Chapter 1

INTRODUCTION

This study is concerned with farm-level resource allocation and the efficiency of Javanese agriculture. The survey on which it was based was carried out in three villages of East Java in 1978. The villages were chosen to be representative of problems in Indonesian agriculture with the efficient use of farm resources. Studies concerning the inefficieness in Indonesian agriculture are very limited. Indeed, in East Java, there are no extant studies. There are many questions about the efficient use of resources which are without answers. For example, are the small farmers farming more efficiently than large farmers? Do owners farm more efficiently than tenants? These questions are still being asked. The answers are obviuosly very important for agricultural development and land tenure in Indonesia because of the large population of Indonesia living off a very small land base. They are also important because of the large size of the rural population directly dependent on agriculture for a living.

1.1 Efficiency of Resource Use

One of the fundamental concerns of economics is the question of the efficient use of resources. The growth and development of an economy depends, in part, on the efficiency with which resources are used. At the firm level the efficiency of resource use influences the output obtained from a given set of resources and therefore the income to be derived from those resources.

To permit a detailed analysis of the above questions it is useful to consider efficiency of resource use from three different perspectives. Technical efficiency is a measure of the physical inputs required to produce a given output while allocative efficiency is a measure of the extent to which the marginal pricing conditions of economic theory are satisfied. Economic efficiency is a combined measure of both technical and allocative efficiency.

Inefficiency in both technical and allocative terms implies that greater returns can be obtained from the available set of resources if they can be combined in more appropriate ways. The significance of improving such allocations, if only by a small amount, for very large numbers of small-scale farmers can be very great to an economy as a whole and therefore well worth pursuing. From a policy point of view it is very useful to know if farm-level operations are technically and/or allocatively inefficient since the policy prescriptions will be different depending on the nature of the inefficiency.

1.2 Agriculture in the Indonesian Economy

Indonesia is largely an agrarian economy. This can be indicated by the fact that some 70 per cent of people live in rural areas and most of them (i.e., 62 per cent of the labour force) are engaged in agricultural activities. Accordingly, the agricultural sector plays an important role in the Indonesian economy. This can be seen by the large contribution the agricultural sector makes to the gross domestic product. Table 1.1 containts data on the gross domestic product in Indonesia by industrial origin for selected years from 1939 to 1978. From this table, it can be seen that 50.9 per cent of the gross domestic product in 1978 was accounted for by agriculture. Table 1.1 shows that the agricultural sector in the Indonesian economy has retainted its relative importance over a period of 40 years, from 1939 to 1978. In the decade 1960 to 1970 the manufacturing sector of the economy grew slowly. Furthermore, the relative importance of the agricultural sector increased from 1970 to 1975 and then decreased during the period 1975 to 1978. Mining, quarrying and public administration grew slowly.

Table 1.1

Share of Gross Domestic Product by Industrial Origin, in Selected Years, Indonesia

Sector	1939	1960	1965	1970	1975	1978
			%			
1 Agriculture, forestry, and livestock	52.7[a]	53.9	58.7	47.6	53.8	50.9
2. Mining and quarrying	9.3	3.7	2.5	5.4	7.9	8.3
3. Manufacturing	15.0	8.4	7.6	9.8	8.1	9.2
4. Wholesale and retail trade	-	14.3	12.4	18.5	12.4	12.4
5. Public administration	-	4.5	3.6	5.1	5.4	6.0
6. Services	-	6.2	8.4	5.4	2.7	2.4
7. Others	23.0[b]	9.0	6.8	8.2	9.7	10.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a]Estate plantations are not included.

[b]Includes Public administration.

Source: For 1939 figures, D.S. Paauw (1960), in Hadiwigeno (1974, p.8). For 1960, 1965 and 1970 figures, Biro Pusat Statistik (1970 and 1971), in Hadiwigeno (1974, p.8). For 1975 and 1978 figures, Biro Pusat Statistik (1979).

The decline of the share of agricultural products in the gross domestic product since 1975 is not surprising, because economic development in Indonesia increased rapidly during the first and second Repelita (Five-Year Development Plans) (7.3 per cent and 6.7 per cent annual growth in gross domestic product respectively, in Repelita I, 1968/69 to 1973/74 and Repelita II, 1974/75 to 1979/80). As the rate of economic development in the agricultural sector has gradually declined, development of the non-agricultural sector, particularly mining and industrial activities, has increased.

The recent decline in the importance of agricultural products in the gross domestic product is largely due to the declining contribution of smallholder estates but is also partly due to the declining contribution of food crops and fisheries. However, gross domestic product from livestock, large estates and forestry increased during Repelita I and II (Table 1.2). These changes were mainly stimulated by the increased level of domestic food consumption resulting from the relatively high rate of population growth in Indonesia which was 2.3 per cent per year during Repelita I and II. Even though the yield of the starchy foods increased (rice 2.35 per cent and maize 3.62 per cent) in Repelita I and II, this was not enough to match the increased requirement. The rising import figures for staple foods, especially rice and maize reflect this slow growth in food production. During Repelita I and II, rice imports increased at an exponential growth rate of 17.9 per cent and maize imports 0.10 per cent (more details are presented in Table 1.4). The rapid growth in food demand and the relatively slow increase in supply is the core policy problem relating to food in Indonesia. This is what has been referred to as the 'food problem' by Schultz (1953) and Mears (1978).

Table 1.2

Gross Domestic Product from the Agricultural Sector, in Selected Years, Indonesia

Sector	1969	1973	1977
		%	
1. Food crops	58.5	58.0	58.2
2. Livestock	5.8	6.1	7.1
3. Fisheries	5.9	5.0	5.1
4. Smallholder estates	14.5	11.9	11.1
5. Largeholder estates	6.4	5.6	7.0
6. Forestry	8.9	13.4	11.5
Total	100.0	100.0	100.0

Source: Departemen Pertanian (1979, p.24).

The relative importance of the agricultural sector can also be measured by the available statistics on agricultural exports which show the proportion of export revenue originating in the agricultural sector. Export revenue from agriculture is shown in Table 1.3 and is seen to be very significant, accounting for 44.8 per cent and 24.7 per cent, respectively, of the total during Repelita I and II. The declining position of agricultural exports since 1970/71 has occured as oil exports have increased. This situation is consistent with the figures shown in Table 1.1.

1.2 Nature of the Problem

The green revolution greatly increased food production in most poor agricultural nations of the world including Indonesia.[1]

Even though it has been underway since 1963 and implemented more seriously since the First Five-Year Development Plan in 1968/69, it has not solved the problems of low productivity in Indonesian agriculture.

Differences in the use of resource endowments are partly due to different farm sizes and different tenure systems in the particular areas. These differences are mainly concerned with the 'first generation' problems (problems of increasing farm productivity) of using the high yielding crop varieties. Several extensive studies have been undertaken in the three sample villages used for this study, for example, Soekartawi et al.(1979), Soekartawi (1979a,b, 1981a), Hartoyo and Soentoro (1980), Soentoro and Hartoyo (1979) and Soentoro et al.(1980). These failed to consider questions of the efficient use of resources. Nor have these questions been dealt with in other studies carried out in a variety of other places as reported by Collier (1972) and Lains (1979). Nevertherless there are studies concerned with land tenure relationships, including those by Sinaga (1978), Siahaan (1977), Wiradi

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[1]'Green revolution' has meant different things in different countries. Indonesia, by 1968, had begun large-scale planting of IR-8 and associated varieties of miracle paddy seeds. The seeds, their associated technology, and the potential they represent in the poor countries, including Indonesia, have often been referred to as 'the green revolution'.

Table 1.3

Exports by Commodity Groups During Repelita I (1969/70 to 1973/74) and II (1974/75 to 1978/79), Indonesia

Commodity	Repelita I						Repelita II					
	1969/70	1970/71	1971/72	1972/73	1973/74	Average	1974/75	1975/76	1976/77	1977/78	1978/79	Average
						million US$						
1. Agricultural products												
1.1 Major commodities[a]	369	530	540	678	1454	714.2	1410	1256	2048	2564	2791	2013.8
1.2 Others[b]	33	93	106	121	199	110.4	213	216	299	335	405	293.6
1.3 Total value	402	623	646	799	1653	824.6	1623	1472	2347	2899	3196	2307.4
1.4 Percentage	38.5	51.7	47.0	41.2	45.8	44.8	22.6	20.6	25.5	26.7	28.2	24.7
2. Other products[c]												
2.1 Value	258	138	138	175	252	192.2	410	410	516	608	783	543.6
2.2 Percentage	24.7	11.5	10.0	9.0	7.0	12.4	5.7	5.6	5.6	5.6	6.9	5.9
3. Oil												
3.1 Value	384	443	590	965	1708	818.0	5153	5273	6350	7353	7374	6300.6
3.2 Percentage	36.8	36.8	43.0	49.8	47.2	42.7	71.7	73.8	68.9	67.7	64.9	69.4
Total value	1044	1204	1374	1939	3613	1834.8	7186	7146	9213	10860	11353	9151.6

[a]Wood, rubber, oil palm, coffee, tobacco, tea and seed palm.

[b]Animals and their products, pepper, copra (coconut) and foods.

[c]Tin and other mineral products, and unspecified products.

Source: Republik Indonesia (1981); calculated from Table V.3 and V.4, pp.71-2.

et al.(1980), Yusuf et al.(1980), Kasryno et al.(1980), and Siregar (1974). These studies do not answer the questions related to the efficient use of resources.

More specifically, the problem for this study is concerned with the first generation problems of the green revolution. These include the difficulties of obtaining the best combination of inputs in order to achieve optimum yields. In agricultural production, it is essential that supplies of inputs, including knowledge and management services, be available to farmers at the right time and in the right amounts.

Agricultural output in Indonesia increased substantially following the first Five-Year Development Plan set up in 1968/69; it also benefited from the green revolution. Domestic agricultural production increased by 5.62 per cent during Repelita I and 2.94 per cent during Repelita II. During Repelita III (1980/81 to 1984/85) production was expected to increase by a further 3.80 per cent (Departemen Pertanian 1979). Despite such increased agricultural output in Indonesia, crucial problems still exist. The International Service for National Agricultural Research for Indonesia (ISNAR) identified the major problem of Indonesian agricultural development to be as follows (1981, p. 35):

> 'The agricultural sector is confronted with a sizable task if it is to meet the objectives laid down for it in Repelita III (equity, growth and national stability). The task will have to go beyond simply increasing agricultural productivity. Objectives of equity, growth, and national stability imply that benefits of increased agricultural productivity will be shared'.

A number of other problems for agricultural development in Indonesia, particularly during the third Five-Year Development Plan, have been identified. These are presented in Chapter III of the Repelita III for the agricultural sector (Departemen Pertanian 1979). One of the main problems of food-crop production in Indonesia outlined in that document is that production has not yet achieved its potential. It is suggested that this is due to:

(a) the non-development of potentially arable land both inside and outside Java, an area which includes the worst structural agrarian relationships (uneven distribution of operated land);

(b) weaknesses in the intensification programme which allow the benefits to go to large rather than small farms.

(c) the problems of agricultural and rural institutions (for example, land tenure and socio-economic factors).

In East Java, the location for this study, the main problems of agricultural development are similar to those outlined above. However, the farmers also face particular regional problems which have been outlined in a report by the Regional Office of the Department of Agriculture in East Java (Kanwil Departemen Pertanian Jawa Timur 1978). This report provides two suggestions which are particularly pertinent to East Java:

(a) that the increases in agricultural food-crop production, especially the secondary crops (maize, cassava, groundnut, soybean), should be maintained, while 'the levelling off' in the rate of yield increase for other food crops should also be changed; and

(b) that because farmers, particularly small farmers, seem to farm inefficiently, they should therefore be encouraged to increase their efficiency in order to maximize their farm income and to utilize excess family labour.[1]

The above statements are reflected in the figures presented in Table 1.4. This table shows that the area of harvested rice increased at an annual exponential growth rate of 0.08 per cent per year from 1968 to 1978. Even though total production increased, annually, by 3.11 per cent per year and yield increased by 2.35 per cent over the same period, rice imports also tended to increase. A similar situation applies to maize. Even though the harvested area of maize decreased at an annual average rate of 0.09 per cent per year from 1968 to 1978, total production increased, annually, by 2.13 per cent per year, and yield increased by

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[1]These statements were reported in 1978 by the Department of Agriculture coinciding with the time when this research was begining. However, since 1984, the rice situation in Indonesia has changed dramatically. In 1984, the total production of rice was nearly 24 million tonnes, and therefore Indonesia was said to be self-sufficient in rice although the productivity is still relatively low, that is 2.30 tonnes per hectare of milled rice.

Table 1.4

Area, Production, Yield and Imports of Rice and Maize Indonesia, 1968-78[a]

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Rate of growth (%) (ln t)[c]
1. Harvested area (million ha)												
1.1 Rice	8.02	8.01	8.14	8.32	7.90	8.40	8.54	8.62	8.39	8.36	8.89	0.08
1.2 Maize	3.22	2.44	2.94	2.63	2.16	3.43	2.67	2.45	2.10	2.57	3.03	-0.09
2. Production[b] (million tonne)												
2.1 Rice	11.67	12.35	13.45	13.72	13.18	14.61	15.45	15.52	15.15	15.18	16.82	3.11
2.2 Maize	3.17	2.29	2.83	2.61	2.54	2.63	3.01	2.90	2.57	3.14	3.86	2.13
3. Yield[b] (tonne/ha)												
3.1 Rice	1.45	1.54	1.62	1.65	1.67	1.74	1.81	1.80	1.81	1.82	1.89	2.35
3.2 Maize	0.98	0.84	0.96	0.99	1.04	1.08	1.13	1.19	1.23	1.22	1.27	3.62
4. Imports[b] (million tonne)												
4.1 Rice	0.49	0.24	0.32	0.12	0.34	1.86	1.13	0.69	1.30	1.97	1.84	17.90
4.2 Maize	0.00	0.00	0.00	0.00	0.00	0.001	0.001	0.001	0.069	0.014	0.046	0.10

[a] For rice, figures from 1968 to 1975, International Rice Research Institute (1977,p.46) and figures from 1976 to 1978, Biro Pusat Statistik (1979). For maize, Biro Pusat Statistik, In Baharsyah and Suryana (1980).

[b] As milled rice and dried kernel of maize.

[c] Calculated by using the exponential trend, $y=ab^x$ or $\ln y = \ln a + x(\ln t)$.

3.62 per cent per year over the same period. Maize imports also increased dramatically. As Java has approximatelly 6.9 per cent of the total area of Indonesia and 63 per cent of the total population (86.6 million people in 1978), the available natural resources in Java tend to be inadequate. Two major challenges are faced by the Indonesian Government: first, to provide enough food for a rapidly growing population; and second, to absorb the expanding labour force in productive employment. Although 62 per cent of labour force is engaged in direct agricultural production, and significant gains in food output have been achieved in the past 10 to 15 years, Indonesia continues to experience difficulty in increasing food production at a rate sufficient to match demand growth.

With the average size of landholding in Java at 0.66 hectare per household in 1973 (Dinas Pertanian Jawa Timur 1979, p.29), a positively skewed distribution (concentrated on the smaller farm sizes) and a limited potential to expand the arable land area in Java and Madura, the Indonesian Government must look to methods which increase productivity per hectare, rather than emphasizing labour productivity, as has been the case in the developed countries. According to Lains (1979), the possible avenues for improving agricultural productivity are:

(a) improved allocation of resources;
(b) technologically more efficient farming; and
(c) improved tenure arrangements or other agrarian reforms.

Many studies have shown that productivity on farms is generally lower than that in agricultural experiment stations (Hakim 1979). Previous reports by Soekartawi et al. (1979) and Hartoyo and Soentoro (1980) have shown that agricultural productivity in the sample villages of this study was much lower than the national or regional average. It is hypothesized that there are five factors contributing to this problem, namely:

(a) economic factors, such as the profitability of using new technological inputs, fertilizers, seeds and pesticides;

(b) social factors, such as education, family size, rice farming experience and social status;

(c) physical aspects, such as the altitude of farming areas, soil types and availability of irrigation;

(d) institutional factors, such as Government services and tenure relationships; and

(e) information factors (lack of agricultural information so that farmers are reluctant to use such new agricultural technology).

The contribution of these factors to farm productivity is explained in Chapter 4, Section 2. These factors are rather similar to those faced by most farmers in South East Asia (de Datta 1981). The underlying problem is that inefficient farming will negate the positive effects of Government aid through intensification programmes.

The concern by many authors is that the institutional arrangements under which Indonesian agriculture operates leads tc inefficiency in the production of agricultural products and therefore a worsening relative economic position, particularly for tenants aand the landless. The arguments as to the precise causes are not widely agreed to in the literature.

Another important issue which is still being debated is that of efficiency under different types of land tenure. On the one hand, some economists argue that under sharecropping, leasing and other tenancy systems, agriculture operates inefficiently (Adams and Rask 1968, 1969, 1970). On the other hand, others argue that tenant systems are efficient (Boxley 1971, 1972, Cheung 1969, Scott 1970, and Ip and Stahl 1978). Excellent discussions of the development of this conflict have been provided by other scholars (Lucas 1979, Binswanger and Rosenzweigh 1981) and,therefore are not repeated here.

An analysis of these questions can also be useful for Government in formulating policy to increase agricultural production. It can also be useful for extension workers and farmers to improve and to plan the use of inputs in an efficient way. Finally, it can also be used to determine the efficiency problems in the different tenure systems which are related to the Agrarian Reform Act of 1960, particularly Articles 2 and 5 (these articles are also discussed in Chapter 2, Section 3).

Based on the above discussion, it is understandable that Indonesian policy makers are concerned about agricultural food crop production, the inequities in rural development and slow rates of growth in agricultural output.

1.3 Objectives the Study

The major objective of this study is to understand the factors affecting resource efficiency under different farm sizes, tenure classes and farm locations.

Specifically, the study is designed:

(a) to examine the characteristics of farm operations in East Java in terms of their use of technology and to determine the effects of the technology used on output from different farm sizes, under different tenure classes and in different farm locations;

(b) to examine the level of input use for different farm sizes and tenure classes, in the different farm locations, with varying prices of inputs and outputs in order to assess maximum profit, and then to compare actual levels of input use to the optimum and investigate factors affecting the difference;

(c) to compare the technical efficiency, allocative efficiency and economic performance of farmers on farms of different farm sizes, different tenure arrangements and in different farm locations, by using a standard of comparison of efficiency, the relative economic efficiency, and its components (technical and price efficiency);

(d) to examine the likely effects of input and output subsidies on farm profits per unit of output.

(e) to describe the distributional performance of the sample farmers in terms of farm profits and to examine whether or not the distribution of profits is largely determined by the distribution of ownership of operational land holdings and the different levels of farm efficiency.

An analysis of factors affecting the performance of farmers is important to the Government both for policy-making and planning. It is also likely to be important in developing improved intensification programmes.

1.4 Hypotheses for the Study

Given a lack of knowledge regarding the effects of different farm sizes, land tenure arrangements, farm locations and a host of other factors affecting farm profitability, the following main hypothesis is proposed. It is hypothesized that the level of farm efficiency and the optimal (profit maximizing) use of inputs will be the same for different farm sizes, different farm tenure classes and different farm locations. This hypothesis serves as a guide for inquiry into the theory of the farm-firm. Working hypotheses, formulated for achieving the above five major objectives, are provided below. Detailed hypotheses, are introduced at the beginning of each appropriate chapter. The working hypotheses are:

(a) that farm yields obtained by farmers are the same for different tenancy status and regions;

(b) that farmers are equally efficient in technical terms for different tenancy status and regions;

(c) that farmers are equally efficient in economic terms for different tenancy status and regions;

(c.1) that 'small' and 'large' farmers are equal in terms of economic efficiency;

(c.2) that tenants and owners are equal in terms of economic efficiency;

(c.3) that farmers in each of the regions are equal in terms of economic efficiency;

(d) that farm profits per unit of output are not affected by changes in farm wages, the price of seed or price of fertilizer;

(e) that the distribution of farm profits is the same as the distribution of the area under rice and economic efficiency ratings;

(e.1) that the distribution of farm profits is the same as the distribution of the area under rice;

(e.2) that the distribution of farm profits is the same as the distribution of the economic efficiency ratings.

1.5 Organization of the Study

The chapter sequence in the thesis is designed to follow the objectives as set out in Chapter 1. In Chapter 2 the study area and survey method are discussed, and in Chapter 3 a review of the production function and farm efficiency models is provided. This review includes various types of production function and farm efficiency models used in the study.

The analytical framework and techniques used in the study are presented in Chapter 4. In this chapter, factors affecting farm yield and farm efficiency are discussed and then details of the analytical techniques are justified. In Chapters 5, 6, 7, 8 and 9, detailed results of the analysis are described. The partial productivity analysis will be discussed in Chapter 5. Chapters 6 and 7 contain analysis of the technological and economic performance of the sample farms. Chapters 8 and 9 contain an analysis in relation to input and output subsidies and the distributional performance of the sample farms respectively.

The summary, conclusions and policy implications derived from the study will be described in Chapter 10. Some improvements in the methodology of the thesis will be recommended, and several avenues for future reseach concerned with similar problems will also be suggested in Chapter 10.

Finally, some tables and other relevant information concerned with the content of the thesis which are too long to be presented in the 'body' of thesis will be in the Appendices.

1.6 Concluding Remarks

It is clear that the agricultural sector is very important to the economy in Indonesia, particularly in East Java. It is not just in terms of its large proportion of the gross domestic product, but also because it is able to utilize labour, particularly in rural areas. The Indonesian Government has been striving to eliminate the problems of agriculture, but without much success. This thesis aims to shed some light on some of the difficulties being experienced.

Chapter 2

THE STUDY AREA AND SURVEY METHOD

2.1 Introductory Remarks

Details of the study area and survey method are provided in this chapter. Five major aspects of East-Javanese agriculture are discussed; they are, land, water, climate, farm size and land tenure. This discussion is provided so as to help the reader understand the general characteristics of the agriculture. Past problems in agriculture have led the Government to formulate policies which are concerned with increasing agricultural productivity. These policies are also discussed.

In the following section there is a discussion of the survey method including information on the sampling method used for data collection.

2.2 The General Characteristics of Agriculture in East Java

Five major aspects of agriculture in East Java will be considered in the following sections: land, water, climate, farm size and the land tenure system.

2.2.1 Land

East Java is a province of Indonesia, which extends from 7° 12′ to 8° 48′ South Latitude and from 111° to 114° 21′ East Longitude. The province consists of 29 regencies (Kabupaten), 8 municipalities (Kotamadya) and 8,322 villages, which together cover a total area of 47,922 sq.km.

Table 2.1 shows the distribution of land according to its uses. Some 55.5 per cent of the total area of East Java is used for agriculture. The remaining area is used for: settlements, 13.4 per cent; 25.4 per cent, forestry; and 5.7 per cent, various other uses. These figures indicate that the land area of East Java is used mainly for farming purposes. This is supported by the population figures which show a higher population density for rural than for urban areas. Some 22 million or 80 per cent of the total population of East Java in 1977 lived in rural areas.

The land in East Java can also be categorized, according to its topography, into lowland and upland areas. The lowlands, which have an average slope of 0 to 25 per cent, comprise 61 per cent of the total. The remaining upland area, which has an average slope of more than 25 per cent, comprises 39 per cent of the total (Dinas Pertanian Jawa Timur 1978).

Table 2.1

Land Use in East Java, 1978

Land use	Area ('000 ha)	%
1. Agricultural areas		
1.1 Ricefields	1247.4	26.0
1.2 Dry land	1187.7	24.8
1.3 Estate plantations	164.3	3.4
1.4 Yards	43.1	0.9
1.5 Vegetable areas	18.9	0.4
2. Forest areas		
2.1 Forest land	797.6	16.7
2.2 Protected forest land	400.2	8.4
2.3 Sedge-grasses	10.3	0.2
3. Settlement and unproductive land[a]		
3.1 Settlement	641.8	13.4
3.2 Unproductive land	162.3	3.3
4. Other uses		
4.1 Tanks and dams	31.9	0.7
4.2 Lake and swamp areas	20.2	0.4
4.3 Ponds and salt-making areas	29.6	0.7
4.4 Land for non-agricultural activities	36.9	0.7
Total	4792.2	100.0

[a]Land cannot be cultivated because, for example, it contains too much rock and sand.

Source: Dinas Pertanian Jawa Timur (1978).

2.2.2 Water

As well as the topography, the availability of water in part determines the potential of the land. Irrigated land is usually of better quality than non-irrigated land. There are five main rivers which can be used to irrigate farm areas in East Java. These rivers are the Sampeyan and Bondoyudo in the east, the Brantas in the middle and south, the Madiun in the west and the Solo in the north. Three big dams (the Proyek Brantas, Wlingi and Selorejo) have been built on the Brantas river mainly for irrigation purposes. By having these dams, the irrigated areas can be used for rice farming 2 or 3 times per year. In 1978, some 1.25 million hectares (26.2 per cent relative to the whole area of East Java) was irrigated land.

Agricultural land in East Java, and particularly in the three regencies in this study area, can also be categorized into irrigated (water available throughout the year) and non-irrigated land as shown in Table 2.2. The overall figures in Table 2.2 show that the proportion of non-irrigated land is higher than irrigated land. The Regions 1 and 2 (in the regencies of Ngawi and Jember) have almost equal proportions of irrigated and non-irrigated with over 80 per cent irrigated (detailed data on the sample villages is presented in Table 2.8). The other village, in Region 3 (in the regency of Trenggalek), has a small proportion of irrigated land. Accordingly, the major crops grown in the lowland villages are rice, soybeans and maize, while in the upland village, maize and cassava are grown. Rice is also grown in the sample village in Region 3, particularly along the small river valley of this village.

2.2.3 Climate

Readings on four climatic variables, namely, temperature, humidity, raindays and rainfall were collected in East Java over 10 years (from 1969 to 1978) and were used to determine the general characteristics of the climate in the study area.

East Java has two seasons, a wet season (from October to March) and a dry season (from April to September). The temperature and humidity is relatively stable throughout the year. The average monthly temperature

Table 2.2

Average Size and Percentage of Agricultural Land in East Java and Three Sample Regencies for Sample Villages, 1973-78

Place	Irrigated ricefield	Non-irrigated	Total area
	('000 ha)		
1. Province of	861.6	1962.2	2823.8
East Java	(30.5)[a]	(69.5)	(100.0)
2. Regencies of:			
2.1 Ngawi	41.4	44.2	85.6
(Region 1)	(48.4)	(51.6)	(100.0)
2.2 Jember	69.6	66.8	136.4
(Region 2)	(51.0)	(49.0)	(100.0)
2.3 Trenggalek	11.1	46.9	58.0
(Region 3)	(19.1)	(80.9)	(100.0)

[a]Figures in brackets are percentages of the respective total areas.

was about 26 to 28 °C and the average monthly humidity was about 61 to 77 per cent. However, the rainfall was not so consistent between seasons. In the wet season, rainfall averaged 214.0 mm per month over 12 raindays and in the dry season, rainfall was 43.9 mm over 5 raindays. The highest rainfall was in January (313.5 mm over 15 raindays per month) and the lowest was in July (7.1 mm over 3 raindays). Details of the climatic data are presented in Table 2.3.

2.2.4 <u>Farm Size</u>

Because farm size and tenure in different locations are important to the study, it is necessary to first review the situation in Java so as to gain a perspective on East Java. The whole of Java was chosen because the situation in East Java is not unlike that in the rest of Java and suitable data were available for comparisons over time.

Since independence in 1945, two agricultural censuses have been held in Indonesia, in 1963 and 1973. A summary of the average land areas derived from these censuses is shown in Table 2.4. This table shows average land holdings over 10 years. During this period there has been a tendency for the numbers in medium to large sizes to decrease, and those in small size groups to increase. The net effect has been a decline in the average area of holdings. In Java the changes over 10 years do not show such a clear pattern.

The situation in 1905 and 1973 are compared in Table 2.5 for Java. In 1905, the small group (31 per cent) owned an average of 0.27 hectare, the medium group (41 per cent) an average of 0.63 hectare, and the large group (28 per cent) an average of 2.2 hectare. A comparison of these figures with those of 1973 indicate that there has been a 17 per cent and 11 per cent decline in the large and medium groups respectively, whereas the number in the small group has increased by 28 per cent. On the other hand, it was surprising to note that the average land holding of the medium group increased while the average area of holding for the small group decreased slightly. These observations raise the question of whether or not farming is more efficient and profitable in small and medium sized farms than larger farms. This question will be examined in

Table 2.3

The Average Climatic Data for 10 Years, East Java, 1969 to 1978[a]

Month	Temperature (°C)	Humidity (%)	Raindays	Rainfall (mm)
January	27.2 (0.63)[b]	77.7 (3.50)	15 (3.93)	313.5 (191.11)
February	27.2 (0.63)	77.2 (3.33)	13 (3.08)	223.6 (119.43)
March	27.1 (0.57)	78.5 (3.84)	15 (2.50)	218.3 (73.76)
April	27.3 (0.68)	73.8 (4.49)	9 (3.21)	153.3 (96.92)
May	27.6 (0.70)	73.6 (4.99)	9 (4.44)	115.7 (67.55)
June	27.0 (1.25)	72.5 (4.45)	5 (3.56)	50.6 (44.75)
July	26.1 (0.74)	68.1 (3.54)	3 (3.59)	17.0 (17.32)
August	26.5 (0.85)	65.5 (4.60)	1 (2.24)	7.1 (15.51)
September	27.6 (0.97)	65.0 (2.58)	3 (2.30)	26.7 (33.91)
October	28.1 (1.20)	61.4 (9.65)	5 (3.77)	46.0 (49.01)
November	28.6 (0.97)	68.5 (5.84)	8 (4.10)	157.3 (67.40)
December	27.6 (0.84)	73.5 (4.91)	15 (2.57)	217.9 (56.40)

[a]Data from 1969 to 1974, from Pemda Jawa Timur (1975); and data from 1975 to 1978, from Biro Pusat Statistik (1979).

[b]Figures in the parentheses are a standard deviations of the respective figures.

Table 2.4

Average Land Holding in Indonesia Calculated from Agricultural Census Data, 1963 and 1973

Item	Farm size (ha)	1963 No. of farmers (%)	1963 Land holding (ha)	1973 No. of farmers (%)	1973 Land holding (ha)
1. Small	0.10-0.50	41.4	0.27	43.5	0.27
2. Medium	>0.50-1.00	28.8	0.67	27.4	0.66
3. Large	>1.00	29.8	2.34	29.1	2.21

Source: Calculated from Table 5 and 6 of Team Analisa Sensus Pertanian (1977).

Table 2.5

Average Land Holding in Java, 1905 and 1973

Item	Farm size (ha)	1905 No. of farmers (%)	1905 Land holding (ha)	1973 No. of farmers (%)	1973 Land holding (ha)
1. Small	0.10-0.50	31	0.27	59	0.25
2. Medium	>0.50-1.00	41	0.63	24	0.70
3. Large	>1.00	28	2.20	17	1.80

Source: Sayogyo (1978).

detail later in the study. The main reason for the increase in the small group was the high population pressure in Java, which resulted in smaller land holdings. The population grew by 1.5 per cent per year from 1930 to 1961, and by another 2.1 per cent per year from 1961 to 1971 (McNicoll and Mamas 1978).

2.2.5 Land Tenure System

The land tenure system in Indonesia, particularly in East Java, is very complex. This results, in part, from the colonial farming system developed during the Dutch occupation of Indonesia over a period of 350 years. According to Wiradi (1978) the colonial Agrarian Law of 1870 gave rise to a dual system in which the traditional land rights for Indonesians, based on customs (adat), existed side by side with Western land rights based on concepts appropriate for investors. This latter approach created the potential for free selling or leasing of land, because heritable individual possession could be transformed into a 'property' or eigendom system. It was actually aimed at creating an environment more suitable for private enterprises to obtain land.

In an attempt to come to terms with the complexities of land tenure, the Indonesian Government through the Agrarian Law of 1960 termed Undang Undang Pokok Agraria (UUPA) and the Sharecropping Act termed Undang Undang Pokok Bagi Hasil (UUPBH), brought in regulations for land tenure. The Agrarian Law aimed to unify the dual system and abolish the colonial Agrarian Law of 1870. The Agrarian Law of 1960 was based on heritable individual possession with individual rights over land, and freed the holder from communal restrictions. On the other hand, the Sharecropping Act aimed at creating more just sharecropping relationships and a better position for sharecroppers (Gautama and Badwi 1973; Utretch 1969).

The above situation has lead to the following classes of farm population:

(a) Owner-cultivator or proprietor who has full property rights and cultivates a small sized holding, mainly with the help of family labour and a small amount of hired labour. He may also be a tenant.

(b) Non-owner cultivator who may be a tenant or a casual labourer.

(c) Non-cultivating owner.

There are no figures showing the number of owners, tenants and mixed cultivators (owner, but also tenart) based on the corresponding size classification shown previously. The available data, as shown in Table 2.6, are figures according to different farm sizes, that is, less than 0.25 hectare, from 0.25 hectare to 0.50 hectare, and more than 0.50 hectare.

The high percentage of owner-cultivators is not surprising. In general, the situation of land holding in East Java is better than in Indonesia as a whole in the sense that there is a higher proportion of owner-cultivators. That the number of tenants decreases as farm size increases is also not surprising because small farmers are more willing than large farmers to be tenants. On the other hand, the high percentage of mixed farmers when farm size increases is interesting.

2.3 Government Policies Arising Out of the Problems of Farmers

A vast number of agricultural programmes have been implemented by the Indonesian Government. To understand these programmes the following discussion outlines the major policies concerned with organizing farm structure and increasing farm productivity.

The main policy dealing with the organization of farm structure was outlined in the Agrarian Law of 1960. Article numbers 7, 10 and 17 of the Basic Agrarian Law of 1960 were policies concerned with making farm holdings more equal. These articles set out the maximum and minimum permissable size of land holdings, either by resident owners or absentee owners. The maximum was made dependent on the population density of the

Table 2.6

Number of Owner, Tenant and Mixed Cultivators in Indonesia and East Java, 1980

Item	Farm size (ha)	Percentage of total: Owners	Tenants	Mixed	Total	Total farm households (million)
		Indonesia				
Small	<0.25	70.5	18.5	11.0	100.0	6.26
Medium	0.25-0.50	69.1	18.4	12.5	100.0	5.06
Large	>0.50	76.6	7.9	15.5	100.0	6.44
		East Java				
Small	<0.25	81.3	14.6	4.1	100.0	1.35
Medium	0.25-0.50	75.8	13.8	10.4	100.0	1.10
Large	>0.50	76.4	5.7	17.9	100.0	1.09

Source: Calculated from Table 15, Biro Pusat Statistik (1981).

Table 2.7

Maximum Permitted Area in Indonesian Farm Businesses

Population density	Ricefields	Dryland
	(ha)	
1- 50 inhabitants per sq.km	15	20
51-250 inhabitants per sq.km	10	12
251-400 inhabitants per sq.km	7.5	9
Over 400 inhabitants per sq.km	5	6

Source: The Agrarian Law 1960, Appendix 4, Article No.1.

region, whilst the minimum for every peasant family was 2 hectare of arable land. Table 2.7 delineates maximum areas permissable, including land lease, sharecropping and gade or pawning.[1]

In East Java, where the population density is more than 400 inhabitants per sq.km (644 for Java and 575 for East Java in 1977), the maximum land holding is 5 hectare of irrigated ricefield or 6 hectare of non-irrigated land. Although the minimum landholding in Java was stated as being 2 hectares of arable land, this is not representative of the present situation. The average land holding in Java in 1973 was 0.7 hectare. The maximum and minimum areas outlined in the Agrarian Law 1960 have been subject to criticsm, for example, by Utretch (1969) and Ladejinsky (1977). This criticsm was directed at revision of the Agrarian Law, particularly in relation to the maximum and minimum areas which no longer seem to be relevant to the current situation.

Another policy, concerned with more equal distribution of the land, is in Government Regulation no. 41, 1964, Article 3d. This regulation states that the sale of land by residents to outsiders in one sub-district (Kecamatan i.e administrative district) is prohibited. This policy encourages more equal distribution of land within subregions.

The Government policies concerned with increasing farm productivity have been mainly concentrated on the intensification programme (Departemen Pertanian 1979). This programme has the objective of increasing farm productivity by more efficient resource use. It is implemented through the schemes called Bimas, Inmas and Insus. Bimas or 'mass guidance' is an agricultural intensification programme providing farmers with a package of inputs, including fertilizers and credit. Bimas embodies three principles:

(a) the ideology of modern farming;

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[1]Pawning is the same as cash rental. Pawning can be used for longer-term loans than would normally be the case with cash renting, although there is an incentive to repay principal quickly. For example, a small farmer, due to the limited size of his holding, and having no money or capital with which to operate, pawns his land to another person who is often a wealthier farmer and who can then buy the necessary production inputs to use the land.

(b) credit to purchase a package of improved inputs and to hire labour; and

(c) intensive guidance for participating farmers.

The following section provides a discussion of the above principles. The ideology of modern farming is known as Panca Usaha (five efforts), that is:

(a) proper soil preparation;

(b) improved seed varieties;

(c) proper irrigation;

(d) use of fertilizer, either chemical or green manure; and

(e) the use of pesticides.

The intensification programme has been important since 1968/69 when the Indonesian Government set up the first Five-Year Year Development Plan. Bimas concentrated on improving not only rice productivity, but also other food-crop production such as cassava, maize and soybeans. This programme appears to have been very successful in increasing agricultural food production in Indonesia. For example, average rice production per year for the periods 1960-65, 1965-70 and 1970-75 was 8.5, 9.9 and 14.3 million tonnes of milled rice, respectively. The growth rates of production over the same period were 0.24 per cent, 6.6 per cent and 3.1 per cent, respectively (Republik Indonesia 1981).

Inmas or 'mass intensification' is an agricultural intensification programme providing farmers with agricultural extension services. Thus, farmers who were members of the Bimas programme, and had successfully used the programme for several years, were able to manage and to finance their farming, they could then join another programme, called the Inmas programme. This scheme also seems to have been successful. For instance, the harvested rice area at the begining of Repelita I (under the Inmas programme), was only 821 thousand hectares, whereas in 1977 it was 2,173 thousand hectares--an increase of 265 per cent over 8 years (Departemen Pertanian 1979).

Insus or 'special intensification' is the equivalent of the Bimas in relatively small areas, and is more closely supervised. This programme has shown surprising results. For instance, in the dry season of 1979 the rice yield under this programme was 5.46 tonne of milled rice per hectare; then in the wet season of 1979/80, the dry season of 1980 and the wet season 1980/81, it was 4.28 tonne of milled rice per hectare, 5.85 tonne of milled rice per hectare and 5.49 tonne of milled rice per hectare, respectively (Sukirno 1981). This programme was implemented in a particular area and needs to be expanded to the large areas of irrigated-rice. This is an aim of the Government.

In order to accelerate the intensification programmes, the Indonesian Government has set up various agrisupport policies, such as providing agricultural credit, agricultural extension services, an agricultural marketing board, agricultural price policies, irrigation and agricultural research.

2.4 Survey Method

2.4.1 Selection of the Study Area

This study uses data from the Rural Dynamics Study which was carried out in East Java in the crop seasons of 1978. The reasons for using these data are:

(a) the data are detailed and provide information on farm management and labour utilization;

(b) data were collected by 8 to 10 specially trained people, either domestic (Rural Dynamics Study, Brawijaya University and Jember University) or foreign.[1]

The Rural Dynamics Study group is a research unit which operates under the Agro Economic Survey of Indonesia. It has carried out data collection in connection with its research in the four central provinces of West Java, Central Java, East Java and South Sulawesi. Its research

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[1]The author was a member of the team and a principle researcher for this project and was involved from the begining to the stage of analysing the data.

has concentrated on the most important problems which were faced by the Government in fostering rural development.

Begining in the crop year 1977/78, the Agro - Economic Survey developed the project of the Rural Dynamics Study to study problems of farm production, farm and rural incomes, rural employment, rural institutions and their relationship to income distribution in East Java. Six villages in the area of East Java were chosen on the basis of the following factors:

(a) forms of production studied should be those which are the largest in East Java, for example, irrigated land, non-irrigated land, brackish water land and fishing ground areas;

(b) the important commodities, such as rice, maize, cassava, soybeans, sugarcane and tobacco should be considered; and

(c) all sample villages should have been researched previously (by the Agro - Economic Survey or by scholars who would be involved in this study).

Detail of these considerations and the research method used have been reported by the Rural Dynamics Study team (Soentoro and Hartoyo 1979).

2.4.2 Sampling Method and Data Collection

Currently there are five development regions in East Java, two of which will not be considered in this study. These two are Region 4, which is situated in the north and centre on Surabaya (the capital city of East Java), and region 5 which was used for industrial purposes and covers Madura Island, an area with pond and fishery production (detailed information concerning the regional development of East Java can be seen in Bappeda 1979).

The three sample villages chosen for investigation in this study, were located in the remaining regions, that is, Gemarang (Region 1, Ngawi Regency), Sukosari (Region 2, Jember Regency) and Petung (Region 3, Trenggalek Regency). These three villages are situated in the irrigated lowland, irrigated semi-highland and irrigated highland, respectively. The descriptions of lowland, semi-highland and highland are arbritary and are defined largely on their altitude. The location of the study area is shown in Figure 2.1.

These three villages were investigated before this study was carried out. Gemarang and Sukosari were investigated under 'the Intensification of Ricefields Study' which was carried out by the Agro-Economic Survey in 1974 and Petung was investigated by Soekartawi et al.(1979) under 'The Marginal Areas Study' in 1977. Each village had been randomly sampled in the previous study and therefore, in this study, the villages were selected again. Each village was considered as typical of the regional development of East Java. The village of Gemarang is located in Region 1 which is situated less than 200 metres above sea level in the 'irrigated lowland areas' of the west. Agricultural production in this region is primarily food crops; mainly rice and soybeans. The village of Sukosari is located in Region 2 which is situated from 200 to 500 metres above sea level in the 'irrigated semi-highland areas' in the east. Agricultural production in this region is primarily for food crops such as rice, maize and cassava, or cash crops such as tobacco. The village of Petung, which is located in Region 3 in the south, covers mostly 'highland areas', more than 500 metres above sea level. Agricultural production in this area is primarily secondary crops, such as cassava and maize.

The main characteristics of the sample villages are presented in Table 2.8. From this table, three things can be observed:

(a) the lower the altitude of the village, the greater the population and number of households;

(b) the lower the altitude of the village, the closer it is to the regency capital and thus to the main sources of information; for example, agricultural information and services; and

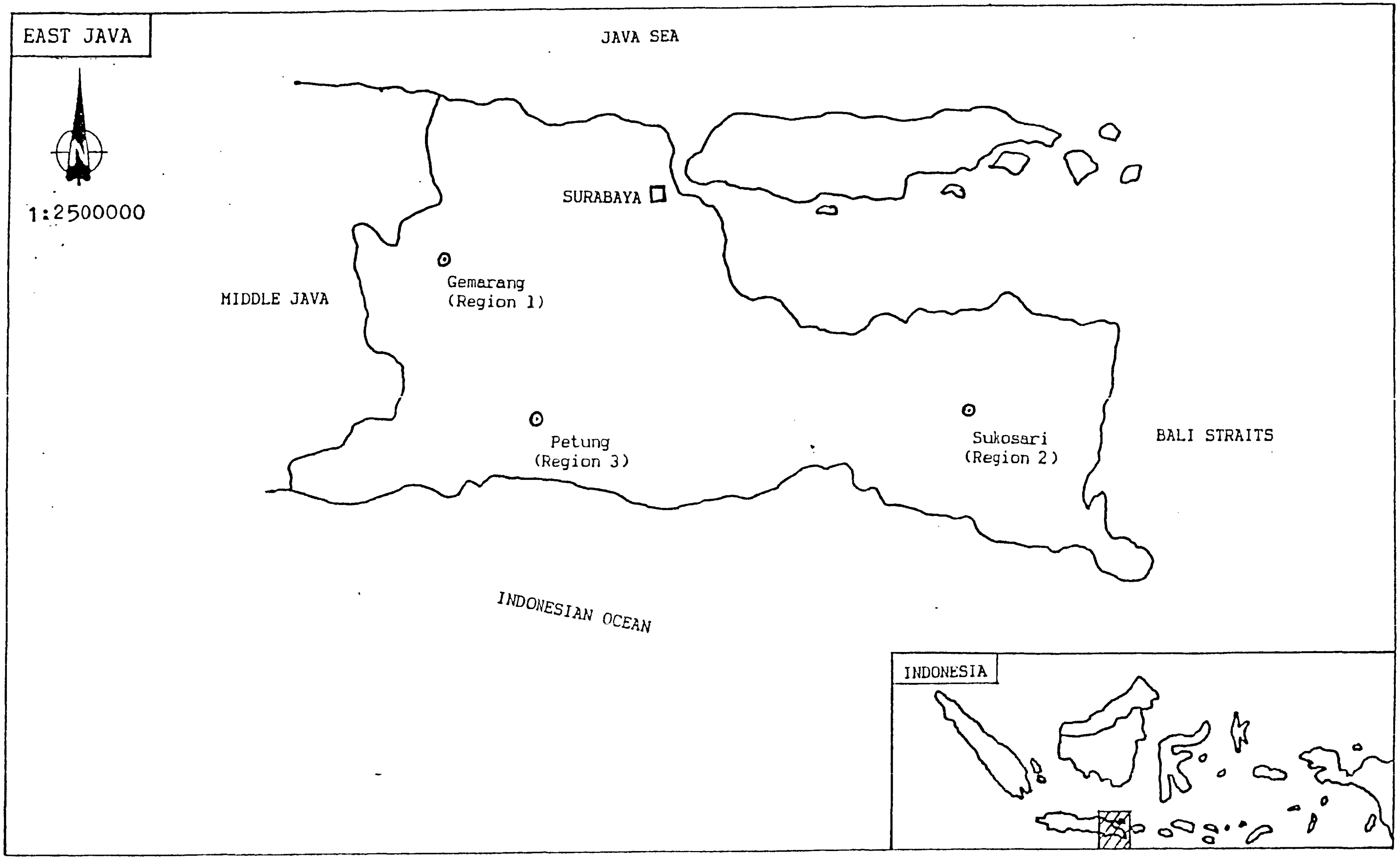

Figure 2.1 Location of the three sample villages in East Java.

Table 2.8

Description of the Three Selected Villages, East Java, 1978

Item	Village		
	Gemarang	Sukosari	Petung
1. Location	Region 1	Region 2	Region 3
2. Height above sea level (m)	90	313	682
3. Distance to respective regency capital (km)	12	32	43
4. Population (persons)	7541	6444	3127
5. Population density (persons/sq.km)	636	1516	246
6. No. of households	1736	1327	516
7. Person per households	5	5	6
8. Area of agricultural-land (ha)			
8.1 Irrigated	977	341	90
	(82.3%)	(80.2%)	(7.1%)
8.2 Non-irrigated	210	84	1182[a]
	(17.7%)	(19.8%)	(92.9%)
8.3 Total	1187	425	1272
	(100.0%)	(100.0%)	(100.0%)

[a]Including forest land.

Source: Village office.

(c) the lower the altitude of the village, the greater the amount of irrigated land which indicates a greater potential.

For the Rural Dynamics Study there were two types of data collected by survey methods. The first, a partial census, and the second, a survey of sample farm-households. In the partial census, a questionnaire was prepared to obtain information from each of the sample households regarding (see Appendix A for the questionnaire):

(a) farm size and its tenure status;

(b) production factors (for example, current expenses and labour);

(c) occupations of the household head and members;

(d) housing;

(e) assets;

(f) income and expenditure;

(g) participation in rural institutions; and

(h) other characteristics of family dependants.

The census produced about 300-500 farm households per village from which to draw samples. To select these samples, local communities were selected by cluster random sampling and then each farm household was treated as a unit of analysis (the local communities are known as Rukun Tetangga which consist of about 20 to 200 farm households). Sample farm households were then selected on the basis of proportionate random sampling which resulted in 255 sampled farm households. This number included 47 landless labourers who, for the purposes of this study, were disregarded. The remaining 208 farmers were used as samples for the study. About 143 out of 208 farmers had irrigated rice and were used as sample farms for the study. The total number of sample ricefarms in the dry season of 1978 was 101. The decrease in the number in the sample (from 143) was due to various reasons, including leaving the area, changing from rice growing, death, etc. The distribution of samples in the three villages is presented in Table 2.9.

A questionnaire was prepared in order to survey farm households and obtain more information regarding the above eight main variables (Appendix B). The data used in this study was mainly the data collected from the sample survey questionnaires for each season. Additional data series were gathered from Government Offices. Immediately after the interview, the enumerators transfered the data onto a coding form and sent it to Jakarta for computerized data entry. Since the sample survey data had not been edited in time for use in Australia the unedited questionnaires were shipped to Australia along with a computer tape in February 1981. This permitted detailed editing and checking of the data in Australia.

To account for inconsistencies in the data and extreme values, additional information was sought by sending the enumerators back to the field. A FORTRAN programme (Appendix C) was used for this purpose. The major sources of inconsistency in the data were errors in simple calculations which were previously done manually, for example, addition, subtraction, multiplication or division. Using the computer programme presented in Appendix C, such inconsistencies were easily discovered and corrected. A number of deficiencies of such a data collection should be noted. These include problems of recall over a period of time by respondents, very limited records on financial transactions, a degree of scepticism on the part of respondents as to the purpose of the survey and the usual interviewer biases. Attemps were made to keep such errors to a minimum but such survey methods are inevitably a somewhat imprecise instrument.

2.5 Concluding Remarks

The general characteristics of agriculture in East Java, Government policies arising out of the problems faced by farmers and details of the study area and survey methods used have been discussed in this chapter. It is apparent that the Government has tried to implement programmes

Table 2.9

Distribution of Samples in the Study Area, East Java, 1978

Farm size*	Season	Gemarang (Region 1)	Sukosari (Region 2)	Petung (Region 3)	Total
		Samples by farm size			
Small		29	29	42	100
Large		41	36	31	108
Total		70	65	73	208
		(46)	(51)	(46)	(143)
		Samples by farm size and season			
Small	Wet	6	15	21	42
	Dry	5	13	10	28
Large	Wet	40	36	25	101
	Dry	34	26	13	73
Total	Wet	46	51	46	143
	Dry	39	39	23	101

(Village: Gemarang, Sukosari, Petung)

*The definition of 'small' and 'large' farms can be seen in Appendix E. Figures in parentheses are sample rice-farmers.

designed to solve some of the problems farmers face. Despite all the various efforts, however, many of the major problems, indicated in Chapter 1, have not been solved. Therefore it seems worthwhile examining, both descriptively and analytically, some of the connections between aspects of productivity of farms and the incomes derived from them. Some 143 sample rice-farmers of 208 sample households in three villages in different regions have been selected as a basis for the study. The techniques of production economics will be used to examine some of the relationships involved and test the various hypotheses outlined in Chapter 1.

Chapter 3

MODELS FOR ASSESSING FARM EFFICIENCY: A REVIEW

3.1 Introductory Remarks

The nature of, and the need for, production functions have been discussed in many studies of agricultural problems, for example Heady and Dillon (1961, Ch. 1). The production function is basically a physical or biological relationship. It is usually used to relate some variation of output resulting from changes in the use of inputs used. A production function can be expressed as a mathematical relationship between the quantity of some measured output and the quantity of input used. If Y is output, X_i is the i-th input and Y requires n different types of inputs; the production relationship can be written as follows:

(3.1) $$Y = f(X_1, X_2, \ldots, X_n).$$

The production function can also be used to analyse the problems of resource allocation and farm efficiency. A considerable number of techniques for constructing models of resource allocation and farm efficiency have been derived from production functions developed during the past fifty years. These have varied widely in purpose and extent of sophistication and have been developed on the basis of classical, neo-classical and modern economics. Furthermore, the intent and analytical content of the models have varied from the normative approach to the positive approach, and from simple models to complex dynamic models.

This section contains a review of some models concerned with theories of resource allocation and farm efficiency. It also presents a survey of the major methodologies developed by various researchers and discusses the strengths and weaknesses of their approaches. The final section, deals with the models used in this study.

3.2 Production Function Models

There are many different types of production functions. This section describes the major types used. These are the constant elasticity of substitution (CES), quadratic, transcendental, translog and Cobb-Douglas. These functions have been discussed extensively in the standard literature of production economics; for example Heady and Dillon (1961), Walters (1963), Nerlove (1965), Dillon (1977), and Dillon and Hardaker (1980).

3.2.1 Constant Elasticity of Substitution (CES)

The CES production function proposed by Arrow et al. (1960) is now widely used in agricultural research. When the true production function is CES with constant returns to scale, the value of the elasticity of substitution is constant and can be estimated easily. When two inputs are used, the CES function can be written as follows:

$$(3.1) \qquad Y = \gamma[\delta K^{-p} + (1 - \delta)L^{-p}]^{-1/p},$$

where Y is output, γ is an efficiency parameter ($\gamma > 0$), δ is a distribution parameter ($0 < \delta \leq 1$), K is capital input, L is labour input and p is a substitution parameter ($p \geq -1$).

Equation (3.1) has been modified by Lu and Fletcher (1968) and Soskice (1968). The modified version of the CES (Lu and Fletcher) is called the variable elasticity of substitution function (VES). This can be written as follows:

$$(3.2) \qquad Y = \gamma[\delta K^{-p} + (1 - \delta)\eta\ (K/L)^{-c(1+p)}L^{-p}]^{-1/p}.$$

where η and c are constants. Equation (3.2) has the properties of positive marginal products, downward sloping marginal product curves over the relevant ranges of inputs, and homogeneity of degree one. A limitation of this model is that it becomes unmanageable when the number of inputs is more than two.

3.2.2 Quadratic

The simple quadratic function with a single input, X, may be written as follows:

$$Y = a_0 + bX + cX^2 + u, \tag{3.3}$$

where Y is output, a_0 is the intercept, b and c are parameters to be estimated, X is the input, and u is the disturbance term. To be relevant for economic analysis, the coefficient of b should be positive and larger in absolute terms than the coefficient of c, and the coefficient of c should be negative. Unlike the Cobb-Douglas production function, the production elasticity of the quadratic function is not constant but declines with the input levels.

3.2.3 Transcendental

The general functional form of transcendental functions with two inputs may be written as follows:

$$Y = AX_1^{b_1} e^{c_1 X_1} X_2^{b_2} e^{c_2 X_2} + u, \tag{3.4}$$

where Y is output, A is the intercept, X_1 and X_2 are inputs, b_1, b_2, c_1, c_2 are parameters to be estimated, and u is the disturbance term.

The transcendental function becomes a Cobb-Douglas function when parameters c_1 and c_2 are not significantly different from zero. When Halter et al.(1957) initiated the development of this model, they found that the transcendental production function was useful in describing data that showed the three traditional phases of the marginal product curve (increasing, decreasing and negative marginal products). The disadvantage of this function is that if the value of a single input, X, is zero, then Y will also be zero.

3.2.4 Translog

The translog function with two inputs may be written as follows:

$$(3.5) \qquad \ln Y = \ln A + b_1 \ln X_1 + b_2 \ln X_2 + b_3(\ln X_1 \ln X_2) + u,$$

where Y is output, A is the intercept and b_1, b_2, b_3 are parameters to be estimated, X_1 and X_2 are inputs, and u is the disturbance term. The translog function becomes a Cobb-Douglas function when parameter b is not significantly different from zero. Recent developments of this model have shown that its flexibility is useful in estimating production relationships. Christensen et al.(1973) developed the translog function and have shown how various restrictions can be imposed and thus statistically tested. This model has also been modified by Ranade and Herdt (1978) who replaced $b\ (\ln X_1 \ln X_2)$ in equation (3.8) with $b\ (\ln X_1 - \ln X_2)^2$.

3.2.5 Cobb-Douglas Production Function

The Cobb-Douglas production function may be expressed as follows:

$$(3.6) \qquad Y = AX_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} e^u,$$

where Y is output, $X_1, X_2, \ldots, X_n$ are inputs, $b_1, b_2, \ldots, b_n$ are production elasticities, A is the intercept, e is the exponential function, and u is the disturbance term.

Equation (3.6) may also be written in a logarithmic form as shown in equation (3.7).

$$(3.7) \qquad \ln Y = \ln A + b_1 \ln X_1 + b_2 \ln X_2 + \ldots + b_n \ln X_n + u.$$

Thus, the Cobb-Douglas production function is linear in the logarithms and can be estimated by ordinary least squares. The sum of the production elasticities indicates the returns to scale and will be increasing, constant or decreasing if $b > 1$, $b = 1$, or $b < 1$, respectively. The average product (AP) and marginal product (MP) of a Cobb-Douglas production function with respect to input i can easily be calculated as follows:

$$AP_i = Y/X_i \text{; and}$$
$$MP_i = b_i Y/X_i.$$

In the case of the Cobb-Douglas production functionwhen the sum of the production elasticities is equal to unity, it is a linearly homogeneous function of degree one. Given the condition of a linearly homogeneous function of degree one, and following Euler's theorem, the production elasticies then represent respectively, the relative factor shares of the respective inputs in the total product.

Because of the merits of the Cobb-Douglas production function such as simplicity, readily estimated elasticities and measures of returns to scale (Heady and Dillon, 1961 p. 25), and given the objectives of this study, the Cobb-Douglas production function was therefore chosen as a functional form with which to estimate the relationship between output and inputs. As well, it was possible to readily compare the estimates obtained to the work of others who have used the same functional form. These advantages have also been discussed in the literature, for example, the studies of Walters (1963), Nerlove (1965), Dillon (1977), Saini (1979), Dillon and Hardaker (1980). However, the Cobb-Douglas production function suffers from the disadvantage that if one of the inputs equals zero the output will also be zero. A further disadvantage of the Cobb-Douglas production function is that it is undefined if there are zero or negative observations in the data. This is because the logarithm of zero or negative numbers will be undefined. Further, care should be taken when the Cobb-Douglas production function is applied using cross-section data. The problems of specification, unobserved variables, multicollinearity, and measurement errors can impact on the estimated results. these disadvantages have also been discussed in the literature, for example, Sau (1971), Anderson and Johda (1972), and Rudra (1973).

Only a few researchers have applied the Cobb-Douglas production function to the agricultural problems of Indonesia. Nurdin (1974) fitted individual crop (rice) production functions to farm management data collected in West Sumatra. He found that the variable, land, had a high production elasticity, which indicates that land is a more sensitive variable for rice farming, particularly in West Sumatra. Sawit and Nurmanaf (1980) used land, working capital, fixed capital and labour inputs to explain farm output (quantity of rice) from four villages in West Java. They found that the variable land had the highest coefficients (more than 0.65) compared with other inputs. However, as some of the coefficients of the other inputs were negative these findings are subject to criticism. In evaluating the above studies Soekartawi (1981b) argued that the negative production elasticities may have been generated by factors not considered in the model. Asnawi (1981) fitted labour, fertilizer, other working capital and water depth as inputs to the farm output of rice in West Sumatra. He also fitted zero-one dummy variables for tenure status, irrigation, crop damage and education of the farm operator to the farm yield of rice. He found that all regression coefficients had correct signs and were significantly different from zero, even though the adjusted R^2 was only moderate (adjusted R^2 = 0.45).

The use of the Cobb-Douglas production function, has been extensive in less developed countries such as India. For example, Hopper (1965), Chennareddy (1967), Sahota (1968), Dillon and Anderson (1971) and Saini (1979). Saini fitted both individual and aggregate crop production functions to farm management data collected in the Punjab and Uttar Pradesh. He used land, human labour, bullock labour, farm manures and fertilizers, and irrigation cost to explain the variability of farm output. In the case of aggregate production functions, he derived a 'macro function' from several 'micro-variables' by using an arithmetic technique assuming that inputs could be perfectly substituted for other inputs and outputs with outputs. This technique was also applied by Chandra (1976) to Fijian agriculture. Chandra fitted gross output as a dependent variable and land, fixed capital, labour and other working capital as independent variables. Zero-one dummy variables were included to determine the yearly effect, as well as for two groups of farmers and the farming environment.

Other recent studies carried out in other less developed countries using the Cobb-Douglas production function have been Gautam's (1973) study of allocative efficiency in Nepalese farming and Huang (1975) in Malaysian farming and Hossain (1977) in Bangladesh farming.

The Cobb-Douglas production function enables farm efficiency to be easily estimated for different regions and for different farm sizes. However, it should be noted that before choosing this model, several factors had to be considered. These included prior knowledge of input-output relationships from studies using similar functional forms in the surrounding areas (particularly in Java), the available data, and the statistical and economic interpretation of the estimates which would result.

The Cobb-Douglas production function has been used extensively for single product systems, for example rice or maize. Major reasons for its widespread use are because of its convenience in estimating elasticities of production and because it is simple and fairly manageable from an estimation point of view.

3.3 Farm Efficiency Models

For the purposes of this section, models designed specifically to obtain estimates of the efficiency of resource use will be considered in this section. Farm efficiency models may be classified into two broad categories, the frontier efficiency models and the non-frontier efficiency models.

3.3.1 Frontier Efficiency Models

An excellent survey of frontier production functions and their relationship to efficiency measurement has been provided by Forsund et al. (1980) and Kopp (1981). From their surveys, these models may be classified into two broad categories. These are: measuring farm efficiency from production functions; and using the duality approach through cost functions. The following sections represent a summary of some of that material.

(a) The Frontier Production Function Approach

There is a vast quantity of literature on measuring farm efficiency which uses the frontier production function approach, and this can be classified into four types:

(a) deterministic non-parametric frontiers;
(b) deterministic parametric frontiers;

(c) deterministic statistical frontiers; and

The first approach, known as the deterministic non-parametric frontier approach is largely based on the work of Farell (1957) who used the Cobb-Douglas production function. Farrell's model has been further developed by others, such as Farrell and Fieldhouse (1962), Seitz (1970, 1971), Boles (1971) and Afriat (1972).

Farrell (1957) hypothesized that economic efficiency could be split into two components reflecting physical efficiency of the input-output production transformation (technical efficiency), and the pricing efficiency of factor allocation (allocative efficiency). For example, technical efficiency can be measured by calculating a technical efficiency index, while allocative efficiency can be measured by the degree to which the marginal value products of inputs are equal to respective input prices. A representation of Farell's approach can be seen in Figure 3.1 which shows the relationship between a single output Y and two inputs X_1 and X_2 . UU' is an unit-output isoquant derived as $f(X_1, X_2)/Y$, while PP'is an unit-output isocost line. The production function (frontier) is $Y = f(X_1, X_2)$ and the assumption that it is characterized by constant returns to scale permits the firm to be observed to use (X_1, X_2) to produce Y at point C which can be seen to inefficient.

Farrell then defined:

(a) Technical efficiency (TE) $= OB/OC \leqslant 1$

(b) Economic efficiency (EE) $= OA/OC \leqslant 1$

(c) Allocative (price) efficiency (AE) = EE/TE

$= (OA/OC)/(OB/OC)$

$= OA/OB \leqslant 1.$

Farrell's approach is non-parametric in the sense that the input-output ratios he used were derived from linear programming techniques. The main advantage of this approach is that no functional form is imposed on the data. The main disadvantage is that the frontier is computed from a subset of observations from the sample, and is therefore particularly susceptible to extreme observations and measurement error (Forsund et al. 1980).

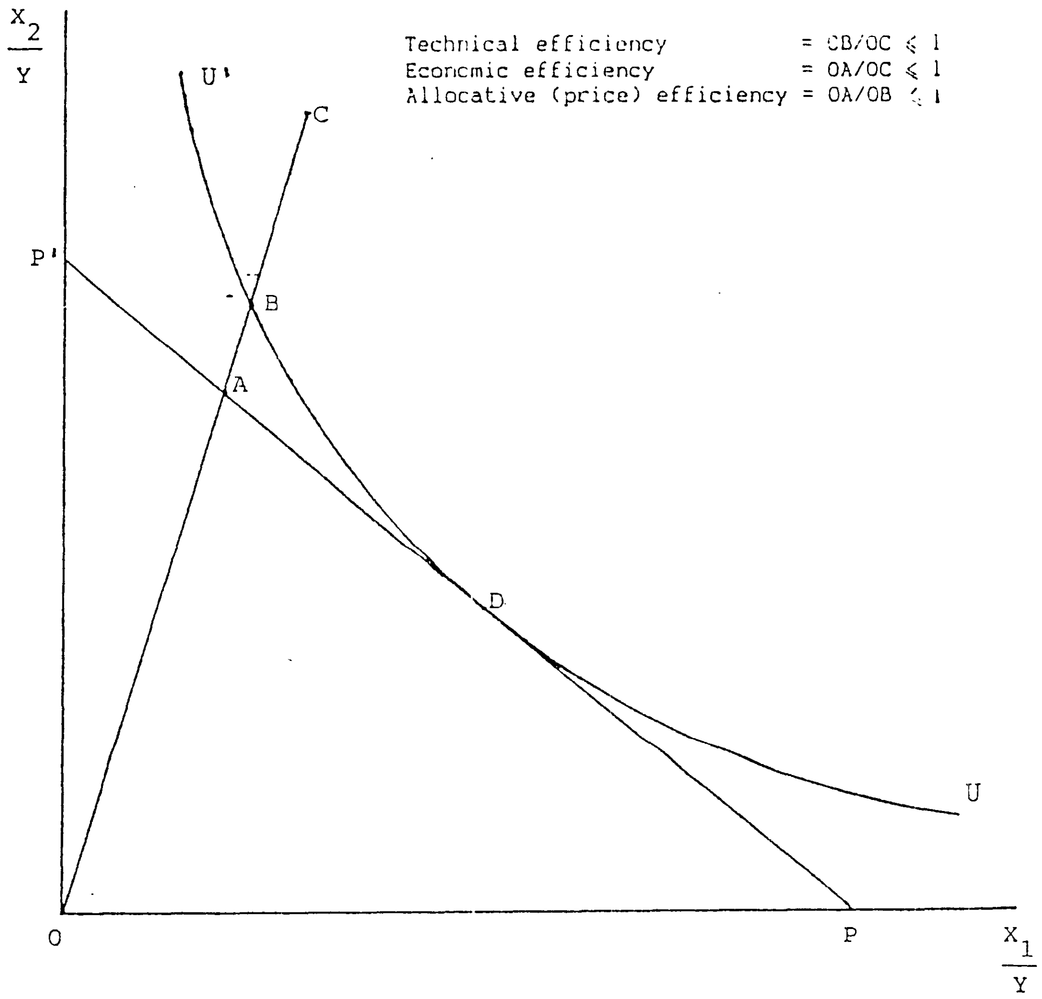

Figure 3.1 Farrell's efficiency measures.

The second approach, the deterministic parametric frontier approach, was also based on Farrell's work and developed by Aigner and Chu (1968). Unlike Farrell, Aigner and Chu used a specific mathematical form to identify the frontier, as shown in equation (3.8).

(3.8)
$$\ln y = \ln f(x) - u,$$
$$\ln y = a_0 + \sum_{i=1}^{m} a_i \ln x_i - u,$$
$$u \geqslant 0 \text{ and } v > 0.$$

In this equation the one-sided error term forces $Y \leqslant f(x)$ and the elements of the parameter vector $a_0 = a_1, a_2, \ldots, a_n$ 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 quadratic programming (minimizing the sum of squared residuals, subject to the same constraint). According to Forsund et al. (1980), the main advantages of this approach are that it has the ability to characterize frontier technology in a simple mathematical form and the ability to accomodate non-constant returns to scale. Because this approach employs mathematical programming, statistical parameters such as standard errors and t-values are difficult to obtain. Further, this approach has been extended by others; for example, Timmer (1971) and Forsund and Hjalmarsson (1979).

The third approach is called the deterministic statistical frontiers approach. This approach may be written as equation (3. 9).

(3. 9)
$$y = f(x)e^{-u},$$
$$\ln y = \ln [f(x)] - u,$$
$$u \geqslant 0,$$

where ln [f(x)] is linear and of the Cobb-Douglas form and $0 \leqslant e^{-u} \leqslant 1$. Afriat (1972) proposed that this model could be estimated by the maximum likelihood method, and therefore the nature of the distribution for u is important. This approach has been used by Richmond (1974), Schmidt (1976) and Greene (1980a). The main problem in employing the method is that maximum likelihood estimators may result in bias because the range of the dependent variable (output) depends on the parameters to be estimated. As pointed out by Schmidt (1976) this is unrealistic. However, this approach is compatible with Farrell's technique on three points:

(a) the frontier function must be a well-behaved, neo-classical production function;

(b) the frontier should be a boundary function or a full frontier, where all sample observations are either on or below the frontier surface; and

(c) the frontier model should attribute all variation in output to the presence of technical and allocative efficiency.

The fourth approach is referred to as the stochastic frontier method. It is called 'stochastic' because of the real possibility that a firm's performance may be affected by factors entirely outside its control. A stochastic production frontier model may be written as equation (3.10):

$$y = f(x) \exp(v-u), \qquad (3.10)$$

where f(x)exp(v) is the stochastic production frontier. According to Forsund et al.(1980), v should have the property of a symmetric distribution to capture the random effects of measurement error and exogeneous shocks which cause the placement of the deterministic kernel f(x) to vary across firms. The exp(-u) is technical inefficiency where $u \geqslant 0$ and this condition ensures that all observations lie on or beneath the stochastic production frontier.

The main advantage of this approach is that it can provide an estimate of the mean inefficiency over the sample. However, the main disadvantage is that the condition $u \geqslant 0$ means that some observations on or beneath the stochastic production frontier may result from unknown sources of inefficiency. The inefficiency may be due to true inefficiency and also to random variation in the frontier. This approach has been used by Aigner et al.(1977), and Meeusen and van den Broeck (1977).

(b) The Cost Function Approach

Another approach to measuring efficiency is the so called cost frontier approach based on cost functions. As mentioned previously, using a cost function implies minimizing cost at a given level of output and input prices. The assumption underlying a direct estimation of the cost function is that a firm minimizes cost with exogeneous output.

This approach, like that of the production frontier, can be applied by using both deterministic and stochastic frontiers. The deterministic cost function was developed by Forsund and Jansen (1977), whereas the stochastic cost frontier was developed by Schmidt and Lowell (1979). Forsund and Jansen (1977) used linear programming as the basis for their analysis and a maximum likelihood estimator as the basis for their estimation. Schmidt and Lowell (1979) considered the stochastic Cobb-Douglas form as given in equation (3.11):

$$\ln y_i = a_0 + \sum_{i=1}^{n} a_i \ln x_i + (v-u), \quad u \geqslant 0. \tag{3.11}$$

where y_i is the total cost of firm i and x_i is the value of output of firm i. They assumed that the first order conditions for cost minimization were as shown in equation (3.12):

$$\ln (x_i/x_n) = \ln (a_i W_i / a_n W_n) + e_i, \quad i = 1, \ldots, n-1, \tag{3.12}$$

where e_i is symmetrically distributed (normal with zero mean) and the W_i are the input prices). The condition $e_i \lessgtr 0$ permits production to occur on the least-cost expansion path. The combination of technical ($u \geqslant 0$) and allocative ($e_i \lessgtr 0$) inefficiency yields a stochastic cost frontier as stated in equation (3.13):

$$\ln(W'x) = b_0 + 1/r \ln y + \sum_{i=1}^{n} (a_i/r) \ln W_i - 1/r\,(v-u) + E, \tag{3.13}$$

where $r = \sum_{i=1}^{n} a_i$. Observed expenditure exceeds the stochastic cost frontier for two reasons: $(1/r)u \geqslant 0$ due to technical inefficiency, and by an ammount $E \geqslant 0$ due to allocative inefficiency. The term E is a well-specified function of the e_i. The model is estimated by using the maximum likelihood method. Even though this approach is capable of shedding light on a wide variety of questions concerning the magnitutes and costs of technical and allocative inefficiency, it is, however, saddled with the fairly restrictive homogeneous Cobb-Douglas functional form. Also, the data used in this approach, such as the data on both input prices and input quantities, may not always be available.

A deterministic approach was developed by Greene (1980b). According to Forsund et al. (1980) the main advantage of this approach is flexibility, and the main disadvantage is the impossibility of providing an explicit derivation for the production function corresponding to the translog cost function.

3.3.2 Non-Frontier Efficiency Models

Non-frontier efficiency models may be classified into two broad groups, profit functions and deterministic linear programmes. The first approach was developed by Lau and Yotopoulos (1971), and Yotopoulos and Lau (1973). The second approach (Sampath 1979) uses linear programming which is an approach that has not yet been extensively developed for measuring efficiency.

(a) The Profit Function Approach

The profit function is a relationship between firm profits and input use. Using the assumption of profit maximization it is possible to derive estimates of technical efficiency and price or allocative efficiency. This approach, according to Forsund et al. (1980), may be represented as in equation (3.14):

$$(3.14) \qquad y = A_i \, f\,(x_i), \quad i = 1,2,$$

where $A_i > 0$ is the index of technical efficiency of a group of firms i, with the two different types of firm being equally technically efficient if, and only if, $A_1 = A_2$; and $f(x_i)$ is the production function and x_i is the vector of inputs employed by firm i, and y is the output. The first-order condition for equation (3.14) under profit maximization may be written as follows:

$$(3.15) \qquad \partial A_i \cdot f(x)/\partial x_{ij} = \lambda_{ij}(w_{ij}/p_i),$$

$$i = 1,\ 2 \ \text{ and } j = 1,\ 2,\ \ldots,\ n.$$

where p is the price of output and w is the price of the input. Equation (3.15) is a condition for profit maximization where the term $\lambda_{ij} \geq 0$ measures price efficiency. The two firms are equally price efficient if, and only if, $\lambda_{1j} = \lambda_{2j}$ for j = 1, ...,n. Then, two firms are equally economically efficient if, and only if, $A_1 = A_2$ and $\lambda_{1j} = \lambda_{2j}$, for j = 1, ...,n. So, an advantage of this approach is that one can estimate technical efficiency ($A_1 = A_2$), allocative efficiency ($\lambda_{1j} = \lambda_{2j}$) and relative economic efficiency ($A_1 = A_2$ and $\lambda_{1j} = \lambda_{2j}$) separately for averages of groups of firms. This model was developed by Yotopoulos et al.(1973), Yotopoulos and Nugent (1976) and Tamin (1979). It has also been used by Flinn et al.(1982). The main advatage of this technique is that one can estimate technical, allocative, and economic efficiency between farm groups but it is assumed that perfectly competitive conditions prevail. The main disadvantage is that the price variables are not likely to vary greatly between firms at a single point in time. Further, with cross-section data and the use of averages of groups of observations as a basis of analysis (for example, small and large farms, owners and tenants) this approach cannot be extended to investigate the efficiency of the individual firm.

(b) Deterministic Linear Programming

This approach has been developed by Sampath (1979) based on some of the advantages of linear programming. Sampath argued that the Cobb-Douglas model is frequently biased because it uses inappropriate assumptions. For example, every farm or group of farms does not always have a Cobb-Douglas type production function, and therefore, every farmer does not necessarily have the same Cobb-Douglas technology. Sampath (1979), argued that, in the strict sense, constant returns to scale in the Cobb-Douglas function are not necessarily a true reflection of reality.

In resolution of the above problems, Sampath (1979) offered a series of 'new approaches' for measuring farm efficiency which were termed 'the system', 'individual', 'economic' and 'perfect economic

efficiency' measures. He defined 'the system' or environment as all those factors which are external to the farmer (or decision maker), which influence his decisions but which are not under his control, such as, the infrastructure available in the economy at any point of time. 'A system' is called 'perfect' if it satisfies all the conditions of a perfectly competitive market such as perfect mobility of factors of production.[1]
Further, he defined 'the individual' as the individual decision maker. The decision maker is said to be 'rational' if, given the system characteristics, he maximizes his profit or net income. Finally, he defined 'perfect economic efficiency'. A system is said to have perfect economic efficiency if both the system and the individual are both technologically and allocatively efficient. His linear programming matrix used 53 crop activities and 10 input availability constraints.

As mentioned before, the disadvantage of measuring efficiency by using linear programming is that it does not provide statistical estimates such as standard errors. This is therefore also the main disadvantage of Sampath's approach. The main advantage of Sampath's approach is that the simple technique of linear programming can be used to obtain efficiency estimates for individual farms.

3.3.3 Farm Efficiency Models Used in this Study

In this section, the farm efficiency models are reviewed, with emphasis on the use of the Cobb-Douglas frontier production function and profit function models. The use of these techniques has been discussed in Section 3.2.5 in this chapter; therefore the following discussion will concentrate on some evidence from Indonesian agriculture.

The Cobb-Douglas frontier production function and profit function have not yet been widely used in the case of Indonesian agriculture. Soejono (1977) may be the first person to have applied the Cobb-Douglas profit function to irrigated-rice farms in Central Java. His work concentrated on the impact of new production technology on the farm income distribution of rice farmers. He evaluated the impact of the new

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[1]The condition of perfect competition has been discussed extensively in the standard literature, for example, Koutsoyannis 1979, pp. 154-5.

rice technology (mainly the high yielding varieties and fertilizer) on the trend of income distribution of irrigated-rice farmers in 8 villages from 1968/69 to 1973/74. Since he concentrated on the problems of income distribution, his work concerning relative economic efficiency was not detailed. He found that the new rice technology had generated a better farm income distribution among the farmers in Central Java.

Saragih (1980) applied the Cobb-Douglas profit function to the oilpalm smallholders and plantations in North Sumatra. The comparison of the economic efficiency of the two typical enterprises revealed that oilpalm plantations were more economically efficient than smallholdings. One possible reason for the greater efficiency is that the oilpalm plantations are better organized and do not have any difficulties in providing capital. He suggested that because each enterprise has a very different agricultural resource endowment the research on the economic efficiency of oilpalm smallholders and plantations should be done separately.

Asnawi (1981) has also done research concerned with the economic efficiency of rice farming in West Sumatra. The major objective of his research was to evaluate the impact of different irrigation systems on farm performance and particularly on the yield. He classified the sample farms into three categories, farms which were located in the 'head', 'body' and 'tail' of the irrigation canal. He found that farms with sufficient water from irrigation, that is, those which were located close to the irrigation canal, had a high yield. In contrast, farms which were located far from the irrigation canal had low yields. This finding is not surprising since the use of modern inputs, such as seeds and fertilizer are complementary to the availability of the water.

Soekartawi (1981a) has reported preliminary findings of his analysis of the relative economic efficiency of rice farms in East Java. These preliminary findings will be reported in detail later in this thesis. He argued that productivity in agriculture is mainly dependent on two sets of factors, technological changes and institutional arrangements. The technological factors include the use of agricultural inputs and methods of production: the institutional factors include such things as the size of farms and tenure systems. Thus, from a policy point of view, researching resource allocation and farm efficiency under different farm size and tenure systems is important.

Finally, Sugianto (1982) completed the most recent work in the area. His study is of the relative efficiency of irrigated-rice farms in West Java. He concentrated on the impact of tractors. He found that farmers who used tractors in their farming were relatively more efficient. Sugianto (1982, p. 141) recommended that:

> '... research to determine the economic efficiency of small irrigated-rice farms still needs to be done'.

The Cobb-Douglas frontier production function originally proposed by Farrell (1957) has been extended by many people. References to the advantages and disadvantages of the Cobb-Douglas frontier production function have been provided in Section 3.3.1. In this study, the Cobb-Douglas frontier production function was estimated by using linear programming. Details of this technique will be presented in Chapter 4, Section 4.3.4.

The aim of using the Cobb-Douglas frontier production function in this study is to measure technical efficiency of the individual farm. This technique provides more information than can be gained by measuring technical efficiency using average production functions. The Cobb-Douglas frontier production function enables the characteristics of individual farms to be explored, and provides results which may be more useful for extension workers. Forsund and Hjalmarsson (1974) argued that efficiency measures should be regarded as dynamic over time due to altered substitution possibilities before and after investment in new production techniques. These changes can be measured by the value of the technical rating or technical efficiency of the farm over time. Thus, from a policy point of view the problem is to optimize a continuing process between ex ante and ex post production possibilities.

In this study, a comparison between average and frontier functions will be carried out in order to determine whether or not the frontier production functions have been shifted neutrally from the position of average production functions.

Use of the Unit-Output-Price Cobb-Douglas Profit Function to Measure Relative Efficiency

The advantages and disadvantages of the unit-output-price form of the Cobb-Douglas profit function have been discussed in Section 3.3.1. As above, the model was used to determine the economic performance of sample farms. This technique can be used to estimate technical efficiency, allocative or price efficiency and relative economic efficiency for different groups of farms in different regions. Relative economic efficiency may not be derived from the frontier production function; therefore, relative economic efficiency should be derived from the unit-output-price profit function. Given this, the unit-output-price Cobb-Douglas profit function is proposed for use in this study.

3.4 Factor Analysis Models

In this section a review of the use of factor analysis is presented. Factor analysis is used as a method for extracting common variation from a data set so as to reduce the number of variables involved. In this study the reduced set of composite variables is then used in an attempt to explain differences in the technical efficiency of individual sample farms.

3.4.1 Types of Factor Analysis

Kim (1975) has argued that 'factor analysis' can be organized into three parts: first, the preparation of the correlation matrix; second, extraction of the initial factors and third, the rotation to the terminal solution. These three alternatives have been designated on the basis of components of computer packages, for example the factor analysis programme in the Statistical Package in the Social Sciences (Nie et al. 1975).

The first task in factor analysis is selecting the set of relevant variables. This can be done by examining the variables used in earlier research work. The second step is the extraction of the initial factors. This is concerned with the data reduction by constructing a set of new variables on the basis of the interrelationships in the original data. This can be done by transforming a given set of variables into a new set of composite variables. The last step is carrying out a rotation of axes to obtain the terminal solution. There are many techniques for rotating the variables in order to get a final solution. Some literature dealing with factor analysis suggests that the rotation to the final solution depends on the problem that must be solved. The two common procedures, quartimax and varimax, have been widely developed in the literature and in computer packages because of their simplicity. Quartimax emphasizes the simplification of the description of each variable of the vector matrix, whereas varimax emphasizes the factor's distinction.

Further details of factor analysis can be seen in the literature, for example Lawley and Maxwell (1971), Harman (1967), and Nie et al.(1975).

The history of factor analysis and its application has been well documented by Harman (1967, Ch. 1). Historically, factor analysis was first used in the field of psychology. Then it was developed for other fields, for example education (Guildford 1956), sociology (Petersen et al.1964), communications (Westly and Jacobson 1962), geology (Krumbein and Imbrie 1963) and economics (Farrar 1962).

In the field of agricultural economics, factor analysis has also been used on a limited scale. Shapiro and Muller (1977) used factor analysis in determining the technical efficiency of cotton farms in Tanzania. In particular, they analysed the role of information and modernization in the production process. Four information-scale variables, namely knowledge of cotton growing recommendations, knowledge of input and output prices, knowledge of local agricultural officials, and seeking agricultural information, were used in searching for appropriate factors affecting technical efficiency. The other variables used in their study were: types of crops grown, farm inputs employed, farm possessions, household appliances and structural material of the house. These variables were treated as proxy variables for modernization. They found that the modern farmers were more willing to strive for greater technical efficiency.

By using data from Rajasthan, in India, Adams and Bumb (1979) applied factor analysis in explaining the determinants of agricultural productivity. They argued that productivity differences in agriculture were associated with a number of climatic, infrastructure, input, technological, and social characteristics. They used 18 variables in their analysis and found that land productivity depended directly upon three main variables, namely supplies of conventional inputs, the cropping pattern and cropping intensity, and the use of modern mechanical and chemical technologies. The other relevant variables in determining land productivity were infrastructure and institutional facilities.

In the case of Indonesia, factor analysis has not been used in the field of agricultural economics. It is proposed to employ factor analysis in determining the most significant groups of variables that affect technical efficiency.

3.4.2 Factor Analysis Model Used in this Study

Technical efficiency is defined as the capacity of producers or farmers to maximize output from a given set of inputs. A firm is said to be more technically efficient than another if it consistently produces a larger quantity of output from the same quantity of measurable inputs. Thus, the level of land productivity can be a reflection of the level of technical efficiency. The greater the technical efficiency, the greater the land productivity. Most studies dealing with factors affecting technical efficiency have been done by relating some variables on farmers' education and entrepreneurship to the production function (Chaudhri 1979 and Moock 1981). Chaudhri and Moock have argued that technical efficiency is a technical problem in choosing inputs and is not an economic problem.

In this study, factor analysis was chosen as an alternative method for analysing the relationships of variables explaining technical efficiency. The reason for this choice was to try to avoid the simplification involved in the use of the production function. The approach allows for many variables that may affect technical efficiency. When the production function is used in explaining factors affecting technical efficiency, its limitation is that only a narrow range of input variables is employed. Given this circumstance, along with the problem of multicollinearity and simultaneous equation bias, some important variables may be omitted from the production function. However, it is most likely that effects of the omitted variables are captured to an unknown degree in the few included variables. In other words, mis-specified models of production functions may generate mis-specified policy implications.

3.5 Concluding Remarks

Several types of production function, farm efficiency and factor analysis models have been discussed in this chapter. A review of these models including a discussion of their advantages and disadvantages, has been presented.

The basic model most often used for production function studies is the Cobb-Douglas production function. One of the reasons for its common use is its convenience in interpreting the coefficients as elasticities of production and its ease of estimation. In this study the so-called frontier Cobb-Douglas production function and the unit-output-price Cobb-Douglas profit function will be used. In order to estimate technical and economic efficiency of individual farms, the frontier production function will be estimated by using linear programming, while the unit-output-price profit function will be estimated econometrically and be used in determining relative economic efficiency of groups of farms. Details of these techniques will be discussed in Chapter 4.

The discussion presented in this chapter is from a theoretical point of view. Before applying the proposed models several factors must be considered. These include prior information on input and output relationships, the characteristics of the data to be used and the statistical and economic limitatiors of the estimates. To make the models operational and reflect the problems in the study area it is necessary to consider the detailed specification of the models involved. Discussion of the analytical framework and techniques used is further developed in Chapter 4.

Chapter 4

ANALYTICAL FRAMEWORK AND TECHNIQUES

4.1 Introductory Remarks

As outlined in the previous chapter, there are many techniques used in assessing farm performance with respect to efficiency and the allocation of resources. Some of these will be applied to the situation of farmers in East Java. In this chapter the theoretical background to these techniques will be examined. The basis for using these techniques will also be examined.

Five main areas will be dealt with:

(a) The agricultural environment will be considered using simple cross-tabulations of the sample data.

(b) Technical performance which will be evaluated by using the simple technique of cross tabulations and partial productivity measures, and the more advanced techniques involving the Cobb-Douglas production function, factor analysis and linear programming.

(c) Economic performance will be evaluated by using the Cobb-Douglas profit function and linear programming.

(d) The nature of the firm's demand for inputs and supply of output will be examined using factor demand functions and output supply functions derived from the profit function.

(e) Lorenz curves and Gini coefficients will be used to examine factors affecting the distribution of profits.

Before proceeding with further analysis, it should be noted that the techniques used in this study assume that risk is not an important consideration in the specific farm environment of the three villages considered. In other words, farmers are expected to maximize profit rather than maximize some form of utility which incorporates risk. It should be noted that in the region of this study, prices of major food crops are more or less controlled by the Government. The production inputs such as seed, fertilizers and pesticides are largely provided by the Government and are distributed by local village unit cooperatives. This situation implies that price risk is relatively small so that, for this analysis, it is not included in the techniques used. Output risk is similarly small and it also is not included in the analysis. The factors that contribute to this situation include a low risk climate (for example, temperature, rainfall, and humidity are relatively stable during each season (see Table 2.3), there is little hazard from floods, droughts and typhoons). Furthermore, a well trained task force in every village (supported by the Government) helps minimize damage from insects and disease. Their task is simplified by the fact that most farmers now cultivate high-yielding rice varieties which are resistent to insects. Since the environment can be considered reasonably favourable for agriculture and analysis of the effects of risk were not a major concern of this study the analytical methods used have not included elements of risk directly. Further, although there is an extensive literature on economic analysis under risk there are still many significant theoretical difficulties with such work that have yet to be resolved in relation to efficiency analysis. These are well beyond the scope of this study. These comments should not be taken to imply that the decision making environment is risk free but that risk is not seen as a major element significantly affecting the conclusions of the study.

The following discussion explains the analytical framework and techniques used. The first section presents an analysis of the factors affecting farm yield and farm efficiency. The second section presents details of the the various techniques used in this study.

4.2 Analytical Framework

The role of agriculture in promoting economic growth has been adequately dealt with in recent economic literature (for example, Lewis 1963, Kuznets 1961, Witt 1965 and Malassis 1975). At the micro level, the ability of agriculture to contribute directly to economic growth is dependent on the level of farm income and the resultant surpluses generated in the agricultural sector. As Saini (1979) has argued, the level of farm incomes, besides being the principal determinant of the welfare of farm families, emerges as one of the important factors that condition economic growth.

Further, theories of economic growth and development have been postulated and related, in varying degrees, to the small-farmer problem (Dillon 1979, Berry and Cline 1979, Harword 1979). For example, Dillon (1979) argues there have been three important theories dealing with problems of small farmers, particularly those in less developed countries, these are, the dual-economy model (Jorgenson 1961, 1969), Schultz's 'poor but efficient' model of traditional agriculture (Schultz 1964, Mellor 1967), and the theory of unequal exchange or exploitation between the 'center' and the 'periphery' of the world economy (Janvry 1979, Stavenhagen 1969). The first theory, according to Jorgenson (1961, 1969), encompasses what has come to be known as the classical approach (a fixed real wage rate and a surplus of agricultural labour) and the neo-classical approach (a variable real wage rate and no labour surplus). The second theory, according to Schultz (1964), encompasses the small farmer problem without linking it to the general problem of national economic growth. Schultz (1964, p. 37) argues that:

> 'There are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture'.

The third theory, in contrast to the dual-economy and Schultzian theories is that small farmers operate under an actively malevolent socio-economic environment. In commenting on this theory, Dillon (1979, p. 172) argues that:

> 'The existence of small farmers and their continuing impoverishment is seen as crucial to sustaining the transfer of surplus value from the less developed periphery of the world to the developed center ... Under this theory there appears little hope for a solution of the small-farmer problem'.

The central issue in these theories would appear to relate to the question of efficiency of resource use, particularly in the cases of the dual economy and the 'poor but efficient' theories. The comparative efficiency of farms under traditional or semi-traditional agriculture is still being debated. For example, Hopper (1965), Chennareddy (1967) and Sahota (1968) found that farmers in India followed Schultz's hyphothesis: 'they were poor but efficient'. Welsch (1965) reported similar results in Nigeria. A study of Tanzanian farmers showed that farmers were poor and not efficient, a result which did not support Schultz's hypothesis. There is limited evidence to support, or to reject Schultz's hypothesis in Indonesia because there has only been limited research carried out into farm efficiency.

With the Indonesian Government attempting to assist small farmers in <u>Repelita</u> III, through a scheme termed '14 steps towards more equal distribution of agricultural development' (Departemen Pertanian 1979), understanding of the behaviour of small farmers is very important. This scheme was emphasized in <u>Repelita</u> III, in contrast to the previous <u>Repelita</u> where the main development aim was to maximize economic growth, expecting that benefits of development would percolate 'down' from the 'top'. However, the accumulating evidence shows that, far from percolating down, these benefits invariably tended to congeal (Gibbons et al. 1980).

The remaining discussion in this section will concentrate on two major items which are fundamental to gaining the greatest economic benefits from the farming system. These are; factors affecting farm yield, and factors affecting farm efficiency. The following section will concentrate on the analytical techniques used in this study.

4.2.1 Factors Affecting Farm Yield

De Datta (1981, p. 572) has pointed out that there are two contrasting ideas that have been suggested to explain low yields and production of rice in many tropical countries in Asia. The first, from agricultural scientists who feel that farmers and the institutional system are not taking full advantage of the technology, and the second, from social scientists who indicate that the technology developed in the experimental stations in many instances is inappropriate for the farmer's environment. Similar ideas, to those indicated above, exist in East Java in relation to the production of food crops, such as rice, maize, cassava and soybean.

Given the two contrasting views, the factors causing the yield gap can generally be classified as biological constraints and socio-economic constraints. However, Gomez (in Dillon and Hardaker 1980) argued that there are three major constraints causing the yield gap: biological constraints, socio-economic constraints and the non-transferability of technology because of environmental differences. This is illustrated in Figure 4.1.

From Figure 4.1, it can be seen that, given the same environment in which crops are grown, the main problems causing the yield gap are likely to be biological and socio-economic constraints. This indicates that with the use of new seed varieties, control of weeds, diseases and insects, cultivation in good soil and irrigation, crop production will be higher. From the socio-economic point of view the gap may be because of:

(a) unprofitable farming (farm costs more than farm returns);

(b) a lack of knowledge of how to use technology, such as chemical

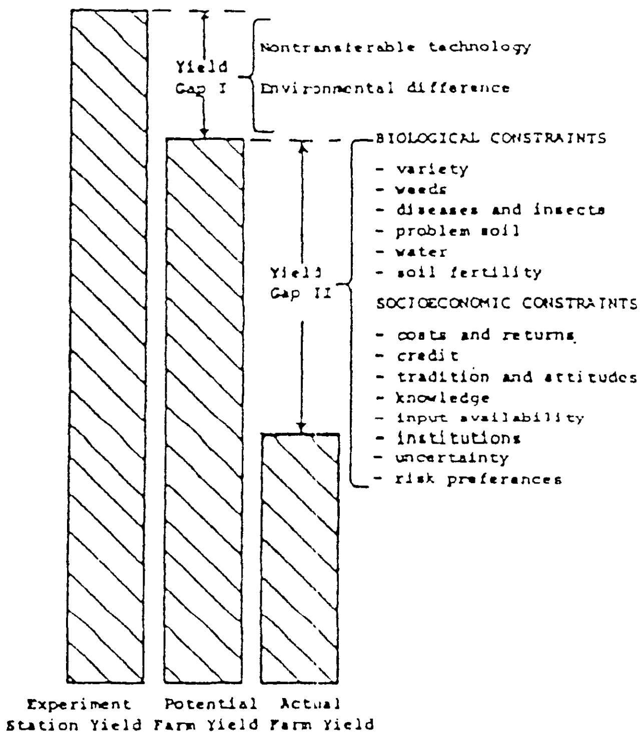

Figure 4.1 Conceptual model explaining the yield gap between experiment station yield and actual farm yield (Gomez, in Dillon and Hardaker, 1980, p. 19).

fertilizers and pesticides;

(c) a general lack of knowledge;

(d) lack of input availability; and

(e) institutional factors, such as traditional beliefs, tenure systems, farm sizes, etc.

Therefore crop production should be higher when farmers have sufficient knowledge of the use of technology, a good supply of agricultural credit, available inputs and institutional services.

4.2.2 Factors Affecting Farm Efficiency

A further argument regarding the yield gap relates to the existing concept of farming efficiency (Schulter and Mount 1975-76, De Datta 1981; Soekartawi 1981a,b). If farmers operate efficiently, so that profits are maximized, then incomes can only be increased by introducing improved methods of production. In contrast, if farmers do not act efficiently, it may be desirable to reallocate resources within traditional or semi-traditional agriculture. This situation might be explained by depicting the relationship between the yield gap and the concept of efficiency which is illustrated in Figure 4.2 (De Datta 1981, p. 571).

Figure 4.2 demonstrates how the yield gap can be divided into three components. The first segment of the gap relates to profit-seeking behaviour and reflects the difference in input levels resulting from maximum profit versus maximum yield. The second segment, referred to as price or allocative inefficiency, reflects the farmers' failure to use inputs to achieve maximum profit. The third segment refers to technical inefficiency and is defined as the failure to produce on the most efficient production function. These measures parallel those of Farrell (1957) presented in Figure 3.1.

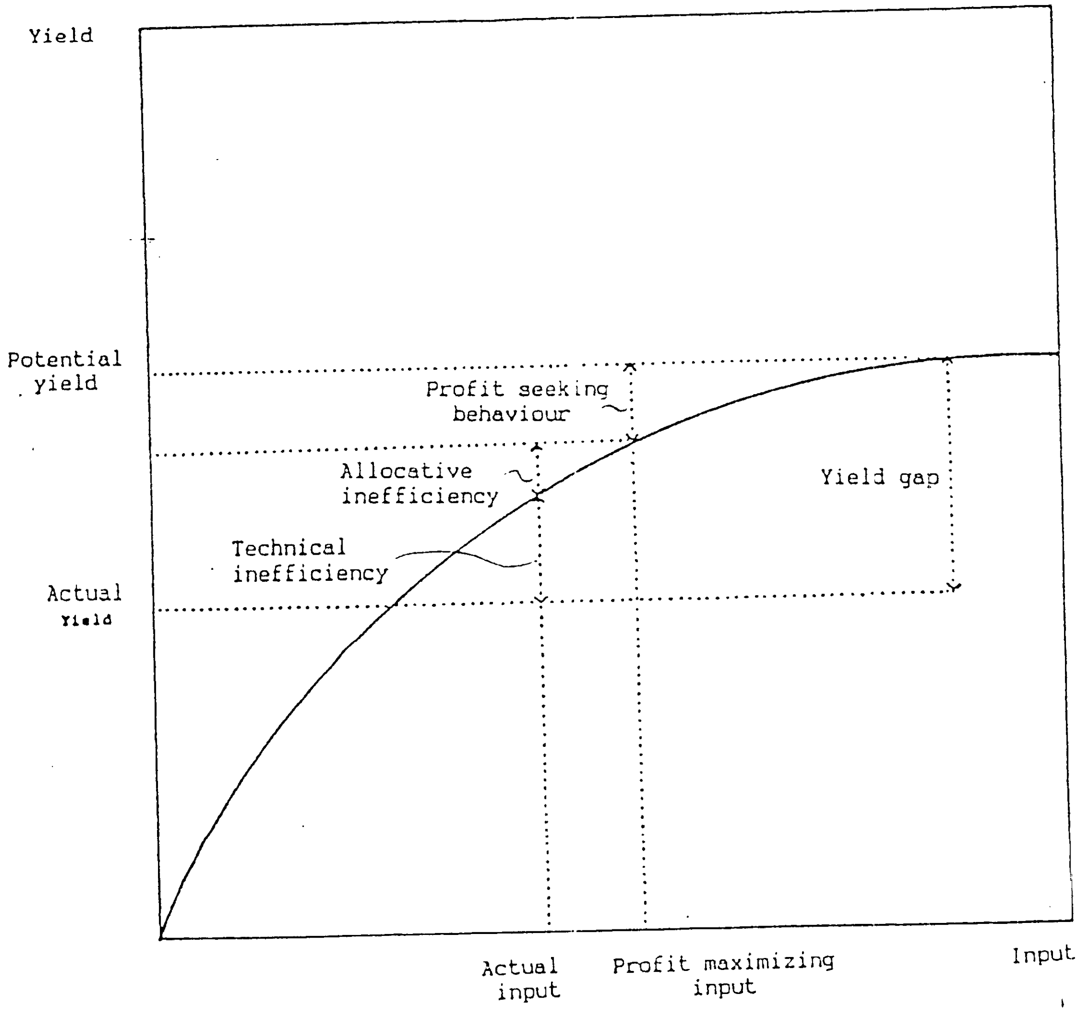

Figure 4.2 Three economic components of the yield gap (Barker 1979 in De Datta 1981, p. 571).

There are several ways of assessing the problem of farm efficiency and optimal resource use. Philosophically, one may say that any scientific problem, such as finding technical coefficients to measure farm efficiency, has no single and complete answer and may be approached in various ways according to human ingenuity. The technical aspects of production, too, can be approached in a variety of ways. Classical economists offer the production function approach, whereas modern theorists propound the 'unit-output-price' (UOP) profit function as an alternative. The above two approaches differ in the way the prices of inputs or outputs are treated in a model. For example, the production function does not take into account how inputs are chosen and their dependence on prices. If the profit function is used, it directly shows the technical relation between a given set of inputs and outputs which implies some measure of technical efficiency, and the effects of using given inputs, which implies some measure of allocative efficiency. According to Yotopoulos and Lau (1973), a firm is said to be technically more efficient than another if it consistently produces a larger quantity of output from the same quantity of measurable inputs. A firm is said to be price or allocatively efficient if it allocates inputs to maximize profits. Finally, a firm is said to be economically more efficient than another, if it has a greater technical and allocative efficiency.

The production function, therefore, cannot be used to measure relative (economic) efficiency; it can only be used to measure technical and allocative efficiency separately. To estimate relative (economic) efficiency it is proposed to use the profit function.

The approach to analysing the technical and allocative efficiency was therefore to fit a Cobb-Douglas production function to measure technical efficiency and allocative efficiency, and a Cobb-Douglas profit function to measure relative economic efficiency. Then a frontier production function was derived by using linear programming to support these models and obtain individual farm estimates of the various efficiency measures. Before dealing with the more sophisticated approaches simple partial productivity measures will be examined.

4.3 Analytical Techniques

The various analytical techniques are discussed in the following sections.

4.3.1 Partial Productivity Analysis

Tabulation is used in order to relate characteristics of sample farms to measures of productivity. Farm area and farm locations are treated as explanatory variables, while the inputs and outputs are treated as variables to be explained. Due to the importance of seasonal and crop differences, these variables are analysed according to seasons. In spite of the inaccurate terms of 'wet season crop' and 'dry season crop', these are the commonly used terms in Indonesia. To avoid confusion, in this thesis, 'wet season crop' refers to the first crop grown (in season I) and 'dry season crop' refers to the second crop grown (in season II).

The differences between two groups of farms or two regions can be tested by using the test of differences between two groups of means. The z- and t-statistics will be used (Freund and Williams 1975, pp. 237-41):

(4.1) $$z = (x_i - x_j)/(s_i^2/n_i + s_j^2/n_j)^{\frac{1}{2}},$$ for large samples, $n \geq 30$;

(4.1a) $$t = (x_i - x_j)/[\{((n_i - 1)s_i^2 + (n_j - 1)s_j^2)/(n_i + n_j - 2)\}^{\frac{1}{2}}\{1/n_i + 1/n_j\}^{\frac{1}{2}}],$$ for small samples, $n < 30$;

where x_i and x_j denote the mean values of two groups; n_i and n_j are the respective sample sizes of each group; and s_i^2 and s_j^2 denote estimates of the population variance of group i and j, respectively. The above statistics follow a normal distribution and student 't-distribution' with $n_i + n_j - 2$ degrees of freedom respectively.

4.3.2 Linear Regression

Much of this study involves the use of regression analysis. On a number of occasions comparisons are made between regressions. In this section the Chow test used for these comparisons is developed.

Model Specification and Assumptions

A simple regression may be expressed as follows:

$$(4.2) \qquad Y = a + bX + u,$$

where Y is the dependent variable, X is the independent variable, b is the coefficient to be estimated, a is the intercept and u is the disturbance term which is assumed to have the usual properties. The true regression line from equation (4.2) is:

$$(4.3) \qquad E(Y) = a + bX,$$

and the estimated relationship is:

$$(4.4) \qquad \hat{Y} = \hat{a} + \hat{b}X + \hat{e},$$

then the estimated regression line is:

$$(4.5) \qquad \hat{Y} = \hat{a} + \hat{b}X,$$

where $\hat{Y}$ is an estimated value of Y, $\hat{a}$ is an estimate of the true intercept, $\hat{b}$ is an estimate of the true parameter b and e is an estimate of the true value of the disturbance term u.

The multiple linear regression model can be expressed as:

(4.6) $$Y = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n + u,$$

where Y is the dependent variable of crop i, X_1 , X_2 , ... , X_n are the independent variables of crop i, b_1 , b_2 , ... , b_n are regression coefficients and u is a disturbance term. The linear regression model assumes that a linear relationship exists between the dependent variables and the independent variables. This model may be estimated by using ordinary least squares (OLS) in which the least squares estimator of b is the best linear unbiased estimator (BLUE). The procedure for estimating such an equation has been discussed extensively in the standard literature in econometrics (for example, Johnston 1972, Ch. 5; Koutsoyiannis 1977, Ch. 7).

Comparison of Regression Models

The test of equality between sets of coefficients in two linear regressions has been developed by Chow (1960, pp. 591-605). Using matrix notation, the two equations may be written as:

(4.7) $$Y_1 = X_1b_1 + Ob_2 + u_1;$$

(4.8) $$Y_2 = Ob_1 + X_2b_2 + u_2,$$

where 1 and 2 denote the first and the second set of observations respectively, the X_1 matrix is of order kxn and the X_2 matrix is of order kxm. By assuming that u_1 has the same normal distribution as u_2 with variance-covariance matrix $\sigma^2 I$, equations (4.7) and (4.8) can be written as:

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}. \quad (4.9)$$

Under the hypothesis $b_1 = b_2 = b$, the above model (equation 4.9) becomes:

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} b + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}. \quad (4.10)$$

When applying least-squares, the sum of squared residuals from the fitted function is as follows:

$$Q_1 = [u_1' u_2'] [I - \begin{pmatrix} X_1 \\ X_2 \end{pmatrix} (X_1'X_1 + X_2'X_2)^{-1} (X_1' X_2')] \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}. \quad (4.11)$$

Equation (4.11) is a quadratic form, where the u's have the rank $k+m-n$, where k and m are the numbers of the first and second samples and n is the number of explanatory variables.

If least squares is applied separately to each of the two relations and the sum of the squared residuals is obtained from each, the following equation can be written:

$$Q_2 = u_1'[I - X_1(X_1'X_1)^{-1}X_1']u_1 + u_2'[I - X_2(X_2'X_2)^{-1}X_2']u_2, \quad (4.12)$$

where the two quadratic forms on the right side have ranks $k-n$ and $m-n$ respectively. Since u_1 and u_2 are independent, X/σ^2 will have a Chi-squared distribution, X^2, with $k+m+2n$ degrees of freedom. The sum of squared residuals can also be written as follows:

$$Q_1 = \left\| \begin{matrix} Y_1 - X_1\hat{b}_0 \\ Y_2 - X_2 b_0 \end{matrix} \right\| \text{; and } Q_2 = \left\| \begin{matrix} Y_1 - X_1\hat{b}_1 \\ Y_2 - X_2 b_2 \end{matrix} \right\| \quad (4.13)$$

By combining the components shown in equation (4.13), they can be written as follows:

$$(4.14)\qquad \begin{bmatrix} Y_1 - X_1\hat{b}_0 \\ Y_2 - X_2\hat{b}_0 \end{bmatrix} = \begin{bmatrix} Y_1 - X_1\hat{b}_1 \\ Y_2 - X_2\hat{b}_2 \end{bmatrix} + \begin{bmatrix} X_1\hat{b}_1 - X_1\hat{b}_0 \\ X_2\hat{b}_2 - X_2\hat{b}_0 \end{bmatrix}$$

Taking the sum of squares of both sides, the cross product term on the right-hand side vanishes and equation (4.14) can be written as:

$$(4.15)\qquad Q_1 = Q_2 + Q_3; \text{ where } Q_3 = \left\| \begin{matrix} X_1(\hat{b}_1 - \hat{b}_0) \\ X_2(\hat{b}_2 - \hat{b}_0) \end{matrix} \right\|$$

As mentioned before, under the hypothesis $b_1 = b_2 = b$, and under the null hypothesis Q_2 and Q_3 will be distributed independently as $\chi^2_{(k+m-2n)}\sigma^2$ and $\chi^2_{(n)}\sigma^2$. The distribution of Q_3 is affected if the null hypothesis does not hold, but Q_2 will have the same distribution regardless. In a case where m is more than n, the hypothesis $b_1 = b_2 = b$ may be tested using an F-test:

$$(4.16)\qquad F = (Q_3/n)/\{(Q_2/(k+m-2n)\},$$

with degrees of freedom (n,k+m-2n).

4.3.3 Cobb-Douglas Production Function

Model-Specification and Assumptions

The general form of the Cobb-Douglas production function can be written as follows:

$$(4.17)\qquad Y = AX_1^{b_1}X_2^{b_2}\ \ldots\ X_n^{b_n}e^u,$$

and in logarithmic form, Equation (4.17) can be expressed as:

$$(4.18) \qquad \ln Y = \ln A + b_1 \ln X_1 + b_2 \ln X_2 + .. + b_n \ln X_n + v,$$

where Y is output, X_1 ,X_2 , ... ,X_n are inputs, b_1 ,b_2 , ... ,b_n are production elasticities, A is the intercept, and u and v are the disturbance terms.

Several assumptions need to be made. First, that there are no non-neutral differences in the respective technologies which means that the intercepts of the production functions may vary but the slopes may not. Secondly, that there are only positive and non-zero observations for the data. This is because the logarithm of zero or negative numbers will be undefined. There are three possibilities for solving this problem: these are, the addition of a positive constant to all sample observations (Heady and Dillon 1975, p. 229); the replacement of zero observations from samples and the exclusion of zero observations from samples. According to Johnson and Rausser (1971, pp. 124-4), the second possibility results in a smaller bias in estimated parameters than do the other two. The third assumption is that the differences in individual physical environments are captured by the error term. The Cobb-Douglas production function is used to estimate the output variations between various farm groupings. The differences in technical efficiency between farm groups will be examined more carefully in the following sections using frontier production functions.

4.3.4 Cobb-Douglas Frontier Production Function

In this section, a discussion of the method for measurement of individual farm efficiency levels is presented. Two types of 'efficiencies' will be discussed in the case of individual farms, namely, the technical efficiency rating and the economic efficiency rating. The technical efficiency rating is defined as the ratio of the actual yield to the maximum yield of the farm and the economic efficiency rating is defined as the ratio of the actual profit to the maximum profit of the farm.

Measurement of the Individual Technical Efficiency Rating

Use of an index of efficiency for each farm, termed the technical efficiency rating, is an important means of removing management bias in agricultural production function analysis. The main reason for using this technique is to find the maximum possible yield given a set of farm conditions. The technique is derived from the Cobb-Douglas frontier production function and is estimated by using linear programming.

Farrell developed the technique which was then modified by Timmer (1970, 1971). Technical efficiency is measured with a probabilistic frontier production function, that is, the ratio of the actual yield of farm i (Y_i) to the estimated yield of farm i ($\hat{Y}_i$) derived from the estimated frontier function. This can be expressed as follows:

$$(4.19) \qquad TER_i = (Y_i/\hat{Y}_i),$$

where TER_i is the technical efficiency rating of farm i. By measuring the technical efficiency rating for each farm, the technical efficiency rating of the whole population of farms can be ranked. The technical efficiency rating for a group of farms is measured as equation (4.20):

$$(4.20) \qquad TER_g = (1/n)(\sum_{j=1}^{n} (Y_i/\hat{Y}_i),$$

where g is the group of farms, n is the number of farms in that group and i is the i-th farm.

$\hat{Y}_i$ can be derived from the frontier production function. By using Timmer's technique (Timmer 1970, 1971), $\hat{Y}_i$ can be derived by the following procedure. Consider the usual Cobb-Douglas model, which is:

$$(4.21) \qquad Y_j = \prod_{i=0}^{m} a_i X_{ij}^{\alpha_i} e_j,$$

where y_j is the output of farm j, a is the intercept, x_{ij} is the use of factor i by farm j and α_i is the parameter and e_j is a random error term. By taking logarithms, equation (4.21) becomes:

$$(4.22) \qquad Y_j = \sum_{i=0}^{m} \alpha_i X_{ij} + E_j.$$

where the capital letters indicate logarithmic values. To make this a frontier function all the E_j must be constrained to one side of the estimated production surface. Thus, equation (4.22) can be estimated as follows:

$$(4.23) \qquad \sum_{i=0}^{m} \hat{\alpha} X_{ij} = \hat{Y}_j \geq Y_j,$$

where $\hat{Y}_j$ is a set of estimated levels of yield for each farm and $\sum_{j=1}^{n} E_j$ should be equal to zero or should be minimized. The problem then can be written as:

$$(4.24) \qquad \text{Minimize} : \sum_{j=1}^{n} \hat{E}_j,$$

$$\text{Subject to:} \quad \sum_{j=1}^{m} \hat{\alpha}_i X_{ij} \geq Y_j;$$

$$\text{and} \quad \hat{\alpha}_i \geq 0.$$

This problem can be solved for α_i by linear programming.

The problem in (4.24) can be re-written by summing the equation (4.22) over j, so that:

$$(4.25) \qquad \sum_{j=1}^{n} \sum_{i=0}^{m} (\hat{\alpha}_i X_{ij}) - \sum_{j=1}^{n} E_j = \sum_{j=1}^{n} Y_j;$$

$$\sum_{j=1}^{n} E_j = \sum_{j=1}^{n} \sum_{i=0}^{m} (\hat{\alpha}_i X_{ij}) - \sum_{j=1}^{n} Y_j,$$

where $-\sum_{j=1}^{n} Y_j$ is a constant, so it can be dropped from equation (4.25) without consequences. The remainder is suitable as a linear programming objective function. According to Timmer (1971), the arithmetic mean of the observations for the i-th input ($\bar{X}_i$) can be used instead of the total, thus the objective function can be maximized by minimizing:

$$(4.26) \qquad \sum_{i=0}^{m} \alpha_i \bar{X}_i$$

The problem can then be written as follows:

$$(4.27) \qquad \begin{aligned} &\text{Minimise} &&: \hat{\alpha}_0 + \hat{\alpha}_1 \bar{X}_1 + \hat{\alpha}_2 \bar{X}_2 + \ldots + \hat{\alpha}_m \bar{X}_m \\ &\text{Subject to} &&: \hat{\alpha}_0 + \alpha_1 X_{11} + \hat{\alpha}_2 X_{21} + \ldots + \hat{\alpha}_m X_{m1} \geq Y_1 \\ & && \;\;\vdots \qquad\quad \vdots \qquad\quad \vdots \qquad\qquad\quad \vdots \qquad\;\; \vdots \\ & && \;\;\hat{\alpha}_0 + \hat{\alpha}_1 X_{1n} + \hat{\alpha}_2 X_{2n} + \ldots + \alpha_m X_{mn} \geq Y_n \\ & && \;\;\text{and } \alpha \geq 0, \end{aligned}$$

where x_{m1} is the input m of the first farm, Y_n is the yield of n-th farm, and $\hat{\alpha}_j$ are the parameters to be estimated.

This can be solved by a linear programming package and the vector $\hat{Y}_i / Y_i$ is the index of efficiencies. The $\hat{Y}$ are calculated from Y_i less any slack value in the particular constraint.

To avoid the problem of extreme observations, Timmer suggested the use of a probability frontier, in which equation (4.26) must be stated as follows:

$$(4.28) \qquad P_r\left(\prod_{i=0}^{m} X_{ij}^{\hat{\alpha}_i} \geq Y_j \right) > P,$$

with P as an externally specified probability (for example, 98 per cent) for which the inequality is to hold (Aigner and Chu 1968, p. 838). The procedure for choosing P, as suggested by Timmer (1971, pp. 781-2), is carried out by solving the problem in equations (4.26) for all farms, and then discarding the first (100-P) per cent of the efficient observations until the resulting estimated coefficients stabilize.

Measurement of the Individual Economic Efficiency Rating

The economic efficiency rating for each farm is also derived from the Cobb-Douglas frontier production function. This can be expressed as follows:

$$EER_i = ANP_i/MNP_i, \qquad (4.29)$$

where EER_i is the economic efficiency rating of farm i; ANP_i is actual net profit (total revenue less total variable cost) of farm i; and $(MNP)_i$ is maximum net profit of farm i calculated by using linear programming techniques. This can be expressed as follows:

$$MNP_i = \hat{Y}_i p_i - \sum_{j=1}^{m} X^*_{ij} P_{ij}, \qquad (4.30)$$

where X^*_{ij} is the optimum levels of the input j; p_i is the price received for the crop by farmer i; P_{ij} is the price of input j of farm i; and the other variables as previously defined.

Based on equations (4.19) and (4.29), the price efficiency rating (PER) can be calculated by dividing the economic efficiency rating (EER) by the technical efficiency rating (TER).

$$PER = EER/TER \qquad (4.31)$$

4.3.5 Cobb-Douglas Profit Function

Profit function analysis is used in order to determine the relative economic efficiency of groups of farms, the derived demand for variable inputs and the output supply. The unit-output-price profit function is used in this study. This technique is based on the assumption that firms act so as to maximize profit and simultaneously determine input and output levels given a set of product and factor prices. The unit-output-price profit function contains normalized prices of variable inputs and fixed inputs. The following discussion uses the unit-output-price theory developed by Lau and Yotopoulos (1971, 1972, 1973) and Yotopoulos and Lau (1979).

Suppose the production function is given by:

$$(4.32) \qquad Y = AF(X, Z)$$

where Y is the output; A is the technical parameter; X is the variable input used; and Z is the fixed variable. The profit relation for a firm can be derived from the production function, as in equation (4.32), and can be written as follows:

$$(4.33) \qquad \Pi = ApF(X_1, \ldots, X_m; Z_1, \ldots, Z_n) - \sum_{i=1}^{m} c_j X_j - \sum_{j=1}^{n} f_j Z_j,$$

where Π is the total monetary profit of the farm; A is the technical efficiency parameter; p is the price of output per unit; X_j is the variable input used (j = 1, ...,m); Z_j is the set of fixed variables (j = 1, ...,n); c_j is the unit price of the variable input j; and f_j is the unit price of the fixed input Z_j. In the short run, the fixed variables do not influence profit maximization behaviour; therefore they drop out when the function is differentiated with respect to variable inputs. Thus, equation (4.33) then can be written as:

$$(4.34) \qquad \Pi = ApF(X_1, \ldots, X_m; Z_1, \ldots, Z_n) - \sum_{j=1}^{m} c_j X_j .$$

Taking the logarithm of the Cobb-Douglas profit function, enables the model to be expressed as follows:

$$(4.35) \qquad \ln (\Pi/p) = \ln A + \sum_{j=1}^{m} \beta_j \ln (c_j/p) + \sum_{j=1}^{n} \alpha_j \ln Z_j;$$

$$\ln \Pi^* = \ln A + \sum_{j=1}^{m} \beta_j \ln(c_j/p) + \sum_{j=1}^{n} \alpha_j \ln Z_j,$$

where Π^* is the normalized profit; β_j is the coefficient of the normalized price of the j-th variable input; α_j is the coefficient of the j-th fixed input; and the other variables are as previously defined. Equation (4.35) can be written:

$$(4.36) \qquad \ln \Pi^* = \ln A + \sum_{j=1}^{m} (1 - \beta_j) \ln p + \sum_{j=1}^{m} \beta_j \ln c_j + \sum_{j=1}^{n} \alpha_j \ln z_j .$$

If m = 3 and n = 1, equation (4.36) can be expressed as:

$$(4.37) \qquad \ln \Pi^* = A^* + \sum_{j=1}^{3} \beta_j \ln c_j + \alpha_j \ln z_j ,$$

where: $A^* = \ln A + \sum_{j=1}^{m}(1 - \beta_j) \ln p$. Equation (4.37) can be used to estimate the actual normalized profit function.

The Measurement of Relative Economic Efficiency for Groups of Farms

The assumptions underlying the measure of relative economic efficiency, as indicated by Lau and Yotopoulos (1971), are that:

(a) there exists a profit function which is decreasing with the fixed input quantities;

(b) individual farmers use different criteria in addition to input market prices in their attempt to maximize profit;

(c) the farms concerned may have identical production functions up to the neutral technical efficiency parameter and, yet, may differ in their quantities of comparable fixed inputs.

The normalized profit function is used for the purpose of measuring relative economic efficiency. Given comparable endowments, identical technology, and normalized input prices, the unit-output-price profit function of two firms should be identical if they both have maximized profits.

To obtain the difference in relative economic efficiency of two firms, the production function, as specified in equation (4.32), is restated as follows:

(4.38) $$Y^1 = A^1F(X^1, Z^1);$$

(4.39) $$Y^2 = A^2F(X^2, Z^2),$$

where superscripts identify firms. The marginal conditions for a profit maximum, for the production of, Y^1 and Y^2, are:

(4.40) $$[\partial A^1F(X^1, Z^1)]/(\partial X_j^1) = k_j^1 c_j^1;$$

(4.41) $$[\partial A^2F(X^2, Z^2)]/(\partial X_j^2) = k_j^2 c_j^2 .$$

Equations (4.40) and (4.41) show that two firms are equally technically efficient if, and only if, $A^1 = A^2$. Furthermore, two firms are equally price or allocatively efficient with respect to all the variable inputs if, and only if, $k_j^1 = k_j^2$, $j = 1, \ldots, m$. Since the relative economic efficiency embodies technical efficiency and allocative efficiency, two firms are said to be equally relatively economically efficient if, and only if, $A^1 = A^2$ and $k_j^1 = k_j^2$. In the case for the normalized profit function, as specified in equation (4.35), the test of relative economic efficiency in the model used in this study can be explained as follows:

(4.42) $$\ln \Pi^* = \ln A + \gamma D_j + \sum_{j=1}^{m} \beta_j \ln(c_j/p) + \sum_{j=1}^{n} \alpha_j \ln Z_j,$$

where D_j is the dummy variable of the j-th group of farms (for example, D = 1 for large farms and D = 0 for small farms); and other variables are as previously defined in equations (4.35) and (4.37). For the normalized profit function in the logarithmic form, the coefficient of a dummy variable differentiates the two groups of farms and the test of relative economic efficiency is whether the coefficient of the dummy variable is significantly different from zero.

The Demand for Variable Inputs and Output Supply

There are three points to be discussed in this section. First, the derivation of the demand for variable inputs and output supply; second, the own- and cross-price elasticities of output and variable inputs; and third, the elasticities with respect to the quantity of an input.

Equation (4.35), with m=3 and n=1, is rewritten in order to show the derivation of the demand for variable inputs and output supply, that is:

$$\ln \Pi^{*} = \ln A + \sum_{j=1}^{3} \beta_j \ln (c_j/p) + \alpha_j \ln Z_j;$$

$$(4.43) \qquad = \ln A + \beta_1 \ln S + \beta_2 \ln F + \beta_3 \ln L$$

$$- (\beta_1 + \beta_2 + \beta_3) \ln p + \alpha_1 \ln Z,$$

where Π^{*} is the actual farm profit, normalized by the price of output per kilogram; S is the price of seed per kilogram normalized by the price of output per kilogram, measured in rupiahs; F is the price of fertilizer per kilogram normalized by the price of output per kilogram, measured in rupiahs; L is the money wage per man-hour normalized by the price of output per kilogram, measured in rupiahs; Z is the fixed input, farm area, measured in hectares; ln A is the intercept of the normalized profit function; and α_i and β_j are the parameters to be estimated. These particular variables illustrate those used in the rest of the study.

According to Lau and Yotopoulos (1972, p. 12), a set of dual transformation relations connects the production functions and the profit functions. Applying Shephard's Lemma (Shephard 1970), enables the demand function (equation (4.44)) and supply function (equation 4.45) to be derived from equation (4.33):

(4.44) $$X_j = -\partial \Pi^* (c, Z)/\partial c_j^* ;\text{ and}$$

(4.45) $$V = \Pi^* (c, Z) - \sum_{j=1}^{m} [\partial \Pi^* (c, Z)] c_j^* / \partial c_j^* ,$$

where V refers to the supply and $\Pi^* (c, Z)$ refers to the unit-output-price profit function and $c_j^* = c_j /p$.

Multiplying both sides of equation (4.44) by $-c_j^*/\Pi^*$, then:

(4.46) $$(-c_j^* X_j)/\Pi^* = \frac{-c_j^*}{\Pi^*} . X_j = \frac{-\partial \Pi^*(c, Z)}{\partial c_j^*} . \frac{-c_j^*}{\Pi^*}$$
$j = 1, \ldots, m;$

which for the Cobb-Douglas unit-output-price profit function becomes:

(4.47) $$(-c_j^* X_j)/\Pi^* = \beta^*$$
$$X_j = -\beta^* \Pi^* / c_j^*$$
$$X_j = -\beta^* \Pi^* p / c_j ,$$

where β^* is the normalized coefficient of the variable input demand function and other variables are as previously defined. Therefore, the demand function for the j-th variable input restated in its logarithmic form, as specified in equation (4.47) is:

(4.48) $$\ln X_j = \ln (-\beta^*) + \ln \Pi^* + \ln p - \ln c_j .$$

By substituting equation (4.43) into (4.48), the final form of the input demand function for seed, is:

$$\ln S = [\ln(-\beta^*) + \ln A] + (\beta_1 - 1)\ln S + \beta_2 \ln F + \beta_3 \ln L + \alpha_1 \ln Z + (1 - \beta_1 - \beta_2 - \beta_3)\ln p. \quad (4.49)$$

The demand function for fertilizer, is:

$$\ln F = [\ln(-\beta^*) + \ln A] + \beta_1 \ln S + (\beta_2 - 1)\ln F + \beta_3 \ln L + \alpha_1 \ln Z + (1 - \beta_1 - \beta_2 - \beta_3)\ln p. \quad (4.50)$$

The demand function for labour, is:

$$\ln L = [\ln(-\beta^*) + \ln A] + \beta_1 \ln S + \beta_2 \ln F + (\beta_3 - 1)\ln L + \alpha \ln Z + (1 - \beta_1 - \beta_2 - \beta_3)\ln p. \quad (4.51)$$

To represent the output supply function, equation (4.45), is used. The output supply function, V, as specified in equation (4.45), can be rearranged as:

$$\begin{aligned} V &= \Pi^*(c,Z) - \sum_{j=1}^{m} [\partial \Pi^*(c,Z)]\, c_j^*/\partial c_j^* \\ &= \Pi^* \left[1 - \sum_{j=1}^{m} (c_j^*/\Pi^*)(\partial \Pi^*/\partial c_j^*)\right] \quad (4.52) \\ &= \Pi^* \left(1 - \sum_{j=1}^{m} \beta^*\right). \end{aligned}$$

In the logarithmic form equation (4.52) can be written as follows:

$$\ln V = \ln \Pi^* + \ln\left(1 - \sum_{j=1}^{m} \beta^*\right). \quad (4.53)$$

By substituting the actual normalized profit function, as specified in equation (4.35), into the output supply function, as specified in equation (4.53), the final form of the output supply function becomes:

$$(4.54) \qquad \ln V = [\ln (1 - \sum_{j=1}^{m} \beta^{*}) + \ln A] + \beta_1 \ln S + \beta_2 \ln F + \beta_3 \ln L + \alpha_1 \ln Z - (\beta_1 + \beta_2 + \beta_3) \ln p.$$

The input demand function, as specified in equations (4.49), (4.50) and (4.51) and the output supply function, as specified in equation (4.54), are used to obtain the own- and cross-price elasticities of output and variable inputs and the elasticities related to the quantity of the fixed input. These elasticities are derived from the normalized profit functions with varying restrictions.

In addition, it should be noted that since the slope coefficients of the normalized profit function are the same for all groups of farms, the derived elasticities are also the same for all groups of farms. According to Lau and Yotopoulos (1972, p. 17), the derived elasticities from the normalized profit function should be interpreted mutatis mutandis, so that they have a different interpretation from the conventional ceteris paribus elasticities. The derived elasticity from the normalized profit function describes the effect of a one per cent change in an independent variable on the dependent variable when other independent variables are adjusted to their short-run profit maximizing levels. As such, the derived demand elasticities from the normalized profit function will be greater than the conventional elasticities.

4.3.6 Factor Analysis

The merits of the use of factor analysis have been discussed in Chapter 3, Section 3.4. The reason for using factor analysis has also been discussed there.

In this section, details of the technique of factor analysis will be discussed. As has been mentioned in Chapter 3, Section 3.4 the main task in factor analysis is to select some of the relevant variables, and then, to obtain the best linear combination of variables. The assumption behind factor analysis is that the observed variable is influenced by various determinants, some of which are shared by other variables in the set (termed 'common variables') while others are not shared by any other variables (termed unique variables). The following is a summary of the factor analysis method (Kim 1975).

Suppose the basic model is:

(4.55) $$Z_j = a_{j1}F_1 + a_{j2}F_2 + \dots + a_{jm}F_m + d_jU_j;$$

$$j = 1, 2, \dots, n;$$

where z_j is the dependent variable j in standardized form; a_i ($i = 1, 2 \dots, m$) is the standardized multiple regression coefficient of variable j on factor i (factor loading); F_i ($i = 1, 2, \dots, m$) is the set of hypothetical factors; d_j is the standardized regression coefficient for variable j on unique factor j; and U_j is a unique factor for variable j. The assumptions underlying equation (4.55) are that the correlation between F_j and U_j equal zero,

(4.56) $$r(F_i, U_j) = 0;$$

$$i = 1, 2, \dots, n; \; j = 1, 2, \dots, n; \qquad i \neq j,$$

and the correlation between unique .

(4.57) $$r(U_j, U_k) = 0,$$

$$j \neq k .$$

These assumptions mean that the unique factor is assumed to be related to any other variable or to that part of itself which is due to the common factor. Thus, if two variables j and ℓ are correlated to each other, this correlation is assumed to be the common factor. This can be written as follows:

(4.58) $$r_{j\ell} = r_{jF_1}r_{\ell F_1} + r_{jF_2}r_{\ell F_2} + \dots + r_{jF_n}r_{\ell F_n}$$
$$= a_{j_1}a_{\ell_1} + a_{j_2}a_{\ell_2} + \dots + a_{j_n}a_{\ell_m}$$
$$= \sum_{i=1}^{m} a_{ji}\, a_{\ell i}.$$

If there is only a single common factor, equation (4.58) can be restated:

$$r_{j\ell} = a_{jF_1} a_{\ell F_1} . \qquad (4.59)$$

The terminal solution, as specified in equation (4.58), can be obtained in the varimax factor matrix which is derived in the final step of the factor analysis.

4.4 Concluding Comment

The context of the analytical framework of this study was reviewed in the early part of this chapter. That review also included discussion of the aspects of farm resource-allocation and efficiency with particular emphasis on the discussion of the factors affecting farm yield and efficiency.

The analytical techniques were then reviewed in some detail at the end of this chapter. A procedure for measuring and explaining the efficiency of farm resource allocation was presented. This procedure used various techniques: partial productivity analysis, linear regression analysis, Cobb-Douglas production function analysis, Cobb-Douglas frontier production furction analysis, Cobb-Douglas profit function analysis and factor analysis.

Chapter 5

PARTIAL PRODUCTIVITY ANALYSIS

5.1 Introductory Remarks

In this chapter, a series of productivity measures are presented as measures of farm performance with respect to yield, level of input use, and level of profit of the sample farms. Simple cross-tabulation, is used to show the differences between the measures and provide a background against which to interpret the more detailed analysis on farm efficiency in Chapters 6 and 7. Emphasis was placed on farm yields obtained by farmers in order to test the first hypothesis, which is that yields obtained by farmers are the same regardless of farm size, region or tenancy status. In detail the hypothesis is broken into the following parts:

(a) That yields obtained by survey farmers are the same as the regional and national average yields.
(b) That yields obtained by 'small' farmers are the same as 'large' farmers.
(c) That yields obtained in one region are the same as those in any other region.
(d) That yields obtained by owners are the same as those of tenants (sharecroppers).

5.2 Definition of Measured Variables

The main variables used in the analysis were output per hectare, farm size (large and small farms), labour use, current expenses, gross output, gross margin, season and region. Output per hectare, farm size, labour use and current expenses were measured in quintal, hectare, mandays and rupiah, respectively. The distinction between small and large farms was calculated on the basis of the farm size related to a minimum food requirement. A small farm was considered to be a farm whose area was less than 0.675 hectare, whereas a large farm was defined to have an area equal to or greater than 0.675 hectare. Labour used was measured both in monetary terms and in physical units, and current expenses were calculated as the value of seed, fertilizer, manures and pesticides. Gross value of output is a measure of the value of all crops produced using the farm-gate price measured in rupiah. Gross margin is the gross value of output minus variable costs. The 'wet season crop' refers to the first crop grown (in the season I) and 'dry season crop' refers to the second crop grown (in the season II). By using irrigation, some farmers were able to grow three crops (rice) in 14 months. Region 1 is the village of Gemarang, Region 2 is Sukosari and Region 3 is Petung. Detailed definitions of these variables are provided in Appendix E.

5.3 Yield Performance of Selected Crops

The yield performance of the major crops of the sample farms (rice, maize, soybean, cassava and tobacco) was broken down according to the various farm groups and regions. This approach is essential to gain an understanding of farmers' behaviour in the different farm groups and regions.

From Table 5.1 (column 2), it can be seen that the yield for rice in season 2 was higher on large farms than that for small farms. The yields for other crops, except for maize and tobacco, were significantly different as between large and small farms. The z-test was used when there were more than 30 observations. The rice yield for large farms was 3.19 tonnes of rough rice in the season 2 or about 40 per cent higher than that for small farms. The data presented in Table 5.1 are

Table 5.1

Arithmetic Means of the Input and Output Levels per Farm, per Hectare and per Season by Farm Group and Major Crops, East Java, 1978[a]

Crop[b]	Farm groups	Output (qt/farm/ season)	Land (hectare /farm/ season)	Labour (mandays/farm/ season)	Current expenses (Rp'000/farm/ season)	Sample size
	1	2	3	4	5	6
Rice 1	Small	6.00	0.180	26.88	5.51	42
		(33.33)		(150.00)	(30.61)	
	Large	26.86	0.723	83.50	36.12	101
		(37.15)		(116.00)	(49.96)	
		z=0.928		z=2.520**	z=2.377**	
Rice 2	Small	3.78	0.166	22.13	5.36	28
		(22.77)		(132.00)	(32.29)	
	Large	20.86	0.654	79.00	29.60	73
		(31.87)***		(121.00)	(45.23)	
		z=3.240		z=0.749	z=1.585	
Rice 3	Small	3.48	0.133	15.65	1.46	3
		(26.17)		(118.00)	(10.98)	
	Large	22.89	0.762	93.38	19.97	26
		(30.02)		(123.00)	(26.21)	
		t=0.662		t=0.100	t=0.095	
Soybean[c]	Small	0.99	0.250	16.06	6.75	6
		(3.95)		(64.25)	(27.02)	
	Large	3.21	0.620	34.82	16.44	31
		(5.18)*		(56.17)	(26.51)	
		z=1.545		z=0.704	z=0.230	
Maize[c]	Small	3.00	0.183	26.75	1.46	3
		(16.39)		(146.17)	(8.00)	
	Large	11.17	0.481	22.17	19.12	6
		(23.22)		(46.08)***	(39.75)***	
		t=0.372		t=6.754	t=4.265	
Cassava[c]	Small	2.83	0.067	6.69	0.89	3
		(42.24)		(103.86)	(13.31)	
	Large	18.00	0.163	34.00	1.54	2
		(111.11)*		(208.58)***	(9.45)	
		t=1.844		t=6.253	t=0.798	

Table 5.1 continued

Crop	Farm groups	Output (qt/farm season)	Land (hectare /farm/ season)	Labour/ (mandays/ farm/season)	Current expenses (Rp'000/farm/ season)	Sample size
	1	2	3	4	5	6
Cassava[d]	Small	9.19 (50.77)	0.181	26.91 (148.67)	0.74 (4.09)	15
	Large	31.58 (46.99) z=0.372	0.672	47.92 (71.32)*** z=4.637	4.03 (6.00) z=0.552	18
Tobacco[d]	Small	17.50 (118.24)	0.148	5.31 (35.90)	1.68 (11.35)	2
	Large	80.13 (114.64) t=0.039	0.699	76.25 (109.08)** t=1.976	34.25 (49.01)* t=1.650	16

[a]Small farm is defined as less than 0.675 hectare and large farm as greater than or equal to 0.675 hectare. The z- and t-values were calculated from the per hectare figures. Rice, soybean and maize, and cassava qualities are expressed in rough rice, dried kernel, and in fresh root, respectively; whereas tobacco is in fresh leaf.

[b]Rice 1, 2 and 3 were grown in the wet season, 1st dry season and 2nd dry season respectively.

[c]Grown on irrigated land (<u>sawah</u>).

[d]Grown on non-irrigated land (<u>tegal</u>).

[e]Figures in parentheses are per hectare.

*, ** and ***, respectively, mean that the t-statistics were significant at 10, 5 and 1 per cent levels (using two-tailed z- and t-tests).

the farm level data in which the yields have not been adjusted for crop damage. For the purpose of comparison between the average farm-yield and national or regional average, the yield data presented in Table 5.1 were adjusted for crop damage using a technique presented in Appendix E.

When food-crop yields of the major crops grown in the study area are compared with the average yields taken from Insus (this system has been explained in Chapter 2, Section 2.3), and the regional and national levels (Table 5.2), the yields are seen to be low. The results are presented in Table 5.2. Thus, the hypothesis that yields for rice grown in the study area are the same as those in Insus, regional and national levels should be rejected (this also applies to other food crops). For example, irrigated rice yields for both small and large farms were:

(a) about 31 per cent lower than the average yield produced by the Insus system which was 9.30 tonnes of rough rice per hectare (Sukirno 1981);

(b) lower than the national average yield of 4.22 tonnes per hectare and the regional average yield of 4.95 tonnes rough rice per hectare in 1978 (Biro Pusat Statistik 1979).

These results are not surprising, since the Insus system is closely supervised and sustained by the provision of credit, whereas some of the sample farmers were not supported in this way. This finding for irrigated rice yields is consistent with evidence in many less developed countries, for example; in the Philippines the average yields according to farm surveys are 30 per cent lower than those yields calculated from 'crop-cutting data' (Herdt and Mandac 1981, p. 398).

There are several reasons which can be given to explain the yield differentials. First, the difference may be due to different methods of collecting and calculating data. Yields measured under the Insus project were measured by the output of a crop area on 10 square metres. This was then multiplied by 100 in order to get an average production per hectare. Second, differences have also resulted from a higher percentage of pest and disease damage during the survey period (about 20

Table 5.2

Yields for the Food Crops in the Study Area, Regional, and National Levels in 1978[a]

Crops[b]	Farm groups	Yields (qt/hectare)		
		Study area	Regional	National
	1	2	3	4
Rice 1	Small	33.33 (15.66) n=42	49.51 (13.86) n=30 t=6.69***	42.23[c] (3.94) n=7 t=3.68***
	Large	37.15 (34.03) n=101	49.51 (13.86) n=30 t=7.78***	42.23[c] (3.94) n=7 t=5.63***
Rice 2	Small	22.77 (3.32) n=28	49.51 (13.86) n=30 t=42.44***	42.23[c] (3.94) n=7 t=31.39***
	Large	31.87 (23.36) n=73	49.51 (13.86) n=30 t=6.46***	42.23[c] (3.94) n=7 t=3.79***
Rice 3	Small	26.17 (3.39) n=3	49.51 (13.86) n=30 t=11.91***	42.23[c] (3.94) n=7 t=8.19***
	Large	30.02 (30.88) n=26	49.51 (13.86) n=30 t=3.22***	42.23[c] (3.94) n=7 t=2.02**
Soybean	Small	3.95 (0.02) n=6	7.56[d] (0.62) n=28 t=45.12***	8.17[e] (1.23) n=24 t=52.75***
	Large	5.18 (4.43) n=31	7.56[d] (0.62) n=28 t=2.98***	8.17[e] (1.23) n=24 t=3.74***
Maize	Small	16.39 (4.66) n=3	22.59 (9.57) n=30 t=2.30**	21.21[f] (3.52) n=26 t=1.79*
	Large	23.22 (30.46) n=6	22.59 (9.57) n=30 t=0.05	21.21[f] (3.52) n=26 t=0.16

Table 5.2 continued

Crops	Farm groups	Yields(qt/hectare) Study area	Regional	National
1		2	3	4
Cassava 1	Small	42.24 (34.47) n=3	85.45 (29.36) n=30 t=1.72*	91.85[f] (12.02) n=26 t=1.98**
	Large	111.11 (25.02) n=2	85.45 (29.36) n=30 t=1.45	91.85[f] (12.02) n=26 t=1.09
Cassava 2	Small	50.77 (25.02) n=15	85.45 (29.36) n=30 t=5.37***	91.85[f] (12.02) n=26 t=6.36***
	Large	46.99 (33.42) n=18	85.45 (29.36) n=30 t=4.88***	91.85 (12.02) n=26 t=5.69***

[a] Rice, soybean and maize, and cassava were expressed as rough rice, dried kernel and fresh root, respectively. Figures in parentheses are standard deviations. The yield data for different seasons and farm groups were not available. Since u was known the differences between two means were tested using the following formula, $(\bar{x}-\mu)/(s^2/n)^{\frac{1}{2}} \sim t_{n-1}$ (G.E. Battese, personal communication, 1983).

[b] Rice 1, 2 and 3 were grown in the wet season, first dry season and second dry season respectively. Soybean, maize and cassava 1 were grown on sawah land; cassava 2 and tobacco were grown on tegal land.

[c] Yields in the main areas of rice production (Provinces in Java, Bali, West Nusa Tenggara and South Sulawesi).

[d] Data for two regions (Sampang and Pamekasan) were not available.

[e] Data for three provinces (Jakarta, East Timor, and Central Kalimantan) were not available.

[f] Data from East Timor Province were not available.

*, ** and ***, respectively, mean that t-statistics were significant at the 10, 5 and 1 per cent levels (using two-tailed t-tests).

Source: Data in column (2) were taken from yield data presented in Table 5.1. Data for regional and national areas were taken from Dinas Pertanian Jawa Timur (1979) and Biro Pusat Statistik (1979), respectively.

Statistical test were carried out between pairs (figures in columns 2 and 3, and 2 and 4).

per cent of the total crop) while the percentage of crop damage at a regional level (East Java Province) was 16 per cent for the same period.

The yields for the rice crop by region and tenancy status are presented in Table 5.3. From this table, it can be seen that yields obtained by small farmers were not the same as large farmers. The yields obtained by owners were the same as those of sharecroppers. The yields obtained in one region were not the same as those in any other region.

Finally, input and output levels per farm and per hectare by major crops and regions are presented in Table 5.4. A conclusion which may be derived from the data presented in Table 5.4, although not statistically tested, is that, given the agricultural environment, the lower the altitude of the region, the higher the yield.

In the foregoing analysis, an attempt has been made to depict the performance of the sample farm households through a productivity approach. Besides trying to determine whether or not labour and other inputs make a substantial contribution to gross returns, the analysis provides an overall picture of the sample farms in terms of yields. Overall, yields were low compared with national or regional yields.

5.4 Other Productivity Measures

5.4.1 The Effect of Farm Area

Various productivity measures for the sample farms per unit of farm area are presented in Table 5.5. From this table, two important conclusions can be drawn: first, gross output per hectare and gross output per hectare per rupiah of variable costs are higher for the larger than for the smaller farms. This finding also applies to the various gross margin measures. From these findings, one may conclude that large-area land holdings are not necessarily less productive under certain criteria. Second, the percentage of irrigated rice gross output in relation to total gross output and percentage of irrigated rice gross margin in relation to total gross margin are relatively high, that is, they vary from 72 to 78 per cent which indicates that rice plays an important role in the income of farm households.

Table 5.3

Yields for the Rice Crop in the Study Area by Region and Tenancy Status, East Java, 1978

Items	Yield[a]		
	Wet season	Dry season	Pooled data
Farm groups[b]			
Large	42.3* (34.75)[e] n=101	53.46**[f] (89.69) n=73	46.88** (61.10) n=174
Small	34.74 (20.97) n=42	29.54 (19.26) n=28	31.66 (20.15) n=70
Tenancy status[c]			
Owners	37.76 (24.71) n=130	46.85 (81.05) n=92	41.52 (55.51) n=222
Sharecroppers	45.61 (19.38) n=13	38.15 (14.93) n=9	42.56 (17.70) n=22
Regions[d]			
I (Gemarang)	51.96*** (24.08) n=46	48.56*** (23.67) n=39	50.40 (23.61) n=85
II (Sukosari)	32.38 (23.14) n=51	34.69** (26.60) n=39	33.15 (24.16) n=90
III (Petung)	31.84 (20.04) n=46	21.53 (16.51) n=23	26.86 (18.79) n=69

[a] Yields adjusted for crop damage (rough rice, qt/ha).

[b] The tests were carried out for a comparison between large and small farms.

[c] The tests were carried out for a comparison between owners and sharecroppers.

[d] The tests were carried out for Regions 1 and 2 in relation to Region 3.

[e] Figures in parentheses are standard deviations.

[f] *, ** and ***, respectively, mean that the t-statistics were significant at the 10, 5 and 1 per cent levels (using two-tailed tests).

Table 5.4

Arithmetic Means of the Input and Output Levels per Farm and per Hectare by Region and Major Crops, East Java, 1978

Crop[a]	Output (qt/farm/ season)	Land (hectare /farm/ season)	Labour (mandays/ farm/ season)	Current expenses (Rp'000/farm/ season)	Sample size
		Gemarang (Region 1)			
Rice 1	37.37	0.756	96.13	56.83	46
	(49.43)[d]		(127.00)	(75.17)	
Rice 2	27.58	0.639	84.67	43.67	39
	(43.16)		(132.00)	(68.34)	
Rice 3	19.24	0.406	48.15	13.99	6
	(47.39)		(119.00)	(34.46)	
Soybean[b]	2.85	0.560	31.78	14.87	37
	(5.09)		(56.75)	(26.55)	
		Sukosari (Region 2)			
Rice 1	20.40	0.706	73.58	20.18	51
	(28.90)		(105.00)	(28.58)	
Rice 2	22.01	0.602	62.92	14.26	39
	(36.56)		(106.00)	(23.69)	
Rice 3	29.61	0.773	95.03	19.11	23
	(38.31)		(123.00)	(24.72)	
Cassava[b]	38.33	0.417	11.83	9.82	6
	(91.33)		(28.37)	(22.55)	
Maize[b]	8.44	0.381	24.29	13.23	9
	(22.15)		(63.76)	(34.72)	
Tobacco[c]	71.17	0.638	68.36	30.64	18
	(111.55)		(107.15)	(48.03)	
		Petung (Region 3)			
Rice 1	2.31	0.212	30.27	4.05	46
	(10.90)		(143.00)	(19.10)	
Rice 2	2.58	0.174	23.81	1.34	23
	(14.83)		(137.00)	(7.70)	
Rice 3	0	0	0	0	0
Cassava 1[b]	8.70	0.105	17.77	1.15	5
	(82.86)		(169.24)	(10.95)	
Cassava 2[c]	18.10	0.356	44.27	0.87	27
	(50.84)		(124.35)	(2.44)	

[a]Rice 1, 2 and 3, respectively, grown in wet season, 1st dry season and 2nd dry season.

[b]Grown on irrigated land (sawah).

[c]Grown on non-irrigated land(tegal).

[d]Figures in parentheses are per hectare.

Table 5.5

Partial Productivity Measures of Sample Farms by Farm Size and Cropping Pattern, East Java, 1978

Items[a]	Irrigated land (rice)		Irrigated and non-irrigated land (rice and non-rice)		Percentage irrigated land/total land	
	Small farm n=100	Large farm n=108	Small farm n=100	Large farm n=108	Small farm n=100	Large farm n=108
1	2	3	4	5	6=2:4	7=3:5
	(Rp'000)		(Rp'000)		(%)	
Gross output/hectare	95.55	184.76	122.82	249.34	78	74
Gross output/hectare /manday	0.67	1.55	0.59	1.53	144	101
Gross output/hectare /Rp of variable cost	2.25	2.71	2.70	2.59	83	105
Gross margin/hectare	53.17	116.57	63.42	160.99	78	72
Gross margin/hectare /manday	0.37	0.98	0.33	0.99	112	99
Gross margin/hectare /Rp of variable cost	1.25	1.71	1.51	1.67	83	113

[a]Actual gross output and gross margin.

Small farm is defined as less than 0.675 hectare and large farm as greater than or equal to 0.675 hectare.

Often, a small farm has a higher gross output per unit of land than a large farm; however, this situation was not found in this study. Several reasons can be advanced as to why large farms may have a higher value of gross output and gross margin per hectare. First, on a large farm, there is usually enough capital to operate the farm more intensively. This capital may come from either farmers' savings or Government aid or both. In terms of fixed capital, the average value of agricultural equipment, transport equipment and animals, on the large farms was Rp 100.9 thousand, whereas for small farms it was Rp 26.6 thousand (or more than 3.7 times as much). This indicates a greater financial ability to provide capital inputs. Furthermore, Government aid through Bimas appears to have been more beneficial to large farmers than to small farmers as shown by Soewardi (1976), and Gibbons et al. (1980). They argued that large farmers made substantial gains from increased production and privileged market access in the wake of the high-yielding varieties. This means capital accumulation increased their capacity to finance further innovations. Indeed, if hired labour is employed in preference to family labour and if more non-traditional capital is used, then large-sized holdings and higher crop productivity can co-exist. Second, the low gross output per hectare per manday and the low gross output per hectare per rupiah of variable costs indicate the low productivity of small farms based on these measures (see Table 5.5).

Furthermore, the importance of irrigated rice to the farm family can be shown from Table 5.5 by the higher percentage value of rice-farm production in relation to the value of total-farm production; that is, 78 per cent. This figure is higher for small farms than for large farms, which indicates that rice, which is a staple food for Indonesia, plays a more important role on small farms.

5.4.2 The Effect of Farm Area and Region

The effects of farm area and region on gross output and gross margins are presented in Tables 5.6 and 5.7. These tables provide three-dimensional cross-tabulations which show the relationship between regions (Regions 1, 2 and 3) and gross output and gross margin for both

Table 5.6

Partial Productivity Measures of Small Farms[a] by Region[b] and Cropping Pattern, East Java, 1978

Items[c]	Irrigated land (rice)			Irrigated and non-irrigated land (rice and non-rice)			Percentage irrigated land/ total land		
	Region 1 n=29	Region 2 n=29	Region 3 n=42	Region 1 n=29	Region 2 n=29	Region 3 n=42	Region 1 n=29	Region 2 n=29	Region 3 n=42
	(Rp'000)			(Rp'000)			(%)		
Gross output/ hectare	248.36	70.89	63.07	281.11	107.80	85.76	88	66	74
Gross output/ hectare/manday	1.50	0.53	0.42	1.19	0.61	0.38	126	87	111
Gross output/ hectare/Rp of variable cost	2.56	2.78	4.94	2.52	3.15	5.55	102	69	89
Gross margin/ hectare	124.65	38.34	42.72	139.39	68.54	53.35	89	56	80
Gross margin/ hectare/manday	0.75	0.28	0.28	0.59	0.39	0.24	127	117	72
Gross margin/ hectare/Rp of variable cost	1.28	1.18	3.35	1.25	2.01	3.45	102	59	97

[a]A small farm is defined as less than 0.675 hectare.

[b]Regions 1, 2 and 3 are Gemarang, Sukosari and Petung respectively.

[c]Actual gross output and gross margin.

Table 5.7

Partial Productivity Measures of Large Farms[a] by Region[b] and Cropping Pattern, East Java, 1978

Items[c]	Irrigated land (rice)			Irrigated and non-irrigated land (rice+non-rice)			Percentage irrigated land/ total land		
	Region 1 n=41	Region 2 n=36	Region 3 n=31	Region 1 n=41	Region 2 n=36	Region 3 n=31	Region 1 n=41	Region 2 n=36	Region 3 n=31
	(Rp'000)			(Rp'000)			(%)		
Gross output/ hectare	253.74	140.09	79.88	303.93	256.56	108.66	83	55	74
Gross output/ hectare/manday	1.97	1.31	0.57	1.82	1.64	0.55	108	80	104
Gross output/ hectare/Rp of variable cost	2.46	3.12	3.82	2.19	2.94	4.03	112	106	95
Gross margin/ hectare	150.69	95.35	58.96	175.07	182.03	83.93	86	52	70
Gross margin/ hectare/manday	1.17	0.89	0.42	1.05	1.17	0.43	111	76	98
Gross margin/ hectare/Rp of variable cost	1.46	2.12	2.81	1.26	2.09	3.17	116	101	89

[a]A large farm is defined as greater than or equal to 0.675 hectare.

[b]Regions 1, 2 and 3 are Gemarang, Sukosari and Petung respectively.

[c]Actual gross output and gross margin.

rice and non-rice. In Table 5.6 the various productivity measures for small farms and Table 5.7 for large farms are presented. Even though the data have been broken down into different farm areas and regions, the results support the previous conclusions (Section 5.4.1), that is, the lower the altitude of the region, the higher the gross output per hectare and gross margin per unit of land, both in the small farms and large farms. Another reason for the difference in gross output per hectare is the difference in the gross output per hectare per manday reflecting labour productivity and the gross output per hectare per rupiah of variable cost reflecting the productivity of working capital (Tables 5.6 and 5.7). Both for small and large farms, the region with the lower altitude has a higher gross output per hectare per manday but a lower gross output per hectare per rupiah of variable cost. This result applies to both rice and non-rice crops.

5.5 Concluding Remarks

In this chapter, the yield performance, the level of the input use and gross output have been discussed. Several main conclusions that can be summarized from this chapter are:

First, that yields of the major crops grown were very low when compared with both regional average yields and national average yields (hypothesis (a), is rejected). Unlike farmers in the Philippines (Roumasset 1976, p.99), where the variation in farm size is large (from 0,6 to 49,9 hectares), the farm size in the study area ranges from 0,050 to 3,075 hectares. It was found that, as a whole, the rice crop yields achieved by large farmers were greater than those achieved by small farmers (hypothesis (b) is rejected). Furthermore, the lower the altitude of the region (Regions 1 and 2) the better the agricultural environment, the higher the yield (hypothesis (c) is rejected). It was also found that farm production was not higher under a share-tenancy system (hypothesis (d) is rejected). The implication is that the Government policy on share tenancy in agriculture which controls and limits all land leasing and land sharing in agriculture is not likely to significantly affect levels of output.

Second, it appears that the lower the altitude of the regions (Regions 1 and 2), the higher gross output and gross margin per unit of land. This indicates that the better agricultural environment (i.e. land quality and other factors), the higher output per unit of land.

The above findings were derived by using simple techniques, cross-tabulation, and regression. Therefore, the results may not adequately portray more complex relationships between inputs and outputs. The cross-tabulations are useful in terms of explaining the overall picture of the sample farms but they are not able to provide a detailed explanation of the underlying structure. In other words, the results may provide inconsistent conclusions with regard to relative productivity as also indicated by Yotopoulos and Nugent (1976).

Given the above results and, in order to establish their validity, alternative techniques will be used to further the analysis, namely, production function analysis, profit function analysis, and mathematical programming. Production function analysis and mathematical programming will be used in order to uncover the detailed relationships between inputs and outputs, and the technical performance of the sample farms; profit function analysis will be used to explain economic performance. A detailed discussion of results relating to these techniques is presented in the following chapter.