the problem of simultaneous equation bias that arises.

Quality differentials were also ignored in some of the studies made. An example is in the case of land. No attempt was made to reflect the quality of this input by previous researchers.

The present study however, attempts to correct some of the deficiencies prevalent in the previous investigations by incorporating a wider selection of relevant input factors into the analysis. A Cobb-Douglas production function is applied to cross-sectional data in order to identify the determinants of cocoa production. In addition this study also attempts to examine whether the resources used in the production process are efficient or not. It is hoped that the information obtained will provide some useful information for the development of the cocoa industry in Malaysia.

4.5. SUMMARY

This study has attempted to examine some of the previous studies that have been conducted by other research workers in related discipline both for cocoa and other crops, either locally or broad. It has been found that studies dealing with cocoa productivity are limited, especially in Malaysia. The investigations that have been undertaken by the local researchers are deficient in terms of the statistical tools employed and the variables selected for the analysis. As a result little information is available as regards to the factors that actually contribute to the production of cocoa which are vital for policy action.

Although the present study has some similarities with other investigations carried abroad, nevertheless, it differs mainly with the selection of the farm inputs and the measurement techniques employed for some of the variables as well as the socio-economic environment that exists. This study therefore, hopes to generate some new information to assist the development of the cocoa industry as a whole.

CHAPTER FIVE

ESTIMATION OF COCOA/COCONUT PRODUCTION FUNCTION

In this chapter, the types of inputs used and the justification for their selection in the present study will be presented. In addition, the techniques of measuring these inputs, the basis of selecting the production function for cocoa at the farm level, as well as the hypotheses to be tested, will be discussed.

5.1. THE NATURE OF INPUTS USED IN COCOA PRODUCTION

As shown in chapter three, numerous inputs are involved in the production of cocoa and it is quite impossible to list them all. Basically we can divide them into two categories, namely; controllable and non-controllable inputs. Inputs like solar radiation, amount of rainfall and relative humidity are important for the production of cocoa but these inputs are beyond the control of the operator. Although they can cause considerable variations in the yield nothing much can be done about them in the process of production at the farm level. Controllable inputs like fertilizers, insecticides, weedicides, planting materials and farm tools, to mention a few, can be varied in their applications depending on the circumstances that arise. For example, a farmer may reduce the application of insecticides if there is no pest attack on his holding; or he may not apply large amount of weedicides if there is ample supply of labour to perform the weeding operation in the field.

In the production of cocoa, there are also inputs that can be substituted with one another but their degree of substitution is not actually known. A particular farmer has the choice whether to use organic or non-organic fertilisers; weedicides or weeding labour; or using less fertilisers and more cocoa trees in order to produce a certain amount of output. Thus numerous alternatives are available and it is up to the individual farmer to decide which one is the best in his farming operation.

The issue of defining and measuring the inputs used and the output produced should also deserve considerable attention in any production process. According to Heady and Dillon (1966, p 218):

> 'The applicability of an empirically derived function depends on the way in which the input and output factors are defined and measured, and on the use to which the fitted function is to be put. If a high degree of aggregation is used, the implications of the resultant function may be of little relevance in decision making process.'

Ideally, both the inputs as well as the output should be measured in physical units of homogeneous nature since the production function stresses a physical relationship between inputs and output produced. However, in farm management studies which involved the use of either cross-sectional or time-series data, it is impossible to measure all the factors in physical terms. Because there are many different types of inputs and outputs involved in crop production, aggregation has to be made to some extent. This is especially the case for capital goods and services, labour and the different kinds of outputs produced. Under certain circumstances, these factors have to be aggregated and measured in monetary terms for the purpose of computation.

It should also be stressed that within a single input category, no matter how finely we define the category, there will usually be quality differences. These quality differences are likely to be negligible only under experimental conditions where the inputs can be made of uniform quality through the application of chemicals and other standards. But for inputs such as land and labour, quite large quality differentials will be the rule. Generally, little account is taken of these differences - one acre of land is regarded as being much the same as any other acre. If adjustments are made, they can only be approximate in the absence of precise knowledge of the quality differentials.

Quality improvement in a resource is said to occur if the average unit of the resource provides an increased flow of services to the production function. For a durable resource, the service flow is provided by both the old and the new entrants to the resource stock. Under such situation, quality change can arise not only from the embodiment in the current investment but also from a change in the average age of the stock (Lingard and Rayner, 1975). Since quality change in inputs is likely to be an important factor in determining the growth of aggregate output, failure to take this factor into account in the production function analysis is equivalent to the omission of a number of variables and will bias the resulting estimates (Heady and Dillon, 1966).

In the present study only the most important inputs are taken into consideration and they are discussed in the pages that follow. In addition, the techniques of measurement used and the question of quality will be dealt with wherever applicable.

5.1.1. <u>LAND SIZE</u>

In agricultural production it has been mostly found that land size has a considerable impact on the yield of the crops planted. Numerous studies have confirmed such a relationship. As far as the production of cocoa is concerned, studies conducted by Gyimah-Brempong, (1987) and Boateng (1982) both in Ghana as well as De Souza Menezes (1974) in Brazil have pointed out that there was significant relationship between this input and the output of cocoa obtained. Similar outcomes have also been found by Nasuddin *et al.* (1987) and Shukri *et al.* (1987) in Malaysia.

Olayemi and Oni (1974) on the other hand, found that in Western Nigeria output per acre declines when cocoa holdings are more than 10 acres in size but on the contrary below 4.9 acres output per acre increases. This gives an implication that smaller farms outperform larger farms in value added per acre. In other words, smaller farms are more productive than the larger ones.

In the present study, land size is expected to have a significant effect on the production of cocoa and coconuts. This input is measured in terms of acres. It represents the actual area used for the cultivation of cocoa under coconuts and includes both the area owned and rented from others. However, it does not take into account the land area rented to others.

5.1.2. LABOUR

Labour is a tool with which capital and managerial skill are used to extract output from land. It is a group of productive services provided by human beings through physical effort, skill and mental power. Labour like land is not a homogeneous input; its skill and effort varies from one individual to another.

Agricultural labour can be categorised into three main groups, namely: 1) family labour; 2) hired labour which comprises contract and casual or temporary labour; and 3) communal labour.

In the developing countries most commercial holdings are family farms of 2 to 20 hectares in size concentrating on one major commercial crop which provides the chief source of income to the farmers. Much of the work involved however, is seasonal in nature. Labour is often critical during certain period of the year for performing certain agricultural activities such as crop harvesting. At other times, seasonal underemployment occurs. Because there are little or no alternative uses of such labour, they are prepared to accept low rewards for their services.

In the smallholdings, normally family labour outnumbered hired labour (Morgan,1980). In areas with communal land tenure, communal labour is important. Several families are involved in performing certain agricultural activities in rotation with the host providing food and refreshment needed. As for hired labour, a wage has to be paid for the services rendered. In most farms, the wages of this group of labour form the largest single component of the overall cost of production. Contract labour is used mainly for short durations to perform specific agricultural activities such as land clearing and planting. Casual or temporary workers are employed in order to cope with the seasonal work peak such as planting and harvesting of the crops. Any delay could cause a loss of yield and as such the labour has to complete the tasks within the specified period.

Labour requirement varies from crop to crop and also the production methods employed; the more mechanised the production method the less labour is required.

As for cocoa, a number of estimates have been established as regards to labour utilisation. In establishing and maintaining activities, the figure varies from 240 man-days to 300 man-days per acre (Okali, 1973). In the establishment of cocoa, there are two distinct types of operation involved; namely, maintenance and harvesting activities. The former has to be undertaken both in immature and mature areas while the latter only in areas where the trees have come into bearing.

Maintenance labour, however, is not as crucial as that of harvesting labour. Cocoa can still be obtained from poorly maintained holdings as long as it is harvested.

Both in immature and mature areas, weeding is the dominant maintenance activity. It was reported that a total of 33 man days/acre/annum is taken up by this activity alone out of a total of 36 man days spent for the maintenance of 13 months old plants to full bearing. The remainder of 3 man days are consumed by other maintenance work such as spraying, thinning and pruning. In mature areas the time spent is reduced to 27 man days with harvesting occupying 13 man days, weeding 12 man days and the remainder for other maintenance work (Okali,1973).

Some of the harvesting operations for cocoa require considerable skill on the part of the harvester. In the harvesting process, only the ripe pods are to be harvested. Labourers who are new to this job have to be taught how to distinguish the ripe pods which are borne on the cushions of the stem. These cushions may cease to bear fruits if damaged and, as such, care must be exercised when plucking is undertaken. The pod stem should be cut close to the tree.

Owing to the importance of labour in agricultural production therefore, in this study, this input is expected to contribute significantly in the production of cocoa and coconuts.

In this study labour is divided into 2 distinct categories, that is, maintenance and harvesting labour. The treatment of this input is different from that of previous studies wherein no distinction was made to classify this variable under such categories. Under such circumstances, it is difficult to draw a priori conclusions as to which particular activity has a significant effect on production.

Harvesting labour includes such activities as picking and breaking the ripe pods; removing the beans and transporting them to the fermentary for cocoa; plucking up the nuts; dehusking; removal of the shells and drying of the copra in case of coconut. Whereas maintenance labour in this study comprises manual and chemical weeding, control of pests and diseases, manuring and pruning.

In this analysis, labour is measured in terms of man-days based on the standard of eight hours of working per day. Since spouses and children are mainly engaged in light work such as plucking and breaking up the ripe pods where there may be little difference in performance between men, no attempt is made to use different weights in the conversion of these categories of labour into man equivalent.

5.1.3. CAPITAL

Capital is one of the essential factors of production and it comprises assets which are used to earn future income. The usage of this input normally increases the productivity of both labour and land.

Based on the length of their production lives, this productive resource may be classified into long-term, medium and short-term capital. The long-term capital, includes buildings and land improvements. Apart from that, certain tree crops especially those which are perennial in nature may come under this category. Medium-life capital which may extend between 2-5 years includes items such as livestock, certain types of tools such as knapsack sprayer and certain types of field crops. Finally, capital items such as stocks of food, seed, agricultural chemicals and cash which are generally consumed within one year are termed as short-term or working capital.

Owing to the fact that capital is composed of so many different items, it is often misleading to treat it as a single resource. Heady and Dillon (1966) recommended that this problem could be minimized by classifying the capital inputs into a number of categories in the production function analysis, based on the following general rules:

1) The inputs within an individual category should be as nearly perfect substitutes or perfect complements as possible.

2) Relative to each other, the categories of each inputs should be neither perfect substitutes nor perfect complements.

In the Third world agriculture, capital expenditure in most farming systems is often very low unless innovations are being introduced. Generally the lack of capital has been one of the chief factors inhibiting agricultural development in many areas especially where production for subsistence is dominant. For some commercial cropping development very little capital has been required. Tree-cropping, however, even on smallholdings has required capital to survive the period before and after the trees come into bearing, to pay for seedlings, chemical sprays and fertilizers and to pay for equipment used in the process of production (Morgan, 1980).

In this study, capital is categorised into two main components, namely, the cocoa and the coconut trees as living capital, and farm implements. The latter includes knapsack sprayer, harvesting tools, weeding implements, baskets and wooden boxes which are used for fermenting cocoa beans. Owing to the importance of capital inputs in agricultural production process, in this study, it is anticipated that the use of these inputs will have a positive effect on the yield of the crops planted.

In production theory, it is the quantity of capital services which is entered in the production process. In this study, in the case of farm implements, only the depreciation costs are computed to reflect the actual services flow. No discount rate is used in the computation mainly because most kinds of equipment, except for knapsack sprayer, used have short life expectancies. The maintenance, operating as well as repair costs are also not added. Based on the nature of the equipment used such type of cost, if it exists, is very negligible indeed.

As for the living capital, this service flow is a function of the age of the trees; it increases at the early stage and decreases when the trees become older.

Boateng (1982) however, treated the age of the cocoa trees as a variable by itself in his economic analysis of cocoa production. It is felt that this variable would better be treated as a capital item as discussed above for this will provide a true reflection of the actual services contributed by the trees at a particular age in the production process.

Yotopoulos (1967) suggested the use of the capital market value approach in the computation of service flow for perennial crops. This method, in fact, poses a great problem in areas where the market for land is imperfect and speculative activity is rife. In this study, it is not empirically feasible to adopt this approach. Chew (1984) used the expected yield concept as a proxy for capital service flow in fitting the production function for rubber smallholders. By this method, a graphical yield profile of the trees was first constructed from sources other than the sampled farmers. This represents the yield potential of the planting materials under more idealised conditions than that of the smallholdings. By assuming proportionality between these two conditions, then given the age of the trees of a particular smallholder, the expected yield which is estimated from the yield profile will represent a perfect substitute for the capital service flow per unit area of land. This method proved to be simple and effective and this will be adopted in the study.

As for farm implements, the straight-line method of depreciation is used to compute the annual amount of the service flow for this input. The procedure assumes that the equipment service flow is constant irrespective of age. This assumption is consistent with the actual situation. The age of the equipment may not have much effect on the amount or the quantity of cocoa produced. A harvesting knife, for instance, is just as useful, irrespective of its age; indeed, sometimes an older and 'seasoned' harvesting knife is sharper and harvests better than a new one.

5.1.4. FERTILISERS

Numerous studies have shown that fertilisers are essential in cocoa production. Besides increasing the soil fertility, the application has also resulted in an increase in the yield of the crop. In Ghana, it was reported that the yield increase due to fertiliser application averaged 45 per cent over a ten year period (Asomaning, 1976). Increase in yields of nearly 50 per cent was also observed in Western Nigeria as a result of an annual application of 261 pounds of urea and 67 pounds of triple superphosphate per acre (Opeke, 1976).

In Malaysia, Wyrley-Birch (1972) reported that on Kinabutan soil in Sabah, the yield of cocoa increased from 228-285 kilogrammes to 683-795 kilogrammes of dry beans per hectare after the application of lime and fertilizers. But in the production of cocoa, however, it has been observed that the requirement of fertilizers for this crop cannot be considered independently of the shade under which it is grown; they are interrelated. Yield will reach its maximum with fertilizers at 75 per cent light and splitting of the dosage into two applications per year gives better results than a single application (Wood, 1975). Thus based on the importance of this variable in increasing the yield of cocoa, it is expected that in this study the effect will be significant.

As there could be different types of fertilisers used by the smallholders, aggregating them in a standard monetary measurement presents one of the best practical ways of measuring this input. Thus in this study, this variable is measured in terms of total cost involved. A better method is to calculate the nutrient contents of various fertilisers based on the ratios given. This will provide a true picture of the actual nutrients that are being used in the production of cocoa. However, this method is not adopted here since it is felt that with improper storage of the fertilisers in the hands of the smallholders as well as the hygroscopic nature of the nutrients especially that of nitrogen, there is bound to be reduction in the actual content of the nutrients. Moreover, this weight loss is not known by the farmers and as such poses difficulties in trying to estimate the correct amount.

5.1.5. WEEDICIDES

Weed control is one of the major maintenance activities that has to be undertaken in order to secure a good yield for the crop. Lack of control measures will result in severe competition for nutrients with the main plant, hinders access to the trees and therefore makes the tasks of spraying and harvesting difficult.

In coconut plantation, Barnes and Evans (1971) revealed that as a result of weedicides application, an overall increase of 2 per cent in yield was recorded. In addition to that, they further pointed that plants tend to grow vigorously and were healthier as a result of the control measures being undertaken.

When cocoa is planted under coconuts, weedicide application is a problem. This is due to the fact that both crops responsed differently to the types of weedicides applied. Leach *et al.* (1971) showed that good results could be obtained by the application of 2000 - 3000 mt Ansar 529 with 2.3 kg sodium chlorate in 183 litres of water. This formulation is found to be safe for both crops planted. Since in practice, there are various types of weedicides available in the market, the choice is entirely dependent upon the smallholder's financial capacity to purchase it, and the types and conditions of weeds present. In this study the usage of this chemical is expected to have a significant effect on the yield of both crops planted.

Given the fact that there are a number of different brands of weedicides used by the farmers, in this analysis, this input is measured in terms of the total cost involved. Although the use of active ingredients present in the chemicals serves as a better method of measuring this variable, nevertheless, it was not adopted in this study as the actual quantity was not known by the farmers and moreover, it is difficult to get the correct estimate.

5.1.6. PESTICIDES

In the tropics cocoa is subject to a number of pests and diseases and various methods have been employed to control them. These comprise chemical sprays, dusts, fumigants and also biological control.

The effects of applying pesticides on cocoa production is tremendous. In Ghana, it was reported by the

International Capsid Research Team (1971) that the application of pesticides on capsids, the most serious insect pest in most cocoa producing countries, has resulted in an average increase of yield of 449kg. of dry cocoa per hectare on the Amazon variety. This treatment was applied from the second to the fourth year from planting. Similar success has been achieved in mature cocoa areas where an increase of 227kg. of dry cocoa was recorded when pesticides are used on degraded cocoa. The team also pointed out that spectacular results have also been achieved in the control of blackpod disease which is caused by a fungus in Cameroon and South America. In Cameroon, for example, there was an increase in yield from 250kg. to 500kg. of dry cocoa as a result of the application of fungicides. In the present analysis the application of pesticides is expected to bring significant results on cocoa and coconut production.

In this analysis since the farmers used numerous types of pesticides with different weights and forms, it is appropriate to standardise them using the total cost involved.

5.1.7. PLANTING DENSITY

Great variations are found in the planting distance for cocoa and these are closely related to the types of planting materials used, the ecological factors, economic considerations and the pathological conditions of the area in which the plant is grown.

On the Amelonado and Trinitario varieties in Nigeria, based on the trials conducted, it was reported that population density of 800 to 1100 trees per acre was the most advantageous. The optimum planting density for the Amelonado was 800 trees per acre while that of the Trinitario at 1020 trees per acre give the highest yield Bonaparte (1973). Based on an experiment in Ghana, West African Amelonado cocoa growing under thinned forest gave the best yield per acre at 7.5ft x 7.5ft. However, when the overhead shade was removed, yield increased, but trees planted at spacing 6ft x 6ft eventually performed better than more widely-spaced ones. Furthermore, close-spaced trees (5' x 5', 6' x 6' and 6' x 7.5') contain higher nutrient status than wide-spaced plots (7.5' x 7.5' and 15' x 15'). In other words higher plant densities are more suitable for the maintenance of the fertility of the soil than wide spacing (Bonaparte, 1973).

He further revealed that in Nigeria, the Amelonado variety when planted too closely, will result in the high incidence of black pod disease than those with large spacing. In the present study, this variable is not taken into account as it is taken up by land size in the analysis. Furthermore, it is rather difficult on the part of the farmers to provide the exact figure when no records are available.

5.1.8. PLANTING MATERIALS

Yield of cocoa is heavily dependent upon the types of planting material used. Good planting materials are those which are capable of producing higher yield; resistant to pests and diseases; early fruiting and thrive well in the environment under which they are grown. Apart from these qualities, the types of beans produced are also important for they will determine whether the planting materials used are of superior quality or not. Manufacturers give high priority to large size beans containing high amount of fat and a low shell proportion capable of producing good flavoured chocolate. Hence in the selection of the materials used for cocoa cultivation, this aspect has to be seriously considered by the producers (Urquhart, 1967).

The types of materials used are varied in Malaysia. Hybrid cocoa of crosses between Amelonado, Trinitario and Upper Amazon varieties are commonly used and these hybrids progenies have shown remarkable growth rates and early high yields, but the variation within any hybrid in terms of pod production can be wide (Jones, 1971). In a mixture planting, trees from more vigorous progenies which produce large trees at maturity will depress those with a slower growth rate and tree size. Such problems however, would be resolved through the use of clonal planting as the yield obtained is high compared to what is being obtained in Sabah.

Arasu and Phang (1971) reported that based on trials conducted in Malaysia, a maximum yield of 1135kg. - 1705kg. can be obtained from the best clonal seedlings planted under thin jungle shade.

In this study, only the Sabah Hybrid will be looked into as this is the most common variety that is planted by all the farmers since cocoa was first introduced in the study area.

5.1.9. SOIL TYPES

Wood (1985), pointed out that it is impossible to give precise soil requirements for cocoa since the crop can be grown on a wide range of soil. He, however, gives the general guidelines as follows:

1) Soil depth should not be less than 1.5m;

2) The soil must provide adequate moisture throughout the year, and should be fairly free-draining as

cocoa-trees are sensitive to waterlogging. Where rainfall is well distributed the moisture-holding capacity of the soil is less important than in countries with a dry season. Therefore, the suitability of the soil varies with the climate, heavier soils being desirable where there is a dry season.

3) The optimun soil pH for cocoa is about 6.5 but a fairly wide range from 4.5 to 7.0 can be tolerated.

Soils with different chemical and physical properties have different effects on cocoa yield because trees have different fertilizer requirements both in terms of quantity and type.

In Malaysia only two main types of soil have been utilised for cocoa cultivation on a large scale - a marine clay and a sedentary soil derived from acid igneous rocks. The marine clay although coarser in structure is better endowed with nutrients and moisture and it has been found that cocoa grows and yields better on this type of soil than those of the sedentary type (Wong, 1972).

In this study, the main soil series involved are the Kangkong and Selangor Series and these soils have a high clay content and adequate cation exchange capacity. Their soil pH is low. The phosphorous exchangeable magnesium and potassium are generally high but calcium is low. These soils are extensively cultivated with cocoa and are found mainly in the West Coast of Peninsula Malaysia.

In this study it is anticipated that the differences in the types of soil cultivated will have a significant impact on the yield obtained. A dummy variable, however, is used to measure the effect of this input on the criterion variable.

5.1.10. CLIMATIC FACTORS

As stated in Chapter three, environmental factors are vital for cocoa production. In Trinidad for example, it was found that 50 per cent shade is optimum for young cocoa. Under heavy shade, that is, with 15 and 25 per cent light intensities, yields are low irrespective of manuring at light intensity level of greater than 50%. It was also noted that on a highly fertile soil, optimal yield could be obtained with little or no overhead shade. On the contrary under situations of low soil fertility cocoa could be grown under fairly heavy shade with 50 per cent light but the yield obtained is not very high. Another alternative available is to reduce or completely remove the shade but in this case fertiliser application is greatly needed in order to obtain higher yield (Murray

1975). The above analysis implies that these two variables are closely interrelated and cannot be separately considered.

No attempt is made to incorporate shade in this study as this variable is rather difficult to determine at the farm level. The farmers themselves have no knowledge as regard to the actual light intensity in their own holdings. As for the amount of rainfall and temperature required for cocoa, since the areas covered by the survey are adjacent to each other; it is assumed that there were no significant difference in the climatic conditions that exist.

5.1.11. CREDIT

Credit plays a pivotal role in fostering an equitable distribution of increasing agricultural income. In traditional agriculture it is largely used for maintenance as distinct from the expansion of agricultural activities and is normally provided by traditional money-lenders, village traders, friends and relatives. In addition to this need, credit plays an important role in meeting the cash needs of the farmers which are normally large relative to income especially in the case of subsistence agriculture. Owing to the close linkage between the household and the farm enterprise, it is rather difficult to distinguish between the production and consumption needs of the farmers. It has generally been found that the demand for credit will fluctuate considerably from one year to another owing to the seasonal nature of agricultural production.

To modernise the agricultural sector a large infusion of credit is therefore required in order to finance the use of working capital such as fertiliser, improved seeds, insecticides, etc. The effects of transforming this sector will result in the increase of profitability of the agro-based industries, thus increasing the demand for capital. Owing to the fact that savings in traditional agriculture tend to be relatively small at initial stages of development, increased demand for working and fixed capital must largely come from increased supply of credit.

In most of the less developed countries, small farmers have much less access to institutional credit than large farms (Morgan 1980). For long term credit, lenders want collateral. For the poor, this is a disadvantage. They have little or no collateral to raise loans and as a result are being charged a high interest rate because of the high risk involved by the private money lenders. This unequal distribution of credit often leads to income inequities especially when agricultural innovations have made major strides.

Although credit provision can do much to help develop peasant farming, there is a danger that too much may be expected of it and it becomes regarded as the tool to raise output quickly. In fact credit is not essential for agricultural development; it is merely an accelerator and can cause disaster if misused. Credit alone cannot alter a poor farmer into a rich one. Even at low interest rates, credit will not automatically raise output or the incomes of the rural poor. Only in the modernising sector of peasant agriculture will more credit yield a high return.

In this study, an attempt is made to see what effects credit has on the production of cocoa and coconut. This input is measured by the use of a dummy variable to distinguish between those who have taken any credit or not from the financial institution for cocoa production.

5.1.12. REGIONAL INFLUENCE

The influence of location also tends to affect crop production. In this study the smallholders are grouped into four localities based on the area surveyed. In order to find the effects of location on the yield of cocoa and coconuts, regional dummies are introduced in the analysis. A value of one will be given to the location involved and zero, otherwise.

5.2. MANAGEMENT FACTOR

The importance of the management factor in the process of production cannot be overlooked. As such it should deserve considerable attention in this study. According to Shaudys and Wodland (1968) the term management may be defined as the force within the firm that directs resource use after interpreting the wants, needs and desires of those owing or controlling production resources. Johnson (1982) defines management as the active process of making decisions so that the use of available human and material resources of the organisation is planned and controlled to achieve its specific objective(s).

Production resources such as land, labour and capital will not be productive unless they are organised and co-ordinated by someone who makes the necessary conditions and sees that they are implemented (Upton, 1987). In Malaysia, where farm resources are limited, their efficient use depends to a large extent on the management ability of the farmers. At the farm level such as the cocoa smallholding, the managerial decision is made by the individual cocoa farmer. The situation is different in the plantation sector whereby there are a lot of decision makers present. The managers who are paid will decide the daily activities. Others, including the owners of the plantation will determine the overall objectives, seeking out the new opportunities for gains and bearing associated risks. A cocoa smallholder, however, is an entrepreneur, a manager as well as a labourer. He does not employ a manager but performs all these functions himself, often with the assistance of his family members.

The importance of management however, increases as the farm business increases in size and complexity and as the technological level become complex in the farm. In fact management is considered the "key" to the success of farm business (Krause and Schultz, 1968).

Although management might be expected to be an important input in agricultural production, it is not usually included in the production function analysis owing to lack of a generally accepted measure. However, failure to include this input may result in management bias. (Griliches, 1957; Mundlak, 1961; Massell, 1967), and this occurs if both inputs and outputs are functionally related to farmer's managerial ability. The bias that exists depends on the nature of relationship between management ability and all other included variables. If the relationship is positive, the estimated coefficients will be biased upwards and downwards if the relationship is negative (Griliches, 1957). Mundlak (1961) and Dawson and Lingard (1982) use the covariance approach to eliminate the management bias. By incorporating firm dummy variables and time-effect dummies into the analysis, the production elasticities, marginal products and the equi-proportionate returns to factors tend to be lowered and the statistical fit of the production function improves.

Although it has been generally accepted that management is a difficult input to define and measure, especially so in the field of farm management, nevertheless, some attempts have been made to quantify the contribution of this input.

Heady and Dillon (1966) suggest a simple procedure to make use of the residuals between the estimated production level derived from the fitted function and the actually observed production level as a basis for an objective management rating. The actually observed output-input combination that lies above the fitted function would be given a positive rating while those below, a negative rating, with each rating proportionate to the size of the residual. The basis of using the residual index is that all the other factors of production are assumed to be paid the value of their marginal products; which in actual fact is not true. The residuals obtained may not be due to management factor alone but a host of other interrelated elements such as the soil properties, and climatic factors. This procedure as such is unreliable to be used as an indicator for measuring management performance.

According to Upton (1976) there are some economists who argue that management should not be treated as a variable in the production function analysis. In crop production analysis it is assumed that apart from the random variations caused by the uncontrolled factors of production; the relationship between the inputs and output is stable and as such the same output should be produced by using exactly the same combination of inputs under exactly the same physical conditions. According to this view it is impossible for nature to produce one outcome at one time and another outcome at another time under otherwise similar situations simply because of differences in management. This view has a weakness since it disregards the numerous decisions which are left to the farmer's judgement. In fact differences among the individual farmers' ability to make decisions are reflected in the different level of outputs obtained from similar input combination.

Upton's argument is pertinent in relation to cocoa smallholdings. Given a ceteris paribus condition, for example, although all smallholders may have decided to apply the same quality and quantity of fertilizer to their farms, the smallholder's decisions as to when and how to apply the fertilizer would affect their cocoa yield.

There have also been few attempts to treat management as a explicit variable in the production function analysis. Pugh *et al.* (1965) used an index of farm tenant ability based on ratings by professional farm managers as explicit variables in their study. Results of the analysis showed that this input had a statistically significant effect on farm output. There was a positive relationship with output; output increased by an important magnitude with increase in tenant ability.

Massell (1967) in an attempt to measure managerial ability classified the farmers into 3 categories namely; master farmers, plot holders and co-operators. Master farmers are those who have reached high standard of crop and animal husbandry whereas plot holders are those who are under tuition by the extension worker and co-operators are those farmers who use fertilisers, carry out some crop rotation and plant their crops in rows. He further regrouped the master farmers and plot holders as skilled farmers, co-operators as semi-skilled and the rest as unskilled. The skill category of a farmer is served as an index of management. Using the Cobb-Douglas production function, results of the analysis indicated that there was a marked difference in terms of the yield obtained by these different groups of farmers. On the average skilled farmers obtained 47 per cent more output than semi-skilled farmers and more than twice as much as the unskilled farmer. The findings reveal that difference in managerial ability does have some impact on productive performance.

Kahlon and Acharya (1967) used an index of management, based on 46 different factors ranging from agronomic and economic aspects in the study of the effects of management input in farming. Decisions taken by different farmers pertaining to these factors were ranked and converted into scores. A weighted sum of these scores for each farmer was used as a management index and this was then incorporated in the production function. Results of the analysis indicated that wide variation in the output could largely be explained by this input. A very highly significant correlation existed between farm income and management input. The average index of management input was significantly different at 0.1 per cent level between high income and low income farmers. The sum of the production elasticities indicated that returns to scale were under-estimated if management was excluded from the production function analysis.

Upton (1970), however, used the personal characteristics of the farmers as a proxy variable for management. These characteristics are; progressiveness, personal control, independence of thought, sophistication, innovation, status, farmer's age and attitude to family size. These variables are incorporated into the production function together with other inputs. The findings revealed that the introduction of the management factor (independence of thought, sophistication and innovation) as proxy variable for management inputs leads to a significant increase in the explanation of the variation in total gross margin. The management factor explains 6% of the total variation in gross margin. Only the management factor and 'attitude to family size' are significantly correlated with the total gross margin.

Makary and Rees (1981) use a management index in their investigation on cotton production in Egypt. This index is derived by regressing crop yield on educational level and years of experience. The latter is measured as the number of years that the family has held the land up to two generations while the former is used as a dummy variable. The management index is then fitted into the production function together with other inputs. Results showed that farmers with long experience and a good education are most productive. The production elasticities of the derived index of management efficiency are all positive and the management coefficient is significant at the one per cent level. Evidently an index of educational level and years of experience is an appropriate proxy for managerial ability on large farms in Egypt. The measure of working experience is rather unsatisfactory in this study since owing to the longer time period involved, the accuracy of the data obtained is doubtful. Such a problem could be solved with the maintenance of proper records and not through the use of memories.

Khandker (1988) selects a measurable indicator, occupation, as a proxy for the farmer's management ability with the belief that the decision whether to work or not off the farm in order to earn additional income is made within the household with much the same goal as good management, to maximize income. He further argued that the occupational decision is based on the same characteristics that affect management skills, that is, the size of the farm, family size, education, the actual time spent on farming, community wages for agricultural labourers and the exposure to modern technology. He classified farmers into 2 occupational categories : full-time and part-timers. The Cobb-Douglas function shows that there are significant differences in the production behaviour between the two groups of farmers in terms of input utilisation. Moreover, it was revealed that the full-time farmers have larger than average farm productivity because they are able to supervise the traditional inputs effectively. The study indicated that occupational status can serve as a convenient, measurable indicator to measure management ability.*

Although past studies which are reviewed here have not generally validated or developed accepted techniques for measuring management because of the methodological difficulties, nevertheless they provide insight relative to the kinds of human attributes which might be important in understanding management. However, from these studies little has been done to relate biographical and other personal factors to some criterion of managerial performance.

It has been observed that an individual's past experience and his present circumstances influence what he knows, how he thinks, acts and reacts to a set of stimuli. This biographical information and past performance feedback also plays an important function in the development of values, motivation and capabilities of the individuals and also considerably influence the management process. As such it is proper that the biographical component be given a central place in management research.

Just as in the business organization, the importance of biography and performance in agriculture cannot be overlooked. In the smallholding sector, decision making is done mostly on a collective basis. The farmer's spouse and children will exert a certain influence in the decision making process. Factors such as the levels of education of the farmer and his family members, age of the operator, his farming experience, contact with the extension officer and the practice of keeping farm records and accounts all have a considerable impact on the nature of the managerial decision taken at the farm level. In the present study all these variables will be incorporated into the analysis as proxies for the management ability and all of them are treated explicitly in the production functions. The basis of choosing these variables as well as the techniques of measurement involved are discussed below and in the next few pages.

a. FARMER'S EDUCATION AND EXTENSION CONTACT

Investment in education is regarded as a central ingredient in a strategy to improve agricultural productivity especially where the use of modern inputs is emphasised. Numerous studies conducted in the United States and India have shown that educational levels are positively correlated with the increase in efficiency of agricultural production. (Lockhead *et al.*, 1980).

A study by Jamison and Lau (1982) in low income countries also indicated the significant contribution of education towards agricultural production. The study revealed that a farmer who had completed four years of elementary education, obtained on the average 13.2% more output than those with no education. Further evidence can be found in studies carried out in South Korea, Malaysia and Nepal. In these countries, the estimated percentage increase in annual farm output due to four years of primary education was 9.1% for South Korea, 20.4% for Malaysia and 20.4% for Nepal. These increases occurred because of the availability of complementary inputs. However if these inputs were not available the increase in output on average will be small - but still significant. By fitting education as a variable into the production function for different types of farms, results indicated that the effects of education are positive and statistically significant (World Development Report, 1980).

Beside investigating the effects of formal education in the production of the staple food crop, maize, in area of Western Kenya, Moock (1981) also incorporated the extension service contact as a factor of production in his Cobb-Douglas model. Results obtained indicated that extension services increase technical efficiency.

A 10% increase in extension, ceteris paribus, has resulted in an increase of yield by 0.2%, or about 7 pounds per acre at the mean. The study further revealed that those who have completed four or more years of schooling produced around 2% more maize than those who have never attended school.

The evidence from those studies shows that the role of education and the extension service are extremely important for development and the management of low-income agriculture. It is the responsibility of the extension worker to influence farmers and their families to adopt improved practices in crop and livestock production, management, conservation and marketing. They should concern not only with teaching and securing adoption of a particular improved practice, but also changing the outlook of the farmer so that he will be receptive to, and on his own initiative continuously seek, means of improving his farm business and home. For this to succeed, frequent personal contacts between the extension workers and the farmers are vital in order to improve the efficiency of the farm business, increase farm income and raise levels of living.

Based on the importance of these two variables, in this study, it is expected that they will have a significant effect on the income of the cocoa smallholder.

Extension contact in this study denotes the numbers of times the smallholder had made official contacts with the extension personnel concerning cocoa and coconut production. This could either be in the form of farm visits, courses conducted or meetings at the extension office itself during the past year which ran from January till December 1988.

In this investigation, farmers' education is measured by means of a dummy variable. A value of one is assigned to those who had formal education and zero for those who had no formal schooling at all.

b. SPOUSE'S AND CHILDREN'S EDUCATION

The level of education obtained by the spouse is as important as that of the farmer. An educated wife could supplement her husband's knowledge and management ability in farming through her own reading and listening to agricultural programmes on radio and from other sources of communication. Similarly, the farmer's technical knowledge will also be improved through their children's education. The new ideas that the children acquired through schools or through reading publications and other agricultural materials supplied by the various research organisation and extension bodies could be imparted to the farmer and thus help to broaden his outlook. The influence of the children's education is important especially when the farmers are illiterate.

Dummy variables are used to measure both the spouse's and their children's education in this investigation. The spouses are divided into two groups based on the level of education attained. A value of one is assigned to those who had formal education and zero for those who had no formal schooling at all. In Malaysia, compulsory education is provided until the children have reached the age of 15, that is, until they have attained lower secondary education. At the end of this stage, they have to sit for the national examination and it is only upon passing this examination they are allowed to proceed to the upper secondary level, otherwise, they have to leave school and join the employment market. Using this as the cut-off point, a zero value will be assigned to those who had completed their compulsory education and one for those who either are still attending upper secondary education and above or had completed these levels.

c. WORKING EXPERIENCE AND AGE OF THE FARMERS

Experience is important in all professions for it is related to one's ability to execute one's duties. It is expected to be quite highly correlated with output up to a certain number of years, but after that it may be negatively correlated. This is because of the fact that as one gains farming experience, one's productivity may increase but as one grows older productivity may start to decrease.

Ghazali and Rashid (1974) who analysed the causes of unsuccessful land development schemes in Trengganu, Malaysia, indicated that most of the partially - subsidised land scheme participants, who had previous experience in rubber farming, planted large proportions of their allocated rubber plots, while those without previous experience did not. It was also reported that the majority of those experienced smallholders used high yielding budded rubber compared to those with less experience. This study implies that experienced farmers are more concerned with obtaining higher earnings from their holdings since the usage of the better varieties and maximum utilization of land may lead to higher production and hence higher income.

Attitudes towards change and adoption of new technologies are also influenced by the farmer's age.

Normally younger farmers are more receptive towards change than the older ones. Afifudin (1973) who did an investigation on the commercial attitudes of padi farmers in Kedah, Malaysia, indicated that farmers between the age of 21-30 years were less traditional than the older farmers owing to the fact that the former were socialised in a more modernised period and environment. Apart from that, age is also related to one's health and fitness.

Both these variables therefore are expected to have significant effects on the income of cocoa in this study. Working experience is measured in terms of the number of years that the smallholder has acquired in the cultivation of cocoa and coconuts either in the present holding or elsewhere, till the period under study. On the other hand, age of the smallholder is also measured in terms of the number of years, that is, from the time of birth till December 1988.

d. <u>RECORD-KEEPING</u>

Record-keeping is one of the essential tools of good farm management but this activity is the most unpopular one to be carried out by many smallholders. They should realise that, in order to make correct decisions for the farm, detailed information about the business is highly desirable and this is only feasible provided the farmers keep farm records.

Records kept at the farm level can be classified into two groups, namely; physical and financial records. Both these records are highly complementary in nature. Financial records show both the income and expenditure data while that of the physical records focus on the units of output and input. Through the data obtained from these two types of records it is possible then to measure the efficiency of the physical and financial resources.

Record-keeping normally consumes time and this is one of the scarcest resources of the farmers. Therefore, any farm records kept should enable, potentially at least, farm profits to be raised enough to warrant the time and effort.

The advantages derived from keeping good physical records are numerous and some of them are:

1) farmers will be in a capacity to make the best use of their available resources;
2) the decision making process will be more effective through the facts obtained from properly analysed records, hence removing much of the guesswork involved;

3) processing of loans or credits will be much easier through the data supplied by the farm records: and

4) comparison with published 'standards' is feasible when records are made.

Numerous physical records can be kept by the farmers and they should include the following:

1) stock control record
2) labour record
3) crop record and
4) livestock record.

However there is no point in keeping a record unless it fully satisfies an essential need. Records are essential control tools. Without adequate records, there is no basis for planning and the farmers could not reasonably predict the future. Hence in this study this input is expected to have a significant impact on the expected income. A dummy variable is used to measure its influence on the criterion variable.

5.3. EXPECTED INCOME

This indicates the amount of gross income of cocoa and coconut that are expected to be obtained by the farmers for the year in question. In this study, farmers grow both cocoa and coconut on the same farm. Since the products involved are not similar in nature, the method of measurement adopted is to aggregate them on a value basis. In order to obtain the total expected gross income which serves as the dependent variable in this analysis, the formula as outlined below is used:

$$Y = Y_1 P_1 + Y_2 P_2 \qquad (5-1)$$

where:

Y = Total expected gross income from cocoa and coconuts per annum measured in Malaysian Ringgit.

$Y_1 P_1$ = Gross expected income from cocoa which is derived by multiplying the expected gross yield (Y_1) in kilogrammes with its expected price (P_1).

$Y_2 P_2$ = Gross expected income from coconuts which is derived by multiplying the expected number of nuts to be obtained (Y_2) by its expected price (P_2).

It should however, be noted that in this study, the computation of the total expected income is mainly based on the information given by the farmers interviewed during the year in question.

5.4. PRODUCTION FUNCTION USED IN THIS STUDY

Although there are a number of algebraic forms which can be utilised to derive production functions, no single form exists which can be used to describe conclusively, the true nature of agricultural production. The algebraic form of the functions will vary with the types of soil, crops, livestocks and the climatic conditions (Heady and Dillon, 1966). Similarly, Upton (1973, 1979, 1987) emphasised that since the production functions available are practically limitless, the choice is basically determined by the technique of production, the local conditions, the soil types and the climate involved. Owing to the complex nature of agricultural production, it cannot be proved conclusively that a particular form of function is the most appropriate one. The usage of simpler models is highly recommended so that they can be applied and understood easily by the farmers and their advisors. Thus in this case, subjective judgement is required in formulating such a model.

Bosworth (1976) stated that the central issue in the formulation of a particular production function is to understand the technology of production involved. Yotopoulos (1967) indicated that three main rules exist in the selection of the appropriate functional form. The first rule is based on the logic of production or the basic mechanism involved; second, its theoretical fruitfulness; and finally, its computational feasibility. Heady (1956), however revealed that the guide to the use of the production function may be based on previous studies as well as the researcher's imagination.

Thus in the derivation of the most appropriate form of production function in this study, the criteria adopted will be based on the logic of production of cocoa; the functions used in earlier investigation; the theoretical fruitfulness as well as the computational feasibility of the function.

5.4.1. LOGIC OF COCOA PRODUCTION PROCESS

There are three main stages in cocoa production. The first stage encompasses land clearing, burning and planting; the second, deals with field and crop maintenance; while the final or productive stage (where the trees start to bear fruits until the time of replanting) is concerned with the routine agronomic practices as well as harvesting activities (Miranowski and Simmons, 1976).

As stated in chapter three, cocoa starts bearing in the second year after planting and harvesting commences when the pods are ripe which normally takes about 5-6 months to mature after fertilization takes place (Wood, 1975). Being a perennial crop, the yield of cocoa varies with the age of the plants; at the initial stage, yield starts to increase as young trees begin to mature and finally, as the trees become older, it starts to decline after passing the age of 25-30 years (Olayemi, 1970). In Malaysia, it was reported that with proper management practices an average yield of 125 kilogrammes of dry beans per acre can be obtained after 3-4 years of planting and rising to 409 kilogrammes at the age of 7-8 years (Leach, 1967). A maximum yield of 430 kilogrammes can be obtained at the age of 9-10 years after planting. Thereafter yield remains stagnant for several years before declining. However, a good yield can still be expected from cocoa until it reaches the age of 25-30 years before rehabilitation or replanting programmes are undertaken (Wood, 1975).

This relationship between yield and age of the plant points to the fact that there are three areas of production in cocoa; increasing, decreasing and possibly negative marginal product. Assuming that farmers are rational in their actions towards farming and are also profit maximizers, they would use inputs to the extent that the marginal revenue obtained is equal to the marginal factor cost.

Preliminary investigation by the researcher revealed that although labour was abundant in the study areas, usage of labour is only heavy during harvesting time. Thus, the possibility of using an excessive labour force for the management of cocoa farms which can lead to negative productivity of this input does not rise in this case.

A negative marginal productivity of fertilizer is possible if the farmers use too much of this input, as this can cause deleterious effects to the plant growth and hence its yield. Owing to economic constraints in terms of limited cash available none of the farmers is thought to over-fertilize their trees. On the contrary the majority of them seemed to have utilised less fertiliser than expected.

Pests and diseases if not properly controlled could seriously affect the growth of the plants and their production. Preliminary results obtained by the researcher revealed that the trees did not suffer from serious damage from pests and diseases. Damage by pests, if it occurs, is very localised. Furthermore, the favourable climatic conditions with a fairly even distribution of rainfall has prevented any outbreak of capsids attack. It has been found that many pathogens which have been found in some cocoa growing areas in other countries such as the one that cause serious pod rot do not exist in the country. Thus the possibility of the farmers using too much pesticides and other related chemicals does not arise in this situation.

Similarly, owing to limited cash, the usage of other purchased inputs such as herbicides and other equipment is not excessive. These inputs are only bought when the needs arise and provided that they have the means to do so. This again gives an indication that the marginal productivities of these inputs will not be negative.

However, the possibility of having negative marginal productivity for uncontrollable inputs cannot be ruled out in this study. If there is a strong wind or serious drought in the area, this will cause serious damage to the plants. In this analysis such inputs are not taken into account.

These arguments regarding the nature of the marginal productivities of the inputs used in cocoa production points to the fact that the third stage of the production function is unobservable as far as the usage of the controllable inputs are concerned. Furthermore, the average age of the trees in the study areas was only 13.5 years and by rights with proper agronomic and management practices, the yield should be at the maximum stage. On the contrary, this is not the case, for the average yield obtained by the farmers were much less than expected that is only 282 kilogrammes per hectare (Nasuddin *et al.*, 1987).

Thus based on the nature of marginal productivities of the inputs a linear function is rejected because it has a constant marginal product. This leaves us with the option of using other forms of production function such as the Cobb-Douglas production function, Constant Elasticity of Substitution function, Transcedental or log - log inverse. According to Timmer (1970) the most commonly employed agricultural production functions are the Cobb-Douglas and the Constant Elasticity of Substitution.

In this study, based on the nature of the marginal productivities of the controllable inputs, the Cobb-Douglas function is used as a basis of analysis. Other reasons for its usage are because of its theoretical fruitfulness, and computational feasibility. Moreover, this form of production function has not been tested yet as far as cocoa production is concerned in Malaysia.

5.4.2. ESTIMATION PROCEDURE

Since in this study the Cobb-Douglas production function is used, the function which will be empirically derived from the data is as follows;

$$Y_j = a_0 \Pi X_{ij}^{a_i} \exp(\sum b_i D_{ij}) \exp(u_{ij}) \qquad (5-2)$$

where

Y_j = the expected gross income from cocoa and coconut of the jth farm.

X_{ij} = the ith factor input used by farm j.

D_{ij} = dummy variable for the jth farm.

U_{ij} = random error term that is assumed to be normally distributed with the mean equal to zero and constant variance.

a_0 = the constant term.

a_i, b_i = parameters associated with the ith factor used by farm j.

exp = exponent.

The above equation can be transformed into logarithmic form as:

$$\log Y = \log a_0 + a_1 \log X_1 + --- + a_n \log X_n + b_1 D_1 + --- + b_n D_n + \mu \qquad (5-3)$$

The use of fertilisers, pesticides and weedicides is heavily dependent upon the availability of financial resources to the farmers. Because of this situation, there are farmers who might not be able to use all these chemicals in the production process if they do not have the means to do so. This implies that if these chemicals are treated in a multiplicative manner in the Cobb-Douglas production function, output will be zero if there are non-application of these inputs. This in fact is illogical since there are other inputs being utilised in the production process. To avoid this problem, a constant value of 0.0001 is added to these variables before taking logs.

Besides estimating the function for the entire study area, this study will also estimate the function for the various classes of farm size in order to determine the allocative efficiency among the inputs used. In this study the farms are categorised into two classes based on the mean value of the land size obtained from the overall samples.

Thus we distinguish the small size group as farms that cultivate less than the mean and the large size group consists of farms that lie above the overall sample mean. The main reason for dividing the samples into two different groups is based on the hypothesis that fitting a single function is a misspecification of the true functional form. This is because the sample observations of the underlying population may not obey the same law over the entire range of inputs used (Yotopoulos, 1967).

5.5. HYPOTHESES

A number of hypotheses will be tested in this study and they are outlined as follows:

1. Owing to the importance of land size, labour, capital, fertilisers, pesticides, weedicides, farm implements,

credit, soil types, regional influence and the variables which serve as proxies for management ability as outlined earlier, in this study it is hypothesised that all these inputs have statistically significant impact on expected income. Such relationships are expected to exist in all the areas surveyed and also in both small and large farms.

2. In the earlier studies that had been conducted in this area, it was reported that the use of modern inputs such as fertilisers, pesticides and weedicides was minimal. The land size cultivated was also very small and no proper agronomic practices were undertaken by the farmers to ensure the healthy growth of the crop. This has a consequence of reducing the yield and hence the gross income obtained.

   Maximum profit is attained when the farmers have made the correct choice as regards to the combination of the input factors coupled with the knowledge of using the correct techniques in the utilisation of such inputs. Because of the limited knowledge and financial means, the above target is not effectively achieved. In such a situation it is hypothesised that the allocation of the factors of production in this area is still not economically optimum. The marginal value productivity of the respective inputs is not equal to the marginal factor cost.

5.6. SUMMARY

The chapter has attempted to examine the input factors that are required for cocoa production and the justification for their selection in the present study. Only those inputs which can be controlled are incorporated into this analysis. Based on the logic of production, its theoretical fruitfulness and computational feasibility, the Cobb-Douglas production function is used in spite of the drawbacks that this function exhibits. This chapter ends with the discussion on the hypotheses that are going to be tested in the present study.

CHAPTER SIX

DATA COLLECTION

In the preceding Chapters, the problem of the study was identified and outlined, the theoretical framework was detailed, the literature related to the study was reviewed, the variables as well as the model to be used and the hypothesis to be tested was developed. Chapter six presents the research procedures in terms of the data to be collected for the purpose of this study.

6.1. SOURCES OF DATA

The data used in this study were derived primarily from farm surveys of the cocoa farmers in one of major cocoa growing areas in Peninsula Malaysia that is Hilir Perak in the State of Perak. Apart from that, data which were obtained from personal interviews made with the local agricultural officer, extension personnel and from the marketing officers of the Federal Agricultural Marketing Authority (FAMA) and from other sources such as that from the local government agencies that are considered relevant to this study were also secured. It should be mentioned here that the survey data gathered in this study were confined to the calendar year 1988, that is, beginning from the month of January till December 1988.

6.2. SELECTION OF THE STUDY AREA

In Peninsula Malaysia the three largest cocoa growing areas are:

i) District of Hilir Perak in the State of Perak;

ii) Districts of Sabak Bernam and Kuala Selangor in the State of Selangor and;

iii) Districts of Muar and Batu Pahat in the State of Johore.

Should the desired resources in terms of time, personnel and financial means be unlimited, all the three major growing areas should be surveyed so that we can pinpoint what are the causes of productivity differences among the areas involved.

In this study, owing to the financial constraint and time factor involved it was impossible for the researcher to survey all these cocoa areas. A decision was made only to survey one district, that is Hilir Perak. Based on the information obtained from the Department of Agriculture out of a total area of 13,975 ha. under cocoa smallholding in the state in 1988, about 11,209 ha. (80.2%) are located in this district. However, in spite of its status as one of the largest cocoa growing areas in the country, productivity as mentioned earlier is the lowest when compared to other cocoa growing areas. In 1986 the annual average was 360 kg. of dry beans per hectare whereas in 1987 it had dropped to 282 kg. compared to 715 kg. in the districts of Batu Pahat, and 442 kg. in Sabak Bernam for the same period (Nasuddin *et al.*, 1987).

This points to the fact that this area needs immediate attention compared to the other areas. This forms a strong basis of choosing Hilir Perak as the study area.

6.3. BRIEF DESCRIPTION OF THE STUDY AREA AND ITS ADMINISTRATIVE STRUCTURES.

The area of Hilir Perak covers approximately 649.6 square miles. Based on the census conducted in 1986, the total population of this area was 186,343 or 11.6 per cent of the total population in the state of Perak. The main components were the Malays (49.4%), Chinese (29.5%) and the rest were Indians. The majority of them (75.8%) especially the Malays, are found in the rural areas, while the Chinese who are mainly businessmen are found in the urban centres. Based on the personal communication with the District Office, it was found that in 1988, approximately, 77 per cent of the land (i.e. 128690 ha) is being used for agriculture and the major crops planted are mainly oil palm owned by private plantations and cocoa and coconut owned mostly by the smallholders.

There are nine *Mukim* in the district of Hilir Perak and each *Mukim* is made up of a number of *Kampung*. In Malaysia, the *Kampung* is the smallest formal administrative unit in the rural community. It comprises several households with two basic formal social systems. The first and the smallest social system is the family. This is followed by the village committee consisting of an elected *Ketua Kampung*, a title given to the person who heads the village and who serves as the spokesman of the local people to the government; and 5 to 8 committee members. This committee serves as the smallest working unit in the rural areas. The *Penghulu* is the head of the *Mukim* and he is appointed by the government. At the *Mukim*'s level, there is a committee comprising all village headmen with the *Penghulu*, acting as the chairman. This committee is involved with all aspects of rural development and at the same time acting as a linkage between the people and the government departments. The *Mukim* are being serviced by a police substation, a *balai raya* (community hall), a primary and secondary schools and some governmental suboffices. The head of the district is known as the District Officer who is responsible for development of the whole area. In this region, the principal town centre is Teluk Intan and it is here where all the government machineries and business centres are located.

6.4. SAMPLING METHOD

In order to secure the data from above farmers certain factors have to be considered beforehand. Considering the time, effort and financial resources available it would be impossible to interview the whole population in the entire study area. It would be more economical and the information obtained would be more accurate if only a fraction of the population is interviewed. This could only be achieved provided the samples collected follow the laws of chance in the selection process. Otherwise, the conclusions that are drawn will be biased or erroneous (De Vaus, 1986).

Numerous sampling methods could be employed in order to gather the data and they comprise mainly :

i) Simple Random Sampling;
ii) Stratified Random Sampling;
iii) Area or Cluster Sampling;
iv) Systematic Sampling;
v) Quota Sampling;
vi) Judgemental or Purposive Sampling; and
vii) Snowball Sampling.

In this study, simple random sampling was used in the gathering of the farm data required for analysis. This technique assumes each element in the population has an equal chance of being chosen. The term equal chance here implies that each element possesses the same probability of being included. The elements are numbered from 1 to N in the population and normally in practice the sample is drawn element by element (Marascuilo and Serlin, 1988). In order to draw the numbers, one can either use the table of random numbers or mixing them in a container. When the elements, once drawn, are not replaced the procedure is known as sampling without replacement. On the other hand, when the elements are returned to the container, such technique is described as sampling with replacement. In the present study, the latter technique was not adopted since there is not much gain in having the same element twice in the sample. (Black and Champion, 1976).

Although this method is the easiest to apply and the most simple to understand among all the probability sampling plans, it has one major drawback in the sense that the sampling error is greater when compared to stratified random sample of the same size. (Raj, 1968). This is because sampling error is based in part on the heterogeneity of the sample drawn. Samples that have been stratified are at least somewhat typical of the population in terms of that characteristic. And more typical samples are usually increasingly accurate estimates of populations from which they were obtained.

6.5. SAMPLING FRAME

In order to survey the cocoa farmers in this area permission had to be sought first from the State Director of Agriculture and also the District Agriculture Officer. Briefings were given to the latter pertaining to the objective of the survey and the information to be gathered. This was to ensure that no sensitive issues were touched upon during the process of data collection.

Before a complete execution of the survey can be made it is essential to have the sampling frame. The latter is considered as the keystone around which the selection process is evolved (Kish, 1965). In this study the frame is defined as the total number of cocoa smallholders and landless peasants who are involved in cocoa production and are residing in the district of Hilir Perak. In this context smallholders are defined as persons who own or cultivate agricultural land of less than 100 acres (40 hectares). As for the landless peasants, this refer to individuals who do not possess agricultural land but have access to it either in the form of renting or other means of arrangement with the landlords.

A complete list of the cocoa farmers living in the above district was obtained from the register kept by the Department of Agriculture at Teluk Intan. This list was further counter checked with those available at the Mukim level. This was to ensure that only those farmers who were residing in the <u>Mukim</u> would be taken into account. In the final analysis, it was found that there were a total of 3870 farmers involved in cocoa production and their distributions according to <u>Mukim</u> are shown in Table 6.1. It is revealed from the table that out of 9 <u>Mukim</u> available, only 4 <u>Mukim</u> are actively engaged in cocoa

TABLE 6.1.
DISTRIBUTION OF REGISTERED COCOA FARMERS IN THE DISTRICT OF HILIR PERAK ACCORDING TO MUKIM, 1988.

MUKIM	NO. OF FARMERS	TOTAL ACREAGE (Ha)
Labu Kubung	37	14
Rungkup	1414	3226
Bagan Datoh	785	3750
Cangkat Jong	10	5
Sg. Manik	14	55
Teluk Baru	442	1065
Durian Sebatang	10	13
Hutan Melintang	1071	3024
Sungai Durian	87	57
TOTAL	3870	11209

Sources: Compilation from several reports:
1) Jadual-Jadual Banci Taraf Pertanian, Hilir Perak 1985
2) Department of Agriculture, Hilir Perak, 1988.

production, while the rest are not as reflected by the low acreage and the small number of farmers involved. Thus in this study concentration was given to these 4 Mukim only. The distribution of Kampung in each of the 4 Mukim together with the number of cocoa farmers are shown in Appendices 4 and 5. It is found that as for Mukim Rungkup there are 13 Kampung while that for Bagan Datoh, Teluk Baru and Hutan Melintang the corresponding figures are 11, 7 and 9, respectively.

6.6. SAMPLE SIZE

One of the most common problems facing the researcher concerns the size of the samples to be collected. Although it sounds to be rather simple and straightforward, it is in fact one of the most difficult problems to be solved precisely.

Generally, the larger the sample size, the lesser will be the sampling error and the more efficient it will be in estimating the population parameter. Efficiency in this context refers to the extent in which the sample statistics can reflect the true parameters of the population (Sudman, 1976).

One of the methods employed in determining the sample size is to take sampling fraction equal to the 1/10th of the total population. However, there are exceptions to this rule depending on the size of the population, the means and the time available (Black and Champion, 1976).

Beside this approach, the researcher can also employ statistical formulae in order to obtain the required sample. In this case, he has to arbitrarily determine the level of significance required, the tolerance level (error limit) permitted and the estimate of the sample standard deviation. This method has its weakness since there is no guarantee to ensure that the estimated values are the best values for the particular situation. It requires much experience and ability on the part of the researcher to know which values and levels are the most appropriate one under such situation. Futhermore, it may be impractical when the means are limited.

Cochran (1963) however, suggested the formula[1] below in the computation of sample size:

$$n = \frac{\left(\frac{tC}{d}\right)^2}{1 + \frac{1}{N}\left(\frac{tC}{d}\right)^2}$$

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1. A detailed explanation of the derivation of the equation can be found in W.G. Cochran, Sampling Techniques (New York : John Wiley and Sons Inc.), Chapters 2 and 4.

where:

- t = a constant value to hold good the probability statement, which is approximately equal to 1.96;
- C = Coefficient of variation
- d = margin of error tolerated from the estimated mean and true mean; and
- N = total population of the cocoa farmers in the region.

From the previous investigations of the cocoa smallholders in the region, the coefficients of variation computed for land size was 1.77 for the region of Hutan Melintang, 3.11 for Bagan Datoh and 1.24 for Teluk Baru (Nik Fuad and Mohd Sharif (1978). While for that of the gross income derived from cocoa was 0.6 (Nasuddin *et al.*, 1987). Since the variable of interest in the present study is more towards income, it was decided therefore, to use the value computed by Nasuddin *et al.* in the calculation of the present sample size.

Thus based of the formula at various values of d (at 95% confidence level), n can be computed as shown in Table 6.2.

From this table, the required sample size increases as the level of error decreases. However, since the cost of obtaining information was fixed at M$ 12.00 per sample and based on the budget available, it was decided therefore, to sample 260 farmers from the total population in the 4 Mukim. This figure falls within the error ranging from seven to eight per cent (at 95 per cent confidence level)

TABLE 6.2. DISTRIBUTION OF SAMPLE SIZE BY DIFFERENT LEVELS OF ERRORS

ERRORS (d)	SAMPLE SIZE (n)
0.05	501
0.06	364
0.07	272
0.08	212
0.09	170
0.10	138

This constituted about approximately 7 per cent of the total smallholders population. With a sampling fraction of n/N = 260/3717, the sample size (n) for each Mukim was then computed and the results are shown in Table 6.3. To select the samples in each of the 4 Mukim, simple random sampling where each respondent has an equal chance of being selected was conducted, using the Kendall Random Table.

TABLE 6.3.
DISTRIBUTION OF SAMPLE SIZE ACCORDING TO MUKIM

MUKIM	N	n
RUNGKUP	1414	99
BAGAN DATOH	785	55
TELUK BARU	442	31
HUTAN MELINTANG	1071	75
TOTAL	3717	260

6.7. QUESTIONNAIRES.

The instrument of this study is a questionnaire of items which were designed in line with the objectives that have been outlined in the earlier chapter. Moser and Kalton (1971 : 308) stated that.

> "No survey can be better than its questionnaire, a cliche which well expresses the truth that, no matter how efficient the sample design or sophisticated the analysis, ambiguous questions will produce non-comparable answers, leading questions biased answers and vague questions vague answers."

They further pointed out that the discussion on the questionnaire should commence at the start of the planning stages and only end when the pilot survey has successfully been undertaken.

This instrument can be used conveniently when the number of respondents required to be reached are large. Moreover, it allows anonymity on the part of the respondent which sometimes in certain circumstances is considered essential (Turney and Robb, 1971).

Basically, the questions that were asked were in line with the objectives of the study and the hypothesis to be tested and they comprised mainly :

i) Background information of the farmer and his family members;

ii) Farm status (comprises land size and type of soil);

iii) Fertilizer, weedicides and pesticides application;

iv) Labour utilisation;

v) Farm tools/equipment used;

vi) Crop yield;

vii) Credit, farm records/accounts and extension contact.

The details of the questionnaire are given in Appendix 6.

6.8. PILOT SURVEY

Before the actual survey was being conducted, a pilot survey which is a small-scale replica of the main survey was carried out in the study area in August 1987. Only 20 smallholders were randomly selected for this purpose. Through this means it was possible to determine the adequacy of the questionnaire. The response obtained were noted under several categories. They comprised mainly those questions that are considered as ambiguous, technical questions which the farmers found difficult to understand; the time taken for anwering the questions, and whether the answers suggest that too much strain is being put on people's memories.

One point to be stressed here is that since the samples collected were very small, they are not of much value in providing estimates of variability with any worth-while precision regarding the population to be studied.

The final part of the questionnaires was designed after amending some of the parts based on the comments received in the pilot survey. All the questions were asked in Bahasa Malaysia since all the respondents are Malays.

6.9. INTERVIEW AND FIELD SURVEY

Although permission was granted by the District Agriculture Officer regarding the survey to be undertaken, nevertheless, at the Mukim and the Kampung levels, the

Penghulu and the Ketua Kampung had also to be approached for the sake of courtesy. This was to ensure that the fullest cooperation could be given to the enumerators during the process of data collection. Normally, farmers were very suspicious of any individual who tries to get some information regarding their farming activities mainly because of income tax implications. However, with the assurance from these two key figures at the Mukim and Kampung levels, the unwillingness on the part of the farmers to furnish the necessary details was greatly reduced.

Before the start of the main survey three enumerators were recruited to assist the researcher in the collection of data. In selecting these individuals due consideration was given to their behaviour, personality, knowledge of the local farm conditions and their educational standard. These factors have a bearing on the success of the survey. A good personality and behaviour, for example, has a profound effect in securing the willingness of the respondents to cooperate. Enumerators who are familiar with the local farm conditions will be able to check the accuracies of the information given. Since in this area there are many unemployed high school graduates, a decision was made to select a few based on the above criteria. The recruitment of these graduates provides an added advantage in terms of the agricultural knowledge that they have acquired. At least they have the skill in guiding the farmers to be on the right track in line with the required information. This in a way will improve the quality of the data gathered.

After the selection process, the next step was the training of these enumerators. During this stage the purpose and the importance of the survey were made known to them. The importance of their role was explained so that they were made to feel that the value of the survey was dependent upon the accuracy and the completeness of the information that they gathered. A detailed study and discussion were made on the questionnaires together with the techniques of assessing the different weights and measures used. Before going to the field, a mock interview was conducted among the enumerators in the presence of the researcher. This was to familiarise themselves with the questions and the techniques of interviewing that were to be applied.

Each enumerator was allocated interviews with 80 farmers and the remainder were undertaken by the researcher himself. The actual field survey lasted for about 45 days at an average rate of two questionnaires per day. Sometimes, it was only possible to interview one farmer a day due to the difficulties in transportation, accessibility, distance and inadequate infrastructure in the area. All the interviews were conducted from midday till the evening in order to avoid taking the farmer's time working on their farms.

During the course of the survey as shown in the schedule outlined in Table 6.4. constant visits were made in order to check the work in progress. As human beings, enumerators were liable to make mistakes however sound the training process might be. As such fieldwork checks were undertaken mainly to test whether they were asking the questions and interpreting as well as recording the answers in line with the instructions given or to test whether they had made all the interviews claimed.

TABLE 6.4. TIMETABLE OF FIELDWORK

	ACTIVITIES	STARTING DATE	DURATION
A.	Preparation of Survey -		
	1. Seeking permission from the Department of Agriculture, Hilir Perak, the Penghulu and the Village Headmen. 2. Compiling the list of cocoa farmers to be surveyed. 3. Recruitment and Training of Eumerators.	Last Week of December 1988 till 2nd week of January 1989	3 Weeks
B.	Survey of cocoa farmers	3rd Week of January 1989 till end of February 1989	6 Weeks

Every alternate day, the enumerators and the researcher met to examine the completed questionnaires and to take the necessary actions, wherever appropriate.

6.10. SUMMARY

This chapter has attempted to examine the sampling procedures employed in the collection of the cross-sectional farm survey data. Owing to the time and financial constraints, only a fraction of the smallholders population were selected for sampling using the simple random technique. Personal interviews were undertaken with the help of the questionnaires that were designed. Although all information gathered from the respondents were based from their memories and some field inspections made, nevertheless with all the measures that had been undertaken, it is believed that the data obtained were reliable enough to provide some practical solutions to the problem of low productivity that prevails in this region.

CHAPTER SEVEN

SAMPLE PROFILE

This chapter is focussed on the description of the sample profile which encompasses the sociological as well as the farm characteristics obtained from the regions to which the investigation pertains.

In this analysis, three statistical techniques were used; tabular, chi-square and an analysis of variance. Only those variables which are relevant to the present study are discussed. It is hoped that the information presented here will provide the reader with a general picture of the present status of the cocoa smallholders in the study area.

7.1. SOCIOLOGICAL CHARACTERISTICS

Some basic sociological characteristics of the sampled farmers comprising the age of the operators and their spouses, level of education attained by the family members and the farming experience acquired will be presented below.

7.1.1 AGE OF THE FARMER

The results of the survey are shown in Table 7.1. The age of the farmers ranged from less than 30 years to more than

71 years, the majority (79.7%) being over 41 years old. Those in the age group between 51 to 60 years old constituted about 36.0% of the total sample. The major portion of those in this group (38.7%) came from Rungkup.

In this analysis, however, there were 258 samples as two farmers refused to respond to this particular variable.

TABLE 7.1
AGE GROUP OF FARMERS BY REGION

AGE GROUP (YEARS)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤30	-	2 (3.7)*	2 (2.0)	6 (8.0)	10 (3.9)
31-40	6 (19.4)	12 (22.2)	19 (19.4)	8 (10.7)	45 (17.4)
41-50	7 (22.6)	15 (27.8)	24 (24.5)	21 (28.0)	67 (26.0)
51-60	12 (38.7)	18 (33.3)	36 (36.7)	27 (36.0)	93 (36.0)
61-70	6 (19.4)	7 (13.0)	10 (10.2)	12 (16.0)	35 (13.6)
≥71	-	-	7 (7.1)	1 (1.3)	8 (3.1)
TOTAL	31	54	98	75	258
MEAN AGE	51.32	49.43	51.27	50.97	50.80
STD. DEV.	10.35	10.43	11.60	11.45	11.14
F. RATIO	0.59				
F. PROB.*	0.61				

* Figures within parentheses are percentages.
* The F probability used here and in other tables that follow refers to critical F-value.

The results also indicated that in each of the respective regions, more than a third of the farmers were within this age group. The finding from this study reveal that the mean age of the farmers was 50.8 years. The F statistics obtained from the analysis of variance however, showed that there was no significant difference in age for the regions surveyed. Table 7.1 illustrates the fact that in this area, cocoa farming is mostly being undertaken both by the middle and the older age groups and it seems that the interest by the young age group is lacking as shown by the small percentage involved. A similar trend has also been reported by Chua (1981) in his study of coconut smallholders in Johore, Malaysia.

7.1.2. SPOUSE'S AGE

The average age of the spouse obtained from this survey (see Table 7.2) was 43.9 years and the difference in age among the four regions surveyed was statistically significant as indicated by the F statistics obtained from the analysis of variance.

The majority were between 41 to 50 years old and this constituted about 39.3% of the total sample. In Teluk Baru, this formed about 45.2%, Rungkup 44.9% and Hutan Melintang, 32.0%. In Bagan Datoh most of the spouses were between 31 to 40 years of age and this constituted about 37.7% of the total in that region. The table also shows that about 21.4% of the spouses were between 51 to 60 years old while those below 40 years constituted about 36.6% of the total sample. On the whole the spouses were younger than their husbands by a difference of 6.9 years.

TABLE 7.2
AGE GROUP OF SPOUSES BY REGION

AGE GROUP (YEARS)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
21-30	2 (6.5)*	7 (13.2)	11 (11.2)	15 (20.0)	35 (13.6)
31-40	7 (22.6)	20 (37.7)	18 (18.4)	14 (18.7)	59 (23.0)
41-50	14 (45.2)	19 (35.8)	44 (44.9)	24 (32.0)	101 (39.3)
51-60	8 (25.8)	6 (11.3)	22 (22.4)	19 (25.3)	55 (21.4)
61-70	-	1 (1.9)	3 (3.1)	3 (4.0)	7 (2.7)
TOTAL	31	53	98	75	257
MEAN	45.58	41.53	44.86	43.93	43.99
STD. DEV.	8.49	8.79	10.05	11.36	10.08
F. RATIO	2.49				
F. PROB.	0.06				

* Figures within parentheses are percentages.

7.1.3. EDUCATIONAL LEVEL OF THE FARMERS

The level of education attained by the farmers could be considered to be very low. Table 7.3 shows that 11.6% of them had no schooling at all. Nearly half of the total sample, that is, 49.6% had primary education and this was true for all the regions except Hutan Melintang. In this region the majority of the farmers (46.7%) had attended adult education and only 32.0% had attended primary school.

TABLE 7.3
EDUCATIONAL LEVEL OF THE FARMERS BY REGION

EDUCATIONAL LEVEL OF FARMERS	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
No Schooling	5 (16.1)•	5 (9.3)	8 (8.2)	12 (16.0)	30 (11.6)
Adult Education	9 (29.0)	12 (22.2)	28 (28.6)	35 (46.7)	84 (32.6)
Primary Education	14 (45.2)	36 (66.7)	54 (55.1)	24 (32.0)	128 (49.6)
Lower Secondary	3 (9.7)	-	5 (5.1)	3 (4.0)	11 (4.3)
Upper Secondary	-	1 (1.9)	3 (3.1)	1 (1.3)	5 (1.9)
TOTAL	31	54	98	75	258

CHI-SQUARE (PEARSON)* 24.56
SIGNIFICANCE 0.02

• Figures within parentheses are percentages.
* The Chi-square is used here in order to test for a significant difference in terms of proportions rather than the means.

The former refers to the special educational programme organised by the government to cater for the needs of the adult. Through this programme basic literacy tools, such as writing and reading in romanized Malay is taught in a formal manner to the interested parties so as to enable them to acquire the skills desired. Not many farmers, however, had secondary schooling; out of the total sample, 4.3% had attended lower secondary and only 1.9% managed to reach upper secondary level. The Chi-square value shows that there was significant difference in terms of the educational levels attained by the farmers in all the regions concerned.

7.1.4. EDUCATIONAL LEVEL OF THE SPOUSES

As for the spouses, the level of education attained by them was considered very low too, and there was significant difference in the educational levels achieved among the regions surveyed. About 16.0% of the sample had no schooling at all. However, a major portion (43.6%) of the spouses had attended primary education in all the regions concerned except for Hutan Melintang where only 26.7%, came under this category. In this region, it was those who had the adult education that constituted the majority of the sample. At the secondary level, only 4.3% had lower secondary and 1.6% upper secondary education (Table 7.4).

TABLE 7.4
EDUCATIONAL LEVEL OF SPOUSES BY REGION

EDUCATIONAL LEVEL OF SPOUSES	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
No Schooling	8 (25.8)*	7 (13.2)	11 (11.2)	15 (20.0)	41 (16.0)
Adult Education	10 (32.3)	13 (24.5)	31 (31.6)	35 (46.7)	89 (34.6)
Primary Education	12 (38.7)	31 (58.5)	49 (50.0)	20 (26.7)	112 (43.6)
Lower Secondary	1 (3.2)	1 (1.9)	5 (5.1)	4 (5.3)	11 (4.3)
Upper Secondary	-	1 (1.9)	2 (2.0)	1 (1.3)	4 (1.6)
TOTAL	31	53	98	75	257
CHI-SQUARE (PEARSON)		19.84			
SIGNIFICANCE		0.07			

* Figures within parentheses are percentages.

Comparatively speaking, there was not much difference between the levels of education attained by the farmers and their spouses in this study. Such a situation was to be expected since in Malaysia, it is considered a norm for a man to choose someone who either possessed the same educational level or lower than him in order to be his spouse. The total number of samples in this study was 257 as three farmers were widowers during the time of the survey.

7.1.5. EDUCATIONAL LEVEL OF FARMER'S CHILDREN

The levels of education of the children varied from those who had not reached schooling age to those who had completed tertiary education. As shown from Table 7.5

TABLE 7.5
EDUCATIONAL LEVEL OF FARMER'S CHILDREN BY REGION

CHILDREN'S LEVEL OF EDUCATION	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
Not School Yet	1 (3.2)*	4 (7.3)	11 (11.1)	12 (16.0)	28 (10.8)
Still attending Primary Educ.	24 (77.4)	6 (10.9)	7 (7.1)	11 (14.7)	48 (18.5)
Comp. Primary Educ.	1 (3.2)	-	3 (3.0)	-	4 (1.5)
Still attending Lower Secondary	-	15 (27.3)	22 (22.2)	16 (21.3)	53 (20.4)
Comp. Lower Secondary	-	-	12 (12.1)	3 (4.0)	15 (5.8)
Still attending Upper Secondary	5 (16.1)	18 (32.7)	24 (24.2)	15 (20.0)	62 (23.8)
Comp. Upper Secondary	-	7 (12.7)	12 (12.1)	9 (12.0)	28 (10.8)
Still attending Tertiary Educ.	-	5 (9.1)	5 (5.1)	8 (10.7)	18 (6.9)
Comp. Tertiary Educ.	-	-	3 (3.0)	1 (1.3)	4 (1.5)
TOTAL	31	55	99	75	260
CHI-SQUARE (PEARSON)		110.07			
SIGNIFICANCE		0.00			

* Figures within parentheses are percentages.

there was a significant difference as regard to the educational level attained among the regions. The majority of the farmer's children were still attending upper secondary education and this constituted about 23.8% of the total sample. The second largest group comprised those who were still attending the lower secondary level, followed by primary education (18.5%). Only a small proportion of the farmer's children managed to proceed to institutions of higher learning and this formed about 6.9% of the total sample.

Although it is the policy of the government to give opportunities to pupils to continue schooling until the age of 15, that is, up to the lower secondary level, nevertheless in this survey, it was found, there were a small percentage (1.5%) of the farmer's children who had not resumed their studies after completing primary education.

This probably could be attributed to the attitudes of the parents; since the children did not fare well at this level, it would be better to terminate their schooling and use them as a source of family labour in the daily operations of the farm.

7.1.6. FARMING EXPERIENCE

The farming experience acquired by the farmers ranged from less than five years to more than 26 years, giving an overall average of 12.7 years. There was, however, no significant difference in terms of the farming experience acquired by the farmers in the regions surveyed as indicated by the value of the F statistics obtained from the analysis of variance.

TABLE 7.6 FARMING EXPERIENCE BY REGION
(in years)

FARMING EXPERIENCE (Years)	TELUK BARU	BAGAN DATUH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 5	3 (9.7)*	5 (9.1)	6 (6.1)	13 (17.3)	27 (10.4)
6-10	11 (35.5)	18 (32.7)	27 (27.3)	27 (36.0)	83 (31.9)
11-15	12 (38.7)	14 (25.5)	50 (50.5)	20 (26.7)	96 (36.7)
16-20	4 (12.9)	15 (27.3)	8 (8.1)	10 (13.3)	37 (14.2)
21-25	-	1 (1.8)	3 (3.0)	2 (2.7)	6 (2.3)
≥ 26	1 (3.2)	2 (3.6)	5 (5.1)	3 (4.0)	11 (4.2)
TOTAL	31	55	99	75	260
MEAN	11.84	13.71	13.14	11.81	12.72
STD. DEV.	5.77	6.15	5.59	6.52	6.03
F RATIO	1.45				
F PROB.	0.23				

* Figures within parentheses are percentages

Most of the farmers (36.7%) had 11 to 15 years of experience in farming. In Rungkup for example, this constituted about half of total farmers in that region. The next largest group was those whose farming experience ranged from 6 to 10 years and this formed about 31.9% of the total sample. Only 20.7% of the farmers had more than 15 years and 10.4% had less than or equal to five years of experience as shown in Table 7.6.

7.2 FARM CHARACTERISTICS

Under this sub-topic, the discussion will be centred on the following variables, namely; land size, age of the cocoa plants, the use of chemicals and fertiliser inputs, labour utilisation, service flow from farm implements, extension contact, the use of farm records and accounts, credit and the yield obtained.

7.2.1. LAND SIZE USED FOR COCOA CULTIVATION

Almost all the farmers (99%) owned and worked the farms they lived in. This, therefore, suggests that they had full control over the management of the farms.

The land size used for cocoa cultivation in the study area averaged 3.5 acres and varied from less than an acre to more than 11.01 acres. More than half of the farmers (53.5%) had land size between 1.01 to 3.00 acres and the largest proportion came from Rungkup which constituted about 36.0% of the sample in that group. Table 7.7 shows

TABLE 7.7. DISTRIBUTION OF LAND SIZE USED FOR COCOA CULTIVATION BY REGION
(in acres)

LAND SIZE (acres)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 1	-	4 (7.3)	9 (9.1)	9 (12.0)	22 (8.5)
1.01-3.00	20 (64.5)*	25 (45.5)	50 (50.5)	44 (58.7)	139 (53.5)
3.01-5.00	6 (19.4)	22 (40.0)	26 (26.3)	16 (21.3)	70 (26.9)
5.01-7.00	4 (12.9)	2 (3.6)	3 (3.0)	3 (4.0)	12 (4.6)
7.01-9.00	1 (3.2)	2 (3.6)	5 (5.1)	2 (2.7)	10 (3.8)
9.01-11.00	-	-	2 (2.0)	-	2 (0.8)
≥ 11.01	-	-	4 (4.0)	1 (1.3)	5 (1.9)
TOTAL	31	55	99	75	260
MEAN	3.44	3.29	3.99	3.03	3.49
STD. DEV.	1.77	1.62	3.67	1.97	2.69
F. RATIO	1.98				
F. PROB.	0.12				

* Figures within parentheses are percentages

that, the majority of the farmers in each of the 4 regions possessed land size within this range, that is, 64.5% in Teluk Baru, 45.5% in Bagan Datoh, 50.5% in Rungkup and 58.7% in Hutan Melintang.

The second largest group of farmers was those possessing land size between 3.01 to 5.00 acres and this formed about 26.9% of the total sample in the regions. Only 1.9% of the farmers had land size equal or greater than 11.01 acres. The F statistics obtained from the analysis of variance revealed that there was no significant difference in terms of land size acquired by the farmers in the four regions. Table 7.7 reflects that the land size cultivated with cocoa was extremely small in this study area. The traditional system of land inheritance by sub-division practised by the local farmers might have contributed to this unfavourable condition where there were a large number of small farms.

Field observation revealed that there were several factors which served to impede the ability of the farmers to increase the size of their operational holding. In the first instance lack of ready cash hindered them from enlarging their farms. Although mortgage credit was made available through the local Agricultural Bank, the risk involved especially because of crop failure, and the incapacity to settle debts within the specified period might pose a serious impediment to those who wished to expand their operations.

Most of the occupants however, were reluctant to sell their holdings because of traditional attachment to land, also land has proved to be a good source of investment and even more significantly, there is lack of alternative occupations for the cocoa farmers.

7.2.2. AGE OF COCOA PLANTS

The age of the cocoa plants as shown in Table 7.8 ranged from less than 5 years to 25 years, giving an overall mean of 13.5 years for the entire region. There was however, not much difference from the result of the earlier study where the mean age was reported to be 11.0 years (Nasuddin *et al.*, 1987).

In the earlier study, only two regions, namely Bagan Datoh and Hutan Melintang were examined compared to four in the present study. Most of the plants however, were between 11 to 15 years and this accounted about 49.2% of the total sample. Out of this, the largest (43.0%) came from Rungkup, followed by Hutan Melintang (28.1%), Bagan Datoh (15.6%) and Teluk Baru (13.3%). About 27.3% of the farmers surveyed had their cocoa plants within the age group of 16 to 20 years and only a small percentage (1.5%) were in the 21 to 25 years group. The rest, about 22.0% had plants less than 10 years. Through the analysis of variance

TABLE 7.8. AGE OF COCOA PLANTS BY REGION
(in years)

AGE OF COCOA PLANTS (Years)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 5	-	2 (6.1)*	6 (4.0)	3 (4.0)	11 (4.3)
6-10	6 (19.4)	8 (14.5)	15 (15.2)	17 (22.7)	46 (17.7)
11-15	17 (54.8	20 (36.4)	55 (55.6)	36 (48.0)	128 (49.2)
16-20	8 (25.8)	25 (45.5)	21 (21.2)	17 (22.7)	71 (27.3)
21-25	-	-	2 (2.0)	2 (2.7)	4 (1.5)
TOTAL	31	55	99	75	260
MEAN	13.68	14.29	13.01	13.32	13.45
STD. DEV.	2.94	3.83	3.75	3.88	3.73
F RATIO	1.59				
F PROB.	0.19				

* Figures within parentheses are percentages

conducted, it is found that there was no significant difference in the age of the cocoa trees in all the four regions.

The means from these four locations however, suggest that the cocoa plants were still in their productive stage and if properly maintained could produce an average yield of 570 kg. of dried beans per acre per annum (Hong and Kee, 1987).

It should be stressed here that since the information gathered on this particular input was solely based on the memories of the farmers, there are bound to be inaccuracies in the measurement of this variable. Therefore, under such situation, due caution should be exercised in interpreting the data given in the above table.

7.2.3. FERTILISER APPLICATION

In this study area, it was revealed that the majority of the farmers used the compound fertilisers, CCM 66 and CCM 77 (Chemical Company of Malaysia Compound No. 66 and 77) which contains 14% nitrogen (N_2), 14% phosphate (P_2O_5) and 14% potash (K_2O) for CCM 66 and 17% N_2, 8% P_2O_5 and 17% K_2O for CCM 77. Besides these two types of fertilisers, the farmers also used Urea and lime for their cocoa plants. On the average, for the entire survey area, the quantity of CCM 66 and CCM 77 used was considered to be very little amounting to 12.5kg. and 22.5kg. per acre per annum, respectively. This was well below the recommended dosage of 120kg. as outlined by the local Agriculture Department. As for the other types of fertilisers, the quantum applied was extremely small averaging around 7.7kg. which again was far below the recommended rate of 100kg. for every acre of plot cultivated.

TABLE 7.9 AVERAGE ANNUAL EXPENDITURE OF FERTILISERS PER ACRE BY REGION
(in M$)

FERTILISER COST (M$/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 10.00	7 (22.6)*	27 (49.1)	61 (61.6)	30 (40.0)	125 (48.1)
10.01-50.00	21 (67.7)	21 (38.2)	26 (26.3)	26 (34.7)	94 (36.2)
50.01-90.00	3 (9.7)	5 (9.1)	7 (7.1)	12 (16.0)	27 10.4)
90.01-130.00	-	1 (1.8)	3 (3.0)	3 (4.0)	7 (2.7)
130.01-170.00	-	1 (1.8)	1 (1.0)	1 (1.3)	3 1.2)
≥ 170.01	-	-	1 (1.0)	3 (4.0)	4 (1.5)
TOTAL	31	55	99	75	260
MEAN	27.76	20.63	19.14	37.49	25.78
STD. DEV.	21.64	27.11	36.93	55.69	40.89
F RATIO	3.32				
F PROB.	0.02				

* Figures within parentheses are percentages

The purchase of this input could be made either from the local Farmers Association or the local shopkeepers and the choice where to purchase was entirely left to the farmers themselves to decide. However, there were bound to be some differences in the cost incurred but on the whole it was relatively cheaper to purchase fertilisers from the Farmers Association.

Through the analysis of variance performed, it was found that there was a significant difference in terms of the amount of expenditures on this input among the farmers in the four regions sampled. From Table 7.9 it was found that farmers in Hutan Melintang spent more on fertilisers than the rest of the regions surveyed. This implies that the farm operators in this particular locality used more of this input compared to those in Teluk Baru, Bagan Datoh and Rungkup.

Although all the farmers realised the importance of fertiliser for crop production, nevertheless, the use of this input factor is closely associated with their financial standing and the ease involved in obtaining it. In Hutan Melintang, for example, based on the information obtained from the local Farmers Association, almost three quarter of the farmers in this area are members of this organisation. In fact, this association is among the few in the country where the management is controlled by the members themselves.

As members, they not only received benefits in terms of the annual dividends through the shares that they acquired but also in terms of the relatively lower price of the input purchased compared to the ones bought from the local shopkeepers. Thus the larger the quantum bought, the more income the association will receive and the more dividends will be obtained by the members. This incentive therefore, serves as a stimulant for the farmers who are members to purchase more of this input and use it for crop production. Although in this study no question was put forward to determine the status of the farmers as to whether they are members of the association or not, nevertheless the high expenditure on fertilisers in this region might give an indication that they are members of this body and had purchased this input from the latter. Hence this explains why in this particular locality, expenditure on fertilisers was the highest averaging approximately M$ 37.49 compared to M$ 27.76 in the case of Teluk Baru, M$ 20.63 for Bagan Datoh and M$ 19.14 in Rungkup.

7.2.4. CHEMICALS

In this study chemicals denote pesticides as well as weedicides used by the farmers for the purpose of pests, disease and weed control in the cocoa farms.

From this analysis it was found that the average annual amount of pesticides used per acre was very little and it amounted to 0.15 litre. Normally heavy application was made when serious infestation occurred and the farmers had the financial means to do so. Since during the study period, there was no major outbreak of pests and diseases such a small quantity as reported here was to be expected. As for weedicides, the annual quantity used per acre was approximately 1.5 litres for the whole of the survey area. It should be emphasised here that the purpose of weed control is basically to reduce competition, to allow access to the plots and therefore, makes the tasks of spraying and harvesting easier. Farmers can either make use of the herbicides if they had the financial capabilities to purchase this input or to remove the weeds manually by using the weeding tools such as a sickle or a hoe. In mature cocoa, weed growth is normally suppressed by the heavy shade beneath the canopy.

However, a regular weeding operation is still a necessity but the job becomes lighter involving the use of less labour for each cycle. Therefore, the small amount of weedicides applied as reported from the present finding was anticipated considering the fact that since this is already a matured area, weed competition was not that serious compared to the situation when cocoa is still in its immature stage. Furthermore, manual slashing was normally undertaken in place of weedicides when the amount of weeds present was not extensive.

TABLE 7.10
AVERAGE ANNUAL COST OF CHEMICALS PER ACRE BY REGION
(in M$)

CHEMICAL COST (M$/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 10	10 (32.3)*	28 (50.9)	56 (56.6)	33 (44.0)	127 (48.8)
10.01-15.00	5 (16.1)	6 (10.9)	14 (14.1)	11 (14.7)	36 (3.8)
15.01-20.00	6 (19.4)	7 (12.7)	9 (9.1)	10 (13.3)	32 (12.3)
20.01-25.00	1 (3.2)	4 (7.3)	2 (2.0)	7 (9.3)	14 (5.4)
25.01-30.00	4 (12.9)	5 (9.1)	5 (5.1)	7 (9.3)	21 (8.1)
30.01-35.00	5 (16.1)	3 (5.5)	4 (4.0)	6 (8.0)	18 (6.9)
35.01-40.00	-	2 (3.6)	1 (1.0)	1 (1.3)	4 (1.5)
40.01-45.00	-	-	3 (3.0)	-	3 (1.2)
≥ 45.01	-	-	5 (5.1)	-	5 (1.9)
TOTAL	31	55	99	75	260
MEAN	15.67	12.32	12.07	12.80	12.76
STD. DEV.	11.92	12.12	17.79	11.45	14.34
F RATIO	0.52				
F PROB.	0.67				

* Figures within parentheses are percentages

The summation of the weedicides and the pesticides costs gives rise to the total chemical cost. It ranged from less than M$10.00 to more than M$45 per acre per year with an average of M$12.76 for the whole sample as shown in Table 7.10. There was however, no significant difference in the cost incurred for all the regions concerned as shown by the F statistics obtained from the analysis of variance.

7.2.5. LABOUR UTILISATION

Once the cocoa plants start fruiting, the two major activities that have to be undertaken by the farmers are to maintain their fields in good shape and to undertake the harvesting activities.

As explained earlier, field maintenance is an essential operation in the management of the cocoa farms. It comprised mainly those farm operations associated with drain maintenance, weeding, manuring, pest control and pruning of the cocoa trees. From this study, the amount of labour utilised ranged from less than 1.00 man-day to more than 13.01 man-days per acre annually, giving an overall average of 4.95 man-days for the whole of the survey area. This amount was relatively low compared to the recommended labour requirement of 11.1 man-days which is computed based on the best technical practices. Such a great difference stems from the fact that the majority of the farmers did not undertake the pruning operation and drain maintenance during the period in question. Other maintenance activities such as weeding, manuring and pest control were also minimal owing to the low dosage of chemicals and fertilisers applied. This has the consequence of lowering the total consumption of labour. From the analysis of variance, it was found that there was a significant difference with regard to the amount of labour utilised among the four regions involved.

Comparatively speaking, the farmers in Teluk Baru spent more time on maintenance activities than the other three regions as shown by the mean obtained (see Table 7.11).

In this region the farmers used on the average about 8.1 man-days per acre per annum compared to 5.38 man-days in Bagan Datoh, 4.59 man-days in Hutan Melintang and 4.0 man-days in Rungkup. From the analysis made, it was found that such a high labour consumption in Teluk Baru was based on the fact that in this locality farmers spent relatively more time on pruning their cocoa trees and the execution of other maintenance work than the rest of the regions. Furthermore, it was also found that most of the farmers applied insecticides for protective measures even though there was no major insect infestation. All these farm operations as such resulted in higher labour utilisation in this area.

TABLE 7.11
AVERAGE ANNUAL AMOUNT OF MAN-DAYS SPENT ON FIELD MAINTENANCE ACTIVITIES BY REGION
(in man-days)

MAINTENANCE LABOUR (MAN-DAYS/AC/YR)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 1.00	-	7 (12.7)*	14 (14.1)	8 (10.7)	29 (11.2)
1.01-4.00	5 (16.1)	16 (29.1)	43 (43.4)	30 (40.0)	94 (36.2)
4.01-7.00	7 (22.6)	13 (23.6)	29 (29.3)	26 (34.7)	75 (28.8)
7.01-10.00	10 (32.3)	14 (25.5)	10 (10.1)	8 (10.7)	42 (16.2)
10.01-13.00	7 (22.6)	4 (7.3)	2 (2.0)	3 (4.0)	16 (6.2)
≥ 13.01	2 (6.5)	1 (1.8)	1 (1.0)	-	4 (1.5)
TOTAL	31	55	99	75	260
MEAN	8.10	5.38	4.00	4.59	4.95
STD. DEV.	3.70	3.59	2.78	2.83	3.33
F RATIO	14.52				
F PROB.	0.00				

* Figures within parenteses are percentages

Harvesting activities in this study encompassed the plucking of the pods from the cocoa trees, splitting of the pods, fermentation, drying and transporting the beans to the selling points. It was found that the amount of labour spent in carrying out the harvesting activities ranged from less than 10 man-days to more than 30 man-days, giving an overall average of 19.78 man-days per acre per annum as shown in Table 7.12.

TABLE 7.12
AVERAGE ANNUAL HARVESTING ACTIVITIES BY REGION
(in man-days)

HARVESTING ACTIVITIES (MAN-DAYS/AC/YR)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 10.00	-	-	10 (10.1)*	3 (4.0)	13 (5.0)
10.01-15.00	6 (19.4)	6 (10.9)	21 (21.2)	12 (16.0)	45 (17.3)
15.01-20.00	11 (35.5)	34 (61.8)	23 (23.2)	25 (33.3)	93 (35.8)
20.01-25.00	10 (32.3)	12 (21.8)	23 (23.2)	14 (18.7)	59 (22.7)
25.01-30.00	4 (12.9)	3 (5.5)	18 (18.3)	13 (17.3)	38 (14.6)
≥ 30.01	-	-	4 (4.0)	8 (10.7)	12 (4.6)
TOTAL	31	55	99	75	260
MEAN	19.52	18.89	19.15	21.36	19.78
STD. DEV.	4.50	3.43	7.07	7.65	6.44
F RATIO	2.23				
F PROB.	0.09				

* Figures within parentheses are percentages

This figure again is relatively low compared to the recommended level of 29.1 man-days. Nevertheless, because of low crop yield and since the majority of the smallholders sold their beans in the wet form, less labour was therefore, required to perform the harvesting activities.

From the analysis of variance, it was revealed that there was significant difference in terms of labour utilisation for harvesting activities among the four regions.

7.2.6. TOTAL LABOUR UTILISATION

By summing up the time spent on the maintenance and harvesting activities, we obtain the total amount of labour used by the farmers for the production of cocoa.

As shown in Table 7.13, this ranged from less than 10 man-days to more than 40 man-days per acre per annum giving an annual average of 24.73 man-days per acre. The F statistics derived from the analysis of variance indicated that there was significant difference among the four regions in terms of the total amount of labour used for crop production. In Teluk Baru more than a third of the farmers were reported to have used between 30.01 to 35.0 man-days per acre annually whereas in Bagan Datoh, the majority of them (38.2%) spent between 20.01 to 25.0 man-days. In Hutan Melintang although most of them used between 20.01 to 25.0 man-days, this only formed about 29.3 % of the farmers in this region.

TABLE 7.13
AVERAGE ANNUAL QUANTITY OF LABOUR PER ACRE BY REGION
(in man-days)

LABOUR (man-days/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 10.00	-	-	6 (6.1)*	1 (1.3)	7 (2.7)
10.01-15.00	-	2 (3.6)	8 (8.1)	5 (6.7)	15 (5.8)
15.01-20.00	4 (12.9)	7 (12.7)	25 (25.3)	13 (17.3)	49 (18.9)
20.01-25.00	7 (22.6)	21 (38.2)	15 (15.2)	22 (29.3)	65 (25.0)
25.01-30.00	7 (22.6)	18 (32.7)	24 (24.2)	13 (17.3)	62 (23.8)
30.01-35.00	11 (35.5)	6 (10.9)	18 (18.2)	12 (16.0)	47 (18.1)
35.01-40.00	2 (6.5)	1 (1.8)	3 (3.0)	2 (2.7)	8 (3.1)
≥ 40.01	-	-	-	7 (9.3)	7 (2.7)
TOTAL	31	55	99	75	260
MEAN	27.62	24.27	23.15	25.95	24.73
STD. DEV.	5.69	5.47	7.67	8.41	7.41
F RATIO	3.96				
F PROB.	0.01				

* Figures within parentheses are percentages.

The overall analysis revealed that farmers in Teluk Baru used the highest amount of labour, averaging around 27.62 man-days per acre per annum. Such a significant difference was mainly due to the high consumption of labour to undertake both the maintenance as well the harvesting activities.

7.2.7. SERVICE FLOW OF FARM EQUIPMENT

Equipment used for cocoa production may be broadly classified into that used in field maintenance, harvesting and in processing. From this survey, it was found that the maintenance equipment used by the farmers consisted mainly of 'cangkuls' (hoes), 'parang' (big knives), knapsack sprayers and scissors. Harvesting equipment includes harvesting knives and baskets while that of the processing includes fermentation boxes, wooden shovel and rakes, drying mats and gunny sacks. All these equipment have a different life-span ranging from 1 to 5 years based on the guidelines given by the extension officer in the area. Thus for example, in the case of hoes, big knives, scissors and harvesting knives, this equipment may last only for 3 years, knapsack sprayer for 5 years, fermentation boxes for 2 years while that of the wooden shovels, rakes, baskets, gunny sacks and drying mats have a life span of 1 year.

However, in the survey, the majority of the farmers still used this equipment although it had exceeded its life expectancy.

As noted in Chapter five, in the computation of the equipment service flow no discount rate was taken into account in this analysis as most kinds of equipment used have short life expectancies. Maintenance cost was also not considered as the amount incurred was neglible. In the context of the present study we use the original value of each piece of equipment together with its life expectancy to compute the annual service flow. The sum of all these pieces of equipment current service flow for each farm, constituted the farm's equipment input in the analysis.

From the survey results as shown in Table 7.14, the annual service flow ranged from less than M$5.00 to more than M$30.01 per acre giving an overall mean for the entire study area of M$8.45. An analysis of variance shows that there was a significant difference in the amount of service flow in all the regions concerned. Farmers in Teluk Baru seem to have the highest service flow compared to the rest as indicated by the means computed.

The large variation in the amount of service flow could be attributed to the variation in the number of pieces of

TABLE 7.14 AVERAGE ANNUAL SERVICE FLOW OF FARM EQUIPMENT PER ACRE BY REGION (in M$)

SERVICE FLOW (M$/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 5.00	1 (3.2)*	9 (16.4)	51 (51.5)	15 (20.0)	76 (29.2)
5.01-10.00	13 (41.9)	27 (49.1)	40 (40.4)	34 (45.3)	114 (43.8)
10.01-15.00	9 (29.0)	13 (23.6)	5 (5.1)	13 (17.3)	40 (15.4)
15.01-20.00	3 (9.7)	5 (9.1)	2 (2.0)	6 (8.0)	16 (6.2)
20.01-25.00	4 (12.9)	-	-	3 (4.0)	7 (2.7)
25.01-30.00	1 (3.2)	1 (1.8)	-	4 (5.3)	6 (2.3)
≥ 30.01	-	-	1 (1.0)	-	1 (0.4)
TOTAL	31	55	99	75	260
MEAN	12.28	9.65	5.33	10.09	8.45
STD. DEV.	5.45	4.39	5.71	6.48	6.19
F RATIO	17.67				
F PROB.	0.00				

* Figures within parentheses are percentages

equipment possessed by the smallholders. For those who normally sold their beans in the wet form, no processing activities had to be undertaken and as such it was not necessary for them to acquire the related equipment. As a result the total service flow incurred will be much less than for those who undertook such activities. In Teluk Baru, for example, the majority of the farmers sold their products in the form of dried beans. This, therefore, required the use of additional equipment such as a fermentation box and other processing tools as outlined earlier. This, therefore, has the consequence of increasing the amount of service flow as depicted in Table 7.14.

One point to be stressed here is that, it was not a necessity on the part of the farmers to replace the whole set of equipment although they had exceeded their life span. This equipment in fact could still be in use and replacement was only made when they were totally worn-out. Thus it was common to have a combination of a few pieces of equipment which were still not obsolete and a larger proportion of the old ones in the production process in this study area.

7.2.8. EXTENSION CONTACT

Extension contact in this analysis refers to the number of times the farmers had formal contact with the extension agents during the study period. Table 7.15 shows that the number ranges from less than 5 to more than 26 times per

TABLE 7.15
AVERAGE NUMBER OF EXTENSION CONTACT PER ANNUM BY REGION

EXTENSION CONTACT (per yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 5	29 (93.5)*	38 (69.1)	87 (87.9)	70 (93.3)	224 (86.2)
6-10	2 (6.5)	12 (21.8)	7 (7.1)	2 (2.7)	23 (8.8)
11-15	-	1 (1.8)	3 (3.0)	1 (1.3)	5 (1.9)
16-20	-	4 (7.3)	1 (1.0)	-	5 (1.9)
21-25	-	-	-	2 (2.7)	2 (0.8)
≥ 26	-	-	1 (1.0)	-	1 (0.4)
TOTAL	31	55	99	75	260
MEAN	1.74	4.82	2.44	2.13	2.78
STD. DEV.	2.28	5.19	4.30	4.39	4.46
F RATIO	5.36				
F PROB.	0.00				

* Figures within parenthese are percentages

annum with an annual average of 2.78 times. Most of the farmers (86.2%) reported that they had contact less than or equal to 5 times with the extension agents and the majority (38.8%) of them came from Rungkup. About 8.8% of the farmers surveyed reported to have contact between 6 to 10 times followed by 3.8% having between 11 to 20 contact per annum. Only a small percentage of the sample had more than 21 formal contacts with the extension agents.

From the analysis of variance, it was found that there was a significant difference in the amount of extension contact among the regions surveyed. Farmers in Bagan Datoh had more frequent contact with the extension staff during the period under review. This is perhaps due to the fact that the farmers in this area still lack the necessary technical knowledge required for the management of their cocoa holdings. As a result more contact has to made with the extension workers in order to acquire such knowledge.

7.2.9. FARM RECORDS AND ACCOUNTS

From Table 7.16 the survey results indicated that only 10% of the farmers kept farm records and accounts while the majority (90%) of them never practised it. On a regional basis, it was found that in Teluk Baru about 22.6% of the farmers were involved with this activity compared with 12.1% in Rungkup, 8.0% in Hutan Melintang and 1.8% in Bagan Datoh.

Comparatively speaking the highest number of farmers who kept farm records and accounts came from Rungkup which constituted about 46.2% out of the total in the affirmative

TABLE 7.16
AVERAGE NUMBER OF FARMERS KEEPING FARM RECORDS AND ACCOUNTS BY REGION

RESPONSE	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
No	24 (77.4)*	54 (98.2)	87 (87.9)	69 (92.0)	234 (90.0)*
Yes	7 (22.6)	1 (1.8)	12 (12.1)	6 (8.0)	26 (10.0)
TOTAL	31	55	99	75	260
CHI SQUARE (PEARSON)		10.37			
SIGNIFICANCE		0.02			

* Figures within parentheses and percentages

group followed by those in Teluk Baru (26.9%) and Hutan Melintang (23.1%). The least was in the region of Bagan Datoh where only about 3.8% of the farmers were associated with this form of farm activity. As for the group which did not keep farm records and accounts, the results showed that the highest proportion was found in Rungkup (37.2%), followed by Hutan Melintang (29.5%), Bagan Datoh (23.1%) and Teluk Baru (10.3%).

What can be revealed from this analysis is that since only a small percentage of the population practised farm bookkeeping, a major effort must be made by the Department of Agriculture to inculcate into the minds of the farmers the importance of this tool in the decision making process and planning at the farm level. The distribution of free farm records and account books as is being practised now should be accompanied by incorporating the above step if fruitful results are to be expected.

7.2.10. CREDIT

Although credit plays a pivotal role in developing peasant farming, in this study area, only a minority of the farmers took advantage of the facilities provided both by the formal and informal sources. During the period under investigation, only 1.2% of the farmers reported that they had taken credit for cocoa production (see Table 7.17).

The majority of them (98.8%) reported did not take this input during the study period and this is especially so in the regions of Teluk Baru and Rungkup where none of the farmers were involved. Out of those in the affirmative group, the largest was found in Bagan Datoh (66.7%) and the least was in Hutan Melintang (33.3%).

The reason for the low response could be attributed partly to the risk involved in taking this input. Besides that, religious factors, old age and attitudes could also partly explain for the low response.

TABLE 7.17
AVERAGE NUMBER OF FARMERS TAKING CREDIT BY REGION

RESPONSE	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
No	31 (100.0)*	53 96.4)	99 (100.0)	74 (98.7)	257 (98.8)
Yes	-	2 (3.6)	-	1 (1.3)	3 (1.2)
TOTAL	31	55	99	75	260
CHI SQUARE (PEARSON)		4.51			
SIGNIFICANCE		0.211			

* Figures within parentheses are percentages

7.2.11. OUTPUT

There are two types of output produced by the farmers, namely wet and dried cocoa beans. As for wet beans, the average annual output produced ranged from less than 100kg per acre to more than 700kg, giving an average of 270.02kg.

This figure however, differs with the result obtained in the earlier study conducted by Nasuddin *et al*, (1987), where the average yield obtained was 338 kilogrammes per acre. This decline in productivity might be partly attributed to the decrease in the use of fertiliser as a result of the low cocoa price received during the study period. Because of the decrease in the income obtained,

TABLE 7.18
AVERAGE ANNUAL OUTPUT OF WET COCOA PER ACRE BY REGION
(in kilogrammes)

OUTPUT (kg/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 100	4 (12.9)*	-	6 (6.1)	9 (12.0)	19 (7.3)
100.01-200	9 (29.0)	22 (40.0)	34 (34.3)	20 (26.7)	85 (32.7)
200.01-300	4 (12.9)	19 (34.5)	29 (29.3)	29 (38.7)	81 (31.2)
300.01-400	3 (9.7)	6 (10.9)	20 (20.2)	14 (18.7)	43 (16.5)
400.01-500	9 (29.0)	7 (12.7)	7 (7.1)	1 (1.3)	24 (9.2)
500.01-600	-	-	1 (1.0)	2 (2.7)	3 (1.2)
600.01-700	1 (3.2)	1 (1.8)	1 (1.0)	-	3 (1.2)
≥700.01	1 (3.2)	-	1 (1.0)	-	2 (0.8)
TOTAL	31	55	99	75	260
MEAN	310.28	278.61	270.01	247.09	270.02
STD. DEV.	186.43	121.28	128.86	112.09	131.63
F RATIO	1.82				
F PROB.	0.14				

* Figures within parentheses are percentages

they might face financial difficulties to purchase more of this input for crop production. The declining productivity might also indicate that the management of the cocoa holdings in this area has worsened during the study period.

The F statistics computed from the analysis of variance indicated that there was no significant difference in the amount of wet beans produced by all the regions in this study area (see Table 7.18).

The table also revealed that the majority of the farmers, that is, about 63.9% of them obtained between 100.01 to 300kg. per acre and 25.7% obtained between 300.01 to 500kg. Only a small proportion managed to produce more than 500kg.

The income received from the sales of wet beans is illustrated in Table 7.19. From the analysis of variance it was found that there was no significant difference in the amount obtained among the regions surveyed.

As for those who processed their products in the form of dried beans, the output obtained ranged from less than 50kg to 200kg per acre per annum. As shown in Table 7.20, most of the farmers (82.3%) produced less than or equal to 50kg. per acre annually and only 17.7% produced more than that quantum.

From the analysis of variance, it was found that on a regional basis, there was a significant difference in the amount of dried cocoa produced and farmers in Teluk Baru obtained the highest output averaging about 41.71kg. per acre per annum. This is followed by Hutan Melintang with

TABLE 7.19
AVERAGE ANNUAL INCOME DERIVED FROM WET COCOA BEANS PER ACRE BY REGION
(in M$)

INCOME (M$/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 100	4 (12.9)*	-	7 (7.1)	10 (13.3)	21 (8.1)
100.01-200	10 (32.3)	22 (40.0)	35 (35.4)	23 (30.7)	90 (34.6)
200.01-300	3 (9.7)	19 (34.5)	27 (27.3)	27 (36.0)	76 (29.2)
300.01-400	4 (12.9)	6 (10.9)	20 (20.2)	12 (16.0)	42 (16.2)
400.01-500	8 (25.8)	7 (12.7)	8 (8.1)	3 (4.0)	26 (10.0)
500.01-600	1 (3.2)	-	1 (1.0)	-	2 (0.8)
600.01-700	1 (3.2)	1 (1.8)	-	-	2 (0.8)
≥ 700.01	-	-	1 (1.0)	-	1 (0.4)
TOTAL	31	55	99	75	260
MEAN	281.48	275.09	262.99	233.19	259.16
STD. DEV.	169.13	118.56	126.19	105.83	125.64
F RATIO	1.73				
F PROB.	0.16				

* figures within parentheses are percentages

an average annual output of 28.89kg, and the least was in Rungkup where the output was only 11.91kg.

The possible reason why production was the highest in Teluk Baru was because most of the farmers in this locality realised the benefits accruing from processing the wet beans produced into the dried form so that they could

TABLE 7.20 AVERAGE ANNUAL OUTPUT OF DRIED COCOA BEANS PER ACRE BY REGION (in kilogrammes)

OUTPUT (kg.)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 50	19 (61.3)*	47 (85.5)	90 (90.9)	58 (77.3)	214 (82.3)
50.01-100.00	9 (29.0)	8 (14.5)	6 (6.1)	12 (16.0)	35 (13.5)
100.01-150.00	3 (9.7)	-	3 (3.0)	4 (5.3)	10 (3.8)
150.01-200	-	-	-	1 (1.3)	1 (0.4)
TOTAL	31	55	99	75	260
MEAN	41.71	15.86	11.91	28.89	21.19
STD. DEV.	45.53	29.42	29.67	44.69	37.83
F RATIO	6.86				
F PROB.	0.00				

* Figures within parentheses are percentages

receive better prices for their products. In addition, adequate manpower as well as processing equipment were also available to undertake this processing activity which normally consumed time.

For the entire sample, the average annual output of dried beans obtained was 21.19kg. Such a low quantum was to be expected. In spite of the fact that selling the product in the form of dried beans could fetch a higher selling price, the farmers preferred to sell the beans in the wet form. This would not only shorten the duration for processing (which normally takes around 7 - 10 days) but at the same time they would get immediate cash to meet their basic needs.

Table 7.21 shows the average annual income derived from the sale of dried beans. From the F statistics derived from the analysis of variance, it was revealed that there was a significant difference in the average income obtained among the regions surveyed. Depending on the quantity and quality produced, the income obtained ranged from less than M$100 to M$500 giving an average annual income of M$61.12 for the entire sample.

About 73.1% of the farmers received less than or equal to M$ 100 per acre per annum and this formed the bulk of the farmers sampled in all the four regions. The table also shows that farmers in Teluk Baru obtained the highest average annual income of M$116.73 and this was mainly associated with the greater amount of dried bean being produced.

TABLE 7.21
AVERAGE ANNUAL INCOME DERIVED FROM DRIED BEANS PER ACRE BY REGION
(in M$)

INCOME (M$)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 100	15 (48.4)*	42 (76.4)	85 (85.9)	48 (64.0)	190 (73.1)
100.01-200.00	7 (22.6)	9 (16.4)	6 (6.1)	13 (17.3)	35 (13.5)
200.01-300.00	7 (22.6)	4 (7.3)	5 (5.1)	9 (12.0)	25 (9.6)
300.01-400.00	2 (6.5)	-	2 (2.0)	-	4 (1.5)
400.01-500.00	-	-	1 (1.0)	5 (6.7)	6 (2.3)
TOTAL	31	55	99	75	260
MEAN	116.73	46.09	34.21	84.68	61.12
STD. DEV.	127.25	85.86	88.05	131.33	110.14
F RATIO	6.48				
F PROB.	0.00				

* Figures within parentheses are percentages

The total gross annual income derived both from the sales of wet and dried cocoa beans is shown in Table 7.22.

TABLE 7.22
AVERAGE ANNUAL INCOME DERIVED FROM COCOA BEANS PER ACRE BY REGION (in M$)

TOTAL GROSS INCOME (M$/ac/yr)	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG	TOTAL
≤ 100	-	-	1 (1.0)*	-	1 (0.4)
100.01-200	-	13 (23.6)	30 (30.3)	15 (20.0)	58 (22.3)
200.01-300	8 (25.8)	19 (34.5)	32 (32.3)	30 (40.0)	89 (34.2)
300.01-400	6 (19.4)	10 (18.2)	20 (20.2)	16 (21.3)	52 (20.0)
400.01-500	12 (38.7)	10 (18.2)	10 (10.1)	9 (12.0)	41 (15.8)
500.01-600	4 (12.9)	-	4 (4.0)	-	8 (3.1)
600.01-700	1 (3.2)	3 (5.5)	-	4 (5.3)	8 (3.1)
≥ 700.01	-	-	2 (2.0)	1 (1.3)	3 (1.2)
TOTAL	31	55	99	75	260
MEAN	398.20	320.36	298.67	318.16	320.75
STD. DEV.	107.25	130.43	131.10	127.51	130.29
F RATIO	4.81				
F PROB.	0.00				

* Figures within parentheses are percentages

From the analysis of variance, it was found that there was a significant difference in the gross income among the four regions. It ranged from less than M$100 to more than M$700 per acre per annum, giving an average of M$320.75 for the entire study area.

Most farmers (34.2%) reported earning between M$200.01 to M$300 followed by 22.3% receiving between M$100.01 to M$200. The third largest group were those obtaining between M$300.01 to M$400. Only a small percentage, that is 7.4% of the farmers reported receiving earnings greater than M$500. On the whole, farmers in Teluk Baru received the highest average annual gross income mainly, due to the proper field maintenance being undertaken and also arising from the use of more farm implements as reflected by the greater amount of service flow incurred. In addition farmers in this area processed a greater portion of the wet beans produced into its dried form. The average gross income received for the whole of the study area was relatively lower than that reported by Nasuddin *et al*, (1987). In the earlier study undertaken the farmers obtained an average gross income of M$ 428 per acre compared to M$ 320 in the present study. This difference arises because of the relatively low output produced and the decrease in the price of the cocoa beans as a result of the glut in the world market. In 1987 the average price of the wet beans per kilogramme was M$ 1.27 compared to M$

1.18 during the study period.

7.2.12. SUMMARY

This chapter has analysed some of the characteristic features of the cocoa farming in the District of Hilir Perak, which is regarded as one of the largest cocoa growing areas in Peninsula Malaysia.

The survey indicated that the cocoa smallholders sampled were relatively old and had ample experience in cocoa farming. Although most of them had attained some education, nevertheless, the levels achieved were relatively low.

On the whole, the average land size cultivated was rather small and could not generate a sufficient amount of income to bring the farmers above the poverty level. Owing to the lack of financial means, the use of modern inputs such as fertilisers and chemicals was minimal.

As these factors of production directly influence crop production, their minimal use reduced the yield drastically. Labour consumption per acre was relatively low in this study area and this was attributed mainly to the minimal usage of complementary inputs and less maintenance work that was being undertaken. The small amount of annual service flow for farm implements incurred, pointed to the fact that farmers surveyed might have used less farm equipment during the study period. The study also revealed that the extension contacts that the farmers had were minimal and as a result the diffusion of appropriate new technology which is vital to the development of the smallholders is thus, restricted. It was also demonstrated that the farmers in this locality had still not realised the importance of keeping farm records and accounts as only a small portion of them were reported to undertake this form of farm activity.

The response of the farmers towards the credit facilities provided by the credit institutions was rather poor during the study period since only a very small percentage of the sample were involved in taking advantage of the facilities provided.

On the whole it can be seen that the average annual income received by the smallholders was quite low in this survey area. The lack of awareness among the cocoa farmers of proper agronomic practices, lack of ready cash to purchase fertilisers and chemicals, lack of technical knowledge as reflected by the low level of education attained and infrequent contact with the extension personnel might have contributed to this phenomenon. Considerable attention must be devoted to these factors in the effort to increase their productivity.

CHAPTER EIGHT

STATISTICAL RESULTS AND INTERPRETATIONS

In the previous chapter, some of the main features of the sample profile were examined and compared for the four regions under investigation. It was noted that one of the major problems facing the smallholders in this study area was the prevalence of low productivity as indicated by the low crop production and hence the low gross income obtained. The present chapter, however, is devoted to identify those factors of production that contributed significantly to the production of cocoa intercropped with coconut in this study area.

The above information obtained is vital in the sense that if the government wishes to increase agricultural production, for example, it would have to facilitate and encourage the use of those inputs that have significant influence on the total product of the farms being considered. At the same time, it is also considered important to know which factors have more influence than the others so as to enable the government to design the appropriate development strategies which are considered relevant to the area under investigation.

In order to acquire the above information, the expected gross income was regressed with the inputs mentioned in

Chapter Five. Expected income as the dependent variable was measured through the yield expected to be obtained from the production of cocoa and coconut multiplied by the expected selling prices of the produce received during the year 1988, that is, the period to which the investigation pertains.

Average production functions are used in this analysis. In the words of Timmer (1970), the use of the average production functions would serve as a foil to the frontier functions that will be estimated in Chapter 10.

8.1. PRODUCTION FUNCTION USED IN THE ANALYSIS

The Cobb-Douglas form of production function was used as the basis of the analysis in this study mainly on a priori grounds connected with the logic of production, its attractive economic theory properties and its statistical manageability as mentioned in Chapter Five earlier.

To aid the memory, the estimated farm production function used in its logarithmic form is written as:

$$\log Y = \log a_0 + a_1 \log X_1 + \ldots\ldots + a_8 \log X_8 + b_1 D_1 + \ldots\ldots b_{10} D_{10} + \mu$$

Where

log Y = log of expected income from cocoa and coconut

$\log X_1$ = log of age of farmers

$\log X_2$ = log of land size

$\log X_3$ = log of labour

$\log X_4$ = log of services from farm implements

$\log X_5$ = log of extension contact

$\log X_6$ = log of chemical cost (comprising cost of weedicide and pesticide)

$\log X_7$ = log of fertiliser cost

$\log X_8$ = log of living capital

D_1 = Region Teluk Baru

D_2 = Region Bagan Datoh

D_3 = Region Rungkup

D_4 = Region Hutan Melintang

D_5 = Soil-Selangor Series

D_6 = Soil-Kangkong Series

D_7 = Educational Level of Farmers

D_8 = Educational Level of Spouses

D_9 = Educational Level of Children

D_{10} = Farm Records and Accounts.

A number of regression models comprising both the production functions expressed in its overall form and on a per acre basis were used in this analysis. The former were employed in order to provide long term planning at the macro level under the assumption that all inputs can be expanded to reap the benefits of large scale production. The use of the production function on a per acre basis provides the foundation for the short term measures that are required to be taken under the condition where land is limited as what the farmers in this study area are facing now.

All the equations were estimated by using the Ordinary Least Squares regression technique and all the variables except the dummies were transformed into the logarithmic form to the base e. To obtain regression models that were meaningful and interpretable for the problem under investigation, a number of computer runs using the SPSSX package were undertaken. In each run, minor modifications were made on the regression equations based on the inclusion of different sets of independent variables.

In choosing the model, these basic questions were continuously asked:

a) Were the regression equations estimated reasonable? That is, did the variables make sense in light of theoretical argument; and

b) Were the estimated regression coefficients reasonable? That is, were the signs and the magnitudes of the coefficients intuitively reasonable?

Initially, the following variables, namely; credit, farming experience, maintenance and harvesting labour, pesticides and weedicides were supposed to be incorporated into this analysis. Based on the data collected, only three farmers were reported to take credit for the production of cocoa under coconut. Owing to their small number, this input was, therefore, not included in the analysis. Farming experience is normally associated with the age of the farmers. Because of the inconsistencies in the results, farming experience was dropped from the main equation. Similarly, the splitting of labour into maintenance and harvesting labour also produced inconsistencies in the results obtained. Thus, it was decided that these two types of labour should be aggregated into one variable, that is, total labour. The same principle also applies in the case of weedicides and pesticides, where they were grouped into one input, namely, chemicals, in this analysis.

As regard to the dummy variables that were included in the production function analysis, the rule which was applied was to drop one variable less the number of values of the original variable. Otherwise, the Ordinary Least Squares technique would breakdown because of the perfect collinearity between the intercept and all the dummy groups. In this study, since there were two types of soil series being involved, namely; the Kangkong and the Selangor series only one soil type, that is the Kangkong series was included in the model in order to destroy the collinearity that might exist. The same principle applies to all other dummy variables used in this study. Hence, the estimates obtained in the analysis were made with reference to farmers who cultivated their plots on Kangkong soil series, practised keeping farm records and accounts, have formal education, having children whose level of education higher than that of the lower secondary schooling and have spouses with formal education.

In order to avoid a singular matrix due to the linear dependence of the values of 1's which might cause an equation to be inestimable, the regional dummy Hutan Melintang (D_4) was dropped from the analysis. This dropped dummy is measured as a norm and the coefficients of other regional dummies measure the shift from this normal level.

8.2. REGRESSION MODELS

The various regression models used are summarised in Tables 8.1 and 8.2. In Table 8.1 all the models used were expressed in their overall form in order to enable us to determine the impact of those inputs on the expected income. Table 8.2, however, depicts the models adopted to determine the contribution of all the variables on a per acre basis.

TABLE 8.1. REGRESSION MODELS USED TO DETERMINE THE FACTORS AFFECTING EXPECTED INCOME FOR THE ENTIRE SURVEY AREA, ACCORDING TO FARM SIZE AND REGION - USING OVERALL PRODUCTION FUNCTION

INPUTS	REGRESSION MODELS (R)		
	R_1, R_3	R_2, R_4, R_5	R_6, R_7, R_8, R_9
Farmer's Age	✓	✓	✓
Land size	✓	✓	✓
Labour	✓	-	-
Labour/acre	-	✓	✓
Farm Implements	✓	✓	✓
Extension Contact	✓	✓	✓
Chemicals	✓	✓	✓
Fertilisers	✓	✓	✓
Living Capital	✓	-	-
Living Capital/acre	-	✓	✓
Region Teluk Baru	✓	✓	-
Region Bagan Datoh	✓	✓	-
Region Rungkup	✓	✓	-
Soil-Kangkong Series	✓	✓	✓
Farmer's Education	✓	✓	✓
Spouse's Education	✓	✓	✓
Children's Education	✓	✓	✓
Farm Records & Accounts		✓	✓ ✓

✓ input used in the respective models

Note:

R_1 - Regression model used to determine the determinants of expected income for the entire survey area.

R_2 - Regression model used (after solving the multicollinearity problem) for the whole area.

R_3 - Regression model used for small farm.

R_4 - Regression model used for small farm after solving the multicollinearity problem.

R_5 - Regression model used for large farm after solving the multicollinearity problem.

R_6 - Regression model used for region Teluk Baru.

R_7 - Regression model used for region Bagan Datoh.

R_8 - Regression model used for region Rungkup.

R_9 - Regression model used for region Hutan Melintang.

TABLE 8.2. REGRESSION MODELS USED TO DETERMINE THE FACTORS AFFECTING EXPECTED INCOME USING PRODUCTION FUNCTION ON A PER ACRE BASIS.

INPUTS	REGRESSION MODELS (R)	
	R_{10}, R_{11}, R_{12}	R_{13} to R_{16}
Farmer's Age	✓	✓
Farm Implements/acre	✓	✓
Extension Contact	✓	✓
Chemicals/acre	✓	✓
Fertilisers/acre	✓	✓
Labour/acre	✓	✓
Living Capital/acre	✓	✓
Region Teluk Baru	✓	-
Region Bagan Datoh	✓	-
Region Rungkup	✓	-
Farmer's Education	✓	✓
Soil-Kangkong Series	✓	✓
Spouse's Education	✓	✓
Children's Education	✓	✓
Farm Records and Accounts	✓	✓

✓ inputs used in the respective models.

Note:

R_{10} - Regression model used for the entire area.
R_{11} - Regression model used for small farms.
R_{12} - Regression model used for large farms.
R_{13} - Regression model used for region Teluk Baru
R_{14} - Regression model used for region Bagan Datoh
R_{15} - Regression model used for region Rungkup
R_{16} - Regression model used for region Hutan Melintang

8.3. STATISTICAL RESULTS AND INTERPRETATION

8.3.1. PRODUCTION FUNCTION - POOLED DATA

The results of using model R_1 to determine which factors of production that had a significant influence on the expected income are presented in Table 8.3.

The adjusted coefficient of multiple determination (that is the $\bar{R}$ square) obtained was 0.8680, which means that approximately, 87 per cent of the variation in the dependent variable could be explained by the variation in the independent variables included in the analysis. Thirteen per cent of the variation might be due partly to input factors which were not being taken into account such as climatic factors and quality differentials.

Examining the correlation matrix as shown in Appendix 7, revealed that land size was highly correlated with living capital ($r = 0.91$) and labour ($r = 0.85$). Such a high value of the bivariate relationship according to Heady and Dillon (1966) indicated the presence of multicollinearity among the explanatory variables. Regressing each of the independent variable on all the other independent variables as suggested by Farrar and Glauber (1967) also indicated that there was a high collinearity in the variable, land size (see Table 8.4).

TABLE 8.3. OVERALL PRODUCTION FUNCTION STATISTICS FOR THE ENTIRE SURVEY AREA

INPUTS	PARAMETERS	REGRESSION (R_1)
Constant	a_0	4.8918*** (0.5300)▪
Farmers' age	a_1	-0.1190* (0.0697)
Land size	a_2	0.5091*** (0.0779)
Labour	a_3	0.1481*** (0.0526)
Farm Implements	a_4	0.0092* (0.0050)
Extension contact	a_5	0.0057* (0.0032)
Chemicals	a_6	0.0032 (0.0021)
Fertilisers	a_7	0.0167*** (0.0029)
Living Capital	a_8	0.2207*** (0.0585)
Region Teluk Baru	b_1	0.0029 (0.0880)
Region Bagan Datoh	b_2	-0.0043 (0.0656)
Region Rungkup	b_3	0.0331 (0.0399)
Soil-Kangkong Series	b_6	0.0120 (0.0708)
Farmer's Education	b_7	0.1399** (0.0699)
Spouse's Education	b_8	-0.0418 (0.0628)
Children's Education	b_9	-0.0087 (0.0326)
Farm Records/Accounts	b_{10}	0.1139** (0.0546)
Adjusted R square	0.8680	
F - Statistic	105.39***	
D - W Statistic	1.95	
No. of Cases	260	

▪ figure in brackets are the standard errors
Level of significance: * 10 per cent, ** 5 per cent, *** 1 per cent

TABLE 8.4.
R SQUARE VALUES OBTAINED BY REGRESSING EACH OF THE INDEPENDENT VARIABLE ON ALL OTHER INDEPENDENT VARIABLES.

INDEPENDENT VARIABLES AS DEPENDENT VARIABLES	R Square
Land	0.8984
Farmers' Age	0.0899
Labour	0.7868
Extension Contact	0.1974
Chemicals	0.3566
Fertilisers	0.4739
Living Capital	0.8438

The pertinent question that arises is the extent or the 'degree' of multicollinearity that is acceptable in the analysis. Until now no consensus has been reached regarding this issue (Thomas, 1985).

Klein (1962) suggested that multicollinearity was not a problem for prediction if

$$r_{ij} < R$$

where R is the square root of the coefficient of multiple determination and r_{ij} is the correlation between X_i and X_j, where $i = 1 \ldots k$.

Applying this method, the outcomes obtained showed that for land and living capital, R value of 0.8947 was less than the value of the sample correlation of 0.907, thus indicating that the degree of multicollinearity was quite severe. On the other hand, for land and labour, the R value of 0.9022 was higher than the sample correlation of 0.849 which implied that the degree of multicollinearity that existed was not that severe. The same also applies in the case of labour and living capital where the R value (0.8958) was higher than the value of r (0.777).

However, to reduce the problem of multicollinearity in this study, it was therefore, decided that both living capital and labour should be expressed on a per acre basis as illustrated in model R_2, Table 8.5. From the correlation matrix (Appendix 8), all the bivariate relationships were below 0.8 indicating the absence of multicollinearity among the variables. Further, the results obtained are similar to Table 8.3. in terms of the level of significance of the explanatory variables, as well as the value of the adjusted R square. Only the magnitude of land size differed.

From Table 8.5 it was revealed that farmers' age had a significant and negative relationship with expected income and also with fertilisers, chemicals, labour, living capital and their level of education as shown in Appendix 8.

TABLE 8.5. OVERALL PRODUCTION FUNCTION STATISTICS FOR THE ENTIRE SURVEY AREA (AFTER SOLVING THE MULTICOLLINEARITY PROBLEM)

INPUTS	PARAMETERS	REGRESSION (R_2)
Constant	a_0	4.8918*** (0.5300)•
Farmers' Age	a_1	-0.1190* (0.0697)
Land Size	a_2	0.8779*** (0.0299)
Farm Implements	a_4	0.0092* (0.0050)
Extension contact	a_5	0.0057* (0.0032)
Chemicals	a_6	0.0032 (0.0021)
Fertilisers	a_7	0.0167*** (0.0029)
Labour/acre	a_9	0.1481*** (0.0526)
Living Capital/acre	a_{10}	0.2207*** (0.0585)
Region Teluk Baru	b_1	0.0029 (0.0880)
Region Bagan Datoh	b_2	-0.0043 (0.0656)
Region Rungkup	b_3	0.0331 (0.0399)
Soil-Kangkong Series	b_6	0.0120 (0.0708)
Farmer's Education	b_7	0.1399** (0.0699)
Spouse's Education	b_8	-0.0418 (0.0628)
Children's Education	b_9	-0.0087 (0.0326)
Farm Records and Accounts	b_{10}	0.1139** (0.0546)
Adjusted R square	0.8680	
F - Statistic	105.39***	
D - W Statistic	1.95	
No. of cases	260	

• Figures in brackets are the standard errors
Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

Older farmers might find difficulties in coping with the latest technology in cocoa farming compared to younger farmers who tend to make better decisions concerning their farming operations because of their access to knowledge about cocoa production through the various sources available.

Spouse's education did not contribute significantly towards expected income in this analysis. The plausible explanation is that since the husbands were more dominant in the decision making process, it appeared that although the spouses might possess the necessary technical knowledge, they were not able to influence their husbands to be more innovative and receptive towards modern farm practices.

Children's education was not statistically significant in the regression analysis. Despite its academic orientation, formal education is supposed to provide knowledge and skills to every individuals. The education acquired will enable them to acquire agronomic and other related information from the relevant sources. In this study, it seemed that formal education of the children did not contribute significantly to expected income. From the survey, it was found that the farmers rarely involved their children in their farming operations. This probably could be attributed either to a lack of interest on the part of the children to be involved in cocoa farming or might be because of the positive attitude that farmers had towards their children's education that encouraged them to study and excell for the pursuit of other more lucrative professions. Under such circumstances, it was logical to find that children's education did not have a significant impact on cocoa production.

Regional influence did not contribute significantly to the income obtained as none of the regional dummies were significant in this analysis. Perhaps the underlying factor why there was no significant difference among the regions was because of the fact that all the regions concerned produced the same type of crops and used similar technology for crop production.

Soil type as an input was also found not to be significant in this study. In this survey area, the two types of soil that were being extensively used for cocoa and coconut production were the Kangkong and Selangor series which were predominantly marine clay. According to Kee (1967) this marine clay had been found to be the richest soil in the country in terms of its nutrient status. However, exhaustive use of the soil due to long period of cultivation might deplete the nutrient contents available. This however, could be remedied by the application of the right amount of fertiliser during crop production. As far as this study area was concerned, the quantity to be applied by the farmers is based on the guidelines given by the Local Department of Agriculture. From the correlation matrix, it was found that D_6 (Kangkong series) had a positive significant association with fertiliser and this was probably one of the reasons why it did not contribute significantly to the production of cocoa since its influence has been 'blurred' by fertilisers which was statistically significant in the estimated function.

During the reference period, there was no major insect infestation and most of the farmers did not apply any insecticides for control measures. Those who applied it used only a small amount averaging around 0.15 litre per acre per annum.

Such a small amount, of course, would have a negligible effect on cocoa production. The same applies in the case of weedicides where, on the average only about 1.5 litres were used for every acre annually. Hence the low quantity of chemicals applied was too small to cause any variation in the production of cocoa. Another possibility was that the lack of technical knowledge among older farmers might result in improper application techniques.

Thus from this model, R_2, the inputs that were found to have significant influence on expected income were the farmer's age, land size, labour, fertilisers, farm implements, extension contact, living capital, farmer's education and farm records and accounts.

8.3.2. PRODUCTION FUNCTIONS ACCORDING TO FARM SIZE

In this analysis, the pooled data was split into two different groups based on the average land size computed. Since the average obtained was approximately 3.5 acres, we thus, have two groups of farms; the first, with land size equal to or less than 3.5 acres, herein referred to as small farms, and second, those greater than 3.5 acres which were considered as large farms. The basis of dividing the farms into various sizes is very subjective in Malaysia. Tamin (1978), for example, classified small farms as those with land size less than or equal to 3.0 acres while those above 3.0 acres were considered as large farms.

In this study, using the arithmetic mean as a basis of classification is regarded as more sensible considering the ambiguities that surround the classification procedures (Yotopoulos, 1967).

The results obtained through the use of model R_3 were presented in Table 8.6. It was found that when land size was incorporated into the analysis, this input had a

TABLE 8.6. OVERALL PRODUCTION FUNCTION STATISTICS FOR SMALL FARMS

INPUTS	PARAMETERS	REGRESSIONS (R_3)
Constant	a_0	4.4467*** (0.6493)•
Farmer's Age	a_1	-0.2208** (0.0871)
Land Size	a_2	0.4308*** (0.1089)
Labour	a_3	0.2263*** (0.0673)
Farm Implements	a_4	0.0115** (0.0052)
Extension Contact	a_5	0.0090** (0.0039)
Chemicals	a_6	0.0022 (0.0028)
Fertilisers	a_7	0.0155*** (0.0036)
Living Capital	a_8	0.2998*** (0.0724)
Region Teluk Baru	b_1	0.1267 (0.1153)
Region Bagan Datoh	b_2	0.0216 (0.0884)
Region Rungkup	b_3	0.0785* (0.0473)
Soil-Kangkong	b_6	-0.0363 (0.0972)
Farmer's Education	b_7	0.1097 (0.0801)
Spouse's Education	b_8	-0.0454 (0.0749)
Children's Educ.	b_9	-0.0011 (0.0406
Farm Records & Accounts	b_{10}	-0.1484* (0.0895)
Ajusted R square		0.7919
F - Statistic		38.82***
D - W Statistic		1.91
No. of Cases		165

• Figures in brackets are the standard errors.

Level of significance: * 10 per cent, ** 5 per cent, *** 1 per cent.

tendency to be highly correlated with living capital which thus caused unreliability in the estimates because of the existence of multicollinearity among the explanatory variables (see Appendix 9).

Adopting the approach of expressing both labour and living capital on a per acre basis produced results as depicted in model R_4 of Table 8.7. From the correlation matrix computed (see Appendix 10) no presence of multicollinearity was indicated among the explanatory variables. The magnitudes of the estimated regression coefficients except in the case of land size were exactly the same as what was presented in model R_3 of Table 8.6. The same applies to the value of the adjusted R square calculated. The variables as a whole explained approximately 79 per cent of the variation in the expected income that was received. Thus for the small farms, factors which statistically affected expected income were farmer's age, land size, labour, farm implements, extension contact, fertilisers, living capital and farm records and accounts.

Only one regional dummy was significant in this model but only at the 10 per cent level of probability. The value of the regression coefficient of 0.0785 for Rungkup implied that this region was more productive compared to Hutan Melintang.

TABLE 8.7. OVERALL PRODUCTION FUNCTION STATISTICS FOR SMALL AND LARGE FARMS (AFTER SOLVING THE MULTICOLLINEARITY PROBLEM).

INPUTS	PARAMETERS	SMALL FARMS (R_4)	LARGE FARMS(R_5)
Constant	a_0	4.4467***	6.3187***
		(0.6493)*	(0.8552)
Farmer's age	a_1	-0.2208**	-0.1024
		(0.0871)	(0.01443)
Land Size	a_2	0.9469***	0.8952***
		(0.0544)	(0.0734)
Farm Implements	a_4	0.0115**	-0.0041
		(0.0052)	(0.0178)
Extension Contact	a_5	0.0090**	0.0028
		(0.0039)	(0.0051)
Chemicals	a_6	0.0022	0.0015
		(0.0028)	(0.0033)
Fertilisers	a_7	0.0155***	0.0221***
		(0.0036)	(0.0048)
Labour/acre	a_9	0.2263***	0.0043
		(0.0673)	(0.0797)
Living Capital/acre	a_{10}	0.2998***	0.0795
		(0.0724)	(0.0951)
Region Teluk Baru	b_1	0.1267	-0.2608*
		(0.1153)	(0.1309)
Region Bagan Datoh	b_2	0.0216	-0.0294
		(0.0884)	(0.0942)
Region Rungkup	b_3	0.0785*	-0.0399
		(0.0473)	(0.0649)
Soil-Kangkong	b_6	-0.0363	0.0802
		(0.0972)	(0.0952)
Farmer's Education	b_7	0.1097	0.1112
		(0.0801)	(0.1383)
Spouse's Education	b_8	-0.0454	-0.0998
		(0.0749)	(0.1102)
Children's Education	b_9	-0.0011	0.0134
		(0.0406)	(0.0586)
Farm Records & Accounts	b_{10}	-0.1484*	0.3095*
		(0.0895)	(0.0673)
Adjusted R Square		0.7919	0.7872
F - Statistic		38.83***	22.27***
D - W Statistic		1.91	1.89
No. of Cases		165	95

* Figures in brackets are the standard errors
Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

It was surprising to note that although farm records and accounts was significant at 10 per cent level of probability it has a negative sign in the model.

This indicated that farmers who practised keeping farm records and accounts for this group of farms obtained less income than those who did not. Perhaps they had better and more accurate records on income that led to the outcome of this negative sign.

In the case of large farms, different outcomes were obtained when the same variables were being regressed with expected income (see Table 8.7, model R_5). In this analysis both living capital and labour were again expressed on a per acre basis so as to avoid the occurrence of multicollinearity among the variables. The main determinants that affect farm income for this group of farm size were farm records and accounts, land size, and fertilisers. The regional dummy which was significant at 10 per cent level of probability was Teluk Baru with a regression coefficient of -0.26. This value gives an implication that farmers in this region were less productive compared to those in Hutan Melintang and they received less income than what was obtained by those in Hutan Melintang.

For large farms, the significant negative association of farmer's age with land size, extension contact, living capital, farmer's education, and spouse's education (see Appendix 11) implied that, the older farmers in this group of farm size, are less educated, have land size comparatively smaller than the younger ones, had lesser extension contact, less educated wife, and had lesser planting density both for cocoa and coconut palms. This phenomena might have resulted in the decrease of the farm income obtained and hence explains why farmer's age was not statistically significant for large farms.

Labour, however, had a significant negative association with farm size in this analysis as indicated by their bivariate relationship in Appendix 11. This shows that the larger the farm size, the less labour is being utilised in the production process. As the amount used might have been too small to have any significant impact in the production of cocoa, this explains why this input was not significant in this analysis.

Living capital, extension contact and farm implements also lost their significant influence for large farms. In the case of living capital perhaps the old age of the trees might have caused this particular input not to have any significant impact on farm income.

Owing to the large farm size, it was quite impossible for the extension agent to have frequent contacts with the farmers especially when the number of extension workers was limited in this study area. Although it was the duty of the extension workers to disseminate the relevant technical information and provide the necessary guidance to the farmers with respect to cocoa production, it must be emphasised that the effectiveness of the whole process does not only depend on the frequency of the visits made but also on the attitude and the receptivity of the smallholders. It appeared that in this study, for large farms, older farmers had lesser contacts with the extension workers implying the existence of negative attitudes among this group of farmers. Under such situations, it was logical to find that this input having no significant influence on the expected income.

In order to examine whether the functions that were fitted to the two groups of farms and the function for the pooled data were significantly different from one another, the Chow-Test was employed (Chow, 1960). In other words, we were testing the null hypothesis that $\beta_1 = \beta_2 = \beta$, where the β's refer to the coefficient vectors for both the farm groups and the pooled data, respectively.

This test examines the reduction in the residual sum of squares (RSS) for the separate regressions of the two farm groups and with the RSS for the overall sample to obtain the F - statistics. From Table 8.8, the F value computed was 2.92 and was significant at one per cent level of probability.

TABLE 8.8 CHOW-TEST FOR DIFFERENCES BETWEEN FARM GROUP

	No. of Cases	RSS	NO. OF REGRESSORS
Pooled data	260	13.3731	16
Small Farms	165	7.4129	16
Large Farms	95	3.5557	16

The null hypothesis was thus rejected. The test, therefore, suggests that the small farms and the large ones had different production functions which differed both in terms of the intercepts and factor elasticities.

8.3.3. <u>PRODUCTION FUNCTIONS ACCORDING TO REGION</u>

By categorizing the data on a regional basis (see Tables 8.9 and 8.10), it was found that in region Teluk Baru (Model R_5) only land size was significant at a one per cent level of probability. On the other hand, inputs like

TABLE 8.9. OVERALL PRODUCTION FUNCTION STATISTICS ACCORDING TO REGION

INPUTS	PARAMETERS	TELUK BARU (R_6)	BAGAN DATOH (R_7)
Constant	a_0	5.3307**	4.2546***
		(2.3091)*	(0.9718)
Farmer's Age	a_1	-0.0873	-0.1250
		(0.1561)	(0.1347)
Land Size	a_2	0.5981***	0.9341***
		(0.0940)	(0.0663)
Farm Implements	a_4	0.0789	0.0329
		(0.0754)	(0.1125)
Extension Contact	a_5	0.0011	0.0040
		(0.0059)	(0.0061)
Chemicals	a_6	0.0087*	1.4429E-04
		(0.0046)	(0.0047)
Fertilisers	a_7	0.0084	0.0191***
		(0.0086)	(0.0047)
Labour/Acre	a_9	0.2881*	0.3738***
		(0.1538)	(0.1365)
Living Capital/Acre	a_{10}	0.1163	0.1898**
		(0.2664)	(0.0838)
Soil-Kangkong	b_6	no. correlation	0.0026
			(0.0744)
Farmer's Education	b_7	0.0558	0.0704
		(0.1199)	(0.2053)
Spouse's Education	b_8	-0.1408	-0.0115
		(0.1210)	(0.1939)
Children's Education	b_9	-0.1083	0.0568
		(0.0835)	(0.0558)
Farm Records and Accounts	b_{10}	0.1237	0.1887
		(0.0871)	(0.2101)
Adjusted R square		0.8219	0.9328
F - Statistic		12.53***	55.44***
D - W Statistic		2.11	2.34
No. of Cases		31	55

* Figures in brackets are the standard errors
Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

TABLE 8.10 OVERALL PRODUCTION FUNCTION STATISTICS ACCORDING TO REGION

INPUTS	PARAMETERS	RUNGKUP (R_8)	HUTAN MELINTANG (R_9)
Constant	a_0	5.6794***	4.1459***
		(0.9547)[a]	(1.1289)
Farmer's Age	a_1	-0.2043*	0.0596
		(0.1223)	(0.1451)
Land Size	a_2	0.8545***	0.9137***
		(0.0494)	0.0782)
Farm Implements	a_4	0.0092	-0.0011
		(0.0068)	(0.0139)
Extension Contact	a_5	0.0110*	0.0031
		(0.0057)	(0.0076)
Chemicals	a_6	0.0049	-0.0013
		(0.0039)	(0.0048)
Fertilisers	a_7	0.0158***	0.0209***
		(0.0053)	(0.0075)
Labour/Acre	a_9	0.1589*	-0.0360
		(0.0822)	(0.1327)
Living Capital/Acre	a_{10}	0.1605	0.3039**
		(0.1137)	(0.1300)
Soil-Kangkong	b_6	no correlation	-0.0460
			(0.2853)
Farmer's Education	b_7	0.1286	-0.0466
		(0.1321)	(0.0741)
Spouse's Education	b_8	-0.0151	-0.0323
		(0.1199)	(0.1188)
Children's Education	b_9	0.0263	-0.0466
		(0.0577)	(0.0741)
Farm Records and Accounts	b_{10}	0.1475	0.0966
		(0.0973)	(0.1282)
Adjusted R square		0.8724	0.8105
F - Statistic		55.69***	25.34***
D - W Statistic		1.96	2.06
No. of Cases		99	75

a Figures in brackets are the standard errors.

Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

labour and chemicals were significant at the 10 per cent level. Nevertheless, all other inputs, were not statistically significant because of their large standard errors attributed to small sample size collected.

As for Bagan Datoh, (model R_7) factors that contributed significantly to expected income were land size, labour, fertilisers and living capital while the remaining production factors did not appear to have any meaningful effects on the dependent variable. In the case of Rungkup and Hutan Melintang (models R_8 and R_9) both land size and fertilisers were significant at 1 per cent level of probability, whereas living capital affected expected income only in Hutan Melintang.

Inputs comprising labour, extension contact and farmer's age were however, significant at 10 per cent level and this applied to Rungkup alone. Thus, from the examination of models R_6 to R_9, it was found that the determinants of expected income varied from one region to another. No consistent results were obtained except in the case of land size which was significant in all the four models.

Fertilisers was significant in models R_7, R_8 and R_9 but not in model R_6 mainly due to its high standard error. As for labour, only in Hutan Melintang was this input not significant and on top of that it had a negative sign implying that this factor of production was excessively used in the production of cocoa. In spite of the existence of the small number of significant inputs, the high values of the adjusted R square in all the four models indicated the goodness of fit of the estimated regression equations.

From the Chow-Test conducted (see Appendix 12) it was found that the functions that were fitted to each of the four regions were significantly different from one another at one per cent level of probability. This showed that, it was therefore, justified to fit a separate production function for each of the regions concerned.

8.4. OVERALL PRODUCTION FUNCTION ON A PER ACRE BASIS

Since land is limited in this study area, expressing the function on a per acre basis provides more meaningful guidelines for the policymakers to suggest new recommendations on the use of the farm inputs for every acre of plot planted with cocoa.

It was found that through this functional form, none of the variables had a bivariate relationship greater than 0.8 thus indicating the absence of multicollinearity in the data. As shown in Table 8.11 (model R_{10}) the value of the adjusted R square dropped to 0.3877 indicating that

TABLE 8.11. PRODUCTION FUNCTION ON A PER ACRE BASIS FOR THE ENTIRE SURVEY AREA

INPUTS	PARAMETERS	COEFFICIENTS (R10)
Constant	a_0	4.9771***
		(0.5239)[a]
Farmers' Age	a_1	0.1147*
		(0.0696)
Farm Implements/Acre	a_{11}	0.0095*
		(0.0053)
Extension Contact	a_5	0.0056*
		(0.0032)
Chemicals/Acre	a_{12}	0.0033
		(0.0024
Fertilisers/Acre	a_{13}	0.0179***
		(0.0032)
Labour/Acre	a_9	0.1535***
		(0.0517)
Living Capital/Acre	a_{10}	0.2165***
		(0.0585)
Region Teluk Baru	b_1	0.0104
		(0.0879)
Region Bagan Datoh	b_2	-0.0024
		(0.0656)
Region Rungkup	b_3	0.0330
		(0.0399)
Soil-Kangkong	b_6	0.0124
		(0.0708)
Farmers' Education	b_7	0.1320**
		(0.0686)
Spouse's Education	b_8	-0.0400
		(0.0625)
Children's Education	b_9	-0.0104
		(0.0325)
Farm Records and Accounts	b_{10}	0.1131**
		(0.0544)
Adjusted R square		0.3877
F - Statistic		11.08***
D - W Statistic		1.95
No. of Cases		260

a Figure in brackets are the standard errors
Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

approximately 39 per cent of the variation in the dependent variable could be explained by the independent variables included in the model. Inputs which were statistically significant in this model were farmer's age, farm implements, extension contact, farmer's education, farm records and account, labour, living capital and fertilisers.

The rest of the inputs seemed not to have any significant impact on expected income. Tables 8.12 and 8.13 depict the results of the regression analysis computed both for small and large farms. The values of the adjusted R squares for the respective farms were 0.4419 and 0.4470 implying that those independent variables incorporated in the models explained approximately 44 per cent and 45 per cent respectively, in the variation of the expected income. For small farms, the main determinants of expected income were farmers' age, labour, farm implements, farm records and accounts, extension contact, fertilisers and living capitals. While for large farms, factors which significantly affected income were fertilisers and farm records and accounts.

In terms of inputs utilisation results as presented in Table 8.14 clearly revealed that there were significant differences between the two groups of farms involved. It seemed that small farms utilised more labour per acre than

TABLE 8.12. PRODUCTION FUNCTION STATISTICS ON A PER ACRE BASIS FOR SMALL FARMS

INPUTS	PARAMETER	COEFFICIENTS (R_{11})	STANDARD ERROR
Constant	a_0	4.4502***	0.6471
Farmer's Age	a_1	-0.2235***	0.0867
Extension Contact	a_5	0.0092***	0.0039
Labour/acre	a_9	0.2277***	0.0669
Living Capital/acre	a_{10}	0.2984***	0.0722
Farm Implements/acre	a_{11}	0.0117**	0.0054
Chemicals/acre	a_{12}	0.0022	0.0029
Fertilisers/acre	a_{13}	0.0161***	0.0038
Region Teluk Baru	b_1	0.1225	0.1144
Region Bagan Datoh	b_2	0.0231	0.0882
Region Rungkup	b_3	0.0763*	0.0469
Soil-Kangkung	b_6	-0.0356	0.0968
Farmer's Education	b_7	0.1004	0.0779
Spouse's Education	b_8	-0.0469	0.0748
Children's Education	b_9	-0.0017	0.0406
Farm Record/Accounts	b_{10}	-0.1505*	0.0894
Adjusted R square		0.4419	
F - Statistic		9.39***	
D - W Statistic		1.91	
No. of Cases		165	

Level of significance: * 10 per cent, ** 5 per cent, *** 1 per cent.

TABLE 8.13 PRODUCTION FUNCTION STATISTICS ON A PER ACRE BASIS FOR LARGE FARMS

INPUTS	PARAMETER	COEFFICIENTS (R_{12})	STANDARD ERROR
Constant	a_0	6.0803***	0.8366
Farmer's Age	a_1	-0.0831	0.1137
Extension Contact	a_5	0.0031	0.0051
Labour/acre	a_9	0.0425	0.0748
Living Capital/acre	a_{10}	0.0652	0.0952
Farm Implements/acre	a_{11}	-0.0013	0.0196
Chemicals/acre	a_{12}	8.17736E-04	0.0037
Fertilisers/acre	a_{13}	0.0252***	0.0054
Region Teluk Baru	b_1	-0.2480*	0.1316
Region Bagan Datoh	b_2	-0.0179	0.0944
Region Rungkup	b_3	-0.0470	0.0650
Soil-Kangkong	b_6	0.0696	0.0957
Farmer's Education	b_7	0.0856	0.1382
Spouse's Education	b_8	-0.0845	0.1101
Children's Education	b_9	0.0118	0.0589
Farm Records/Accounts	b_{10}	0.2911***	0.0667

Adjusted R square	0.4470
F - Statistic	5.96***
D - W Statistic	1.90
No. of Cases	95

Level of Significance: * 10 per cent, ** 5 per cent, *** 1 per cent.

TABLE 8.14 MEAN INPUT UTILISATION PER ACRE BETWEEN LARGE AND SMALL FARMS

INPUTS	SMALL FARM	LARGE FARM	t-STATISTIC
Labour (man-days)	25.59 (7.44)*	23.21 (7.14)	2.53***
Farm Implements (M$)	9.49 (7.13)	6.63 (3.44)	3.66***
Chemicals (M$)	13.98 (15.93)	10.63 (10.790	1.82*
Fertilisers (M$)	22.60 (34.10)	31.29 (50.31)	1.65*
Living Capital (M$)	1284.63 (282.78)	1204.34 (269.64)	2.24***
TOTAL EXPECTED INCOME(M$)	641.59 (201.45)	597.19 (183.76)	1.77*

Source : Survey Data
Level of significance : *** 1 per cent; * 10 per cent.
* Figures in parentheses are the standard deviations.

large farms. This was to be expected since in the small farm, family labour was mainly utilised to undertake the various farm operations where wage rate could almost be zero. Whereas in the case of large farms some of the maintenance work had to be done by employing hired workers because of the incapacity of the farm operator to perform the task himself. There is a possibility that less of these workers would be employed if the farmers expected that less profit would be received because of bad harvest or low prices of the product. Under such situation less maintenance activities would be undertaken because of the cost incurred and as a consequence less labour would be employed.

Fertiliser usage, however, was low for small farms as reflected by the small amount of expenditure spent on this input. This might imply that either small farmers lack the financial means to purchase more of the input or face different price regimes for this factor of production. Hence, this explains why small farmers spent less on fertilisers compared to the large ones.

On the other hand, the cost incurred for farm implements was higher in the case of small farms which gave an indication that small farmers had more of this input compared to those in the bigger group. This might be because of the fact that during the employment of hired workers, the latter brought with them the necessary tools for the execution of the various tasks assigned. Since these tools were not computed in the cost of depreciation of farm implements owned by the farmers in the large farms, the total service flow as such would be lower than those in the small farms.

The greater expenditure on the use of chemicals reflects the fact that small farms were well maintained compared to the larger ones in this study. Living capital, however, was also higher in the case of small farms giving on implication that the cultivation system was more intensive in this category compared to the one in the large group.

On a regional basis, in the case of Teluk Baru, only two inputs played a dominant role in affecting expected income and they comprised mainly farm implements and labour. All the variables included in the analysis managed to explain approximately 37 per cent of the variation in the expected income (see Table 8.15, R_{13})

The situation, however, differed in the case of Bagan Datoh. Here, beside labour, fertilisers and living capital were the two additional inputs that contributed significantly towards expected income. Other factors of production were not statistically significant mainly because of their high standard errors. The adjusted R square value of 0.5993 indicated that approximately, 60 per cent in the variation of the dependent variable was explained by all the inputs incorporated in the model (see Table 8.15, R_{14}). As for the other two regions, Rungkup and Hutan Melintang, it was revealed that in the case of the former, the main determinants of expected income were extension contact, labour, farmer's age and fertilisers whereas the latter comprised mainly living capital and

TABLE 8. 15.
PRODUCTION FUNCTION STATISTICS ON A PER ACRE BASIS FOR THE REGIONS OF TELUK BARU AND BAGAN DATOH

INPUTS	PARAMETERS	TELUK BARU R_{13}	BAGAN DATOH R_{14}
Constant	a_0	0.7387**	4.1952***
		(2.5129)•	(0.8695)
Farmer's Age	a_1	-0.0562	-0.1157
		(0.1937)	(0.1317)
Extension Contact	a_5	0.0031	0.0042
		(0.0076)	(0.0059)
Labour/acre	a_9	0.5963***	0.3521**
		(0.1663)	(0.1320)
Living Capital/acre	a_{10}	0.4639	0.1937**
		(0.3228)	(0.0790)
Farm Implements/acre	a_{11}	0.1623*	0.0595
		(0.0919)	(0.0642)
Chemicals/acre	a_{12}	0.0056	2.7097E-04
		(0.0064)	(0.0046)
Fertilisers/acre	a_{13}	0.0149	0.0208***
		(0.0118)	(0.0049)
Soil-Kangkong Series	b_6	no correlation	-0.0044
			(0.0712)
Farmer's Education	b_7	0.0841	0.0741
		(0.1539)	(0.1993)
Spouse's Education	b_8	-0.1730	-0.02391
		(0.1553)	(0.1833)
Children's Education	b_9	-0.1600	0.0572
		(0.1060)	(0.0547)
Farm Records and Accounts	b_{10}	0.0100	0.1714
		(0.1047)	(0.1973)
Adjusted R Square		0.3669	0.5993
F - Statistic		2.58*	7.36***
D - W Statistic		1.49	2.30
No. of Cases		31	55

• Figures in brackets are the standard errors

Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

TABLE 8.16
PRODUCTION FUNCTION STATISTICS ON A PER ACRE BASIS
FOR THE REGIONS OF RUNGKUP AND HUTAN MELINTANG

INPUTS	PARAMETERS	RUNGKUP R_{15}	HUTAN MELINTANG R_{16}
Constant	a_0	5.4182***	3.8173***
		(0.9823)•	(1.0853)
Farmer's Age	a_1	-0.1546*	0.0929
		(0.1256)	(0.1422)
Extension Contact	a_5	0.0115**	0.0042
		(0.0059)	(0.0076)
Labour/acre	a_9	0.1937**	-0.0137
		(0.0839)	(0.1247)
Living Capital/acre	a_{10}	0.1367	0.3058**
		(0.1177)	(0.1302)
Farm Implements/acre	a_{11}	0.0044	-9.2272E-04
		(0.0071)	(0.0147)
Chemicals/acre	a_{12}	0.0053	-0.0012
		(0.0044)	(0.0052)
Fertilisers/acre	a_{13}	0.0175***	0.0202***
		(0.0059)	(0.0078
Soil-Kangkong Series	b_6	no correlation	-0.0771
			(0.2839)
Farmer's Education	b_7	0.1020	0.1012
		(0.1364)	(0.1294)
Spouse's Education	b_8	-0.0323	-0.0332
		(0.1235)	(0.1192)
Children's Education	b_9	0.0117	-0.0609
		(0.0594)	(0.0732)
Farm Records and Accounts	b_{10}	0.0633	0.0836
		(0.0955)	(0.1279)
Adjusted R Square		0.3516	0.1643
F - Statistic		5.73***	2.21**
D - W Statistic		1.89	2.09
No. of Cases		99	75

• Figures in brackets are the standard errors
Level of significance : * 10 per cent, ** 5 per cent,
*** 1 per cent.

also fertilisers. Although, the regression equations were statistically significant in both these models (see Table 8.16, R_{15} and R_{16}), nevertheless, the values of the adjusted R square computed were rather low, that is approximately, 35 per cent for Rungkup and 16 per cent for Hutan Melintang.

8.5. DETERMINATION OF THE RELATIVE IMPORTANCE OF THE PRODUCTION FACTORS.

From the computations made in all the analyses, it was difficult to compare the relative importance of each input because of the differences in the unit of measurement adopted. One of the means that can be used to make the regression coefficients more comparable is to compute the 'Beta' weights (Marijn, 1985). These weights in fact are the coefficients of the independent variables obtained after converting them into standardized (Z-score) form. They correct the unstandardised partial slope (B_i) by the ratio of the standard deviation of the independent variable to the standard deviation of the dependent variable, that is,

$$BETA_i = \beta_i \frac{S_{xi}}{S_y}$$

where S_{xi} is the standard deviation of the ith independent variables and S_y, the standard deviation of the dependent variable involved. $Beta_i$ indicates the average standard deviation change in the dependent variable (Y) associated with a standard deviation change in the independent variable X_i, when the other independent variables are held constant.

TABLE 8.17
BETA WEIGHTS FOR THE ENTIRE SURVEY AREA AND ACCORDING TO FARM SIZE (OVERALL PRODUCTION FUNCTION)

INPUTS	SMALL FARMS	LARGE FARMS	POOLED DATA
Land size	0.7032	0.7205	0.8055
Fertilisers	0.2108	0.3270	0.1769
Living Capital	0.1594	-	0.0909
Labour	0.1429	-	0.0749
Farmer's Age	-0.0994	-	-0.0421
Extension Contact	0.0944	-	0.0457
Farm Implements	0.0935	-	0.0489
Farm Records and Accounts	-0.0650	0.2622	-0.0529
Farmer's Education	-	-	0.0692

For the purpose of this section regression models R_2, R_4, R_8, R_{10}, R_{11} and R_{12} would be used and all the beta weights for the significant inputs were presented in Tables 8.17 and 8.18 both according to farm size and also for the entire survey area.

As illustrated in Table 8.17 in the case of small farms, the most important input in relation to other productive factors was land size, followed by fertilisers, living capital, labour, farmer's age, extension contacts, farm implements and farm records and accounts. As for large farms, only three factors of production appeared to be of great importance in determining expected income and they comprised according to rank mainly land size, fertilisers and farm records and accounts.

The situation for the pooled data was identical to that of the small farms in the case of the first four productive factors but for the rest of the variables, the ranking changed. Farmer's age seemed to be of the least importance for the entire survey area. Thus, from the beta weights presented in Table 8.17 we could conclude that the impact of land size, as measured in standard deviation units, was greater than the impact of the other inputs, likewise measured. Indeed, it seemed that the effect of land size on expected income was 3.3 times that of fertilisers for the small farms, 2.2 times in the case of large farms and 4.6 times for the pooled data.

Table 8.18 depicts the beta weight obtained when the functions were expressed on a per acre basis. In terms of the relative importance of the factors of production it was found that fertilisers was top of the rank both for the small and large farms as well as for the entire regions surveyed. Farm records and accounts however, occupied the second place for large farms but it was the least important input for the small farms. The impact of fertilisers on the expected income was 1.3 times that of living capital in the case of small farms and approximately 2.0 times for entire survey area.

TABLE 8.18
BETA WEIGHTS FOR THE ENTIRE SURVEY AREA AND ACCORDING TO FARM SIZE (PRODUCTION FUNCTION ON A PER ACRE BASIS)

INPUTS	SMALL FARMS	LARGE FARMS	POOLED DATA
Fertiliser	0.3406	0.5288	0.3807
Living Capital	0.2605	-	0.1941
Labour	0.2361	-	0.1566
Farmer's Age	-0.1653	-	-0.0876
Extension Contact	0.1576	-	0.0958
Farm Implements	0.1474	-	0.1019
Farm Records and Accounts	-0.1082	0.3957	0.1141
Farmer's Education	-	-	0.1478

With the details given in Tables 8.17 and 8.18 it was thus possible to provide some useful guidelines to the policy makers in their efforts to take the appropriate remedial actions in terms of priority, with the hope of increasing the productivity of the cocoa smallholders in this study area.

8.6. SUMMARY OF RESULTS

A number of inputs were analysed to determine their impact on expected income. Two types of functions were used, namely;

i) production function expressed in its overall form, and
ii) production function expressed on a per acre basis.

Summary of the results obtained were tabulated in Tables 8.19 and 8.20 and the effects of the inputs analysed were as follows:

1) LAND SIZE

This input contributed significantly towards expected income for the whole of the survey area, large and small farms and in each of the four regions surveyed.

2) **FERTILISERS**

This input was statistically significant in all the analyses made both in its overall and on a per acre basis, except in the case of Teluk Baru.

3) **LIVING CAPITAL**

This input factor had significant impact for the whole of the study area, small farms, and on a regional basis, this involves Bagan Datoh and Hutan Melintang. Similar outcomes were obtained for functions expressed on a per acre basis.

4) **LABOUR**

For functions expressed both in its overall form and on a per acre basis, this variable was statistically significant for the entire area under investigation, small farms, and in all the regions except for Hutan Melintang.

5) **FARM IMPLEMENTS**

From the analyses made using both types of functions, it was only for the pooled data and small farms that this production factor had a significant impact on the expected income. On a regional basis, this input was significant only in Teluk Baru and this applies to the function which was expressed on a per acre basis.

6) <u>CHEMICALS</u>

Chemicals as an input factor contributed significantly towards expected income only in the region of Teluk Baru in the analysis made through the use of the overall production function.

7) <u>EXTENSION CONTACT AND FARMER's AGE</u>

This input had a significant impact on the expected income in the case of the pooled data, small farms and in Rungkup using both types of functions.

8) <u>FARMER'S EDUCATION</u>

This production factor was statistically significant for the pooled data that were expressed either in its overall or on a per acre basis.

9) <u>FARM RECORDS AND ACCOUNTS</u>

This variable was important in determining expected income for the entire area under surveyed and also for both groups of farm sizes in the analyses using both types of functions.

10) <u>SOIL SERIES, SPOUSE'S AND CHILDREN'S EDUCATION</u>

None of these inputs were statistically significant in all the analyses made.

TABLE 8.19. SUMMARY OF THE EFFECTS OF THE INPUT FACTORS ON EXPECTED INCOME - USING OVERALL PRODUCTION FUNCTION

INPUTS	POOLED DATA	SMALL FARMS	LARGE FARMS	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
Farmer's Age	*	X	ns	ns	ns	*	ns
Land Size	✓	✓	✓	✓	✓	✓	✓
Labour/acre	✓	✓	ns	*	✓	*	ns
Farm Implements	*	X	ns	ns	ns	ns	ns
Extension Contact	*	X	ns	ns	ns	*	ns
Chemicals	ns	ns	ns	*	ns	ns	ns
Fertilisers	✓	✓	✓	ns	✓	✓	✓
Living Capital/ acre	✓	✓	ns	ns	X	ns	X
Region Teluk Baru	ns	ns	*	-	-	-	-
Region Rungkup	ns	*	ns	-	-	-	-
Farmer's Educ.	*	ns	ns	ns	ns	ns	ns
Farm Records and Accounts	X	*	*	ns	ns	ns	ns
Soil Series-Kangkong	ns	ns	ns	ns	ns	ns	ns
Spouse's Educ.	ns	ns	ns	ns	ns	ns	ns
Children's Educ.	ns	ns	ns	ns	ns	ns	ns

Notations:

✓ - significant at 1 per cent level.
X - significant at 5 per cent level.
* - significant at 10 per cent level.
ns - not statistically significant.

TABLE 8.20. SUMMARY OF THE EFFECTS OF THE INPUT FACTORS ON EXPECTED INCOME - ON A PER ACRE BASIS

INPUTS	POOLED DATA	SMALL FARMS	LARGE FARMS	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
Farmer's Age	*	✓	ns	ns	ns	*	ns
Farm Implements/ acre	*	X	ns	*	ns	ns	ns
Extension Contact	*	X	ns	ns	ns	X	ns
Chemicals/acre	ns	ns	ns	ns	ns	ns	ns
Fertilisers/acre	✓	✓	✓	ns	✓	✓	✓
Labour/acre	✓	✓	ns	✓	X	X	ns
Living Capital/acre	✓	✓	ns	ns	X	ns	X
Region Teluk Baru	ns	ns	*	-	-	-	-
Region Bagan Datoh	ns	ns	ns	-	-	-	-
Region Rungkup	ns	*	ns	-	-	-	-
Soil-Kangkong	ns	ns	ns	ns	ns	ns	ns
Farmer's Education	X	ns	ns	ns	ns	ns	ns
Spouse's Education	ns	ns	ns	ns	ns	ns	ns
Children Education	ns	ns	ns	ns	ns	ns	ns
Farm Records and Accounts	*	*	✓	ns	ns	ns	ns

Notations:
✓ - significant at 1 per cent level.
X - significant at 5 per cent level.
* - significant at 10 per cent level.
ns - not statistically significant.

8.7. COMPARISON WITH OTHER LOCAL STUDIES

The present study, however, faces severe limitations in terms of its comparative usefulness owing to the lack of similar studies in Malaysia. As far as cocoa is concerned, no comprehensive study has been undertaken in this country to examine empirically the determinants of expected income and resource use efficiency which are vital for policy action. As such for the purpose of this section, appraisal is also made in comparison with other crops, mainly rubber and paddy, which have been empirically investigated by other research workers who mostly used the same analytical tools as the present study does. For our discussion the results as illustrated in Table 8.5 model R_2 would be used as the basis of comparison.

Table 8.21 presents the findings from the previous and present investigations. Nasuddin *et al.* (1987), Shukri *et al.* (1987) and Raja Badrul (1982) used the linear functions in their analyses. The rest of the research workers except Abdullah (1978), however, used the Cobb-Douglas model. In the latter case, the translog function was used as his basis of analysis.

As far as land size was concerned, the finding from the present study is similar to the outcomes from the previous cocoa investigations that had been undertaken by Nasuddin *et al.* (1987) and Shukri *et al.* (1987). Identical results were also obtained by Bhati (1975), Barnum (1976), Tamin (1978) and Nasuddin (1983), all in the case of paddy production, and with those conducted by Abdullah (1978) and Raja Badrul (1982) in the case of rubber. Abdullah (1978) however, used the number of rubber trees as proxy for land size in his model. Nevertheless, all the results indicated that this input was statistically significant in the production of both crops.

Fertilisers as an input is also significant in the present study. This is identical to the research results obtained by the three researchers as shown in the Table 8.21.

Other studies, however, placed this input under different classifications. Barnum (1976) specified fertilisers and pesticides under the category of 'other variable inputs'. Bhati (1975) used the term operating capital to denote fertiliser, insecticides, weedicides and the services of power tiller. This aggregation of inputs posed a major problem, in the sense that the influence of the individual input was difficult to detect and under such circumstances, comparison with the present study was actually hard to make.

No comparison could be made as far as living capital and farm records and accounts were concerned as none of the earlier studies had incorporated these inputs into their analyses. As regard to farmer's education, the present study confirmed the finding of Abdullah (1978)

TABLE 8.21 COMPARISON WITH SELECTED CROSS-SECTIONAL PRODUCTION FUNCTION STUDIES UNDER LOCAL CONDITIONS

INPUTS	PAST STUDY (COCOA)		RUBBER			PADDY				PRESENT STUDY (COCOA)
	1	2	3	4	5	6	7	8		
Farmer's Age	x	x	✓	✓		-	-	-	-	✓
Land size	✓	✓	-	✓		✓	✓	✓	✓	✓
Farm Implements	-	-	-	-		-	✓	-	-	✓
Extension contact	-	-	✓	-		-	-	-	-	✓
Chemicals	-	-	x	-		-	-	-	-	x
Fertilisers	x	x	✓	-		-	✓	✓	-	✓
Labour/Acre	x	x	-	✓		x	✓	-	✓	✓
Living Capital/Acre	-	-	-	-		-	-	-	-	✓
Farmer's Education	-	-	✓	x		-	-	-	-	✓
Spouse's Education	-	-	✓	-		-	-	-	-	x
Children's Education	-	-	✓	-		-	-	-	-	x
Farm Records & Accounts	-	-	-	-		-	-	-	-	✓

Note:

1 - study conducted by Nasuddin *et al.* (1987)
2 - study conducted by Shukri *et al.* (1987)
3 - study conducted by Abdullah (1978)
4 - study conducted by Raja Badrul (1982)
5 - study conducted by Bhati (1975)
6 - study conducted by Tamin (1978)
7 - study conducted by Nasuddin (1983)
8 - study conducted by Barnum (1976)
✓ - statistically significant either at 1 per cent, 5 per cent or 10 per cent levels.
x - not statistically significant either at 1 per cent, 5 per cent or 10 per cent levels.

in his investigation on the importance of this input in rubber production.

Similar outcomes were also obtained with the studies conducted by Raja Badrul (1982), Tamin (1978) and Barnum (1976) in terms of the significance of labour in crop production. Abdullah (1978) split this variable into two categories and only harvesting labour was found to be important in the case of rubber. Finally, for farm implements, the result for this study is identical to the finding of Tamin (1978) in the case of paddy production.

8.8. COMPARISON WITH OTHER INTERNATIONAL STUDIES

Comparison with other cocoa production function studies which have been undertaken by other research workers at the international level was also hampered due to the differences in the specification of the variables adopted. As such in this section concentration was given only to those variables which had been treated individually in these studies.

For land size as an input, the finding from the present study corresponds to the outcomes with all the previous investigations as tabulated in Table 8.22, except in the case of the one carried out by Costa and Reiss (1982), where this input was not statistically significant.

TABLE 8.22. COMPARISON WITH OTHER COCOA PRODUCTION FUNCTION STUDIES ABROAD

INPUTS	PRESENT STUDY	OTHER STUDIES 1	2	3	4
Farmer's Age	✓	-	-	-	x
Land Size	✓	x	✓	✓	✓
Farm Implements	✓	-	-	-	-
Extension Contact	✓	-	-	-	-
Chemical	x	-	-	-	-
Fertilisers	✓	✓	-	-	-
Labour/Acre	✓	✓	✓	✓	-
Living Capital/Acre	✓	-	-	-	-
Farmer's Education	✓	-	-	-	-
Spouse's Education	x	-	-	-	-
Children's Education	x	-	-	-	-
Farm Records and Accounts	✓	-	-	-	-

Note:

1 - study conducted by Costa and Reiss (1982) in Bahia, Brazil.
2 - study conducted by Souza Menezes (1974) in Brazil.
3 - study conducted by Thirtle (1984) in Eastern Cameroon, Africa.
4 - study conducted by Boateng (1982) in Ghana, Africa.
✓ - statistically significant either at 1 per cent, 5 per cent or 10 per cent levels.
x - not statistically significant either at 1 per cent, 5 per cent or 10 per cent levels.

In the case of labour, the result from the present research resembles the findings from the earlier studies undertaken by Costa and Reiss (1982), Souza Menezes (1974) and Thirtle (1984).

Finally, as for farmer's age, only Boateng (1982), incorporated this input in his production function study. He, however, indicated that this production factor was not statistically significant in the analysis conducted. This result, therefore, differs from the present finding.

Owing to differences that exist not only in terms of the socio-economic background of the study areas but also with regard to the agricultural practices adopted, due caution must therefore be exercised in the interpretation of Table 8.22.

8.9. SUMMARY

This chapter has attempted to examine a number of issues pertaining to the problem under investigation. Using the Cobb-Douglas production function both in its overall and on a per acre expressions as the basis of our analysis, a number of regression models were run to determine which factors contribute significantly to the expected income. In all the analyses that were undertaken, it was found that the determinants of expected income were generally identical for both types of functions used. It seemed that among the inputs analysed, land size and fertilisers were the two factors of production that were statistically significant in most of the computations made.

The findings from this analysis also revealed that there were significant differences in terms of the input utilisation between the small and large farms. Both these farms were found to operate on a different production function. From the beta weights obtained it was shown that land size was the most important input that affects expected income at a macro level. Whereas on a per acre basis, fertilisers was ranked top.

Finally, this chapter also tried to compare the present finding with the other studies conducted both in Malaysia and abroad but was hampered due to lack of similar research and differences in the specification of the variables adopted.

CHAPTER NINE

ALLOCATIVE EFFICIENCY

In the previous chapter, attempts were made to examine the factors of production that contributed significantly to the expected income obtained both from cocoa and coconut in the study area. The analyses were made for the entire survey area, on a regional basis and according to farms of different sizes. Having determined the main determinants of expected income, this chapter attempts to perform some economic interpretations of the estimates obtained from the production functions used. This mainly centres on the elasticities of production and the marginal returns from the inputs incorporated into the analyses. Besides that, this chapter also aims at examining whether the inputs used in the process of production were allocatively efficient or not ; if they were inefficient, how should the inputs be reallocated to achieve the maximum profit?. Such information will aid a society in making the best decisions regarding the use of the scarce resources.

One point to be stressed here is that in the analyses made, only the essential inputs comprising land size, fertilisers, labour, living capital and farm implements which were significant in the models were chosen and the non-significant inputs were left out as they had no impact on the expected income (Kmenta, 1971; Koutsoyiannis, 1977). These significant factors of production were then regressed onto the dependent variable and the new estimates obtained are shown in Tables 9.1 and 9.2.

TABLE 9.1
PRODUCTION FUNCTION STATISTICS - EFFECTS OF THE SIGNIFICANT INPUTS ACCORDING TO FARM SIZE AND OVERALL STUDY AREA.

INPUTS	SMALL FARMS	LARGE FARMS	POOLED DATA
Constant	3.6125*** (0.5441)ª	6.3677*** (0.1138)	4.3267*** (0.4436)
Land Size	0.9894*** (0.0527)	0.9880*** (0.0663)	0.9289*** (0.0283)
Farm Implements	0.0107** (0.0049)	-	0.0091** (0.0048)
Fertilisers	0.0193*** (0.0032)	0.0264*** (0.0036)	0.0213*** (0.0025)
Labour/acre	0.2023*** (0.0659)	-	0.1301** (0.0523)
Living Capital/acre	0.3072*** (0.0711)	-	0.2452*** (0.0572)
Adjusted R Square	0.7745	0.7411	0.8601
F - Statistic	112.27***	135.52***	319.38***
D - W Statistic	1.79	1.41	1.81
No of Cases	165	95	260
$\sum b_i$	1.53	1.01	1.33

ª Figures in brackets are the standard errors.
Level of significance: * 10 per cent, ** 5 per cent, *** 1 per cent.

TABLE 9.2
PRODUCTION FUNCTION STATISTICS - EFFECTS OF THE SIGNIFICANT INPUTS ACCORDING TO REGION

INPUTS	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
Constant	5.6527*** (0.4762)*	4.0938*** (0.6314)	6.5479*** (0.0606)	4.4099*** (0.8110)
Land size	0.7237*** (0.0647)	0.9654*** (0.0461)	0.9160*** (0.0431)	0.9450*** (0.0559)
Fertilisers	-	0.0224*** (0.0041)	0.0277*** (0.0042)	0.0202*** (0.0045)
Labour/acre	0.3530*** (0.1321)	0.4177*** (0.1095)	-	-
Living Capital/acre	-	0.1451* (0.0748)	- -	0.2902*** (0.1128)
Adjusted R Square	0.8163	0.9329	0.8509	0.8284
F - Statistic	67.67***	188.85***	280.61***	120.09***
D - W Statistic	2.46	2.22	1.65	2.00
No. of Cases	31	55	99	75
	$\sum b$ 1.08	$\sum b$ 1.55	$\sum b$ 0.94	$\sum b$ 1.26

* Figures in brackets are the standard errors.
Level of significance : * 10 per cent, ** 5 per cent, *** 1 per cent.

9.1. ELASTICITIES OF PRODUCTION.

In the Cobb - Douglas production function, the coefficients of the independent variables are also their production elasticities. The latter indicate the percentage change in output if the input factor is increased by one per cent. For example, the regression coefficient of the logarithm of land in Table 9.1 on the logarithm of expected income for small farms was 0.9894, which gave an indication that, on the average, an increase in the amount of land by one per cent, holding other factors constant, was associated with an increase in expected income of 0.98 per cent. A similar interpretation holds for other coefficients. Judging from the high elasticities of the expected income with respect to land relative to the rest of the input factors, it could be concluded that in cocoa production at the smallholders' level, expected income was more responsive to percentage changes in land size than other farm resources.

The standard errors placed under each regression coefficients showed the relative reliability of an estimate of the regression. Thus in the case of land for small farms, the standard error was 0.0527 which implied that a one per cent increase in land input, would, on the average increase expected income from 0.89% to 1.09%, at 95% confidence interval, holding the other factors constant. A similar principle also applies for other coefficients.

From the regression models as depicted in both the tables all the elasticities as reflected by the values of the regression coefficients, were less than unity which gave an indication that diminishing marginal returns to each of the input factor: holding each of the inputs constant, the marginal return of each input will decrease the more that factor is used. This conclusion is vital in the economic analyses for it indicates the first condition for the optimum use of resources.

The sum of production elasticities serves to measure returns to scale. From the test performed (see Appendix 13), constant returns to scale seemed to prevail in the regions of Teluk Baru, Rungkup and Hutan Melintang as well as for the large farms. This implied that in these areas, a one per cent increase in all the resources used would add to one per cent increase in the expected income. On the contrary in the case of the pooled data, small farms and Bagan Datoh, there were increasing returns to scale which means to say that the proportionate growth in income was greater than the proportionate growth of inputs used.

9.2. RETURNS TO RESOURCES

From the estimated elasticities we can obtain a set of estimated marginal productivities. The Cobb-Douglas production function is very convenient for calculating these values, especially, when the variables are measured in value flows. Under such situation, the marginal revenue products are computed as shown in equation 9.1 below:

$$MRP_{ij} = \frac{b_i \; TR_j}{X_{ij}}$$

where:

MRP_{ij} = Marginal Revenue Product of input X_i by the jth farm.

b_i = Estimated coefficient of input i in the Cobb-Douglas function.

TR_j = Total Expected Revenue of the jth farm.

X_{ij} = Value of the flow input of variable X_i by the jth farm.

Because of the multiplicative nature of the production function used in this study, the estimated marginal revenue products were calculated at the geometric means of the variables and consequently related to the average farm.

Strictly speaking, allocative efficiency exists if there is a situation of perfect competition. The latter implies price taking behaviour and perfect markets which are characterised by perfect communication, instantaneous equilibrium and costless transactions (Pasour, 1981). As far as this study area was concerned, the prices of cocoa beans and coconuts were controlled and fixed by the Federal Agricultural and Marketing Authority (FAMA). The producers here, were price-takers since they did not have any say in the produce being sold. However, they had the right to sell their commodities either to FAMA or any licensed buyers appointed by the former in their own localities. For most of the farm inputs such as fertilisers, weedicides, insecticides and farm implements, these were being sold by the local Farmers' Associations operating in the area. The prices of these inputs were the same regardless of the locations involved and farmers who were members were well informed about this. Nevertheless, those non-members were also aware of such information through the contact that they had with the members of this association. In spite of the existence of this body, farmers were also free to purchase these inputs from the local shopkeepers depending upon their own convenience and the prices offered.

While factors market tend towards partial competition, the capital market for land was relatively much less perfect with transactions normally involved within the family circle. Under such a situation, the factor share had also to depend upon the demand elasticity of output and the supply elasticity of the input. Yotopoulos and Nugent (1976), however, stated that since these two values were not easily available, the assumption of perfect competition served as the next best alternative in detecting resource misallocation in the analysis of production function.

Since in this study, farmers seemed to have approaching a perfect knowledge of some of the relevant variables and were price-takers both in the output and input market, it was reasonable to assume that they were operating in a competitive environment. In this case, we could then express the equilibrium condition as the equality between the marginal revenue product of each of the input factor and the marginal cost to detect whether there was any resource misallocation in the production process.

In the calculation of the marginal revenue products of the input factors, it was assumed that the prices of the cocoa beans and the nuts were fixed. Since the data used were cross-sectional in nature, prices did not exhibit much variation during the reference period. Within the regions, the distributions of the prices of the major agricultural inputs also did not differ much.

9.2.1. MARGINAL FACTOR COST

The marginal factor cost of fertiliser used in this study was based on the average price of the input per kilogramme which at the time of the survey was M$1.00

As for labour the marginal factor cost was based on its opportunity cost. The computation of the opportunity cost of labour posed some difficulties in this study. Based on the skills and level of education attained, the farmers could secure alternative employment opportunities either in other agricultural sectors, for example, such as plantation workers; in the industrial sectors such as the factory workers or to perform odd jobs such as carpentry or contract labour. This in a way implied that if he did not work in his cocoa farm he could secure these jobs at any time he desired. In actual fact this situation might not be true for the employment opportunities for this group of producers normally depend on the vacancies that are available. From field observations, during the period where no harvesting was undertaken or no maintenance work had to be performed, some farmers remained totally unemployed and under such situation during this slack season the opportunity cost of labour should be zero.

Because of the seasonal nature of agricultural production the opportunity cost of labour tends to vary with season (Upton; 1987). During the busy season the opportunity cost would be higher than the slack season. During the former period the marginal product of labour would be higher since an addtional man-hour would result in the increase of the total product considerably simply because any delay in the execution of the farm operations such as harvesting might reduce the yield. This is true in the case of cocoa production; once the pods are ripe, they have to be picked immediately before the quality starts to deteriorate.

Yotopoulos (1967) suggested that the opportunity cost of labour could be computed throughout the year by weighing the seasonal wage rate by the proportion of the total agricultural work that was performed during the peak season. However, in this study, this technique was not adopted owing to the lack of the relevant data.

Sen (1966) and Bardhan (1973), however, stated that the opportunity cost of family labour is equal to the wage rate multiplied by the probability of success in securing alternative employment. If the probability is equal to one which happens during the situation of full employment the the opportunity cost will be equal to the wage rate. On the contrary, the opportunity cost of labour will be zero when the probability of success is zero. In this study a probability level of 0.5 was taken to compute the opportunity cost of labour. This value was based on the earlier study by Abdullah (1978) in the state of Malacca. Taking into account the low educational level and skills of the rubber smallholders, he revealed that based on the response given by the respondents, the chances of success in securing alternative employment such as plantation and factory workers as well as odd jobs were only 50%. Since the characteristic features of the cocoa smallholders were identical with that group of producers analysed by Abdullah (1978) and also the geographical features did not differ much with the present study area, therefore, it is reasonable to use this value in the computation of the present opportunity cost of labour. The wage rate used by the Department of Agriculture in the computation of this input was M$ 12.00 per man-day. This rate in fact corresponds to the amount received by the plantation workers employed by the cocoa plantation in the area. Thus based on the probability level of 0.5, the opportunity cost of labour was M$ 6.00 per man-day throughout the year.

As for the case of land size, it was rather difficult to determine its opportunity cost in this study area. This was because owing to the nature of the soil, only cocoa and coconut were the two most suitable crops to be planted. In this study the majority of the sampled farmers (99%) owned and cultivated their own plots and only one per cent rented their land to others. During the study period, it was found that the average annual rent for every acre of land was M$300.00. Assuming that this figure is correct, since data on the annual rent are not easily available, so the marginal factor cost of this input would then be based on the average rent that was being computed.

In the case of capital inputs comprising farm equipment and living capital, the marginal factor costs were based on the opportunity cost of a dollar worth of these inputs invested in the Agricultural Bank plus an average interest of 6.5 per cent per annum charged by this institution during the study period.

9.2.2. ESTIMATES OF MARGINAL REVENUE PRODUCTS

Using the formula as outlined earlier, the estimates of the marginal revenue products with respect to the significant inputs were presented in Tables 9.3 and 9.4.

TABLE 9.3
MARGINAL REVENUE PRODUCT AT THE GEOMETRIC MEANS OF THE THE INPUTS ACCORDING TO FARM SIZE AND OVERALL STUDY AREA

INPUT	SMALL FARMS	LARGE FARMS	POOLED DATA
Marginal Revenue Product			
Labour	1.32 (0.4286)*	-	0.89 (0.3593)
Land Size	3.14 (0.1675)	2.05 (0.1377)	3.00 (0.0915)
Farm Tools	4.83 (2.2107)	-	3.06 (1.6125)
Fertilisers	4.14 (0.6859)	3.30 (0.4606)	4.45 (0.5227)
Living Capital	0.24 (0.0544)	-	0.20 (0.0455)
Geometric Means			
Labour (man-days)	49.60	-	67.97
Land Size (acres)	2.03	5.34	2.89
Farm Tools (M$)	4.29	-	8.34
Fertilisers (M$)	9.03	26.61	13.40
Living Capital (M$)	2530.06	-	3519.24

* Figures in brackets are the standard errors.

TABLE 9.4
MARGINAL REVENUE PRODUCT AT THE GEOMETRIC MEANS OF THE INPUTS ACCORDING TO REGION

INPUT	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
<u>Marginal Revenue Product</u>				
Labour	2.17 (0.8113)*	3.39 (0.8888)	-	-
Land Size	2.40 (0.2146)	3.70 (0.1768)	2.04 (0.0962)	2.67 (0.1575)
Fertilisers	-	5.58 (1.0210)	8.33 (1.2629)	6.37 (1.4211)
Living Capital	-	0.15 (0.0776)	-	0.19 (0.0769)
<u>Geometric Means</u>				
Labour (man-days)	83.43	67.96	-	-
Land size (acres)	3.09	2.88	3.09	2.57
Fertilisers (M$)	-	13.29	6.88	6.88
Living Capital (M$)	-	3187.52	-	3186.52

* Figures in brackets are the standard errors.

<u>LABOUR</u>

The marginal revenue products indicate the returns which on, the average, are expected from the addition of one more unit of the various input factors. As shown in Table 9.3 in the case of labour for the small farms, a dollar's worth of this input contributed M$ 1.32 to the expected income. The situation, however, differs in the case of the pooled data where the returns from this particular input was slightly lower, that is, amounting to M$ 0.89. Nevertheless, such an overall low return from this input might be attributed to the measurement error that arises. Since there are great variations in the age and skills of the labour used, this might cause a downward bias in the coefficients and thus causes the estimates to be very low. The low returns from labour, therefore, makes cocoa farming a less attractive activity to the rural youth. This has resulted in the exodus of this labour force to the cities as is now being observed.

On a regional basis, the returns were M$ 2.17 in the case of Teluk Baru and M$ 3.39 in Bagan Datoh. This points to the fact that, it still pays to add this input in the production process in both these regions as it was too sparingly used. Thus from the marginal returns computed in both the tables, it could be concluded that labour was not efficiently used in crop production for the area under investigation.

<u>LAND SIZE</u>

The marginal returns for this input ranged from M$ 2.05 to M$3.14 (see Table 9.3) and M$2.04 to M$3.70 from the four regions under investigation (see Table 9.4). This implied that land was consistently too sparingly being used regardless of farm size and the regions involved. This might be attributed to the imperfections in the land market. Also it could be that the market rental of land was below the economic value of land. However, since this factor of production is a constraint in this study area, no further expansion could take place in order to get higher returns.

FERTILISERS

As shown in Table 9.3, the marginal returns for fertiliser were the highest in the case of the pooled data, averaging around M$4.45, followed by M$4.14 for the small farms. Among the four regions involved it was in Rungkup that the returns were the highest and the least was in Bagan Datoh. Owing to the very low level of fertilisers being applied, while from the agronomic experiments it is known that the output of cocoa is closely associated with the amount of fertilisers used, an estimated marginal returns which were computed in Table 9.3 and 9.4 were quite high. This shows that the cocoa farms in this area were still underfertilised.

Relatively speaking, the returns from large farms were the lowest in this analysis. One possible reason could be due to the greater quantity of this input being used by the farmers in this category of farm size as compared to the smaller ones. This is reflected from Chapter Eight (Table 8.14), where the expenditure on fertilisers was relatively higher in the case of large farms amounting to approximately M$31.29 compared to M$22.60 per acre for small farms. Nevertheless, this amount is still considered to be very low and it still pays for the farmers to purchase more of this input in order to get higher returns. It is believed that the amount of soil nutrients that were already present is insufficient to cater for the needs of plant growth, during the study period. Greater application of this input in fact will bring beneficial effects to crop production, and hence the expected income. In addition, the discrepancy in the marginal returns of this input factor is also attributed to the difference in the production technology as indicated by the difference in the production functions for both groups of farms (see Chapter Eight).

LIVING CAPITAL

As stated in the earlier chapter, this input was measured based on the expected yield concept. A graphical yield profile of both cocoa and coconuts was first constructed from field experiments. This represents the yield potential of the planting materials being used. Thus given the age of the trees of a particular smallholder, the expected yield which was estimated from the yield profile could then be ascertained. By multiplying these physical values with the prices of the commodities during the study period, the service flow from this input was thus obtained.

The returns from this input were very low in all the analyses made. No estimation was made for the large farms and for the regions of Teluk Baru and Rungkup as this input was not statistically significant in the regression analyses. Such a low marginal returns for this input factor was anticipated since it was composed of two different types of crops, namely; cocoa and coconut with varying ages, therefore, there is bound to be great variation in the productivity status of this input. This as consequence might bias the production coefficient downwards and thus caused the estimates to be very low.

Furthermore it was suspected that the use of expected yield concept obtained from field experiments might not actually reflect the true yield potentials of the cocoa and coconut trees planted by smallholders owing to the differences in agronomic and management practices.

FARM IMPLEMENTS

This input was statistically significant only in the case of small farms and the whole of the survey area. As such no information on its productivity was available for comparison either between farms of different sizes and on a regional basis. As shown in Tables 9.3 and 9.4, the returns from farm implements were M$3.06 for the entire area under investigation, and M$4.83 for small farms. but the standard errors were rather high in both the analyses. Considering the low level of investment in agricultural implements such a high marginal return in these analyses implied that the farms were underequipped during the period under study.

Thus from the analyses that had been made it is shown that the significant input factors were not used in the proper combination in the process of production. Living capital and labour were being used too much in this study area and should be decreased. On the contrary, inputs like land size, farm implements, and fertilisers were used too sparingly and their amount should be increased.

Because of the inequality between the marginal revenue products of these inputs with their respective marginal costs we can, therefore, conclude that these factors of production were not allocatively efficient in crop production in relation to their ruling input and output prices. This, therefore, implies that the hypothesis as outlined earlier that the factors of production were not efficiently allocated is accepted in this study.

After obtaining some ideas about the productivities of the inputs used in cocoa production, a plan of reorganisation and development of the farms being studied can be set up on the basis of the estimates obtained.

9.3. REORGANISATION OF THE INPUTS

The extent to which the farmers, on the average, should change the relevant MRP through resource reallocation in order to arrive at the equality of MRP and MC is given in Table 9.5. The great percentage change in the marginal revenue products for most of the inputs indicates that there are major deviations from allocative efficiency in the study area. This is at variance with the conclusions of most studies on traditional agriculture such as those conducted by Schultz(1964) and Sahota(1968).

In the process of production, the inputs are said to be used efficiently when the ratios of the value of their marginal revenue products to their marginal costs have a

TABLE 9.5. PERCENTAGE CHANGE IN MRP REQUIRED TO EQUATE WITH MARGINAL COST OF INPUTS

CATEGORY	FERTILISERS	CHEMICALS	LIVING CAPITAL	LAND SIZE	FARM TOOLS	LABOUR
Small Farms	78.85	-	343.75	68.15	77.95	24.24
Large Farms	69.69	-	-	51.22	-	-
Teluk Baru	-	-	-	58.33	-	53.92
Bagan Datoh	82.08	-	610.00	72.97	-	70.50
Rungkup	87.99	-	-	50.98	-	-
Hutan Melintang	84.33	-	460.53	62.55	-	-
Pooled Data	77.53	-	432.50	66.67	65.20	12.36

common value for all inputs, this value being equal to the degree of returns to scale of the production function (Hebden, 1983). Assuming there are two inputs being used in the production process, namely labour (L) and fertiliser (F), in order to have efficiency,

$$\frac{MRP(L)}{MC(L)} = \frac{MRP(F)}{MC(F)} = a + b$$

where a and b are the regression coefficients of labour and fertilisers, respectively. Thus if there are constant returns, this ratio is unity. In the analyses made, the summation of the regression coefficients obtained were as follows : 1.53, 1.01, 1.33, 1.08, 1.55, 0.94 and 1.26 for the small farms, large farms, pooled data, region of Teluk Baru, Bagan Datoh, Rungkup and Hutan Melintang, respectively. Through the test performed it was only in the regions of Teluk Baru, Rungkup, Hutan Melintang and for the large farms that exhibited constant returns to scale while the rest did not.

Bearing these values in mind, we now proceed to compute the change in the levels of the inputs required in order to equate the marginal revenue products with their respective marginal costs.

As for fertilisers, by setting the marginal revenue product in equation 9.1 equals to the price of the input and solving for X_{ij} which is the amount of fertiliser measured in value flow, it is found that in the case of the small farms, this resulted in an increase of the fertiliser expenditure to M$ 24.41, whereas that of the larger farms, the expenditure has to be increased to M$ 87.79 (see table 9.6). For the entire region, the table also illustrates that the farmers have to increase the amount to M$ 44.87 as a result of equating the marginal revenue product of this input with its marginal cost.

Such a large increase required might give an indication that there is a greater depletion of soil nutrients in this study area. Considering the fact that fertiliser is vital for the production of cocoa, such a readjustment in the expenditure pattern of this input is feasible to be undertaken by the farmers in the locality provided the relevant assistance is given to them. It has been the policy of the government to provide fertiliser subsidy only during the first three years of cocoa cultivation, that is, from the time of planting until the trees start to fruit.

TABLE 9.6. CHANGES IN RESOURCE EXPENDITURE FOR FERTILISERS (M$)

CATEGORY	BEFORE ADJUSTMENT	AFTER ADJUSTMENT	DIFFERENCE	% CHANGE
Small farms	9.03	24.41	15.38	+170.32
Large farms	26.61	87.79	61.18	+229.91
Bagan Datoh	13.29	47.83	34.54	+359.89
Rungkup	6.88	57.30	50.42	+732.91
Hutan Melintang	6.88	43.79	36.91	+536.48
Pooled Data	13.40	44.87	31.47	+234.85

However, after that stage the ability to use is greatly dependent upon the farmers' own financial capabilities. Owing to lack of cash, the use of this input was minimal.

Thus to encourage the farmers to use more fertilisers during crop production, credit must be made accessible to the needy smallholders. The farmers also must be supplied with the reliable technical information and advice regarding the use of this input. Group purchase for bulk discount should also be encouraged in order to reduce the cost of production.

While resource adjustment in fertilisers is relatively easier to undertake, changes in labour utilisation is one of the most arduous tasks to perform. As shown in Table 9.7, for the regions of Teluk Baru and Bagan Datoh, labour utilisation have to be increased to 180.87 and 148.65 man-days, respectively, in order to achieve allocative efficiency.

TABLE 9.7. CHANGES IN THE AVERAGE ANNUAL AMOUNT OF LABOUR UTILISATION (MAN-DAYS)

CATEGORY	BEFORE ADJUSTMENT	AFTER ADJUSTMENT	DIFFERENCE	% CHANGE
Small farms	49.60	42.65	6.95	- 14.01
Teluk Baru	83.43	180.87	97.44	+116.79
Bagan Datoh	67.96	148.65	80.69	+118.73
Pooled Data	67.97	45.68	22.29	- 32.79

In the case of the small farms although a dollar's worth of labour contributed M$ 1.32 to the expected income, this input however, had to be reduced to 42.65 man-days after adjustment. As stated earlier, in order for the input to be efficient, the ratio of the marginal revenue product to the marginal cost should be equal to the degree of returns to scale which in this case is 1.53. Since the latter figure is greater than 1.32, this points to the fact that labour was excessively used and should therefore, be decreased.

For the pooled data, this input has to be reduced to 45.68 man-days in order to be allocatively efficient. However, the decrease in labour input as suggested by this analysis in the case of the small farms and the pooled data will only be beneficial if the excessive labour can be put into some other productive activities and the earning of that excessive labour in the new productive activities is larger than the decrease of the expected income from the original activity.

As for farm implements, under the present situation, the average annual service flow for this input factor was M$8.34 for the whole of the study area. As shown in Table 9.8 in order to equalise the marginal revenue product and the marginal cost of this resource, the farmers have to increase the amount by an additional of M$9.46, thus giving the total amount of annual service flow to M$17.80.

TABLE 9.8. CHANGES IN THE AVERAGE ANNUAL EXPENDITURE ON FARM IMPLEMENTS (M$)

CATEGORY	BEFORE ADJUSTMENT	AFTER ADJUSTMENT	DIFFERENCE	% CHANGE
Small farms	4.29	12.71	8.42	+196.27
Pooled Data	8.34	17.80	9.46	+113.43

In other words, the percentage increase required is 113.43 per cent. The situation is also pressing in the case of the small farms as here the amount involved is quite substantial, that is, amounting to 196.27 per cent in order to achieve the equilibrium condition. Such a drastic increase stems from the fact that the cocoa farmers were underequipped during the study period. Relatively speaking, the acquisition of additional farm implements is easier to undertake provided the government or semi-governmental agencies in the area can provide better credit facilities to those who are in dire need of this input.

The adjustment in living capital comprising both cocoa and coconut trees is rather difficult to be undertaken in the present study. From Table 9.9 it is revealed that within the framework of the measurement technique used, the farmers have to reduce the use of this resource by an average of 86.22 per cent for the whole of the study area.

TABLE 9.9. CHANGES IN THE AVERAGE ANNUAL SERVICE FLOW OF LIVING CAPITAL (M$)

CATEGORY	BEFORE ADJUSTMENT	AFTER ADJUSTMENT	DIFFERENCE	% CHANGE
Small farms	2530.06	278.66	2251.40	-88.99
Bagan Datoh	3187.52	290.92	2896.60	-90.87
Hutan Melintang	3187.52	592.02	2595.50	-81.43
Pooled Data	3519.24	485.00	3034.24	-86.22

Based on the finding of this investigation it was reported that the average planting density of cocoa was 308 plants per acre which is in line with the recommended density of 300 to 500 trees. If the suggestions of the present study is to be followed it means to say that a major portion of the trees have to be demolished. To the farmers, this would mean a total loss of income in the short term. Logically speaking, such a drastic reduction does not make sense at all. This might arise because of the bias in the estimates obtained as stated earlier.

From the field observation made during the study period, it was found that the shade level was excessively heavy in this study area. This was partly due to the high coconut densities present. Most of the farmers planted Malaysian Tall palms with a density well above the recommended level (55 palms per acre). The heavy shade provided by the coconut palms coupled with the presence of fruit trees in the cocoa plots reduce light penetration and as a consequence may limit the yield. In addition, since the majority of the farmers did not prune their cocoa trees, the self-shading of the excessive cocoa leaves may further aggravate the situation. All these explanations point to the fact that what is required under the present situation is actually to undertake some proper agronomic practices in the maintenance of this crop, so as to achieve higher crop yield. Those older coconut palms should be replaced and only the recommended density should be maintained. The practice of mature budding as is being partially adopted by the farmers in this area also deserves considerable attention by the authority concerned. A more aggressive campaign should be undertaken so that all the farmers are aware of its benefits. Under this system, the smallholders did not have to totally demolish their old cocoa trees.

What is actually required is for them to discard a certain portion of the trees for the budding to take place while still maintaining the parts that still bear fruits. It is only when the new branches started to fruit that the older parts are being totally chopped off.

In the adjustment made in Table 9.9 since all the amounts involved are beyond the observed range of the present data, care therefore, must be exercised in trying to interpret the information given. This is because we have no knowledge concerning the nature of the production function at this extreme.

Adjustment in land size is rather difficult to be undertaken in the short-run. Although based on the finding of this study, this input has to be expanded between 2 to 3 times of its present quantity in order to achieve allocative efficiency, nevertheless, no adjustment could be made as there is no opportunity to bring more land under cultivation in this study area. Furthermore, most of the farmers however, were reluctant to sell their holdings because of the traditional attachment to land and also due to lack of alternative occupations for them.

After gaining some insight pertaining to the changes in the levels of the respective inputs required in order to achieve allocative efficiency, the next stage is to examine the impact of these adjustments on expected income.

It should, however, be stressed that only changes in the levels of fertiliser expenditure and services from farm tools are taken into account in the computation of the new expected income. Other inputs comprising land, labour and living capital remain fixed at their present geometric means since their adjustments are relatively difficult to make in the very short run. Land is a constraint in this area; therefore, no further increase is anticipated. As for living capital, the optimum levels that had been determined were beyond the observed range of the present data where we have no knowledge concerning the nature of the production process at that extreme. Labour on the other hand is difficult to displace unless there are avenues available to absorb the surplus.

For the pooled data, it has been found that by increasing the level of fertiliser expenditure to M$44.87 (see Table 9.6) and farm tools to M$17.80 (see Table 9.8) while the other three inputs (land, labour and living capital) remained unchanged, the increase in expected income amounts to M$93.71 as shown in Table 9.10.

Since the additional total cost for the use of these two inputs is M$40.93, that is M$31.47 for fertilisers and M$9.46 for farm implements, there is still a net gain of M$52.78 as a result of this adjustment. For the small farms, the net gain is M$36.74 while that for the larger ones is M$45.42. The corresponding figures for Bagan Datoh, Rungkup and Hutan Melintang are M$61.92, M$74.65 and M$51.15, respectively.

Table 9.10 CHANGES IN EXPECTED INCOME AS A RESULT OF CHANGES IN FERTILISERS AND FARM IMPLEMENTS

CATEGORY	BEFORE ADJUSTMENT (M$)	AFTER ADJUSTMENT (M$)	DIFFERENCE (M$)
Pooled Data	2801.75	2895.46	+ 93.71
Small Farms	1935.46	1996.00	+ 60.54
Large Farms	3321.58	3432.00	+106.43
Bagan Datoh	3312.97	3409.43	+ 96.46
Rungkup	2068.75	2193.82	+125.07
Hutan Melintang	2168.09	2250.71	+ 82.62

In spite of the gains obtained after adjustment, nevertheless, the monthly gross income of M$ 241.28 for the pooled data, M$ 161.29 and M$ 286.00 both for the small and large farms are still below the poverty line of M$ 350.00. The same situation also applies in the case of Bagan Datoh, Rungkup and Hutan Melintang. The monthly expected income of M$ 276.08, M$ 172.39 and M$ 180.67 in these respective areas points to the fact that the smallholders are still living in poverty.

9.4. SUMMARY

The present study attempts to examine the nature of the production elasticities as well as the marginal returns to each of the input factors used in the production process. Besides that it also attempts to examine whether the inputs were being used in the proper combination or not in the production of cocoa.

From the analyses made it was demonstrated that the values of the marginal productivities of the respective inputs that were incorporated into the re-estimated regression models were not equal to their marginal factor costs. Inputs like fertilisers and farm implements as well as land size were being too sparingly used in the case of the overall study area. Whereas that of living capital and labour were found to be excessively utilised during the period under investigation.

It seems that the ideal adjustment in resource allocation for the whole area is through a decrease in living capital and labour followed by an increase in the investment in farm implements, fertlisers and land size.

CHAPTER TEN

A FRONTIER PRODUCTION ANALYSIS

An important conventional wisdom with respect to traditional agriculture is that farmers are highly efficient given the resources and technology available to them (Schultz, 1964). The acceptance of this view has led the governments of the developing countries to place emphasis on capital investment such as improved varieties of seeds, tractorisation, mineral fertilisers, etc.

However, in situations where some farmers perform better than their neighbour with the same technology, there may exist scope for increasing output without major investments in the immediate future. There are actually several factors which lead to the farmers to produce below their potential. Among them is the presence of either allocative inefficiency and or technical inefficiencies. The latter refers to the inability of the farmers to produce the 'best' level of output with available resources and given technology.

In the previous chapter the question of allocative efficiency has been dealt with. The present chapter, however, intends to generate farm specific technical efficiency indices and to employ the computed indices in identifying the gaps between actual and potential output.

The hypothesis to be examined in this analysis can be stated as follows: there are technical inefficiencies in traditional agriculture and these inefficiencies lead to a considerable gap between the actual and potential output.

The present chapter is divided into five sections. The first section contains a brief discussion of the alternative measures of technical efficiency, while the second part describes the approach adopted in the present study. Section three presents the results computed by means of the average and frontier production functions. The efficiency differentials among the various groups of samples are examined in section four. The final section attempts to examine the determinants of technical efficiency.

10.1. SOME ALTERNATIVE MEASURES OF TECHNICAL EFFICIENCY

The theoretical definition of a production function is that it represents the maximum possible output which can be produced from given input bundles. This indicates that there is a frontier which sets a limit to the maximum possible output which could be obtained. Thus a farm producing less than the maximum possible output may lie below the production frontier and is regarded as an inefficient farm. The measurement of ineffICency has been the main motivation for the study of the production frontier.

There are three frontier production models that have been widely used in empirical studies, namely, 1) a deterministic production frontier estimated by means of a linear programming technique; 2) a statistical production frontier which is estimated either by using the corrected ordinary least squares or the maximum-likelihood techniques and; 3) a stochastic production frontier with a composed error structure which is also estimated by using maximum-likelihood techniques (Forsund *et al*, 1980). In the deterministic model all the deviations from the frontier are attributed to technical inefficiency. In the case of the stochastic model, the error term is composed of two parts - a symmetric and a one sided component. The former represents the random variation of the frontiers across the farms and captures the effects of errors in measurement and other 'statistical noise' during estimation (i.e. factors beyond the farm's control). The latter however, captures the effects of inefficiency relative to the frontier.

1) <u>Linear Programming Frontiers</u>

The starting point for the discussion of frontiers was provided by Farrell (1957). In his seminal paper, Farrell rejected the idea of an absolute measure of efficiency based on some presumed ideal situation. Instead, he proposed that efficiency may be viewed in a relative sense, and measured as the deviation from the best performance in a given peer group. The empirical approach used by Farrell involves the estimation of a frontier isoquant using linear programming methods and he simultaneously calculates input-based measures of efficiency for all data points in the sample. His estimated frontier is said to be free of any parametric specifications and assumes linear homogeneity. However, one disadvantage with Farrell's method is that the frontier production function is not estimated in a form yielding explicit representation of the function.

Aigner and Chu (1968) argued that with Farrell's method, it may not be possible to estimate production functions which conform to the law of variable proportions. With this criticism in mind, and drawing on Farrell's ideas, they expressed the frontier in a simple mathematical form. They specified a homogeneous Cobb-Douglas production frontier, and required all observations to be on or beneath the frontier. The model may be written as:

$$\ln y = \ln f(x) - \mu$$

$$= a_0 + \sum_{i=1}^{n} a_i \ln x_i - \mu, \quad \mu >= 0, \qquad (10-1)$$

where y is the maximum output obtainable from inputs (x), a_i's are the parameters to be estimated and μ is a one-sided error term. The elements of the parameter vector a = (a_0, a_1, ..., a_n) may be estimated either by linear programming (minimizing the sum of the absolute values of the residuals, subject to the constraint that each residual be non-positive) or by quadratic programming (minimizing the sum of squared residuals, subject to the same constraints). The technical efficiency of each observation can be computed directly from the vector of residuals, since μ represents technical inefficiency.

Timmer (1970) suggested a similar approach to measuring the technical efficiency of each observation using the revised residuals, e_i, from an estimated production function. He specified a homogeneous Cobb-Douglas function which he estimated using linear programming techniques. His measure of technical efficiency can be considered essentially as an output-based measure. It may be specified as output actually produced divided by the maximum technically feasible output, given the levels of input used. His measure thus indicates how much extra output could be obtained if the producer concerned were operating on the frontier. The measure can be expressed as:-

$$\text{Timmer } TE_i = \frac{\text{Actual Output}}{\text{Maximum Feasible Output}} = \leqslant 1$$

2) <u>Statistical Frontiers</u>

Following Greene (1980), a statistical production frontier can be expressed as :-

$$Y_j = a_o + \sum_{i=1}^{m} \beta_i X_{ij} - e_j \qquad (10\text{-}2)$$

Where a_o is the intercept term, e_j is assumed to be identically and independently distributed with non-negative mean and finite variance, m is the number of factors, Y_j and X_{ij} are the logs of output and inputs of the jth farm, respectively.

The central issue in estimating the statistical frontiers is whether the differences in efficiency between farms are assumed to be induced by an explicit distributional form or not. Greene (1980) showed that if the distribution of e_j follows the gamma distribution, the frontier can be estimated by using the maximum-likelihood techniques. But if no explicit form for the error distribution is made, the statistical production frontier can be estimated by the Ordinary Least Squares (OLS) technique yielding best linear unbiased estimates of the regression coefficients. However, the OLS intercept is biased downwards and must be corrected, giving rise to the name corrected ordinary least squares (COLS). The intercept estimate as suggested by Greene (1980) can be obtained by shifting the constant term upwards by an amount equal to the largest positive residual (e_{max}). When this correction is performed, all the residuals are non-negative and at least one is zero which implies that no farm can exceed 100 per cent efficiency.

Through this technique the equation in (10-2) can then be expressed as :-

$$Y_j = (a_o + e_{max}) + \sum_{i=1}^{m} \beta_i X_{ij} - (e_j + e_{max}) \qquad (10-3)$$

Greene (1980) has shown that this correction provides a consistent estimate of a_o. Researchers, however, argued that the problem associated with this technique is that some of the residuals may still have the wrong sign, even after correcting the constant term, thus giving the observations above the estimated frontier.

3) **Stochastic Frontiers**

In this type of frontier, the error term is composed of two parts; a symmetric and a one-sided component. As noted earlier, the former allows random variation of the frontier across the farms and captures the effects of measurement error, other statistical 'noise' and random shocks outside the farm's control. The latter captures the effects of inefficiency relative to the stochastic frontier.

Aigner *et al* (1977) and Meeusen and van den Broeck (1977) developed their composed error model of the form:

$$y = x\beta + \mu + v \qquad (10\text{-}4)$$

where y is a column of vector of output; x, the matrix of inputs used in the production of y; β, is the column vector of production parameters to be estimated, μ the one sided efficency component and v, the vector representing the statistical error.

From the above equation, the ith farmer's maximum yield for its specific level of inputs is defined by X,β provided it uses the best practice technique ($\mu_i = 0$), there are no statistical errors and the influence of external factors on production is negligible ($v_i = 0$). If the farm uses the best practice technique but there are either statistical errors such as measurement error or the influence of other factors not included in the model, then the farm's yield is calculated as ($X_i \beta + v_i$). The presence of v here also means that the model may vary randomly across farms or over time for the same farm.

On the other hand if there are no statistical errors and no influence of external random factors on production, then the farm yield obtained will be equal to or less than maximum yield depending on whether it uses the best practice technique or not, that is, whether μ is zero or negative, respectively. Assuming density functions for μ or v, the model can be estimated using the maximum likelihood method.

This method provides a means to examine statistically the sources of the difference between the farmer's yield and that estimated by the frontier. According to Battese and Corra (1977) this can be achieved by calculating the variance ratio parameter (γ) which relates the variability of μ to total variability (σ^2)

in the following manner:

$$\gamma = \sigma_{\mu}^2 / \sigma^2$$

where $\sigma^2 = \sigma_{\mu}^2 + \sigma_v^2$ and $0 =< \gamma =< 1$

The variance ratio parameter γ has two important features:

i) When σ_v^2 tends to zero, the μ is the predominant error in the model and $\gamma \to 1$. This implies that the output of the sampled farmers differs from the maximum output mainly because of differences in technical efficiency.

ii) When σ_{μ}^2 tends to zero, then the symmetric error v is the predominant error in the model, so $\gamma \to 0$.

Therefore, based on the value of γ, it is possible to identify whether the difference between a farmer's output and the efficient output is due to statistical errors ($\gamma \to 0$) or the sample's less-than-efficient use of technology ($\gamma \to 1$).

Thus from the above discussions, two types of frontier could be distinguished, i.e. the deterministic or the best-practice frontiers and the stochastic or the absolute frontiers. The former refers to the frontier which is fitted without assuming the form of the distribution of the one-sided error. The latter, on the other hand, involves an explicit assumption of the distribution of the error.

The main advantage of using the deterministic frontier production function seems clearly to be the availability of a measure of technical ineffICency for each production unit. The main drawback is that it is subject to 'statistical noise'. For the stochastic frontiers the situation is reversed.

However, according to Forsund *et al* (1980: pp.23) 'there is not yet a consensus on how one should, or whether one can, measure the technical efficency of a firm, even if this is agreed to be a useful thing to measure'. Whatever the case may be, they further pointed out that 'the practical importance of the distinction is not likely to be large, since the absolute and the best-practice frontiers necessarily converge asymptotically (as the sample size grows without bound)' (Forsund *et al*, 1980, pp.20).

10.2. METHOD USED IN THE PRESENT STUDY

In this study Timmer's approach of estimating the deterministic production frontier through the use of linear programming methodology is employed in the analysis that follows. In addition, the chance constrained frontier production function approach is also used. As will be explained later, the use of the chance constrained frontier is to get rid of the problem of random errors that might exist in the data set.

The main reasons for choosing the Timmer's approach as opposed to the other techniques outlined earlier is that this approach can be applied for the measurement of technical inefficiency for each observation in the sample. This is important because an understanding of the individual farm performance will allow us to ascertain whether or not it is possible to exploit known practices used by the more successful farmers in an effort to improve the output of the least efficient producers. The efficiency measures used by Meeusen and van den Broeck as well as that used by Aigner *et al* (1977) are of an average nature and cannot be applied to the individual observation. Consequently, it may not be possible to analyse the factors responsible for the variation in the technical efficiency levels across observations (Kopp, 1981). Besides this, the method used in this study also provides the ease of comparing the frontier estimates with that of the 'average' production function estimates computed in Chapter eight.

The frontier function operates in total output-input space. A functional form for the hyperplane is first specified. In this case the Cobb-Douglas production function is selected based on the fact that this function gave reasonably good and logical results in the average production function discussed in Chapter eight. In addition its use in this chapter will allow direct comparison with the results of that chapter.

ASSUMPTIONS

An important assumption in the use of the approach is that technical efficiency is subsumed within the disturbance term of the chosen function. Therefore, the linear programming objective function is the sum of the disturbances. It is further assumed that all the disturbances are of the same sign so that all observed points in the production space lies on or below the frontier.[1] The specification errors as well as errors of measurement in all variables are assumed to be negligible.

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[1] This assumption holds true only for the deterministic frontier function and not for the probability function.

THE MODEL

Consider the Cobb-Douglas production function.

$$Y_j = \sum_{i=0}^{m} a_i X_{ij} + e_j \qquad (10\text{-}5)$$

where

Y_j = logarithm of the output of farm j

X_i = logarithm of the level of input used by farm j

m = number of inputs

a_i = parameters

e_j = logarithm of the random error term.

To make this a frontier function, all the error terms are constrained to one side of the estimated production surface. Thus (10-5) is estimated such that:

$$\sum_{i=0}^{m} \hat{a}_i X_{ij} = \hat{Y}_j >= Y_j \qquad (10\text{-}6)$$

Where, $\hat{Y}_j$ = potential output and Y_j = actual output.

If it is assumed that $e_j >=0$, (10-5) is rewritten as:

$$\sum_{i=0}^{m} \hat{a}_i X_{ij} - e_j = Y_j \qquad (10\text{-}7)$$

Summing over all j's:

$$\sum_{j=1}^{n} \sum_{i=1}^{m} \hat{a}_i X_{ij} - \sum_{j=1}^{n} e_j = \sum_{j=1}^{n} Y_j \qquad (10\text{-}8)$$

and

$$\sum_{j=1}^{n} e_j = \sum_{j=1}^{n} \sum_{i=0}^{m} \hat{a}_i X_{ij} - \sum_{j=1}^{n} Y_j \qquad (10-9)$$

Y_j's are constant for any sample. Any set of $\hat{a}i$ that minimises:

$\sum_{j=i}^{n} e_j$ for a value of $\sum Y_j$ will minimise it for any vector

of Y_j's - including zero. Hence the term may be dropped with no consequence.

Therefore

$$\sum_{j=1}^{n} e_j \sim \sum_{j=1}^{n} \sum_{i=0}^{m} \hat{a}_i X_{ij} \qquad (10-10)$$

Dividing by n gives

$$\frac{1}{n} \sum_{j=i}^{n} e_j \sim \sum_{i=0}^{m} \hat{a}_i \bar{X}_{ij} \qquad (10-11)$$

where

$$\bar{X}_i = \frac{1}{n} \sum_{j=1}^{n} X_{ij} \qquad (10-12)$$

The problem then is to minimise

$$\sum_{j=1}^{n} e_j$$

Subject to

$$\sum_{i=0}^{m} \hat{a}_i X_{ij} >= Y_j \qquad (j=1, 2.....n)$$

$$\hat{a}_i >= 0 \qquad (10-13)$$

In an expanded form :

$$\text{Minimize} \quad \hat{a}_0 \bar{X}_0 + a_1 \bar{X}_1 + a_2 \bar{X}_2 +---+ a_m \bar{X}_m \qquad (10-14)$$

Subject to

$$\hat{a}_0 X_{01} + \hat{a}_1 X_{11} + \hat{a}_2 X_{21} + --- + \hat{a}_m X_{m1} >= Y_1$$

$$\vdots$$

$$\hat{a}_0 X_{0n} + \hat{a}_1 X_{1n} + \hat{a}_2 X_{2n} + --- + \hat{a}_n X_{mn} >= Y_n$$

where

X_0 = column of ones (intercept)

m = number of inputs and

n = number of observations.

POINTS OF DEPARTURE

Four points of departure from a standard Linear Programming model should be noted:

1. The objective function minimises the mean resource levels used for the production of a given output levels.

2. Matrix of constraints is given by individual farm observation of inputs in contrast to input-output coefficients of standard Linear Programming.

3. The level of constraints, that is, the right hand side values are represented by individual farm output levels.

4. Activities in the matrix will be the coefficients, that is, with a_0 being the intercept of the frontier production function and $a_1 \ldots\ldots a_m$ the elasticities of the respective factors.

But in the primal form (as represented above) the number of constraints is equal to the number of observations and is greater than the number of activities (that is, the number of factors). Hence it may be more convenient and easier to solve the dual of the problem.

The dual problem may be written as:

$$\text{Maximize} \quad \sum_{j=1}^{n} W_j \; Y_j \qquad (j = 1 \ldots\ldots n) \tag{10-15}$$

Subject to

$$\sum_{j=1}^{n} W_j X_{ij} =< X_i \qquad (i = 0, 1, \ldots\ldots m)$$

$$(W_j = \text{shadow prices})$$

In an expanded form

$$\text{Maximize} \quad W_1 Y_1 + W_2 Y_2 + --- + W_n Y_n \qquad (10\text{-}16)$$

Subject to

$$W_1 X_{o1} + W_2 X_{o2} +----+ W_n X_{on} =< \bar{X}_o$$

$$\vdots$$

$$W_1 X_{m1} + W_2 X_{m2} +----+ W_n X_{mn} =< \bar{X}_m$$

In the dual form, the following observations may be made:

1) The objective function maximises the level of output produced from given levels of inputs. (There are as many activities as there are observations).

2) The matrix of restrictions is given by the individual farm observations of factors of production as specified in the starting production function.

3) The levels of constraints, that is, the right hand side values are represented by the mean levels of resources used.

4) The 'shadow prices' in the Linear Programming output provides the required a_i's of the primal, that is, the elasticities of the factors in the frontier function.

CHANCE CONSTRAINED FUNCTION

This admits random data variations and permits constraint violation up to specified probability limits. This method is used to eliminate random cases from the estimated frontier function.

To derive a chance constrained frontier from the dual of the problem, the constrained model is replaced by probabilistic statement. Instead of the deterministic inequality the constraint statement becomes

$$Pr \left(\sum_{j=1}^{n} W_j X_{ij} =< \bar{X}_i \right) >= P \qquad (10-17)$$

where P is a specified probability level with which the equation is to hold. The frontier is deterministic when P = 100 per cent and probabilistic when P < 100 per cent.

The following procedure is used in obtaining the probabilistic frontier coefficients. First, the deterministic frontier production function is estimated.

Second, the most 'efficient' farms are discarded in stages until the estimated coefficients appear to have stabilised. These 'efficient' farms may be efficient because of errors of observations or other problems (Timmer, 1970).

In the dual form the objective function and restriction becomes

$$\text{Maximize} \sum W_j \; Y_j \qquad (10\text{-}18)$$

Subject to

$$\sum_{j=1}^{n-p} W_j \; X_{ij} \; >= \bar{X}_i \quad (a)$$

$$W_j \;\; >= 0$$

where p = number of observation indicated by the constrained level of P and

(a) = implies the mean resource levels are adjusted accordingly.

The technique involved is to discard the first (100-P) per cent of 'efficient' farms until a prespecified level of P is reached. Thus two per cent of the extreme observations might be discarded with 98 per cent of the observations determining the frontier.

The technical efficiency of the jth farm can then be estimated directly from the Linear Programming solution by computing an index of technical efficiency given by the ratio $\hat{Y}_j/Y_j$. Farms for which $Y_j = \hat{Y}_j$ are considered to be 100 per cent technically efficient.

10.3. ESTIMATED FRONTIER PRODUCTION FUNCTION COEFFICIENTS

Tables 10.1 through 10.5 reported the results of fitting the linear form of the Cobb-Douglas production function using the frontier approach. The columns labelled LP (100) are the results from fitting the deterministic function; while the labels LP(99), LP(98), and LP(94) are the results obtained from the chance constrained functions after removing one, two and six per cent of the extreme observations from the sample respectively, The re-estimated average production function coefficients for the conventional inputs from Chapter 8 are presented in the first column in order to provide the statistcal tests of significance in hand when looking at the estimates of the frontier. In this manner we can be confident that a production surface exists for the cocoa production in this area.

Results from the overall sample (Table 10.1) indicated the following:

TABLE 10.1 REGRESSION COEFFICIENTS FOR POOLED DATA-USING AVERAGE AND FRONTIER PRODUCTION FUNCTIONS.

VARIABLES	AVERAGE PRODUCTION FUNCTION n = 260	LP(100) n = 260	LP(98) n = 255
Intercept	4.4684*** (0.4443)	4.6224	4.8628
Land	0.5702*** (0.0756)	0.5679	0.5691
Farm Tools	0.0091** (0.0047)	0.0082	0.0087
Chemicals	0.0070** (0.0031)	0.0040	0.0057
Fertilisers	0.0181*** (0.0029)	0.0298	0.0168
Labour/acre	0.1197** (0.0520)	0.2429	0.1324
Living Capital/acre	0.2310*** (0.0571)	0.2385	0.2296
R^2	0.8624		
F - Statistic	271.49***		

Figures in parentheses are the standard errors
Level of significance : *** 1 per cent
** 5 per cent,
* 10 per cent

i) A comparison of the deterministic frontier (LP100) and the average production function results indicated that the major difference between the two to be: the larger coefficient for labour for the frontier function. When a closer examination of the magnitude of the frontier intercept was made it was revealed that its value was actually within the 95 per cent confidence interval of the average production function estimate. This therefore implied that there was no significant difference in its value between the two methods used. The large labour coefficient was rather puzzling. The plausible explanation is that the efficient farmers might have used less labour input compared to the less efficient farmers in this study area. This has the consequence of increasing the marginal productivity of this input. The magnitude of the frontier coefficient indicated that the increase in the use of this input would increase total output by a higher amount for farmers on the frontier than it would for farmers on the average. For instance, while a 10 per cent increase in labour would result in 2.4 per cent increase in output for farmers on the frontier, the corresponding increase for farmers on the average is 1.2 per cent.

ii) With two per cent of the observations removed the estimated coefficients looked remarkably like those estimated with ordinary least squares. All the coefficients were very similar to those of the analogous average function. The intercept as well as the magnitude of the labour coefficient of the chance constrained function were also within the 95 per cent confidence interval of the average estimates. The rest of the inputs have similar output elasticities because the amounts used increased proportionately, or approximately so, with output.

With the exception of the high labour elasticity of output with respect to the deterministic frontier function, overall, the results of this analysis clearly seemed to indicate that the frontier production function has shifted almost neutrally outward from the average production function.

Splitting the sample according to regions produced different outcomes. As for the region of Teluk Baru, the following results were obtained (see Table 10.2).

TABLE 10.2 REGRESSION COEFFICIENTS FOR TELUK BARU -USING AVERAGE AND FRONTIER PRODUCTION FUNCTIONS

VARIABLES	AVERAGE PRODUCTION FUNCTION n=31	LP(100) n=31	LP(94) n=29
Intercept	5.3639*** (1.5737)	5.9258	6.0864
Land	0.3303 (0.2210)	0.5756	0.2742
Farm Tools	0.0176 (0.0718)	0.0235	0.0159
Chemicals	0.0054 (0.0059)	0.0161	0.0025
Fertiliser	0.0029 (0.0075)	0.0149	0.0058
Labour/acre	0.3615** (0.1432)	-	0.3025
Living Capital/acre	0.0266 (0.2123)	0.0257	0.0260
R^2	0.8029		
F-Statistic	21.37***		

Figures in parentheses are the standard errors.
Level of significance : *** 1 per cent
** 5 per cent
* 10 per cent.

i) The absence of labour in the solutions LP(100) implied an excess capacity on the part of the farmers on the frontier.[2] A closer examination of the resource endowments of farmers defining the frontier indicated that while the constraint capacity was set at 69.6 man-days, farmers on the frontier had on the average 190 man-days of the resource. This confirmed the plausibility of the explanation of zero labour elasticity of output.

ii) With six and ten per cent of the observations removed the estimated coefficients changed remarkably.

iii) Since the results of LP(90) were similar with LP(94), only the results of LP(94) were reported here. The table revealed that the coeffcients of at least three inputs : farm tools, chemicals and fertilisers were almost identical with that of the average production function.

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[2]. The exclusion from the solution for those variables for which the farmers that determine the frontier have excess capacity or do not use appreciable amounts of specific inputs may not necessarily be a disadvantage of the approach. At least it ensures that the coefficients that are eventually used to determine the efficiency indices are based on resources whose levels are generally within the reach of farmers on the average.

iv) Although the intercept was higher nevertheless, the magnitude was still within the 95 per cent confidence interval of the estimate obtained from the average production function. The same situation also applied in the case of both the labour and the land frontier coefficients.

For the region of Bagan Datoh (see Table 10.3), the observations made were as follows:

i) All the variables except for chemicals were in the solution. From the examination of the data it was revealed that there was an excessive use of this input with respect to farmers on the frontier. This gave rise to zero chemical elasticity of output.

ii) For other inputs comprising land size, fertilisers, farm tools and living capital, the values of the regression coefficients were almost similar with those estimated by the average production function. The frontier coefficient for labour (both for LP(100) and LP(98))[a] however, was still within the 95 per

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a. The results of LP(98) were similar with that of LP(95) and only the results of LP(98) were reported here.

cent confidence interval of the estimate obtainable from the average production function. Thus there was no significant different in the magnitude of this input between the methods used.

The results obtained for the region of Rungkup were as follows (see Table 10.4):

i) A comparison between the frontier production functions [LP(100) and LP(98)] and the average production function results indicated that the major difference between the two to be: the exclusion of labour and chemicals from the solutions. An examination of the data revealed that the farmers on the frontier used an excessive amount of these inputs relative to the constraint level so that the excess capacity gave rise to zero elasticities.

ii) Frontier LP(100) coefficients did not include labour - implying excess capacity on the part of the farmers on the frontier.

iii) With two per cent of the observations removed the coefficients seemed to have stabilised. There was a remarkable increase in the elasticity of land size compared to the corresponding figure in the LP(100).

Nevertheless, the value was still below the one estimated by the average production function. This outcome suggests that farmers on the frontier used a greater amount of land in the production process compared to the 'average' farmers.

TABLE 10.3 REGRESSION COEFFICIENTS FOR BAGAN DATOH-USING AVERAGE AND FRONTIER PRODUCTION FUNCTIONS

VARIABLES	AVERAGE PRODUCTION FUNCTION n=55	LP(100) n=55	LP(98) n=54
Intercept	4.1318*** (0.6898)	4.3618	4.5681
Land	0.4161*** (0.1377)	0.4211	0.3876
Farm Tools	0.0384 (0.0801)	0.0921	0.0571
Chemicals	0.0043 (0.0055)	-	-
Fertiliser	0.0206*** (0.0206)	0.0164	0.0170
Labour/acre	0.3689*** (0.1209)	0.3048	0.3361
Living Capital/acre	0.1487** (0.0769)	0.1599	0.1136
R^2	0.9311		
F-Statistic	124.03***		

Figures in parentheses are the standard errors
Level of significance: *** 1 per cent, ** 5 per cent, * 10 per cent.

TABLE 10.4 REGRESSION COEFFICIENTS FOR RUNGKUP - USING AVERAGE AND FRONTIER PRODUCTION FUNCTIONS

VARIABLES	AVERAGE PRODUCTION FUNCTION n=99	LP(100) n=99	LP(98) n=97
Intercept	5.1379*** (0.8548)	4.9021	4.4208
Land	0.6444*** (0.1424)	0.3667	0.4854
Farm Tools	0.0118* (0.0066)	0.0455	0.0268
Chemicals	0.0144** (0.0055)	0.0094	-
Fertiliser	0.0173 (0.0050)	0.0178	0.0145
Labour/acre	0.0888 (0.0778)	-	0.2059
Living Capital/acre	0.1601 (0.1132)	0.3444	0.2638
R^2	0.8678		
F-Statistic	108.25***		

Figures in parentheses are the standard errors
Level of significance : *** 1 per cent
** 5 per cent
* 10 per cent.

Finally, for the region of Hutan Melintang, the results demonstrated the following (see Table 10.5):

i) The results from LP(100) and LP(98) were identical and the estimated coefficients seemed to have stabilised at LP(98).

ii) Both chemicals and labour were not in the solution implying excess capacity on the part of farmers on the frontier.

iii) Both the intercept as well as the estimated coefficients for the rest of the inputs on the frontier were almost identical with that estimated by the average production function.

In summary, high production elasticity for labour constitutes the major difference between the estimated frontier (LP 100) and average function for the pooled data. Except for the differences in the values of the estimated regression coefficients for labour and chemicals, on a regional basis it was shown that there were no significant different in the magnitudes of other estimates as their values were within the confidence intervals of that estimated by the use of the average production functions.

TABLE 10.5 REGRESSION COEFFICIENTS FOR HUTAN MELINTANG-USING AVERAGE AND FRONTIER PRODUCTION FUNCTIONS

VARIABLES	AVERAGE PRODUCTION FUNCTION n=75	LP(100) n=75	LP(98) n=74
Intercept	4.5485*** (0.9062)	4.7161	4.7161
Land	0.6887*** (0.1520)	0.6499	0.6499
Farm Tools	0.0003 (0.0129)	0.0301	0.0301
Chemicals	-0.0044 (0.0064)	-	-
Fertiliser	0.0237*** (0.0067)	0.0124	0.0124
Labour/acre	-0.0468 (0.1232)	-	-
Living Capital/acre	0.2930*** (0.1151)	0.3067	0.3067
R^2	0.8224		
F-Statistic	58.12***		

Figures in parentheses are the standard errors.
Level of significance : *** 1 per cent
** 5 per cent
* 10 per cent.

10.4 EFFICIENCY DIFFERENTIALS

In order to examine the efficiency differentials a technical efficiency index was computed for the individual farms. This is obtained by dividing the farm's actual output by its potential output. The potential output is derived by multiplying the farm's resource levels by the corresponding estimated frontier function coefficients and summing over the number of resources in the optimal solution.

$$\sum_{i=0}^{m} \hat{a}_i X_{ij} = \hat{Y}_j$$

and TEI (Technical Efficiency Index) = $Y_j / \hat{Y}_j$

where:

$\hat{a}_o$ = intercept

$\hat{a}_i$ = (i = 1....m) = estimated coefficients

X_{ij} = logarithm of the amount of inputs

$\hat{Y}_j$ = potential output of farm j

Y_j = actual output of farm j

The index is thus a reflection of how each farm employs the inputs available relative to the best practice in the sample.

The frequency distribution indices are presented in Tables 10.6 through 10.7.

For the entire sample, it was observed that the least efficient operator had an index of 0.66. The average technical efficiency indices was 0.820. These indicate average technical efficiency levels of 82 per cent for the sample, with standard deviation of 0.072.

It was noted that in the sample, all farmers were assumed to rely on similar inputs and similar technologies. In other words it was assumed that they employed identical inputs in the production process, except for quality differences which were reasonably reflected in the values of these factors. In discussions, the District Agriculture Officer and the cocoa Research Officer in the area confirmed the validity of this assumption. Thus it was assumed that the technical efficiency differentials among the farmers did not reflect differences in the types of inputs, but rather differences in how these inputs were used and managed.

TABLE 10.6
FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY (TE) INDICES FOR POOLED DATA

TE Indices	POOLED DATA n=255
>=0.50 <0.55	-
>=0.55 <0.60	-
>=0.60 <0.65	-
>=0.65 <0.70	19 (7.45)
>=0.70 <0.75	17 (6.67)
>=0.75 <0.80	49 (19.22)
>=0.80 <0.85	84 (32.94)
>=0.85 <0.90	53 (20.78)
>=0.90 <0.95	28 (10.98)
>=0.95 = <1.00	5 (1.96)
Mean	0.820
Std. Dev.	0.072
Minimum	0.660
Maximum	1.000

Figures in parentheses are percentages.

FIGURE 7. HISTOGRAM OF THE DISTRIBUTION OF THE TECHNICAL EFFICIENCY INDICES (POOLED DATA)

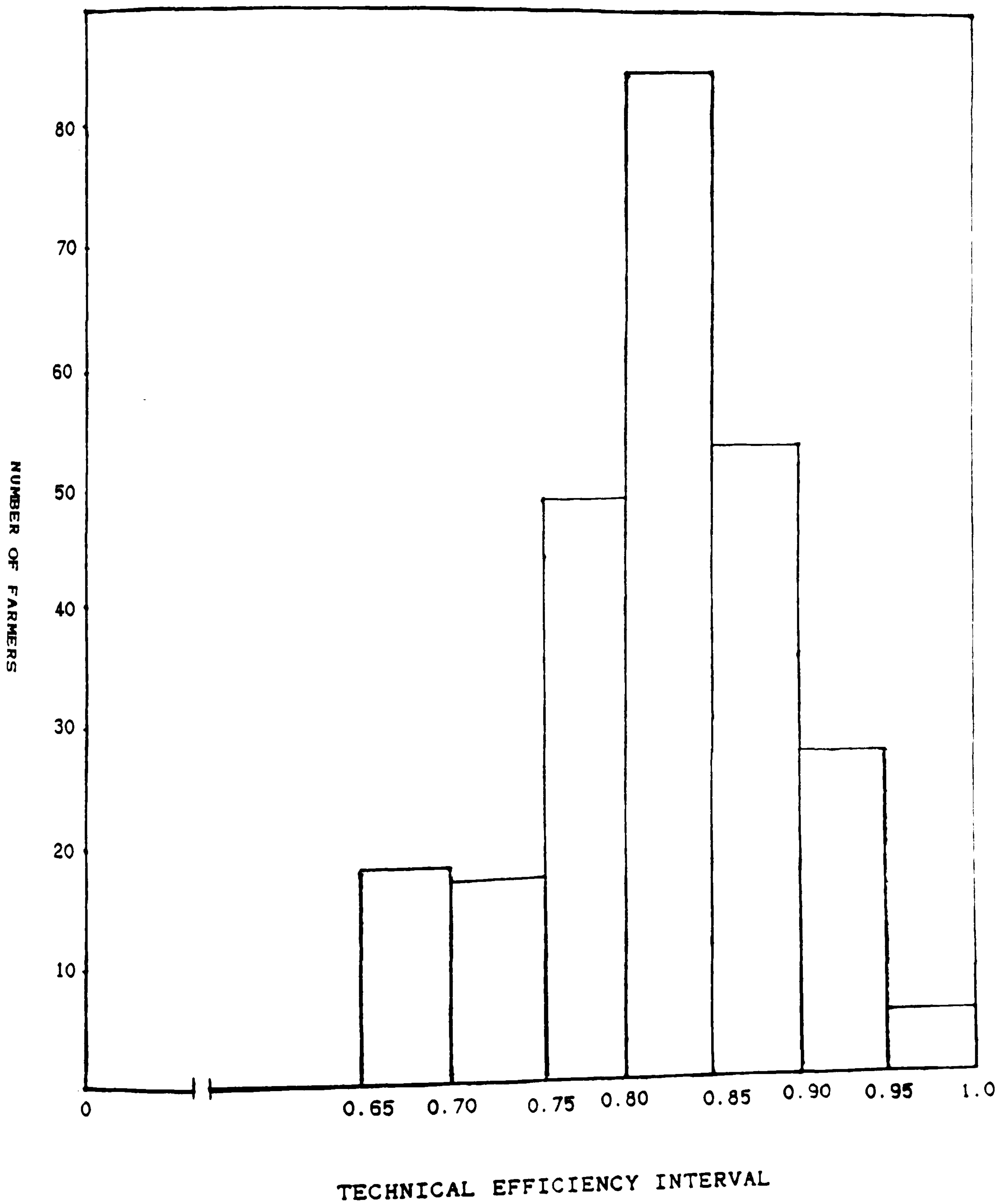


TABLE 10.7
FREQUENCY DISTRIBUTIONS OF TECHNICAL EFFICIENCY (TE) INDICES ACCORDING TO REGION

TE Indices	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
>=0.50 <0.55	-	-	-	-
>=0.55 <0.60	-	-	-	-
>=0.60 <0.65	-	-	-	-
>=0.65 <0.70	-	-	10 (10.31)	-
>=0.70 <0.75	-	5 (9.26)	5 (5.15)	8 (10.67)
>=0.75 <0.80	-	5 (9.26)	33 (34.02)	10 (13.33)
>=0.80 <0.85	1 (3.45)	5 (9.26)	24 (24.74)	21 (28.00)
>=0.85 <0.90	9 (31.03)	22 (40.74)	17 (17.53)	15 (20.00)
>=0.90 <0.95	14 (48.27)	11 (20.37)	2 (2.06)	12 (16.00)
>=0.95 =<1.00	5 (7.24)	6 (11.11)	6 (6.19)	9 (12.00)
Mean	0.915	0.863	0.809	0.858
Std. Dev.	0.039	0.077	0.079	0.073
Minimum	0.841	0.700	0.650	0.709
Maximum	1.000	1.000	1.000	1.000

Figures in parentheses are percentages

Accordingly, the average technical efficiency levels of 82 per cent recorded implies that, if the average farmer were to improve his management expertise, or improve the efficiency in the use of available input factors, so as to operate on the production frontier, he would obtain 18 per cent more output (i.e. 1 - 0.820). With respect to the least efficient farmer, it is evident that the level of output would be increased by 34 per cent i.e (1 - 0.66) if these actions were taken.

Considering the frequency distributions as illustrated in Tables 10.6 and 10.7, it is clear that the ranges of efficiency in all the sample groups were quite large. For the whole survey area the range was 0.66-1.00, with approximately 86 per cent of all farmers having an index of 0.75 or more. The corresponding figures for Teluk Baru, Bagan Datoh, Rungkup and Hutan Melintang are 0.84-1.00 (100 per cent), 0.70-1.00 (89.1 per cent), 0.65-1.00 (84.5 per cent) and 0.71-1.00 (89.3 per cent), respectively.

The least technically efficient farmer in Teluk Baru was 16 per cent away from the efficient function. The corresponding statistics for Bagan Datoh, Rungkup and Hutan Melintang were 30, 35 and 29 per cent, respectively.

10.4.1. TECHNICAL EFFICIENCY AND LEVEL OF RESOURCE USE

In agriculture it is argued that good and efficient farmers often use their inputs in large quantities and in the right combination to achieve larger output (Timmer, 1970). In this subsection, the extent to which the levels of resource use differ for different technical efficiency classes is examined.

Tables 10.8 through 10.12 present the mean levels of various factors of production applied per unit of land area by technical efficiency class.

In these tables, the following notations are used:

TE Class		Technical Efficiency Indices
1	=	>=0.65 <0.70
2	=	>=0.70 <0.75
3	=	>=0.75 <0.80
4	=	>=0.80 <0.85
5	=	>=0.85 <0.90
6	=	>=0.90 <0.95
7	=	>=0.95 =<1.00

In the case of the production factors analysed the following notations were used:

D = Land size under cocoa (acres)

F = Fertiliser/acre

C = Chemicals/acre

T = Farm Tools/acre

L = Labour/acre

K = Living capital/acre

For the whole region it was observed that (see Table 10.8):

TABLE 10.8
RESOURCE UTILIZATION BY TECHNICAL EFFICENCY (TE) CLASS - POOLED DATA (BASED ON SAMPLE WITH OUTLIERS OMITTED)

TE Class	D	F	C	T	L	K
1 (19)	1.12	6.89	5.84	9.86	22.93	1142.51
2 (17	1.74	21.95	13.14	9.59	22.67	1204.52
3 (49)	2.26	4.83	10.82	8.77	24.43	1328.49
4 (84)	3.04	25.24	15.53	8.15	26.40	1259.20
5 (53)	4.43	32.32	12.35	8.54	24.62	1213.72
6 (28)	6.12	58.82	14.49	7.43	25.82	1269.45
7 (5)	13.20	25.60	10.66	3.17	17.66	1259.89
<u>ANOVA</u>						
F-Statistic	5.15***	4.78***	1.52	1.09	2.08**	1.50

*** Significant at 1% level.
** Significant at 5% level.
Figures in parentheses are number of farmers in each class.

i) Land size tends to be positively related to efficiency. Those with technical efficiency scores between 0.95-1.00 used more land compared to the least efficient farmers.

ii) As for fertiliser and labour although there were significant differences in the level of usage among the various technical efficiency classes, the relationship with efficiency was not monotonic.

iii) For other inputs comprising chemicals, living capital and farm tools, no significant differences were noted in the levels of resource use among the various technical efficiency classes.

On a regional basis, the following observations are made for the region of Teluk Baru (Table 10.9):

i) Only land size was positively correlated with efficiency.

ii) Other inputs did not exhibit significant differences in the use of the farm resources among the various technical efficiency classes.

TABLE 10.9
RESOURCE UTILIZATION BY TECHNICAL EFFICIENCY CLASS
- TELUK BARU (OUTLIERS OMITTED)

TE Class	D	F	C	T	L	K
4 (1)	2.00	33.00	0.00	12.00	32.00	1203.00
5 (9)	2.25	29.07	19.48	14.56	27.78	1307.19
6 (14)	3.07	26.75	16.76	12.23	29.05	1239.15
7 (5)	6.50	27.08	9.38	8.65	23.30	1164.88
<u>ANOVA</u>						
F-Statistic	3.35***	0.04	1.61	1.56	1.78	0.53

*** Significant at 1% level.
Figures in parentheses are number of farmers in each class.

In Bagan Datoh (Table 10.10), the outcomes were as follows:

i) Land size, labour and the use of chemicals increased as the technical efficiency indices increased. In other words the relationship with efficiency was monotonic. The least efficient farmers were found to use less of these inputs compared to the more efficient ones.

ii) The levels of resource use for fertilisers, farm tools and living capital did not show any significant difference among the various classes involved.

TABLE 10.10 RESOURCE UTILIZATION BY TECHNICAL EFFICIENCY CLASS - BAGAN DATOH (OUTLIERS OMITTED)

TE Class	D	F	C	T	L	K
2 (5)	1.20	0.00	0.00	12.33	17.53	1021.20
3 (5)	1.88	0.00	5.00	9.66	16.91	1387.23
4 (5)	2.28	19.81	13.63	11.30	24.35	1200.04
5 (22)	3.22	21.93	12.39	8.99	25.78	1172.48
6 (11)	4.17	23.21	16.35	7.93	25.37	1197.00
7 (6)	6.00	31.33	19.69	7.75	27.07	1197.00
ANOVA						
F-Statistic	4.99***	1.74	2.17*	1.62	4.82***	0.75

*** Significant at 1% level.
* Significant at 10% level.
Figures in parentheses are number of farmers in each class.

As for the region of Hutan Melintang (Table 10.11), it was observed that:

i) Both land size and fertiliser use were positively related with efficiency.

ii) The rest of the inputs did not indicate significant differences among the efficiency categories.

TABLE 10.11 RESOURCE UTILIZATION BY TECHNICAL EFFICIENCY CLASS - HUTAN MELINTANG

TE Class	D	F	C	T	L	K
2 (8)	1.00	21.83	13.33	15.07	29.58	1228.00
3 (10)	1.73	15.09	16.45	11.16	26.68	1190.36
4 (21)	2.33	15.77	9.48	11.45	25.38	1308.73
5 (15)	2.59	41.86	16.05	7.31	30.37	1215.92
6 (12)	4.22	61.99	9.03	9.37	23.38	1290.92
7 (9)	6.30	88.58	12.57	8.71	23.38	1290.92
<u>ANOVA</u>						
F-Statistic	3.20***	3.66***	1.04	1.76	1.82	0.55

*** Significant at 1% level.
Figures in parentheses are number of farmers in each class.

Finally, in the case of Rungkup the results indicated that:

i) Except for land size, fertiliser and living capital where observed differences were significant, other differences were, however, non-significant.

ii) In the case of fertiliser and living capital, both these inputs have a non-monotonic relationship with efficiency.

TABLE 10.12 RESOURCE UTILIZATION BY TECHNICAL EFFICIENCY CLASS - RUNGKUP (OUTLIERS OMITTED)

TE Class	D	F	C	T	L	K
1 (10)	1.31	0	3.87	4.42	22.15	1088.31
2 (5)	1.92	49.17	15.00	9.50	23.23	1130.67
3 (33)	2.42	11.67	10.82	5.64	24.13	1382.21
4 (24)	4.02	19.08	16.68	4.37	22.36	1225.59
5 (17)	4.91	36.04	12.84	6.56	26.18	1304.34
6 (2)	7.50	0	0	5.60	21.60	2219.87
7 (6)	12.00	26.44	15.98	3.52	17.99	1327.21
ANOVA						
F-Statistic	5.91***	1.98*	0.69	0.91	1.13	4.88***

*** Significant at 1 % level.
* Significant at 10% level.
Figures in parentheses are number of farmers in each class.

10.4.2. RELATIONSHIP BETWEEN TECHNICAL EFFICIENCY AND OTHER PERFORMANCE MEASURES

In this subsection the relationship between computed technical efficiency indices and the two commonly used farm management performance measures, that is, output per man and gross margin per acre is examined. It must be stressed here that not all differences in gross margin and labour productivity are attributable to differences in technical efficiency. However, a positive relationship between computed technical efficiency indices and other farm performance measures would be reassuring at least with respect to the efficacy of the methodology, as well as indicating the potential sources of inefficiencies.

TABLE 10.13 RELATIONSHIP BETWEEN TECHNICAL EFFICIENCY AND OUTPUT PER MAN EQUIVALENT (M$) (POOLED DATA)

TE Class	OUTPUT PER MAN EQUIVALENT (M$)
1 (19)	20.80
2 (17)	23.27
3 (49)	26.57
4 (84)	26.41
5 (53)	28.29
6 (28)	29.26
7 (5)	48.84
<u>ANOVA</u>	
F-Statistic	5.05***

*** Significant at 1% level.
Figures in parentheses are number of farmers in each class.

Table 10.13 indicates that for the entire region, there were significant differences between output per man for the different efficiency classes. For the least technically efficient farmers output per man was M$20.80 compared to the top performer of M$48.84. In other words, the most efficient farmers have output per man over double the amount received by the least efficient group.

On the regional basis (see Table 10.14) only in the regions of Rungkup and Hutan Melintang did significant

TABLE 10.14 RELATIONSHIP BETWEEN TECHNICAL EFFICIENCY AND OUTPUT PER MAN EQUIVALENT (M$) (ACCORDING TO REGION)

TE Class	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
1	-	-	19.88	-
2	-	25.39	22.32	17.58
3	-	27.51	28.31	23.04
4	16.88	24.93	28.51	24.17
5	25.70	24.03	29.58	27.88
6	25.93	25.72	27.65	33.59
7	23.95	26.62	52.63	31.53
<u>ANOVA</u>				
F-Statistic	1.36	0.38	4.01***	3.16***

*** Significant at 1% level.

differences exist between output per man for the different efficiency classes. As for the other two regions, no significant differences were observed.

The relationship between gross margin per acre and technical efficiency is presented in Tables 10.15 through 10.16. It was noted that in almost all the sample groups, gross margin tends to increase as the technical efficiency

TABLE 10.15 RELATIONSHIP BETWEEN TECHNICAL EFFICIENCY AND GROSS MARGIN PER ACRE (M$) (POOLED DATA)

TE Class	GROSS MARGIN (M$)
1 (19)	228.06
2 (17)	316.77
3 (49)	414.64
4 (84)	450.21
5 (53)	453.50
6 (28)	506.00
7 (5)	524.00
<u>ANOVA</u>	
F-Statistic	6.41***

*** Significant at 1% level.
Figures in parentheses are number of farmers in each class.

TABLE 10.16 RELATIONSHIP BETWEEN TECHNICAL EFFICIENCY AND GROSS MARGIN PER ACRE (ACCORDING TO REGION)

TE Class	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
	(M$)			
1	-	-	268.83	-
2	-	312.47	310.99	282.27
3	-	318.05	445.01	331.03
4	303.00	413.30	387.98	361.80
5	466.02	418.31	535.57	539.12
6	514.61	445.31	462.13	465.63
7	362.52	500.48	640.23	484.28
<u>ANOVA</u>				
F-Statistic	3.95**	2.00**	4.14***	4.54***

*** Significant at 1% level.
** Significant at 5% level.

scores increase. For the whole of the survey region, for example, while the gross margin was M$228.06 for the least technically efficient farmers, the top performers however, managed to obtain almost twice the amount received by the least efficient group.

The results of this subsection clearly indicate that in general more efficient farmers achieved their levels of output with relatively low levels of labour input and and at the same time managed to obtain a higher gross margin per acre than the less efficient farmers.

10.4.3. ESTIMATED LOSSES FROM TECHNICAL INEFFICIENCY

Theoretically, given the levels of input and technology, a farmer's actual output should be equal to his potential, if he operates on the frontier production function. The efficiency indices distribution as demonstrated in section 4, indicated that in the five groups of samples analysed only a small proportion of the farmers were on the efficient frontier which implies that the majority of them have output levels below their potential.

In this section, an attempt is made to analyse the magnitude of losses due to technical inefficiency for the least efficient group (bottom 5%) and top performers (top 5%) Tables 10.17 through 10.18 present actual and potential output values for these two groups of farmers. The gap between these two values was then expressed as a percentage of actual output value to arrive at the estimated loss. The following conclusions were derived from the tables:

i) For the entire sample the least efficient performers lose as much as 48.7 per cent of their actual output.

ii) On a regional basis, the losses in actual output incurred by the least efficient group were 17.5 per cent in Teluk Baru, 39.5 per cent in Bagan Datoh, 52.4 per cent in Rungkup and 41.1 per cent in Hutan Melintang.

TABLE 10.17
ESTIMATED LOSS FROM TECHNICAL INEFFICIENCY :
LEAST EFFICIENT AND TOP PERFORMERS -OVERALL AREA
(After the Removal of Outliers)

SAMPLE GROUP	MEAN TE SCORE	MEAN ACTUAL OUTPUT (M$)	MEAN POTENTIAL OUTPUT (M$)
i) Overall Area			
Bottom 5%	0.67	459.52	683.08(13)*
Top 5%	0.96	6188.85	6428.66(13)
Area Average	0.82	1725.03	2103.69(255)

* Number in brackets are number of farmers in each efficiency group.

TABLE 10.18 ESTIMATED LOSS FROM TECHNICAL INEFFICIENCY: LEAST EFFICIENT AND TOP PERFORMERS - ACCORDING TO REGION (After the Removal of Outliers))

SAMPLE GROUP	MEAN TE SCORE	MEAN ACTUAL OUTPUT (M$)	MEAN POTENTIAL OUTPUT (M$)
i) <u>Teluk Baru</u>			
Bottom 5%	0.85	1187.38	1395.56(2)
Top 5%	1.00	3964.41	3964.41(2)
Area Average	0.91	2063.17	2254.83(29)
ii) <u>Bagan Datoh</u>			
Bottom 5%	0.72	481.91	672.26(3)
Top 5%	0.99	5226.92	5243.14(3)
Area Average	0.86	1669.03	1933.99(54)
iii) <u>Rungkup</u>			
Bottom 5%	0.66	431.58	657.67(5)
Top 5%	0.98	8994.25	9150.23(5)
Area Average	0.81	1772.24	2190.66(97)
iv) <u>Hutan Melintang</u>			
Bottom 5%	0.71	488.25	689.07(4)
Top 5%	0.99	4989.71	5036.93(4)
Area Average	0.86	1573.41	1833.81(75)

Figures in brackets are number of farmers in each efficency group.

iii) Even the top performers in the entire survey area could have obtained about 3.9 per cent more than they did. The corresponding figures for the four regions involved were 0.3 per cent for Bagan Datoh, 1.7 per cent for Rungkup and 0.9 per cent for Hutan Melintang. It appeared that the top performers in the region of Teluk Baru have achieved 100 per cent technical efficiency as the actual amount obtained was equal to the potential output. Nevertheless, due caution should be exercised in the interpretation of this result since the number of top performers involved was only two. This was mainly attributed to the small sample size collected for this particular region.

iv) On an area sample average, the losses were 21.9 per cent for the entire survey area.

v) Splitting the sample on a regional basis, produced different outcomes. The losses were highest in Rungkup (23.6 per cent) and lowest in Teluk Baru (9.3 per cent). The figures for Bagan Datoh and Hutan Melintang were 15.9 and 16.6 per cent, respectively.

In summary, the above results implied that the hypothesis stated at the beginning of this chapter cannot be rejected : there are technical inefficiencies in traditional agriculture, and such inefficiencies can give rise to a considerable gap betwen actual and potential output. The results also implied that there may be some scope for increasing farm output at little cost and without major investments in traditional agriculture.

10.5. DETERMINANTS OF TECHNICAL EFFICIENCY

The observed differentials in technical efficiency may be attributed to the following factors:

i) Differences in managerial ability;

ii) The employment of different levels of technology; and

iii) Difference in physical factors such as soil quality.

In some of the previous studies that had been undertaken, factors which were exogenous to the ability and the control of the farmers such as the part played by information (Muller, 1974) and modernization (Shapiro and Muller, 1977) were used to explain the variations in technical efficiency that arise. In the present study, however, an attempt is made to identify the factors endogenous to the farming environment which were thought might have some power to explain variations in technical efficiency among the cocoa farmers in the study area.

.hese endogenous variables comprised the farmer's age, his educational level, his spouse's and children's education as well as to whether he practises keeping farm records and accounts or not. All these variables were used as proxies for the farmer's management ability and their justification for using them in this way has been well elaborated in Chapter 5. The basis for their selection need not be repeated here.

Beside the management factors, land size used for the cultivation of cocoa might also contribute to variation in technical efficiency in this study. This was clearly demonstrated in the earlier section where it was shown that the more efficient farmers have larger land size compared to the least efficient group.

Different types of soil have different nutrient levels as well as different chemical and physical properties. In this study since there are two types of soil series involved, namely; the Kankong and Selangor soil series, it is expected that there are bound to be variations in technical efficency depending upon how this input is managed by the farmers during crop production.

In addition to the above variables, regional dummies were also incorporated into the analysis in order to capture the possible effects of the environmental factors.

Using the Ordinary Least Squares technique, the function to be estimated can then be written as:

$$\hat{Y}_j / Y_j = f(X_1, \ldots\ldots, X_8, e) \qquad (10-19)$$

where:

$\hat{Y}_j / Y_j$ = the dependent variable, that is, the individual technical efficiency scores computed from the stable frontier

X_1 = farmer's age

X_2 = farmer's education

X_3 = spouse's education

X_4 = children's education

X_5 = practice of keeping farm records and accounts: (1 = yes, 0 = no)

X_6 = soil series: (1 = Kankong, 0 = otherwise)

X_7 = regional dummies:

1 = Teluk Baru

0 = otherwise

1 = Bagan Datoh

0 = otherwise

1 = Rungkup

0 = otherwise

X_8 = land size under cocoa

10.5.1. CORRELATION ANALYSIS

The correlations between these selected factors and technical efficiency were reported in Tables 10.19 through 10.20. The following observations are made:

TABLE 10.19 PARTIAL CORRELATION COEFFICIENTS OF SELECTED FACTORS WITH TECHNICAL EFFICIENCY (POOLED DATA)

INPUTS	CORRELATION COEFFICIENTS
Farmer's Age	-0.2047***
Farmer's Education	0.2780***
Spouse's Education	0.1630**
Children's Education	-0.0160
Farm Records & Accounts	0.3195***
Soil Dummy:	
Kankong series	-0.0833*
Regional Dummies:	
Region Teluk Baru	0.1013**
Region Bagan Datoh	-0.0257
Region Rungkup	0.0377
Land size	0.6634***

*** significant at 1% level, ** significant at 5% level,
* significant at 10% level.

TABLE 10.20. PARTIAL CORRELATION COEFFICIENTS OF SELECTED FACTORS WITH TECHNICAL EFFICIENCY (ACCORDING TO REGION)

INPUTS	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
Farmer's age	0.0038	-0.2829**	-0.1812**	-0.2548**
Farmer's educ	0.0832	0.2718**	0.1985**	0.4605***
Spouse's educ.	0.1224	0.2633**	0.0497	0.3472***
Children's educ.	-0.1227	-0.0705	0.0392	0.0298
Farm records & accounts	0.3918***	0.2447**	0.4768***	0.0902
<u>Soil dummy</u>:				
Kangkong series	a	0.0761	a	0.1396
Land size	0.76059***	0.9076***	0.8877***	0.8788***

a no correlation
*** significant at 1% level
** significant at 5% level
* significant at 10% level

i) The age variable was negatively correlated with efficiency in all the sample groups, except for the region of Teluk Baru. The results implied that efficiency tends to decline with age.

ii) Educational level of the farmers was positively correlated with technical efficiency in all groups of sample except in Teluk Baru.

iii) It was only for the regions of Teluk Baru and Rungkup that spouse's education was not significantly correlated with technical efficiency.

iv) There was no significant relationship between children's education and efficiency.

v) Soil series was negatively correlated with efficiency for the pooled data. The plausible explanation for the decline in soil fertility was the outcome of low fertiliser application and improper management with regard to the use of this input. Perhaps the low prices of the cocoa beans they received as a result of the glut in the world market might have disuaded them from using more fertiliser in the process of crop production. They were prepared to reap whatever was produced rather than to incur extra cost for the purchase of this input. Drainage is also essential in this soil especially when it contains high amount of magnesium and sodium which causes poor structure and low permeability. It was also observed that the farmers did not put much effort in the management of their drainage system. All these as a consequence would affect the chemical and physical properties of the soil which ultimately results in the negative relationship of this input with technical efficiency.

vi) Except for the case of Hutan Melintang, the relationship between farm records and accounts was found to be significantly positive with technical efficiency in all the regions.

vii) Only regional dummy, Teluk Baru, was positively correlated with efficiency.

viii) In all the sample groups, land size was significantly correlated with technical efficiency and the relationship was positive.

10.5.2. REGRESSION RESULTS

The results of regressing some of the selected factors with technical efficiency indices were presented in Tables 10.21 and 10.22.

Each estimated regression coefficient represents an estimated change in the technical efficiency index in response to a one unit change in the particular factor - other factors held constant.

In the first stage analysis, only the effects of farmer's age, farmer's education, spouse and children's education, farm records and accounts, soil series and the regional dummies were incorporated into the analysis. The results, however, bore little fruit when applied to the Malaysian data as shown in Table 10.25. Although the explanatory power of the regression equation is low, nevertheless, three variables, namely, farmer's age, farmer's education and farm records and accounts were statistically significant at one per cent level of probability.

Splitting the data on a regional basis also bore little fruit. The respective values of the adjusted R square computed were 0.0248, 0.0801, 0.2566 and 0.2495 for the regions of Teluk Baru, Bagan Datoh, Rungkup and Hutan Melintang. Only the regression models for Rungkup and Hutan Melintang were statistically significant at one per cent level.

However, when land size was included in the analysis, the results changed dramatically. It was found that about 51 per cent of the variability in the efficiency indices for the entire survey area could be explained by the factors specified in the model. On a regional basis it was indicated that in Teluk Baru and Rungkup the variables specified in the model explained about 52 per cent of the variability in the technical indices while for the rest of the two regions the figures were: 50 per cent in Bagan Datoh and 59 per cent in Hutan Melintang. In Table 10.22 only the results of combining land size together with the inputs mentioned above are presented.

The results shown in Tables 10.21 through 10.22 indicated the following:

i) The coefficient of farmer's age was only statistically significant for the pooled data.

ii) Farmer's education was statistically significant for the entire survey area and in the regions of Bagan Datoh and Hutan Melintang.

iii) The practice of keeping farm records and accounts was an important contributor to variation in efficiency for the whole of the survey area and in the region of Rungkup at one per cent level.

iv) Land size was statistically significant at one per cent level for the pooled data and in all the four regions.

v) Other variables comprising soil type, spouse's and children's education were not an important determinant of technical efficiency in this study.

TABLE 10.21. DETERMINANTS OF TECHNICAL EFFICIENCY: ESTIMATED REGRESSION COEFFICIENTS FOR POOLED DATA

VARIABLES	REGRESSION COEFFICIENTS	
Intercept	1.0124***	0.8463***
	(0.0774)	(0.0589)
Farmer's age	-0.0597***	-0.0259*
	(0.0185)	(0.0146)
Farmer's educ.	0.0695***	0.0533***
	(0.0182)	(0.0142)
Spouse's educ.	-0.0062	-0.0117
	0.0162)	(0.0219)
Children's educ.	0.0058	-0.0010
	(0.0086)	(0.0067)
Farm records & accounts	0.0733***	0.0387***
	(0.0137)	(0.0109)
<u>Soil Dummy</u>:		
1 = Kankong, 0 = otherwise	-0.0239	0.0086
	(0.0174)	(0.0146)
<u>Regional Dummies</u>:		
Teluk Baru	-0.0023	0.0098
	(0.0221)	(0.0183)
Bagan Datoh	-0.0062	-0.0126
	(0.0162)	(0.0134)
Rungkup	0.0074	0.0027
	(0.0099)	(0.0078)
Land Size	-	0.0881***
		(0.0069)
Adjusted R square	0.1996	0.5138
F - statistic	8.04***	27.58***

figures in parentheses are the standard errors
*** significant at 1% level, ** significant at 5% level
* significant at 10% level

TABLE 10.22. DETERMINANTS OF TECHNICAL EFFICIENCY: ESTIMATED REGRESSION COEFFICIENTS ACCORDING TO REGION

VARIABLES	TELUK BARU	BAGAN DATOH	RUNGKUP	HUTAN MELINTANG
Intercept	0.9622***	0.8485***	0.8282***	0.8829***
Farmer's age	-0.0191 (0.0259)	-0.0221 (0.0411)	-0.0192 (0.0261)	-0.0282 (0.0937)
Farmer's educ	0.0244 (0.0208)	0.1529*** (0.0614)	0.0353 (0.0274)	0.0668*** (0.0207)
Spouse's educ	-0.0164 (0.0186)	-0.0956 (0.0573)	-0.0199 (0.0244)	-0.0016 (0.0189)
Children's educ	0.0046 (0.0143)	-0.0131 (0.0164)	-0.0018 (0.0119)	-0.0001 (0.01210
Farm records & accounts	0.0071 (0.01360	0.0801 (0.0576)	0.0736*** (0.0182)	0.0144 (0.0209)
<u>Soil Dummy</u>:				
1 = Kangkong 0 = otherwise	a	0.0144 (0.0177)	a	0.0129 (0.0485)
Land size	0.0579*** (0.0112)	0.0958*** (0.0155)	0.0902*** (0.0129)	0.0986*** (0.0129)
Adjusted R square	0.5193	0.4960	0.5117	0.5895
F-statistic	6.40***	8.17***	17.77***	16.18***

figures in parentheses are the standard errors
*** significant at 1% level
** significant at 5% level
* significant at 10% level
a no correlation

Finally, an examination of the beta coefficients and their ranking (in order of magnitude) illustrate that land size used for cocoa cultivation was found to be the most important determinant of technical efficiency in all the survey areas. For the pooled data, beside land size, the next important determinants were farmer's education, the practice of keeeping farm records and accounts and farmer's age.

In Bagan Datoh and Hutan Melintang, apart from land size, farmer's education was the second most prominent determinant of efficiency. However, in Rungkup, the practice of keeping farm records and accounts was the second most important factor beside land size.

10.5.3. DISCUSSION OF THE RESULTS

Small land size is usually identified as the key contributor to low farm income. However, work related to land size which has been undertaken by other research workers has not produced consistent results. In India, for example, Lau and Yotopoulos (1971) found smaller farms to be more efficient than larger farms. In Pakistan, greater efficiency appears to be associated with larger farms (Khan and Maki, 1979).

In this study, the results with respect to the influence of land size were consistent for all the regions. It had a statistically significant effect on technical efficency and the relationship was positive. This indicates that the larger the land size the more technically efficient the farmers become. This is in contrast to the finding of Berry and Cline (1979) in the case of rice farming in Malaysia.

As regard to education, Schultz (1964) stated that this input serves as a central ingredient in the strategy to improve agricultural productivity, principally through its complementarity with new inputs such as chemicals, fertilisers and pesticides, high-yielding varieties and extension services.

A number of previous studies have been undertaken to examine the effect of education on technical efficiency. Jamison and Lau (1982) found a significant contribution of this input in affecting efficiency among the rice farmers in Malaysia, Korea and Thailand. Lingard *et al* (1983) also revealed that education was a contributing factor that caused variation in technical efficiency among the Philippines rice farmers.

It appears that the outcome of the present study was in accord with the findings of the above research workers.

In this study, it was indicated that farmer's education had a positive and statistically significant effect on technical efficiency. This outcome implies that the more educated the farmers the more tecnically efficient they become. The substantial quantity of knowledge that they acquired through years of formal education might have enhanced their abilities to manage the cocoa farms. They had the capacity to identify alternatives and to assess and compare the benefits and costs associated with each of the alternatives, possibly under different states of nature. The availability of specific agricultural knowledge which they acquired through other sources such as from the media and contact with the extension workers was also a contributing factor which led to the significance of the input in affecting technical efficiency in this study area.

The present analysis also revealed the importance of keeping farm records and farm accounts in affecting the variation in technical efficiency. This outcome was to be expected. Given the nature of the agricultural activity where the elements of risk and uncertainties are involved, it is essential that in order to assist them in making correct decisions about their farms, detailed information about the farming activity is highly essential and this is only feasible provided that they have farm records and accounts. With the records kept, they had the capacity to make the best use of the available resources. Hence it is not surprising that farmers who kept farm records and accounts were found to be more technically efficient than those who did not.

Finally, the results computed indicated that there was a decline in technical efficiency as the age of the farmers increased. The plausible explanation for this outcome was that the farmers in this area have already passed their productive 'age' and the experience that is normally associated with this variable seems not to have had any significant effect on their decision-making process.

10.6. SUMMARY

This chapter has attempted to examine the efficiency differences among the cocoa farmers in Malaysia. The measurement of technical efficiency in this study relies on the outer-bound Cobb-Douglas production function derived with a linear programming methodology developed by Timmer (1970). The results indicated that there were technical inefficiencies in the cocoa farming and such inefficiencies gave rise to a considerable gap between the actual and the potential output. This study also indicated that there may be some scope for increasing output that do not depend on major new investments at least in the short-run.

CHAPTER ELEVEN

SUMMARY AND CONCLUSION

In this concluding chapter we shall first provide a brief summary of the study and then summarise the major conclusions and findings of the study. In addition, we shall try to focus on the implications of the study and its findings for the planner and policy maker in general. In the final section, the limitations and suggestions for future research are discussed.

11.1 SUMMARY OF THE STUDY

In spite of the significant role played by the agricultural sector in the Malaysian economy, this sector is still beset with the problem of low productivity among the smallholders engaged in the production of cocoa and coconut (Zulkifli, 1988). This problem if it persists will contribute to adverse economic, social and political consequences that will hinder the government's objective of eradicating poverty among this group of producers. Identifying those factors that affect the farm productivity and performances will enable the government to devise more appropriate policy measures essential in improving their living standard. At present no complete applied economic research had been undertaken to examine the productivity status of the cocoa smallholders in Malaysia. The absence of such research makes remedial actions difficult to undertake. The present study, therefore, was undertaken with the hope of generating some new information, considered vital in assisting the policymakers to take the appropriate actions.

There are four main objectives of this study and they are as follows:

i) To isolate the factors that determine the production of cocoa;

ii) To examine whether the inputs used in the production process were allocatively efficient or not;

iii) To estimate the level of technical efficiency of the individual cocoa producers; and

iv) To identify factors which contribute to variations in technical efficiency.

Cross-sectional data collected from 260 cocoa smallholders in the region of Lower Perak, one of the largest cocoa growing areas in the country, were used for the study. The analytical framework used comprised a combination of averaging, tabular analysis, analysis of variance, chi-square and correlation analysis. In addition both the average production function estimated by the Ordinary Least Squares techniques and the frontier production function estimated by the Linear Programming methodology were employed.

11.2 SUMMARY OF FINDINGS

The major findings from this study are as follows.

i) It was found that among the input factors used by the cocoa smallholders, the ones which had significant impact on the production of cocoa for the whole region were land size, labour, living capital, farm implements and fertilisers. Among the management proxies, only farmer's age, extension contact, farmer's education and the practice of keeping farm records and accounts were important.

ii) For the whole region, this study however, revealed that inputs such as chemicals, spouse's and children's education as well as soil types did not have any significant influence on cocoa production.

iii) The data presented in this study also lend support to the hypothesis that the cocoa smallholders were highly inefficient allocatively. Computation of the ratios of the Marginal Revenue Products (at the mean value of the inputs) indicated that appreciable deviations from allocative efficency were found for land size, labour, living capital, fertilisers and farm implements. Inputs like land, fertilisers, and farm implements were underused while that of labour and living capital were overused.

iv) Technical inefficiencies were also present in the study area. This gave rise to a considerable gap between the actual and the potential output. Computation of the individual efficiency indices showed that only a small proportion of the farmers were on the efficient frontier indicating that the majority of them have output levels below their potential.

v) Computation of the potential losses from technical inefficiencies indicated that the least efficient farmers could have obtained between 18 and 52 per cent more output if they had been able to achieve the level of output predicted by the frontier function.

vi) The study also revealed that there exists a positive relationship between technical efficiency and profitability. This implies that differences in efficiency at the producer's level are likely to affect the individual's profits or profitability. An examination of the levels of technical efficiency of each individual producer is therefore, considered vital if the identification and the elimination of technical inefficiency is necessary for the success of programmes intended to stimulate higher profitability within this group of producers.

vii) From this study it emerged that the variations in technical efficiency among the cocoa farmers in this area were explained by differences in land size used for the cultivation of cocoa, farmers' educational level, their age and the practice of keeping farm records and accounts.

11.3 CONCLUSIONS AND POLICY IMPLICATIONS

The major conclusions drawn from this study are as follows:

i) The findings of this study were not entirely in support of the conventional belief that no appreciable increase in traditional agriculture production is possible by reallocating the factors at the disposal of the cocoa smallholders. The analysis clearly indicated that there were appreciable dispersion in the individual technical efficiencies.

The efficiency scores computed ranged from 0.66-1.00 with a mean efficiency scores of 0.82 which was considered relatively high. These results therefore, imply that it is possible to increase the production of cocoa by drawing on the experience of the more efficienct farmers, through better and effective management practices and better organization of farm activity at large without major new investments, at least in the short-run.

ii) The positive and significant relationships between between land size and efficiency (Chapter 10) and the important role that fertiliser, living capital, farm implements and labour play in affecting farm productivity (Chapter 8), pointed out that the observed differences in efficiency may in part be attributed to the differences in quantity as well as to the qualities in the farm resources and perhaps due to the distribution of risk aversion among the farmers in the production process.

There is also a possibility that these farmers did not have equal access to some of the inputs required especially that of fertiliser, farm implements and chemicals as shown by the small quantity used in the production of this crop (Chapter 7). Furthermore, from the analysis made in Chapter 9 it was also revealed that both fertiliser as well as farm implements were allocatively inefficient and their amount have to be increased in crop production in order to be efficient. The implication of this outcome is that it is not possible to improve efficiency without improving the resource base of the least efficient farmers. Because of the small amount of gross income received as well as the small amount of money spent for the purchase of farm imputs (Chapter 7) an improvement in the resource base may need financial resources beyond the farmer's disposal. This leads to the familiar issue of ensuring the availability and the utilisation of the inputs, including credit, when and where they are required through the appropriate distribution and extension system.

As stated by Muller (1974) farmer's access to farm credit has a considerable effect on efficiency in particular. He argued that all farmers did not have equal and adequate access to this service. This situation might be true in this study since only about 1.2 per cent of the farmers took credit during the study period. In order to make this facility accessible to the needy farmers, it is therefore recommended that improved credit facilities from the Bank Pertanian (Agricultural Bank) or from other sources such as the Credit Society should be made available to those needy farmers in the area. The demand for collateral, long period of loan processing involved and the repayment period should be reviewed in order to allow these farmers to take advantage of the facility provided by these agencies.

The present practice of using land titles as the main form of collateral posed problems to the farmers since such collateral is rarely available; administrative and legal problems involved in land charging and stamp duties are so cumbersome and expensive that neither the farmers nor the credit agencies are prepared to undertake the excercise.

Policies should be developed to cope with fortuitous and seasonal crop failure by adjustment of credit payment conditions. Repayment terms should be adjusted according to the client's capacity to pay, which should be based on the average yields and prices in each area minus allowances for family maintenance rather than based on a fixed time period as is now being practised. In unfavourable periods a reduced payment would reflect those conditions; and during higher yields, larger amounts would have to be repaid. Over times, the bad and good times would balance out.

It is also recommended that a special relief fund, as what has been introduced to the rubber smallholders, should also be introduced by the relevant authority to assist the farmers during the bad times. Such fund will enable the farmers to repay part of the loan taken and to meet other expenses incurred.

One may therefore conjecture that the adequate provision of this service may substantially increase efficiency on the cocoa farms in this area. Although there is a point in the above argument, this particular study nevertheless, cannot say much on this particular issue, except to state that this could be a potential area of research in the future.

iii) From this study it emerged that land size was the most important determinant that affects cocoa production (Chapter 8). However in Chapter 9, this input was too sparingly used by the farmers and has to be increased between two to three times its present size in order to achieve allocative efficiency. Since land is a constraint in this study area, and the results from Chapter 10 further indicated the importance of this input in affecting technical efficiency, it is therefore suggested that more efforts should be directed at group farming in this area. A bigger holding will be in a capacity to exploit the economies of scale, have more access to information, credit and better management than the smaller ones. At present this system of farming is still on a trial basis involving only few selected areas in the district. The outcome of this study will enable the policy makers to be more confident that their efforts are directed along the right direction.

iv) The presence of excess labour as indicated in the analysis of allocative efficiency should deserve considerable attention to the policy makers involved with the rural development of the area. The low returns from labour (Chapter 9) makes cocoa farming less attractive to the rural youths to be engaged in this activity. This has resulted in the migration of the labour force to the urban areas as is now being observed. Efforts must be made to stop this exodus otherwise in the long run this will have a serious repercussion on the economic development of this area. As it is now, the undertaking of cocoa farming is left with elderly farmers of over 50 years old

(Chapter 7). and the time has come for the younger generation to take over the running of these farms. It is suggested that an agricutural training programme should be organised for the rural youth by the agencies involved with rural development in the area as what is being done in the case of rubber production in the country. At the same time frequent visits to the villages must be arranged by urban young groups and missions mostly of students and social workers who should work with the village youth and village youth clubs for fostering enthusiasm and zeal of the village people and for changing their outlook and attitude towards life and work of the villagers, who should not feel isolated and neglected.

v) The observed dispersions in efficiency indices also point to the need of improving cocoa production through extension efforts which need to be focussed especially on the managerially 'worst' farms as suggested by Lingard *et al* (1983). It should be stressed that improved agronomic practices could not be undertaken effectively, if the farmers lack the necessary knowledge regarding the management of their cocoa farms. The study indicated that there was lack of awareness of proper agronomic practices among the cocoa farmers in the area (Chapter 7). In spite of the availability of surplus family labour, minimal time was spent especially, in the execution of basic maintenance activities such as pruning, crop protection, weeding and drain maintenance which are essential for the healthy growth of the crop. Some of them even refused to use insecticides because their neighbours did not use it.

There is also a possibility that the low dosage of the complementary inputs used (Chapter 7) could be attributed to the farmers' lack of awareness of the benefits of these inputs. To encourage these farmers to increase their use of these inputs, concerted extension efforts are necessary. Because of the risk involved and because of their limited resources, the extension efforts must not only be in the form of routine advice but must seek to convince them by specific demonstration and economic evidence relating to the costs and benefits.

This clearly emphasises the need for increasing efforts to be directed at educating the least efficient farmers so as to increase their technical knowledge on the management of their holdings. A more knowledgeable farmer will be in the capacity to use the family labour in a manner which will increase his output. He would do a better job in the application of fertilisers and other chemicals evenly and thoroughly. To increase farmers' knowledge, it is recommended that apart from field demonstrations, more short courses and workshops should be organised for them. With limited staffing, a group activity approach should be adopted. The training of village leaders and model farmers to play the role of the extension workers should be intensified in the short-run.

vi) In this area since most of the farm activities such as weeding, pruning, harvesting and fertiliser application are done jointly by men and women, it signifies that women also play an important role in cocoa production. The culture in this area is that a male extension agent is not allowed to talk freely with women, especially if he comes from outside the village. If he teaches the men, and they in turn teach their spouses, much of the information is lost, especially in the feedback of ideas from the women to the extension agent. More change in farm women's behaviour could be achieved if the Department of Agriculture appoints female extension agents in the area as under the present situation all extension workers are male.

vii) Farmers also should be encouraged to keep a record of their farm activities as these basic data will help them in monitoring, understanding and evaluating future problems. This study has clearly established the fact that farmers who practised keeping farm records and accounts were more technically efficient than those who did not. As the number of farmers involved was very small, i.e. only 10 per cent (Chapter 7), it is recommended that more intensive effort must be made by the extension workers to encourage more farmers to undertake this form of activity to enable them to make effective decisions at the farm level. At the same time this will also facilitate the credit agency in processing any credit facilities required by the farmers. Mere encouragement is not sufficient, what is of utmost important is for the extension workers to teach the farmers the basic principles involved in using these particular farm records and accounts.

One of the questions that arise is how to identify the least efficient farmers in an area. The positive relationships that were shown to exist between technical efficiency and output per man and also with gross margin suggest that the identification based on this performance measure though not equivalent to technical efficiency is mostly consistent with it.

viii) This study also recommends that more intensive effort must be made to encourage the farmers to join the local Farmers Association as is being done in the region of Hutan Melintang. By becoming members of these organisations, the farmers can represent themselves more effectively to the outside (essentially government agencies), can effectively pool their resources and strength and can provide a means whereby these pooled resources and outside assistance of various forms can be maximally exploited for the members' benefits.

In conclusion this study clearly demonstrates to us that output could be increased without changing the technology and knowledge now available to the farming community in the area.

11.4 LIMITATIONS OF THE STUDY AND SUGGESTION FOR FUTURE RESEARCH

This study acknowledges a number of limitations and the first concerns the coverage of the study. Although there are other areas in the country that produce cocoa, nevertheless, this study was only confined to the region of Lower Perak. Therefore, the results obtained from the present study are specific to the area where the data were collected and cannot necessarily be generalised to other areas involved in the cultivation of cocoa.

Secondly, since the data collected were cross-sectional in nature, it was quite impossible to measure the timing of and the extent to which specific farm activities such as weeding, pruning, and harvesting were undertaken by the smallholders. However, this is not to say that the data collected pertaining to these specific farm operations are inaccurate, but merely to pinpoint the problems that the potentially interested research workers should consider.

Furthermore, within the limits imposed by the cross-section data, only those hypotheses relating to the variables that vary across farms could be tested. The variables which vary across time such as prices and technological change which could be important determinants of variation in efficiency could not be examined under such circumstances. Clearly, this is an area for further reseach.

An other limitation of this study is that it did not explicitly examine the effect of risk and uncertainty in the empirical analysis. It is possible that one of the main reasons why the inputs were not used efficiently in this study is because of the fact that the farmers were risk averse. Because of uncertainty in the market prices of the products and the risk associated with crop failure mainly because of bad weather and other disaster, farmers could not plan with certainty given the farm resources avaialable at their disposal. Ideally, a combination of cross-section and time series data of inputs, output and prices are needed to examine the effect of risk in the analysis. However, such data are not available in this study. It is suggested that future work should include this element in the analytical framework.

Nevertheless, it is hoped that these limitations do not seriously distort the conclusions that are derived from this study.

BIBILIOGRAPHY

ABDULLAH SEPIEN, (1978). 'Technical and Allocative Efficiency in Malaysian Rubber Smallholdings: A Production Function Approach', Ph.D. Thesis, Australian National University.

ABDUL RAHMAN OSMAN, (1987). 'Increasing the Cocoa Yields', *New Straits Times*, May 14, p.7.

ADULAVIDHAYA, K., KURODA, Y., LAU, J. L., LERTTAMRAB, P., and YOTOPOULOS, P.A. (1979). 'A Microeconomic Analysis of the Agriculture of Thailand', in *Resource Use in Agriculture: Applications of the Profit Function to Selected Countries*, edited by Pan A. Yotopoulos and Lawrence J. Lau, Food Research Institute Studies, Vol XV11 (1), Chapter V1.

AFIFUDIN, HJ. OMAR, (1973). *The Social, Political and Economic Framework of MUDA Rice Farmers. A Historical Perspective*, Publicaton No. 23, MUDA Agricultural Development Authority, Alor Star, Kedah, Malaysia.

AGRAWAL, A.N, (1981). *Indian Agriculture - Problems, Progress and Prospects*, Vikas Publishing House PVT Ltd., India. Second Edition.

AIGNER, D.J., and CHU, S.F. (1968). 'On Estimating the Industry Production Function', *American Economic Review*, Vol. (58), pp. 826-839.

AIGNER, D., LOVELL, C.A.K., and SCHMIDT, P. (1977). 'Formulation and Estimation of Stochastic Production Function Models', *Journal of Econometrics*, Vol.6, pp. 21-37.

ALLEN, R.G.D. (1963). *Mathematical Economics*, Macmillan and Company Ltd. London.

ARASU, N.T., and PHANG, C.I. (1971). 'Cocoa Improvement in West Malaysia', in *Cocoa and Coconuts in Malaysia*, edited by R.L. Wastie and D.A. Earp, Kuala Lumpur: I.S.P., pp. 28-42.

ARROW, K.J., CHENERY, H.B., MINHAS, B.S., and SOLOW, R.W. (1961). 'Capital and Labour Substitution and Economic Efficiency', *Review of Economics and Statistics*, 43, pp. 225-250.

ASOMANING, E.J. (1976). 'Cocoa Research in Ghana', in *Cocoa Production: Economics and Botanical Perspectives*, edited by J. Simmons, Praeger Special Studies, New York, pp 168-201.

BARDHAN, P.K. (1973). 'Size, Productivity and Farm Returns to Scale : An Analysis of Farm-Level Data in Indian Agriculture', *Journal of Political Economy*, Vol. 81 (3), pp. 1370-1386.

BARNES, D.E., and EVANS, R.C. (1971). 'Weed Control in Cocoa and Coconuts in Malaysia', in *Cocoa and Coconuts in Malaysia*, edited by R.L.Wastie and D.A.Earp, Kuala Lumpur: I.S.P., pp. 412-421.

BARNUM, H.N., and SQUIRE, L. (1976). ' Model of Agricultural Household : Theory and Evidence', World Bank Staff Occasional Paper, No. 27, Washington, D.C.

BATTESE, G. E., and CORRA, G. S. (1977). 'Estimation of a Production Frontier Model: with Application to the Pastoral Zone of Eastern Australia', *Australian Journal of Agricultural Economics*, Vol. 21, pp.167-79.

BERRY, R.A., and CLINE, W.R. (1979). *Agrarian Structure and Productivity in Developing Countries*, John Hopkins University Press, Baltimore.

BHATI, U.N. (1975). 'Technical Knowledge as a Determinant of Farmer's Income', in *Economic Theory and Practice in the Asian Setting*, edited by Committee on Economics Teaching Material for Asian Universities, Wiley Eastern Limited, New Dehli, Vol.3, pp. 45-62.

BLACK, J.A., and CHAMPION, D.J. (1976). *Methods and Issues in Social Research*, John Wiley and Sons Inc.

BOATENG, M.Y. (1982). 'Problems of Increasing Output of Small Cocoa Farmers in Ghana. A Case-study of the Ashanti Cocoa Project', Ph. D. Thesis, University of Missouri, Columbia.

BONAPARTE, E.E.N.A. (1973). 'An Agronomist's Assessment of Recent Research Findings and Their Implications for Cocoa Production', in *The Economics of Cocoa Production and Marketing*, edited by P.A. Kotey, C. Okali, and B.E. Rourke, Legon, pp. 73-83.

BOSWORTH, D.L. (1976). *Production Function : A Theoretical and Empirical Study*, Saxon House D.C., England.

CHEW, T.A. (1984). 'Fitting Production Functions to Perennial Crops', *Pertanika* 7 (1) pp. 97-99.

CHENNAREDDY, V. (1967). 'Production Efficiency in South Indian Agriculture', *Journal of Farm Economics*, Vol.49, pp. 816-820.

CHIANG, A.C. (1984). *Fundamental Methods of Mathematical Economics*, Third Edition, McGraw-Hill International Book Company.

CHOW, G.C. (1960). 'Tests of Equality Between Sets of Coefficients in Two Linear Regressions', *Econometrics*, Vol. 28(3), July, pp.591-605.

CHRISTENSEN, L. R., JORGENSON, D. W., and LAU, J. L. (1973). 'Transcendental Logarithmic Production Frontiers', *Review of Economics and Statistics*, Vol. 55, pp.28-45.

CHUA, P.C. (1981). 'Kajian Urusan Ladang Kelapa Di Kawasan Rancangan Pembangunan Pertanian Bersepadu Johor Barat', Kementerian Pertanian Malaysia.

COCHRAN, W.G. (1963). *Sampling Techniques*, Wiley, New York, Second Edition.

COSTA, A.D.S., and REIS, A.J.D. (1982). 'Eficiencia Economia Dos Recursos Em Dois Grupos De Propriedades Cacaueiras Do Municipio De Ilheus, Bahia', *Proceeding of the 8th. International Cocoa Research Conference*, 18-23 Oct. Lagos, Nigeria, pp. 621-626.

DAWSON, P.J., and LINGARD, J. (1982). 'Management Bias and Returns to Scale in a Cobb-Douglas Production Function for Agriculture', *European Review of Agricultural Economics*, Vol. 9, pp. 1-24.

DE CARVALHO, A.M.F. (1972). 'Analisae Dos Factors Productivos Na Exploraca De Cacau', *Cacau Actualidades*, 10(1), pp. 12-16.

DE SOUZA MENEZES, J.A., PANIAGO, J., LADEIRA, H.O., and BANDERA, A.L. (1974). 'Economicidae Dos Insumos Modernos em Fazendas De Cacau', *Revista Theobroma*, Vol.4 (2), pp. 21-33.

DE VAUS, D.A. (1986). *Surveys in Social Research*, London, George Allen and Unwin.

DILLON, J.L., and ANDERSON, J. R. (1971). 'Allocative Efficiency, Traditional Agriculture, and Risk', *American Journal of Agricultural Economics*, Vol. 53, pp. 26-32.

FAMA (1987). 'Malaysia Cocoa Outlook', Market Intelligence Division, FAMA, Kuala Lumpur.

FAMA (1988). 'Malaysia Cocoa Outlook', Market Intelligence Division, FAMA, Kuala Lumpur.

FARRAR, D.E., and GLAUBER, R.R. (1967). 'Multicollinearity in Regression Analysis : The Problem Revisited', *Review of Economics and Statistics*, Vol. 49, pp. 92-107.

FARRELL, M.J. (1957). 'The Measurement of Productive Efficiency', *Journal of the Royal Statistical Society*, Vol. 120(3), pp. 253-90.

FERGUSON, C.E. (1969). *The Neoclassical Theory of Production and Distribution*, Cambridge University Press.

FORSUND, F.R., LOVELL, C.A.K., and SCHMIDT, P. (1980). 'A Survey of Frontier Production Functions and on their Relationship to Efficiency Measurement', *Journal of Econometrics*, 13, pp. 5-25.

GHAZALI, N. and RASHID, M. (1974). 'A Socio-Economic Survey of Land Development Scheme in Kampong To' Hin, Trengganu. A Case-Study of an Unsatisfactory Land Scheme', Economics and Planning Division, RRIM, Kuala Lumpur.

GREENE, W. H. (1980). 'Maximum Likelihood Estimation of Econometric Frontier Functions', *Journal of Econometrics*, Vol. 13, pp. 27-56.

GYIMAH-BREMPONG, K. (1987). 'Scale Elasticities in Ghanaian Cocoa Production', *Applied Economics*, Vol. 19, pp. 1383-1390.

GRILICHES, Z. (1957). 'Specification Bias In Estimates of Production Functions', *Econometrica*, Vol. 39, pp. 8-20.

HAYAMI, Y., and YAMADA, S. (1970). 'Agricultural Productivity at the Beginning of Industrialization', in *Agriculture and Economic Growth: Japan's Experience*, edited by K. Ohkawa., B. F. Johnston and H. Kaneda, Princeton University Press, Chapter 4.

HEADY, E.O. (1956). 'Technical Consideration in Estimating Production Functions', in *Resource Productivity, Returns to Scale and Farm Size*, edited by Heady, E.O., Johnson, G.L., and Hardin, L.S., State College Press, Iowa, pp. 1-15.

HEADY, E.O., and DILLON, J.L. (1966). *Agricultural Production Function*, Iowa State University Press, Ames.

HEATHFIELD, D.F. (1971). *Production Functions*, Macmillan Press Ltd.

HEBDEN, J. (1983). *Application of Econometrics*, Philip Allan Publishers Ltd.

HOCH, I. (1958). 'Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function', *Econometrica* (26), pp. 556-578.

HONG, Y.P., and KEE, P.P. (1987). 'Inter-Upper Amazon Cocoa Hybrids of Sabah Series in Progeny Trial', *SASS Seminar : Palm Kernel Utilisation and Recent Advances in Cocoa Cultivation*, Tawau, Sabah. pp. 1-28.

HOPPER, D. W. (1965). 'Allocative Efficiency in a Traditional Agriculture', *Journal of Farm Economics*, Vol. 47, pp.611-624.

HUANG, D.S. (1970). *Econometric Methods*, McGraw-Hill Book Company.

INTERNATIONAL CAPSID RESEARCH TEAM (1971). 'Control of Capsid', *Cocoa Growers Bulletin*, Vol. 17. pt. 11, pp. 5-19.

JAMISON, D. T., and LAU, J. L. (1982). *Farmer Education and Farm Efficiency*, A World Bank Research Publication, The John Hopkins University Press, Baltimore.

JOHNSON, D.T. (1982). *The Business of Farming. A Guide to Farm Business Management in the Tropics*, Macmillan International College Editions.

JOHNSTON, B. F., and MELLOR, J. W. (1961). 'The Role of Agriculture in Economic Development', *American Economic Review'*, Vol. 51, pp. 566-593.

JOHNSTON, J. (1963). *Econometric Methods*, McGraw - Hill Book Company.

JONES, J.B.O. (1971). 'Harvesting of Cocoa as a Intercrop', in *Cocoa and Coconut in Malaysia*,,edited by R.L. Wastie and D.A. Earp, Kuala Lumpur, I.S.P., pp. 65-170.

KAHLON, A.S. and ACHARYA, S.S. (1967). 'A Study on Management Input in Farming', *Indian Journal of Agricultural Economics*, Vol. (23), pp. 45-53.

KEE, N.S. (1967). 'Fertiliser Problems in Mixed Cocoa-Coconut Plantings', in *Cocoa and Coconuts in Malaya'*, edited by J.W. Blencowe and P.D. Turner, Kuala Lumpur, pp. 23-31.

KHAN, M.H., and MAKI, D.R. (1979). 'Effects of Farm Size on Economic Efficiency: The Case of Pakistan', *American Journal of Agricultural Economics*, Vol.61 (1), pp.64-69.

KHANDKER, S.R. (1988). 'Input Management Ability, Occupational Patterns, and Farm Productivity in Bangladesh Agriculture', *Journal of Development Studies*, Vol. 24 (2), pp. 214-321.

KISH, L. (1965). *Survey Sampling*, John Wiley and Sons, Inc.

KLEIN, L.R. (1962). *An Introduction to Econometrics*, Prentice -Hall Inc.

KMENTA, J. (1971). *Elements of Econometrics*, The Macmillan, New York.

KOPP, R. J. (1981). 'The Measurement of Productive Efficiency: A Reconsideration', *Quarterly Journal of Economics*, Vol. XCV1 (3), pp. 477-503.

KOUTSOYIANNIS, A (1973). *Theory of Econometrics*, The Macmillan Press Limited, London.

KRAUSE, K.R. and SHULTZ, S.R. (1968). 'Review of Managerial Ability Studies of Farms, The Management Factor on Farming : An Evaluation and Summary of Resources', Minnesota Agricultural Experiment Station, Technical Bulletin, No. 258.

LAU, L.J., and YOTOPOULOS, P. A. (1971). 'A Test for Relative Efficiency and Application to Indian Agriculture', *American Economic Review*, Vol. 61, pp.94-108.

LEACH, J.R. (1967). ' The Economics of Cocoa-Coconut Interplanting', in *Cocoa and Coconuts in Malaya,* edited by J.W. Blencowe and P.D. Turner, Kuala Lumpur, pp. 103-111.

LEACH, J.R., SHEPHERD, R., and TURNER, P.D. (1971). 'Underplanting Coconuts with Cocoa in Malaysia', *Cocoa Growers Bulletin*, Vol. 16 (1), pp. 21-26.

LECAILLON, J., MORRISON, C., SCHNEIDER, H. and THORBECKE, E. (1987). *Economic Policies and Agricultural Performance of Low-Income Countries,* Development Centre of the Organization For Economic Co-operation and Economic Development, Paris.

LEWIS-BECK, M.S. (1980). 'Applied Regression : An Introduction', in *Quantitative Applications in the Social Sciences,*edited by John, L. Sullivan, Saga University Paper No. 22.

LINGARD, J., and RAYNER, A.J. (1975). 'Productivity Growth in Agriculture: A Measurement Framework', *Journal of Agricultural Economics*, Vol. XXV1 (1), pp. 87-103.

LINGARD, J., CASTILLO, L. and JAYASURIYA, S. K. (1983) 'Comparative Efficiency of Rice Farms in Central Luzon, the Philippines', *Journal of Agricultural Economics,* Vol.34, pp. 163-73.

LIPTON, M. (1968). 'The Theory of Optimizing Peasant', *Journal of Development Studies,* Vol.4(3), pp. 327-51.

LOCKHEAD, M.E., JAMISON, D.T., and LAU, L.J. (1980). 'Farmer, Education and Farm Efficiency : A Survey', *Journal of Economic Development and Cultural Change,* Vol. 29 (1), October, pp. 37-75.

MAKARY, S.R., and REES, H. (1981). 'An Index of Management Efficiency for Egyptian Agriculture. A Case Study of Large Farms', *Journal of Agricultural Economics,* Vol. XXXII, (2), pp. 189-196.

MALAYSIA, ECONOMIC PLANNING UNIT (1978). 'Estimation of Poverty Line Income 1977, Peninsula Malaysia', Paper No.5, Kuala Lumpur.

MALAYSIA, MINISTRY OF AGRICULTURE (1984). 'Status Survey of Cocoa Smallholders in West Malaysia', Jabatan Pertanian, Kuala Lumpur.

MALAYSIA (1985). 'Jadual-Jadual Banci Taraf Pertanian, Hilir Perak', Kementerian Pertanian

MALAYSIA (1985). 'Laporan Tahunan', Jabatan Pertanian, Hilir Perak.

MALAYSIA (1986). *Fifth Malaysia Plan, 1986-1990,* National Printing Department, Kuala Lumpur.

MALAYSIA, KEMENTERIAN KEWANGAN (1988). *LAPORAN EKONOMI 1988/1989,* Jabatan Percetakan Negara, Kuala Lumpur.

MALAYSIA (1988). *Information Malaysia Yearbook,* Berita Publishing, Kuala Lumpur.

MALAYSIA (1989). *Information Malaysia Yearbook,* Berita Publishing, Kuala Lumpur.

MARASCUILO, L.A., and SERLIN, R.C. (1988). *Statistical Methods for the Social and Behavioral Sciences,* New York : W.H. Freeman and Company.

MARDI (1984). 'Nota Kursus: Panduan Tanaman Koko', Bahagian Koko/Kelapa, Cawangan Latihan Teknikal Bahagian Perkhidmatan Pusat, MARDI, Serdang, Selangor.

MARIJIN, J.N. (1985). *Advanced Statistics Guide*, Mc Graw-Hill.

MASSELL, B.F. (1967). 'Farm Management in Peasant Agriculture', *Food Research Institute Studies*. Vol. 7 (2), pp. 205-215.

MEEUSEN, W., and VAN DEN BROECK, J. (1977). 'Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error', *International Economic Review*, Vol. 18. pp.435-44.

MICHAEL, G., SCHLUTER, G. and MOUNT, T. M. (1976). 'Some Management Objectives of the Peasant Farmer: an Analysis of Risk Aversion in the Choice of Cropping Pattern, Surat District, India', *Journal of Development Studies*, Vol. 12 (3), pp. 246-57.

MIRANOWSKI, J., and SIMMONS, J. (1976). 'Economics of Cocoa-Production', in *Cocoa Production: Economics and Botanical Perspectives*, edited by J. Simmons, Praeger Special Studies, New York. Chapter 3.

MOOCK, P.R. (1981). 'Education and Technical Efficiency in Small-Farm Production', *Journal of Economic Development and Cultural Change*, Vol. 29 (4), July, pp. 724-739.

MORGAN, W.B. (1980). *Agriculture in the Third World : A Spatial Analysis*, Bell and Hyman, London.

MOSER, C.A., and KALTON, G. (1971). *Survey Methods in Social Investigation*, Heinemann Education Books, London, Second Edition.

MULLER, J. (1974). 'On Sources of Measured Technical Efficiency - The Impact of Information', *American Journal of Agricultural Economics*. Vol. 56 (4), pp. 730-738.

MUNDLAK, Y. (1961). 'Empirical Production Function Free of Management Bias', *Journal of Farm Economics*, Vol. 43, pp. 44-56.

MURRAY, D.B. (1975). 'Shade and Nutrition', in *Cocoa*, edited by G.A.R. Wood, Longman.

NASUDDIN OTHMAN, (1976). 'Efficiency of the Factors of Production use in the Cultivation of Padi - A Case-Study in Tanjong Karang, Selangor, Malaysia', M. Sc. Thesis, Bogor Agricultural University.

NASUDDIN OTHMAN, (1983). 'Economic Efficiency of Some Input Factors for Padi. A Case-Study in Perlis, Malaysia', M.A.D. Thesis, University of Ghent, Belgium.

NASUDDIN OTHMAN, SHUKRI SHAMSUDDIN, and ZAKARIA TAJUDDIN (1987). 'Status Penanam Koko Di Hilir Perak', I.T.M. Cawangan Pahang, Kuantan, Pahang.

NICHOLLS, W. H. (1964). 'The Place of Agriculture in Economic Development', in *Agriculture in Economic Development*, edited by C. Eicher and L. Witt, McGraw-Hill Book Company, New York, pp. 11-44.

NIK FUAD MOHD KAMIL and MOHD SHARIF AHMAD. (1978). 'Socio-Economic Status of Coconut Smallholders in Lower Perak', *Proceedings of a Cocoa and Coconut Conference*, Kuala Lumpur, pp. 731-741.

OKALI, C. (1973). 'Labour Inputs on Cocoa Farms', in *The Economics of Cocoa Production*, edited by J. Simmons, Praeger Special Studies, New York, pp. 20-46.

OLAYEMI, J.K. (1970). 'Peasant Cocoa Production in West Nigeria : An Economic Analysis', Ph.D. Thesis, University Mc Gill, Montreal.

OLAYEMI, J.K., and ONI, S.A. (1974). 'Acreage Response in A Developing Country : A Case-Study of Western Nigeria Cocoa Farmers', *African Studies Review* 17(2); pp. 318-395.

OPEKE, L.K. (1976). 'Cocoa Research in Nigeria', in *Cocoa Production: Economic and Botanical Perspectives*', edited by J. Simmons, Praeger Special Studies, New York, pp 202-232.

PASOUR, E.C. Jr. (1981). 'A Further Note on the Measurement of Efficiency and Economics of Farm Size', *Journal of Agricultural Economics*, Vol. 32(2), pp. 135-143.

PHANG, C.I.(1978). 'Tanaman Koko', *Risalah Perkembangan*. No.13, Kementerian Pertanian Malaysia.

PUGH, C.R., THOMAS, D.W., and EISGRUBER, M. (1965). 'Farm Tenant Ability, Output and Resource Productivity', Purdue Agric. Experimental Station. Research Bulletin, No. 793.

PURSEGLOVE, J.W.(1968). *Tropical Crops: Dicotyledons 2*, Longman.

RAJA BADRUL SHAH KOBAT, (1982). 'A Socio-Economic Study of Performance Among Rubber Farmers in West Malaysia', Ph. D. Thesis, University of Ghent.

RAJ. D. (1968). *Sampling Theory*, McGraw-Hill, Inc.

SAHOTA, G.S.(1968). 'Efficiency of Resource Allocation in Indian Agriculture', *Journal of Agricultural Economics*, Vol. 50(3), pp 586-602.

SATO, R., and HOFFMAN, R.F. (1968). 'Production Functions with a Variable Elasticity of Factor Substitutions: Some Analysis and Testing', *Review of Economics and Statistics*, Vol. 50, pp. 453-460.

SCHULTZ, T.W. (1964). *Transforming Traditional Agriculture*, Yale University Press, New Haven.

SEN, A.K. (1966). 'Peasants and Dualism With or Without Surplus Labour', *Journal of Political Economy*, Vol. LXXIV (5), Oct. pp. 438-450.

SHAABAN SAHAR, (1980). 'Report of the Coconut-based Farming System Survey in Sabak-Bernam', MARDI.

SHAABAN, S., and MOHAMMED. H. (1984). 'Beberapa Masalah Dalam Pembangunan Industri Kecil Koko Dalam Sektor Pekebun-Pekebun Kecil', MARDI, Serdang, Selangor.

SHAPIRO, K. H. (1974). 'Efficiency and Modernization in African Agriculture: A Case-study in Geita District, Tanzania', PH.D Thesis, Stanford University.

SHAPIRO, K. H., and MULLER, J. (1977). 'Sources of Technical Efficiency: The Role of Modernization and Information', *Economic Development and Cultural Change*, Vol. 25, pp. 293-310.

SHAUDYS, E.T. and WODLAND, T, (1968). 'Biography and Performance - The Management Factor of Farming : An Evaluation and Summary of Research', Minnesota Agricultural Experiment Station, Technical Bulletin, No. 258.

SHUKRI SHAMSUDIN, ZAKARIA TAJUDDIN, and NASUDDIN OTHMAN (1987). 'Status Penanam Koko di Tanjong Karang, Selangor', I.T.M. Cawangan Pahang, Kuantan, Pahang.

SOMEL, K. (1979). 'Technological Change in Dryland Wheat Production in Turkey', in *Resource Use in Agriculture: Applications of the Profit Function to Selected Countries*, edited by Pan A. Yotopoulos and Lawrence J. Lau, Food Research Institute Studies, Stanford, Vol. XV11 (1), Chapter 1V.

SUDMAN, S. (1976). *Applied Sampling*, Academic Press.

TAMIN, M. (1978). 'Microeconomic Analysis of Production Behaviour of Malaysian Farms : Lessons From MUDA', Ph.D. Dissertation. Stanford University.

TEOH, K.C., ABDUL KADIR, A.H., SYED KAMARUDDIN, S.W. and CHAN, C.L. (1977). 'Preliminary Survey of Problems in Cocoa Cultivation by Smallholders in Lower Perak', MARDI Report, No. 58.

THIRTLE, C. (1984). 'Cocoa Production in Eastern Cameroon', *Manchester Paper on Development*, Issue 10, pp. 45-54.

THOMAS, R.L. (1985). *Introductory Econometrics: Theory and Application*, London, Longman.

TIMMER, P.C. (1970), 'On Measuring Technical Efficiency', *Food Research Institute Studies*, Vol.9 (2), pp. 99-171.

TSURUMI, H. (1970). 'Non-Linear, Two Stage, Least Squares Estimation of C.E.S. Production Functions', *Review of Economics and Statistics*, Vol. 12 (2), pp. 200-209.

TURNEY, B.L. and ROBB, G.P. (1971). *Research in Education : An Introduction*, The Dryden Press Inc.

UPTON, M. (1970). 'The Influence of Management of Farm Production on a Sample of Nigerian Farm', *Farm Economist*, Vol. 11 (12), pp. 526-36.

UPTON, M. (1973). *Farm Management in Africa : The Principles of Production and Planning*, Oxford University Press, London.

UPTON, M. (1976). *Agricultural Production Economics and Resources Use*, Oxford University, Press.

UPTON, M. (1979). 'The Unproductive Production Function', *Journal of Agricultural Economics*, Vol. 30 (2), pp. 179-194

UPTON, M. (1987). *African Farm Management*, Cambridge University Press.

URQUHART, D.H. (1962). *Cocoa*, Longman Group Ltd. London, Second. Edition.

WELSCH, D. E. (1965). 'Response to Economic Incentive by Abakaliki Rice Farmers in Eastern Nigeria', *Journal of Farm Economics*, Vol. 47, pp. 900-914.

WOLGIN, J. M. (1975). 'Resource Allocation and Risk: A Case-study of Smallholder Agriculture in Kenya', *American Journal of Agricultural Economics*, Vol. 57, pp. 622-30.

WONG, I.F.T. (1972). 'Suitable Cocoa Soils in West Malaysia', in *Cocoa and Coconuts in Malaysia*, edited by R.L. Wastie and D.A. Earp, Kuala Lumpur : Incorporated Society of Planters, pp. 127-135.

WOOD, G.A.R. (1975). *Cocoa*, Longman Group Ltd., London.

WOOD, G.A.R. (1985). 'The Cocoa trees and its Cultivation,' in *Cocoa Production, Present Constraints and Priorities for Research*, edited by R.A. Lass, and G.A.R. Wood, World Bank Technical Paper, No. 39.

WORLD BANK, (1980). *World Development Report 1980*, Oxford University Press for the World Bank, Washington, D.C.

WORLD BANK, (1982). *World Development Report 1982*, Oxford University Press for the World Bank, Washington, D.C.

WRYLEY-BIRCH, E.A. (1972). 'Manuring of Cocoa', in *Cocoa and Coconuts in Malaysia*, edited by R.L. Wastie and D.A. Earp, Kuala Lumpur : Incorporated Society of Planters, pp. 136-142.

YOTOPOULOS, P.A. and NUGENT, B.J. (1976). *Economics of Development Empirical Investigations*, Harper International Edition, Harper, Row Publishers.

YOTOPOULOS, P.A. (1967). *Allocative Efficiency in Economic Development. A Cross-section Analysis of Epirus Farming*, Athens, Centre of Economic Reseach.

ZULKIFLI HJ. MUSTAPHA, (1988). 'The Evolution of Malaysia Agricultural Development Policy : Issues and Changes', *Proceeding of International Seminar on Malaysian Agriculture Policy : Issues and Directions*, Universiti Pertanian Malaysia, pp. 1-46.

APPENDIX 1.

AGRICULTURAL PRODUCTION IN MALAYSIA, (1980-83)
('000 tonnes)

ITEMS	1980	1981	1982	1983
Rubber	1,530.0	1,510.2	1,494.2	1,563.7
Crude Palm Oil	2,575.9	2,834.5	3,514.2	3,018.3
Palm Kernel Oil	222.3	243.4	337.0	372.1
Sawn Logs	27,916.0	30,653.5	32,824.4	32,783.8
Sawn Timber	6,238.0	5,564.0	6,293.0	7,139.0
Cocoa	36.5	45.2	66.2	69.0
Padi	2,040.2	2,016.2	1,878.7	1,774.3
Copra	787.5	255.0	257.0	264.1
Pepper	31.6	28.8	25.3	24.5
Pineapple	185.3	153.6	153.0	148.2
Fisheries	743.7	766.6	693.6	742.1
<u>LIVESTOCK</u>:				
Beef	17.2	16.8	17.3	16.7
Mutton	0.8	0.6	0.6	0.6
Poultry	125.6	127.1	129.4	138.6
Eggs	2,534.7	2,592.2	2,690.1	2,783.5
Pork	135.9	144.4	143.0	141.5
Milk	8,254.0	15,305.0	16,951.0	19,965.0

Source: Compiled from the relevant reports of the various Ministries and Agencies.

APPENDIX 2.

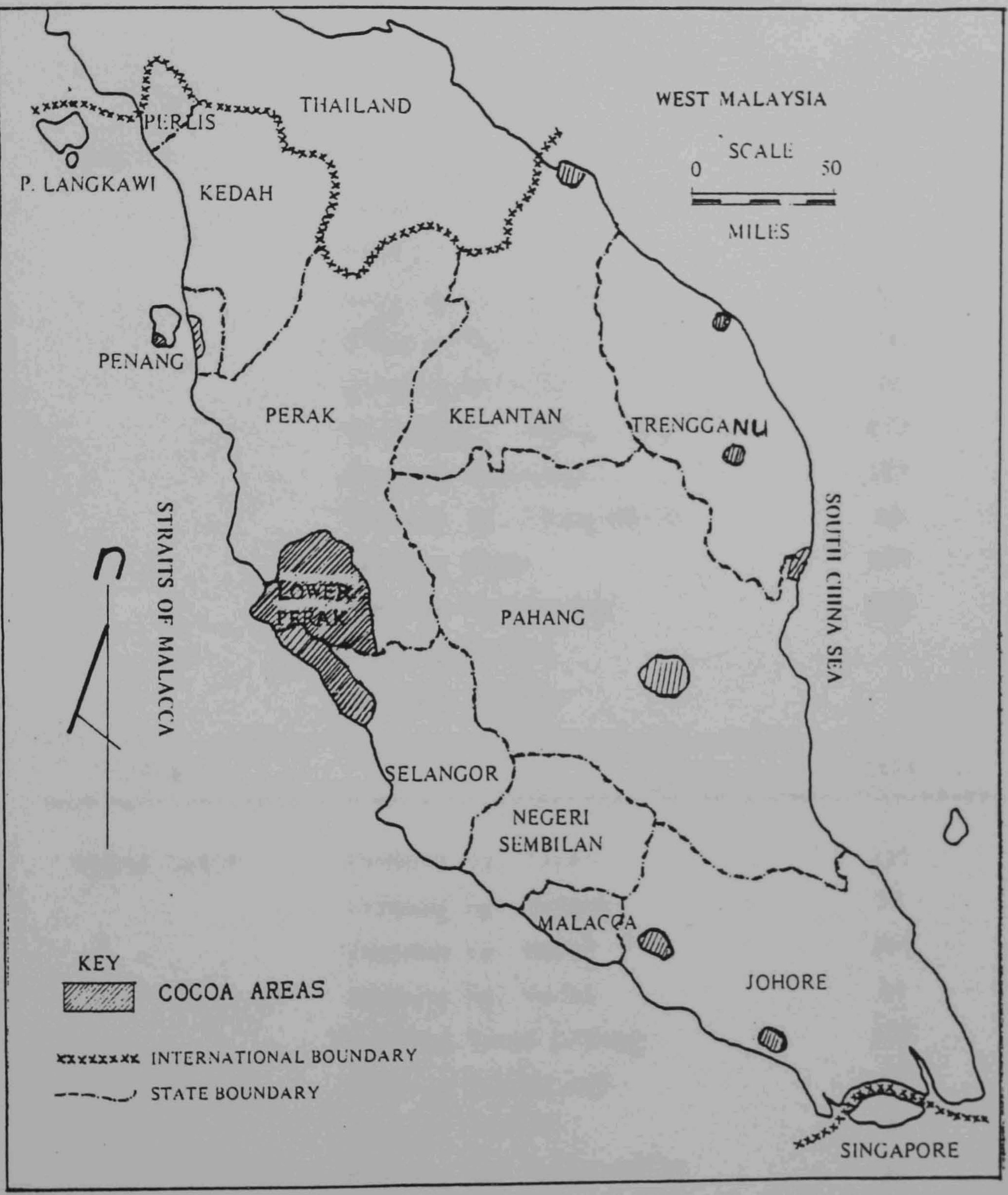
AGRICULTURAL PRODUCTION IN MALAYSIA, (1984-1985)
('000 tonnes)

ITEMS	1984	1985	% Change 1980/85
Rubber	1,529.2	1,450.0	-5.2
Crude Palm Oil	3,715.7	4,130.0	60.3
Palm Kernel Oil	415.2	501.2	125.8
Sawn Logs	30,702.3	31,340.0	12.3
Sawn Timber	5,807.6	5,500.0	-11.8
Cocoa	79.3	103.0	182.2
Padi	1,711.8	1,931.2	-5.3
Copra	256.1	250.0	-68.3
Pepper	15.0	19.0	-39.9
Pineapple	144.3	147.0	-20.7
Fisheries	670.2	697.1	-6.3
LIVESTOCK:			
Beef	17.4	19.1	11.0
Mutton	0.7	0.8	0
Poultry	151.8	154.4	22.9
Eggs	3,240.5	3,460.9	36.5
Pork	154.6	158.8	16.9
Milk	25,935.0	28,925.0	250.4

Source: Compiled from the relevant reports of the various Ministries and Agencies.

APPENDIX 3

COCOA AREAS IN PENINSULA MALAYSIA



APPENDIX 4.

DISTRIBUTION OF <u>KAMPUNG</u> IN <u>MUKIM</u>
RUNGKUP AND BAGAN DATOH

MUKIM	KAMPUNG	NO OF FARMERS
RUNGKUP	Kampung Sg. Lancang	257
	Kampung Rungkup Kecil	63
	Kampung Simpang 3	130
	Kampung Sg. Hj. Mohd.	68
	Kampung Selekoh	14
	Kampung Batu 20	42
	Kampung Sg. Tiong Darat	273
	Kampung Belukang	127
	Kampung Sg. Tiong Baruh	39
	Kampung Nipah	103
	Kampung Sg. Batang	294
	Kampung 702022	1
	Kampung 702122	3
TOTAL	_	1414
BAGAN DATOH	Kampung Sg. Perak	131
	Kampung Sg. Pergam	25
	Kampung Sg. Nipah	160
	Kampung Sg. Betul	44
	Kampung Tanah Lalang	105
	Kampung Pasang Api	89
	Kampung 703007	8
	Kampung Sg. Balai Darat	63
	Kampung Batu 26	57
	Kampung Selekoh	68
	Kampung Sri Nipah Darat	35
TOTAL	-	785

APPENDIX 5.

DISTRIBUTION OF <u>KAMPUNG</u> IN <u>MUKIM</u> TELUK BARU AND HUTAN MELINTANG

MUKIM	KAMPUNG	NO OF FARMERS
TELUK BARU	Kampung Batu 8	61
	Kampung Tebing Rebak	19
	Kampung Tapak Semenang	28
	Kampung Bharu	207
	Kampung Sg. Dulang	50
	Kampung Sg. Sari	35
	Kampung Teluk Baru	42
TOTAL	-	442
HUTAN MELINTANG	Kampung Pubu Ganda Suli	40
	Kampung Sg. Manila	107
	Kampung Parit 21	260
	Kampung Parit 13	94
	Kampung Teluk Buluh	131
	Kampung Bagan Lalang	26
	Kampung Sg. Sumun	236
	Kampung Kota	104
	Kampung Samak	73
TOTAL	-	1071

APPENDIX 6. (QUESTIONNAIRE)

A. <u>BACKGROUND INFORMATION OF THE FARMER</u>

1. Name of Farmer :........................

2. Kampung: ....

3. Mukim: ....

4. Race: ....

5. Sex ( ) Male, Female ( )

6. Age: ....

7. Marital Status: ( ) Single, ( ) Married ( ) Others.

8. Highest Level of Education Attained:

<u>Educational Level</u>	(Please tick)
1) No Schooling	( )
2) Adult Education	( )
3) Primary Level	( )
4) Lower Secondary Level	( )
5) Upper Secondary Level	( )
6) Tertiary Education	( )

9. Number of years experienced in cocoa farming: ....

B. INFORMATION OF FAMILY MEMBERS

1. Age of spouse: ....

2. Highest Level of Education of Spouse:

Educational Level	(Please tick)
1. No Schooling	( )
2. Adult Education	( )
3. Primary Education	( )
4. Lower Secondary	( )
5. Upper Secondary	( )
6. Tertiary Education	( )

3. Highest Level of Children's Education.

Educational Level	(Please tick)
Not School Yet	( )
Still Attending Primary Education	( )
Comp. Primary Education	( )
Still Attending Lower Secondary	( )
Comp. Lower Secondary	( )
Still Attending Upper Secondary	( )
Comp. Upper Secondary	( )
Still Attending Tertiary Education	( )
Comp. Tertiary Education	( )

C. FARM STATUS

1. Total acreage planted with cocoa/coconut :.......acres.
2. Total acreage where cocoa is still not productive :

   ....acres.
3. Total acreage where cocoa is already productive:

   ....acres.
4. State the annual cost of renting per acre if you are renting the land: $.......
5. Name the type of soil series involved :.............

D. PLANTING MATERIAL/VARIETY

COCOA

1. Name the type of cocoa variety planted: ....
2. State the source of planting material:

   Own breeding ( )

   Department of Agriculture ( )

   MARDI ( )

   Farmers Organization ( )

   Other Sources: ( )
3. What is the planting density per acre: ....
4. State the year when cocoa was being planted: ....
5. Please specify the age of the plants as at December

   1988:.........

COCONUT PALMS

1. Name the variety of coconut palms planted: ....

2. What is the planting density per acre: ....

3. State the year of the palms as at December 1988 : ....

4. Please specify the age of the palms as at December 1988:

....

E. FERTILIZER APPLICATION

1. Do you fertilize your cocoa and coconut.

Yes ( )

No ( )

2. If yes please fill in the details below:

TYPES OF FERTILIZER	Quantity Used/ac/yr.		Quantity Purchased		Subsidy (if any)	
	kg.	$	kg.	$	kg.	$

3. Do you apply lime to you plants

Yes ( )

No ( )

4. If yes, please state the amount applied: ....kg/ac/yr.

5. Please specify the cost of lime incurred: $ ....

F. <u>WEEDICIDES</u>

1. Do you apply weedicides to you cocoa and coconut palms:

Yes ( )

No ( )

2. If yes, please fill in the details below:

TYPES OF WEEDICIDES	Quantity Used/ac/yr		Quantity Purchased		Subsidy (if any)	
	kg/litre	$	kg/litre	$	kg/litre	$

G. PESTICIDES

1. Do you apply pesticides to your cocoa and coconut palms.

Yes ( )

No ( )

2. If yes, please fill in the details below:

TYPES OF PESTICIDES	Quantity Used/ac/yr		Quantity Purchased		Subsidy (if any)	
	kg/litre	$	kg/litre	$	kg/litre	$

H. LABOUR

1. Labour utilization per acre/month for cocoa and coconut.

ACTIVITIES	Family labour (hours)	Hired Labour (hours)
	Male/Female/Child	Male/Female/Child
Maintenance of Cocoa & Coconut		
Pest control		
Weed control		
Manuring		
Drainage and path maintenance		
Pruning		
Harvesting of Cocoa:		
Collection of Pods		
Breaking of Pods		
Fermentation		
Drying of beans and bagging		
Harvesting of Coconuts:		
Collection of nuts		
Breaking of nuts		
Drying		
Bagging		

2. What is the cost of hired labour per man-day: $..................

I. FARM TOOLS AND EQUIPMENT

Please fill in the details below.

Type	Quantity Owned	Year of Purchase	Purchasing Price	Duration of Usage	Total Price	Depreciation

J. CROP YIELD (1987)

COCOA

1. State the annual yield obtained per acre according to the details below:

TYPE	Quantity (kg)	Income ($)
Wet Beans		
Dried Bean		

2. What is the expected yield to be obtained from wet beans per acre/yr : ....kg.

3. What is the expected yield to be obtained from dried beans per acre/yr : ....kg.

4. State the average annual price per kilogram of:

Wet Beans: $................/kg.

Dried Beans: $............../kg.

5. State the average expected price per kilogram of:

Wet Beans :$................/kg.

Dried Beans: $............./kg.

COCONUT

1. State the annual yield obtained per acre base on the details below:

Type	Quantity (kg)	Income ($)
Nuts		
Copra (if any)		

2. What is the expected yield per ac/yr from nuts/copra:...........kg.

3. What is the expected yield per ac/yr from copra (if any) :

$......... ....kg.

4. Specify the price for each nut sold : ....¢

5. Specify the price for each kilogram of copra sold:

$.............

6. Specify the average expected price for each nut sold:

...........¢

7. Specify the average expected price for each kilogram of copra sold : $............

K. CREDIT

1. Did you ever take any credit during the year 1988.

Yes ( )

No ( )

2. If yes please state the source:

Relatives	( )
Neighbours	( )
Friends	( )
Middle-men	( )
Agricultural Bank	( )
Cooperative	( )

Farmers Association ( )

Others (please specify ( )

3. State the amount borrowed: $....................

4. State the annual interest rate charged: ....%

L. <u>FARM RECORDS AND ACCOUNT</u>

1. Did you practise keeping farm records and accounts.

Yes ( )

No ( )

M. <u>EXTENSION CONTACT</u>

1. Did you ever receive any guidance from the extension officer in 1988?

Yes ( )

No ( )

2. If yes, please state the amount of contact made during the period?

....

APPENDIX 7. CORRELATION MATRIX OF EXPECTED INCOME AND FARM INPUTS - POOLED DATA

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y	1.000								
X_1	-0.202	1.000							
X_2	0.887	-0.171	1.000						
X_3	0.834	-0.120	0.852	1.000					
X_4	0.355	-0.098	0.314	0.268	1.000				
X_5	0.195	-0.058	0.115	0.075	0.142	1.000			
X_6	0.427	-0.092	0.278	0.378	0.182	0.183	1.000		
X_7	0.418	-0.046	0.191	0.375	0.226	0.209	0.572	1.000	
X_8	0.848	-0.177	0.909	0.781	0.257	0.085	0.288	0.183	1.000

Contd. APPENDIX 7. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
Y	0.099	-0.001	0.025	0.102	0.283	0.157	-0.020	0.321
X_1	0.029	-0.072	0.032	-0.006	-0.149	-0.197	0.239	0.017
X_2	0.040	0.006	0.087	0.057	0.230	0.105	0.015	0.263
X_3	0.121	0.021	-0.023	0.131	0.199	0.110	0.003	0.221
X_4	0.154	0.167	-0.334	0.235	0.124	0.010	-0.035	0.118
X_5	-0.045	0.206	-0.069	0.047	0.035	0.044	0.117	0.252
X_6	0.066	0.034	-0.067	0.150	0.138	0.113	-0.015	0.173
X_7	0.220	0.016	-0.245	0.218	0.156	0.118	0.011	0.161
X_8	0.044	-0.071	0.124	-0.002	0.209	0.138	-0.062	0.266

Contd. APPENDIX 7. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
D_1	1.000							
D_2	-0.188	1.000						
D_3	-0.291	-0.397	1.000					
D_6	0.617	0.487	-0.472	1.000				
D_7	-0.050	0.034	0.086	0.028	1.000			
D_8	-0.109	0.053	0.109	0.010	0.724	1.000		
D_9	-0.206	0.125	0.029	-0.047	-0.048	-0.022	1.000	
D_{10}	0.152	-0.138	0.056	0.002	0.002	-0.073	0.018	1.000

APPENDIX 8. CORRELATION MATRIX OF EXPECTED INCOME AND FARM INPUTS - POOLED DATA (AFTER SOLVING THE MULTICOLLINEARITY PROBLEM)

	Y	X_1	X_2	X_3/X_2	X_4	X_5	X_6	X_7	X_8/X
Y	1.000								
X_1	-0.202	1.000							
X_2	0.887	-0.171	1.000						
X_3/X_2	-0.061	-0.087	-0.235	1.000					
X_4	0.355	-0.098	0.314	-0.073	1.000				
X_5	0.195	-0.058	0.115	-0.071	0.142	1.000			
X_6	0.427	-0.092	0.278	0.198	0.182	0.183	1.000		
X_7	0.418	-0.046	0.191	0.350	0.226	0.209	0.572	1.000	
X_8/X_2	0.054	-0.043	-0.054	-0.042	-0.084	-0.055	0.070	0.012	1.000

Contd. APPENDIX 8. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
Y	0.099	-0.001	0.025	0.102	0.283	0.157	-0.020	0.321
X_1	0.029	-0.072	0.032	-0.006	-0.149	-0.197	0.239	0.017
X_2	0.040	0.006	0.087	0.057	0.230	0.105	0.015	0.263
X_3/X_2	0.152	0.027	-0.201	0.139	-0.048	0.014	-0.021	-0.067
X_4	0.154	0.167	-0.334	0.235	0.124	0.010	-0.035	0.118
X_6	0.066	0.034	-0.067	0.150	0.138	0.113	-0.015	0.173
X_7	0.220	0.016	-0.245	0.218	0.156	0.118	0.011	0.161
X_8/X_2	0.015	-0.185	0.104	-0.132	-0.010	0.097	-0.180	0.051

Contd. APPENDIX 8. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
D_1	1.000							
D_2	-1.188	1.000						
D_3	-0.291	-0.397	1.000					
D_6	0.617	0.487	-0.472	1.000				
D_7	-0.050	0.034	0.086	0.028	1.000			
D_8	-0.109	0.053	0.109	0.010	0.724	1.000		
D_9	-0.206	0.125	0.029	-0.047	-0.048	-0.022	1.000	
D_{10}	0.152	-0.138	0.056	0.002	0.002	-0.073	0.018	1.000

APPENDIX 9. CORRELATION MATRIX OF EXPECTED INCOME AND FARM INPUTS - SMALL FARMS

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y	1.000								
X_1	-0.153	1.000							
X_2	0.795	-0.008	1.000						
X_3	0.758	-0.008	0.753	1.000					
X_4	0.284	-0.082	0.212	0.150	1.000				
X_5	0.126	-0.018	-0.008	-0.040	0.162	1.000			
X_6	0.419	-0.130	0.234	0.375	0.167	0.181	1.000		
X_7	0.470	-0.104	0.190	0.423	0.200	0.235	0.526	1.000	
X_8	0.742	-0.043	0.814	0.633	0.132	-0.028	0.026	0.155	1.000

Contd. APPENDIX 9. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
Y	0.249	-0.074	-0.020	0.150	0.317	0.195	-0.070	0.051
X_1	-0.054	-0.069	0.072	-0.070	-0.181	-0.211	0.245	-0.042
X_2	0.141	-0.078	0.052	0.072	0.278	0.131	-0.042	0.038
X_3	0.235	-0.099	-0.062	0.123	0.160	0.092	-0.024	0.019
X_4	0.187	0.180	-0.395	0.258	0.108	-0.021	-0.072	0.092
X_5	-0.017	0.187	-0.084	0.048	0.058	0.077	0.116	0.272
X_6	0.131	-0.093	-0.061	0.113	0.104	0.043	0.086	0.110
X_7	0.286	-0.028	-0.244	0.213	0.125	0.053	0.068	0.163
X_8	0.129	-0.107	0.075	0.053	0.252	0.229	-0.085	0.080

Contd. APPENDIX 9. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
D_1	1.000							
D_2	-0.170	1.000						
D_3	-0.301	-0.358	1.000					
D_6	0.677	0.454	-0.444	1.000				
D_7	0.000	0.049	0.083	0.070	1.000			
D_8	-0.025	0.032	0.130	0.064	0.728	1.000		
D_9	-0.168	0.159	0.001	-0.057	-0.176	-0.143	1.000	
D_{10}	0.087	-0.103	-0.006	0.001	-0.064	-0.045	0.096	1.000

APPENDIX 10. CORRELATION MATRIX OF EXPECTED INCOME AND FARM INPUTS - SMALL FARMS (AFTER SOLVING THE MULTICOLLINEARITY PROBLEM)

	Y	X_1	X_2	X_3/X_2	X_4	X_5	X_6	X_7	$X_{8/X2}$
Y	1.000								
X_1	-0.153	1.000							
X_2	0.795	-0.008	1.000						
X_3/X_2	0.216	-0.002	-0.032	1.000					
X_4	0.284	-0.082	0.212	-0.022	1.000				
X_5	0.0126	-0.018	-0.008	-0.051	0.162	1.000			
X_6	0.419	-0.130	0.234	0.293	0.167	0.181	1.000		
X_7	0.470	-0.104	0.190	0.420	0.200	0.235	0.526	1.000	
X_8/X_2	0.167	-0.062	0.004	0.053	-0.068	-0.037	0.120	0.001	1.000

Contd. APPENDIX 10. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
Y	0.249	-0.074	-0.020	0.150	0.317	0.195	-0.070	0.051
X_1	-0.044	-0.069	0.072	-0.070	-0.181	-0.211	0.245	-0.042
X_2	0.141	-0.078	0.052	0.072	0.278	0.131	-0.042	0.038
X_3/X_2	0.191	-0.058	-0.156	0.102	-0.085	-0.014	0.013	-0.016
X_4	0.187	0.180	-0.395	0.258	0.108	-0.021	-0.072	0.092
X_5	-0.017	0.187	-0.084	0.048	0.058	0.077	0.116	0.272
X_6	0.131	-0.093	-0.061	0.113	0.104	0.043	0.068	0.110
X_7	0.286	-0.028	-0.244	0.213	0.125	0.053	-0.087	0.163
X_8/X_2	0.025	-0.075	0.056	-0.009	0.045	0.211	-0.168	0.084

Contd. APPENDIX 10. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
D_1	1.000							
D_2	-0.170	1.000						
D_3	-0.301	-0.358	1.000					
D_6	0.677	0.454	-0.444	1.000				
D_7	0.000	0.049	0.083	0.070	1.000			
D_8	-0.025	0.032	0.130	0.064	0.728	1.000		
D_9	-0.168	0.159	0.001	-0.057	-0.176	-0.143	1.000	
D_{10}	0.087	-0.103	-0.006	0.007	-0.064	-0.045	0.096	1.000

APPENDIX 11. CORRELATION MATRIX OF EXPECTED INCOME AND FARM INPUTS - LARGE FARMS

	Y	X_1	X_2	X_3/X_2	X_4	X_5	X_6	X_7	X_8/X_2
Y	1.000								
X_1	-0.069	1.000							
X_2	0.783	-0.142	1.000						
X_3/X_2	-0.188	0.175	-0.397	1.000					
X_4	0.179	0.028	0.133	-0.094	1.000				
X_5	0.151	-0.037	0.022	-0.064	-0.100	1.000			
X_6	0.401	0.055	0.164	0.155	0.116	0.116	1.000		
X_7	0.347	0.144	0.031	0.325	0.262	0.095	0.604	1.000	
X_8/X_2	0.190	-0.074	0.161	-0.022	-0.039	-0.042	0.066	0.082	1.000

Contd. APPENDIX 11. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
Y	-0.056	-0.163	0.164	-0.104	0.145	0.030	-0.079	0.443
X_1	0.153	-0.028	-0.031	0.138	-0.024	-0.149	0.276	0.157
X_2	-0.042	-0.243	0.311	-0.186	0.068	-0.029	-0.063	0.241
X_3/X_2	0.093	0.189	-0.284	0.237	0.097	0.102	-0.049	-0.046
X_4	0.119	0.079	-0.245	0.181	0.013	0.040	0.039	0.052
X_5	-0.094	0.202	-0.044	0.012	-0.088	-0.056	0.100	0.208
X_6	-0.027	0.136	-0.082	0.161	0.160	0.207	-0.197	0.160
X_7	0.119	0.030	-0.257	0.201	0.182	0.221	-0.109	0.109
X_8/X_2	0.001	-0.308	0.199	-0.290	-0.104	-0.106	-0.311	0.085

Contd. APPENDIX 11. CORRELATION MATRIX

	D_1	D_2	D_3	D_6	D_7	D_8	D_9	D_{10}
D_1	1.000							
D_2	-0.222	1.000						
D_3	-0.285	-0.471	1.000					
D_6	0.531	0.515	-0.536	1.000				
D_7	-0.175	-0.038	0.114	-0.1000	1.000			
D_8	-0.278	0.072	0.078	-0.103	0.717	1.000		
D_9	-0.280	0.057	0.064	-0.055	0.249	0.214	1.000	
D_{10}	0.242	-0.236	0.125	-0.047	0.018	-0.158	-0.083	1.000

APPENDIX 12

CHOW-TEST FOR DIFFERENCES AMONG THE REGIONS

REGION	n	RSS	NO. OF REGRESSORS
Teluk Baru	31	0.3379	13
Bagan Datoh	55	1.1023	13
Rungkup	99	5.8336	13
Hutan Melintang	75	4.5316	13
Pooled Data	260	13.4179	13

F statistic used is :

$$F_{[k+1,\ m+n-2(k+1)]} = \frac{[RSS_{(m+n)} - (RSS_{m)} + RSS_{(n)})]/k+1}{RSS_{(m)} + RSS_{(n)}/(m+n-2(k+1))}$$

Where:

$RSS_{(m+n)}$ = the residual sum of squares (RSS) of the pooled data regression,

$RSS_{(m)}$ and $RSS_{(n)}$ = the RSS of regression of groups m and n respectively.

k = number of regressors.

If F calculated > that F table we conclude that the reduction is RSS due to fitting two separate regressions is significant. We therefore, accept that there has been a significant change in the set of regression coefficients considered as a whole.

1. <u>TELUK BARU AND BAGAN DATOH</u>

$$\text{F statistic} = \frac{[13.4179-(0.3379+1.10232)]/13+1}{0.33791 + 1.10232/(86-2(14))}$$

$$= 43.52$$

2. <u>TELUK BARU AND RUNGKUP</u>

$$\text{F statistic} = \frac{[13.4179 - (0.33791+5.83360)]/13+1}{0.33791 + 5.83360/(130-2(14)}$$

$$= 8.55$$

3. <u>TELUK BARU AND HUTAN MELINTANG</u>

$$\text{F statistic} = \frac{[13.4179-(0.3379+4.5316)]/13+1}{0.3379 + 4.5316/106-28}$$

$$= 9.78$$

4. <u>BAGAN DATOH AND RUNGKUP</u>

$$\text{F statistic} = \frac{[13.4179-(1.1023+5.8336)/14}{1.1023+5.8336/(154-28)}$$

$$= 8.41$$

5. Bagan Datoh and Hutan Melintang

$$\text{F statistic} = \frac{[13.4179-(1.1023+4.5316)]/14}{1.1023 + 4.5316/130-28}$$

$$= 10.07$$

6. RUNGKUP AND HUTAN MELINTANG

$$\text{F statistic} = \frac{[13.4179-(5.8336+4.5316)]/15}{5.8336+4.5316/164-28}$$

$$= 2.86$$

APPENDIX 13.

TO TEST WHETHER RETURNS TO SCALE ARE CONSTANT (See Huang, 1970 ; Johnston, 1963). Assuming that we have 3 inputs used in the production process, namely; Labour (L), capital (K) and fertilisers (F), then the model can be written as follows:

$$Y = c_0 + c_1L + c_2K + c_3F + u$$

where Y, for example, denotes expected income.

The test for constant returns to scale can then be performed by setting the null hypothesis as:

$$H_0 : c_1 + c_2 + c_3 = 1$$

against the alternative hypothesis :

$$H_1 : c_1 + c_2 + c_3 \neq 1$$

The general procedure then is to estimate the model without imposing any constraints and calculate the residual sum of squares (SSR). After that impose the constraints on the regression model.

Let us say that the constraint is

$$c_3 = 1 - c_1 - c_2$$

Then the regression model becomes:

$$Y = c_0 + c_1 L + c_2 K + (1-c_1-c_2)F + u$$

which resolves into:

$$Y - F = c_0 + c_1(L-F) + c_2 (K-F) + u$$

Using the ordinary least square techniques we can then calculate the residual sum of squares from this restricted model.

The test statistic used then is

$$F = \frac{(SSR_R - SSR_U)/h}{SSR_U / n-k-1}$$

Where:

SSR_R = residual sum of squares for unrestricted model.

SSR_U = residual sum of squares for restricted model.

h = the difference in the number of parameters between both models.

n-k = refers to the degrees of freedom associated with the unrestricted model, n being the sample size and k the number of unrestricted regressors.

The null hypothesis is rejected if the calculated F-statistic with (h, n-k-1) degrees of freedom is greater than the values obtained from the F table and accept the alternative hypothesis if the F-value is non-significant.

Applying this principle to regression models in Tables 8.1 and 8.2 produces the results as follows:

1) Small Farm

$$F \text{ ratio} = \frac{(10.13908 - 8.84038)/1}{(8.84038/(165-5-1)} = 23.36$$

Since F calculated > $F_{(1,\ 159)}$ value from the table, the null hypothesis is rejected and we accept the alternative hypothesis

2) Large Farms

$$F \text{ ratio} = \frac{(5.36322 - 5.36046)/1}{5.36046/(95 - 2 - 1)} = 0.05$$

Since F calculated < $F_{(1,\ 92)}$ value from the table, the null hypothesis is accepted.

3) Region Teluk Baru

$$F \text{ ratio} = \frac{(0.54576 - 0.54196)/1}{0.54196/(31 - 2 - 1)} = 0.19628$$

Since F calculated < $F_{(1,\ 28)}$ value from the table, the null hypothesis is accepted.

4) <u>Region Bagan Datoh</u>

$$\text{F ratio} = \frac{(1.94004 - 1.47866)/1}{1.47866/(55 - 4 - 1)} = 15.60$$

Since F calculated $> F_{(1, 50)}$ value from the table, the null hypothesis is rejected.

5) <u>Region Rungkup</u>

$$\text{F ratio} = \frac{(7.86902 - 7.72855)/1}{7.72855/(99 - 2 - 1)} = 1.74$$

Since F calculated $< F_{(1, 96)}$ value from the table, the null hypothesis is accepted.

6) <u>Region Hutan Melintang</u>

$$\text{F ratio} = \frac{(5.03408 - 4.77510)/1}{4.77510/(75 - 3 - 1)} = 3.85$$

Since F calculated $< F_{(1, 71)}$ value from the table the null hypothesis is accepted.

7) <u>Pooled Data</u>

$$\text{F ratio} = \frac{(16.07512 - 15.18970)/1}{15.18970/(260 - 5 - 1)} = 14.81$$

Since F calculated $> F_{(1, 254)}$ value from the table the null hypothesis is rejected.