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Supply response and food demand in Lampung, Indonesia

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

A. Background

Indonesia is a nation comprised of 13,677 islands, making it the world's largest archipelago and one of the most diverse and heterogeneous countries in the world. This sprawling chain of islands stretches across the equator between the Indian and Pacific oceans, forming a bridge between the continents of Asia and Australia (Figure 1.1). About 6,000 of these islands are inhabited. The principal islands are Sumatra, Java, Kalimantan (formerly Borneo), Sulawesi (formerly Celebes), Bali, and Irian Jaya. Java, where the central government of the country is seated, has about 7 percent of the total area of the country. Compared to Java, the other major islands are much larger. For example, Sumatra, Kalimantan, Sulawesi, and Irian Jaya are 3.5, 2.08, 1.53, and 3.5 times larger than Java respectively. The country has 27 provinces: 8 provinces in Sumatra, 5 in Java, 4 in Kalimantan, 4 in Sulawesi, and one each in Bali, West Nusa Tenggara, North Nusa Tenggara, Timor Timur, Ambon, and Irian Jaya.

After the People's Republic of China, India, Soviet Union, and United States of America, Indonesia is the world's fifth most populous country. According to the 1985 Inter-Census Population Survey (SUPAS), Indonesia had 174.49 million people, of which about 60.72 percent lived in rural areas. Indonesia's population was 119.2 million in 1971 and rose to 164.62 million in 1980. Average annual population growth was 2.3 percent during the decade of 1970s and dropped to about 2.15 percent by the mid 1980s. The result of the 1990 Population Census showed that the population is now 179.36 million with an average rise of 1.9 percent per year. More than 60 percent of the Indonesian population live on the islands of Java and Madura which account for only 7 percent of the total area of the country (Table 1.1). About 20 percent of the

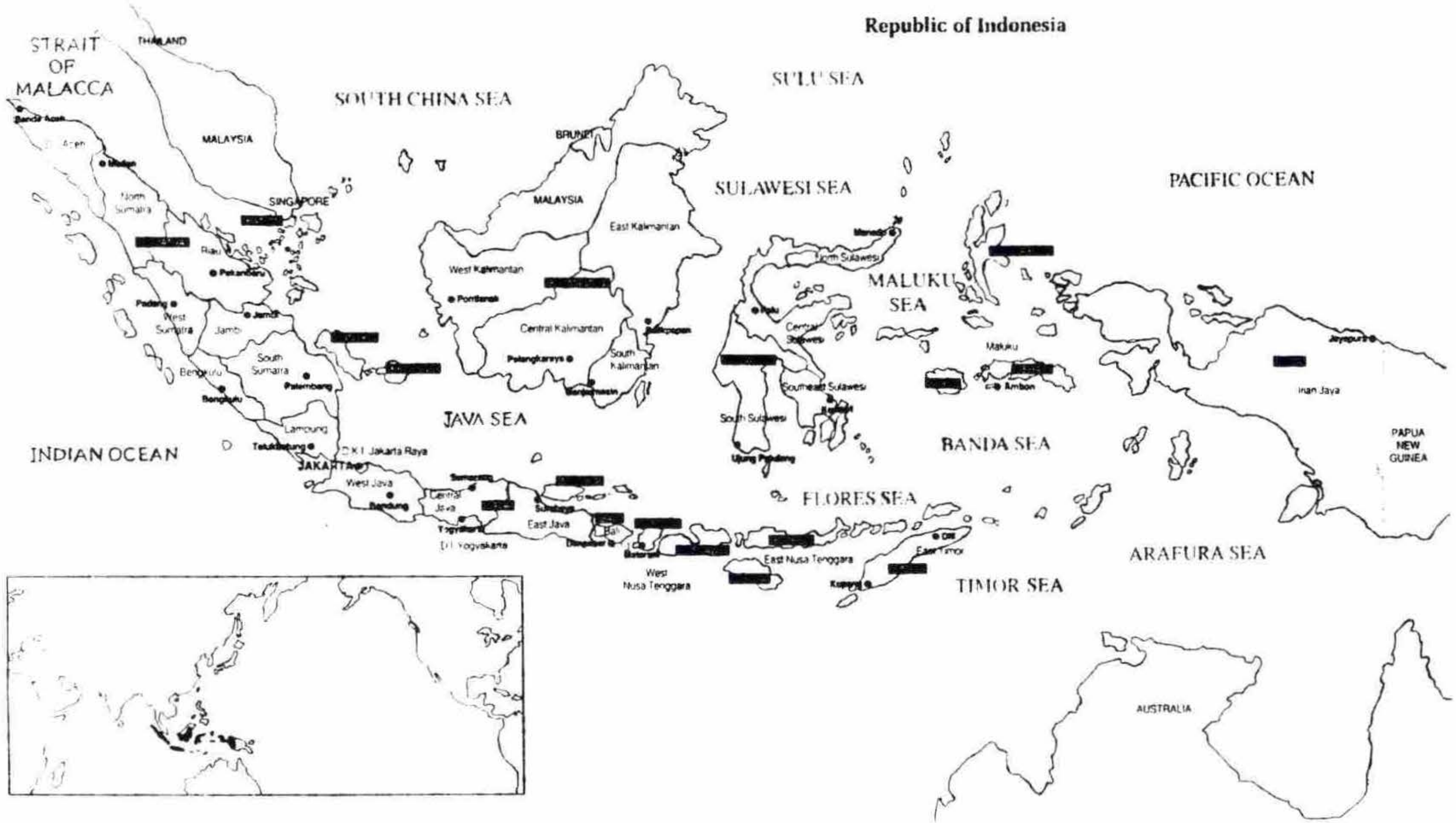

Figure 1.1 Map of Indonesia

Table 1.1. The Indonesian population (in million), 1961-1990

Georgraphical Areas	1961	1971	1980	1985	1990	Percent of Change 1961-71	1971-80	1980-90
Java & Madura	63.0	76.1	91.3	100.3	n.a.8	1.91	2.08	n.a.
Outer Java	34.0	43.1	56.2	64.3	n.a.	2.40	3.03	n.a.
Indonesia	97.0	119.2	147.5	164.6	179.3	2.08	2.32	1.97

Source: Central Bureau of Statistics, (1989,1991).

total population is concentrated in Sumatra, and the remaining 20 percent is concentrated in Sulawesi, Kalimantan, West and North NusaTenggara, Irian Jaya, Bali, and the other 6,000 inhabited islands. The imbalance of population to the available land resources of these densely populated islands constitutes one of the most serious challenges to the promotion of agricultural development.

B. Agricultural Sector in Indonesia

Since 1969 the Indonesian government has instituted four five-year development plans (called Repelita). Through implementation of these plans the government has attempted to control the relative growth of the various sectors of the economy by strategic placement of public investment. The long-term goal is to build an industrial nation supported by a sustained agricultural sector. The general approach has been to expand rice production (the major food staple) while at the same time attempting to produce rapid growth in manufacturing and mining. The results of agricultural development have been successful. The target of self-sufficiency in rice was achieved in 1985. The growth of manufacturing, however, has been less spectacular. The mining sector, a large component of which is the oil industry, has undergone dramatic surges and downturns, mainly in response to price changes in the international oil market.

Consequently, mining is currently in decline, especially before the Gulf Crisis began. Nevertheless, it remains the second largest sector after agriculture in terms of its contribution to GDP.

Hence, Indonesia's economy is based primarily on agriculture, mineral and oil exploitation, manufacturing, and trade. Agriculture is the largest sector in Indonesia's economy. Through all four five-year development plans, the food-producing sector of agriculture has received special attention from the government. At first this policy was followed because agriculture was such a dominant part of the economy, contributing more than 50 percent of GDP, and hence agricultural growth was essential to overall economic growth. More recently, the attention given to the food-producing sector has been in an effort to drive the country towards food self-sufficiency and to ensure stability in agriculture as the basic employment-generating sector of the economy.

Table 1.2 presents the contribution of various sectors of the economy to GDP. Although its share in GDP has been declining, agriculture (including forestry and fishing) is still the largest

Table 1.2. Sectoral contributions to GDP at current prices

Sector (percent)	1960	1970	1980	1985	1986	1987	1988
Agriculture	53.9	48.6	24.0	23.6	25.8	25.5	21.6
Non-Agriculture	46.1	51.4	76.0	76.4	76.2	74.5	78.4
Mining	3.7	5.3	23.0	16.2	16.7	13.1	15.9
Manufacturing	8.4	9.0	13.0	13.5	14.2	13.9	15.8
Electricity	0.3	0.5	0.5	0.8	0.9	0.9	1.1
Construction	2.0	3.1	5.3	5.3	5.5	5.3	5.6
Trade	14.3	16.6	15.0	15.4	17.0	16.8	15.9
Transport. & Communication	3.8	3.0	4.5	6.5	6.7	6.5	5.7
Public Administrations	4.5	5.6	6.6	8.5	8.7	7.8	8.3
Others	9.1	8.3	8.1	10.2	10.2	10.2	11.0

Source: 1960 - Booth and Glassburner (1975); 1970 - United Nations (1983); 1980-88 - CBS (1989).

sector. In 1988 it contributed 21.6 percent of GDP (CBS 1989), a share that suggests a structural change from agriculture to industry and service in the economy. Since 1980, the output of food crops has expanded due to price policy stimulus, technological change, and relative decline in the value of oil export. The figures in Table 1.3. show that food crops continue to provide a majority share of agriculture output. Food crops typically account for more than 60 percent of the value of total agricultural output.

Table 1.3. The contribution of food and nonfood crops to agricultural output measured at current prices

Product (percent)	1960	1970	1980	1985	1986	1987	1988
Food Crops	63.8	61.0	57.1	62.4	n.a.	n.a.	n.a.
Nonfood Crops	36.2	39.0	42.9	37.5	n.a.	n.a.	n.a.

Sources: 1960 - Booth and Glassburner (1975); 1970 - United Nations (1983); 1980-88 - Central Bureau of Statistics (1989).

The food producing segment is characterized by small holdings. It uses more than 80 percent of agricultural land, and more than 75 percent of the population is located in the rural areas. On the consumption side, more than 60 percent of consumer expenditure is devoted to food (CBS 1989). The relative importance of various food crops in the agricultural economy is indicated in Table 1.4. Among food crops, rice and corn are predominant in caloric consumption and, together with cassava, form the bulk of food crop production. Various government programs have attempted to reduce the importance of rice by encouraging the production of sugarcane and secondary food crops (corn, cassava, soybeans, mungbeans, peanuts, and sweet potatoes). However only partial success has been achieved. The main difficulty is that secondary food crops are considered inferior to rice by many consumers.

Table 1.4. Relative position of rice and secondary food crops in Indonesia (1988)

Commodity	Area	Production	Available Consumption Per Capita	Equivalent Rice Calories Available Per Capita
	(000 ha)	(quintal)	(kilogram)	(kilogram)
Rice	9,865	27,253	143	143
Corn	2,768	5,449	33	33
Cassava	1,221	12,103	88	26
Soybeans	1,150	1,204	4	-
Peanuts	573	533	-	-

Source: Central Bureau of Statistics (1989).

With the achievement of rice self-sufficiency in 1985, the focus of Indonesia's food policy was broadened somewhat to include the promotion of secondary food crops and sugarcane production. The basic mechanism of centrally directed supply targets and inputs distribution, however, have remained the means to encourage diversification of the food crops sector. A new super-intensification program to expand rice and secondary food crops output was introduced in West Java for the 1987 crops (MOA 1987). Plans were to extend this program to other major food production regions of Indonesia such as East Java, Central Java, Bali, South Sulawesi, Lampung, West Sumatra, and North Sumatra in the near future.

C. Statement of the Problem

The major objective of Indonesia's agricultural development during the current fifth five-year development plan (Repelita V, 1989-1993) has been to achieve self-sufficiency in food. During Repelita V, Indonesia is implementing economic reforms called deregulation and debureaucratization directed at moving away from an administered economy to one more responsive to domestic and international market forces in every sector. For the agriculture sector, these reforms suggest an increased emphasis on deregulation of the agro-processing sector to shift more of sugarcane and secondary food crops production to off-Java areas, a reduction in agricultural subsidies, a relaxation of commodity production targets, and a better integration of the agricultural sector both with international commodity markets and with other sectors of the economy (Heytens and Meyers 1990)

This reformation of the Indonesian agricultural economy will occur against the backdrop of two sectoral realities: (1) rice self-sufficiency is tenuous and must be pursued vigorously if the trend in domestic production is to meet an even lower than historical trend in domestic consumption in the future, and (2) rising Indonesian incomes are changing the structure of consumer demand and creating different food crop requirements (Heytens and Meyers 1990). The impact of these changing agricultural conditions on the economy at the national level as well as in the regional (provincial) level like Lampung can be analysed. Because the regional characteristics of the production systems and cropping patterns vary widely among regions, it will be fruitful to take a regional focus when setting food and agricultural policy in Indonesia. For this purpose, according to Kesavan (1990a) a comprehensive policy analysis at the regional level is required in order to operate a government pricing programs which, through their impact on the incentive environment, indirectly affect agricultural supply and development. An understanding of aggregate agricultural-commodity supply-and-demand relationships at the provincial (regional) level would be useful for designing agricultural, food, and nutritional strategies and for evaluating regional comparative advantage.

D. Objectives and Organization of the Study

Given the quantitative importance of agriculture in the country, the importance of food crops to the majority of the people, and the potential contribution to the growth of the economy, the knowledge of aggregate agricultural-commodity supply-and-demand parameters is crucial. Since the main economic problem of food crops agriculture is directly or indirectly related to supply and demand of outputs, policy recommendations are determined by a *priori*hypotheses about the responsiveness of output supply and demand functions.

The main purpose of this study is to provide an econometric analysis of area responses and output demands of food crops in Lampung province of Indonesia. A consistent set of supply and demand parameters is required for the economic analysis of agricultural policy options. This is especially important for the food sector since the focus of agricultural programs has shifted from a near single-minded campaign to increase rice production to a more multi-commodity orientation. A clear understanding of the economic inter-relationships among commodities and productive resources is needed to manage a multi-commodity food policy.

The empirical analysis consists of two parts. The first part focuses on estimating the parameters for the economic analysis of area response. The second part focuses on estimating the output demand parameters. In this study, a partial adjustment supply response model and almost ideal demand system model will be used to estimate parameters of supply and demand for economic analysis. The output data cover four food crops: rice, corn, cassava, and soybeans. Data for both supply and demand analyses are time-series from 1969 to 1988 and cross-sectional, from the National Social and Economic Survey (SUSENAS) 1987.

This study, in particular, attempts to contribute to the knowledge of the influence of price on the supply of and demand for food crops in Lampung. Because of their importance to the Lampung economy, the four major crops --rice, corn, cassava, and soybeans-- have been chosen for this study. The overall objectives of this study are four fold:

1. To study the structure and trend of food crops in Lampung province of Indonesia.
2. To understand the importance of individual regions in promoting national economic growth and development, and meeting national food requirements.
3. To estimate area response and output demand elasticities of rice, corn, cassava, and soybeans in Lampung.
4. To utilize estimated elasticities to evaluate pricing policies by the government.

This study is divided into six chapters. Chapter I provides an Introduction. Chapter II discusses food crops policy and structure in Indonesia, the need for a regional policy system, and the previous work done on food crops policy studies in Indonesia with emphasis on rice and secondary food crops. Chapter III reviews the specification of supply and demand models. Chapter IV covers regional supply and demand estimation for the case of Lampung. Chapter V presents empirical results and discussion. And, Chapter VI presents the summary of findings, the conclusion of the study, and the implications and recommendations for future research.

II. FOOD CROPS POLICY AND STRUCTURE IN INDONESIA

There is a long history of government involvement in the food crops policy of Indonesia. Concise but seemingly comprehensive accounts are available in Pitt (1977), Hedley (1978), Rasahan (1983), World Bank (1983; 1987a), IFPRI AND CAER (1986), Johnson, Meyers, Jensen, Teklu, and Wardhani (1986), Rosegrant, Kasryno, Gonzales, Rasahan, Saefudin (1987). Booth (1988), Baharsyah, Hadiwiguno, Dillon, Hedley, and Tabor (1988), Jensen and Teklu (1988), Tabor, Altemeier, and Adinugroho (1988), Timmer (1989), Heytens and Meyers (1990). Government involvement has been for both political and economic reasons and is spreading to secondary food crops. In this chapter attention is focused on five matters: the policy-making process, food crops policies in Indonesia, policy instruments, the need for a regional policy system, and previous work done in food crops policy studies.

A. The Policy-Making Process

Glassburner (1986) probably understood well the matter when he described policy-making in Indonesia as an "obscure process." To the author's knowledge the process has never been documented comprehensively, and this observation in itself suggests some characteristics of the policy-making environment: lack of public debate and the probability that much policy is determined by very small "inner-circles." Those who do have an intimate knowledge of how policy is formulated are not prone to make that knowledge public lest they lose their role in the policy-making process. Also, it is probably the case that some policy decisions are responses to crisis situations in which there is no time for debate.

Liddle (1987b) argues that there are three interest groups competing "for the President's ear." Depending on the prevailing economic climate, the President will seek advice from any one of these three groups. The most important group and the one with the most influence at present is made up by the mainly western or American-trained economists and technocrats whose economic thinking is market-oriented. Another group supports policies which protect state enterprises and the pribumi (Indonesian as opposed to ethnic Chinese) business class. The third group consists of politicians and would seem to be concerned primarily with fostering the popularity of the political party in government.

When policy is decided, it is often not implemented due to co-ordination problems among ministries and agencies as well as inadequate planning (Liddle 1987a, 1987b; Stone 1987). Policies may be and are often rescinded because of political costs or impossibility of implementation (McCawley 1981; Liddle, 1987b). No doubt problems of policy formulation and implementation also occur because of inadequate data and unreliable information (Stone 1987).

The current government has revealed a willingness to turn to foreign advisers for assistance when crises occur. In fact there seems generally to be a substantial number of foreign advisers and agencies involved with economic issues in relation to staple food production, marketing and price policies. Glassburner (1986) emphasizes that foreign advisers do not make policy decisions but are there only to advise. Their presence reflects, in part, a scarcity of professionally-trained policy makers.

BULOG (National Logistic Board), the government agency responsible for implementing policy with respect to pricing and marketing of rice and various other food crops, reports directly to the President. In addition, it can be a powerful influence over the BUUD/KUDs (Badan Usaha Unit Desa/Koperasi Unit Desa or Village Unit Effort Programs/Cooperatives Village Unit) given the dual role of the Chairman of BULOG as State Minister of Cooperatives. Although BULOG's major role is one of policy implementation, it is a member of the "Inter-Agency Team" which is composed of key government economic agencies. This group meets annually to determine the floor price and provide input into the determination of food policies (Amat 1982).

In summary, the policy-making process in Indonesia is ill-defined. Perhaps this is understandable given the imbalance of population to the available land resources of these densely populated islands, the population pressures, and the political importance of rice and secondary food crops. However, it does lead to difficulties in trying to summarize the objectives of food crops policy.

B. Food Crops Policies in Indonesia

During the 1970s and early 1980s, there were four main objectives underlying Indonesian policies with respect to rice and other staples (World Bank 1987a): self-sufficiency, especially with respect to rice; higher farm incomes; reasonable and stable food prices for urban consumers; and containment of the budgetary costs in achieving these objectives. The first objective seems to have been the one pursued with most vigor. In this respect, Indonesian policy objectives have been consistent with those of a number of other South East Asian countries. Moreover, just as is true for other countries pursuing self-sufficiency policies, it is difficult to find precise statements of objectives in the sense that definitions of terms such as self-sufficiency are included. However, the general interpretation of self-sufficiency in the Indonesian context is the ability to meet consumption requirements from domestic production without regard to international price levels.

In recent years, the Indonesian Government has given more emphasis to expanding the production of secondary food crops (MOA 1987). Indonesia produced a surplus of rice in 1985. The increased relative emphasis on secondary food crops may have reflected a belief that the problem of producing sufficient rice had been overcome and so attention could be turned to these other crops. There may have been a belief that the past emphasis on rice had resulted in reduced incentives for the production of secondary crops with consequent adverse nutritional consequences. With the current emphasis on agricultural diversification, agricultural policy has been moving from a predominantly rice strategy to increasing production of major secondary food crops (e.g., corn, cassava, soybeans, peanuts, mungbeans, and sweet potatoes), and of copra, sugar and cash (estate) crops. The great hope is that the success in achieving rice self-sufficiency can be replicated with these other crops. Although in principle the extension of agricultural development efforts to formerly neglected rural areas—notably the rainfed uplands of Java-- must be welcomed, there are significant economic problems in applying a similar rice strategy approach to other crops.

For one, the financial costs of the rice strategy have been high. Rice self-sufficiency was attained through heavy support by government investment and subsidy programs for irrigation, fertilizers, pesticides, higher yielding varieties (HYVs), credit and management. Over the period 1970-1984, the area of HYVs expanded from 0.8 to 6.8 million hectares, and on Java the average area planted with HYVs reached 94 percent; the irrigated area increased from 3.7 to 4.9 million hectares; the distribution of subsidized fertilizer increased from 0.2 to 4.1 million tons; and the distribution of subsidized pesticides increased from 1,080 to 14,210 tons. In 1986-87, the total cost of these input subsidies reached Rp 1.2 trillion (US$725 billion) (World Bank 1987a). These subsidies would have to be roughly doubled if the same support programs were extended to other crops. As the total agricultural and irrigation development budget was only Rp 1.1 trillion (US$665 billion) in 1986-87, and was expected to fall by 15 percent in real terms in 1987-88 (World Bank 1987a), such a strategy to achieve agricultural diversification was not financially realistic.

Finally, if diversification into secondary food crops and estate crops is meant to complement rather than displace rice production, then increased output of the former will mean intensifying production and extending the area of marginal lands brought under cultivation. Rice production, which accounts for 69 percent of the total area harvested under food crops, already occupies the most fertile lowland areas on Java, Bali, Southern Sulawesi and Southern Sumatra. In fact, as there has been little scope for increasing harvesting areas on Java, in recent years a quarter of the increased rice production has come from extending rice cultivation to marginal lands, in particular the tidal swamps of Sumatra and Kalimantan. In addition, recent projections of Indonesia's rice needs suggests that, in order for self-sufficiency to be maintained over the long run, the total wet land rice area must increase from 8.4 million hectares in 1986 to 10.3 million hectares by the year 2000. Wetland rice production, which accounts for 94 percent of the total rice supply, will therefore also require irrigated land "extensification" on marginal land outside of Java and Bali (Tabor, Altemeier,and Adinugroho 1987).

Input subsidies are also proceeding at a high rate. In 1986-87, for example, World Bank (1987a) reported that in 1986-87 fertilizer subsidies to farmers reached Rp 365 billion (US$220.7 million), roughly 42 percent of the agriculture and irrigation development budget, and an effective subsidy of about 38 percent of the farmgate price (68 percent of world prices). If support for fertilizer production and procurement is included, the fiscal cost may be as high as Rp 600 billion (US$362.8 million). As a result, consumption of fertilizer increased by 77 percent (12.3 percent per year) over 1980-1985. The current rate of consumption, 75 kilograms per hectare of arable land, is much higher than in other Asian countries (e.g., 32 kg in the Philippines and 24 kg in Thailand) (World Bank, 1987a). The result is that the rice-fertilizer price ratio has now reached 1.5-2. Given that fertilizer accounts for less than 10 percent of the production cost of rice, and that the largest production response is obtained at relatively low levels of application, such a high price ratio will tend to encourage inappropriate application and wastage, with little stimulation to rice output. For example, in some areas, applications of urea can reach 200-250 kg/ha. Pesticide subsidies in 1986-1987 amounted to Rp 42 billion (US$25.4 million), yielding a farmgate price subsidy of more than 40 percent (World Bank 1987a).

Although the government has recently banned the use of 57 pesticides and is planning an integrated pest management program with the World Bank and Food and Agriculture Organization (FAO), the current subsidy levels will inevitably encourage inappropriate and excessive use. Moreover, although in its 1987-1988 budget the government reduced the total subsidies for fertilizer and pesticides to Rp 204 billion (US$123.3 million), there has yet to be a corresponding increase in the prices of these inputs. Preliminary indications suggest that the costs of these subsidies are being shifted from the official budget to the operations of parastatal producers, who are financing the cost burden through additional borrowing.

Although public works schemes account for over 80 percent of irrigation, the costs charged to farmers for irrigated water are minor. Most of the 5.2 million hectares of irrigated land in Indonesia is devoted to rice production; in the 1970s, about 16 percent of the increased rice output was attributed to expansion and improvements in irrigation. For a medium-sized irrigation project, the average operation and maintenance (O & M) costs and annualized capital cost were about Rp 187,000 (US$155) per hectare, of which less than 13 percent is covered by direct water charges and property taxes paid by farmers. This suggests an annual, government-financed subsidy of Rp660 billion (US$440 million), spread over 4 million hectares. This level of subsidy is clearly causing a tremendous financial burden: even in 1985-86, before the latest budget cuts, total O & M spending fell to Rp 11,300 (US$10.17) per hectare, which is less than half the required level on average (World Bank 1987a). Over the long run, failure to maintain the irrigation network will translate into losses of agricultural productivity, which will be exacerbated by any water scarcity problems caused by overuse.

C. Policy Instruments

The main price-policy instruments that have been used in the pursuit of policy objectives have been producer price support through floor prices for rice, subsidization of production costs (especially fertilizer costs), limits on consumer prices through ceiling prices, and the absorption by the government of part of the costs of storing rice. As will be shown later, a new policy instrument emerged in 1985 that involved a government subsidization of rice exports.

In addition to price policy, the Indonesian Government has devoted resources to the development and extension of improved technology, especially in relation to rice production. This technology encompassed, among other things, pest and disease control, varietal improvements, and irrigation.

BULOG plays a key role in the implementation of policy insofar as it has control over the importation of staple food items and operates the floor-ceiling price arrangements.

Food prices in Indonesia are determined in a market framework through a combination of basic market forces and government intervention. The set of factors that dominates at any given time varies by commodity and the degree to which governmental efforts are exerted in controlling price. Rice prices have nearly always been heavily influenced by direct policy intervention. Governmental intervention to control prices of other agricultural commodities has varied. For example, corn price has been controlled to a significant extent, but the price of gaplek (the dried form of cassava that is traded internationally) has only occasionally been the object of specific price policy. Pricing policies for production inputs directly affect the profitability of crop production, and hence the supplies available in the market. The Indonesian government has used input subsidies designed to assist farmers in purchasing the package of inputs available as part of the Rice Intensification Program (Bimas program).

Government policies have kept domestic rice prices well below world prices, and insulated domestic prices from instability in the world market (Timmer 1986). Administratively, the prices for paddy/rice, corn, cassava, and other secondary food crops are stabilized by the govenrment via BULOG. The prices of other agricultural products are primarily determined by market forces, although the consumer prices of nine basic commodities are kept in line through market intervention when deemed necessary. These nine basic commodities are rice, sugar, salt, dried fish, cooking oil, washing soap, petroleum, rough textile, and batik.

The floor and ceiling prices for rice and later secondary food crops are maintained through buffer stock management. As noted earlier, this program is managed by BULOG. When prices decline, observed usually at the harvest season, BULOG enters the market to make the necessary purchase to maintain the floor price. During the lean months, when the price of rice is high, BULOG releases its stock to keep the price below the ceiling price. Methods used to determine the floor price and the ceiling price in Indonesia can be found in Sapuan and Hasan (1978), Moelyono (1980), Sapuan and Darsono (1986), and Wahyudi Soegiyanto (1987).

In summary, Indonesia has used a mixture of instruments designed to meet policy objectives. Some can be visualized as shifting supply functions to the right (e.g., fertilizer subsidies and dissemination of technology) while another (producer price support) has resulted in output expansion along the (new) supply function. Policies with respect to consumer prices have been pursued through the storage activities of BULOG.

D. The Need for Regional Policy System

In Indonesia, the historical role of international trade in food-crops has been to balance domestic demand and supply at target, or politically sanctioned, levels. The international market has been treated as a residual market, to be used by government or appointed traders to clear markets, rather than as a catalist to movement of domestic resources. The lack of reliance on the international market as an allocative device is related to the role of agriculture or, more broadly, agricultural development, in the national economy (Baharsyah, Hadiwiguno, Dillon, Hedley, and Tabon 1987). By this inward oriented development approach in food-crops development, Indonesia was able to technologically transform the food-crops economy or more specifically the rice economy and stimulate rapid growth in rural incomes and consumption levels while protecting the domestic economy over the fifteen year period ending in 1985. However, a slowdown in economic growth in the mid-1980s combined with a deteriorating external payments situation has led Indonesian planners to adopt a more open, outward oriented approach to economic management. For agriculture, trade liberalitation is understood as being part of this new, outward oriented, development approach.

Indonesia is now experiencing a rapidly changing economic environment and is implementing economic reforms directed at moving away from an administered economy to one more responsive to domestic and international economic forces. Consequently the agricultural economy must now place greater reliance on the international market to improve domestic competitiveness. As Indonesia advances into the 1990s, agricultural policy is in a period of transition. Currently, economic planning and reform in Indonesia are being guided under Repelita V. Within the agriculture sector, the changes introduced under the Fifth Plan include a reduction in agricultural input subsidies, relaxation of commodity production target setting, diversification and regionalization of agricultural production and distribution systems, rationalization of pan-territorial pricing, and greater alignment and integration with international markets and other sectors of the economy (Heytens and Meyers 1990; Kesavan 1990).

Changes both within the Indonesian economy and in the international markets will influence the growth of the agricultural sector, as well as the implementation of policies designed to meet the objectives of Repelita V. Rising incomes and changes in the demographic composition of the population have led to changes in food consumption patterns that place increasing demands on the development of food processing and the livestock industry (CARD 1990; Goungetas, Jensen, and Johnson 1990). Furthermore, differential growth and specialization in regions within Indonesia have led to specialized patterns of change in consumption and production, and have emphasized the important implications for the development of the feed sector, for the interaction between regional and national planning and policies, and for development of investment strategies in the agricultural sector (Heytens and Meyers 1990). These strategies range from an increased emphasis on deregulation of the agroprocessing sector to shifting more of secondary food crops and sugarcane to off-Java areas (Heytens and Meyers 1990). These reforms, among others, are partly motivated by the large burden on the government budget to maintain existing policies, and partly by the adjustments necessitated by Indonesia's transition to a middle-income economy.

These policy changes have a significant impact on the economy at the national level (Baharsyah, Hadiwiguno, Dillon, Hedley, and Tabor 1988; CARD 1990). However, Kesavan (1990a) stated that evaluating the impact of changing agricultural policies on the economy only at the national level masks the sharp regional differences that characterize the Indonesian agricultural economy. Moreover, the production systems and cropping patterns vary widely among regions and imply that national agricultural policies will have differential regional impacts.

Table 2.1 presents the historical and projected growth rates for wet land rice, corn and cassava in Indonesia, selected provinces on Java, South Sulawesi, North Sumatra, South Sumatra, and Lampung (Kesavan 1990a). The table shows that the annual growth rate in area harvested for wetland paddy in Indonesia was about 1.7 percent during 1975-1980 and increased to 2.4 percent during 1980-1985; the annual growth is projected to be less than 0.5 during the next decade. The growth rate of area harvested for wetland rice, corn, and cassava in Java has declined in recent years and is projected to decline further in 1990s.

On the other hand, the annual growth rates in area harvested for corn and cassava in South Sulawesi, Lampung, South Sumatra, West Sumatra, North Sumatra are projected to be more than 2 percent during the next decade.

The levelling off of the area growth in wetland rice cultivation coupled with the shift to off-Java areas has several implications for Indonesia's effort to maintain rice self-sufficiency (Rosegrant, Kasryno, Gonzales, Rasahan, and Sarefudin 1987). One possibility for easing the burden on Java's land is to shift some of the area devoted to other crops such as sugarcane to off-Java regions to allow for increased rice cultivation on Java (Kesavan 1990a). For instances, there is clear evidence that Indonesia would be better off growing rice and Palawija in sugarcane areas on Java (Heytens and Meyers 1990). Efforts are already under way to move sugarcane production off of Java (MOA, 1987).

The regional shift in food production is more transparent for corn, soybeans, and cassava. The demand for these crops is expected to increase indirectly through the increased demand for meat products, adhesives, textiles, paper industry, tahu (tofu), tempe industries due to changes in income, which in turn would induce a higher derived demand for feedstuffs and industrial uses. The direct human consumption of palawija crops is also expected to increase in the future

Table 2.1. Trends in area harvested for various food crops

Year/Region	Wetland Paddy	Corn	Cassava
		Percent Change	
Java			
1970-1980	1.44	-1.37	-0.90
1980-1985	1.96	-3.53	-3.32
1985-1988	-0.76	15.19	-2.10
West Java			
1989-2000	0.28	n.a.	-0.91
East Java			
1989-2000	0.16	-0.16	-0.91
Central Java			
1989-2000	0.27	0.17	-0.60
Off-Java			
1970-1980	2.12	1.00	3.79
1980-1985	2.96	0.53	1.89
1985-1988	2.49	10.05	4.74
South Sulawesi			
1989-2000	1.05	0.65	1.09
North Sumatra			
1989-2000	0.98	n.a.	n.a.
South Sumatra			
1989-2000	0.85	n.a.	n.a.
Lampung			
1989-2000	n.a.	2.33	2.60
Indonesia			
1970-1980	1.71	-0.69	0.12
1980-1985	2.38	-2.69	-1.77
1985-1988	0.65	13.20	0.33
1989-2000	0.43	0.28	-0.29

Note: The historical trends were calculated from data published by the Central Bureau of Statistics by CARD (1990). The figures for 1989-2000 are projections based on a CARD/MOA Special Study (Input Demand Projection 1990).

Source: Kesavan (1990a).

(Goungetas, Jensen, and Johnson 1990). As indicated in Table 2.1, the cultivated area for corn in the Java provinces is expected to grow at a rapid rate in off-Java regions, particularly in South Sulawesi, Lampung, Bali, West Sumatra, and North Sumatra. The regional shift in corn and especially cassava production is even more significant as the corn and cassava area harvested on East Java and West Java have been declining steadily since the 1970s and are expected to continue this downward trend during the next decade. Just the reverse is expected in off-Java areas. Corn, cassava, and soybeans area harvested in South Sulawesi and Lampung have been increasing since 1984 (CBS 1989) and are expected to continue this upward trend during the next decade. From a food policy perspective, such a shift in regional production will have important implications for public investment (Rosegrant,Kasryno, Gonzales, Rasahan, and Sarefudin 1987).

This discussion suggests that areas off Java, especially in South Sulawesi, Lampung, South Sumatra, and North Sumatra will become increasingly important for meeting the overall need of food production. A regional analytical focus is therefore the appropriate means of assessing important issues such as supply and demand reactions within and between commodity markets that arise in this context in order to mount an efficient multi-commodity food policy. This regional perspective for policy analysis would increase the capacity of regional and national agencies to undertake agricultural planning at both the national and regional levels, including regional-level situation and outlook evaluations, and serve as an effective tool with which to create region-specific extension policies (Kesavan 1990a).

E. Previous Work Done on Food Crops Policy Studies in Indonesia

Many studies on food crops in Indonesia have been done over the past twenty five years. However, most of the studies have been focused on rice and in Java. See, for example, Mears (1978; 1981), Mubyarto and Fletcher (1966), Timmer (1975; 1983; 1986; 1990), Hasan (1976), Sutawan (1977), Lains (1978), Timmer and Alderman, (1979), Afiff, S., Falcon, W.P. and Timmer, C.P. (1980), Nazir (1980), Strout (1981), Chernichovsky and Meesook (1982), Rasahan (1983), Timmer, Falcon and Pearson (1983), World Bank (1983; 1987b), Nainggolan and Suprapto (1987), Wahyudi Soegiyanto (1987), Pakpahan (1988), Wardhani (1988), Kesavan, Simatupang, and Syafa'at (1989a, 1989b).

National level studies on food crops (rice and palawija) were done by Pitt (1977), Mears (1978), Hedley (1978), Afiff, Falcon, and Timmer (1980), Mears and Moelyono (1981), Teken and Suwardi (1982), Dixon (1982), Sumodiningrat (1982), Amat (1982), IFPRI and CAER (1986), Klumper (1986), Johnson, Meyers, Jensen, Teklu, and Wardhani (1987); World Bank (1983; 1987a), Nainggolan and Suprapto (1987), Rentetana (1988), Suprapto (1988), Tabor, Altemeier, and Adinugroho (1988), Baharsyah, Hadiwiguno, Dillon, Hedley, Tabor (1987), Timmer (1986; 1989), Deaton (1990), CARD (1990).

Most food crops policy studies have placed emphasis on the demand side. See, for example Timmer (1979; 1986), Strout (1981), Dixon (1982), Sumodiningrat (1982), Chernichovsky and Meesook (1982), Teklu and Johnson (1988), Johnson, Meyers, Jensen, Teklu, and Wardhani (1988), Rentetana (1988), Goungetas, Jensen, Johnson (1990), CARD (1990), Deaton (1990). Few studies have focused on supply sides. For example, see Fletcher and Mubyarto (1966), Sujono (1975), Mears (1978), Wahyudi Soegiyanto (1987), Nainggolan and Suprapto (1987), Suprapto (1988), Wardhani (1988), Kesavan, Simatupang, and Syafa'at (1989a, 1989b). To the author's knowledge, only three studies are related directly to this study: Tabor, Altemeier, and Adinugroho (1989), Heytens and Meyers (1990), and Kesavan (1990a). Following is a review of the previous three food crops policy studies in terms of estimation methods and results.

1. Regional Food Crops Policy Model

The Kesavan's study (1990a), to the author's knowledge, was probably the first Regional Food Crops Policy Model (RFCPM) done in Indonesia. The analytical framework for this prototype model comprises three components: (1) supply; (2) demand; and (3) price linkages. This study encompasses supply of wetland rice, dryland rice, corn, cassava, soybeans, peanuts, and mungbeans. The annual time series data from 1976 to 1988 were used in the supply side.

The system of equations constituting the crop supply sector used in this study is in logarithmic function in which area harvested for each crop, yield per hectare for each crop, input use (fertilizer and labor) in production of each crop, and total crop production were specified in constant elasticity form as follows:

$$\ln AH_{it} = a_0(t) + \Sigma\ a_j \ln FP_{j,t-1} + d_{i1} \ln AH_{i,t-1}, \tag{2.1}$$

$$\ln YD_{it} = b_0(t) + b_1 \ln FP_t + b_2 \ln PF_t + b_3 \ln WR_t, \tag{2.2}$$

$$\ln X_{it} = c_0(t) + c_1 \ln FP_t + c_2 \ln PF_t + c_3 \ln WR_t, \tag{2.3}$$

$$\ln CP_t = \ln AH + \ln YD, \tag{2.4}$$

The demand system consists of rice, corn, cassava, soybeans, peanuts, mungbeans, and sugar. The 1987 household consumption (SUSENAS) survey is used in the demand component. The availability for food consumption is modeled as a log linear food demand system. Accordingly, the logarithm of the demand for food consumption is expressed as a function of the logarithm of real prices and the logarithm of real per capita food expenditure:

$$\ln FD_{it} = d_0 + d_j \ln WP_{jt} + e_i \ln FEXP_{t'} \tag{2.5}$$

where ln FD = logarithm of food availability/demand;

ln WP = logarithm of wholesale real prices;

ln FEXP = logarithm of real food expenditure;

d_j is a set of price elasticities;

and e_i is a set of expenditure elasticities.

A spatial market integration approach is used in order to evaluate the impact of policies emanating from the central government. The main feature of this approach is that a central market (Jakarta) serves as primary determinant of the market in the regional market (Sulawesi Selatan), and this effect is represented in the form of a distributed lag structure. In terms of percentage change, the model is expressed as:

$$\ln P_t - \ln P_{t-1} = a + b(\ln P_{t-1} - \ln P^*_{t-1}) + c(\ln P^*_t - \ln P^*_{t-1}) + d \ln P^*_{t-1} + eX \tag{2.6}$$

where $\ln P_t$ = logarithm of the price at the local market at time t;

$\ln P^*_t$ = logarithm of the price at the reference or central market at time t;

X = set of seasonal, regional, or other environmental variables that influence the local market;

a, b, c, d, and e are parameters.

Equation (2.6) explains changes in prices at the local market as due to changes in the reference price for the same period, lagged spatial price margins, lagged reference market price, and local market characteristics. The elasticities of area response, yield and input demand system, and demand parameters resulting from this study are presented in Table 2.2.

Table 2.2. Supply and demand parameters used in the analytical policy system for South Sulawesi (1990)

Area Response Elasticities

Price/Crop	WL Rice	Corn	Cassava	Peanuts	Mungbeans	Soybeans
Rice	0.30	-0.30	-0.07	0.00	0.00	-0.40
Corn	-0.22	0.40	-0.20	-0.15	-0.30	-0.25
Cassava	0.00	-0.25	0.14	-0.25	-0.08	-0.05
Peanuts	0.00	0.00	0.00	-0.90	-0.05	-0.25
Mungbeans	0.00	0.00	-0.39	-0.15	0.40	0.00
Soybeans	0.00	-0.02	0.00	-0.15	-0.12	0.77
Lag (area)	0.60	0.48	0.21	0.00	0.50	0.38

Output Productivity and Input Demand Elasticities

Factor/Price	Wetland Rice	Corn	Cassava	Soybeans
Yield per ha wrt				
Output Price	0.05	0.38	0.30	0.07
Fertilizer Price	-0.02	-0.28	-0.01	-0.10
Wage Rate	-0.03	-0.10	-0.10	-0.06
Fertilizer Demand wrt				
Output Price	0.34	0.64	1.00	0.68
Fertilizer Price	-0.26	-0.48	-0.80	-0.82
Wage Rate	-0.08	-0.22	-0.10	-0.05
Labor Demand wrt				
Output Price	0.14	0.43	1.04	0.68
Fertilizer Price	0.03	-0.36	0.06	-0.05
Wage Rate	-0.16	-0.07	-0.35	-0.35

Price and Income Elasticities of Commodity Demand

Price/Demand	Rice	Corn	Cassava	Peanuts	Mungbeans	Soybeans	Sugar
Rice	-0.45	0.10	0.30	0.00	0.00	0.00	0.02
Corn	0.08	-0.30	0.12	-0.08	-0.60	0.00	0.02
Cassava	0.06	0.10	-0.45	-0.08	0.00	0.00	0.02
Peanuts	0.02	-0.02	-0.05	-0.30	-0.30	0.00	0.08
Mungbeans	0.02	-0.02	0.05	0.00	0.50	0.00	0.08
Soybeans	0.02	0.02	0.05	0.20	0.00	-0.40	0.20
Sugar	0.03	-0.10	-0.00	0.02	0.01	0.02	-0.30
Food Exp.	0.52	0.45	0.30	0.40	0.70	0.56	0.58

Source: Kesavan (1990a).

2. National Food Crops Policy Model

A second study which develops several models and approaches to food-crops policy was done by Steven R. Tabor, K. Altemeier, and Bambang Adinugroho (1988). The aim of this study, Supply and Demand for Foodcrops in Indonesia, was to provide guidance to the Indonesian government on future foodcrops policy options, with special emphasis on prospects for food sector diversification. The study is divided into four sub-studies in which each sub-study team was assigned to a particular research topic. The first sub-study group developed tools for producing quantitative estimates of commodity supply and demand under a range of policy regime alternatives. The second group analysed food crops trade policy options. The third group examined the role of two major urban markets, Jakarta and Surabaya, in coordinating the flow of secondary food crops commodity between Java and Outer Islands. The fourth sub-study group examined the rural marketing situations for secondary food crops in the provinces of East Java, Lampung, and South Sulawesi. The first sub-study is the most relevant to this study, and therefore will be the only sub-study reviewed here. The fourth study, even though focused on regional level, has placed its emphasis only on rural marketing situation in the three regions (provinces).

The supply of foodcrops is defined as the product of area harvested and yields. Because of the differences in resources endowment and technology, both area and factors allocation decisions are disaggregated into two regions, Java and off-Java. The commodities included in the analysis are wetland rice, dryland rice, corn, cassava, soybeans, mungbeans and peanuts.

The area allocation decision was modelled as the function of own prices and prices of other competing staple crops. The typical form of the area response equation is interpreted as the reduced form of a Nerlovian adaptive response model with single period lagged expectations (Askari and Cummings 1977; Intrilligator 1978; Hedley 1978).

Factor allocation and supply are modelled simultaneously using a translog profit functions approach (Marggraf 1986; Just, Zilberman, and Hochman 1983).

Assuming profit maximization, the first derivatives of the profit function with respect to input prices are the factor demand functions (Yotopoulos and Nugent 1976; Braverman, Choong, and Hammer 1983). For the area response function models, time series data from a set of revised food balance sheets are used. The profit function analysis used farm survey data from a panel of cost production studies conducted by the Ministry of Agriculture, Indonesia, between 1983 and 1985/1986.

To estimate demand parameters for the staple foodstuffs, the study used a weakly separable indirect utility function between the staple food commodities and the other commodities traded in the economy. A flexible form of the cost function, the translog, was chosen for the empirical application.

Seventeen years of time-series data, from 1969 to 1985, are used for the analysis. The estimated area response elasticities and AIDS estimation results are provided in Table 2.3. Own price response for all commodities, except cassava and mungbeans is generally excellent. Parameter values of commodity demand have the expected signs and are within a reasonable range.

3. CARD National Food Crops Policy Model

The third study which developed models for food crops policy in Indonesia was done by Heytens and Meyers of CARD (1990). The objective of Heytens and Meyers's study, A National Food-Crop Policy Model for Indonesia, was to make projections of supply and demand balances

Table 2.3. Supply and Demand Parameters for Food Policy Analysis.

Area Response Elasticities for Java

Price/Crops	WL Rice	DL Rice	Corn	Cassava	Soybean	Peanuts	Mungbeans	Sugar
Rice	43.44	5.84	-	-	-	-	-	-0.82
Corn	-41.85	-	77.12	-0.36	-14.07	-2.55	-5.51	-
Cassava	-	-	-	15.17	-35.01	-	-	-
Soybeans	-	-	-12.57	-	25.43	-	-	-
Peanuts	-	-	-	-2.11	-1.85	2.04	-	-
Mungbeans	-	-2.07	-	-	-	-	2.57	-
Sugar	-18.46	-	-	-	-	-	-0.60	2.02
Lagged Area	-	-	0.78	0.82	0.35	0.79	0.77	0.64

Area Response Elasticities for Outside of Java

Price/Crops	WL Rice	DL Rice	Corn	Cassava	Soybeans	Peanuts	Mungbeans	Sugar
Rice	7.84	16.21	-	-	-	-	-	-0.82
Corn	-2.78	-	77.12	-0.36	-	-	-9.05	-
Cassava	-10.55	-	-	15.17	-7.38	-	-	-
Soybeans	-5.56	-0.13	-12.57	-	6.39	-3.48	-	-
Peanuts	-	-	-	-2.11	-	2.58	-	-
Mungbeans	-	-0.25	-	-	-	-	0.66	-
Sugar	-10.43	-7.62	-	-	-1.62	-	-	2.02
Lagged Area	-	-	0.78	0.82	0.19	0.72	0.72	0.64

Output Demand Parameters for Food Policy Analysis

Price/ Commodity	Rice	Corn	Cassava	Peanuts	Mungbeans	Soybeans	Sugar	Other
Rice	-0.29	0.03	0.04	0.02	0.00	-0.01	0.02	-0.24
Corn	0.34	-0.17	0.04	-0.08	-0.03	-0.02	-0.14	-0.32
Cassava	0.43	0.04	-0.42	-0.07	0.01	-0.06	-0.00	-0.21
Peanuts	0.41	-0.13	-0.10	-0.74	0.11	0.44	-0.05	-0.51
Mungbeans	0.32	-0.26	0.11	0.51	-0.59	-0.24	0.08	-0.57
Soybeans	0.55	-0.03	-0.10	0.47	-0.05	-0.68	0.51	-0.45
Sugar	0.51	-0.09	0.00	-0.02	0.01	0.18	-0.32	-0.41
Others	1.15	-0.01	-0.01	-0.01	-0.00	-0.01	-0.02	-0.94
Budget Share	0.14	0.01	0.01	0.01	0.00	0.01	0.02	0.80
Income Elasticity	0.29	0.39	0.26	0.63	0.70	0.55	0.51	1.15

Source: Tabor, S.R., K. Altemeier, and B. Adinugroho (1988).

for important food crops in Indonesia. The analytical framework for this study includes three components: (1) demand, (2) supply and (3) national income. Demand for eight crops -- rice, wheat, corn, cassava, soybeans, mungbeans, peanuts, and sugar -- was estimated as a function of private expenditures and real food crop prices. Food crop demand per capita is modeled as a linear function of own and other staple food prices and an endogenously determined estimate of real per capita total expenditures:

$$\ln X_{dit} = x_{it} + f_i * \ln TEXPC_t + \Sigma\, g_{ij} * lm\, P_{jt}.$$

Elasticity values are derived under the assumption of a subutility maximizing, two-stage (staple foods and other goods) expenditure budgeting. That is, in the parameters estimations, household consumption is assumed to be determined first by allocating the budget between staple food and other goods, then allocating to different food commodities within the staple food category. Private consumption expenditures per capita, which together with prices drive demand, are defined as a function of an endogenously defined estimate of per capita GDP:

$$\ln TEXPC_t = a_0 + a_1 (\ln GDP_t - \ln POP_t).$$

Supply is also modeled for eight food crops (wheat is not grown in Indonesia, but rice is separated into dryland and wetland production) and is defined as the product of area harvested and yield per hectare. For each commodity, then, domestic production (X_{si}) is defined as the product of area (A_i) and yield (Y_i):

$$\ln X_{si} = \ln Y_i + \ln A_i.$$

Area allocated to food crops production is a function of real own-crop prices, real prices of other land-competing crops, and previous period area achievements. The area allocation process is thus modeled to behave like a Nerlovian adjustment process. The typical form of the area-response equation used is with a single-period lagged expectation as follows:

$$\ln A_{it} = a_{it} + \Sigma\, b_{ij} * \ln P_{j(t-1)} + c_i * \ln A_{i(t-1)}$$

Yields per hectare (Y_{it}) are defined as a function of output price (p), input prices (q) for variable inputs of labor and fertilizer, and time:

$$\ln Y_{it} = y_{it} + d_i * \ln P_{it} + \Sigma\, e_{ij} * \ln q_{it}$$

The yield elasticities are derived from a profit function approach modeling the crop productivity relationship. Under the assumption of profit maximization, farmers apply labor and fertilizer to maximize profits.

Factor demands per hectare (Rijt) are also defined as a linear function of input and output prices and time:

$$\ln R_{ijt} = r_{rjt} + \Sigma\, u_{ik} * \ln q_{ikt} + n_{ij} * \ln P_{it}$$

The factor demand elasticities, like the yield elasticities, are derived from a profit function model.

In the national income component of the model, the economy is partitioned into three sectors. National income (GDP) is defined as the sum of income generated in (1) the food crop sector, (2) the mining and defense sectors, and (3) the other products and services sectors:

$$GDP = GDP_1 + GDP_2 + GDP_3$$

The food crop sector income is derived directly from the supply side of the model. Food crop sector product is defined as the value of food crop sector output valued at real wholesale crop prices less the cost of fertilizer

$$GDP_1 = (\Sigma\ P_i * X_{si} - q_j * \Sigma\ r_{ij} * A_j) * CORR\ (j = fertilizer)$$

The endogenously determined sector income thus includes all wages, rents, profits, and interest generated from farm production minus the cost of chemical fertilizers, the predominant agricultural input used from outside the sector. The parameter CORR is a constant correction factor that accounts for differences between the endogenously determined food crop sector product and figures from national statistical yearbooks.

Production in the industrial, estates, and services sector (GDP_3), then, is defined as a function of exogenous technical change, relative intersectoral prices (P_z/P_f), and the real Rp/US$ exchange rate:

$$GDP_3 = G_t + h * \ln(\hat{P}_z/\hat{P}_f) + e(\ln\ EXC + \ln\ \hat{P}_z)$$

Intersectoral, real price relationships are formed by determining nonfood crop prices as a function of an index of food crop prices. The food crop price index is defined as a share-weighted sum of commodity prices:

$$\ln\ \hat{p}_f = \Sigma\ \hat{W}_j * \ln\left(p_{j(t)}/p_{j(base\ year)}\right)$$

with $\hat{W}_j$ being

$$\hat{W}_j = X_{dj} * P_j/FEXP_{t-1}$$

The aggregate price index (P_a), is defined as the geometric index of food and nonfood prices:

$$\ln\ (P_a) = S_f \ln\ \hat{P}_f + (1 - S_f)\ln\ \hat{P}_z,$$

$$\hat{S}_f = [FEXP/TEXP]_{(t-1)}$$

Because this is a real-price model, $P_a = 1$ by definition, so it is possible to derive nonfood prices from food prices and the relative expenditure shares:

$$\ln \hat{P}_z = V * \ln \hat{P}_f,$$

which is determined by the relative share of food expenditures (FEXP) in total expenditures:

$$V = -S_f/(1 - \hat{S}_f)$$

The elasticity values which Heytens and Meyers (1990) derive are reported in Table 2.4.

Table 2.4. Supply and demand parameters for national food crops model

Area Response Elasticities

Price/Crops	WL Rice	DL Rice	Corn	Cassava	Soybean	Peanuts	Mungbeans	Sugar
Rice	0.157	0.475	0.00	0.00	0.00	0.00	0.00	-0.16
Corn	-0.079	0.000	0.69	-0.03	-0.16	-0.05	-0.67	0.00
Cassava	-0.004	0.000	-0.04	0.09	-0.15	0.00	0.00	0.00
Soybeans	-0.019	-0.006	-0.20	-0.07	1.11	-0.28	0.00	0.00
Peanuts	0.000	0.000	0.00	-0.12	-0.12	0.60	0.00	0.00
Mungbeans	0.000	-0.113	0.00	0.00	0.00	0.00	0.66	0.00
Sugar	-0.155	-0.259	-0.16	0.00	-0.06	0.00	-0.10	0.20
Lagged Area	0.000	0.000	0.68	0.87	0.29	0.77	0.75	0.50

Factor Elasticities

Per Hectare Yields wrt	Wet Rice	Dry Rice	Corn	Cassava	Soybeans	Peanuts	Mungbeans	Sugar
Crops Price	0.30	0.29	0.60	0.27	0.19	0.09	0.19	0.30
Fertilizer Price	-0.03	-0.00	-0.07	-0.05	-0.04	-0.01	-0.01	0.00
Wage Rate	-0.27	-0.21	-0.53	-0.22	-0.15	-0.08	-0.18	0.00

Fertilizer Demand with respect to	All Rice	Corn	Cassava	Soybeans	Peanuts	Mungbeans
Crops Price	0.63	0.96	1.28	1.09	0.26	0.52
Fertilizer Price	-0.47	-0.17	-0.66	-0.84	-0.74	-0.40
Wage Rate	-0.16	-0.78	-0.62	-0.25	0.48	-0.12

Labor Demand wrt	All Rice	Corn	Cassava	Soybeans	Peanuts	Mungbeans
Crops Price	1.58	2.46	1.59	0.88	0.52	1.67
Fertilizer Price	0.00	-0.26	0.06	-0.05	0.07	-0.05
Wage Rate	-1.57	-2.20	-1.65	-0.83	-0.59	-1.61

Demand Parameters

Price/Crop	Rice	Corn	Cassava	Soybeans	Peanuts	Mungbeans	Sugar	Wheat
Rice	-0.16	0.39	0.43	0.21	0.41	0.406	0.155	0.200
Corn	0.04	-0.26	0.06	0.03	-0.12	-0.169	-0.081	0.050
Cassava	0.03	0.04	-0.04	-0.03	-0.10	0.090	-0.001	0.020
Soybeans	0.02	0.03	-0.04	-0.78	0.48	-0.139	0.226	0.020
Peanuts	0.03	-0.06	-0.07	0.27	-0.74	0.403	-0.020	0.000
Mungbeans	0.00	-0.03	0.02	-0.02	0.11	-0.680	0.011	0.000
Sugar	0.02	-0.11	-0.00	0.32	0.05	0.090	-0.292	0.020
Wheat	0.03	0.00	0.02	0.02	0.00	0.000	0.020	-0.380
Expenditure	0.29	0.39	0.26	0.46	0.64	0.614	0.519	0.475

Source: Heytens and Meyers (1990).

III. SPECIFICATION OF SUPPLY AND DEMAND MODELS

A. Introduction

A consistent set of supply parameters as well as demand parameters is required for the economic analysis of agricultural policy options. Knowledge of aggregate supply relationship, aggregate demand relationships, and agricultural policy parameters is also important in evaluating government food policy and can be used to operate government pricing programs which, through their impacts on the incentive parameters, indirectly affect agricultural supply and demand, and agricultural development (Altemeier et al., 1988; Tabor et al., 1989). This is especially important for the food sector of Indonesia since the focus of agricultural programs has shifted from a near single-minded campaign to increase rice production to a more multi-commodity orientation. A clear understanding of the economic inter-relationships among commodities and productive resources is needed to manage a multi-commodity food policy (Tabor et al., 1989; CARD 1990).

From a modelling standpoint, it is essential to identify a set of key commodities whose production, consumption, and prices have an important bearing on the local and national economy. This can be identified, among other things, through the contribution of each food crop on local or national economy.

This chapter is intended to review the analytical framework which could be used to produce aggregate food crops supply and demand elasticities. The supply component, which consists of a number of equations is called supply response model, and introduced in the first section. The second section covers the demand component, which also consists of a number of equations called the Almost Ideal Demand System (AIDS) model.

B. Supply Response Model

Supply response in agricultural economics generally means the variation of output and acreage mainly due to a variation in price. Simple supply response function can be developed by assuming that ouput (Q) is given by the product of acreage (A) and yield per hectare (Y) as follows.

$$Q = A \cdot Y \tag{3.1}$$

or

$$\ln Q = \ln A + \ln Y \tag{3.2}$$

Let us assume that both ahe area harvested under cultivation and the yield per hectare respond to price (P) changes, and furthermore, assume that yield responds to area harvested changes. Totally differentiating with respect to P, we obtain:

$$1/Q \cdot dQ/dP = 1/A \cdot dA/dP + 1/Y \cdot dY/dP \tag{3.3}$$

$$dY/dP = dY/dP + dY/dA + dA/dP \tag{3.4}$$

Substituting eation (3.4) into (3.3) and multiplying by P and dividing the above quation by Q/P, we obtain:

$$\frac{dQ/dP}{Q/P} = \frac{Q/A - dY/dP}{Q/P} + \frac{Q/Y - dY/dP}{Q/P} \tag{3.5}$$

or in terms of elasticities:

$$\Sigma_{Q,P} = \Sigma_{Y,P} + \Sigma_{A,P}(1 + \Sigma_{Y,A}) \tag{3.5}$$

where

$\Sigma_{Q,P}$ is the elasticity of output with respect to price,

$\Sigma_{Y,P}$ is the elasticity of yield with respect to price,

$\Sigma_{A,P}$ is the elasticity of area harvested with respect to price, and

$\Sigma_{Y,A}$ is the elasticity of yield with respect to area harvested.

Supply response ($\Sigma_{Q,P}$), therefore, is estimated indirectly by estimating $\Sigma_{Y,P}$, $\Sigma_{A,P}$, and $\Sigma_{Y,A}$.

Elasticity of aggregate supply response is a measure of responsiveness of planned in response to changes in anticipated output prices. It shows the direction and degree to which the output changes during the specified period in response to price changes. But neither planned output nor anticipated price is observable: the former, because weather and other environmental factors can make observed output deviate from planned output; the latter, because the farmer only knows the past and current prices. Proxies for these variables have, therefore, to be employed and the choice of proxy influence the result obtained. Expectations frequently have been modeled based solely on past prices. Examples include naive expectations, adaptive expectations, and autoregressive integrated moving-average (ARIMA) schemes (Antonovitz and Green 1990).

The supply of food crops in this study is defined as the product of area harvested and yields. It is assumed that farmers follow a two-stage decision making process when allocating resources for food crop production. Here area allocation decisions are considered separable from decisions on variable factors' allocations. It is likewise assumed that the decisions on area allocation are taken in advance of decisons on factor allocation. In the first stage, farmers allocate their land to a particular commodity. In the second stage, farmers utilize variable production factors in a way that maximize profit. The allocation of variable production factors determines their output level with respect to an underlying production function.

The area allocation decision is modelled as the function of own crop prices and prices of other competing staple crops. The model used to estimate the food crop area harvested response is based on the Nerlove formulation (Nerlove 1958; Behrman 19674; Askari and Cummings 1976; Hartley, Nerlove, and Peters 1984). The general form of the long run area harvested equation can be written as:

$$A_t^* = \alpha_0 + \alpha_1 P_{t-1} + \alpha_2 W_t + U_t \tag{3.6}$$

where A_t^* is log of desired or expected long-run of each food crop area harvested,

A_t and P_t are the area harvested and the price of each food crop respectively (the price is deflated by the general price index),

W_t is weather, measured by rainfall,

U_t is the random disturbance terms.

The general assumptions are: (a) farmers make adjustment decisions on current food crop area harvested based on last year's food crop price and farmers make adjustment decisions on future prices based on the error in their prediction of current prices. Assumption (a) may be described as follows:

$$A_t - A_{t-1} = \lambda(A_t^* - A_{t-1}), \quad 0 < \lambda < = 1$$

This model is called the partial adjustment or the habit persistence hypothesis, and λ is called the coefficient of adjustment. This hypothesis states that the change in actual area harvested is proportional to the difference between the desired or expected and the actual area harvested. In the agricultural supply context, this means that farmers increase their area harvested of a crop in any year or season only to the extent of a fraction λ of the difference between the area harvested in the preceding year and the desired area. This assumption reflects the traditional, technological, and institutional constraints which permit only a fraction of the intended levels to be realized during a given period. In the short-run, some of the factors of production are fixed and may be very difficult to shift from one production activity to another. Furthermore, farmers may be reluctant to adopt the new technology until they are convinced by observing other people practice it for a period of time.

Assumption (b) may be described as follows:

$$(b) \quad P_t^* - P_{t-1}^* = \delta(P_{t-1} - P_{t-1}^*), \qquad 0 < \delta < = 1$$

This model is called the adaptive expectations model and δ is called the coefficient of expectation. This hypothesis postulates that each year farmers revise the price expected to prevail in the coming year in proportion to the error they have made in predicting price this period. Using either assumption (a) or (b) or both, we are able to get the reduced form which contains only the observable variables. Substituting (3.6) in assumption (a) and rearranging terms:

$$\begin{aligned} A_t &= (1 - \lambda)\, A_{t-1} + \lambda A_t^* \\ &= (1 - \lambda)\, A_{t-1} + \lambda a_0 + \lambda \alpha_1 P_1^* + \lambda \alpha_2 W_t + \lambda U_t \end{aligned} \qquad (3.7)$$

Lagging (3.7) one period and multiplying by $(1 - \delta)$,

$$(1 - \delta)A_{t-1} = (1 - \delta)A_{t-2} + (1 - \delta)\lambda\alpha_0 + (1 - \delta)\lambda\alpha_1 P^*_{t-1} + (1 - \delta)\lambda\alpha_2 W_{t-1} + (1 - \delta)\lambda U_{t-1} \tag{3.8}$$

Subtracting (3.8) from (3.7) and rearranging term,

$$A_t = \delta\lambda\alpha_0 + \lambda\alpha_1\{P^*_t - (1 - \lambda)P^*_{t-1}\} + \{(1 - \lambda) + (1 - \delta)\}A_{t-1} - (1 - \delta)(1 - \lambda)A_{t-2} + \lambda\alpha_2 W_t - (1 - \delta)\lambda\alpha_2 W_{t-1} + \lambda U_t - (1 - \delta)\lambda U_{t-1}$$

But, from (b) $P^*_{t-1} - (1 - \delta)P^*_{t-1} = \delta P_{t-1}$

This gives

$$A_t = \delta\lambda\alpha_0 + \delta\lambda\alpha_1 P_{t-1} + \{(1 - \lambda) + (1 - \delta)\}A_{t-1} - (1 - \delta)(1 - \lambda)A_{t-2} + \lambda\alpha_2 W_t - (1 - \delta)\lambda\alpha_2 W_{t-1} + \lambda U_t - (1 - \delta)\lambda U_{t-1} \tag{3.9}$$

or in the reduced form of the observable variables:

$$A_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 A_{t-1} + \beta_3 A_{t-2} + \beta_4 W_t + \beta_5 W_{t-1} + V_t \tag{3.10}$$

where

$\beta_0 = \delta\lambda\alpha_0$

$\beta_1 = \delta\lambda\alpha_1$

$\beta_2 = (1 - \lambda) + (1 - \delta)$

$\beta_3 = - (1 - \delta)(1 - \lambda)$

$\beta_4 = \lambda\alpha_2$

$\beta_5 = -(1 - \delta)\lambda\alpha_2$

$V_t = \lambda U_t - (1 - \delta)\lambda U_{t-1}$.

If only the partial adjustment hypothesis is assumed (i.e., $\delta = 1$), equation (3.9) reduces to:

$$A_t = \lambda\alpha_0 + \lambda\alpha_1 P_{t-1} + (1 - \lambda)A_{t-1} + \lambda\alpha_2 W_t + \lambda U_t \tag{3.11}$$

On the other hand, if only the adaptive expectation hypothesis is assumed (i.e., $\delta = 1$), equation (3.9) reduces to:

$$A_t = \delta\alpha_0 + \lambda\alpha_1 P_{t-1} + (1 + \delta)A_{t-1} + \alpha_2 W_t - (1 - \delta)\alpha_2 W_{t-1} + U_t - (1 - \delta)U_{t-1}. \tag{3.12}$$

The differences between equation (3.11) and equation (3.12) are the disturbance terms and the inclusion in equation (3.12) contains the variable W_{t-1} whose coefficient is equal to the negative of the product of the coefficients of A_{t-1} and W_t. Furthermore, equation (3.11) is just identified while equation (3.12) is overidentified. In addition, if we change the specification of the model in (3.6) by assuming that there is no other regressor variable W_t (i.e., $\alpha_2 = 0$), then both (3.11) and (3.12) are reduced to a similar form and we cannot distinguish between the two hypotheses. That is, we do not know empirically whether our estimation equation comes from either the partial adjustment or the adaptive expectation hypothesis.

For $\alpha_0 = 0$, equation (3.11) reduces to

$$A_t = \lambda\alpha_0 + \lambda\alpha_1 P_{t-1} + (1 - \lambda)A_{t-1} + \lambda U_t\,, \tag{3.13}$$

and equation (3.12) reduces to:

$$A_t = \delta\alpha_0 + \delta\alpha_1 P_{t-1} + (1 - \delta)A_{t-1} + U_t + (1 - \delta)U_{t-1}\,. \qquad (3.14)$$

Both equation (3.13) and equation (3.14) are of the form:

$$A_t = Y_0 + Y_1 P_{t-1} + Y_2 A_{t-1} + Z_t \qquad (3.15)$$

Equation (3.15) with the trend variable added is the form that Nerlove (1958) used in his earlier studies to estimate the elasticities of supply of U.S. agricultural commodities.

The interesting point to make here is that when the Nerlovian type model is applied in empirical studies, we must state explicitly what are the hypotheses of the model, whether either the partial adjustment or the adaptive expectations or both hypotheses are assumed. If one assumes either $\delta = 1$ of $\lambda = 1$ while the true model is that neither δ nor λ is equal to unity, the assumption may introduce bias into the estimation of the parameters (Waud 1968).

However, one need not assume either the partial adjustment or the adaptive expectation hypothesis. For example, Waud (1968) specified that A_t is a distributed lag function of P_t, instead of P^*_t, plus some other variable, W_t. In other terms,

$$A_t = a_0 + a_1 \Sigma_{i=0} W(i)P_{t-1-i} + a_2 Z_t + e_t \qquad (3.16)$$

where W(i) is a weight assigned to each lagged variable and its value depends, again, on the assumption used.

If, for example, a geometric lag is assumed, then W(i) is of the form $\delta(1 - \delta)^i$. It can be shown that the reduced form under this assumption is equivalent to the adaptive expectation model.

Substitute $W(i) = \delta(1 - \delta)^i$ into (3.16).

$$A_t = a_0 + a_1 \delta \Sigma_{i=0} (1 - \delta)^i P_{t-1-i} + a_2 Z_t + e_t \tag{3.17}$$

Lag (3.17) one period and multiply by (1 - δ),

$$\begin{aligned}(1 - \delta)A_{t-1} &= (1 - \delta)a_0 + a_1\delta \Sigma_{i=0}(1 - \delta)^{i+1}P_{t-2-i} \\ &+ a_2(1 - \delta)Z_{t-1} + (1 - \delta)e_{t-1}\end{aligned} \tag{3.18}$$

Subtract (3.18) from (3.17) and rearrange terms to get

$$\begin{aligned}A_t &= \delta a_0 + a_1\delta \Sigma_{i=0}(1 - \delta)^i P_{t-1-i} - a_1\delta \Sigma_{i=0} (1 - \delta)^{i+1} P_{t-2-i} \\ &+ (1 - \delta)A_{t-1} + a_2 Z_t - (1 - \delta)a_2 Z_{t-1} + e_t - (1 - \delta)e_{t-1} \\ &= \delta a_0 + a_1\delta P_{t-1} + a_1\delta \Sigma_{i=1} (1 - \delta)^i P_{t-1-i} \\ &= a_1\delta \Sigma_{i=1} (1 - \delta)^i P_{t-1-i} + (1 - \delta)A_{t-1} \\ &+ a_2 Z_t - (1 - \delta) a_2 Z_{t-1} + e_t - (1 - \delta)e_{t-1} \\ &= \delta a_0 + a_1\delta P_{t-1} + (1 - \delta)A_{t-1} + a_2 Z_t - (1 - \delta)a_2 Z_{t-1} \\ &= e_t - (1 - \delta)e_{t-1} .\end{aligned} \tag{3.19}$$

which is the same as (3.11)

Very often, one assumes W(i) = 1 for i = 0 and W(i) = 0 for all i # 0. With the naive assumption, (3.16) reduces to

$$A_t = a_0 + a_1 P_{t-1} + a_2 Z_t + e_t \tag{3.20}$$

which is a traditional static supply model where the explanatory variables contain no lagged dependent variable. The form of the weight depends on the assumption one makes which in turn depends on the nature of the problem studied. For example, in a study of supply analysis of livestock, a polynomial lag may be more appropriate than a geometric lag, e.g., Meilke, Zwart, and Martin (1974). A survey on distributed lag models was given and discussed by Griliches (1967) and a survey of agricultural supply response was given and discussed by Nerlove (1958), Behrman (1974), Askari and Cummings (1976) and Rao (1989).

Following Nainggolan and Suprapto, (1987) and Altemeier, Tabor, and Adinugroho (1988), the ordinary least squares (OLS) technique will be used to estimate parameters in equation (3.11) or equation (3.19). When the equation is fitted, the short-run area harvested elasticity can be derived from the coefficient of P_{t-1} (or given directly by this coefficient if the data are in the logarithmic form). Long-run area harvested elasticity is derived from a_1. Parameter λ can be derived from the coefficient of A_{t-1}. So from equation (3.11) or equation (3.19) we can derive the short-run and the long-run elasticities of area harvested with respect to price ($\Sigma_{A,P}$).

C. Estimation Problems

Consider the general linear model (Judge *et al.* 1982; Kmenta 1985):

$$Y = Z\beta + U$$

where

Y is an n x 1 vector of the dependent variable,

Z is an n x k matrix of the independent variables,

ß is an k x 1 vector of the coefficients

U is an n x 1 vector of the disturbance term,

n is the number of observations, and

k is the number of explanatory variables.

The assumptions are:

(1) $(Z'Z)^{-1}$ exist

(2) Z is fixed

(3) E(U) = 0

(4) $E(UU') = \text{Ó}^2 I_n$

If all the above assumptions hold, then the ordinary least squares (OLS) estimates give the Best Linear Unbiased Estimator (BLUE) of ßs (Gaussian-Markov theorem).

Assumption (1) implies that the rank of Z must be equal to k or that one of the variables in Z is not a linear combination of the other variable(s). In practice, we may not have perfect correlation among these variables but, instead, we may have a partial or high correlation, which is called a multicollinearity problem. As a result, the estimates of the coefficients may not be reliable due to large standard errors. This problem may arise in an equation that contains lagged independent variable.

Assumptions (2) and (3) guarantee the unbiasedness of the OLS estimator. Assumption (4) means that the disturbance term is independently distributed with homogeneous variance. This assumption implies that the OLS estimator will yield a minimum variance. Furthermore, if U is also normally distributed, i.e., $U \sim NID(0, \text{Ó}^2 I_n)$, then the OLS estimator is equivalent to the maximum likelihood estimator (MLE). If Z is stochastic and correlated with U, the OLS estimator is biased and inconsistent. This case may not be difficult to find in econometric problems such as demand or supply analysis where price and quantity simultaneously determine each other, i.e., if one of the explanatory variables is an endogenous variable. In other situations, such as where the explanatory variable is a lagged dependent variable which is not independent of the disturbance term, then if assumptions (3) and (4) hold, the OLS estimator will give consistent estimates, although they are biased.

There are several cases when assumption (4) is violated, and this is called a heteroscedasticity problem. OLS will not yield the minimum variance estimates, even though, in some cases, it may give an unbiased estimator. If we know the distribution of U and its parameters, we may be able to utilize this information by transforming the original data and then applying OLS, which is called the Generalized Least Squares (GLS) procedure. In general, we do not know the distribution of the disturbance term. There are an infinite number of assumptions that can be made about the disturbance term. Different assumptions will lead to a different method of estimation. In this section, however, only the four most relevant and often used will be discussed briefly. For simplicity, let us consider the linear regression of the form (Kmenta 1985):

$$A_t = \beta_0 + \beta_1 A_{t-1} + \beta_2 X_t + V_t$$

The four assumptions are as follows:

(1) $V_t \sim NID(0, Ó^2_v)$

(2) i) $V_t = U_t - (1 - \delta)U_{t-1},\ 0 < \delta < 1$

ii) $U_t \sim NID(0, Ó^2_u)$

(3) i) $V_t = U_t - (1 - \delta)U_{t-1},\ 0 < \delta < 1$

ii) $U_t = þU_{t-1} + e_t,\ |\ þ\ | < 1$

iii) $e_t \sim NID(0, Ó^2_e)$

(4) i) $V_t = þV_{t-1} + e_t,\ |\ þ\ | < 1$

ii) $e_t \sim NID(0, Ó^2_e)$.

Although only assumption (1) will be employed in the present study, it is worth discussing about the consequences of each assumption at least briefly to remind us that the interpretation of the statistical results must be made very cautiously before jumping to any conclusion. For further detail regarding different methods of estimation, information can be found in any standard econometric textbook, e.g., Judge et al. (1982) and Kmenta (1985).

Assumption (1) is the simplest assumption, and it is a possible assumption when the partial adjustment model is assumed together with the assumption that U_t in equation (3.3) is also NID(0, $\acute{O}^2_u$). Since $V_t = lU_t$ (see equation (3.7) and λ is a constant, therefore V_t _ NID(0, λ^2 $\acute{o}2_u$). OLS will yield consistent but biased estimates of the ßs because of the presence of the lagged dependent variable (A_{t-1}) on the right-hand side of the equation. Furthermore, in this case, MLE is identical with OLS.

Assumption (2) is an assumption candidate when an adaptive expectation model is assumed (see equation (3.9). There is not much problem in estimation if δ is known since GLS can be applied. Under this assumption it follows that

$$E(V_t) = 0$$

$$E(V_t V_{t+s}) = \{ \begin{array}{ll} [1 + (1 - \delta)^2]\acute{O})u^2, & s = 0 \\ - (1 - \delta)\acute{O}^2_u, & s = +/\_ 1 \\ 0, & otherwise \end{array}$$

Thus, the covariance matrix (Ω) = E($\underline{V}$V') is known and is of the form

$$\mathring{A} = \delta^2 u \begin{matrix} [1 + (1 - \delta)^2] & -(1 - \delta) & 0 & \ldots 0 \\ -(1 - \delta) & [1 + (1 - \delta)^2] & -(1 - \delta) & 0 \\ & & & [1 + (1 - \delta)^2] \end{matrix}$$

The GLS estimator of ßs is given by

$$(\underline{X}'\Omega^{-1}\underline{X}')^{-1}\ \underline{X}'\Omega'\underline{A}$$

where

$\underline{A}$ is a vector of the dependent variable,

$\underline{X}$ is a matrix in which the t_{th} row contains the following elements $[1,\ A_{t-1},\ X_t]$

$\underline{V}$ is a vector of the disturbance terms, V_t.

In practice, however, δ is generally unknown; therefore, GLS cannot apply directly. Nevertheless, there are several procedures, such as the method of instrumental variable and maximum likelihood, that give consistent estimators of the ßs, though the estimators are still biased in the small sample case. Most procedures deal with searching for the optimum value of σ, which gives the minimum mean square error; the procedures may be iterative in nature.

There is no problem in assumption (3) if both δ and ρ are known, since GLS can be applied directly. In general, δ and ρ are unknown, and the search and iterative procedure may be needed. The models with assumption (2) and (3) are computationally burdensome and are worth doing only if one is very convinced about the specification above. Since we will not apply this procedure here, we will not discuss it further.

Assumption (4) is an autocorrelation assumption of the disturbance term and is not tied with either the adaptive expectations or partial adjustment hypothesis. If ρ is known, the GLS is applicable since we can compute the covariance matrix (Ω) similarly to the method used making assumption (1), and Ω is of the form

$$\begin{matrix} 1 & \rho & \rho^2 & \rho^3 & . & . & . & \rho^{n-1} \\ \rho & 1 & \rho & \rho^2 & . & . & . & \rho^{n-2} \\ \rho^{n-1} & \rho^{n-2} & . & . & . & . & . & 1 \end{matrix}$$

where n is the number of observations. If ρ is unknown, one has to estimate ρ or use a search and/or iterative procedure similar to those in the models using assumptions (2) and (3). Again, we will not discuss these procedures here further.

The assumption regarding the disturbance term is, in fact, crucial. The unbiasedness and consistency properties of the estimators depend on the assumption made about the disturbance term and consequently, on the method of estimation employed.

D. Variable Measurement

1. Dependent Variable

In studying the supply analysis of any crop, one of the main objectives is the empirical estimation of the elasticity of supply or output with respect to price (Nerlove 1958; Behrman 1974; Askari and Cummings 1976; Nainggolan and Suprapto 1987; Altemeier, Tabor, and Adinugroho 1988). However, empirical estimates of elasticities depend both on the methodology adopted and on country (region) specific factors relating to technology, economic structure and macro constraints. Most time-series studies are for particular crops and use acreage as the proxy for output because acreage is thought to be more subject to farmer's control than output. For the price, most researchers assume that farmers anticipate prices from their knowledge of current and past price (following Nerlove 1958) (Behrman 1974; Askari and Cummings 1976; Hartley, Nerlove, and Peters 1984; Nainggolan and Suprapto 1987; Altemeier, Tabor, and Adinugroho 1988)

It goes without saying that the choice of the dependent variable in a supply response study is between the variables for production or output and the planting or harvesting area. If our objective is to estimate the elasticity of harvesting area, then the relevant dependent variable is the area harvested. On the other hand, if our objective is to estimate the elasticity of production, then the relevant dependent variable is the production. Under certain assumptions, however, the area response may give a better approximation of production elasticity (Behrman 1974). Consider the fact that production is the product of area and yield per unit area; if we assume that the elasticity of yield with respect to price is very small or close to zero, which is not unrealistic for less developed countries, then the area response and production response are approximately equal (Behrman 1974). Let Q be production, Y be yield per unit area, and A be the harvested area; then the relationships between the elasticities of Q, Y, and A with respect to price (P) are:

$$E_{Q,P} = E_{A,P} + E_{Y,P}$$

Where

$E_{Q,P}$ = elasticity of Q with respect to P,

$E_{A,P}$ = elasticity of A with respect to P, and

$E_{Y,P}$ = elasticity of Y with respect to P.

If $E_{Y,P}$ is very small, then $E_{Q,P} \cong E_{A,P}$.

However, as pointed out by Behrman (1974) and Askari and Cummings (1976), the realized agricultural output often differs considerably from planned output because of important environmental factors which remain beyond the farmer's control. The frequent large discrepancies between planned and actual agricultural production have led most agricultural economic researchers of agricultural supply response to approximate planned output not by actual output, but by area. The area actually planted in a particular crop is, to a much greater degree, under the farmer's control than output is, and thus presumably a much better index of planned production (Heady and Dillon 1972; Berhman 1974; Askari and Cummings 1976.)

By contrast, the actual output is dependent on the harvested, not the planted area, which in turn depends on the harvesting cost relative to the price of output and the actual yield, which, to some extent, depends on weather conditions. These factors are not under the control of the farmers. The farmer may to some extent be able to adjust output by shifting land from low to high fertility through increased use of fertilizer, water, etc., or by expanding to low fertility land. As a result, the response of yield with respect to price may not be small and cannot be ignored (Behrman 1974; Hartley, Nerlove, and Peters 1984; Nainggolan and Suprapto 1987).

2. The Price Variable

In the simple Nerlovian supply model, only P^*_t is used (Nerlove 1958; Behrman 1974; Askari and Cummings 1976; Nainggolan and Suprapto 1987). If one or more prices of competing crops is used, then the following problem may arise: What are the relevant competing crops? Because of the heterogeneous nature of land, the higher the level of aggregation, the more alternative crops we will have. Furthermore, using more than one price, we may encounter a multicollinearity problem among the price variables (Askari and Cummings 1976; Hatley, Nerlove, and Peters 1984). However, even if we use a single price variable in the model, the problem still remains. That is, the following choices must be considered: (a) the absolute price of the crop actually received by farmers; and (b) the relative price, i.e., the price of the crop under consideration deflated by some deflator (Askari and Cummings 1976; Nainggolan and Suprapto 1987).

If the relative price is used, then the question becomes, what is the appropriate deflator? In order to be able to answer this question, we must know why the farmer wants to alter his production. If the farmer increases production because he/she wants to consume more, then no price variable is relevant, i.e., any price will not yield a significant effect. On the other hand, if profit maximixation is his goal, then the relative price may be appropriate. The deflator should be the index of the price of the alternative crops. What is the appropriate weight, the area, the total output or the marketed output? If the crop under consideration is a subsistence crop as opposed to a cash crop, then the marketed output is a better weight than the total output (Behrman 1974; Askari and Cummings 1976). However, the availability of the data may force one to use other variables as proxy variables (Hartley, Nerlove, and Peters 1984; Altemeier, Tabor, Adinugroho 1988).

3. The Supply Shifter Variable

Supply shifter variables are non-price variables. In general, the reason for including these variables is to avoid the problem of identification in the estimation of the structural parameters (Behrman 1974). The most common variable is a time trend, which is used as a proxy for a technological change or to pick up some autonomous trend or for the purpose of correcting the serial correlation among the disturbance terms (Altemeier, Tabor, and Adinugroho 1988). The weather variables, such as rainfall, temperature and/or some measure of the weather index, are also often used (Nainggolan and Suprapto 1987). This is because weather conditions are one of the constraints that prevent a farmer from planting a crop as much as the farmer wants to.

The selection of the shift variables may depend on the objective of the research. Many times, this variable cannot be quantified, so dummy variables are used instead for factors such as the effect of transportation, diseases, insect attack, and regional or geographical differences.

However, including too many variables in the model may cause a multicollinearity problem and loss of degrees of freedom, and these may cause hypothesis testing to be unreliable (Judge et al. 1982). Some authors include the risk variable such as the standard deviation of price and/or yield (Berhman 1968). The most common goal is to increase the value of the coefficient of the determination (R^2) of the model and to achieve estimated coefficients that have the expected signs (Nainggolan and Suprapto 1987).

E. Almost Ideal Demand System (AIDS) Model

There has been continuing development and search for specification and estimation of demand functions which represent consumers' utility maximizing behavior. Barten (1977) stated that in general, there are three broad approaches to specifying applied demand systems:

1) Deriving a system of demand equations from a utility maximization problem assuming specific forms of utility functions. The linear expenditure system (LES) and indirect addilog model are examples of this approach.
2) Deriving demand equations based on an approximation to an arbitrary specified functional form, as in the Rotterdam model, transcendental logarithmic system, and almost ideal demand system (AIDS).
3) Constructing models with *ad hoc* specifications directly imposing theoretical restrictions as in the generalized addilog model and Theil's multinominal extension of the linear logit model.

Several recent surveys and comprehensive treatments of demand systems are available in Barten (1977), Johnson et al. (1984), and Deaton (1986). An understanding of the use of these demand systems and their limitations is helpful in selecting appropriate models to work with and in assessing the validity of the empirical results from applying the models for various purposes of studies (Johnson et al. 1984). The purpose of this sub-chapter is to review a demand system called the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980a, 1980b).

Deaton and Muellbauer (1980a) list several advantages that make the AIDS model especially attractive: 1) the AIDS gives an arbitrary first order approximation to any demand system; 2) it satisfies the axioms of choice exactly; 3) it aggregates perfectly over consumers without invoking parallel linear Engel curves; 4) it has a functional form which is consistent with known household-budget data; 5) it is simple to estimate, largely avoiding the need for non-linear estimation; and 6) it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters. Because of theoretical and empirical advantages, the AIDS has been perceived as a very useful tool in demand analysis and become popular in recent years (Ray 1982; Blanciforti and Green 1983; Blanciforti, Green, and King 1986; Goungetas, Jensen, and Johnson 1990; and CARD 1990).

1. Derivation of the Almost Ideal Demand System Model

The AIDS model, according to Muellbauer (1975) is derived from the neccesary and sufficient conditions for the existence of a representative budget level. Food crop demand functions, for example, can be represented as if they were the outcome of rational decisions by a representative consumer. These preferences are known as the PIGLOG (price independent generalized logarithm) class. These are represented through the expenditure or cost functions which define the minimum expenditure necessary to attain a specific level of utility at given prices. Deaton and Muellbauer denote cost function c(u, p) for utility u and price vector p, and define the PIGLOG class as:

$$\log c(u,p) = (1 - u) \log [a(p)] + u \log[b(p)] \qquad (3.21)$$

where u in equation (3.21) lies between 0 (subsistence) and 1 (bliss) so that the positive linearly homogeneous functions a(p) and b(p) can be regarded as the cost of subsistence and bliss, respectively. [Appendix of Deaton and Muelbauer (1980a) further discussed this general model as well as the implications of the underlying aggregation theory].

For the resulting cost function to be a flexible functional form, Deaton and Muellbauer proposed the following specific functional forms for log a(p) and log b(p):

$$\log a(p) = \alpha_0 + \Sigma \alpha_i \log p_i + 1/2\ \Sigma\Sigma\gamma^*_{ij} \log p_j \log p_i \qquad (3.22)$$

$$\log b(p) = \log a(P) + \beta_0\, \Pi\, p_i \beta_i \qquad (3.23)$$

Therefore, the AIDS expenditure function is specified as:

$$\log c(u,p) = \alpha_0 + \Sigma \alpha_i \log p_i + 1/2\ \Sigma\Sigma\gamma^*_{ij} \log p_j \log P_i + U\, \beta_0\, \Pi\, p_i \beta_i \qquad (3.24)$$

where α_0, α_i, β_i, and γ^*_{ij} are parameters; U is the utility level; and P_j are prices.

This expenditure function is linearly homogeneous in p, provided by $\Sigma\alpha_i = 1$, $\Sigma\gamma^*_{ij} = \Sigma\gamma^*_{ji} = \Sigma\beta_j = 0$. It is also consistent with aggregation over consumers. The demand functions are derived from equation (3.21). A fundamental property of the expenditure function is that its price derivatives are the demand functions: $dc\ (u, p)/dp_i = q_i$ (Phlips, 1983). Multiplying both sides by $p_i/c(u, p)$, we obtain:

$$\log\ c(u,p)/\log\ p_i = p_i q_i / c(u,p) = W_i \tag{3.25}$$

where W_i is the budget share of good i. Hence, logarithmic differentiation of equation (3.22) gives the budget share as a function of prices and utility:

$$W_i = \alpha_i + \Sigma\gamma_{ij}\ln p_j + \beta_i\mu\ \beta_0\ \Pi p_j\beta_i \tag{3.26}$$

where

$$\gamma_{ij} = \tfrac{1}{2}(\gamma^*_{ij} + \gamma^*_{ji}) \tag{3.27}$$

is required to satisfy the symmetry conditions.

For a utility-maximizing consumer, total expenditure x is equal to c(u, p), and when c(u, p) is a single valued function, this equality can be solved for u as a function of p and x, which is the indirect utility function. If we do this for equation (3.24) and substitute the result into equation (3.26), we have the budget shares as a function of p and x; these are the AIDS demand function in the budget share form:

$$W_i = \alpha_i + \Sigma\gamma_{ij}\log p_j = \beta_i \log(x/p) \tag{3.28}$$

where p is price index defined by

$$\log p = \alpha_0 + \Sigma\alpha_i \log p_i + \tfrac{1}{2}\ \Sigma\Sigma\ \gamma_{ij}\log p_i\ \log p_j \tag{3.29}$$

is an overall price index, which according to Deaton and Muellbauer (1980a) could be replaced by Stone's (1954) price index in empirical applications since equation (3.26) is highly non-linear. The Stone's (geometric) price index is given by:

$$\log P^* = \Sigma W_i \log p_i \tag{3.30}$$

When Stone's index is used in (3.28) the model is termed as a linear approximation of the Almost Ideal Demand System (LA/AIDS) (Blanciforti and Green, 1983). The one application available for evaluating this approximation suggests that it is reasonably accurate (Johnson, et al. 1986). The advantage of the approximation is that if used, the demand system is linear in the structural parameters (Johnson et al. 1986).

The restrictions on the parameters of equation (3.24) plus equation (3.27) imply restrictions on the parameters of the AIDS equation (3.28) which represents a system of demand functions if,

$$\Sigma\, \alpha_i = 1 \qquad \Sigma\, \gamma_{ij} = 0 \qquad \Sigma\, \beta_i = 0 \tag{3.31}$$

$$\Sigma\, \gamma_{ij} = 0 \tag{3.32}$$

$$\gamma_{ij} = \gamma_{ji} \tag{3.33}$$

where equation (3.31), (3.32), and (3.33) are adding-up, homogeneity, and symmetry conditions, respectively. Provided equation (3.31), (3.32), and (3.33), equation (3.28) represent a system of demand functions which add up to total expenditure (Σ W_i = 1), are homogeneous of degree zero in prices and total expenditure taken together and which satisfy the Slutzky symmetry conditions. Note that the adding-up and homogeneity restrictions simply repeat the restrictions imposed on the parameters of the cost function. These restrictions can be applied to equation (3.28) and (3.29) to test the consistency of the demand system with demand theory (Johnson et al. 1986).

The share elasticity with respect to income for equation (3.28) is

$$d \log W_i / d \log Y = \beta_i / W, \tag{3.34}$$

implying the goods are necessities if $\beta_i < 0$ and luxuries if $\beta_i > 0$. For the prices P_i, the share elasticity is

$$d \log W_i / d \log P_i = \gamma_{ij} / W_j - \beta_i / W_i (\alpha_j - \Sigma \gamma_{ji} \log p_i) \tag{3.35}$$

Expressing these elasticities in terms of the quantity demand for commodity i, the income elasticity is

$$\eta_i Y = \beta_i / W_i + 1 \tag{3.36}$$

The own-price and cross-price elasticities are, respectively,

$$\epsilon_{ii} = -1 + \gamma_{ii} / W_i - \beta_i \tag{3.37}$$

$$\epsilon_{ij} = \gamma_{ij} / W_i - \beta_i (W_j / W_j);\ i \neq j \tag{3.38}$$

2. Estimation of Almost Ideal Demand System

Demands for agricultural products are estimated for staple-food goods and other goods. The budgetary share allocated to the staple-food group (SFG) and other goods (OG) at the first stage is given by:

$$W_i = \alpha_i + \Sigma_i \gamma_{ij} \log p_j + \beta_j \log (x / p^*) \tag{3.39}$$

where p_j is the price index of group j (j=SFG, OG), X is the total expenditure on all two groups, and p* is a suitable price index defined by:

$$\log p^* = \alpha_0 + \Sigma_i \log p_i + ½\ \Sigma\Sigma\gamma_{ij}^* \log P_i \log p_j \tag{3.40}$$

A functional form that can be fitted to data can be obtained by substituting equation (3.40) into (3.39):

$$W_i = (\alpha_i - \beta_i\ \alpha_0) + \Sigma\gamma_{ij} \log p_j + \beta_i (\log x - \Sigma\ \alpha_i \log p_i \\ - ½\ \Sigma\Sigma\gamma_{ij} \log p_i \log p_j \tag{3.41}$$

Estimates of the parameters, i.e., as, gs, and bs in this non-linear system of equations can be obtained by applying the maximum likelihood methods. Deaton and Muellbauer (1980b) suggest exploiting the collinearity of prices to obtain a much simpler empirical equation as follows. Note from equation (3.39) that if p were unknown, the model would be linear in the parameters α, ß, and γ, and estimation could be done equation by equation by applying OLS. Given normally distributed errors, OLS is equivalent to maximum likelihood estimation for the system as a whole. The adding-up constraints (3.31) will be automatically satisfied by these estimates. When prices are closely collinear, P can be approximated as proportional to some known price index called Stone's Index defined as: $\log P = \Sigma W_i \ln P_i$ (Stone, 1953). If $P = \varnothing P^*$, then equation (3.39) can be estimated as:

$$W_i = (\alpha_i - \beta_i \log\varnothing) + \Sigma\gamma_{ij} \log p_j + \beta_i \log (x/p^*) \tag{3.42}$$

In equation (3.41), the a_i parameters are identified only up to a scalar multiple of W_i. If we write $\alpha_i^* = (\alpha_i - \beta_i \log \varnothing)$, $\Sigma\beta_i = 0$ implies $\Sigma\alpha_i = 1$. The empirical work is based on a linear approximation to equation (3.41) which is known as LA/AIDS system (Ray, 1982; Blanciforti and Green 1983; Blanciforti, Green, and King 1986; Deaton and Muellbauer, 1980b). At the second stage for the staple-food group the budgetary share equations for five food crops are given by equation (3.39) for rice, corn, cassava, peanuts and soybeans where prices are directly available.

IV. AN OVERVIEW OF LAMPUNG FOOD CROPS AGRICULTURE

A. General Situation

Located in the southern tip of Sumatra island, the Lampung, which covers 33,376 square kilometers or about one-quarter of Java, is one of the most interesting provinces in Indonesia. This province occupies a strategically important position, bounded on the north by the province of South Sumatra, on the east by the Java sea, on the south by Sunda strait, and on the west by the province of Bengkulu (Figure 4.1) A good land transportation network links Lampung to the rest of Sumatra and, through the ferry system, to Java.

The Trans-Sumatra Hughway runs from Banda Aceh in the north, runs through the province to Bakauheni, the harbor on the Southern tip of Sumatra. From here, regular ferries ply the short trip across the Sunda straits to Merak, West Java. The ferry traffic--people, vehicles, and goods--has risen very rapidly, following the completion of Trans-Sumatra Highway and the improved shipping infrastructure. Lampung is thus a 'border' region both in a geographical sense as well as with respect to its socio-economic status. Its strategic location has shaped the province's economic and socio-cultural development. But it has never fully realized its potential as being the 'crossroads' of western Indonesia's commercial and demographic growth.

Topographically the province can be divided into five zones: hilly until mountainous, wave until float, alluvial mainland, tides marsh mainland, and basin river. The distribution of land by its use is as follows: building and yard 184,077 hectares,upland farming 593,784 hectares, grazing land 87,572 hectares, uncultivated swamp area 146,933 hectares, coastal ponds 1,526 hectares, inland ponds 2,059 hectares, rural woodlands 323,589 hectares, estate land 367,550 hectares, and lowland 188,101 hectares. The distribution of lowland by its type of irrigation is: technically irrigated 62,728 hectares, semi-technically irrigated 13,160 hectares, simply irrigated

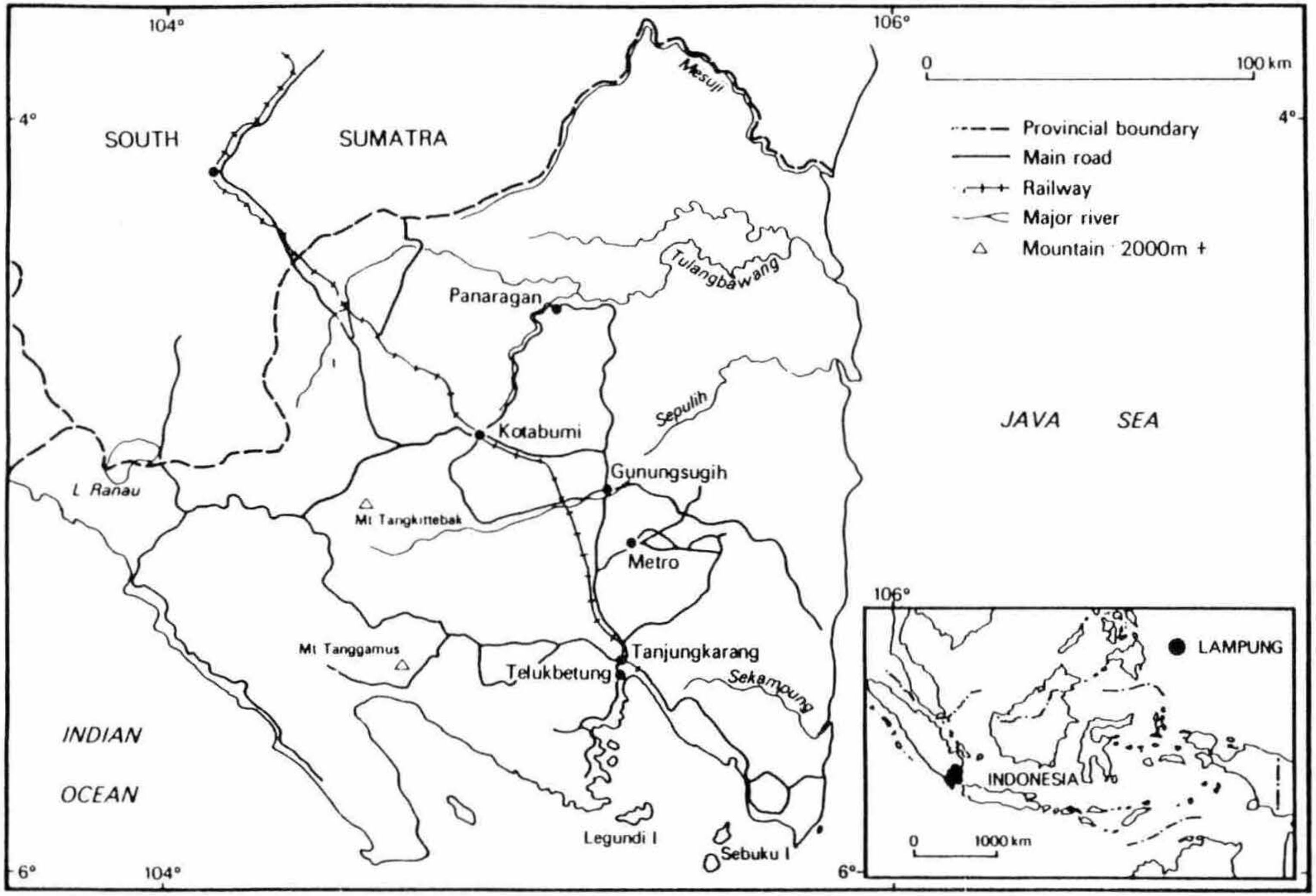

Figure 4.1 Map of Lampung Province

35,552 hectares, rainfed 49,617 hectares, tidal 7,744 hectares, and other 19,300 hectares (Office of Statistics, Lampung 1989).

The annual rainfall varies and is classified into five ranges: areas with rainfall less than 1,750 mm per annum; 1,750-2,000 mm per annum; 2,000-2,500 mm; 2,500-3,000 mm per annum,, and more than 3,000 mm per annum. The number of raindays is 89-170 days per annum for North Lampung, 67-153 days per annum for Central Lampung, 95-184 days per annum for South Lampung (Office of Statistics, Lampung 1989).

The province has four administrative residences, each of which is subdivided into administrative unit called Kabupaten (regency) as follows: Municipality of Bandar Lampung, which covers 169,21 square kilometers and has nine Kecamatans (districts); Residence of South Lampung, which covers an area of 649,29 square kilometer and has 20 sub-districts; Residence of Central Lampung, which cover 9,189 square kilometer and consists of 24 districts; and Residence of North Lampung which occupies an area of 19,368 square kilometer and has 24 districts (Office of Statistics, Lampung 1989).

In 1989, the population of Lampung was 7,231,379 (CBS 1990). The average population growth is 5.77 percent, which is the highest rate among the provinces in Indonesia. This highest rate of growth is attributable to net in-migration from Java. The average population density in 1989 was 4,535 persons per square kilometer for Bandar Lampung municipality, 334 persons for South Lampung, 245 persons for Central Lampung, and 103 persons for North Lampung (CBS 1990). The population distribution by regency in Lampung for the period of 1990-1995 is presented in Table 4.1 which indicates that population tends to be concentrated in Bandar Lampung.

Table 4.1. Lampung population and population density, 1988-1990

Municipality/ Kabupaten	1988	Density (per sq km)	1989	Density (per sq km)	1990	Density (per sq km)
Bandar Lampung	720,435	4,258	767,368	4,535	816,397	4,825
South Lampung	2,149,486	323	2,221,768	334	2,293,782	345
Central Lampung	2,191,870	239	2,247,435	245	2,301,700	250
North Lampung	1,828,263	94	1,994,808	103	2,173,968	112
Total	6,890,054	195	7,231,379	204	7,585,847	214

Source: Central Bureau of Statistics, 1990.

The regional gross domestic product of the province in 1988 can be seen in Table 4.2. The economy of Lampung is still heavily dependent on agriculture. In 1986 the agriculture sector contributed 46.85 percent of gross regional domestic product at 1983 market prices, although recently, other sectors are gaining some importance. Economic activities are still centered on producing, marketing, and processing farm products. In 1988, the food crop sector constituted 37.95 percent and livestock and fisheries constituted 9.21 percent of the GRDP at 1983 market prices.

Although actual levels of food crops production are not very high compared with other provinces in Java, Lampung's contribution to the national market in marketed crop surplus is quite substantial. This creates a niche for Lampung in the national food economy. While yields for all food crops have risen, the most dramatic increase has occured in rice. Owing to government promotional efforts, investments in infrastructure (especially irrigation), and more intensive cultivation, rice yields rose three fold from 1969 to 1984. The next best increase was for corn, yields of which more than doubled followed by cassava, soybeans, sweet potatoes, peanuts, and green peas.

Table 4.2. Growth and distribution of GDP, 1975-1986 (percentage)

			Average Growth				
Distribution	1975	1983	1984	1985	1986	1979-83	1975-83
Agriculture	56.4	41.9	44.8	42.8	47.3	7.1	4.6
Food Crops	28.0	22.9	49.0	44.0	43.9	10.5	4.8
Non-Food Crops	17.3	19.4	29.7	33.2	36.3	0.6	3.2
Forestry	7.8	7.2	n.a.	n.a.	n.a.	-14.3	-9.4
Livestock	1.4	0.3	n.a.	n.a.	n.a.	11.8	7.4
Fisheries	2.0	2.0	4.9	5.6	5.5	8.8	7.9
Mining	0.2	0.2	0.3	0.3	0.3	5.1	4.6
Manufacturing	7.3	13.4	8.4	9.5	7.3	19.5	14.8
Utilities	0.1	0.3	0.3	0.4	0.4	20.4	15.7
Construction	1.5	3.5	4.4	4.2	2.6	23.9	22.3
Trade	17.3	18.4	16.4	15.6	15.2	-1.1	8.1
Transport & Communication	5.0	6.7	6.5	6.4	6.3	3.2	11.7
Finance	5.7	6.7	10.0	11.8	11.0	7.6	9.4
Other Services	6.5	8.5	5.7	6.4	5.9	6.7	11.1
Total	100.00	100.00	100.00	100.00	100.00	6.7	7.8
Rp Billion	232	1,184	1,152	1,225	1,343		

Source: Office of Statistics, Lampung (1989).

B. Agricultural Economy of Four Food Crops in Lampung

1. Paddy

Rice is by far the predominant staple food grown by smallholders together with corn, cassava, soybeans, sweet potatoes, peanuts, and groundnuts (or, as a whole group of non-rice food crops is called *palawija* or secondary food crops) in Lampung as well as in Indonesia. The relative importance of these crops varies according to location. Rice growing is regarded as the farmer's basic way of life. Most of the farmers in all regions in Lampung produce rice to meet their own families' subsistence demand and sell only the surplus on the market.

Rice is by no means a homogeneous crop. Three classifications of rice are possible by the method of planting: broadcasting, transplanting, and upland rice. The decision regarding the method of planting is dependent on the water availability in the area. If the area is quite, then upland rice can be grown on this land. It is planted early in the rainy season by plowing or hoeing the soil, and then making holes with a sharp stick, dropping three to five rice grains into the hole and then covering the grains with the soil around it. Only very limited weed control is done during the growing period. Upland rice is important in Lampung because it accounts for more than half of the rice produced.

For broadcast rice, the land is plowed as early as the rain permits. The seed is broadcast at the beginning of the rainy season. Immediately after the seed is broadcast, a second plowing is done in order to cover the seeds to protect them from birds, rodents, sun, and wind. In some areas where the water level is a little high during the sowing months, the seeds are sprouted by soaking them in water for several days before they are sown. In the first month after sowing, the right amount of rain at the right time is critical. If too much rain comes too early, the seed may not be able to germinate or dies just after it germinates. In later months, however, the rice plant can easily adjust itself according to the water level. Therefore, this kind of rice is suitable in the low and flooded areas like reclaimed swamp areas where other crops cannot be grown during the rainy season. Harvesting this crop may take place while the paddy field is still wet.

In the area where it is possible to control the water level to some degree, the transplanted rice is grown. The farmer constructs a small permanent dike around his field so that it contains the water from either the rain or the irrigated canal. The muddy seedbed is prepared as early as possible, if water is sufficient. The sprouted seed is then sown on the muddy but drained seedbed. After about a month, the seedlings are uprooted and transplanted; they must be transplanted within a day or two after being uprooted. At the same time, the other field must be prepared and made ready for transplanting. The field is plowed two or three times and then harrowed. Again, sufficient water is necessary at this stage in order to plow and harrow the field, especially when the animal power (buffalo or oxen) is used in preparing the soil. This type of planting is the most practiced in Lampung.

After rice has been harvested, it is threshed and cleaned by human and animal power at the paddy field and is then ready to transport to the farmers' storage. Most farmers have their own storage facilities of varying size. Most storage facilities are built beside the farmer's house in the village in order to store rice for home consumption. However, most farmers sell their paddy immediately after it has been harvested. This behavior can be explained by the need for cash to pay back debts incurred during the growing season. In some cases, rice has been sold long before harvesting occurred by an agreement between the farmer and a local middleman who lends the farmer money and some other inputs during the growing period. In this study, rice is treated as a single homogeneous crop.

In general, paddy cultivation in Lampung is divided into two categories: wet land paddy (wet monsoon) and dry land paddy (east monsoon). This distinction is officially used in all government publications. Wet land paddy production covers the period between January and August, while the dry land rice crops are primarily produced from September to December. The wet land rice crops contribute more than 75 percent of the total annual rice production. Dry land paddy production in Lampung is more than in the other provinces in Indonesia. Time series data on area harvested, production, and yield per hectare on wet and dry land rice from 1969 to 1988 are shown in Table 4.3. and Table 4.4.

Table 4.3. Area harvested, production, and yield of wetland rice in Lampung, 1969-1988

Year	Harvested Area('000ha)	% Change	Production (Ton)	% Change	Yield (Qt)	% Change
1969	70.53	169.47	22.63			
1970	75.89	7.53	186.99	10.33	24.64	8.88
1971	87.42	15.19	230.97	23.52	26.42	7.22
1972	90.58	3.61	226.73	-1.83	25.03	-5.26
1973	100.41	10.80	258.78	14.13	25.77	2.96
1974	106.36	5.89	295.14	14.05	27.75	7.68
1975	130.19	22.40	38.44	30.21	29.52	6.38
1976	121.72	6.50	404.35	5.21	33.22	12.53
1977	123.11	1.10	408.61	1.05	31.89	-4.00
1978	128.84	4.67	411.70	0.75	1.95	0.18
1979	130.67	1.39	424.49	12.79	32.49	1.69
1980	151.05	15.59	502.82	13.58	33.29	2.46
1981	167.09	10.62	576.67	14.69	34.51	3.66
1982	174.81	4.62	666.63	15.60	38.14	10.52
1983	190.49	8.90	745.78	11.87	39.15	2.65
1984	211.12	10.83	836.68	12.19	39.63	1.22
1985	204.07	-3.34	823.77	-1.54	40.37	1.87
1986	218.25	6.95	883.89	7.30	40.50	0.32
1987	249.67	14.40	1002.48	13.42	40.15	-0.01
1988	245.63	1.62	995.53	-0.69	40.53	0.01

Source: Office of Food Crops Agriculture, Lampung Province, (1989)

As shown in Table 4.3 and 4.4, the production growth rate for rice has been a result of both yield per hectare improvements and area harvested expansions. Yield growth was 5.26percent per year over the period 1969-1988. On the other hand, area harvested growth accounted for 4.00percent increase per year over the same period. Rice yield per hectare in Lampung was approximately 18percent lower than in the national level. In 1988, the yield in Lampung was 36.00 tons of paddy and 44.00 tons in the national level. For wet land paddy, yield in Lampung was 14.06percent lower than national level, and a 1.08percent differential for dry land paddy (1969-1988).

Table 4.4 Area Harvested, Production, and Yield of Dryland Rice in Lampung, 1969-1988

Year	Harvested Area ('000 ha)	% Change	Production (Ton)	% Change	Yield (qt)	% Change
1969	138.91		110.25		7.93	
1970	139.77	0.62	138.03	20.20	9.88	24.59
1971	144.67	3.50	150.78	9.24	10.42	5.48
1972	143.14	-1.06	158.69	5.24	11.06	5.56
1973	128.41	-10.29	158.28	-0.26	12.32	12.06
1974	111.83	-12.91	134.40	-15.09	12.02	-2.43
1975	103.74	-0.07	148.64	10.59	14.33	19.22
1976	107.33	0.03	135.45	-8.87	12.62	-11.93
1977	112.83	5.12	173.31	27.95	15.36	21.71
1978	128.82	14.17	195.41	12.75	15.17	-1.24
1979	113.68	-11.75	176.92	-9.46	15.51	2.24
1980	121.65	7.01	183.57	3.76	15.09	-2.71
1981	123.38	1.42	187.42	2.10	15.19	0.66
1982	124.96	0.01	208.43	11.21	16.68	9.81
1983	134.14	7.34	214.88	3.09	16.02	-3.95
1984	150.25	12.00	244.75	13.90	16.29	1.68
1985	131.53	-12.46	224.53	-12.35	16.31	0.12
1986	96.81	-26.40	161.38	-24.77	16.67	2.21
1987	119.94	23.89	241.98	49.94	20.17	20.99
1988	119.14	-0.66	254.08	4.76	21.33	5.75

Source: Office of Food Crops Agriculture, Lampung Province (1989)

In the period of 1976-78 rice production was lower than expected because of drought conditions along with the infestation of the brown hopper pest, poor support services and limited availability of fertilizers. In this period rice production increased on average by 2.33 percent annually in Lampung and 2.50 percent annually at the national level. In cooperation with the IRRI in the Philippines, several high yielding varieties (HYV) tolerant to the brown hopper pest, such as IR-26, IR-32, and IR-38, were introduced.

From 1979 to 1984 the growth of output was quite substantial due to increased adoption of new varieties, more widespread use of fertilizers and, not least, because of the stable price policy regime of subsidized inputs and prices and because of rising output prices in real terms. In 1985 and 1986 there was a reduction in the growth of production, yield, and harvested area. Producer prices fell in real terms, and the seasons were poor in terms of weather and insect damage. Furthermore, a reduction in the yield impact of HYV in Indonesia was expected (World Bank, 1987a). Over the period from 1978 to 1988, about one half of the increase in rice output is attributable to the yield improvement, and the remainder to increases in area harvested.

The improvement in rice production, as noted earlier, was attributable to the Rice Intensification Program or BIMAS/INMAS (or mass guidance/mass intensification) Programs and Area Extensification Program. The BIMAS is a package program consisting of a credit packet containing provisions of cash, fertilizers, HYV seeds, and pesticides. Instruction and guidance to the farmers were also provided by the Government extension service. The INMAS exists in addition to the BIMAS program and contains a similar credit packet excluding the cash. These programs have existed for Lampung farms as well as for other farms in the other parts of Indonesia since 1969. Over time, these programs have been gradually modified and improved.

Basically, the program promotes the five basic principles for improving rice production: (1) the use of high yielding varieties of seeds, (2) the use of appropriate fertilizers and pesticides, (3) improved cultivation techniques including better soil preparations, (4) efficient water management, and (5) the availability of loan/credit provided by government.

2. Corn

Corn is one of the dominant upland food crops in Lampung in term of harvested area. The harvested area of corn has expanded steadily from 57,730 hectares in 1969 to 195,760 hectares in 1988 and ranks second, surpased only by rice (Table 4.5). The average yield per hectare also increased from 7.91 quintals in 1969 to 28.03 quintals in 1988. The rapid growth in yield in the early 1980's can be explained by the increase in adoption of improved open-pollinated varieties (e.g., Arjuna-Besi varieties) and, since 1984, of relatively rapid adoption of hybrid corn. Area harvested growth can be explained by higher cropping intensity in Central Lampung and the development of new local transmigration zones in Central and North Lampung. Central Lampung accounts for sixty-two percent of the total acreage and production, followed by North and South Lampung.

Table 4.5. Area harvested, production, and yield of corn in Lampung, 1969-1988

Year	Harvested Area('000ha)	% Change	Production (Ton)	% Change	Yield (Qt)	% Change
1969	57.73	0.00	45.67	0.00	7.91	0.00
1970	63.84	10.58	56.68	24.11	8.88	12.26
1971	76.84	20.36	111.35	96.45	14.49	63.17
1972	59.43	22.66	178.65	-29.36	13.25	-8.55
1973	93.54	57.39	114.98	46.19	12.29	-7.24
1974	71.72	23.33	97.61	-15.11	13.61	10.74
1975	28.55	60.19	31.98	67.23	11.20	-17.71
1976	27.31	4.35	29.94	-6.38	10.96	-2.57
1977	39.72	45.44	49.38	64.93	12.43	9.25
1978	45.12	13.59	54.64	10.65	12.11	-1.51
1979	58.42	29.48	77.30	41.47	13.23	3.53
1980	51.88	11.19	67.65	12.48	13.03	3.85
1981	51.88	26.58	88.59	30.95	13.49	11.77
1982	65.67	-18.71	74.79	-15.58	14.01	6.64
1983	53.38	56.93	131.20	75.42	15.66	17.60
1984	83.77	14.40	160.04	21.98	16.70	5.64
1985	133.08	38.87	261.37	63.33	19.64	-0.43
1986	188.55	41.68	391.24	49.69	20.75	35.60
1987	165.73	12.10	342.47	-12.46	20.66	-0.43
1988	195.76	18.12	548.82	60.25	28.03	35.60

Source: Office of Food Crops Agriculture, Lampung Province, (1989) The main corn harvest period stretches from January to March. A second, smaller dry season harvest occures in July and August. This bipolar harvest pattern is common in Central and North Lampung, with the main harvest occurring at the peak of the wet season rains. In South Lampung, three pronounced harvest periods, in February, June, and August because of the availability of irrigated lands for corn cultivation. In the South Lampung as well, the February harvest period coincides eith the heavy rainfall period. Typical corn-based cropping patterns involve a mixture of corn with paddy and cassava. In North Lampung, corn is commonly planted in September along with cassava, followed by a paddy intercrop in October and a cassava intercrop in late November.

Two kinds of corn grow in Lampung. The first is varieties, such as sweet corn, for direct human consumption and the other is for animal feed. Most of the human consumption varieties are domestically consumed and do not play a major role either in terms of planted area or export earning from other province. In this study, therefore, we consider only the corn used for animal feed.

Even though corn will not compete for land with rice in most areas, it may compete with other field crops since they can grow on the same type of soil and under the same weather conditions. Howver, during the planting season, all crops may compete for labor because most crops are sown in the beginning of the rainy season.

A strong demand from the poultry industry in Jakarta, South Sumatra, and Bandar Lampung has been a key factor in the rapid expansion of corn production in Lampung. Nearly 90percent of the corn supply is sold outside of the province. Farmers generally harvest their corn and then either sun-dry it or sell it directly to a village collector. The collector will either dry the corn or sell it directly to either Kabupaten wholesale or a Bandar Lampung-based wholesale.

One of the constraints to corn development is the lack of a good supply of improved varieties suited to the varied cultivation conditions of Lampung. Hybrid corn has been widely adopted, but the costs of hybrid corn seed in Lampung are nearly twice the cost of non-hybrid corn. The supply of improved seed varieties could be increased, and the price of hybrid seed reduced, if private seed companies were encouraged to establish breeding farms in Lampung.

3. Cassava

Cassava or tapioca is a root crop and is called by various common names in different parts of the world, but all these refer to one species, Manihot esculenta Crantz. Among the leading producing countries are Brazil, Indonesia, Nigeria, Thailand, India, and Zaire. Tapioca products can be used either for human consumption or for animal feed or industrial uses such as producing adhesives, textiles, and paper industry.

Cassava is an upland crop and is usually planted on loam or sandy loam soil. Cassava can be planted either in the dry or rainy season. However, most cassava is planted in the wet season and can be harvested after ten to twelve months of growing. To plant the crop, sticks are cut from the mature plant and buried in the ground at a depth around 3 to 5 centimeters. The length of the stick is about 1.5 meters, and the stick will have two or three buds on it. The plant is grown in rows. The space between plants is about 1 meter and between rows is about 1.5 meters. After ten months of growing, the crop can be harvested at any time that is convenient to the farmers; timing is not so crucial as for other crops such as rice or soybeans. However, if plants are uprooted too early, they may be immature or give a small root weight. If uprooted too late, the roots may contain too much fiber.

Another requirement is that the field should not be so dry that the farmers may not be able to uproot the plant, especially when it is pulled by hand. In some areas, instead of pulling it by hand, the plants are cut and a tractor is used to plow up the root. Then the root is collected by farmers. However, in using this harvesting method, the roots lost due to soil cover may be more numerous than by the pulling method.

Fresh cassava roots are inputs of tapioca factories, which produce flour, sagu, keripik (chips), and pellets. Most farmers sell their cassava in the form of fresh roots either to local assemblers or to factories which produce chips, pellets, fluor, or sagu. Most chip factories sell their product to nearby pellet factories, which in turn sell the pellets to the exporters.

The cassava industry is structured as a wholesale supply source for overseas, Javanese, and Southern Sumatran consumption. Unlike the case of corn and soybeans, a relatively higher degree of within-province cassava processing is undertaken before the final product is sold. More than 95 percent of total cassava production is consumed in final form outside Lampung.

At the farm gate, nearly half of the farmers are engaged in contract harvesting (called *tebasan*) while the balance harvest their own crop. For fresh cassava, the harvest is either contratcted out or sold directly to village collectors. These individuals charter trucks and bring the cassava to the starch or tapioca factories for processing. From these factories, the starch may be stored for over a year, or sold directly to snack and chips industries in Southern Sumatra or to textile, plywood, noodle and snack industries in Java.

In Lampung, cassava has been one of the most rapidly expanding crops during the last decade. The harvested area for Lampung was only 34,690 hectares in 1969, becoming 151,340 hectares in 1988 (Table 4.6). However, the average yield per hectare has fluctuated from year to year and no definite trend is evidence. In 1985, the area harvested under cassava was 79,400 hectares, down considerably from the previous peak value of 1984 with 118,000 hectares, following the collapse of domestic prices in 1984.

Table 4.6. Area harvested, production, and yield of cassava in Lampung, 1969-1988

Year	Harvested Area('000ha)	% Change	Production (Ton)	% Change	Yield (Qt)	% Change
1969	34.69	2	95.64		85.00	
1970	34.35	-0.98	311.27	5.29	91.00	7.06
1971	36.07	5.01	388.14	24.69	108.00	18.68
1972	43.51	20.63	465.32	19.88	107.06	-0.92
1973	65.19	49.83	734.16	57.78	113.00	5.61
1974	53.01	-18.68	604.35	-17.68	114.00	0.88
1975	60.62	14.35	654.73	8.34	108.00	-5.26
1976	61.49	1.43	694.66	6.13	113.00	4.63
1977	71.49	16.26	786.36	13.16	110.00	-2.65
1978	74.11	3.66	807.81	2.73	109.00	-0.91
1979	81.23	9.61	901.65	11.62	111.00	1.83
1980	89.49	10.17	989.37	9.73	110.00	-0.96
1981	77.57	-13.30	830.16	-16.09	107.06	-2.73
1982	80.26	3.44	882.90	6.35	110.06	2.80
1983	81.48	1.52	827.29	-6.29	101.54	-7.69
1984	118.01	44.83	1298.08	56.91	110.00	8.33
1985	79.40	-38.72	929.03	-28.43	117.00	6.36
1986	65.06	-18.06	787.21	-15.27	121.00	3.32
1987	105.82	62.65	1361.75	72.98	128.00	6.35
1988	151.34	43.02	2314.24	69.95	152.92	18.84

Source: Office of Food Crops Agriculture, Lampung Province, (1989)

The cassava industry is concentrated in Central Lampung. Cassava yields range between 10 tons per hectare in South Lampung to 13 tons per hectare in North Lampung. Cassava yields on the factories plantations are between 20 to 25 tons per hectare. This difference in yield can be accounted for by the difference varieties cultivated and by the more intensive use of inputs in Estate cultivation.

The cassava production has one major peak between two months of June to October. This same pattern is repeated in all areas with the major difference being that the harvest season is one to two months longer in South Lampung than in the other two regencies. The main harvest period coincides with the period of least rainfall in all regencies.

4. Soybeans

In 1988, area harvested to soybeans reached 95,590 hectares. In 1980, the area harvested was 29,440 hectares (Table 4.7). This substantial increase in area harvested is a result of strong prices and a crash program for soybeans intensification. Average yields range between seven quintals per hectare in Central Lampung to 12 quintals per hectare in South Lampung. Low

Table 4.7. Area harvested, production, and yield of soybeans in Lampung, 1969-1988

Year	Harvested Area('000ha)	% Change	Production (Ton)	% Change	Yield (Qt)	% Change
1969	14.75		6.44		4.26	
1970	11.85	-19.66	6.87	6.68	5.80	36.15
1971	15.61	31.73	10.11	47.16	6.48	11.72
1972	28.32	81.42	18.28	80.81	6.45	-0.40
1973	42.37	49.61	34.98	91.36	8.26	28.06
1974	52.33	23.51	57.25	63.66	10.94	32.45
1975	36.67	-29.93	35.11	-38.67	9.60	-12.25
1976	34.86	-4.94	28.94	-17.57	8.30	-13.54
1977	30.87	-11.45	27.26	-5.81	8.83	6.39
1978	31.78	2.95	24.41	-10.45	7.68	-13.62
1979	37.61	18.34	35.45	28.84	8.36	8.85
1980	29.44	-21.72	23.64	-24.83	8.03	-3.95
1981	46.62	58.36	36.36	53.81	7.80	-2.86
1982	23.15	-50.34	17.83	-50.96	7.70	-1.28
1983	18.69	-19.27	13.18	-26.08	7.05	-8.44
1984	47.75	155.48	33.62	155.08	7.04	-0.14
1985	87.78	83.83	73.99	120.08	8.43	19.74
1986	139.46	58.87	140.29	89.61	10.06	20.88
1987	108.74	-22.03	117.69	-16.11	10.82	7.55
1988	95.59	-12.09	117.71	0.02	12.31	13.77

Source: Office of Food Crops Agriculture, Lampung Province, (1989) average yields are a reflectation of poor seed quality, insufficient fertilizer application, and pest infestation problems. During the past five years, with the opening of new transmigration lands, North Lampung has sharply increased its area under soybeans.

Except for the months of August to October, soybeans are harvested throughout the the year. The major harvest is December, January, and February. This is followed by a second, smaller harvest period in June and July. A large portion of the soybeans from the June/July harvest is used for planting during the September to November season. Typical cropping patterns are soybeans followed by a two-months fallow period and then soybeans again or soybeans mixed with corn followed by a one-month fallow period and then soybeans mixed with corn again.

In North Lampung, there are three harvest periods. The major harvest is December, followed by a smaller harvest in April and May and then a third harvest in July. The main December harvest period coincides with a time of high rainfall. In central Lampung, there are two pronounced harvest periods: the first from December to March and the second from June to to July. The main December to March harvest coincides with the peak of the rainy season.

In south Lampung, there are also three harvest periods. The main harvest falls between January and February, followed by an equally large harvest between May and June and a smaller harvest in August and September. In the South Lampung case, the second major harvest, that is May/June, falls at a relatively low rainfall period.

The soybeans market in Lampung is structured as a wholesale market to supply local soybeans to the tahu (tofu) and tempe industries of Java and Southern Sumatra. Approximately 85 percent of Lampung soybeans production is sent to Java or Southern Sumatra for use there.

At the farm level, soybeans are harvested, threshed, field dried and then sold to village collectors. These collectors also work as purchasing agents for Kabupaten wholesalers, who advance them credit for production inputs and working capital for commodity procurement. In all three Kabupatens, farmers also sell soybeans directly to Kabupaten wholesalers. From the Kabupaten wholesalers, the soybeans may be sold to a wholesaler in Bandar Lampung or may ship them directly to a wholesaler in West, Central, or even East Java. A small portion of the Kabupaten wholesaler supplies is used to supply KOPTI (tahu/tempe cooperative) for local tempe/tahu industry requirements. In North Lampung, the main terminal market for soybeans is Palembang of South Sumatra, and the second main tra nsit market is Bandar Lampung.

Because of the relatively high number of village and wholesaler merchants in the soybeans industry, there is a relatively high degree of competition for supplies. Village collector's selling soybeans to several different wholesalers within a single season. The existence of multiple, parallel trade channels between the farm gate and the wholesale market reinforces competition in the soybeans market.

In 1986, the crash program for soybeans intensification program was very successful at raising the area planted to soybeans. The results suggest that the area planted rise greatly. During the crash intensification campaign, villages were provided with area targets, and these targets were communicated to the farmers through local village political officials. In certain parts of Southern Lampung, villages that would have traditionally grown corn, swiched completely to soybeans. In several instances, pest infestation problems destroyed the crop. Pest problems were partly related to a lack of understanding on the part of the farmers of proper soybeans-related pest-management procedures. For those farmers who are familiar with soybeans cultivation techniques, area targets are not necessary to stimulate intensification. For those farmers with no tradition of soybeans cultivation, it would be best to introduce soybeans on a smaller scale, through demonstration, and to withhold area targets until there is a demonstrated capacity to produce the crop.

V. EMPIRICAL RESULTS AND DISCUSSIONS

A. Data Sources

Time series data from the Office of Food Crops Agriculture, Lampung Province on area harvested, yield, and production from 1969 to 1988 are used to estimate area response function models. This estimation encompasses wetland rice, dryland rice, corn, cassava, and soybeans area responses, allowing for substitution possibilities among different competing crops. All nominal prices are deflated by a private consumption expenditure price index. Data from the National Social and Economic Surveys (SUSENAS) of households in Lampung Province in 1987 are used for demand analysis. The demand system consists of rice, corn, cassava, soybeans, and peanuts.

The Government of Indonesia periodically conducts these surveys in order to collect data related to expenditure and socioeconomic characteristics of Indonesian households. SUSENAS uses a proportional random sample of households within a primary sampling unit (PSU), which is subunit of a census area segment, to represent the probability of selection. The selected PSUs for this survey were based on stratified sample design established for the Indonesian census.

Data in the SUSENAS surveys were collected by direct interview of the head of the selected households. If the person was unavailable, then the interview proceeded with the household member that best knew the conditions in the households. These interviews were carried out throughout the entire country by trained data collectors from the Central Bureau of Statistics. The time reference was one week for food items and one month and/or one year for non food items.

The research staff of the Center for Agricultural and Rural Development (CARD) at Iowa State University processed data on food and non food consumption from the 1987 surveys in order to study analysis of consumption patterns and commodity demand trends (CARD 1990). For purposes of the study, CARD staff aggregated the information on individual households within each PSU to obtain a representative PSU household. These representative households provided the unit of observation for CARD study. The resulting "processed" data set constituted the main source of information for this study. It was not possible to obtain the original household level data. Detailed description of SUSENAS data used in this study can be found in (Stampley 1990).

Since it was not possible to get individual household level data, as a second best, an "average" or representative household per PSU was constructed by dividing the aggregate levels of some selected variables by the number of households in that PSU. These representative "average" households per PSU observations were the units of observation for this study.

All food items were classified into rice, corn, cassava, peanuts, soybeans, and other foods. Since economic theory does not provide any guidance on the composition of food groups, the construction of the food groups used in this study was influenced by past studies of the Indonesian food sector, by the planned policy analysis, and by a classification reflecting the similarity of food commodities from a consumer's point of view.

Unit prices used for food items were unit values as "prices" because actual prices paid were not reported in the surveys. Unit prices were obtain by dividing the reported expenditure by the reported quantity. Aggregate prices for every major food commodity group were constructed using these unit prices by weighting with appropriate average budget shares.

B. Estimation and Analysis of Food Crops Area Response

Ordinary least square (OLS) techniques were used to estimate parameters in equation (3.4). When the equation is fitted, the short-run and the long-run response elasticities can be computed by the following formulas (for derivation of area response elasticity formula, see Appendix A.1.).

Long-run own-price elasticity: $\epsilon A_{it}, P_{jt-1} = [\beta_{ij}/(1 - \alpha_{ik})]$, for i (5.1)

Long-run cross-price elasticity: $\epsilon A_{it}, P_{jt-1} = [\beta_{ij}/(1 - \alpha_{ik})]$, for $i=/=1$ (5.2)

Short-run own-pricel elasticity: $\epsilon A_{ij}, P_{jt-1} = (dA_{it}/dP_{it-1}) = \beta_{ij}$, for $i=1$ (5.3)

Short-run cross-price elasticity: $\epsilon A_{it}, P_{jt-1} = (dA_{it}/dP_{jt-1}) = \beta_{ij}$, for $i=/=1$ (5.4)

Long-run response elasticities are reported in Table 5.1. In general, it was observed that own-price response for all commodities is significant and displayed the expected signs. Besides wetland rice, other commodities showed significant reactions to previous period areas. Cross-price coefficients, however, were found to be significant for most non-rice or palawija (secondary) food crops in which area competition and substitution are normally observed.

It is interesting to note that most price variables, except wetland rice, have expected signs and significant effects on dryland rice, cassava, corn, and soybeans areas. These results indicate that farmers do change dryland rice area negatively and cassava, corn, and soybeans positively as a response to price changes.

Table 5.1. Area response elasticities with respect to price lagged one year

Price/Crop	Wetland Rice	Dryland Rice	Cassava	Corn	Soybeans
Wetland Rice	0.1294	-0.05469	-0.23995	-0.0046	-1.48719
	(1.6417)*	(-1.8739)**	(2.0732)**	(-1.3422)*	(-0.8222)
Dryland Rice	-0.09701	-0.0934	0.00000	-0.07973	0.00000
	(-1.9853)	(-2.8791)**		(-1.9721)**	
Cassava	-0.00067	-0.0671	0.33230	0.03115	-0.27472
	(0.3299)	(-1.934)**	(4.5484)**	(0.1476)	(-1.3203)*
Corn	0.03111	-0.00078	-1.53305	0.66295	1.21883
	(0.2854)	(-2.4139)**	(-2.1915)**	(1.7589)*	(0.5584)
Soybeans	-0.00768	0.04372	-3.52605	-1.23434	0.49723
	(-0.1897)	(2.5104)**	(-1.0755)	(0.1830)	(2.1251)**
Lag (area)	0.1249	0.09860	0.48927	0.56186	0.66321
	(0.2507)	(2.0090)**	(3.2441)**	(3.8110)**	(3.2348)**

Notes: Data Source: Office of Food Crops Agriculture, Lampung Province (1990) and CBS for others. The dependent variable is harvested area. The observation period is 1969-1989; t-values in parenthesis (* significant on a 80% level and ** significant on a 90 percent level).

Soybeans are the most area-responsive of the food crops to output price interventions. The primary area substitution for soybeanss is cassava, although there is also evidence of insignificant competition for land resources with corn. Cassava is primarily substituted for soybeans and corn. For wetland rice, there is evidence of relatively weak area competition with corn and soybeans. Compared to other secondary food crops, corn is relatively less area responsive to price interventions.

Table 5.2 shows the own-price response from three studies of wetland rice, dryland rice, corn, cassava, and soybeans area response elasticities. All the studies agree that rice showed low reaction to previous period areas and corn, cassava, and soybeans showed high reaction to previous period areas. This suggest that an adaptive response framework is an empirically suitable framework for modeling area allocation behavior. Own-price response for all commodities display expected sign in all studies, however, the magnitudes of the own-price responses are highly varied. Cross-price coefficients were found to be significant and correct-signed for most commodities in which area substitution is normally observed.

C. Estimation and Analysis of Food Demand

The system of demand equations used to obtain the parameter estimates on which the model is based was constructed assuming a two stage budeting process with households making two steps consumption decisions (Deaton and Muellbauer 1980b, Phlips 1983, Tabor et al. 1988). Consumers (households) were assumed to first allocate a share of their budget to foodstuffs, and then the balance to other goods and services. In the second stage, consumers allocate their budget to food staple and other-goods. Food staples are treated as a set of six separate commodities, while all other goods are treated as an aggregate commodity bundle.

The Linear Approximate Almost Ideal Demand System (LA/AIDS) (Blanciforti and Green 1983) was chosen for this study to estimate the parameters of food demand system with five share

Table 5.2. Own-price and lagged area response from four studies on Indonesian food crops area response elasticities

Studies	Region	Food Crop	Area-Response	Own-Price Response
Kesavan of CARD (1990)	South Sulawesi	Wetland Rice	0.60	0.30
		Dryland Rice	0.00	0.00
		Corn	0.48	0.40
		Cassava	0.21	0.14
		Soybeans	0.77	0.38
Heytens and Meyers of CARD (1990)	Indonesia	Wetland Rice	0.000	0.157
		Dryland Rice	0.000	0.475
		Corn	0.680	0.687
		Cassava	0.870	0.093
		Soybeans	0.290	1.106
Tabor, Altemeier and Adinugroho (1988)	Java	Wetland Rice	0.00	43.44
		Dryland Rice	0.00	5.48
		Corn	0.78	77.12
		Cassava	0.82	15.17
		Soybeans	0.35	25.43
	Off Java	Wetland Rice	0.00	7.84
		Dryland Rice	0.00	16.21
		Corn	0.78	77.12
		Cassava	0.82	15.17
		Soybeans	0.19	6.39
This Study	Lampung	Wetland Rice	0.055	0.141
		Dryland Rice	0.080	0.000
		Corn	0.726	0.663
		Cassava	0.659	0.332
		Soybeans	0.663	6.912

equations which was fit to Lampung aggregate data of food products consumption. Using Iterative Seemingly Unrelated Regression (ITSUR) of SHAZAM econometrics computer program (Version 6.2) (White, et al. 1990), LA/AIDS demand system to be estimated are

$$W_i = \alpha_i + \Sigma\gamma_{ij} \log P_J + \beta_i \log (x/p^*);\ i,j = 1,2,...,n \qquad (5.5)$$

where

W_i = expenditure share of commodity i^{th},

p_j = price of commodity j^{th}

x = total expenditure

α_i, γ_{ij}, β_i = parameters to be estimated,

p^* = Stone's price index,

$$\log p^* = \Sigma\, W_i \log p_i \qquad (5.6)$$

There are three sets of relevant theoretical restrictions that can be imposed on this demand system. The three sets of restrictions are

$$\text{Symmetry :} \quad \Sigma\gamma_{ij} = \Sigma\gamma_{ij} \; (i = j;\; i, j = 1,2,...n) \qquad (5.7)$$

$$\text{Homogeneity :} \quad \Sigma\gamma_{ij} = 0 \quad (i = 1,2,...n) \qquad (5.8)$$

$$\text{Adding-up :} \quad \Sigma\alpha_i = 1, \quad \Sigma\gamma_{ij} = 0, \quad \Sigma\beta_i = 0 \qquad (5.9)$$

Provided (5.7), (5.8), and (5.9) hold, equation (5.5) represents a system of demand functions which add up to total expenditure ($\Sigma\, W_i = 1$), are homogeneous of degree zero in prices and total expenditure taken together, and which satisfy the Slutsky symmetry condition (Deaton and Muellbauer 1980a). Table 5.3 reports the estimated parameters of the system along with the corresponding asymptotic t-values.

The parameters of the AIDS model are interpreted as follows: an estimated γ_{ij} represents 10^2 times the effect on the i_{th} expenditure share by a 1 percent change in the price of the j_{th} good, holding real expenditure (x/p^*) constant. The estimates of γ_{ij}s are in general positive for substitutes and negative for complements, and γ_{ij}s are positive for price inelastic goods and negative for price-elastic goods. A luxury good is identified by a positive β_i and necessity a negative β_i (Deaton and Muellbauer, 1980a). The estimated β's from Table 5.4.b classify rice, corn, peanuts, cassava, and soybeans as necessity while other commodities are luxury.

Since the dependent variables sum to unity across equations, the variance-covariance matrix is singular for the six-equation system. This means that one equation can be deleted from the

Table 5.3 Parameter estimates of food crop expenditure system in Lampung

Commodity	Parameters								
	α_i	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	R^2
Rice	0.990	-0.183	0.219	0.002	0.003	0.009	-0.000	-0.233	0.54
	(15.934)	(-11.846)	(7.079)	(0.310)	(1.032)	(0.923)	(-0.011)	(-8.907)	
Corn	-0.027	-0.005	0.002	-0.009	0.00	-0.008	0.000	0.013	0.89
	(-1.596)	(-1.231)	(0.310)	(-2.883)	(0.497)	(-2.791)	(0.212)	(2.109)	
Peanuts	-0.002	-0.001	0.003	0.000	-0.004	-0.002	0.001	0.004	0.88
	(-0.273)	(-1.183)	(1.032)	(0.497)	(-1.725)	(-2.448)	(-0.755)	(1.787)	
Cassava	-0.065	-0.010	0.008	-0.008	-0.002	-0.025	0.003	0.023	0.84
	(-2.189)	(-1.481)	(0.923)	(-2.791)	(-2.448)	(-4.831)	(1.057)	(2.595)	
Soybeans	0.082	-0.009	-0.000	0.000	-0.000	0.003	-0.008	0.005	0.97
	(4.229)	(-1.856)	(-0.011)	(0.212)	(-0.755)	(1.057)	(-1.366)	(0.607)	
Others	-0.042	0.176	-0.232	0.015	0.003	0.023	0.004	0.19	

*Asymptotic t-statistics in parentheses.

system of equations, and estimates of the coefficients of the deleted equation can be recovered from the coefficients of the other five equations by adding-up restrictions. When the coefficient of five equations are estimated by full-information likelihood (ITSUR) methods, the estimates are unaffected by the choice of the equation to delete (Barten 1969).

Table 5.4 shows the price and expenditure elasticities for the AIDS model in Marshallian measures. These measures of elasticities can be computed by the following formulas (Johnson et al. 1986).

Expenditure elasticity: $\eta_{iY} = 1 + \beta_i / W_i$ (5.4)

Own-price elasticity: $\epsilon_{ii} = -1 + \gamma_{ii} / W_i - \beta_i$ (5.5)

Own-price elasticity: $\epsilon_{ij} = \gamma_{ij} / W_i - \beta_i (W_j / W_i)$; where $i \neq j$ (5.6)

(For derivation of elasticity formula, see Appendix A.2.).

There are some features which need to be noted here. First, all own price elasticities are negative. Second, expenditure elasticities show that rice, corn, peanuts, cassava, soybeans, and other foods are necessities. Third the expenditure elasticities all fall between zero and one. This implies that consumers treat all staple food commodities as normal goods. Fourth, notice that own-price elasticities of rice, corn, and cassava are relatively low when compared to their own expenditure elasticities. This suggests that income growth, rather than price change, has been the major factor for increased consumption of rice, corn, and cassava products.

Table 5.4. Price and expenditure elasticities of Lampung food crops demand

Price/Demand	Rice	Corn	Peanuts	Cassava	Soybeans	Others
Rice	-0.134	0.277	1.425	0.499	0.170	0.384
Corn	0.210	-0.156	0.206	-0.400	-0.006	0.226
Peanuts	0.204	0.052	-0.838	-0.126	-0.051	0.247
Cassava	0.150	-1.008	-1.061	-0.307	0.080	0.148
Soybeans	0.079	0.082	-0.474	0.182	-1.208	-0.106
Others	0.580	1.749	1.741	1.189	0.146	-1.663
Food Exp.	0.430	0.676	0.666	0.543	0.753	0.547

Fifth, the demand system estimates tend to conform to patterns of food consumption behavior typically associated with income growth. The declining importance of food in the total expenditure budget, widely known as Engels's law, holds throughout the expenditure range. Also Bennett's law, which states that consumers attempt to improve the quality of their diet as income rises, appears to hold even within the staple foodstuffs. As income rises, expenditure on soybeans and peanuts increase relative to expenditures on rice and cassava. This suggests that consumers increase the vegetable protein content of the diet as income rises.

Sixth, the estimates for the rice expenditure elasticity is 0.43. The own-price elasticity is estimated at -0.13. The value of the cross-price terms between the other foodstuffs and rice is small. The low aggregate expenditure and price elasticities imply that future rice demand growth will depend mainly on population growth and furthermore, will be quite difficult to contain through price policy interventions.

The difficulty in maintaining rice supply growth --due to area constraints, diminishing returns from fertilizer inputs, increasingly frequent pest outbreaks, dependence on rainfall to supplement irrigation supplies, and limited successs in breeding higher yielding rice varieties (Damardjati, Tabor, Oka, and David, 1987)-- suggests that it will be difficult to achieve the magnitude of production growth necessary to keep the real prices in check.

Seventh, the estimated expenditure elasticities for corn and cassava are 0.68 and 0.54 respectively. These estimates are notably higher than those obtained from single equation cross-sectional analysis of corn and cassava consumption patterns (Falcon et al. 1984; Timmer 1987). The results of the cross-sectional demand analysis suggest that corn and cassava are inferior foodstuffs exhibiting inelastic patterns of demand.

In the cross-sectional studies, the elasticities for corn and cassava refer to the demand for these commodities as direct household consumption items. However, with economic growth, the share of corn and cassava used for direct home consumption has fallen precipitously. In 1986, the Ministry of Agriculture estimated that 48 percent of total corn utilization was accounted for by the feed sector, and that 54 percent of total cassava supply was utilized in starch sector (MOA 1988). For direct household consumption, corn and cassava typically behave as inferior foods in the household budget, while for the feed and starch sectors, demand tends to be far more elastic. Hence, when aggregate data are used, the elasticity values reveal the combined effects of demand for home consumption and demand for indirect use. The rapid growth in demand for eggs, noodles, krupuk (crackers) and sweetened products is responsible for increasing the elasticities of the 'inferior' staples so that, on balance, demand patterns behave as they would for normal goods.

Future demand growth for these 'inferior' staples will be increasingly dependent on the growth in demand for livestock and for processed food products (CARD 1989).

Eighth, The higher values commodities, peanuts and soybeans, have estimated expenditure elasticities of 0.66 and 0.75 respectively. As expected, these elasticities are higher than those estimated for the starchy staples like rice and cassava, implying that consumers attempt to improve the quality of staple diet as income rise. Demand for all two of these staple foods is relatively more sensitive to price intervention than is demand for rice, corn, and cassava.

Table 5.5. shows the own price and expenditure elasticities from three studies of Indonesian food demand. All the studies agree that rice, corn, cassava, peanuts, and soybeans are necessities in Indonesia. All the studies agree that own price elasticities of corn, and cassava are smaller than that of peanuts and soybeans in absolute value. This reconfirms that the consumption of corn, and cassava are not relatively sensitive to changes in corn, and cassava prices because corn, and cassava are consumed by more people than peanuts and soybeans. Besides, corn and cassava are generally consumed by low income groups. And, strong preference for rice as the main staple food, seems to be another factor that causes the own-price elasticity to be smaller.

The studies also agree on relatively high own-price elasticity of soybeans and peanuts and relatively low income elasticity of soybeans and peanuts. Therefore, peanuts and soybeans consumption in Indonesia is more sensitive to price change than income change, while consumption of rice, corn, and cassava are more sensitive to income changes.

Table 5.5 Own-price and expenditure elasticities from three studies on Indonesian food demand.

Studies	Commodity	Own-Price Elasticity	Expenditure Elasticity
Tabor, Altemeier,	Rice	-0.29	0.29
and Adinugroho	Corn	-0.17	0.39
(1988)	Cassava	-0.42	0.26
	Peanuts	-0.74	0.63
	Soybeans	-0.68	0.55
Heytens and	Rice	-0.16	0.29
Meyers of CARD	Corn	-0.26	0.39
1990)	Cassava	-0.04	0.26
	Peanuts	-0.74	0.64
	Soybeans	-0.78	0.46
This Study	Rice	-0.13	0.43
	Corn	-0.16	0.68
	Cassava	-0.31	0.54
	Peanuts	-0.84	0.66
	Soybeans	-1.20	0.75

Source: Heytens and Meyers (1990), Tabor, Altemeier, and Adinugroho (1988).

VI. SUMMARY AND IMPLICATIONS

A. Summary of Area Response Study

A set of area response parameters has been generated by applying area response function. The empirical results are satisfactory. The study of area or price responsiveness of agricultural supply in a region like Lampung of Indonesia using simpler, incomplete ad hoc approaches at modeling supply response appear to oversimplify the revealed complexity of real world relationships in the Lampung agricultural economy in particular and Indonesia in general.

However, the analysis of the agricultural supply response is equally important with agricultural commodity demand analysis for making suitable policy for the country. Policy recommendations, in fact, are implied by a priori hypotheses about the responsiveness of a supply function, which is an empirical question (Nerlove 1958). Despite the relative importance of the supply side, studies on Indonesia's agricultural supply seem to be unbelievably limited (see Chapter II). Therefore, this simpler, more ad hoc study can be seen as a simpler attempt to contribute to the knowledge of the influence of price on the area response in which the area response elasticities represent only a part of supply response as a whole.

The period under study was from 1969 to 1988. The food crops include wetland rice, dryland rice, corn, cassava, and soybeans. From this study, it was found that, in general all wetland rice, corn, cassava, and soybeans showed significant response to previous period areas. This suggests that an adaptive response framework is an empirically suitable framework for modeling area allocation behavior. However, the area response for wetland rice is very low and even negative for dryland rice. The estimated area response elasticity of rice harvested area with respect to price lagged one year ranged from 0.09 for dryland rice to 0.12 for wetland rice, respectively.

For corn, cassava, and soybeans, the estimated area response elasticity is 0.66, 0.33, and 0.50. Cross-price coefficients were found to be significant of the and correct sign for most of the commodities in which area substitution and competition are normally observed.

B. Implications

In general, Lampung farmers are very price responsive, based on the evidence from the results of this study. These results suggest that if the government wants to increase the production of these crops at least in terms of harvested area expansion, it can do so by using price as an incentive. However, the increase in area of these crops may cause a reduction in area planted to other crops, especially in zones where the possibility of opening up the new cultivated land is impossible.

The price responsiveness of wetland rice is very low and even negative for dryland rice. This is, however, not a surprising result. Wetland rice is cultivated in flooded paddy fields. This low price responsiveness may be caused by the fact that first, the majority of the farmers in Lampung are small holders. Secondly, most of the BIMAS and INMAS activities have been centered on rice, especially wetland rice. Consequently, being constrained by land, farmers are unable to expand wetland rice acreage with government price incentive. Rather, they will respond by using more of other inputs such as fertilizer, high yielding variety of seeds, pesticides etc., hence the net effect will be increasing yield.

The available data (see Chapter IV) shows that production of rice in Lampung has increased as a results of both yield per hectare improvement and area harvested expansion. Yield growth was 5.26 percent per year and area harvested growth accounted for 4 percent per year over the period of 1969-1988.

C. Summary of Food Demand Study

A set of food crops demand parameters has been generated by applying Linear Approximate Almost Ideal Demand System to Lampung food commodities data. The results of the study agree with the expectations regarding consumer response for food crops as economic development occurs. The general conclusions that can be made from this study are that demand for basic staple food crops has become more inelastic, demand for raw material inputs has raised the expenditure elasticity of non-rice foods (secondary food crops), while demand for high protein staples remain strong.

Own-price elasticity for rice, corn, cassava, peanuts, and soybeans are negative, as expected. Own-price elasticity of rice, corn, and cassava is low (-0.13, -0.16, and -0.31) and smaller in absolute value than the expenditure elasticity of rice, corn, and cassava (0.43, 0.68, 0.54), indicating that these commodities are sensitive to income change, but are not sensitive to price change. Own-price elasticity of peanuts and soybeans is high (-0.84 and 1.20) and greater than expenditure elasticity of peanuts and soybeans (0.66 and 0.75) in absolute value. This results suggest that price change of peanuts and soybeans is the major factor that can change the peanuts and soybeans consumption in Lampung rather than the income growth.

Comparing the elasticities of rice, corn, cassava, soybeans, and peanuts with the previous studies, all the commodities are found necessities in all three studies. All three studies agree that own-price elasticities of rice, corn, and cassava are smaller than of peanuts and soybeans in absolute value. This reconfirms that the consumption of rice, corn, and cassava are not very sensitive to changes in their own-prices.

D. Implications

In Indonesia, rice price policy still the most important government tool for influencing agricultural development, even though self-sufficiency in rice was achieved in 1985. The estimated demand parameters resulting from this study, however, indicate that rice demand in itself has become relatively insensitive to the interventions in the price of rice.

The low of own-price and cross-price elasticities for rice indicate that its preference ranking in the food budget is very high. Consequently, consumer rice price stabilization as a means of stabilizing consumption levels by government via BULOG seems no longer effectively potent. Therefore, government price policy maneuvers either in rice or non-rice food commodities will not have a significant impact on rice demand. Perhaps, the most possible candidates that will influence the future demand of rice are population growth and increase of real income.

As the price policy effectiveness for rice diminishes, it clearly will still have an important impact on the demand for corn and cassava. The growth in the livestock and starch industries that use corn and cassava as inputs will influence the future demand for these commodities. More complex interrelationships among commodity markets together with the transformation of the role of corn and cassava to more normal commodities indicate that single-commodity price approaches like the rice price policy will have more limited effect. Therefore, food policy makers in Jakarta will have to pay more attention to interrelationships between food and non-food sectors to identify appropriate price policy from the side of food demand in Lampung in particular and in Indonesia in general.

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APPENDIX A.1. DERIVATION OF AREA RESPONSE ELASTICITY FORMULA

Let the typical form of the area response equation is as follows:

$$\ln A_{it} = \alpha_{i0} + \alpha_{ik} \ln A_{it-1} + \Sigma \beta_{ij} \ln P_{jt-1} + U_{it} \quad \text{(A1.1)}$$

Where

$\ln A_{it}$ = logarithm of the actual area harvested of the i^{th} crop;

$\ln A_{it-1}$ = logarithm of lag area harvested of the i^{th} crop;

$\ln P_{jt-1}$ = logarithm of lag real farm/producer price of output;

U_{it} = disturbance terms;

α_{i0} = intercept of the model for i^{th} crop;

α_{ik} = coefficient for lag variable of the i^{th} crop;

β_{ij} = coefficient for the influence of lagged price of j^{th} crop on area response of i^{th} crop;

i,j = index of the crop;

t = index of time;

t-1 = lagged.

The above equation may be interpreted as adaptive response model with single period lagged expectations. Inclusion of the single previous period of area harvested reflects the fixity of land resources for adjustments. Inclusion of lagged real prices reflects the adaptive expectation process in decision making by the farmers.

Assuming constant elasticity form, the parameters required are in the form of elasticity, namely area response elasticity.

When the equation is fit, the short-run and long-run area response elasticities for i = 1, for example, can be derived as follows.

$$A_{1t} = \alpha_{10} + \alpha_{1k-1}A_{1k-1} + \beta_{11}P_{1t-1} + \beta_{12}P_{2t-1} + \dots + \beta_{15}P_{5t-1} + U_{1t} \qquad \text{(A1.2)}$$

Long-run elasticity:

$\varepsilon A_{1t}, P_{1t-1}$ = Own-price elasticity = $(dA_1/dP_{1t-1}$

$\varepsilon A_{1t}, P_{2t-1}$ = Cross-price elasticity = (dA_1/dP_{2t-1})

In the long-run, it is assumed that $A_{1t-1} = A_{1t}$

$$A_{1t} = \alpha_{10} + \alpha_{1k}A_{1t} + \beta_{11}P_{1t-1} \dots + \beta_{15}P_{5t-1} + U_{1t}$$

$$(1 - \alpha_{ik})\,A_{1t} = \alpha_{10} + \beta_{11}P_{1t-1} + \dots + \beta_{15}P_{5t-1} + U_{1t}$$

$$A_{1t} = (1/1 - \alpha_{1k})[\alpha_{10} + \beta_{11}P_{1t-1} + \dots + \beta_{15}P_{5t-1}] + U_{1t}$$

Therefore, long-run own-price elasticity:

$$\varepsilon A_{1t}, P_{1t-1} = (dA_{1t-1}/dP_{1t-1}) = [\beta_{11}/(1 - \alpha_{1k}0] \qquad \text{(A1.3)}$$

Similarly, long-run cross-price elasticity for i = 1 and j = 2, for example:

$$\varepsilon A_{1t}, P_{2t-1} = [\beta_{12}/(1 - \alpha_{1k}) \qquad \text{(A1.4)}$$

In a more general form, long-run elasticity formula can be written as:

$$\varepsilon A_{it}, P_{jt-1} = [\beta_{ij}/(1 - \alpha_{1k})], \text{ for } i,j = 1,2,3,4,\dots n\,.$$

where i = j indicates long-run own-price elasticity

i ≠ j indicates long-run cross-price elasticity.

Short-run Elasticity

For short-run elasticity: A_{1t} =/= A_{1t-1}

$$A_{1t} = \alpha_{10} + \alpha_{1k}A_{1t-1} + \beta_{11}P_{1t-1} + \dots \beta_{15}P_{5t-1} + U_{1t} \qquad \text{(A1.6)}$$

Therefore, short-run own-price elasticity:

$$\varepsilon A_{1t}, P_{3t-1} = (dA_{1t}/dP_{1t-1} = \beta_{11} \qquad \text{(A1.7)}$$

Similarly, short-run cross-price elasticity for i = 1 and j = 3, for example:

$$\varepsilon A_{1t}, P_{3t-1} = dA_{1t}/dP_{3t-1} = \beta_{13} \qquad \text{(A1.8)}$$

or in more general form, short-run elasticity formula can be written as:

$$\varepsilon A_{it}, P_{jt-1} = \beta_{ij}$$

where i = j indicates short-run own-price elasticity;

i ≠ j indicates short-run cross-price elasticity.

APPENDIX A.2. DERIVATION OF ELASTICITY FORMULA

Let log P* = Σ W_i log P_i. Substituting this equation into equation (3.28) and multiplying both sides by (X/P_i), then we obtain:

$$Q_i = (X/P_i)\ [(\alpha_i^* + \Sigma\gamma_{ii}\log P_i + \beta_i\ (\log X - \Sigma\, W_i \log P_i)] \tag{A2.1}$$

Taking the partial derivative equation (A.1) with respect to P_i:

$$qQ_i/dp_i = -(XP_i^2)\ (\alpha_i^* + \Sigma\gamma_{ij}\log P_j + \beta_i \log X - \beta_i\ \Sigma\, W_i \log P_i \Big) \\ + (X/P_i)\ (\gamma_{ii}/P_i - \beta_i W_i/P_i)$$

Now multiplying both sides by (P_i/Q_i), then the own price elasticities for i-goods are given by:

$$\varepsilon_{ii} = (dQ/dP_i)(P_i/Q_i) = -1 + \gamma_{ii}/W_i - \beta_i \tag{A2.2}$$

Taking the partial derivative of equation (A.1) with respect to P_j:

$$dQ_i/dp_j = (X/P_i)\ (\gamma_{ij}/P_j - \beta_i W_j P_j)$$

Multiplying both sides by (P_j/Q_i), yields the j-th price elasticities of i-th goods:

$$\begin{aligned} \varepsilon_{ij} &= (dQ_i/dp_j)(P_j/Q_i) = (P_j/Q_i)\ (X/P_i)(\gamma_{ij}/P_j) - (\beta_i W_j P_j) \\ &= (\gamma_{ij} - \beta_i W_j)/W_i \end{aligned} \tag{A2.3}$$

Taking the partial derivative (A2.1) with respect to X:

$$dQ_i/dX = (1/P_i)\ (\alpha_i^* + \Sigma\gamma_{ij}\log P_j + \beta_i \log(X/P^*) + (X/P_i)\beta_i/X \qquad \text{(A2.4)}$$
$$= (W_i + \beta_i)/P_i$$

Multiplying both sides by (X/Q_i), then the expenditure elasticity for the i-th good is given by

$$\varepsilon_{ix} = (dQ_i/dX)(X/Q_i) = (W_i + \beta_i/P_i(X/Q_i)$$
$$= (W_i + \beta_i)/W_i \qquad \text{(A2.5)}$$
$$= 1 + \beta_i/W_i$$

The Slutzky equation states

$$dQ_i/dP_j = k_{ij} - Q_j(dQ_i/dX) \quad (i,j = 1,2,\ldots,n)$$

where K_{ij} is the substitution term. Multiplying both sides by P_j/Q_i,

$$\varepsilon_{ij} = \varepsilon_{ij} + Q_j(P_j/Q_i)(dQ_i/dx)$$

Substituting (dQ_i/dX) from (A.4), then the cross-price Hicksian elasticity is given by:

$$\varepsilon_{ij} = \gamma_{ij}/W_i + W_j \qquad \text{(A2.6)}$$

For the own-price Hicksian elasticity, given i = j:

$$\varepsilon_{ii} = \varepsilon_{ii} + Q_i(P_i/Q_i)(dQ_i/dX)$$

Substituting (dQ_i/dX) from (A.4) gives:

$$\varepsilon_{ii} = -1 + \gamma_{ii}/W_i + W_i \qquad \text{(A2.7)}$$