WORKING PAPER 30

Measuring the Effects of Trade Liberalization: Multilevel Analysis Tool for Agriculture

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The CGPRT Centre
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Foreword

Measuring the Effects of Trade Liberalization: Multilevel Analysis Tool for Agriculture is the product of the projects “Farmers’ Strategies Regarding Agricultural Diversification” (DIVFAM, 1993-1995) and “Agricultural Diversification and Food Crop Trade: Their Implications to Agricultural Policies in Southeast Asia” (DIVAPOL, 1994-1996), both supported by Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and the Government of France.

Multilevel Analysis Tool for Agriculture (MATA) was developed by the French team which was made up of Dr. Françoise Gérard (NRL expert, 1994-1997), Ms. Isabelle Marty (ASSEX, 1994-1996), Dr. Fréderic Lançon (NRL expert, 1990-1997) and Ms. Marion Versapuech (ASSEX, 1996-1998). I thank all of them for their hard work and their contributions to the CGPRT Centre. My thanks should also go to CIRAD and the Government of France for their continued and generous support extended to the projects.

Although **MATA** was developed to apply mostly to Indonesian agriculture, the CGPRT Centre really hopes that it will be useful for other countries and it will be further elaborated by researchers to provide more accurate information on the impact of policy change on agriculture.

Haruo Inagaki
Director

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The study, following an initial idea of Mr Griffon and Dr Benoit Cattin from CIRAD, was designed to provide a tool to help policy makers test different policy measures for the agricultural sector.

Surveys had already been done by Dr Lançon during a former project called SYGAP at the CGPRT Centre with CIRAD cooperation. The data collected were analysed by Ir Marty using a farming systems approach while Dr Gérard was building, with the support of Dr Boussard and Dr Deybe, the model framework. Dr Erwidodo helped to define realistic scenarios with his great knowledge of the country and his skills in economic sciences. Ibu Kustiari collaborated with Dr Lançon to study the complex markets of Indonesia. With the collaboration at the end of the project of Ms Versapuech, the prototype of MATA (Multilevel Analysis Tool for Agriculture) was successfully achieved by Dr Gérard, Dr Erwidodo and Ir Marty and put into its final form, with an easy access for users, by Mr Seys, our computer scientist.

We would like to express our gratitude to Mr Michel Griffon, Mr Michel Benoit-Cattin, Mr Pierre Rondot from CIRAD and Mr Seiji Shindo, former director of the CGPRT Centre that initiated this project.

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1. General Introduction

The agricultural sector has a major role to play in the achievement of sustainable economic development. Economic policy aims at promoting development and a large set of policy instruments exists (trade policy, credit development, public investment, storage and so on). However, evaluation of the impact of any action as well as its cost, ex ante, is difficult and public intervention in agricultural markets has often been characterized by high cost and inefficiency. Several reasons explain the complexity of agricultural policy definition and implementation.

First, the conditions of agricultural production vary greatly making large differences in costs and returns of these activities. In the commodity flow, from producers to consumers, a wide range of conditions exists also, including a large variety of scales of activities in marketing and processing as well as differences in technical itinerary and equipment. Given this diversity, the difficulty is due to the fact that the strategies of actors, in an environment modified by policy, depend on their economic situation, while the success of a policy will depend on the reactions of economic actors.

Second, everyone is concerned with the availability and the price of food, which is one of the most sensitive economic variables from a political point of view. The price of staple food has an important impact on macro-economic variables such as labor cost and inflation rate. Farmers' and consumers' interests conflict, which puts the policy-maker in a difficult situation such that it is only possible to satisfy both groups at the expense of a high subsidy budget.

Third, economic policy is often difficult to implement, especially in developing countries, because of the lack of infrastructure and managerial and financial capacity.

To deal with such a complex setting, a family of micro-macro models, Multilevel Analysis Tool for Agriculture (MATA), was conceived at CIRAD-URPA since 1993, to provide policy makers with useful information on policy impacts. The tool is based on simulations of economic actors' reactions after a change in policy. Actors are described by type to deal with the diversity of economic situations. The bridge to aggregate impacts is achieved through scale parameters reproducing the share of each group in the economy. Simulations are defined as combinations of sector and macro-economic measures, or as external or domestic shocks. Results are given both on the change in the economic situation of each type of actor and on aggregate performance of the sector. The approach has thus the ambition to fill the gap between very aggregated models, which neglect the diversity of farming conditions, and models focusing on the plots or at village level which do not give any indication of aggregated impact. Furthermore, risk in agricultural activity, time necessary for adjustment and the difficulty of self-regulation in agricultural markets take an important place in the approach. Expectations on prices are considered; the tool is recursive, using past results to determine the starting parameters of each period. It takes into account market imperfection for credit, capital, labor, land and products.

MATA methodology combines the farmer approach which gives the impact of food policy on the value and volume of household food production, the commodity chain approach which focuses on the various forms and places taken by a product from farm gate to household basket, the consumer approach which evaluates the impact of change of prices on nutrient intake, and the macro-economic approach which considers the impact on aggregate performance of the sector. This approach considers simultaneously the different levels of analysis, which are often considered separately. Technological progress in computer science allows us to handle and synthesize a very large amount of information and, thus, to consider the agricultural sector in all its facets and to deal with micro-economic behaviour as well as to represent aggregated impacts.

Another challenge of this tool was to give the opportunity to users to make intensive simulations by themselves. To do so, a lot of attention has been devoted to friendliness and a user interface in a Windows (3.1 or 95) environment allows simple access to simulation definitions and results. Most economic tools are indeed impossible to use except by their authors. Here, simulations can be defined from simple menus, where predefined measures or shocks can be easily combined. Runs are performed in a Windows environment and charts are displayed to summarize the results of the simulations within the "MATA interface" software.

This book describes the first project (1994-1997) attempting to apply the MATA methodology in a country study of Indonesia. As constructed, the Multilevel Analysis Tool for Agriculture is able to answer various policy questions and gives the opportunity to users to make intensive simulations by themselves. For this reason this book is divided in two parts.

In Chapters 2 to 7, MATA methodology is used to study the impact of liberalization of food crop trade in Indonesia, where the agricultural sector is characterized by a high diversity of biophysical and socio-economic conditions. The information gathered to perform an economic analysis of food crop trade liberalization in Indonesia is first described. Different levels of analysis are considered. First, the aggregate level, with a macro-economic analysis of Indonesian development, with special attention to the performance of the agricultural sector, is provided (Chapter 2). It is indeed necessary to understand the general socio-economic context in which new policy measures can be defined. Second, as Indonesia is a very large and diversified country, the spatial features of agricultural development are emphasized, with an analysis at the provincial level (Chapter 3). Third, the main characteristics of the economic actors in the agricultural sectors - producers, consumers, traders and processors - are described (Chapters 4 and 5). Because of the diversity of economic situations found in Indonesia, this part will focus on Java, which represents the most densely populated area of the archipelago, with around 60% of the Indonesian population and the main area for food crops production.

Then, the MATA model is described, with its three different modules representing the agricultural sector (Chapter 6). The agricultural production module consists of a set of farming systems represented by non-linear programming and linked together through markets. The consumption-processing module represents consumer choices according to a typology and the different forms of activities in agri-business. The macro-economic module describes the environment in which the actors of the two other modules act, as well as the modifications of policy set up in the scenarios by users of MATA. It also calculates the aggregate impact on employment in the sector and external trade, by adding up the results of the two modules. The main features of the tool are explained and key equations are listed.

Finally, scenarios are described and the results of simulations are analyzed to assess the impact of liberalization of trade on consumers and farmers as well as on the aggregate performance of the sector (Chapter 7).

However, the simulations presented here, already published in previous communications (Gérard et al. 1997; Marty et al. 1997), have unfortunately been overtaken by the current financial crisis and the currency devaluation. Impacts of liberalization of the food crops sub-sector are modified by changes in relative prices following the devaluation and its management. The results presented here thus have just an illustrative purpose.

In Chapters 8 and 9 a user guide is provided. It explains the organization of the different files. The installation process of the files constituting the MATA model for Java lowlands and for the interface is described. Instructions are given for defining scenarios, running simulations, editing results and operating small modifications on files. Then, the full list of files constituting

MATA is provided and contents of each file are listed and explained

2. The Socio-Economic Context

The world is becoming much more integrated as a consequence of multilateral (GATT/WTO), regional (APEC and AFTA) and unilateral reforms. These reforms are implemented simultaneously. For Indonesia, this means new export market opportunities as well as increased import competition in its domestic market. It also means more obligations to open up and further liberalize its own economy. While that will at times be painful for some groups and add to political pressures, the net additional economic gains from further deregulation are expected to continue to be substantial. Anderson and Pangestu (1995) argue that there are basically two alternative approaches for the Indonesian government. One is to resist the liberalization thrust and seek special favors to slow the relative decline of the agricultural sector, as was done in Japan and Korea. The other is to embrace the reform thrust for agriculture in return for accelerated reform in the more protected non-farm sectors, as is being done in Australia and New Zealand.

Indonesia seems to have chosen the second option. Public intervention in agriculture has already been considerably reduced and the domestic market is becoming more liberalized: input subsidies have been progressively reduced since 1987; the floor price was released for maize in 1991; and soybean trade has just been liberalized. Public intervention in agriculture is now mainly concentrated on the rice market. However, as there is a widening gap between agricultural and non-agricultural income, and, because of the urban problems associated with increasing rural migration, the Indonesian authorities are still very keen to maintain specific supports to farmers. This concerns those farmers who are not able to adapt easily to the strong competition to be expected after liberalization. At the other extremity of the commodity chain, consumers may suffer from high price fluctuations as may happen in completely liberalized domestic markets.

This chapter analyzes the historical and socio-economic context in which the liberalization of trade of the food crops sub-sector will take place. It aims to provide the necessary background in the analysis of trade liberalization. A review of main stages of economic development of Indonesia, the place of the agricultural sector and the role of policy in the success story of economic development of this country are provided.

2.1 Economic development and policies

We first describe the information gathered to perform an economic analysis of food crop trade liberalization in Indonesia. Different levels of analysis are considered. First, the aggregate level, with a macro-economic analysis of Indonesian development, with special attention to the performance of the agricultural sector, is provided. It is indeed necessary to understand the general socio-economic context in which new policy measures can be defined. Second, as Indonesia is a very large and diversified country, the spatial features of agricultural development are emphasized, with an analysis at the provincial level. Third, the main characteristics of the economic actors of the agricultural sectors - producers, consumers, traders and processors - are described. Because of the diversity of economic situations found in Indonesia, this part will focus on Java, which represents the most densely populated area of the archipelago, with around 60% of the Indonesian population and the main area for food crop production.

Agriculture plays a major role in the success story of economic development of Indonesia. Agricultural development will be briefly reviewed mainly using the work of Maurer (1986) and Booth (1988). Then, general economic development and the place of agriculture in the economic success of Indonesia is discussed before focusing on recent policies and trends, mainly using studies of Thorbecke (1992), Timmer (1987, 1989a, b; 1995), World Bank (1992, 1996) as well as an analysis of national statistics (CBS, various publications). This section concludes on the possible impact of liberalization of food crop trade on prices before the 1997-1998 devaluation.

2.1.1 An early irrigated agrarian society

Sophisticated agricultural development is not a recent phenomenon in Indonesia, at least in Central Java where relatively intensified rice cultivation with irrigation was already practiced before the Indianisation at the beginning of our era. Slash and burn agriculture was practiced all over the archipelago, but irrigation allowed a greater number of persons to be fed. Indianisation enhanced the already existing hydrological technology and energized the Indo-Javanese agrarian kingdoms characterized generally by steady demographic and economic development.

When colonization started at the end of the 16th century, Java was known for its richness and was more than self-sufficient in rice, spices and other products. About 10 million inhabitants were probably living at this period. At the end of the 19th century, there were about 29 million inhabitants on Java. During these three centuries, important changes took place: after a period without much intervention from the colonialists except a monopoly on the spice trade, the Dutch merchants started to impose a forced cultivation of export crops (coffee, sugar, etc) on farmers obliged to pay heavy taxes in kind. As sugarcane, the principal forced crop, was perfectly adapted to the irrigated fields or *sawah*, irrigation equipment was installed in new perimeters, increasing the amount of irrigated area from 1.3 to 1.7 million ha from 1830 to 1880. This system of *cultuurstelsel*, apart from the growth of these crops, obliged farmers to put more land under cultivation for their own needs. Non-irrigated land (also called *tegal*), less fertile lands, were cultivated more and more with secondary crops (maize, cassava) that are less labour intensive than rice.

In 1870, when *cultuurstelsel* was abolished, a period of quick development of both *sawah* and *tegal* started. First financed by private investors, then by the colonial government in answer to a dramatic decrease of welfare of the Javanese, the irrigation area increased from 2 million ha in 1900 to 3.4 million ha in 1941. Increasing population pressure (growth of more than 1% yearly), brought an even more important development of the non-irrigated area that increased from 800,000 ha in 1900 to 4.55 million ha in 1941. Production of food crops increased greatly during this period but only from area expansion and increased double and multiple cropping, as yields stayed at the same level (for example, 2 tons/ha for rice). Transmigration programs from Java, already cultivated at 60% of the total area, to other far less developed islands started at this time. Production of cash crops (rubber, coffee, copra, tea and tobacco) also increased greatly, with the share of small cultivators from remote regions of Sumatra, Kalimantan and Sulawesi growing more quickly that the production from estates, despite discriminating high production taxes to protect the latter (Booth 1988).

Between 1930 and 1960, the number of holdings grew at a more rapid pace than the agricultural labour force, suggesting that, even if the average size of landholding decreased (from about 1 ha in 1930 to 0.5 ha in 1970), the number of landless was not important. As a result of the diminishing land size, farmers relied more and more on off-farm income. The distribution of holding by size shows a polarized situation: at the beginning of the 20th century, almost half of the holdings in Java were under 0.5 ha, while only 7% of the holdings were more than 3 ha.

2.1.2 A success story in economic development

During the past 30 years, the per capita income increased from only $50 in 1967 to $650 in 1992, the average life expectancy at birth has increased by 20 years during the same period, and a substantial reduction of poverty was achieved (World Bank 1993). To put this success story into context, five periods can be considered from independence until the end of 1997.

During the 1955-1966 period, Indonesian development is characterized by a low growth rate and high inflation. This period of economic stagnation can easily be explained by the political and international context of the preceding period. In fact the country faced successively the disappearance of the colonial order and the associated political troubles, the Japanese invasion and the hard times of occupation, and the social troubles associated with independence, proclaimed on 17 August 1945 but recognized by the Netherlands only in 1949. Then under President Sukarno, the country had to fight secessionist movements in the archipelago as well as with neighbours. This period ended dramatically with the military putsch of 1965, followed by a bloody repression of communists.

In the next decade, Indonesia emerged as one of the few countries in the world with a high rate of growth, estimated at 6.6% per year during the 1965-1973 period (Thorbecke 1992). Stabilization programs were implemented. Reforms succeeded in opening up foreign trade, attracting foreign investment and suppressing hyperinflation, which decreased from 1000% in 1965 to under 4% in 1971.

Then, Indonesia experienced strong improvement in terms of trade during the 1973-1982 period due to the oil boom. In 1982 earnings from oil represented two-thirds of export earnings, 25% of the GDP and 70% of public earning (Thorbecke 1992). These resources were intensively used to fund public investment in modern infrastructure and heavy industries. From 1973 to 1985 a large portion of budgetary resources of the state was devoted to investment (Dorleans 1992). Direct and indirect government intervention in the economy, reversing the previous liberal policy, as well as foreign debt accumulation characterized the period.

However, at that time, Indonesia managed the imbalance called ‘Dutch disease’ particularly well. For an oil exporting country with a large agricultural sector, sudden growth of the oil sector could negatively affect the tradable sector (mainly agricultural) and benefit the non-tradable sector (construction and services), because the ratio of price of tradable to the non-tradable goods declines. In Indonesia, a policy favorable to the agricultural sector countered this market phenomenon and all the sectors of the economy benefited from the growth. The growth rate of GDP between 1971-1974 and 1981-83 was 7.5%, 3.75% for the agricultural sector, 12.66% for manufacturing, 12.74% for construction, 7.57% for wholesale and retail trade and restaurants, and 11.89% for transportation.

With the drop in oil prices after 1982, Indonesia had to cope with a dramatic change in its terms of trade, and it implemented a policy of self-adjustment. A remarkable point is that the country seems to have begun an adjustment before the oil price drop, including devaluation in 1978 (50%) and adoption of a managed floated exchange rate policy, and decrease of growth of public employment. After 1982, other macro-economic measures were rapidly taken, such as devaluation, reform of the fiscal and banking system, liberalization of capital flow, financial deregulation and reforms in the trade and industrial sectors. The rupiah was devaluated by 28% in 1983 to allow exports except oil to be competitive and to stop the exit of capital. Income tax was introduced in 1984 to compensate for the drop in public income related to the drop of oil prices. Public expenditures decreased dramatically. At that time, the challenge was to replace public investment by private investment. The country succeeded, and the growth of private savings was remarkable. The confidence of the financial world was not shaken, allowing recourse to borrowing from the outside and continuation of foreign investment.

The state, because of past investment, stayed a major actor in the economy. Private investment developed but the licensing system allowed collusion between the political and industrial classes, and the period was characterized by scandals related with this situation. International investment was also important, especially for engineering.

Nevertheless, during that period, GDP growth rate fell around 50% (3.73% yearly between 1981-83 and 1987). All the economic sectors were affected, except manufacturing which continued to experience rapid growth (10.43%) and agriculture which was quite stable (growth of 3.04% and 3.75% during the preceding period). During this period, external debt increased quickly from 20.7 billion $ in 1983 to 41 billion $ in 1987/88. The inflation rate, which was 11.5% in 1979-83, decreased to 7.5% yearly between 1983 and 1988 (Thorbecke 1992). A devaluation of the rupiah occurred in September 1986 when oil prices fell. However, the level of public expenditure in the agricultural sector remained relatively high compared to other developing countries: 9.3% of total budgetary expenditure during the 1984-88 period, of which two-thirds was devoted to fertilizer subsidies and irrigation during the 1983/84-1990/91 period.

The nineties until 1996 were characterized by macro-economic stability and continued deregulation, which now concerned all sectors of the economy, including agriculture. Foreign direct investment increased, as did approved domestic investment (+33% in 1992-95). A tight monetary policy allowed management of an overheated economy at the beginning of the period and in 1995 during the Mexico crisis. Inflation rates were around 10%. To compensate for the differential of inflation over major trading countries, the rupiah has depreciated by an average of 1% per year. The growth of GDP was around 7-8%. Industry, construction, transport and communication, trade, services and tourism experienced the highest growth rates. The domestic demand was strong. During this period, external debt rose, as well as foreign investment and the privatization of large public enterprises, such as PT Telkom. External public debt also increased because of depreciation of yen/dollar rate. (World Bank 1996) Lending increased quickly in all sectors except agriculture and property.

In 1997, a financial crisis occurred in Asia, leading to serious problems for the banking system, especially in Thailand and Indonesia. The rupiah was devalued and an IMF plan accepted with credit of over 40 billion US$, which underlines the importance of the crisis. In February 1998, the exchange rate of the rupiah with the $ was around 500% compared to one year earlier. Inflation was already high and more than 2 million tons of rice were imported due to the drought related with the El Nino phenomenon. It is too early to clearly assess the impact of this new situation on the agricultural sector.

Finally, over the last two decades, the economy has diversified, first under high market protection founded by oil exports and then, after the dramatic fall in oil prices, under progressive deregulation. The share of the manufacturing sector in GDP rose from less than 10% at the beginning of the seventies to 15.8% in 1985, to 20.3% in 1990, and 24.3% in 1994. However, the agricultural sector still plays a major role.

2.1.3 Modern agriculture in Indonesia: self-sufficient and diversified

As already noted, the economic success of Indonesia is based on a strong agricultural sector. After the war and independence, a completely different development process started, at least for Java. In fact, Java had already reached its limit of area expansion and only an increase of land productivity could accommodate the demographic growth of nearly 2% per year. First, a rehabilitation program for the irrigated infrastructure damaged by 10 years of conflict was launched by the government as well as an extension program to improve cultural practices and fertilizer use. The results, for both political and social reasons, were not very satisfying: an additional 2 million tons of rice in 15 years (1950 to 1965), mainly due to yield improvement in Java (from 2 to 2.5 tons/ha) and to area expansion outside Java, to feed 20 million additional persons. The growth in production of other food crops increased more quickly than that of rice before 1960, mainly due to area expansion and to yield improvement in Java.

In 1960, an agrarian reform was implemented, but its application was limited: about 680,000 ha among the 940,000 ha eligible for redistribution were effectively distributed to about 867,000 persons in the whole archipelago. In Java alone, about two-thirds of the land came from the state, and the land held by big landlords or absentee owners was only partially distributed. Despite this reform, the 1973 census showed an increase in the percentage of holdings in the smallest size groups.

Various government programs were implemented and the agricultural sector showed good performance in terms of growth of food crop and non-food crop subsectors (3.8% yearly between 1969-1989), the growth being higher in the eighties than in the seventies. The farm food crop sub-sector remained steady at around 60% of agricultural GDP.

For rice and maize, the main growth in production occurred during the 1974-1982 period, while for soybean and cassava it happened during the 1983-1989 period. Rice yields increased from 1.8 t/ha in 1965 to 2.6 t/ha in 1973 to 3.5 t/ha in 1982 and 4.5 t/ha in 1996. Thus, rice production increased sharply, reaching self-sufficiency in 1984 (Table 2.1).

Table 2.1 Growth rate (%) of food production over the three last decades.

	1968/70-1971/73	1974/76-1980/82	1983/85-1987/89	1990/92-1994/96
Rice	1.2	40.9	12.5	6.8
Maize	3.2	38.3	22.4	14.6
Soybean	20.5	10.4	72.2	-1.8
Cassava	-1.5	6	16.4	-2.3

Source: Calculated from FAOSTAT 1998.

Other food crops also experienced a sharp increase of their yields (Table 2.2). During the last 25 years, maize production increased in Indonesia, but the production is not important enough to allow self-sufficiency all the time. In some years, Indonesia is a net importer and in others a net exporter (from 1985 to 1995, seven years were import years).

Soybean production increased annually at a 10% growth rate from 1980 until 1992. The major part of this increase was due to area expansion, whereas yield increase counted for only 3% of the total production increase. However, Indonesia is still far from reaching self-sufficiency and the demand for both human consumption and feed continues to increase quickly. Over the last 10 years (1985-1995), Indonesia had to import about 30% of its needs.

Cassava production also increased over the period, mainly due to an increase of the yield during the last two decades. Indonesia was able to export about 5% of the production every year.

Table 2.2 Contribution of yield and area to production growth (%).

		1950s to 1960s		1971/75 to 1981/85	
Crop		Yield	Harvested area	Yield	Harvested area
Paddy sawah	Java	169	-69	79	21
	Outer islands	7	93	59	41
Paddy dryland	Java	37	61	116	-16
	Outer islands	7	93	153	-53
Maize	Java	39	61	116	-16
	Outer islands	-44	144	68	32
Cassava	Java	-12	112	373	-273
	Outer islands	-4,167	4,267	42	58
Soybean	Java	7	93	168	-68
	Outer islands	-39	139	26	74
Groundnut	Java	18	82	75	25
	Outer islands	-1	101	31	69

Source: Booth 1988.

The increase of rice harvested area in Java is only due to increased cropping intensity. In the 1971-1981 period, increase of harvested area was still the major source of production growth in the outer islands for cassava, groundnut and soybean, showing that it was easier to extend the land frontier or to grow them as a second crop on *sawah*.

However, with the general economic development of the country, the share of the agricultural sector in GDP decreased sharply over the period from 56% in 1967 to 17.6% in 1993 at constant market prices (World Bank 1996). The food crop sector represented 12.5% of GDP in 1969 and first increased to 13.6% in 1989 before decreasing to 9.2% in 1995.

During the same period, agriculture's share in employment dropped from 75% of the active population to less than 50%, even though during that time agricultural employment rose from 27 million people in 1971 to 41 million in 1989. Since 1990, agricultural employment declined steadily to the point that agriculture shed labor at a rate of 2% per year in 1990-1993 (World Bank 1992, 1996). However, it still plays a major role in the economy, because self-sufficiency remains a political objective, and as it is the major source of employment generation in rural areas where poverty is concentrated, as a supplier of inputs for the agro-processing industry, and as a source of export earning. Even in 1981, when earnings from petroleum exports were at their peak, agricultural products (in both primary and semi-processed form) accounted for 12.6% of the value of total export and 70.5% of the value of non-oil/gas exports. With the decline in oil prices in the late 1980s, the growth of agricultural exports relative to total exports more than doubled. Following the fall in primary commodity prices, oil and gas export earnings declined, and because of efforts to promote other forms of manufactured exports, these ratios shifted to 30.4% and 41% respectively in 1993 (Economist Intelligence Unit 1995).

2.1.4 Agricultural policies and performance of agriculture

Agricultural policy accompanied this evolution. The government has devoted a lot of attention to the development of the agricultural sector. During a 25-year period, from 1969 to 1993, covering five five-year development plans (REPELITA 1 to 5), the development of agriculture always appears as a priority and the growth rates of production of the main food crops attest to the economic performance of this sector. Moreover as noted by Timmer (1989a) the food price policy was used in Indonesia "... to pursue a wide range of objectives that includes key macro-economic goals, such as price stability and rates of economic growth, as well as narrower micro-economic targets for production and consumption."

The Indonesian government has provided a favorable environment to agricultural producers mainly through BULOG (Bureau of Logistics), within which sectoral measures such as the Mass Guidance program (BIMAS) have been implemented.

BULOG was created in 1968 as a special government agency with the objective of protecting domestic markets from sharp fluctuations of prices on world markets. Implemented first for rice, the main staple crop in Indonesia, the field of action of BULOG was extended to other crops, particularly soybean.

Rice price stabilization, as managed from the mid-sixties by BULOG by intervention in marketing through public storehouses managed in each district, protected both consumers and producers by a wide announcement of floor and ceiling prices. Stable and low rice prices were seen as a major objective after the period of high economic and political instability of the country until the mid-sixties. In fact, because of the importance of rice in the diet (22% of consumers' expenditure on average), rice prices strongly affected inflation rates and farm wage rates. A change of 10% in rice price results in a corresponding change of 5.3% in the farm wage rate (Sudaryanto and Purwolis 1994).

A floor price is announced before planting time and thus removes part of the seasonal price risk associated with rice production. A ceiling price protects consumers from sharp fluctuations. In the beginning, attention was devoted to the effectiveness of the urban ceiling prices, identified as a political commodity and local prices fell below the announced floor prices in numerous instances until the early seventies. In the seventies, BULOG benefited from the increased oil price and significantly increased its logistical capacity and managerial procedures. Over 1972-1989, the coefficient of variation of prices was 0.16 for domestic prices and 0.59 for international prices (Gérard and Marty 1995) which shows the impact of BULOG. However, BULOG procurement never exceeded 12% of the total production and 15% of the consumption (in normal years BULOG procures and distributes less than 10%), consequently the efficiency of the private marketing structure was always crucial for Indonesia. In order to maintain low urban prices and not to discourage rice production, BULOG enforced a narrower margin between floor and ceiling prices, which sometimes did not cover the storage cost. In the eighties, the policy changed; no ceiling prices were announced any more and retail prices in the outer islands began to be significantly higher than in Java. Higher margins constituted new incentives for private traders, thus reducing the financial and logistical burden for BULOG (Timmer 1989b).

With the world food crisis in 1973-1974, Indonesia was unable to find enough rice on external markets to maintain price stability. After this shock, much effort was expended on rice self-sufficiency and new producer incentives were forthcoming.

Because of the limited possibility of area extension on land adequate for rice cultivation, the development of production was based on yield increase. Rice intensification was launched through special programs: BIMAS and INMAS. Through these programs the government increased the adoption of new technology by disseminating high yielding varieties of rice, providing extension services and distribution of fertilizer and pesticide at a highly subsidized price. The INMAS program was designed to increase production through the use of improved seeds, fertilizers, pesticides, water management, and improved cultural practices. The BIMAS program, in addition to the INMAS program, provided farmers with credit to use modern inputs and cultivation practices. The INSUS scheme**,** an improvement of BIMAS scheme, encouraged farmers in continuous rice production to cooperate and make joint decisions about seeds, planting times, and crop choices in addition to rice. Special attention was given to the establishment of rural institutions. The government encouraged farmers to establish village cooperatives (Koperasi Unit Desa, KUD).

The subsidies allow a higher production at relatively lower farm prices, which gives a direct answer to the classic food price dilemma at the expense of budget subsidies. Fertilizer was the most subsidized input, reaching a peak in the early 1980s, ranging from 40 to 65% above the world price according to the type of fertilizer (Hedley and Tabor 1989; Gonzales et al. 1993). Between 1970 and 1985, fertilizer use increased 500%; in 1984-85 the fertilizer subsidies reached US$ 680 million, 60% of the entire budget for agriculture (Dorleans 1992).

After 1978, higher prices for rice were paid to farmers, and the supply response was dramatic. Rice production, which grew by 3.5 million tons over the eight years prior to 1977, increased by 10.5 million tons over the following eight years. Yields of rice increased from 2.5 t/ha in 1965 to 3.7 t/ha in 1973, and 4.4 t/ha in 1990, which approached the highest world performance (5.02 t/ha in Japan). The best performance was during 1980-1984 in Java (4.4% increase per year).

Indonesia was in the second half of the 1970s routinely the world's largest rice importer with often 1/5 of its rice supplied internationally. However Indonesia reached self-sufficiency in the mid-eighties. It was a dramatic change for the stabilization agency to cope with a self-sufficient nation instead of an importing one. The concept of self-sufficiency in trends, adopted at the beginning of the nineties, allowed Indonesia to maintain cost at a reasonable level, giving flexibility to the system. Despite a lower level of stocks, the coefficient of variation of retail price of rice in Jakarta and Surabaya was lower during the 1989-94 period than during 1984-89, 10 instead of 20% (Timmer 1995).

After 1985, the government decided to reduce subsidies for agricultural inputs, first to reduce the cost of the policy but also because some studies showed that the level of use was sometimes above optimal. In Java, rice farmers have generally been using fertilizer 10-20% above the recommended rates (Sudaryanto et al. 1992). For pesticides the subsidies were gradually decreased from 75% in 1986 to 40% in 1987 and finally totally withdrawn in 1989. The retail prices of fertilizers were raised by 25% in 1987, 8% in 1988, 25.9% in 1990 and 23.5% in 1991. Subsidies for potassic fertilizers were removed in 1993 and for phosphoric in 1994. The budget allocation for fertilizer subsidies decreased from US$ 457 million in 1987 to US$ 229 million in 1993 (ESCAP-FAO-UNIDO various years). In 1996 the subsidies were released for almost all inputs. Nevertheless, the use of fertilizers increased during the whole period and reached 5.9 million tons in 1991. Java is the major fertilizer consuming region in Indonesia with 72% of urea consumption in 1989/1990, 61% of TSP consumption, and 77% of ZA (SA) consumption.

Policies on secondary crops were implemented at the end of the seventies to help the agricultural sector adapt to a more diversified demand induced by income growth. Also, because the area is not expandable and because the increase in yield for rice seemed to have reached a limit, self-sufficiency could only be achieved by a more diversified food diet. In 1978, the government implemented the BIMAS palawija program.

After rice, maize is the most important crop for consumption. It is consumed directly, especially by the poorest, but it is increasingly being used for the feed sector. The share of maize used for feed has increased from 2% in 1968-79 to 6% in 1980-90. Maize was the first secondary crop to have a floor price (1978), which was most of the time ineffective because market prices were always above the targeted floor prices (Timmer 1992; BINUS 1988a; Altemeier et al. 1989; Rosegrant et al. 1987). No ceiling prices were announced, but BULOG ironed out seasonal fluctuations in prices due to high storage costs, especially to protect the feed industry.

This stabilization policy was successful. Compared with international prices, the coefficient of variation of domestic prices was lower than for international markets (17.1% and 34.4% during 1972-1989). Nevertheless, BULOG procurement never exceeded 3% of the domestic production. In 1991, a floor price was no longer fixed and import control has been the main market intervention since then. Some years the country imported maize because of strong increase in demand for this commodity. However, increase of fertilizer use was encouraged through the fertilizer subsidies and intensification programs promoted the adoption of improved varieties since 1983. During the eighties, transportation improved and the commodity was sometimes exported and imported during the same year.

In the early eighties the national soybean deficit increased very rapidly despite policy intending to achieve self-sufficiency. The soybean policy was based on two components: development and adaptation of technical packages along with a reinforcement of extension services targeting soybean, and the establishment of a favorable economic environment through a price policy (Hermanto et al. 1992). Between 1981 and 1991 no less than 15 soybean varieties were released by the Ministry of Agriculture, and numerous packages of technology were adapted to fit in the current production environments including irrigated, rainfed and dry land (CGPRT 1992).

During the 1980-1992 period, BULOG intervened on the price support side in domestic soybean markets through two instruments: a floor price on soybean and import control. The floor price was ineffective, but the level of authorized import maintained the domestic price of soybean well above the import parity price. BULOG is the sole importer of soybeans, but in practice it issues importing and processing contracts (for meal crushing) to the private sector.

Shifts in relative prices between rice, soybean, and especially maize (the major competing crop) explain to a large extent the attraction of soybean for farmers. Between 1980 and 1991, the average soybean price appreciated at an annual rate of 4.5% relative to the price of rice. The increase in planted area resulted from various factors. On Java, there was a shift in cropping patterns in favor of soybean during the dry season and cultivation of fallow fields when water availability or pest management did not permit another rice crop. However, the national production expansion came mostly from opening new production zones outside Java.

After a regular increase in the first years of the soybean policy, soybean yields leveled off since the end of the eighties. This was due to two phenomena: first, a decline in the marginal yield increase (i.e. once the major components of the package are adopted by farmers, the yield growth slows down) and second, the constraints to further intensification of cropping.

Particularly in irrigated areas with high cropping intensity indices and where rice production intensification has already mobilized a large share of production factors, the boundary of farming intensity had been reached. Despite all efforts to increase both yields and area of soybean production, national production increased by much lower rates than its demand. As a result, import grew steadily at around 8.5% per annum. Intensification of soybean production has been marked by high yield variability. This risk is mainly related to the limited efficiency of pest control and to difficulties faced by farmers in water management.

Cassava production did not increase a lot from 1968. No price or intensification policies were implemented for cassava, resulting in low yields. This crop is widely consumed fresh and dried only by poor households. Since the sixties, Indonesian exports have been regular.

2.1.5 A success story in agricultural policy

Over the past thirty years, Indonesia experienced high economic growth and a substantial reduction of poverty. Economic policy played an important role in this evolution. Two different currents have been represented in the government under President Suharto. One current defends market orientation and starts from relative scarcity of factors. The other reaches a path of import substitution for industrial products and self-sufficiency for agriculture. These two currents result in a mixed policy, which deserves attention for its success. Food crop production increased quickly, especially in the eighties. The overall sector benefited from protection, especially rice, soybean and sugar. Nevertheless, this protection constituted a bias for the sector against export. This bias was increased by the import substitution policy for agricultural inputs and equipment, which increased production costs. In that sense, subsidies and public investment in agriculture can be analyzed as a compensation for the sector. In this context, the sharp devaluation of the rupiah can be a good opportunity for the agricultural sector, through competitivity gains, if inflation is not too high and if the country manages to reestablish confidence despite the political crisis.

One major fact is that a lot of attention has been devoted to risk reduction through price stabilization in Indonesia. The Indonesian experience is particularly interesting because of the success of this policy, which a lot of countries attempt to follow; so far very few have succeeded. The public intervention in agricultural markets to reduce uncertainty is aimed at building an efficient private marketing system, not at replacing or displacing it. Constant efforts were made to keep the costs of intervention within limits defined by the benefits for the country. The question now is can the state continue to reduce intervention, especially in rice market stabilization, without markets fluctuating sharply. This question raises another concerning the behavior of international markets and also of market integration within an archipelago as large as Indonesia.

3. Spatial Features of Agricultural Diversification

Food crop production experienced many changes during the last decade. It was marked by success of the rice development policy that reached its target in the mid-eighties when Indonesia became self-sufficient in rice. To respond to significant changes in consumer diets supported by increased income, emphasis was put on the development of non-rice crops, maize and soybean in particular since the mid-eighties. How have this food demand and crop production diversification policy been translated, in terms of spatial distribution of supply and demand and induced trade?

3.1 The supremacy of Java as a food crop supplier

Regarding the supply side, selected figures concerning the level of production, its share and growth trends, are presented for two periods in Tables 3.1 to 3.6.

Province-wise, Java kept its leading position for the total volume of staple food crops produced. However, between 1980 and 1990, it lost 3% of the total production volume to the outer islands, those off Java. This decrease was mainly due to a reduction of East Java's production share from 24.9% to 22.5%, whereas the share of the two other Java provinces remained stable. The gain in production share was evenly distributed among other provinces, all of them slightly improving their respective shares. Production growth was faster in the outer islands than on Java. In particular, the production annual growth rate increased for the non-Java provinces from 5.6% to 6.2% but slowed down in the Java provinces from 3.6% to 3.2% for the 1985 - 1989 period.

Table 3.1 Changes in production of all crops by main production area.

Region	Average production (tons)		Share of total prod. (%)		Growth trend (%)	
	1980-84	1985-89	1980-84	1985-89	1980-84	1985-89
Total	52,680,690	63,271,434	100.0	100.0	4.3	4.3
Total Java	34,333,727	39,413,616	65.2	62.3	3.6	3.2
Total non-Java	18,346,962	23,857,818	34.8	37.7	5.6	6.2
Northern Sumatra	4,684,885	6,116,712	8.9	9.7	6.9	6.2
Other Sumatra	1,923,681	2,648,316	3.7	4.2	8.1	7.0
Lampung	1,975,784	3,074,899	3.8	4.9	9.1	16.1
West Java	9,730,537	11,778,131	18.5	18.6	4.8	3.3
Central Java	11,464,030	13,427,707	21.8	21.2	4.2	3.8
East Java	13,139,160	14,207,778	24.9	22.5	2.2	2.6
Nusatenggara	3,461,069	3,900,454	6.6	6.2	2.0	5.7
Kalimantan	2,086,750	2,528,527	4.0	4.0	1.9	2.6
Other Sulawesi	1,198,594	1,485,961	2.3	2.3	8.9	3.8
South Sulawesi	2,831,152	3,780,660	5.4	6.0	5.7	4.7
Others	185,047	322,290	0.4	0.5	-4.3	-14.6

Crop-wise, the picture differs. In line with the achievement of rice self-sufficiency, a sharp reduction in the growth rate for paddy production can be observed, from 7.9% to 2.2% especially on Java (Table 3.2). The slow down of paddy growth is less important for the non-Java provinces where crop improvement is still possible due to some lag in the adoption of improved technology. The slow down of paddy production development is particularly important in East Java. However, at the end of the decade, Java was still the main supplier of rice on the Indonesian market.

Table 3.2 Changes in production of paddy by main production area.

Region	Average production (tons)		Share of total prod. (%)		Growth trend (%)	
	1980-84	1985-89	1980-84	1985-89	1980-84	1985-89
Total	33,889,862	41,047,935	100.0	100.0	7.4	2.9
Total Java	21,026,895	25,065,363	62.0	61.1	7.9	2.2
Total non-Java	12,862,967	15,982,571	38.0	38.9	6.6	4.0
Lampung	877,496	1,172,205	2.6	2.9	11.8	6.2
East Java	6,956,437	7,763,509	20.5	18.9	4.8	1.6
Other Sulawesi	562,324	758,074	1.7	1.8	8.1	6.8
South Sulawesi	2,085,959	2,828,527	6.2	6.9	8.2	4.6

Maize production growth did not record important changes between the two periods (Table 3.3). It was the only non-rice crop experiencing a significant growth during the first half of the decade. In both Java and non-Java production areas, an acceleration of production expansion during the second half of the decade can be observed. Due to a two-times faster rate of production growth in non-Java provinces than in Java, the share of Java production was reduced by 4% during the 10 years. Sumatra provinces and West Java show faster development of maize production. Lampung is becoming the fourth production area after East Java (40%), Central Java (23%) and South Sulawesi (7.8%).

Table 3.3 Changes in production of maize by main production area.

Region	Average production (tons)		Share of total prod. (%)		Growth trend (%)	
	1980-84	1985-89	1980-84	1985-89	1980-84	1985-89
Total	4,421,853	5,609,806	100.0	100.0	4.9	5.5
Total Java	3,172,723	3,791,017	71.8	67.6	3.7	4.2
Total non-Java	1,249,129	1,818,789	28.2	32.4	7.8	8.8
Northern Sumatra	92,568	200,855	2.1	3.6	12.3	19.7
Other Sumatra	18,690	56,968	0.4	1.0	37.4	19.6
Lampung	104,265	371,343	2.4	6.6	23.7	12.1
West Java	126,110	213,743	2.9	3.8	19.0	13.7

Soybean production evolution is a typical example of the diversification process (Table 3.4). At the national level, its production growth rate increased from 0.6% during the first five years to almost 9% during the second period. However, it has to be noted that the growth rate was already very high (11%) in non-Java provinces between 1980 and 1985. The U turn in soybean production trend that occurred after 1985 on Java did not prevent a sharp reduction of its share of soybean total supply, which decreased from 77% to 60%. In spite of a 5.8% annual growth from 1985 to 1989, East Java's production share fell from 50% to 35%. Meanwhile, new production areas emerged such as northern Sumatra provinces (Aceh in particular). Non-Java production centres already established at the beginning of the decade, such as Lampung, Nusatenggara, and South Sulawesi, strengthened their supplier position.

Table 3.4 Changes in production of soybean by main production area.

Region	Average production (tons)		Share of total prod. (%)		Growth trend (%)	
	1980-84	1985-89	1980-84	1985-89	1980-84	1985-89
Total	636,691	1,168,588	100.0	100.0	0.6	8.9
Total Java	494,978	700,698	77.7	60.0	-2.4	7.0
Total non-Java	141,713	467,890	22.3	40.0	11.6	12.3
Northern Sumatra	32,600	136,133	5.1	11.6	29.4	18.5
Other Sumatra	6,782	23,363	1.1	2.0	21.4	11.8
West Java	25,873	62,858	4.1	5.4	21.8	9.3
East Java	324,300	417,191	50.9	35.7	-6.4	5.8
Nusatenggara	50,194	115,914	7.9	9.9	3.8	18.8

Groundnut production growth increased slightly, but remained low compared to other non-rice crops and soybean in particular (Table 3.5). Changes in production spatial allocations followed the same pattern as for soybean. The share of traditional supply centres (Central and East Java) is diminishing while the share of Sumatra provinces is increasing.

Table 3.5 Changes in production of groundnut by main production area.

Region	Average production (tons)		Share of total prod. (%)		Growth trend (%)	
	1980-84	1985-89	1980-84	1985-89	1980-84	1985-89
Total	475,291	582,337	100.0	100.0	0.9	2.5
Total Java	330,831	365,373	69.6	62.7	0.2	1.6
Total non-Java	144,460	216,964	30.4	37.3	2.7	4.1
Other Sumatra	13,341	21,484	2.8	3.7	24.9	12.5
Lampung	7,565	11,492	1.6	2.0	18.6	0.8
West Java	66,332	87,785	14.0	15.1	5.3	6.5
Central Java	136,948	147,655	28.8	25.4	0.1	3.6

Cassava production stagnated, if not fell, during the first half of the decade in particular on Java (Table 3.6). The second half is characterised by a strong growth of production in the outer islands and a slight increase on Java. Variations in growth trends turned into a decrease of Java's share of 6.3% compared to groundnut's change in supply share.

Table 3.6 Changes in production of cassava by main production area.

Region	Average production (tons)		Share of total prod. (%)		Growth trend (%)	
	1980-84	1985-89	1980-84	1985-89	1980-84	1985-89
Total	13,256,992	14,862,768	100.0	100.0	-3.1	3.8
Total Java	9,308,299	9,491,165	70.2	63.9	-3.8	1.6
Total non-Java	3,948,693	5,371,603	29.8	36.1	-1.2	7.9
Northern Sumatra	431,360	568,982	3.3	3.8	3.9	14.5
Other Sumatra	249,677	557,091	1.9	3.7	14.3	19.9
Lampung	962,923	1,413,185	7.3	9.5	5.8	28.3
South Sulawesi	279,338	434,714	2.1	2.9	8.0	10.9

This overview of the evolution of food crop supply localisation shows that Java remained the main staple food crops producer. But agricultural diversification translated into an increase of the outer islands' shares of the total supply for all the crops, because they recorded higher growth rates. The decline of Java's supply share is particularly important for soybean, cassava and groundnut. However, Java's share decline is less marked for maize and almost non-existent for paddy, the most important food crop.

3.2 A degradation of Java's food balance for non-rice staple food crops

The respective share of Java and the outer islands on the demand side was computed from 1980 and 1990 consumption data (Table 3.7). These figures take into account the equivalent in raw material of processed products (cassava chips, soybean curd, rice flour, etc) and the indirect consumption for maize (estimated on the basis of chicken consumption).

Considering the differences between production and consumption for each group of provinces (Java and non-Java) for maize, Java's surplus is decreasing sharply. Java's share of maize production has decreased while its share of consumption has increased. For cassava and especially for soybean, the gap between production and consumption shares increased during the decade. In 1990, Java's soybean represented 59% of the total production while Java's consumers absorbed 83% of the total supply. The gap between production and consumption shares was only 5% ten years earlier. Soybean food product consumption more than doubled during this period but it remained concentrated on Java where production was not able to match such a rapid increase. The groundnut market spatial configuration is probably evolving along the same line as that for soybean.

Java is less and less in a position of food crops supplier to the outer islands. It still meets the needs for rice, but the balance has deteriorated rapidly for maize, soybean and groundnut.

Table 3.7 Production and consumption share changes for Java and non-Java provinces (%) between 1980 and 1990.

Product	Variable	Java		Non-Java Provinces		
		1980	1990	1980	1990	Change 1980-90
Rice	Production	61.6	60.6	38.4	39.4	1.0
	Consumption	56.0	57.3	44.0	42.7	-1.3
	Production-consumption gap	5.6	3.3	-5.6	-3.3	
Maize	Production	72.7	68.0	27.3	32.0	47
	Consumption	61.0	67.7	39.0	32.3	-6.7
	Production-consumption gap	11.7	0.3	-11.7	-0.3	
Soybean	Production	80.5	59.2	19.5	40.8	21.2
	Consumption	86.0	83.1	14.0	16.9	2.9
	Production-consumption gap	-5.5	-23.9	5.5	23.9	
Groundnut	Production	71.0	66.6	29.0	33.4	4.4
	Consumption	50.0	71.2	50.0	28.8	-21.2
	Production-consumption gap	21.0	-4.6	-21.0	4.6	
Cassava	Production	71.9	63.3	28.1	36.7	8.7
	Consumption	75.0	58.2	25.0	41.8	16.8
	Production-consumption gap	-3.1	5.0	3.1	-5.0	

Source: Computation from SUSENAS 1980, B. Irawan; CBS 1980, 1990.

3.3 Staple food crops marketing flows

Food balances (Table 3.8) have been estimated for the main producing areas for the 1989 - 1991 period when importation of maize and rice were marginal. Taking all crops together, out of a total volume of production of 33,000 million tons, only a mere 1,689 mt had to be shipped between islands to even consumption with production. Even though this figure probably under-estimates the actual total volume of trade between islands because it does not take into account seasonal fluctuations, it indicates that most of the production is consumed on the same island. As expected, Java represents the largest share of the market in terms of both product availability (21,099 mt) and requirements (20,364 mt). The surplus of 735 mt only represents 3% of its supply but more than 40% of the estimated inter-island trade. As already noted, Java only recorded a deficit for soybean and for groundnut, and the bulk of its total surplus was due to its positive balance for rice (662 mt). The second “exporting” island is Sulawesi with a comparable volume of 705 mt of food crop in excess. This amount represents almost a quarter of the Sulawesi availability, making Sulawesi, therefore, much more dependant on the Indonesian food crop markets. Its portfolio of exported crops is also much more diversified with equal shares of rice and maize. The same situation prevails for the southeastern islands of the archipelago, Bali and Nusatenggara, the third and last surplus area, but with a smaller percentage (11%) of their food crops availability shipped to the other islands.

The other islands do not produce enough to match their requirements. The main market is Sumatra with a deficit of 1,100 mt representing 65% of the estimated inter-island trade and around 15% of its total requirements. Kalimantan provinces also have to import a comparable share of their requirements, but, due to the smaller size of its population, Kalimantan imports only represent 14% of inter-island trade. The most dependent areas are Maluku and Irian Jaya, importing around 73% of their annual requirements in rice, maize, soybean, groundnut and dry cassava.

While comparing the overall picture of surplus and deficit distributions among the five crops, it can be observed that the situation is more contrasted on Java where the largest surpluses or deficits are customarily recorded. For each crop, Java’s provinces belong either to the group with the higher surplus or highest deficit. West Java acknowledges the highest deficit for rice, maize and soybean, which is not surprising as Jakarta is located in this province. East Java has important surpluses for these crops, but has a deficit for groundnut and cassava. Central Java has an intermediate position being alternatively a net supplier or a net purchaser of these crops. The situation in Sulawesi is also quite uneven between provinces. The dynamism of South Sulawesi is remarkable. This province has a surplus for every crop except cassava. These differences between neighbouring provinces support the assumption of active trade within each island to equilibrate supply and demand.

In contrast, the situation of each province in the other islands is more homogeneous. This is particularly the case in Maluku, Irian Jaya, Kalimantan and, to a lesser extent, Sumatra and Nusatenggara. Taking the example of rice or maize in Sumatra and Kalimantan, only a few provinces have a positive balance. This implies that in these islands there is less opportunity for intra-island trade or trade between contiguous provinces than in Sulawesi and Java. The higher homogeneity of food crop balance sheets in the provinces of these islands explains why they are very dependent on other islands to satisfy their own demand or to sell their surplus.

Product-wise, different combinations of surpluses and deficits can be observed. For rice there is a high concentration of surpluses in three provinces, namely Central Java, East Java and South Sulawesi, while the deficit is more homogeneously distributed among the other provinces (except for West Java which has the highest deficit). Maize surpluses and deficits follow a similar distribution.

Table 3.8 Availability and required volume ('000 tons) of food crops per province and island for selected food crops*.

Province	Rice			Maize			Soybean		
	Available	Required	Balance	Available	Required	Balance	Available	Required	Balance
Aceh	562	524	37	21	25	-3	127	7	120
North Sumatra	1,285	1,440	-155	170	281	-112	25	40	-15
West Sumatra	791	610	181	24	36	-11	12	11	1
Riau	200	399	-199	19	64	-45	6	14	-7
Jambi	266	297	-31	8	40	-31	5	8	-3
South Sumatra	670	809	-138	43	114	-71	18	29	-11
Bengkulu	138	186	-49	16	16	0	6	5	0
Lampung	648	784	-136	400	411	-11	95	51	45
West Java	5,091	5,989	-898	244	1,875	-1,631	226	397	-171
Central Java	4,161	3,440	720	1,440	866	575	316	426	-110
East Java	4,078	3,239	839	2,334	1,262	1,072	412	401	11
Bali	427	411	17	97	87	10	24	15	9
West Nusatenggara	543	521	22	40	43	-3	100	13	87
East Nusatenggara	173	365	-192	336	269	66	3	3	0
West Kalimantan	342	388	-46	11	64	-53	3	4	-1
Central Kalimantan	130	197	-67	7	18	-12	2	4	-2
South Kalimantan	472	628	145	10	36	-26	3	8	-5
East Kalimantan	107	247	-140	8	34	-26	2	10	-7
North Sulawesi	158	308	-150	167	93	73	28	4	24
Central Sulawesi	191	219	-28	22	33	-11	6	4	2
South Sulawesi	1,573	1,007	565	405	156	249	43	9	34
Southeast Sulawesi	74	135	-62	69	47	23	5	2	3
Maluku	11	138	-126	13	24	-11	1	4	-3
Irian Jaya	14	124	-110	4	14	-10	5	5	0
Sumatra	4,560	5,050	-490	703	988	-286	294	164	130
Java	13,330	12,668	662	4,018	4,002	16	954	1,224	-270
Bali & Nusatenggara	1,143	1,296	-153	473	399	74	126	31	96
Kalimantan	1,052	1,161	-108	36	153	-117	11	26	-15
Sulawesi	1,996	1,671	326	663	329	335	82	19	63
Maluku & Irian Jaya	26	262	-236	16	38	-21	6	9	-3
Total	22,106	22,106	0	5,099	5,099	0	1,473	1,473	0

Sources: Computation from CBS production and consumption data.

Continued ...

* Imported soybean (for food production) was distributed among different provinces according to information provided by BULOG while cassava export (pellets) have been deducted for the year 1990. Maize imports have not been accounted in the trade flow computation because they were marginal (less than 40,000 tons) for the 1989-1990 period.

Table 3.8 Availability and required volume ('000 tons) of food crops per province and island for selected food crop* (continued).

Province	Groundnut			Cassava (gaplek)			All crops		
	Available	Required	Balance	Available	Required	Balance	Available	Required	Balance
Aceh	18	5	13	25	31	-6	753	592	161
North Sumatra	18	16	2	96	207	-111	1,594	1,984	-390
West Sumatra	9	4	5	36	24	12	872	684	188
Riau	3	5	-2	27	40	-13	255	523	-267
Jambi	3	4	-2	66	23	44	348	372	-24
South Sumatra	12	6	6	91	129	-38	835	1,086	-252
Bengkulu	5	1	4	22	15	8	187	224	-37
Lampung	11	11	-1	1	382	-381	1,155	1,639	-484
West Java	97	112	-15	566	476	90	6,224	8,848	-2,624
Central Java	152	72	79	1072	650	421	7,140	5,455	1,685
East Java	132	222	-90	779	936	-158	7,735	6,061	1,674
Bali	12	10	1	88	28	60	648	551	98
West Nusatenggara	18	9	9	48	47	1	748	633	115
East Nusatenggara	9	8	1	317	159	158	937	803	34
West Kalimantan	2	5	-3	57	55	2	415	516	-102
Central Kalimantan	1	2	-1	27	28	-1	168	250	-82
South Kalimantan	11	6	5	30	33	-4	527	411	115
East Kalimantan	3	5	-2	28	26	1	148	323	-175
North Sulawesi	7	13	-6	29	56	-28	388	475	-87
Central Sulawesi	5	10	-5	36	33	2	260	300	-4
South Sulawesi	35	22	14	68	102	-34	2,124	1,296	829
Southeast Sulawesi	4	2	2	73	37	37	226	223	3
Maluku	2	9	-6	60	106	-46	88	281	-193
Irian Jaya	2	10	-8	11	31	-20	37	184	-148
Sumatra	79	53	25	364	849	-485	5,999	7,104	-1,105
Java	381	407	-26	2,416	2,062	354	21,099	20,364	735
Bali & Nusatenggara	39	27	12	453	233	219	2,233	1,986	247
Kalimantan	17	18	-1	142	143	-1	1,257	1,500	-243
Sulawesi	52	47	5	206	228	-23	2,999	2,293	705
Maluku & Irian Jaya	5	19	-15	72	137	-65	124	465	-341
Total	571	571	0	3,652	3,653	0	33,712	33,712	0

Sources: Computation from CBS production and consumption data.

* Imported soybean (for food production) was distributed among different provinces according to information provided by BULOG while cassava export (pellets) have been deducted for the year 1990. Maize imports have not been accounted in the trade flow computation because they were marginal (less than 40,000 tons) for the 1989-1990 period.

On the contrary, for soybean, the largest share of the deficit is concentrated in West and Central Java, which have to purchase respectively 171 mt and 110 mt, and the surpluses are more evenly distributed among other provinces, with the exception of Aceh and West Nusatenggara which report very significant surpluses of this crop.

For cassava and groundnut, another pattern can be observed. For these products, surplus provinces are often contiguous with provinces in deficit. Thus, it can be expected that inter-island trade of cassava by-products and groundnut are limited.

Trade flows (Table 3.9) between provinces can be estimated by equilibrating surpluses and deficits. To easily represent these flows, provinces were aggregated in larger zones when they represent a marginal share of the market. Thus, in our computation the three provinces on Java were kept separated. Sumatra has been divided in three regions: northern Sumatra (Aceh, West Sumatra and North Sumatra), Lampung, and other Sumatra provinces (Jambi, Bengkulu and South Sumatra). The four Kalimantan provinces were considered as one region since none of them is unique, except maybe South Kalimantan, which has a surplus in rice. For Sulawesi, South Sulawesi, which has the highest total surplus after East and Central Java, has been separated from the other Sulawesi provinces. Then Bali, West and East Nusatenggara have been aggregated and the eleventh region combined Maluku and Irian Jaya provinces.

This balancing has been done product by product assuming that a surplus area will first supply the nearest deficit area and then, if any surplus remains, farther provinces. The direction of trade flows also takes into consideration some aspects of transport facilities in the archipelago. For instance, we suppose that trading of bulky commodities is much easier between Java and Kalimantan than between Sumatra and Kalimantan, because Java's economic activities are more complementary with Kalimantan's whereas Sumatra and Kalimantan provinces have less to exchange. Thus, for a given commodity if both Sumatra and Java have a surplus that can be exported to Kalimantan, we give the priority to the surplus of Java. Along the same lines, we assume that South Sulawesi has good connections with East and South Kalimantan but none with West Kalimantan and Sumatra.

Table 3.9 Trade flow and relative share for all crops combined between regions.

Among the 116 possible relations (11 x 11 - 5 provinces which are considered separately) only 42 relations were recorded. From this matrix of exchange, it is evident that an important share of food crops flows from Central Java and East Java to West Java. These flows represent respectively 17% and 21% of the total estimated trade flow, thus more than one-third (38%) of the inter-provincial trade. West Java, where Jakarta is located, is by far the major purchaser for these two provinces and in the trading system as a whole since this province is the destination of 46% of the estimated volume of trade.

The other inter-regional flows are more evenly distributed and never exceed more than 5% of the total inter-provincial trade. Among the remaining 40 relations of assumed trade flow, the northern Sumatra provinces have an important inter-provincial trade which represents two-thirds of their sales and almost half of their purchases. The Nusatenggara provinces are more outward-looking and Kalimantan province surpluses are almost entirely absorbed within the region. For South Sulawesi, the neighbouring provinces represent a market equivalent to West Java. Besides Central Java, East Java and South Sulawesi, which are the main suppliers, the Nusatenggara region has a very spatially-diversified market for its surplus.

To facilitate perception of these estimated trade flows, a map has been built with the food crop balance of each group (Map 3.1). The different groups have been split for purposes of illustration. The domination of intra-Java trade is striking. The map also clearly shows multiple connections between Java's provinces while the three Sumatra groups are less inter-connected. South Sulawesi has its own network oriented toward West Java and its eastern neighbours. Although the Nusatenggara group is strongly connected to Java markets, it also has some connections, with northern and eastern partners.

3.4 Seasonal and spatial supply and demand adjustments

Seasonal variation in supply is a basic feature of agricultural production and a constraint for adjustment of supply to demand. Considering the central position of staple food crops in consumers' diets, the daily supply of rice and also of more elaborated food such as soybean requires a smooth and even delivery to the main markets. Staple crop supplies can be smoothened either by shifting between production centres according to variation in harvesting calendars or through storage of crops or derived stabilised (non-perishable) processed products.

Both strategies prevail in the Indonesian food crops market depending upon cropping calendar variations between provinces and surplus localisation and possible processing of raw material for perishable crops such as cassava.

For instance, the bulk of rice production is concentrated in the February – May period and these markets provide few opportunities for arbitrage between production centres to smoothen the supply (Figure 3.1). On the contrary, the soybean markets are characterised by a flat distribution of harvesting periods among regions, which makes it possible to fully supply the main consumption centres from different sources across the year.

Map 3.1 Trade flows among regions.

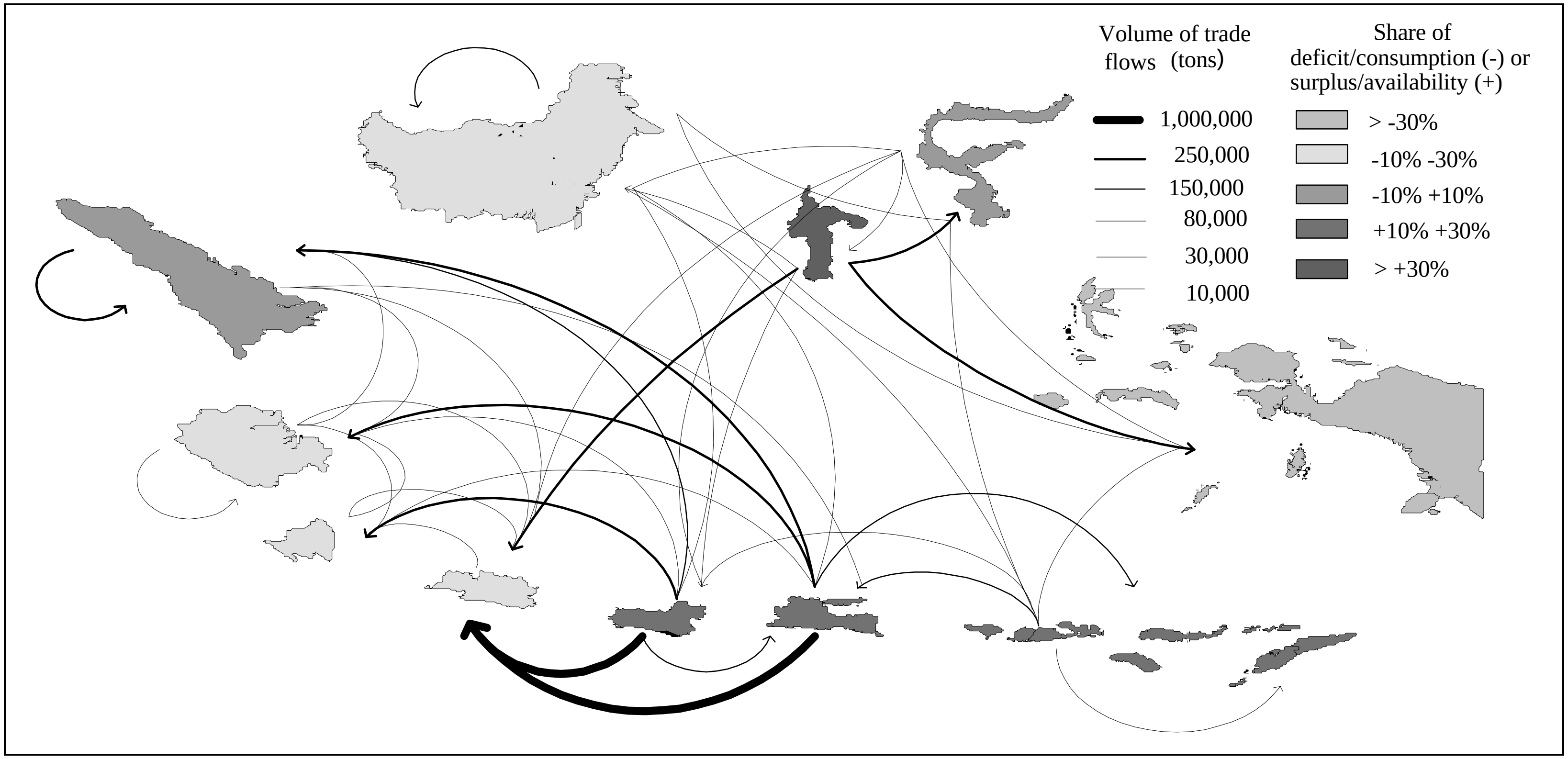


Figure 3.1. Seasonal variation of rice production among provinces.

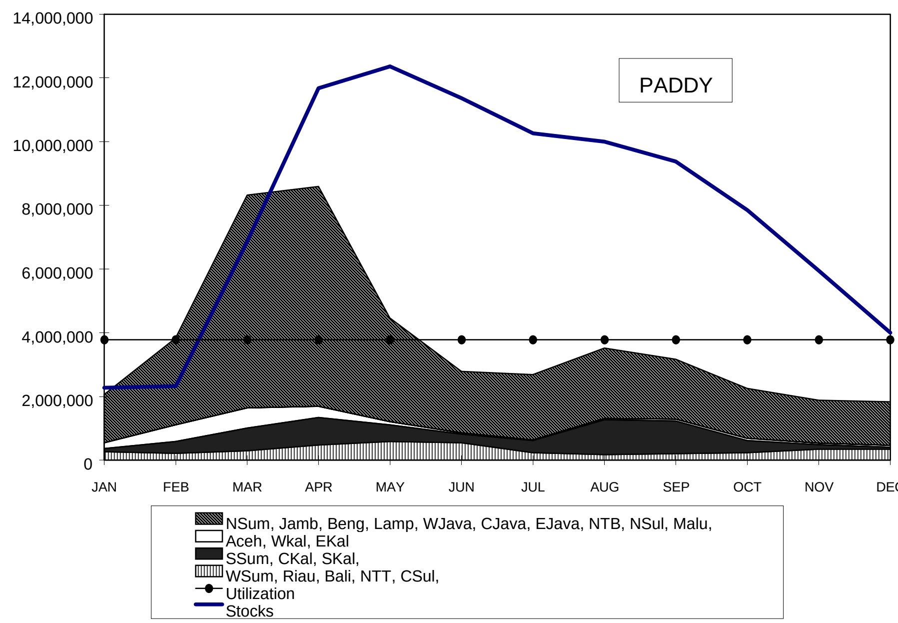
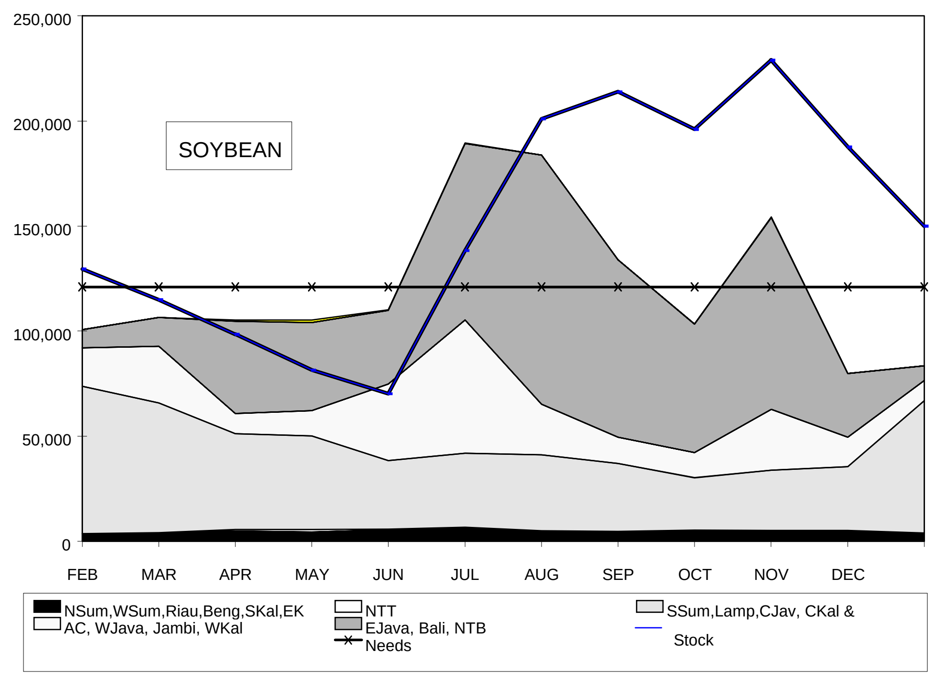


Figure 3.2. Seasonal variation of soybean production among provinces.



These seasonal peculiarities per crop translate into different levels of stocks required to allow supply to match demand on a daily basis. Assuming that the demand for these staple crops is evenly distributed along the year, the volume of stocks for the average 1989-1991 period can be estimated (Table 3.10).

Table 3.10 Contribution of trade and storage to supply and demand equilibrium.

	Paddy (rice)	Maize	Soybean	Groundnut	Cassava (gaplek)	Total
Available (tons)	22,106,387	5,908,837	1,473,043	571,498	3,542,533	33,602,298
Inter-provincial trade	2,526,419	2,068,896	475,520	143,741	796,265	6,010,842
Maximum storage required	6,013,496	1,521,115	232,100	78,968	934,441	8,780,120
in month consump. equi.	3.3	3.1	1.9	1.7	3.2	3.1
% of trade/available	11.4%	35.0%	32.3%	25.2%	22.5%	17.9%
% of storage/available	27.2%	25.7%	15.8%	13.8%	26.4%	26.1%
% of total trade	42.0%	34.4%	7.9%	2.4%	13.2%	100.0%
% of max storage	68.5%	17.3%	2.6%	0.9%	10.6%	100.0%

Source: Computations based on CBS data.

Rice supply smoothening relies more on storage than on inter-provincial trade because the position of this crop in the cropping calendar is quite uniform across the archipelago and because rice production has been widely promoted. For maize, seasonal patterns also explain the importance of storage in supply smoothing (25% of the total available product has to be stored to regularly supply users). However, inter-provincial trade plays a more important role than storage in supply and demand matching because maize consumption for feed tends to be concentrated in Java’s urban and industrial centres where most poultry farms are located. For soybean, the more even distribution of the production calendar and the relative specialisation of production in a limited number of provinces explain that inter-provincial trade plays a crucial role in supply adjustment to demand.

3.5 Spatial dynamics of agricultural diversification

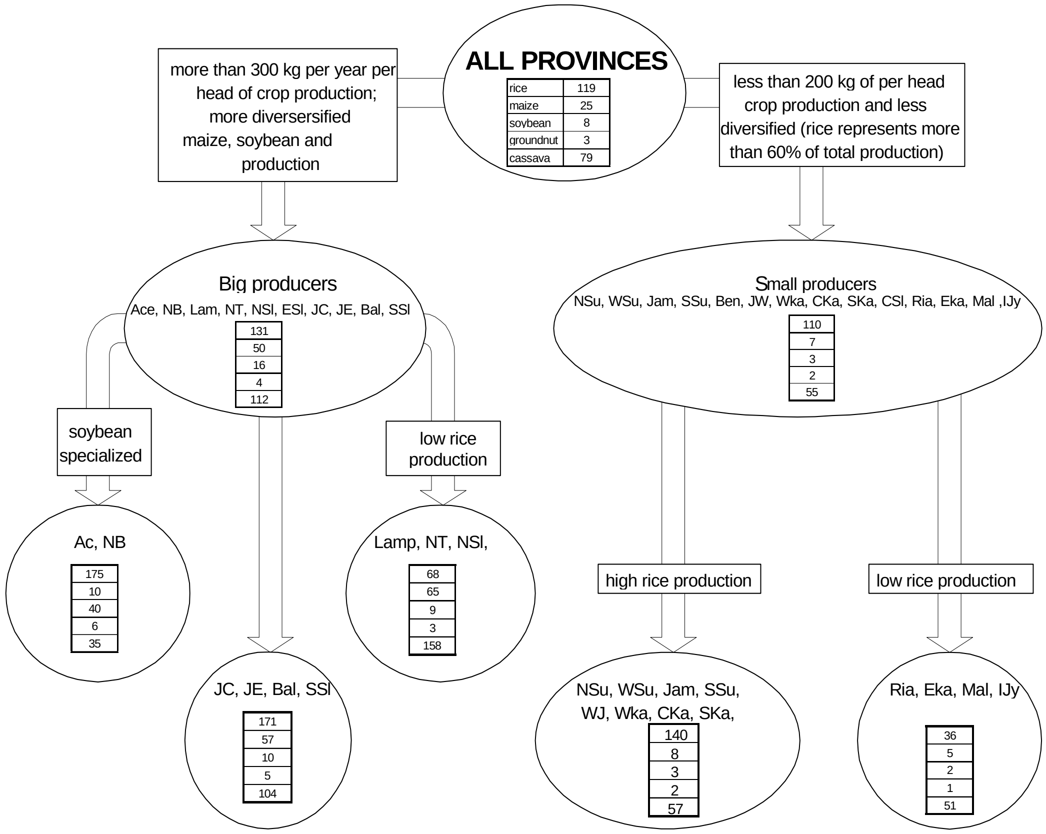
The dynamics of agricultural diversification can be traced by comparing production and consumption patterns across the different provinces of the archipelago. These production and consumption figures have been arrived at through cluster analysis of per head production of rice, maize, soybean, groundnut and maize, and per head consumption of rice, maize, chicken meat, soybean curd, groundnut and cassava flour.

To avoid the influence of market size on the analysis, ten classifications were provided for per capita yearly production and consumption levels. Provinces such as East, Central and West Java would have been separated rapidly by the cluster analysis, not because of their qualitative particulars in terms of production and consumption patterns, but because they represent a very large volume markets. Chicken meat has been incorporated into the analysis as a representative of the new consumer diet.

3.5.1 Production patterns

Regarding production, the 24 provinces are first divided into two initial groups: a group of “big producers” where total average per capita production reaches 310 kg of crops per year and a group of “small producers” where total per capita production is on average around 174 kg (Figure 2.3). These two initial groups are also discriminated by their average per capita production of maize and soybean that is much higher for the “big producers”, 65 kg of maize and 15 kg of soybean, compared to 7 kg and 2 kg for the “small producers”.

Figure 3.3 Production pattern classification (kgcapita/year).



There are no significant differences for rice (average production per head is 130 kg us 109 kg) and for cassava production (although “big producers” average per head production is 111 kg per year vs 54 kg for the others). The “big producers” group is more diversified for rice compared to the “small producers” group. Rice represents 40% of the total production per head in the “big producers” group, whereas it represents 62% of total production of the “small producers”.

Further discriminating these two groups into sub-groups, it can be observed that:

- The “big producers” group can be divided in three sub-groups:
  - one sub-group composed of Lampung, East Nusatenggara, North Sulawesi and South East Sulawesi producers characterised by a very low rice production per head; 68 kg vs 174 and 171 for the remaining provinces of the two other “big producer” sub-groups.
  - a “soybean specialised” sub-group including Aceh and West Nusatenggara features a relatively high level of soybean production (40 kg vs 8 - 10 kg) and a relatively low level of maize and cassava production (respectively less than 9 kg and 35 kg compared to 64-56 kg and 157-104 kg for the other leading producers).
  - a remaining “big diversified” sub-group including East Java, Central Java and South Sulawesi.
- The “small producers” group can be further divided into two sub-groups according to their rice production per head:

- a "low rice production" sub-group which includes Riau, East Kalimantan, Maluku and Irian Jaya (less than 35 kg compared to 139 for the other provinces of the "small producers" group).
- a "high rice production" sub-group which includes the remaining provinces belonging to the "small producers" group.

3.5.2 Consumption patterns

For consumption, an initial group of 6 provinces including all Java's provinces is distinguished from the other eighteen. This group is characterised by a modern diversified diet with a high level of chicken and soybean consumption. On average these consumers eat 2.4 kg of chicken and 5.6 kg of soybean food (in soybean grain equivalent) per year. The same figures for the remaining provinces are 1.6 and 1.7 kg, respectively.

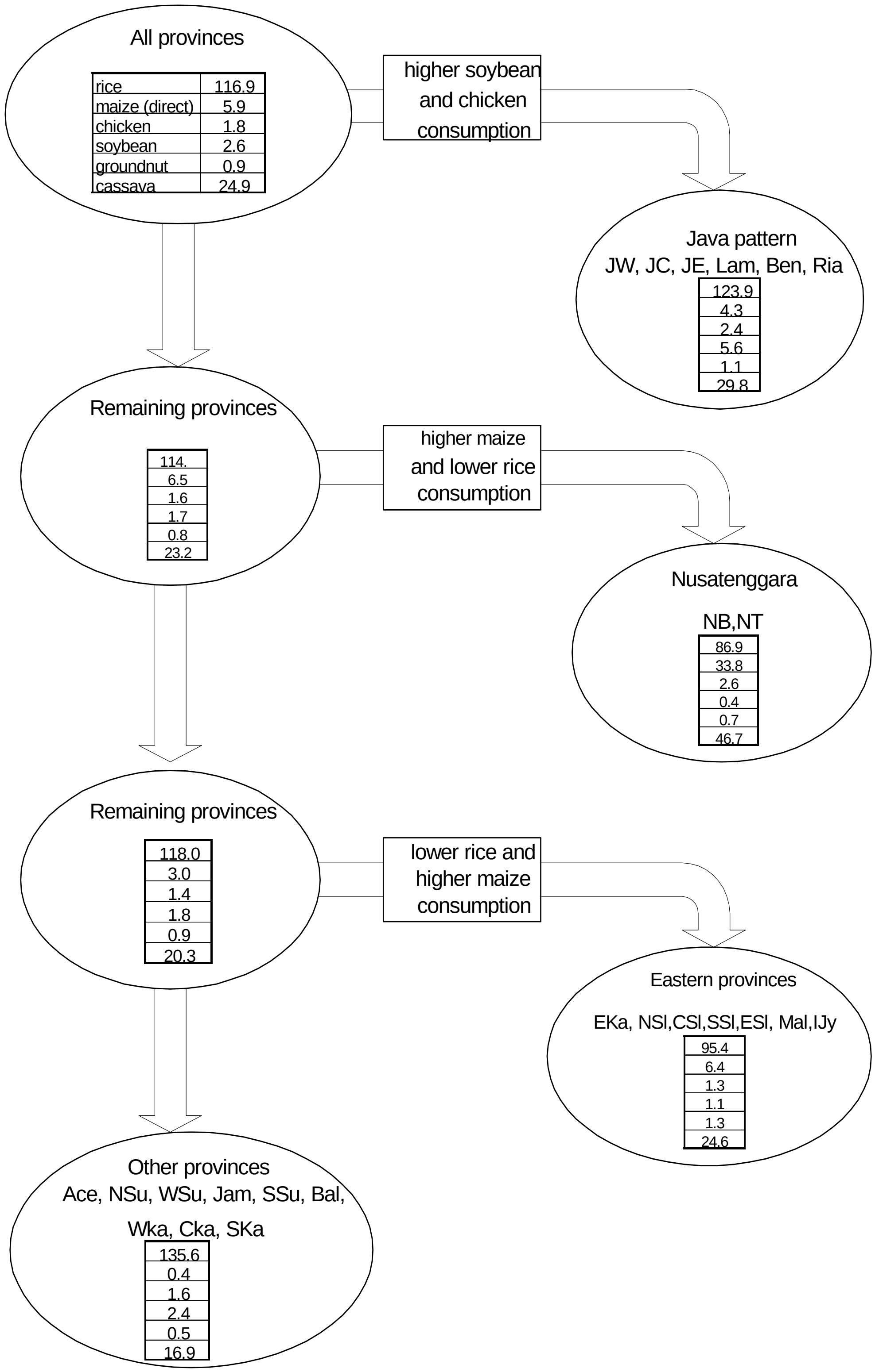
At the next step of the cluster, two provinces emerged from the remaining 18 provinces. West and East Nusatenggara are characterised by a higher maize and lower rice consumption-diet, where direct consumption reaches on average 33 kg per year, and concurrently by a very low level of rice consumption (less than 100 kg per year).

The 16 remaining provinces are divided into two sub-groups according to their rice consumption level:

- A sub-group including East Kalimantan, all Sulawesi provinces, Maluku and Irian Jaya is characterised by a traditional diversified diet with a relatively low level of rice consumption. These consumers eat less than 100 kg of rice per year as in East Nusatenggara but with no substitute. Their consumption of maize, chicken, soybean, groundnut and cassava is also very low.
- A high rice consumer sub-group, eating more than 135 kg of rice per year, is composed of all Sumatra and Kalimantan provinces, except Riau, Bengkulu and Lampung that belong to the modern diversified diet, and East Kalimantan which belongs to the last sub-group.

As Table 3.11 shows, there is no straightforward relation between both clusters. In other words, the fact that two provinces belong to the same type of production pattern does not necessarily imply that they will remain in the same group of consumption pattern. However, some similarities can be observed in particular when a special focus is given to sub-groups characterised by either their rice production or consumption level. For instance, the high rice producer sub-groups belong almost entirely to the high rice consumer sub-groups except for Central Sulawesi, West Java and Bengkulu. Symmetrically, the low rice producers from both small and big producer sub-groups belong to the low rice consumption group except for Riau, East Nusatenggara and Lampung which are characterised by other consumption features (maize, chicken and soybean consumption).

Figure 3.4 Consumption pattern classification (kg/capita/year).



Overlapping these two classifications provides additional insight on interactions between production structure and consumption patterns Map 3.2.

For instance, it can be observed that in East and Central Java, intensive and diversified food crop production matches with a diversified and high level of protein intake in food (assuming that chicken and soybean consumption levels are representative of a modern diet). On the contrary, the classification of West Java in the “modern diversified diet” category is not consistent with its high specialisation in rice production but is understandable due to the high number of urban people (Jakarta). Similarly, Balinese consumers are characterised by a high level of rice consumption while their provincial food crop production is comparable with that of East Java. Another example of inconsistency is given by the high degree of diversification of Aceh’s food crop production while its consumption pattern remains specialised in rice. Along the same line, the persistence of a traditional diversified diet for South Sulawesi consumers is not consistent with its classification in the big producers diversified category on the supply side.

Causalities between changes in spatial allocation of production and consumption patterns are straightforward. Taking the case of West Java, the shift in consumer eating habits toward modern diets has not translated into similar changes on the supply side, which remains highly specialized. Neither have the fast changes in the food crop production in Aceh had an impact on the consumption side, which remains rice specialised. Up to this point, production and consumption match quite well in Kalimantan provinces, Maluku and Irian Jaya. In other words, this consistency suggests that a high degree of self-sufficiency prevails in these provinces and that they are not very much involved in the evolution of the food crop market spatial configuration.

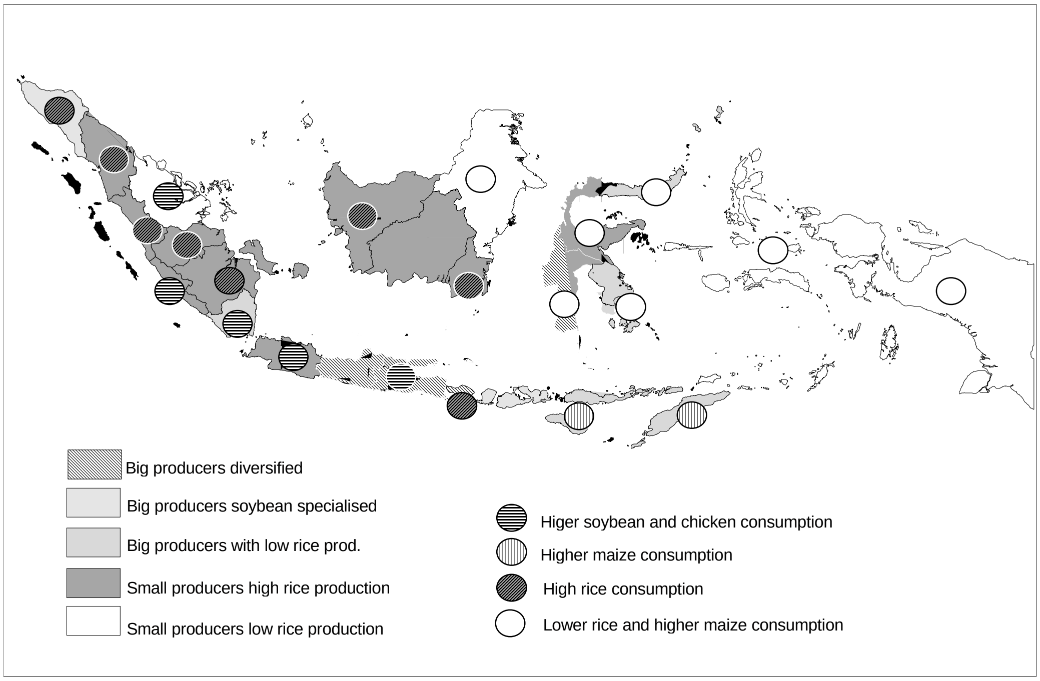
Table 3.11 Comparison between supply and demand groups.

			Consumption characteristics				
			High rice consumption	Low rice consumption	High maize consumption	High soybean and chicken consumption	Total
Production characteristics	Diversified production High per capita production	Soybean specialized	Ace		NB		2
		Low rice production		NSl, ESl	NT	Lam	4
			Bal	SSl		JC, JE	4
	Rice production dominant Low per capita production	High rice production	NSu, WSu, Jam, SSu, Wka, CKa, SKa	CSl		JW, Ben	10
		Low rice production		EKa, Mal, IJy		Riau	4
		Total	9	7	2	6	24

Java clearly plays the key role in this process. It has a great attraction for the neighbouring eastern provinces such as Bali and West Nusatenggara that have a similar production pattern. Its consumption pattern is also disseminating rapidly on Sumatra, again without having yet a clear impact on the production structure apart from Lampung.

Finally, the position of the Sulawesi provinces is much more difficult to characterize. Definitely, the limited weight of rice crops in both production and consumption patterns is not of the same nature as that observed in East and Central Java.

Map 3.2 Production and consumption patterns.



These different degrees of consistency between production and consumption patterns can be put into a common perspective along which each provincial food system evolves through different stages at different paces.

The first stage would be the one found in the eastern provinces of the archipelago with a relatively limited role of rice in both production and consumption. The second stage can be called the “rice food system”, where production and consumption are dominated by rice: most of Sumatra and Kalimantan provinces are representative of this stage. The last stage is characterised by a new type of food consumption pattern combining a high level of rice consumption with a higher level of elaborate food consumption (such as chicken, and soybean-derived products) relative to the two other stages. Java is at the forefront of this evolution. This sequence is based on food consumption pattern evolution that supposes a precedence of consumption over production in the evolution of the food crop market configuration. The similarities in consumption patterns between several Sumatran provinces and Java support this view.

However, discrepancies between the two sides cannot always be interpreted in terms of delay of production in adjusting to a faster dissemination process of new consumption habits. It is also important to consider that, due to various socio-economic or agro-ecological factors (land and labour availability, soil fertility, etc), production systems are not flexible enough to adjust their output to changes in consumer preferences. For instance, West Java, which has the same consumption pattern as East and Central Java, has a production pattern heavily dominated by rice. In contrast, sometimes the consumption pattern does not evolve as fast as the production side. For instance, Bali and Aceh belong to the rice dominated consumption pattern, while their production pattern is more consistent with the third stage type of consumption habit.

However, in the long-term perspective, changes in food consumption habits remain the engine of food crop market evolution. When rural and urban populations are separated in the analysis, the eminent role of urbanisation and industrialisation in the dissemination process of a modern diversified diet becomes clear.

4. The High Diversity of Agricultural Production Conditions in Indonesia

This chapter presents information on the diversity of farming systems and cropping systems which can be found in Indonesia. Given the diversity of conditions of agricultural production, the main types of production units in each agro-ecological zone are defined and a detailed description of each farming system is provided (Thornbecke and Van der Pluijm 1993; Kahin 1994).

4.1 Indonesia: an archipelago of diversity

Indonesia is the largest archipelago in the world, consisting of more than 13,600 islands, almost half of which are inhabited, and stretching across some 5,150 km of sea in the region of the equator, lying for the most part between 5°N and 10°S, and extending over 5,000 km between its longitudinal extremes. A chain of volcanic mountains rising to heights of more than 3,500 m extends from west to east through the southern islands from Sumatra to Timor. The highest points on the chain are Kerinci (3,800 m) on Sumatra and Semeru (3,676 m) on Java. Each of the major northern islands has a central mountain mass, with plains around the coasts. Puncak Jaya (5,030 m), in the Sudirman Range of Irian Jaya, is the highest elevation in Indonesia. About two-thirds of Indonesia is covered with forest and woodland, most of which is concentrated in Kalimantan, Sumatra, and eastern Indonesia, mostly extensively-used tropical rain forests. In the dry eastern islands, a savannah type vegetation is more common.

This geographic diversity is associated with a wide range of climatic, ecologic and socio-economic conditions, which explains why diversity is a main characteristic of Indonesia.

4.1.1 Climatic diversity: from tropical monsoon to semi-arid climate

The climate of Indonesia is tropical, influenced by the proximity of seas and by altitude, with two monsoon seasons, a wet season from November to March and a dry season from June to October. Rainfall varies considerably with location and season. The northern parts of the country have only a slight difference in precipitation between wet and dry seasons. Humidity is generally high, averaging about 80%; the daily temperature range (about 18° to 32° C at Jakarta) varies little. Rainfall in the lowlands averages about 1,780 to 3,175 mm annually, allowing two or even three cropping seasons per year in the main agricultural areas.

In some mountain regions, rainfall reaches about 6,100 mm. In contrast, in the eastern islands, a semi-arid climate can be found.

4.1.2 Soils: from volcanic fertile Java lowlands to very poor eroded soils

Indonesia has a complex soil pattern. The greatest concentrations of old volcanic material, generally with the highest soil fertility levels, are found in Java and Bali. In large areas of Sumatra, Kalimantan and parts of Sulawesi, the soils derived from granite rock, ancient slate, shale and metamorphosed formations tend to be less fertile, even if they are suitable for rubber, oilpalm, etc. In these islands, areas have been degraded consequent to human use (over-cropping, deforestation, etc).

4.1.3 Water resources: Java alone accounts for more than half the irrigated area

Rivers tend to be short and water run off from the higher areas is usually rapid. Ground water resources have not been extensively explored but are proving to be capable of providing water in sufficient quantity for irrigation. The area under irrigation rose to about 7.9 million hectares (1993). The irrigation network was already developed before the Second World War by the Dutch administration and irrigation expenses continue to represent a large share (between 18 and 40%) of the total agricultural budget of the last twenty years (Gérard and Marty 1995).

However, this effort is not equally distributed among the different Indonesian islands. Java represented 55% of the Indonesian irrigated area in 1994, and 94% of the irrigated area with a high degree of water control (CBS 1995).

4.1.4 Demographic distribution: of 197 million Indonesians, 60% live on Java

Indonesia is the fifth most populous country in the world with 197,252,428 inhabitants (Census 1993). The overall population density is around 103 persons per sq km with great differences between islands: 77 persons per sq km in Sumatra, and 17 persons per sq km in Kalimantan. More than 60% of the people live on Java and Madura, on about 7% of the total land area. There, the density reaches 814 persons per sq km, which is among the world’s most densely populated regions.

4.2 Agricultural diversity and agro-socio-ecological zoning of Indonesia

Agricultural production in Indonesia is characterized by a high diversity as illustrated in Maps 4.1 and 4.2, and summarized below:

- agricultural land: about 12% of Indonesia is under cultivation. Much of the arable land is on Java.
- spatial distribution of production: rice is the major staple food of the country, and most of it is grown on Java. Other important crops are *palawija* or secondary crops (cassava, maize, sweet potatoes, soybeans, groundnuts), "industrial" crops (coconuts, tobacco, cotton) and "estate" crops (rubber, tea, sugarcane, coffee).
- agricultural labor: about 55% of the country’s worksforce (approximately 70.4 million persons) is engaged in agriculture, either as owners of small farms or as laborers on estates. The small farms, which produce most of the subsistence crops, also contribute to a substantial proportion of the nation’s rubber crop, tobacco crop, and total export production. Plantation estates produce rubber, tobacco, sugar, palm oil, coffee, tea, and cacao, mostly for export.

In order to consider such diversity, a farming system level approach was applied. Many authors have worked on farming systems analysis. According to Hazell and Norton (1986), in order to group farmers, the variables chosen have to represent the following criteria: (i) similar resource endowment that can be represented by a land to labour ratio, (ii) similar yields, with a separation between irrigated and non irrigated land at least and also differences in climate, soils, elevation that explain (apart from technologies) the differences in the yields, and (iii) similar technologies, that can be done by knowing the predominant crops. "Similar allocation factors", land, labour, and inputs allocated to the different crops can be added to these criteria. To select the main types of situations to be studied, two steps were followed. The first one was a zoning performed to get homogeneous areas in terms of agricultural potential and socio-economic conditions. The second step was a typology of farming systems found in each zone.

An agro-ecological zoning has been elaborated by Las et al. (1991) which differentiates six zones (Table 4.1). An agro-ecological zone is "an area where climate, altitude and topography, soil, water resources, vegetation and land suitability have similar characteristics".

Table 4.1. Distribution of agro-ecological zones of Indonesia.

Zone	Agroclimate	Java 1*	Java 2**	Indonesia
1. Irrigated Lowland	Irrigation water available > 5 months per year Water availability independent of rainfall Elevation < 700 metres asl	19 %	n.a	2.2 %
2. Rainfed Lowland	Irrigation water avail. < 5 months per year Water availability dependent of rainfall Elevation < 700 metres asl	7.3 %	n.a	1.2 %
Total Sawah	At least partially irrigated Rice cultivation predominates Elevation < 700 metres asl	26.3 %	35 %	3.4 %
3. Dryland Wet Climate	Annual rainfall > 2000 mm > 6 consecutive months with at least 100 mm Elevation < 700 metres asl	29.9 %	16.5 %	51.7 %
4. Dryland Dry Climate	Annual rainfall < 2000 mm < 6 consecutive months with at least 100 mm Elevation < 700 metres asl	16.6 %	23.6 %	10.0 %
5. Upland	Elevation > 700 metres asl	26.7 %	23.9 %	14.1 %
6. Tidal Swamps	Land influenced by ocean or river tides Soil characterized by organic matter layer and potentially acid reaction	0.5 %	0.9 %	20 %

Source: Las et al. (1991) from Roche et al. (1992a).
* Estimated manually; ** Estimated from computer digitization.

In the irrigated lowlands, three crops are usually cultivated (sometimes only two) each year with the following patterns: three seasons of rice or two seasons of rice, followed by a secondary crop, or one season of rice followed by two seasons of secondary crop. In the rainfed areas (non-irrigated), usually located in more sloping areas, one crop of rice can be cultivated each year, before or after another crop. In the drylands, which are sometimes uplands, maize and cassava often replace rice as the main food crop.

The socio-economic context modifies the conditions of agricultural production. The density of population and the rural and urban ratio have a direct impact on land availability, pressure of land use, and also on market proximity, which determines the possibility to buy or rent production factors as well as transaction costs for selling the outputs. The density of population has also an impact on labor availability. New agricultural technologies and practices are more quickly disseminated in highly populated areas. The demographic structure, which covers age, migration and education, is also important. These factors are introduced in the zoning used in this study. The adequacy of the level of analysis is always a difficult question. One has to face problems of data homogeneity, difficulties associated with statistical analysis and the necessity of a low level of analysis to be able to assume homogeneity of conditions within the level. In the present analysis, provincial and district level data are used, encompassing the 28 provinces in Indonesia, 212 districts, and 78 rural districts in the three provinces of Java.

To actualize the zoning, agro-climatic and socio-economic data were crossed by mapping and statistical analysis. The following variables were selected for the statistical analysis:

- land per rural person
- % of rural population
- % of land technically irrigated, simply irrigated, rainfed area and dryland
- % of the main crops, that is rice, soybean, maize, cassava, sweet potatoes

- index of cropping intensity in dryland and rainfed areas.

Soil parameters were not included although maps of soils exist in Indonesia, because there are a great number of different soils in each district and province. Such diversity is difficult to include in the present analysis. Moreover, soil condition is not the main constraint for food cropping, since yield and cropping activities depend mainly on rainfall, water management, altitude and farmer's practices (level of inputs, labour, etc used for one crop).

An automatic classification (cluster analysis) based on the coordinates of the observations transformed by principal component analysis defined five groups of districts (Table 4.2):

- Zone 1: Irrigated area with a high degree of water control, densely populated, mainly located in the rich volcanic soils of Java; water availability independent of rainfall.
- Zone 2: Irrigated with moderate to low level of water control and drylands.
- Zone 3: Dominance of rainfed and drylands.
- Zone 4: Dryland area.
- Zone 5: Tidal swamps and drylands.

Table 4.2 Distribution of land type by zone.

Zone	Urban	Type of land %					Ha per rural	% total	% in
	%	tec	sim	rain	oth	dry	inhabitant	are	Java
Zone 1	25	58	12	6	1	20	0.09	7	94
Zone 2	15	8	29	6	1	52	0.14	29.5	44
Zone 3	16	12	15	29	5	37	0.14	21.7	56
Zone 4	13	3	7	6	6	77	0.19	22	21
Zone 5	10	0	4	12	41	41	0.41	19.6	0

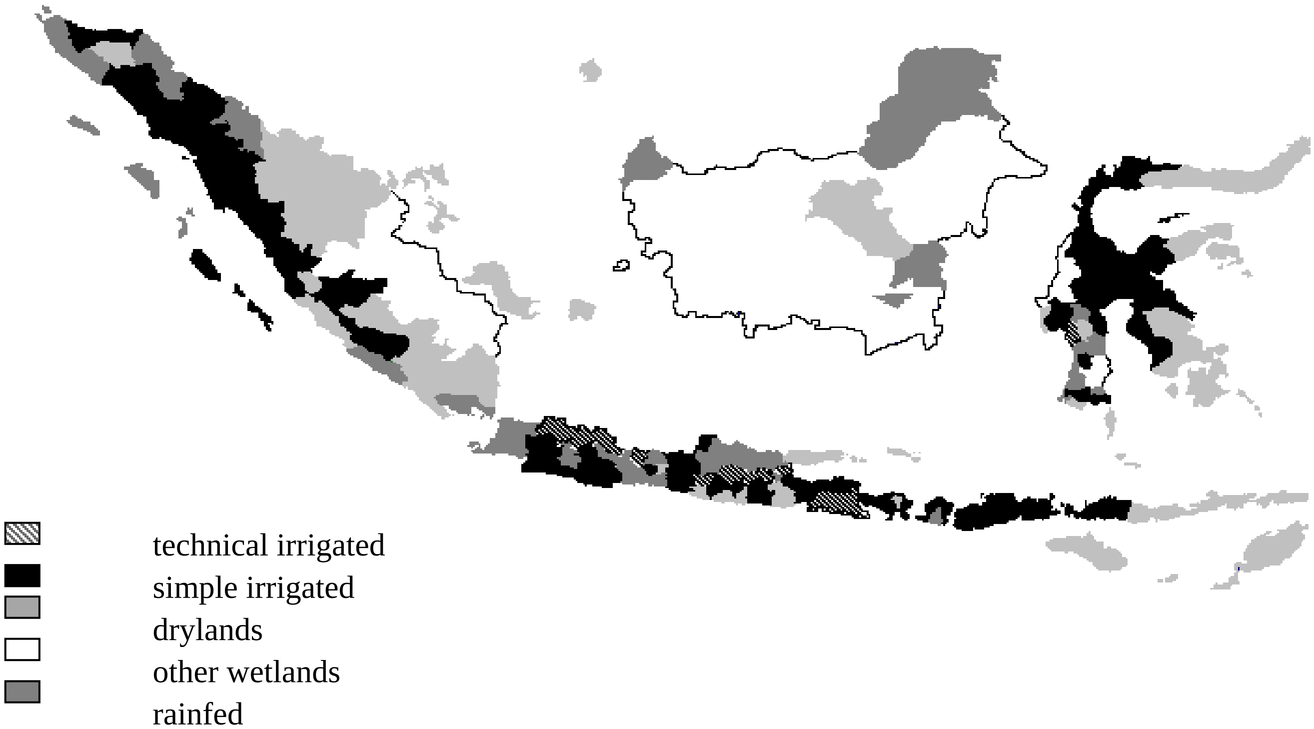
Note: tec = technical irrigated; sim = simple irrigated; rain = rainfed land; dry = dryland; oth = other wetlands, mainly tidal swamps.

The partitioning of the five zones is not homogeneous in Indonesia (see Map 4.1), the irrigated land being mainly located in Java, and the tidal swamps outside Java.

The characteristics of the five areas are close to the zoning of Las et al. (1991) presented above, but as the zoning was based on districts, mixed characters are often found, as is the case in reality. Farm units in Indonesia are made up of a number of discrete parcels of land that are not only spatially distributed but are also in different physical environments. Thus, an individual holding may include parcels in dryland, some rainfed *sawah* (*sawah* is a rice field where the level of water can be controlled) and some irrigated *sawah* (Thorbecke and Van der Pluijm 1993). Also, differences in socio-economic conditions are included in the zoning used in this study.

Finally, Java represents 94% of the highly productive area of lowland irrigated with a high level of water control and produces 60% of the food crops in Indonesia. Within Java, the lowlands produce 90% of the rice and 60% of the soybean of Java. Java represents 60% of the total population, but only 7% of the area. Moreover, as the density of population already reaches 814 inhabitants per km^2 in Java, policy impact on farm income and consequently on rural migration is an important concern for policy-makers. Poverty, which is also an important policy concern, is mainly concentrated on Java. For all these reasons, and also because the diversity is already great within Java, the rest of the study will concentrate on this island.

Map 4.1 Indonesian agro-ecological zoning.



4.3 Java's farming systems

To achieve a good representation of Java's farming systems, additional factors at the farm level were used, in order to reflect the different production factor endowments (land holding, etc) under which farmers make their decisions. This typology is realized for each zone defined above. Representative farms are described and their validity depicted by scale parameters. Thus, following the advice of Thorbecke (1992): "It should be obvious, but regrettably does not appear to be so, that a quantification of existing cropping systems is a necessary input when serious attempts are made to devise intervention policy instruments oriented specifically toward introducing changes in those systems. Not only must the relative use of systems be quantified but the spatial distributions be determined."

Focussing on Java, the zoning performed in the previous section allows distinction of the four zones described above and intermediate zones that have two or more characteristics of the four zones (Table 4.3).

Table 4.3 Java's agricultural zones.

Zone	Characteristic
Zone 1	Lowland irrigated area with high degree of water control (also called technical irrigation), densely populated, near urban areas. Rice is predominant.
Zone 2	Lowland irrigated with low degree of water control (also called simple irrigation) and dryland in wet climate. Rice is predominant. Maize and soybean are the main secondary crops.
Inter 1	Intermediate between irrigated lowlands and drylands.
Zone 3	Rainfed - dryland - wet climate. Rice and maize predominant.
Zone 4	Dryland - dry climate. Maize, cassava are predominant.
Inter 2	Intermediate rainfed-dryland-irrigated.

Since this zoning involves data collected in administrative districts, each zone may contain more than one land/crop type. Some are really homogenous for instance zone 1, which is mostly irrigated area, and zone 3 which is mostly dryland area, while some are more diversified such as zone 2.

Zone 2 has been further subdivided into a large zone where maize is the main crop after rice, and a smaller one where soybean is the main secondary crop.

Table 4.4 Distribution of land types/crops on Java.

Zone	% urban	Type of land (%)				Main crop area				Ratio dry
		tec	sim	rain	dry	wet rice	cass	soy	maize	
Zone 1	28	65	6	8	21	74	4	10	8	14
Zone 2	22	16	23	9	52	61	12	3	15	21
Inter 1	19	31	9	11	48	58	9	7	18	26
Zone 3	16	13	4	45	36	51	3	3	29	68
Zone 4	11	9	6	13	70	26	17	6	39	63
Inter 2	16	27	16	25	32	67	7	3	10	36

Note: tec= technical irrigated; sim = simple irrigated; rain=rainfed land; dry=dryland; ratio dry = % of non-irrigated area in the total area.

As elevation was not included in the analysis since data were not available for all the districts, the upland area did not appear.

In a comparison of the zoning and a mapping of elevation, it is evident that areas of more than 1,000 feet are mostly concentrated in zones 4 and inter 1.

A farming system typology has been described in each zone, i.e. irrigated lowlands (zone 1 and 2), rainfed lowlands (zone 3), and drylands and uplands (zone 4).

Farm surveys, monographs and expert interviews have been used to realize the typology. The SYGAP database (Lançon 1992) was used mainly for the irrigated areas while other studies have been used for the other zones. Farm structural endowment variables, farmer practice variables, farm result variables, or all three of them can be used. Theoretically, farmers with the same production factors and the same practices should get similar production. Nineteen variables (Table 4.5) were used in a principal component analysis, followed by a cluster analysis. Fifteen farm types are defined (Table 4.6).

Table 4.5 Variables used to characterize the farming systems.

Farm structural endowment	Area used	Assets
	Area technically irrigated	Family agricultural labour
	Area semi-technically irrigated	Number of poultry
	Area simply irrigated	Number of cattle
	Area in rainfed	Ratio land per active person
	Area in dryland	
Farmer practices	Use of tractor	Use of input
	Use of animal traction	Use of credit
	Use of hired labour	
Farm results	Production realized	Off-farm labour
	Yields realized	

Table 4.6 Results of the typology.

District Level		Farm Level				
				Socio-Economic Characteristics		
Zone	Characteristics	Type of Farm	Area	Off-farm income (%)	Animal in total wealth (%)	Mechanized
1. Technical irrigated lowland	- high density	F 1	big	12	0.01	yes
	- high degree of water control	F 2	med	26	6.3	yes
	- rice monoculture	F 3	small	36	0.3	yes
2. Simple irrigated lowland	- medium density	F 4	med	17	3.5	yes
	- low degree of water control	F 5	med	29	8.1	yes
		F 6	med	18	3.5	yes
	- high maize demand	F 7	med	35	7.0	yes
3. Rainfed	-multiple food crops	F 8	small	37	0.2	no
		F 9	small	40	0.3	no
4. Dryland	mixed cropping	F 10	small	location dependent		no
	with tree crops				< 1%	
	with vegetable	F 11	med			no
	with dairy	F 12	small			no
		F 13	small		> 10%	no
5. Upland	-vegetable intensive	F 14	small	little	< 1%	no
	-mixed cropping	F 15	med		> 10%	no

Water availability in zones 1 and 2 is a major constraint to cropping patterns, not only influencing the number of cropping seasons possible during one year but also the type of crops and the level of yields. Thus, irrigated areas can be further differentiated based on water availability and the degree of water management.

4.3.1 Zone 1: farming systems in areas with high degree of water management

Irrigated *sawah* with a high degree of water management produces the highest yields in Java. Farmers in these areas use Green Revolution technology, improved varieties of rice, as well as a high level of fertilizer. Their yields reach more than 5.5 tons per ha. They are concentrated mainly in the rich volcanic soils of lowland Java, and the characteristic cropping pattern consists of two crops of rice, often followed during the second dry season by a secondary crop or a vegetable if market channels are available. A third non-rice crop seems to be far more common than a third rice crop, due to labour and pest-control constraints. In some areas, the third rice season is just not allowed and control is performed by local officials to check that no rice is planted. In areas with of high population density, there are important opportunities for off-farm activities.

Three types of farmers are identified in this group: big land owners (Farm 1) with an average of 5.7 ha, who rent part of their land to other farmers, small land owners (Farm 2) with 0.7 ha who rent in some land from other farmers and landless farmers (Farm 3) that rent all their land each season. The number of active persons is higher in the landless families (Table 4.7).

Table 4.7 Farm types in zone 1.

Farm type	Land owned (ha)	Land rented (ha) season 1	season 2	season 3	Active persons per farm
Farm 1	5.7	-3.3	-3.0	-0.65	3
Farm 2	0.7	0.4	0.4	0.2	3
Farm 3	0	0.95	0.85	0.14	4

Source: Calculated from SYGAP data.

The cropping pattern for these farmers is almost a rice monocropping with about 95% of their area devoted to this crop (Table 4.8). During the third season, they grow a secondary crop (soybean mainly) or a vegetable (in this area mainly cucumber and watermelon) or have a short fallow period. It is very risky for farmers to shift from rice to another crop during the first two seasons, as their fields are all flooded together.

Table 4.8 Cropping patterns for farm types in zone 1.

Characteristic	Farm 1	Farm 2	Farm 3
Area controlled	2.4	1.05	0.95
Active persons per farm	3.2	3.2	3.6
Type of land	irt	irt	irt
Crop area cultivated (%)			
- rice	95	96	94
- soybean	2	1.5	1.3
- other	3	2.5	4.7
Mechanization	yes	yes	yes
Yearly income per capita (million rupiah)	1.5	0.34	0.2
% off-farm income	14	30	38
% animal in total wealth	0.01	0.3	6.3

Note: area "controlled" = land "owned" + land "rented in" - land "rented out";
irt = "technical irrigated" or "good level of water management".
Source: Calculated from SYGAP data.

Animal production represents almost no source of income. Even if most of the agricultural activities are still mainly done by hand, animal traction and hand tractors are now used in most of the irrigated areas for land preparation for rice. Hand tractors are often rented by rich farmers or by a local firm, sometimes owned by groups of farmers. This mechanization allows farmers to plant the second crop earlier and thus improves the potential yield of the third season crop because it gets more rain if planted earlier. The number of tractors greatly increased in the 1970s with a number of two and four-wheel machines climbing from 1,914 in 1973 to 13,003 in 1984 (Thorbecke and Van der Pluijm 1993).

As emphasized earlier, off-farm opportunities are important and this income represents an important part of total farm income for the middle-sized and landless farmers. This last category is the poorest with per capita income of Rp 200,000 per year.

Table 4.9 Costs of production and yields, Karawang, West Java.

Item		Rice		Soybean		Cucumber	Watermelon
Planting season		S1	S2	S2	S3	S3	S3
Labour (days)		119	110	130	147	130	131
Hand tractor (days)		4	4				
Fertilizer	urea	192	232	342	161	275	188
(kg)	TSP	184	177	49	32	101	143
	KCl	25	20	48	12	0	13
	NPK	0	0	0	0	33	87
Input costs	Seeds	15	0	0	0	0	5
('000 Rp)	Pesticides	41	49	35	51	23	47
	Others	170	0	0	0	5	4
Yield (kg)		5,725	4,025	900	935	3,400	2,180

Source: Calculated from SYGAP farm surveys.
Note: S1 = Nov - March; S2 = Apr - July; S3 = Aug - Nov.

Farmers use green revolution varieties as well as high levels of fertilizer for rice cultivation. Vegetable crops need many inputs and remain very risky because of pest sensitivity and sharp fluctuations of prices (Ferrari 1994). They are usually cultivated on very small plots.

On some Java lowlands with well-controlled *sawah*, sugarcane or tobacco intensification programs are implemented. In the villages targeted by these programs, which are located nearby factories, typically 33% of the village area for sugarcane to 50% for tobacco is devoted to these "forced" crops (Heytens 1991).

4.3.2 Zone 2: farming systems in areas with moderate to low degree of water management

In areas of moderate water control, water availability often allows two rice crops, but with lower yield than in the well-controlled *sawah*, especially during the second season. A third crop, a *palawija* crop, is also common during the third season.

In areas of poor water control, secondary crops are more developed; the level of rice yields during the two dry seasons makes the other crops more competitive. During the wet season, poor drainage makes the cultivation of non-rice crops nearly impossible. In these areas, traditional varieties of rice can be found. The presence of springs in fields can also oblige farmers to cultivate rice during the three seasons because of flooding. Poorly controlled *sawah* can be found in lowlands as well as in areas above 700 m (Heytens 1991) with terraced hillsides.

Four types of farmer corresponding to the principal situations existing in this zone have been found, characterized by their availability of land and labour:

- Farm 4 and Farm 6 cultivate 1.2 ha of "technical irrigated land" with 2 active persons per hectare.

- Farm 5 and Farm 7 cultivate 0.6 ha of "simple irrigated land" with more than 4 active persons per hectare. They have of less disposable capital than Farm 4 and have less access to credit.

Based on different production factors (Farm 4 and 6 have more land than Farm 5 and 7) and depending on different marketing channels, the crops grown as well as their cultural practices are different. The cropping patterns for the four types of farmers are listed in Table 4.10. Due mainly to differences of the market channels and soil conditions, the secondary crops cultivated are mainly soybean and mungbean for Farms 4 and 5 and maize for Farms 6 and 7.

Table 4.10 Area (ha) devoted to crops in farm types in zone 2.

Farm		Nov-March	Apr-July	Aug-Nov
Farm 4	rice	1.13	0.08	0.03
Farm 6	secondary crop		1.02	0.96
	fallow		0.03	0.14
Farm 5	rice	0.58	0.23	0.24
Farm 7	secondary crop		0.34	0.29
	fallow		0	0.05

Source: Calculated from SYGAP data.

Animal production has a limited place in the agricultural activities of the area. Agricultural activities are mainly done by hand, except for rice land preparation which employs animal traction (always owned for Farms 4 and 6 and sometimes rented for Farms 5 and 7). The use of hand tractors for land preparation was rare at the survey time (only two farmers of 40), but it seems to be of greater importance recently, mainly for the second rice crop.

Agriculture is only part of the family income. Off-farm activities are common for at least one member of the family and represent about 20% of the income of the 1.2 ha farmers and more than 30% for the smaller ones. Since off-farm activities are more profitable than on-farm work, only the difficulty in finding off-farm activities seems to limit it.

4.3.3 Zone 3: rainfed area

Rainfed farms rely on rain for land cultivation and wait for the monsoon rainfall to grow rice with considerably more risk than in irrigated areas. As water control is low, high yielding varieties of rice are used less. The level of fertilizer is also lower and the yields seldom reach more than 4.5 tons per hectare. Due to lack of water during the dry season, rice cannot be grown and soybean is a common crop. The second dry season is usually not cultivated due to drought.

Two types of farms can be observed (Table 4.11): lowland rainfed farms owning 0.26 ha but operating on 0.35 ha (Farm 8) and dryland-rainfed farms owning 0.25 ha and operating on 0.31 ha (Farm 9). These farmers rent from land owners who are not farmers.

Table 4.11 Area cropped (ha) in zone 3.

Crop	Farm 8	Farm 9
Lowland rice / 2nd crop	0.35	
Rice + maize + cassava / soybean		0.08
Lowland rice / vegetable		0.15
Vegetable		0.08

Note: + intercropped; / next season crop.
Source: Kawagoe et al. 1990.

Farmers who operate on drylands grow some vegetables during the wet season in their dryland fields and start to do the same during the first dry season in their rainfed fields. Vegetable cultivation is highly labour intensive. In these areas of rainfed and dry lands, farmers rely mainly on manual labour and sometimes animal labour. Off-farm activities are very important for income generation (about 40% of their income) and, as in the zone 2, the limit to off-farm activities is their availablility. Three cropping patterns, mainly based on maize, cassava and upland rice, exist in rainfed areas (Table 4.12).

Table 4.12 Cropping patterns in rainfed drylands of zone 3.

Crop	Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug
	West Java
Pure stand cassava	P--H
Maize + legumes	P------------------------H
Upland rice	P-----------------------------------H
Cassava	P--H
Maize + legumes	P------------------------H
Cassava	P---H
	East Java
Pure stand cassava	P---H
Maize	P-----------------------------H
Cassava	P---H

Source: Thorbecke and Van der Pluijm 1993.

Around some cities, such as Bogor, more and more land is devoted to pure stand cassava. Cassava is a crop that needs fewer inputs and care and thus allows farmers to have a full-time job off the farm while occupying the land in order to keep their land rights that are still not clearly established.

4.3.4 Zone 4: drylands

Farming systems in the drylands are very diversified. As the soil fertility and water conditions are less favorable to agriculture than in irrigated areas, these farmers are often poorer and their answer to a more risky situation is to diversify their cropping activities. Because most of them live in isolated areas, off-farm activities are less important.

The choice of crops depends mainly on the market opportunities. Mixed cropping is an important feature of the dryland farming systems with a dominance of maize and cassava. There is an important diversity of farm types within this zone. They can be grouped into four types:

- mixed cropping
- mixed cropping with tree crops
- mixed cropping with vegetables
- mixed cropping with dairy activity.

Tobacco and sugarcane are important when farms are located nearby factories.

In order to illustrate this high diversity of farming systems in this zone, many examples are given from different parts of Java.

Located on this type of land, the village of Merden Kidul shows one type of cropping system: cassava+maize/secondary crop. A study of this village in the district of Banjarnegara (Palte 1989) shows that there are two types of farming systems: farmers of 0.81 ha of drylands (40% of the farmers) and farmers of 0.24 ha of drylands (60% of the farmers). Twenty percent of the income comes from fruit and wood trees.

In the same district, the farmers of the village of Kalisari grow either cassava as a pure stand or cassava + maize / maize on drylands. Tree crops represent nearly 60% of farmer income.

In a Solo valley villages such as Cepogo exhibit another cropping system: rice + maize - maize, and on poorer land either a pure stand cassava crop or cassava intercropped with vegetables or legumes (Prabowo and McConnell 1993). The average farm size is about 0.3 ha.

Until the beginning of the 1990s, vegetables were grown mainly for the national market. A recent tendency is the growing of vegetables destined for the export market such as chili for the Japanese market and eggplant for Taiwan.

In Sukorame, also on drylands, a common crop sequence is cassava + maize + paddy. An alternative is the same first season crop under a tree crop such as banana, citrus, papaya or green fodder. When manure is available, legumes or vegetables or a mix of the two can be grown during the second season. The average farm size is about 0.3 ha. There are also in this village dairy cattle and for these farmers part of the land is occupied by Napier grass. In areas where there are milk factories, milk producers become more important, with special credit to buy heifers being available. A limit to the development of the dairy production is the quality of the cold storage chain.

In Sumber Kembar village, Blitar district located in the intermediate dryland-irrigated zone, the cropping patterns of the farmers are similar to those in Surokame, with maize - cassava intercropped during the first season, and sometimes with groundnuts and soybean in the second season (Roche et al. 1992a, b).

4.3.5 Zone 5: uplands

Parts of the dryland farming systems are upland farming systems, either in dry or wet climates. Upland agroclimate areas are defined by Roche et al. (1992a) as land above 700 metres of altitude. The “very high” altitudes, above 1,000 m, exhibit mountain agriculture where, depending on market access, vegetables can be the main crops (the example of Blumbang) or part of the cropping pattern with maize, cassava, potatoes as the main food crops (the example of upper Merapi). At lower altitudes, farmers grow mainly secondary crops, often mixed with tree-crops and sometimes associated with animal production, either dairy or meat. These second systems are very similar to those of the drylands described above.

In particular areas with good access to markets, for example Blumbang, farmers grow only vegetables in a very intensified way. Average farm size is 0.18 ha with two types of cropping systems (Table 4.13).

Table 4.13 Vegetable cropping patterns in Blumbang.

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
System A												
Garlic	P-------------------------------------H											
Carrot		P----------------------------H										
Garlic					P-------------------------------------H							
Onion					P----------------------------H							
Carrot									P--------------------------------H			
Cabbage									P--------------------------------H			
Carrot	-----H											P-----------
Onion	------H										P-	
System B	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Garlic			P-----------------------------------H									
Onion	P------------------------H			P-------------------------------------H								
Kangkung	P------------------------H			P-------------------------H								
Green bean				P-----------------H------H								
Carrot	H					P---------------------------------H				P----------------------		
Cabbage	-------H						P------------------------H				P------	

Source: Prabowo and McConnell 1993.

The labour availability per family is about 450 working days, with very little off-farm opportunities due to isolation. Yields in the mixed cropping system are 65% of the yields for pure cropping. The labour demand is around 665 days per ha for both systems. Wages are low: Rp 1,500 (man) and 1,200 (woman) /day plus two meals in 1992. Inputs are very high. System A needs for 1,000 m^2 5,400 kg of animal manure, 5,400 kg of green manure, 160 kg of urea, 210 kg of triple superphosphate, 120 kg of zinc ammoniac and 60 kg of KCl. Seed for garlic is either local or improved at a high price (20 kg of seed at Rp 5,500 per 1,000 m^2).

Some farmers have a few animals: on average, there are 0.185 meat cattle, 0.85 sheep, and 1.83 poultry per farm in the village. Sheep and cattle produce manure. In terms of manure production, 0.185 meat cattle and 0.85 sheep are equivalent to 0.33 cattle unit equivalents. One cattle unit produces about 11 mt of manure per year. The rest is bought by the farmers. Green manure can be collected from nearby forests or bought at a price that reflects the time required to collect it.

In a mixed cropping system (upper Merapi village), the average size of a farm is 0.75 ha. The main crops are maize, cassava, potatoes, and vegetables in some cases, associated wich dairy cattle or meat production. Two, three, four or more crop species are grown together in the same field at the same time. This system is quite similar to the dryland system, although even more diversified.

Table 4.14 Cropping systems in an upper Merapi vilage.

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize	---	---	---	---H			P---	---	---	---	---H	P---
Potatoes									P---	---	---	---H
Carrot	---	---H							P---	---	---	---
Peas / beans	---	---H							P---	---	---	---
Tobacco			P---	---	---	---	---H					

Source: Prabowo and McConnell 1993.

All land preparation and cultivation are done by hand, even if cattle exist in the village. In that case, they are used for meat, manure or milk production, but seldom as draught animals.

The annual income level is quite low, between Rp 1.5 million and Rp 600,000, especially for farmers who only own a small house garden and have to rent their land. As there are few off-farm labour opportunities, the level of income is among the lowest in rural Java.

4.4 Lowlands and uplands of Java

The diversity of agro-ecological and economic environments and, consequently, of farming systems is very high in Indonesia and even in Java. In this diversity, there is a gradient along diversification. The large farms of the irrigated lowlands are mostly rice monocropping. In the irrigated lowland with less water control, farms are already diversified, oriented towards one or two secondary crops. In the rainfed lowland, farms are very small but exhibit a wide range of activity. Dryland and uplands are very complex and diversified, and quickly change according to market opportunities, so that it is difficult to get a clear picture of them.

Lowland and irrigated lowlands have been the main targets of agricultural policies. These policies allowed the country to reach rice self-sufficiency in the mid-eighties. Considering the technical comparative advantage of irrigated rice and the current level of technology, the potential for investment in irrigation and/or rehabilitation leaves few options in crop choice. Most of the resources devoted to rural development have concentrated on the development of the lowland rice-based farming systems.

With the achievement of rice self-sufficiency, new objectives have been assigned to agricultural policies. However these policies still rely on the adjustment of lowland irrigated farming systems to new market opportunities. For instance, the agricultural policy in favor of soybean production mainly had an impact on lowland soybean production areas. This agricultural policy bias in favor of lowlands is the result of institutional and conceptual factors.

The modalities through which agricultural innovations are channeled to farmers have been developed with reference to lowland irrigated, heavily specialized farming systems. These methods appeared to be less efficient in upland, more diversified farming systems, where flexibility and complexity are the keys. In addition, one outcome of the Green Revolution focus has been to consider that upland areas are less market oriented and more subsistence oriented. For these areas agricultural policy has put more attention on sustainability and food crop development for household consumption (Allen 1993).

However, the impact of the Green Revolution has not been limited to lowland farming systems and urban consumers. The achievement of a cheap rice supply also has had tremendous impact on the dynamic upland areas, which have been able to adjust their production patterns to new market demands without putting their livelihood at stake. This concerns upland areas located near urban centers in Java, that have been able to shift from diversified and subsistence oriented farming systems towards a more specialized and market oriented system. The garlic and apple production areas near Malang in East Java are good examples. Fruit and vegetable production have been at the forefront of this change in the uplands (Hayami et al. 1991).

However, the Java lowlands constitute the main producing area and the majority of the rural population. The impact of crop trade liberalization will focus on this area. Nine types of farms represent the main characteristics of agriculture in the lowlands of Java. These farm types represent 2.3 million hectares and more than 8.5 million active persons in the agricultural sector (Table 4.15).

Table 4.15 Farm types in the lowlands of Java.

District Level	Farm Level	Regional Level Scale Parameters		
Agro climatic zones	Type of Farm	Hectares	Active Persons	Households
1.Technical irrigated lowland	F 1	576,000	768,000	240,000
	F 2	290,000	883,000	276,000
	F 3	684,000	2,590,000	720,000
2. Simple irrigated lowlands	F 4	84,000	140,000	70,000
	F 5	150,000	1,000,000	250,000
	F 6	180,000	300,000	150,000
	F 7	240,000	1,600,000	400,000
3. Rainfed lowlands	F 8	99,000	567,000	283,000
	F 9	88,000	850,000	283,000
Total		2,391,000	8,698,000	2,672,000

These nine farm types produce around 22 million tons of rice, 2.5 million tons of maize and 450 thousand tons of soybean. These crops are either processed or consumed directly. The different actors in the processing industries and an analysis of consumer behaviour will be given in the following section.

5. Food Processing and Marketing: Major Sources of Employment Growth in the Rural Area

Processing and marketing of agricultural produce play a major role in Indonesian economic development. The so-called vertical diversification of the agricultural sector is a major source of employment generation at both rural and urban levels. It is also an effective means of supporting the adjustment of agricultural supply to new consumption habits through the development of a new range of processed food and the indirect use of staple crops for animal feed production.

5.1 Role and forms of agribusiness in Indonesia

In rural areas, food crops processing and marketing allow households to expand the range of their income sources, thus giving more leeway for marketing their agricultural produce (delaying marketing until price seasonal variations are more rewarding). Primary processing of raw material such as production of cassava starch from fresh tubers also increases income at the farm level and smoothes marketing calendars.

In urban areas, food processing provides employment opportunities not only for raw material processing in itself but also for prepared dishes retailed under various forms (small restaurants, street food vendors, etc.). CBS food consumption and expenditure surveys (SUSENAS) record a steady expansion of the budget share for prepared food from 5.1% in 1990 up to 8.5% in 1996. The prepared food budget share is higher for urban consumers, up from 6.5% in 1990 to 9.2% in 1996. Simultaneously, the average budget share of cereal direct consumption decreased from 18% in 1990 to 12% in 1996. Expansion of prepared dish consumption is not only related to changes in consumer diet (more animal protein and less cereals) but it is also a consequence of new practices in taking meals at home and outside the house. More and more women are working outside the house, and thus have less time for preparing meals at home. Activities located farther away from the house force people to take their lunch away from home.

Three types of food systems are now catering to the needs of Indonesian consumers, apart from self-consumption and food preparation within the house.

The traditional food system includes primary processing of staple foodstuffs such as the conversion of paddy into rice, the making of maize flour, or traditional soybean derived products such as *tempe* or *tahu*. These commodity systems involve mainly small to middle scale processing units using simple technology. These units are widely disseminated in both urban and rural areas.

The development of the agri-industries is closely linked to indirect use of agricultural food products for animal feed in particular. This branch consists mainly of medium to large feed mill plants, concentrated around the main urban centers. Agri-industry has enjoyed a quick growth of about 15% per year during the last decade.

These activities have expanded rapidly to respond to the increasing demand of the booming poultry industry. Between 1990 and 1996 the broiler population increased from 327 million birds up to 770 million birds, while the native chicken population, less demanding in prepared feed, has only increased from 201 millions birds to 265 million birds. The growth of the poultry industry is about 20% per year and it is 12% for egg production.

The third food system focuses on the production of elaborated food, such as instant noodles, biscuits, and canned food. It corresponds to the most progressive side of the consumption pattern. It encompasses middle-sized production units (having around 50 workers) with a market niche to larger production units implemented by large Indonesian and foreign food companies such as Indofood and Nestlé.

The last two systems are more dependent on world markets for raw material supplies. In particular, the increasing volume of wheat, soybean meal and maize imports are closely related to the rapid development of animal feed, biscuit and snack industries. However, the production of traditional soybean food also depends upon supplementary supplies of imported soybean grain. Thus, the increasing complexity and diversity of the food crop processing industries is linked to trade policy.

5.2 Data on agro-industries.

The national industrial statistics (CBS 1991) considers four categories of industry: large (more than 100 employees), medium (from 20 to 99 persons engaged), small (from 5 to 19 persons), and cottage or household industry of less than 5 persons. Data for small industries and households are available only on aggregated form. Disaggregated data from the CBS survey of 1991-1992 are very difficult to use, as they need a lot of cleaning. Unfortunately, 61% of the firms in the food industry are household industries (CBS 1995).

Two main difficulties have to be overcome with the data available. First, there is a downward bias due to non-declaration of activities because of tax fear, the seasonal characteristic of the activity and its small scale. Second, household industry usually uses family labor which is not paid. Its estimation is difficult because of the various activities in which family members are involved simultaneously. It is sometimes declared, sometimes not, especially when it is part-time employment. This explains why rural employment in off-farm activities, estimated at around 2.5 million, appears as less than 1 million in official statistics.

Detailed data on cost and returns exist for medium and large-scale industries. The problem with these data is that industries are engaged in several activities. For example, in the rice milling and husking industry outputs are not only rice, fine bran, bran, and broken rice but also maize, dried cassava, groundnut, tapioca flour, maizena, etc. These data are suitable to study aggregate trends of the subsector but do not allow an analysis at the production unit level. The main features of processing industries in Indonesia, as recorded in official statistics, are the following. They are characterized by high growth in terms of added value as well as employment. In manufacturing as a whole, agribusiness shared 62.7% of the value-added in 1971 and 68.7% in 1995 (Saragih and Tampubolon 1996). The food processing industry shared 11.56% of GDP in 1980 and increased to 15.29% in 1990. The growth of the food industry in Indonesia almost doubled within the last five years, particularly in the areas of bakery products, grain milling, cooking oil, canning, and beverage industries, where each industry type had more than 100 establishments by 1990. Grain milling, cooking oil, canning, and beverage industries almost doubled in number of establishments. In 1990, the total number of medium and large-scale food industry establishments was 3,355 with a total of 535,336 workers. Considering the number of workers, medium-scale industry was dominant. There were 2,951 medium-size industries (87%), while the rest were large food industries (13%). However, considering the number of workers employed in one establishment, large industries contribute about 80% of the total employment. The processing of food crops considered in this study is still a small share of the whole agribusiness sector, and represented only 1.85% of GDP in 1980 and 2.98% in 1990.

This sector still represents a small share of employment: 11% of the active population was engaged in the manufacturing sector in 1993, and only 3% in the food industry. The food and beverage sector represented 0.3 million workers in 1980 and 0.6 million in 1990. The growth is even sharper if only food is considered: from 0.1 million to 0.36 million in 1990 (Amang et al. 1996). Processing of soybean and rice as well as the broiler industry carry around 400,000 jobs. Between 1974 and 1986, the annual growth rate of total workers in the processing industry was 7.1% in soybean-based industries and 9% in the krupuk industry (Bottema 1995).

At the same time, food processing is often performed in cottage industries, for which no detailed statistics on production costs are available. In order to promote food industry development in rural areas, the government established 2,069 centers for small-scale food industries throughout the country in 1991. In 1990, the total number of small-scale food industries was 602,168 units (including tobacco) which absorbed 1,996,094 workers.

5.3 Information by type of product processed

Case studies at the village level provide some information on processing by households. Nevertheless, a wide variety of processing technology, equipment and general conditions prevails and this makes it difficult to evaluate costs and returns.

5.3.1 Rice

Rice is processed either in small mills at the village level (about 14% of production), generally owned by a rich farmer, or in a larger factory (68% of production) (Bottema 1995). Per capita income increases have generated a shift in consumer preference toward rice of higher quality or rice with lower percentage of broken grains. In addition, the marked seasonality of paddy production makes post-harvest operation (drying and threshing) critical for efficient storage of the production.

With the diversification process, paddy is no longer considered solely as a source of food, but also as a source of animal feed. It is commonly used as a source of feed not only directly by poultry producers, but also by the feed industry itself. Even though maize and cassava starch are the major sources of calories in animal feed formulae, rice bran provides a sizable amount of input for these industries.

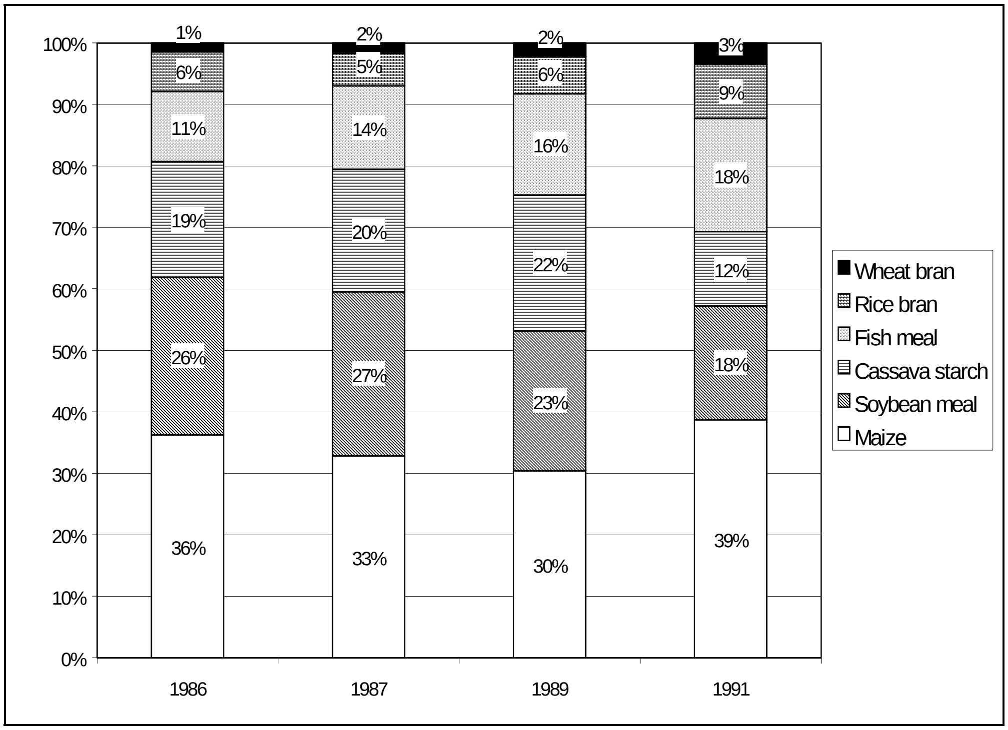
Actually, rice has a very high potential for processing into rice sticks, rice noodles, rice chips and other types of rice products. This, in turn, could be used as substitution for imported wheat flour, provided the rice flour is reasonably economical.

5.3.2 Maize

Maize has a remarkable diversity of end uses. It is consumed as a staple food in a variety of forms. Maize use depends upon its variety and quality characteristics: white or yellow. Most of the processing takes place at the household level. Cracked maize is the major form of maize consumed in East Java, but maize is also sometimes consumed fresh, or in noodle form processed by factories in Central Java and South Sulawesi.

Maize is often processed by rice millers, one or two of which can be found in each village, who annually handle between 300 and 500 tons of each crop (Yonekura 1996). Most of the large wholesale traders in urban areas operate processing units such as rice mills, tapioca flour mills and tahu factories.

Figure 5.1 Share of main inputs in the feed mill industries in volume.



Source: Computed from CBS, Large and Medium Scale Industry Statistics, various years.

While direct consumption of maize tends to be decreasing, maize is a core commodity for animal feed. For industrial animal feed, it represents the main input, and poultry raisers represent the biggest share of maize utilization for animal feed. They buy maize on the local market and supplement it with industrial feed with high protein content.

While feed mill utilization of maize can be estimated on the basis of data published by the feed millers' professional association, it is more difficult to estimate the distribution of the maize market between food use and animal production. After deducting seed and losses, the average volume of maize available for the 1988-1990 period can be estimated at 6 million tons. Feed miller requirements for this period were around 1.6 million tons (Kwanluthay 1995). If one refers to the per capita direct consumption of maize and derived products (such as flour) reported in the SUSENAS, 1 million tons of maize is directly consumed. In fact, this figure is too low because there is no estimation of the maize included in prepared food. Thus a reasonable guess would be to estimate maize utilization for human food at around 1.5 million tons, while the remaining 2.9 million tons correspond to livestock production direct utilization.

5.3.3 Soybean

In the Indonesian food system, soybean was originally used for making foods such as *tahu* (soybean curd) and *tempe* (fermented soybean snack) and *kecap* (soybean sauce) for direct human consumption. Tahu and tempe are mainly produced in small and cottage industries. For instance, for 1986, the only year for which small, medium and large-scale industry statistics are available, the respective share of each category in tahu supply can be estimated. On the basis of the per capita consumption in 1986, the total market volume can be estimated at 1.2 million tons, of which large and medium industries only supplied 22,500 tons, a mere 2%. Small scale industry production can be estimated at around 73,500 tons, around 6% of the total estimated production. This means that cottage industries provided 90% of the total market. These estimations are substantiated by primary data collected from the Tahu and Tempe Processors cooperative branch in Bogor. Processors that handle less than 30 kg of soybean per day represent more than 50% of the tahu supply (Lançon 1995a & b). It is important to stress that tahu processing technology does not vary according to the processing unit size. Actually, large tahu making industries are an aggregation of small processing units handled by one or two workers. These units are often hired on a daily or processed volume basis by processors/retailers who also take charge of distribution of the tahu to end users (consumers, street food shops, and restaurants). Tempe production requires fewer tools than tahu and is almost entirely done by small and cottage industries.

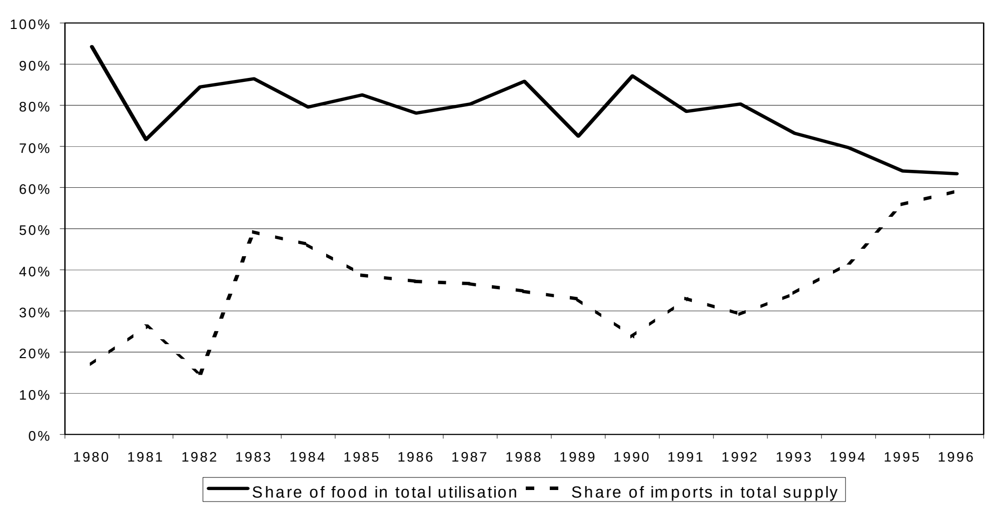
Apart from the introduction of mechanical grinders and fuel boilers for tahu making during the eighties, few technological innovations have been introduced. There is almost no return to scale of economy in these activities which remain labor intensive (Irawan 1989).

Soybean sauce industries are larger in size compared to tahu and tempe units. There are more costs involved, in particular for the packaging of the sauce in bottles. The markets are more and more dominated by branches belonging to agro-food conglomerates.

Most of the issues related to the agricultural diversification process can be addressed through the case of soybean. With the rapid development of poultry and other livestock industries, soybean became a strategic commodity for the agro-industrial sector. Demand for both food and feed utilization increased rapidly during the eighties, and the development of soybean production to reach self-sufficiency was a main objective of the agricultural policy. To support local producers, the soybean market has been highly protected during this period, under the control of BULOG. The logistic agency has been the sole importer of soybean meal until 1996 and of soybean grain until 1997.

This policy option translates into higher soybean prices on the Indonesian market, which was favorable to farmers but unfavorable to processors who faced constantly increased input costs. Various surveys carried out during the decade show that the soybean food processors' margin has been compressed (Lançon 1995a). Processors' net income was above 30% of the gross income in 1982 while it was around 20% ten years later. Concurrently, the share of soybean in the total cost of inputs increased from an average of 70% at the beginning of the eighties up to 90%.

Figure 5.2. Evolution of soybean food share in total soybean utilization and importation in soybean supply.



On the soybean meal side, limited investment in soybean crushing capacity (there is only one crushing unit in Indonesia with an annual capacity of 250 million tons) and import control result in higher prices for feed millers. Based on CBS industrial statistics, the price of soybean meal increased from Rp 325 per kg in 1986 to Rp 772 in 1991. The price of soybean meal relative to other sources of protein for feed formulation increased sharply. While soybean meal price was equivalent to 0.64 of meal flour price in 1986, the ratio was 2.23 in 1991 (Lançon 1995b). This increase in soybean meal relative prices caused a steady decline of its share in feed formulation, from 28% in 1986 down to 18% in 1991. This policy became a heavy constraint for development of the poultry industry. Since 1994, the government of Indonesia has gradually eliminated trade regulations on soybean production. In 1996, soybean meal importation has been entirely liberalized, and as of July 1997, BULOG was no longer the only importer of soybean grain.

As shown in the Figure 5.2 the Indonesian soybean commodity system experienced notable changes during the last decade. It is shifting from a traditional human food oriented system toward an animal feed system which absorbs almost 40% of soybean supplied (soybean meal has been converted into soybean grain equivalent). Indonesian soybean production has shown an impressive growth in 10 years (8% a year), and in 1994 the share of imports in total supply exceeded 50%.

5.3.4 Cassava

Besides fresh cassava consumption limited to home-consumption, cassava is processed into starch, dried cassava (gaplek, opak) and cassava flour. Starch production is performed by households, medium and large units. The production capacity of households is about 4 tons of fresh root per day; it is around 50 tons a day for the medium scale and more than 100 tons a day for the large scale. The technology for household and medium production has not changed much over the past 50 years. Production with large plants was introduced in the mid-seventies with Thai equipment. In 1980, six plants were recorded with a production capacity of 200 tons.

Like soybean, cassava status shifted from that of a traditional component of human food prepared by small scale and cottage industries towards a greater integration within agro-industries using cassava for feed meal. With the development of cassava-based feed formulae in Europe, Indonesian production was partially exported in the form of cassava pellets. Although the Indonesian share of world production is limited to 10%, it represents the second largest cassava exporter behind Thailand.

Cassava use in the Indonesian feed industry is, however, limited because it does not fit well for poultry feed formulation which represents the largest share of the feed market in Indonesia.

5.4 Trade and price formation

The efficiency of trade and transport activities is important for economic development in terms of both price formation and employment. Trading activity is governed by transaction costs and expectations on price differentials, both in time and space. Trade flows between regions are a main variable in price formation, and the dynamism of this activity determines the level of market integration. Some ideas on the trade flow between provinces have been presented previously. Transaction costs cover transportation, loading and unloading, risk of trading and handling. If transaction costs are not too important, markets are integrated and prices move together. The transaction costs define a band, in which trading with other markets is not profitable, and where local supply and demand determine prices. To address the impact of policy, it is important to address this question in order to evaluate, for example, if a change in local supply will lead to a change in price, modifying consumers' welfare and farm income. Several studies conclude that markets are integrated on Java at least for maize (Timmer 1989b), cassava (Falcon et al. 1984), and for rice (Trotter 1992). The good level of transportation facilities in Indonesia, especially for the Java lowlands on which this study focuses, adds credibility to the assumptions of exogenous prices representing world markets and interventions isolating the domestic markets. The fact that some commodities are eventually exported and imported in the same year (maize) shows that transaction costs are not too high. Nevertheless, if isolated farm types would be added into this model, local price formation, or at least penalty on prices to represent transaction costs, should be included.

At the local level, these activities involve a lot of different actors, mainly from the informal sector and mixed with other activities such as processing or farming. It is, for example, common in Indonesia for the farmer and his wife to go themselves to the market (*pasar*) with their baskets or for a larger volume of product, with a bicycle (*becak*). At the other extremity of the wide range of socio-economic conditions, large collectors often own a rice mill and are involved in processing as well as in trading. Trade involves retailers, collectors and wholesalers, and each type covers a wide range of situations, scale of activity and area of business. Some studies at the village level give a wealth of information on this topic. Hayami (1993) undertook a full analysis of trading and marketing in two upland villages of West Java through margins and wage rate. Yonekura (1996) analyzed the marketing system of maize in East Java. Emphasizing its diversity, he analyzed the comparative efficiency of the various actors and scale. Trade involves many actors and forms which means that trade represents a lot of employment. It is difficult to evaluate because of the multiplicity of activities and the informal characteristics.

Given the richness and diversity of market activities, it is difficult to generalize sufficiently to represent trade in the model by simple technical coefficients. Representation of market forces in a spatial way, leading to price formation and trade flows according to transaction costs and seasonality should be considered in the next prototype. Many studies are now in process on various aspects of this question, such as the concept of local economy and spatialization (Bottema 1995). Further developments of MATA will try to represent this process.

5.5 Indonesian consumers

It is necessary to consider consumption in the evaluation of the impact of food crop trade liberalization. Change in prices of food products, following a modification of policy, will lead to a change in consumer expenditure and modify nutrient status. Consumption will be more or less affected, according to the socio-economic situation of the economic agents, but even slight modification of prices can be harmful for the poorest. To be able to estimate in advance the effect of policies, and to eventually allocate some compensation to target groups, consumers' situations and behaviors have to be studied and a typology is necessary to define the main types of economic agents. Moreover, change in consumption will affect external trade.

In 1990, average caloric intake per day in Indonesia was estimated at around 2,500 kcal. This consumption level can be considered exceptionally high given Indonesia's per capita income. It is also high compared to other countries in the region.

The increase of per capita food consumption during the past twenty years is high. Rice consumption increased from 297 g in 1970 to 411 g per person per day in 1990. The daily energy intake per capita increased from 2,042 kcal in 1970 to 2,364 in 1980 and 2,654 in 1988 (World Bank 1992). Surprisingly, despite its high level, rice consumption is still increasing with income. The share of root crops in total calorie intake declined sharply, by 50% over the past 20 years, but consumption is still above that in other Asian countries with comparable development levels. The share of meat, especially chicken, fish, fruit and vegetables in expenditure, is still low but increases quickly with income level. Maize demand is increasing quickly because of development of the feed industry.

Although average food consumption per capita has increased substantially in Indonesia in the past twenty years, a large group of consumers is still in an economic situation where a small increase in prices can have negative impact and 3.34% of the population are still considered malnourished (Amang et al. 1996). One argument for soybean trade liberalization, for example, is that it will decrease the price of this commodity which is rich in proteins, and thus increase the welfare of the poor. This situation makes it useful to evaluate, ex ante, through a study of dietary patterns and consumer behaviour, the impact on consumption of changes in prices.

A typology of consumers has been performed in order to assess the impact of policy measures on nutrient intake according to the economic situation. Data from SUSENAS (1990) were used. Two major difficulties have to be overcome with these data: first, they record only expenditure, thus home consumption, which can be important in rural areas, especially for rice, vegetables, chicken and cassava is not considered. Second, there is a downward bias estimation for all commodities compared to the data from the Food Balance Sheets. The main reason is that “meals away from home” are included in a “prepared foods” category for which only rupiah expenditures are reported. Thus, primary products that are consumed as prepared foods are not included in the per capita consumption estimates. This problem has become worse over time: from 4.3% in 1970 to 10.6% in 1987. In urban areas, the share has reached 16.6%. In the case of wheat, for example, which is generally consumed as cakes and noodles, the consumption estimation based on the survey data is less than one-third of that estimated from import and stock data (Mears 1981). To compensate for this downward bias, prepared meals are included in the consumption estimate, assuming that it has the same content as the global expenditure by type of household. Then the data were adjusted (upward for rice and soybean) to get an aggregated consumption consistent with other sources of information.

Five groups of consumers were obtained by a principal component analysis, considering socio-economic region, geographic region and consumers’ income level simultaneously. The advantage of this grouping approach is that one can identify the consequences of policy measures for a specific income level in a specific region. It is thus posible to address policy impact on regional development as well as to target a population group in terms of income level.

Sixteen variables are used in the principle component analysis: daily calorie intake per capita, daily protein intake per capita and commodity shares of total calorie intake for the given group of products (rice, maize, cassava, chicken meat, other meats, eggs, milks, tahu, tempe, oils, sugar, fish, vegetables and fruits). At the household level, these commodities contribute more than 90% of consumers’ calorie intake.

- Group 1 (H1) includes 3.1% of total persons. It is the poorest group with low income, about $ 5 per person per month on average (at an exchange rate of Rp 2,200/$), and 37.5% of this group has an income under $ 4 per month. Most households 97.5% in this group are located in rural areas, mainly in Java (66%), Nusa Tenggara (23.6%) and Timor (6.5%). Their consumption pattern is characterized by low calorie and protein intake. Maize represents a large share of total calories.
- Group 2 (H2) represents 40% of the sample. With an average income of $ 10 per person per month, it represents the middle-low income group. Further disaggregation of this group allows us to distinguish:
  - H21, which represents 75% of this group and contains mainly rural households (63%) distributed in all provinces.
  - H22 represents 25% of the group H2; 80% of this sample are located in urban areas, mainly in Java, Lampung and Sulawesi.

- Group 3 (H3) includes 56% of the population. It represents the middle rich income group with an income of $ 45 per capita per month. It can be further split into 2 categories:
  - H31 represents 51% of H3, 79% of households of this group are located in rural areas, mainly in Java and Sulawesi.
  - H32 represents 49% of H3; mainly located in urban areas (66%). They are distributed in all provinces.

These five groups and their geographical locations will be used in further analysis, when trade between provinces will be considered. For the purpose of this prototype, it was decided to focus only on Java, with the three main categories of consumers defined above. In fact, given the population density on Java, all the groups are considered. For the poorest households, for which the impact is especially worth considering in the study of the impact of liberalization, 66% are located on Java.

- The low income group is characterized by an average food expenditure of around U$ 40 per year. It represents 1.5% of the Java's population.
- The middle-low income group spends around U$ 80 per year for food, it represents 60.5% of the Java's population.
- The middle-high income group spends on average around U$ 170 per year on food. It represents 38% of Java's population.

The first group is included, despite its small size, because its characteristics designate it as the malnourished population and thus the impact of policy on nutrient intake of this group should be carefully considered. The food expenditure of this group covers only around 27 g of protein and 1,300 Kcal per day which means a deficit of 39% in protein and 35% in calories in comparison to the minimum requirements of 46.2 g of protein and 2,150 Kcal per person per day. It is likely that this group relies partly on consumption of its own products for its nutrition and that the deficit in food intake is lower than that implied by the expenditure figures. Nevertheless, these households may face seasonal food shortage and malnourishment.

The second group suffers deficits of 11% in protein and 6.1% in calories, while the food intake of the third group is well above the recommended level.

A comparison of the share of each product in the total food expenditures for the three categories of households is illustrated in Figure 5.3. The food and non-food expenditures in 1990 and 1996 for each category of household are illustrated by Figure 5.4.

Figure 5.3 Distribution of the food expenditures by main product for the three groups of households.

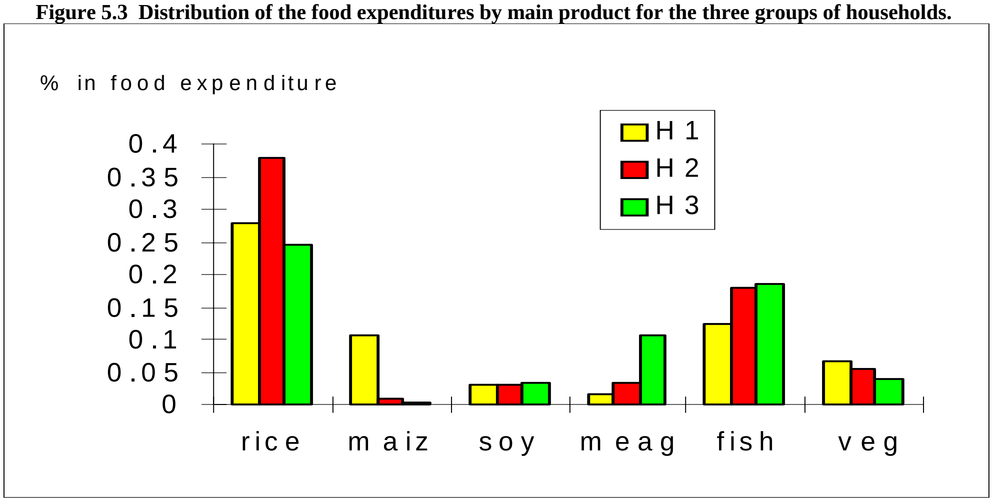
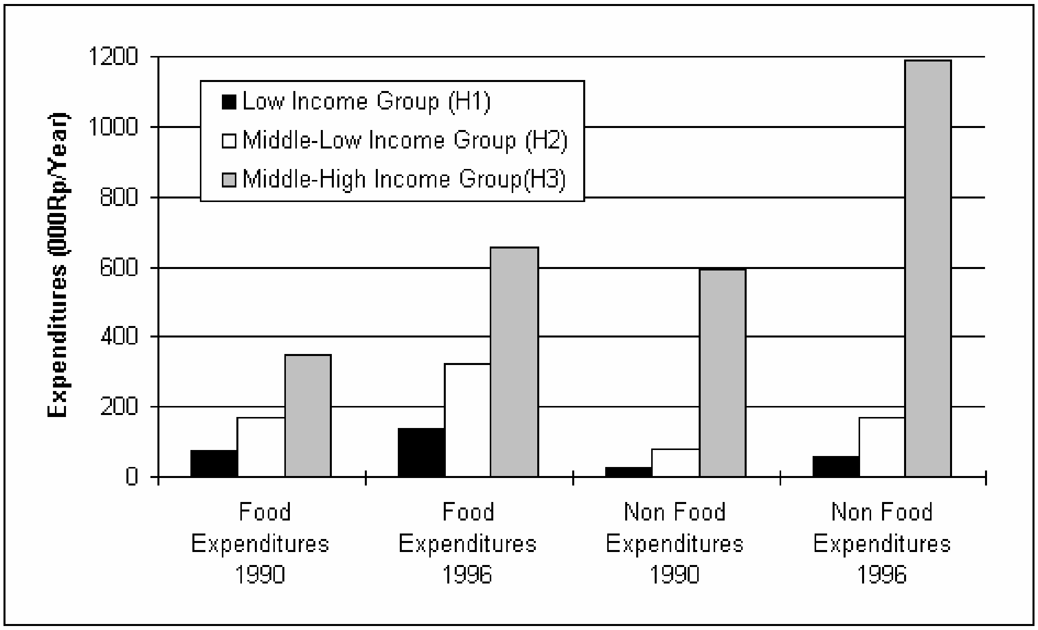


Figure 5.4 Food and non-food expenditures in 1990 and 1996 for the three categories of households.

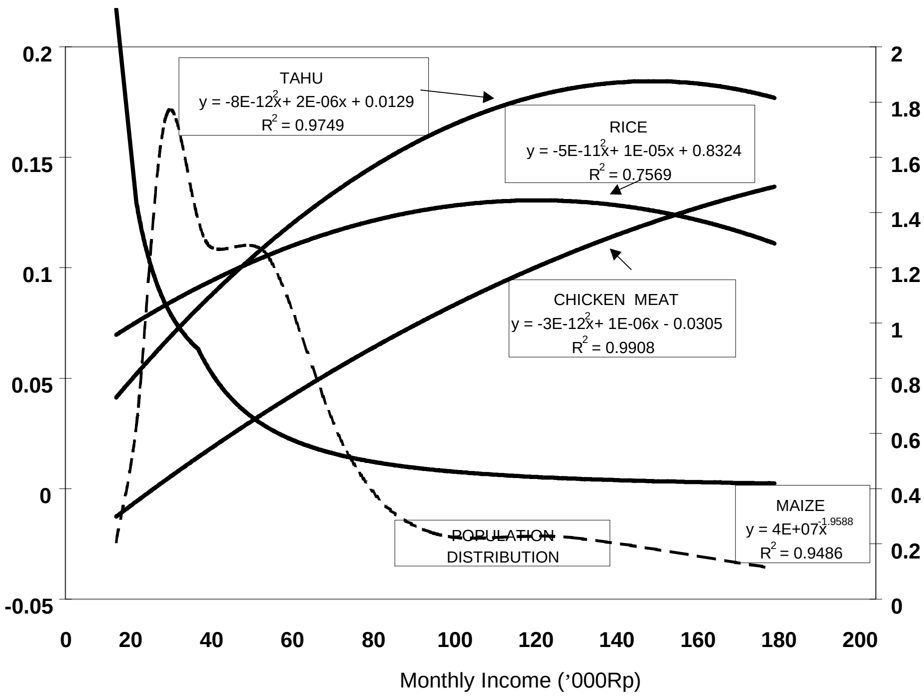


Figures 5.3 and 5.4 illustrate the diversity of consumers' situations and levels of expenditure for both food and non-food products. The increase is important because of the use of current prices for both years while the inflation rate was around 10% yearly. It is a bit quicker for the poorest group, H1, both for the food and non-food expenditures. Non-food expenditures represent a small share of the total household expenditures for consumption for the poorest group and more than 60% of the total expenditures for the middle-high income group (H3).

In Java, the nutrient pattern is characterized by a dominance of rice. It accounts for 35% of calorie intake for the low income group (H1), for 67% for the middle-low income group (H2), and for 57% of calorie intake for the middle-high income group (H3). The share of rice in protein intake is respectively 32%, 60%, and 50%. The poorest group relies highly on maize for nutrient intake.

Processed soybean (tempe and tahu) is a main contributor of protein intake and represents 11% of total protein on average. For the middle-high income group, beef, chicken, eggs, soybean and vegetable expenditures are increasing quickly. Rice expenditure is still increasing, indicating that the saturation level for rice consumption is still not reached for a large part of the population. Population growth and dynamic response of consumption to income increase continue to result in a low growth of rice demand.

Figure 5.5 Per capita consumption of selected foodstuffs according to income changes.



Changes in food consumption pattern are marked by a decrease of direct consumption growth rate with per capita income increase. Figure 5.5, computed from SUSENAS (1993) data, shows that maize direct consumption declines sharply when per capita income increases, while rice consumption tends to stagnate for monthly income level over Rp 100,000. Income elasticity of tahu consumption tends also to decrease for higher incomes, while the growth rate of chicken meat consumption is almost linear.

Although the largest share of the population is still in the range of positive income elasticities of per capita consumption of traditional staple foods, direct human consumption of staple food is expected to decline in the near future. However, population growth and the shift from direct to indirect consumption of cereals will likely increase total demand for cereals according to the dynamics of substitution between rice, wheat and starch-based staples such as noodles. The Indonesian feed industry has grown rapidly over the past decade, accompanying the quick development of the poultry business.

6. MATA: A Tool for Policy Analysis

6.1 Introduction

Chapters 2 to 5 give an overview of the necessary information for the analysis of impacts of policy on the agricultural sector. The information gathered on economic actors of the sector will be used to represent it for simulation purposes. Details of the information depend on the question addressed, but only this kind of approach, at production unit and household levels, can provide adequate results if market imperfections and social and regional disparities have to be considered. To collect all these data is highly time consuming, and to analyze it in a consistent framework, taking relationships within the agricultural sector into consideration, is also difficult. This is what is proposed in this chapter through MATA methodology.

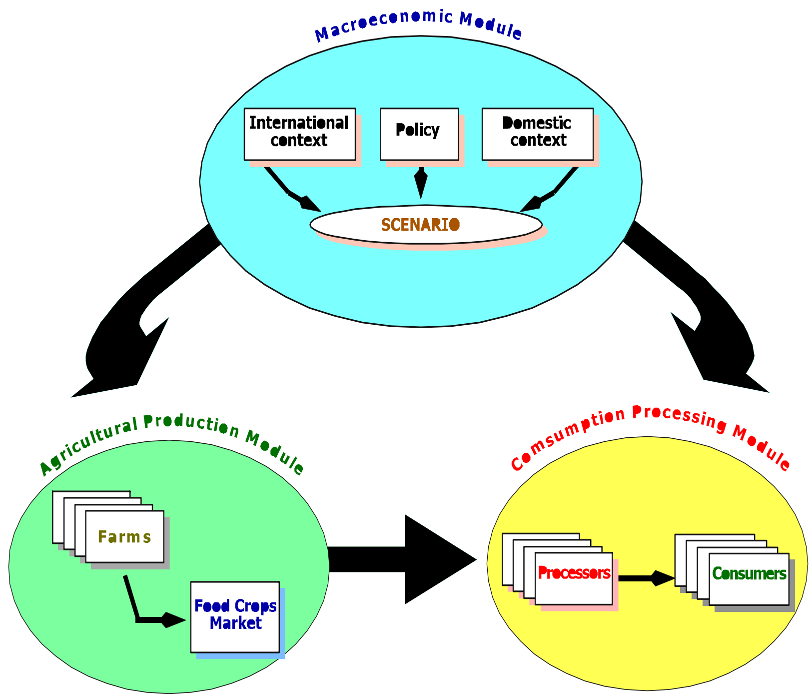
MATA is a micro-macro simulation model which evaluates the impact of any modification of the socio-economic context on the economic performance of the agricultural sector and gives information on the specific situation of each economic agent (Gérard 1997). Scenarios are defined by users by combining parameters changing international or national context as well as economic policy. A large variety of scenarios can be defined. It includes change in international markets as represented by change of prices in external markets or of external demand, change in the national economy induced by domestic economic adjustment and macro-economic policy evolution. Trade and monetary policy, population and income growth, wage increases induced by domestic policy or by tension on the labor markets, as well as sector-based credit policy, subsidies and input and output taxes, can be introduced in scenario form. Impacts are evaluated on agricultural production, farm income, environment variables, consumers, nutrient intakes, activity levels in processing industries, external trade and employment level in the whole sector.

6.2 Three interrelated modules

MATA consists of three modules (Figure 6.1). The macro-economic module describes the environment in which farmers', processors' and consumers' decisions take place. The production module represents farms. The commodity chain module represents processing industries and consumer behavior. So the flow of the product from farm gate to consumers' table is represented. The three modules are linked. The production module competes with the international market to supply the commodity chain, which will process the raw material into final products consumed by consumers.

To capture the heterogeneity of the agricultural sector, actors of each module were split into homogenous groups. Non-linear programming models reproduced the decision process of each type of economic agents with details on their economic situations. The diversity of opportunities and constraints related with agro-ecological and socio-economic context as well as the variety of objectives (income or wealth maximization, consumption level, etc) were considered. An optimization process determined the level of decision variables. Production commercialized by region and type of product is determined in the agricultural production module. Detailed results on farm economic performance are available. In the consumption-processing module, prices of processed products and levels of consumption are determined. Nutrient levels are calculated as well as the activity levels in processing. Results on employment and external trade are calculated, combining output from the two modules, in the macro-economic module.

Figure 6.1 MATA is composed of 3 modules.



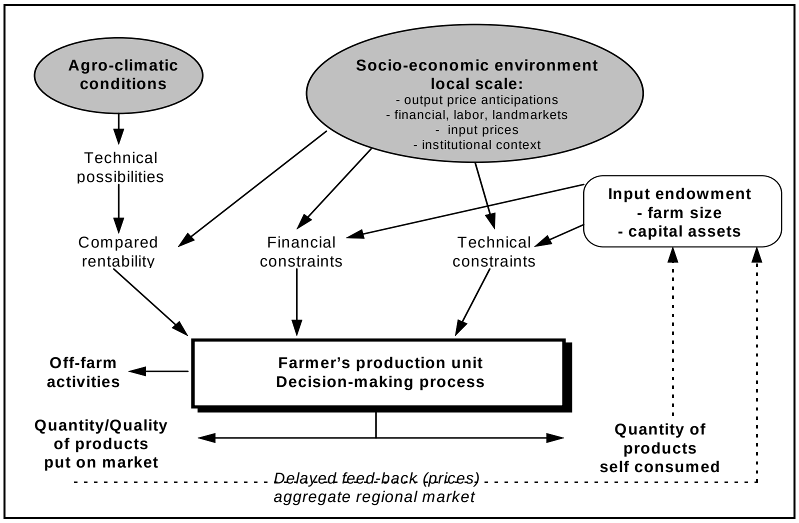
6.2.1 Macro-economic module

In the macro-economic module, the economic context in which the actors of the two other modules make their decisions is described. Trends are given, on macro-economic variables such as population and income growth, evolution of employment opportunities in the non-agricultural sector, interest rate, and relative prices. The scenarios are defined in this module in combination with policy measures which affect these variables. This can be done directly from a friendly interface (Chapter 8). The global impact of policy on employment in the agricultural sector or on external trade, for example, is calculated in this module by adding up the results of the agricultural production and the commodity chain modules.

6.2.2 Agricultural production module

Agricultural production is represented by a set of farming systems, determined by a typology. It is thus possible to consider the high diversity of agro-climatic and socio-economic contexts in which agricultural activity takes place. First, a zonation is set up to determine homogeneous areas in terms of agro-climatic and socio-economic environment. Second, the typology splits existing farms, in each zone, according to endowment in land, labor, equipment, liquidity and saving. Then each farm is represented through the formalization of the decision process of the farmer by a non-linear programming model. Figure 6.2 represents this model for one farm.

Figure 6.2 Farm model.



Opportunities and constraints are determined by agro-climatic and socio-economic conditions for each type of farming system. Then, an objective function allows calculation for each farm type of labor allocation between on- and off-farm activities as well as the land allocation between crops and techniques. After the volume of the output is calculated, that part of the production commercialized is used to calculate the economic performance of each farm. The results of each year determine the starting point of the following year, by updating farm endowment in factors and liquidity.

In the Java lowland application (Erwidodo and Gérard 1997), it is assumed that each farmer chooses from a set of activities and techniques those that maximize the expected utility of wealth under simultaneous constraints (Equation 1). Wealth is defined as the total value of the assets at the end of the year. In order to consider the farmer's risk attitude, the mean-variance analysis (Markowitz 1959), slightly modified to introduce endogenous risk aversion, is used.

Various objective functions are possible with the MATA model. Farming system models usually use profit maximization in market economies and self-sufficiency objectives for subsistence economies. Here, wealth is used as a proxy for the total value of the farm, because the model is dynamic but the optimization is static. Because it is important to allow the state of assets to be modified and to comprehend this choice in the model, and also to account for risk consideration (i.e. it is less risky to own gold than buffaloes), it was better here to consider wealth, and, thus, expected stock rather than flux. However, tests were made with expected profit (still taking risk into account) for the case of Java, leading to the same results. The constraints in the case of Java define a small set of activity combinations as optimum, and the model is not sensitive to the objective function formulation.

(1) $\text{Max } U(W_F) = E(W_F) - \frac{1}{2}\sigma^2_{WF}\, AV_F$

where $E(W_F)$ represents the expected wealth for the farm F, σ^2_{WF} the associated expected possible deviation and AV_F, the risk aversion coefficient, which is endogenous and inversely proportional to the wealth.

(2) $E(W_F) = \Sigma_a A_{F,a} * E(P_a)$

$A_{F,a}$ represents the volume of assets “a” owned by the farm “F” and “$E(P_a)$” the expected price associated with it. Thus, wealth (Equation 2) is defined as the sum of the value of assets (land, equipment, livestock, cash and savings).

The risk associated with a given wealth level depends on the portfolio of activities and assets for the period.

(3) $\sigma^2_{WF} = \Sigma_a (\sigma_a * E(P_a) * A_{F,a})^2 + \Sigma_{act} (\sigma_{act} * E(MB_{act}))^2$

“Act” includes all crop and animal activities and off-farm jobs. $E(MB_{act})$ designates expected gross margin for each activity, and σ_a the associated expected deviation. Covariances between activities are assumed to be zero.

Fixed factor utilization is subject to constraints defined by endowment and possible flux. For example, the land constraint assumes that the sum of land allocation for each crop $J(AL_J)$ represents a smaller or equal area than the land available for cropping activities. This variable is defined by the sum of land owned (Laown), land purchased (Lp) and land rented in (Lrin) minus land sold (Ls) and land rented out (Lrout). Thus for each farm:

(4) $\Sigma_J AL_J \leq Laown + Lp - Ls + Lrin - Lrout$

The same kind of equation determines labor, animal traction and machine allocation.

In accordance with the conditions of input markets, some constraints on the level of inputs used at the village or regional level can be written if shortages occur. If not, they are only constrained by the financial capacity of the farmer, which appears in the cash constraint.

For each period the production cost of each activity (C_{act}) can be covered by cash flow availability coming from the last period (Pcash), current earning activities ($Earn_{act}$), or borrowing (B). If some surplus cash exists, it is transferred to the next period. Family consumption (Cons) as well as investment and savings (Sav) are included in this equation:

(5) $\Sigma_{act} C_{act} + Cons + Inv + Sav = \Sigma_{act} Earn_{act} + Pcash + B + Tcash$

A financial cost is associated with borrowing. Access to credit can be subjected to existing cautions, or globally constrained by a fixed amount for the village or region according to the capital market. Consumption is defined as minimum consumption, representing expenditures which cannot be reduced, such as school costs, minimum clothing and food expenditures, plus one part of the expected profit, defined by a consumption propensity parameter. Investment and savings can be negative if some decapitalization is necessary. For the cost and wage/return of each activity, the time of paying for production costs and the time of earning money have to be carefully determined in order to take into account production lags, which are very important for liquidity constraints of farmers. For crops, the production costs have to be paid at the beginning of the season and the associated earnings, come in only at the end of the season. For outside labor from other farms, consideration must be given to the local rules. When payment is in-kind after the harvest, the lag also has to be taken into account. These lags could be harmful for the farmers, generating cash flow problems and non-linear responses to market incentives (Boussard 1992). Some markets have a small scale of influence and balanced equations may be necessary at village level for renting land, equipment, labor, etc. Similarly, unbalanced equations maybe required, for example, in a labour shortage environment if it is difficult to rent labour in, but not to rent it out.

Time has to be divided according to regional specificities of agricultural production. In the Java lowlands, three seasons are generally considered. The optimization is calculated on a yearly basis according to the expected results of the seasonal activities, in order to consider links between activities of the three seasons. To take into consideration some crops for which production lags are more than one year (e.g. sugarcane), one has to consider a dynamic optimization through several years. This raises problems such as actualization rate, for which results are usually very sensitive. In this study these particular crops were not important enough for the manpower needed. Thus, they are not taken into account.

The decision process leads to land allocation between crops and techniques, livestock activity level, investment and borrowing, and labor allocation between farm and off-farm activities. Decisions are based on expectations of prices and yields, inherent to time lags between decisions and agricultural results. Expectations are subject to information imperfections (Boussard 1987). To approach the concept of rational expectations (Muth 1961), given the fact that prices and yields are determined randomly according to a uniform law around an average, the farmers expect the average gross margins. At the end of each production period, real prices and yields are estimated. These real variables are computed by applying a random coefficient on an average value. The production level is then calculated with 'real variables' at the end of the period and farm endowment for the next period is updated according to the transactions of the previous period. In this way the results of each year are used as exogenous starting parameters for the next period. This methodology was used for a model of French agriculture (Boussard and Gerard 1992) and in a village model for Burkina Faso (Deybe 1998; Deybe and Robillard 1998), in Thailand (Marty 1997) and in Vietnam (Dao The Anh et al. 1997). The model is recursive and dynamic in that sense, because each year is linked with the preceding year, while optimization is static. It is thus possible to consider in current decisions the importance of past results, which determine actual endowment of the farm in terms of liquidity and factor ownership, without using a very large model. The different farm type models are linked together through markets: labor and land markets at the village level and agricultural product markets at the national level.

The formulation based on explicit constraints and opportunities allows a transparent approach, in principle easily adaptable to various economic contexts and policy concerns. The use of technical coefficients for each activity facilitates a multidisciplinary approach, and knowledge from agronomists, pedologists, ecologists and processing specialists can be introduced in the model. The formulation of this model avoids problems associated with supply elasticity estimation and the choice of functional form (Haughton 1986) in a fast changing economy, and allows the existence of inverse supply responses to changes in price (Just and Zilberman 1986).

Because the objective is to identify the effects of policy on decisions, the farm type module is linked with a set of economic variables defining the socio-economic environment in which farmers' decisions take place.

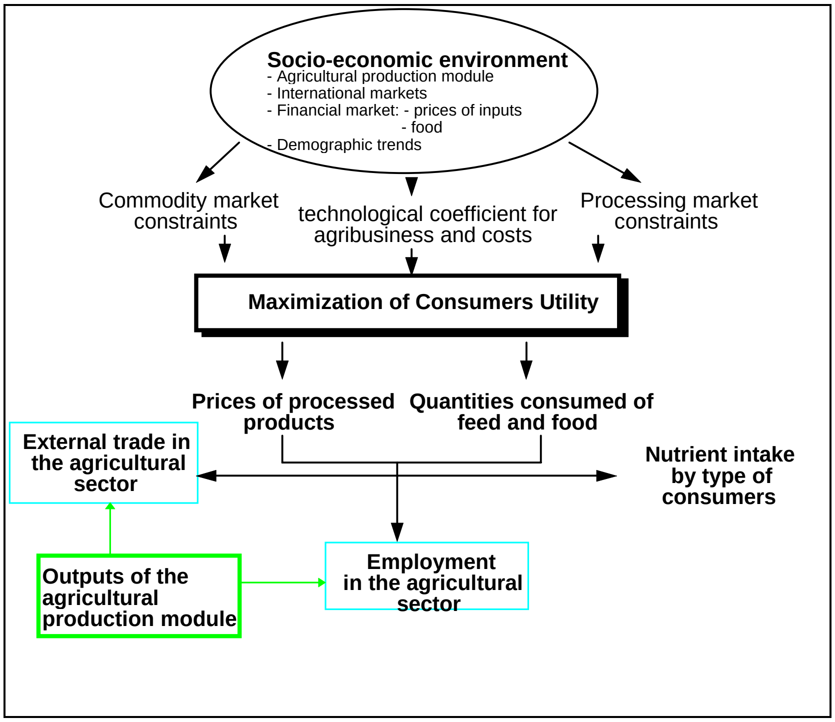
This model addresses policy effects in an original way both at the farm level and, after aggregation of all types of farms, at regional and national levels. It also gives immediate impacts and time lag effects. These features are important primarily because farm heterogeneity will lead to different impacts for a given policy on farm income. It is useful to evaluate these differences in order to quantify spatial and social impact differentials. Secondly, because the reactions of the agents are not instant and their behavior can have delayed impacts (on the environment, for example), it is important to evaluate both short and long term effects. Markets of products or factors are not assumed to be perfect and risk is operationalized, so the idea is to represent as accurately as possible stylized farm situations. With all these features, the dynamics of agricultural supply are better-approached (Nerlove 1979).

6.2.3 The commodity chain module

The commodity chain module represents consumer behavior as well as processing and marketing of agricultural products (Gérard and Versapuech 1997). Consumers are represented by main category according to a typology. The maximization of a utility function determines the quantity consumed for each product. Processing and trade are introduced by technical coefficients.

Because consumers do not react in the same way according to their income and location, it is important to make a typology in order to define major economic situations and objectives characterizing consumers. It allows the splitting of consumers into homogeneous groups in terms of preferences, elasticities and budget constraints. It is then possible to represent all consumers of a group by the same utility function.

Figure 6.3 Commodity chain module.



The linear expenditure system (LES) form has been chosen in the Java model. Other forms for demand used in MATA methodology cover CES function, without processing but including endogenous price formation (Deybe 1998; Deybe and Robillard 1998) and AIDS. The maximization of consumer utility governs the module (Equation 1). At equilibrium, it is assumed that first order conditions hold (Equation 2).

$$(1) \qquad U = \Sigma_h \, POP_h * \Pi_{fc} \, (C_{h,fc} - \gamma_{h,fc})^{\beta}{}_{h,fc}$$

The population (POP) is used to weight the sum of utility by type of household (h). Utility is a function of the quantity consumed (C) of final product and parameters of the LES (β and γ). The γ parameters can be analysed as a committed quantity for commodity i.

(2) Ci = (♑ $_i$ + (♌$_i$ (B - ⋭p_k ♑$_k$)/ pi)

The first order conditions allow calculation of the quantity consumed (C) as a function of the excedent on the committed budget (B - 3p_k ($_k$), price of final product (P), and parameters (γ and β).

Processing and marketing activities represent all activities related with changing the place and form of agricultural products, from farm gate to the consumer's basket. They are represented by technical coefficients describing, for each product and each technical itinerary, how much raw material, intermediate consumption (water, electricity, etc), labour and capital are needed by unit of output. It is possible to represent various technical itineraries for each product and to see the coexistence of techniques and their evolution. However, the use of an integer solver to make this statement operational for economic analysis would be required, in order to represent economy of scale and the required investment to jump from one technology to another. In this prototype it has not been done because of the lack of data on this subject. The table TIO shows all coefficients. Prices of final consumption products are calculated as the sum of the costs induced by transformation (Equation 3). Prices of raw materials are exogenous, determined by international market conditions. Endogenous prices are considered in other versions of the MATA model. In the Indonesian context, because the purpose is to test the impact of liberalization, prices are determined by international markets. Nevertheless, it would be interesting to represent price formation at the regional level, taking into account local supply and demand as well as transaction costs associated with trade with other markets. This has not been done in this prototype.

(3) $P_{fc1} = \sum_{pcp} TIO_{pcp,fc1} * P_{pcp}$

Prices of final products, except animal products (P_{fc1}), are calculated as the sum of the costs, determined by the quantity required (TIO) multiplied by the price of primary product (P_{pcp}).

For broilers, because several combinations can be used for feed, the choice is made by the model in order to meet animal nutrient requirements and to minimize the cost. Technical limits constraining the feed content are also introduced and the price is calculated as the sum of costs (Equations 4 to 7).

(4) $\sum_{feed} FU_{an,feed} * IFE_{car,feed} \geq ANNEED_{car,an}$

Feed characteristics determined by quantity of feed consumed (FU) multiplied by nutrient contents (IFE) should meet the needs (ANNEED) of the animals.

(5) $FU_{an,feed} \leq LIM1_{an,feed} * \sum_{feed} FU_{an,feed}$

(6) $FU_{an,feed} \geq LIM2_{an,feed} * \sum_{feed} FU_{an,fid}$

The quantity (FU) of feed (feed) by animal (an) is constrained by maxima and minima defined by technology (LIM1, LIM2)

(7) $P_{an} = \sum_{iic} TIO_{iic,an} * P_{iic} + \sum_{feed} P_{feed} * FU_{an,feed}$

The maximization of consumers' utility leads to quantities consumed and prices of final products. Consumer nutrient intake can be analyzed for each group.

The consumer choice between products according to change in price and income is thus represented. The competition for secondary crops between human food and animal feed uses is also reproduced in this model.

After solution, results of the model are used for further analysis. The ".L" extension indicated that the results of the optimization are used for these calculations.

The nutrient intake by category of household is calculated by day.

(8) $CARCONS_{h,car} = \Sigma_{fc}\ C.L_{h,fc} * CARC_{fc,car} / 365$

The total consumption of raw material in million tons per year:

(9) $CON_{iic} = \Sigma_h\ \Sigma_{fc}\ TIO_{iic,fc} * C.L_{h,fc} * POP_h$
$+ \Sigma_h\ \Sigma_{an}\ \Sigma_{feed}\ TIO_{iic,feed} * Fu_{an,feed} * C.L_{h,an} * POP_h$

The volume of labor in the processing sector by category of processing in man-years is determined:

(10) $LABC_{fc} = LABVOL_{fc} * \Sigma_h\ C.L_{h,fc} * POP_h$
(11) $LABC_{feed} = LABVOL_{feed} * \Sigma_{an}\ FU.L_{an,feed} * \Sigma_h\ C.L_{h,an} * POP_h$

This module is far less detailed than the agricultural production module, but it could be complicated if required, according to policy questions. However, it allows some evaluation of the impact of liberalization of food crop trade on nutrient intake for different groups of consumers and on activity in processing and on external trade. A more detailed representation of the processing industry, including different technical itineraries and economy of scale would be interesting; it was not possible to perform this during this project given the lack of reliable data and lack of time to collect these data. Nevertheless, it should be possible to include it in this module.

6.3 Data used and base run simulation

MATA mainly uses secondary data and expert knowledge from various sciences. These concern:

- agro-socio-economic zoning, possible cropping activity and techniques, technological alternatives, and impact on environment of agricultural practices;
- typology of farmers, processors and consumers, defining main types of economic agents;
- for each farm type: factor endowment, set of activities, costs and returns, and margin deviations;
- for each consumer: quantities and values of main consumption products, expenditure and price elasticities, trends in expenditure level and in changes in consumer preferences;
- for each type of processor: factor endowment, set of activities, costs and returns, margin deviations, and alternative technologies.

The data collected at the farm level have been presented in detail in Chapter 4 and the full listing of files is available in Chapter 9. Table 6.1 summarizes the main characteristics of the nine farm types representing Java lowland.

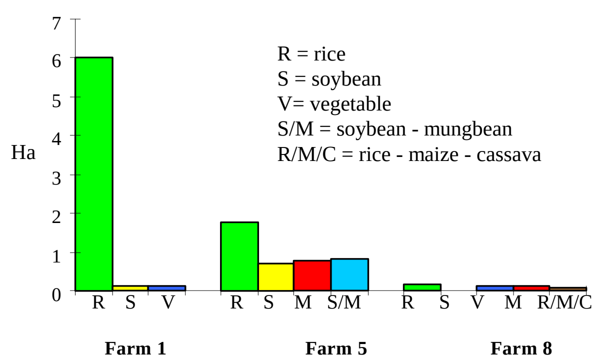
Table 6.1 Main lowland farming systems and their characteristics in Java.

Farming system characteristics	Technical irrigated with high level water control			Simple irrigated with moderate to low water control				Rainfed	
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Area controlled (ha)	2.4	1.05	0.95	1.2	0.7	1.2	0.7	0.35	0.35
Active persons	3.2	3.2	3.6	2.5	2.7	2.5	2.7	2.0	3
Type of land	irt	irt	irt	irt	irt-irs	irt	irt-irs	rai-dry	rai-dry
Cultivated area (%)									
Rice	95	96	94	44	60	56	70	47	30
Soybean	2	1.5	1.3	36	36	8	6	3	2
Maize	0	0	0	19	4	36	24	30	29
Other	3	2.5	4.7	0	0	0	0	20	39
Mechanization	yes	yes	yes	yes	yes	yes	yes	no	no
Yearly net income per cap (million Rp)	2.5	1	0.6	1.6	0.8	1.9	0.9	0.55	0.25
Off-farm income (%)	12	26	36	17	29	18	35	37	40
Animals in total wealth (%)	0.01	6.3	0.3	3.5	8.1	3.5	7	0.2	0.3

Note: land "controlled" is land "owned" + land "rented in" - land "rented out"
irt ="technical irrigated", irs="simple irrigated", rai="rainfed land"; dry="dryland"

The diversity of the nine types of farms representing three different zones of lowland in Java is emphasized in Figure 6.4.

Figure 6.4 The diversity of lowland Java farms.



Non-linear programming models represent these nine farm types are used for the simulations of different policy measures. Then, the analysis is performed in comparison with the base run reproducing current trends in relative prices and the general economic situation (Box 6.1).

Box 6.1 Base run conditions for the production module.

<u>So - Base Run:</u>
- Soybean price increases by 5% and maize by 2.5% per year for Y1 - Y4
- Labor wages for both farm and off-farm increase at 5% per year
- Off-farm activity opportunities increase by 5% per year
- Annual population growth rate is 2%
- Other prices (inputs and outputs) are held constant

Figures 6.5 to 6.7 show that the models adequately represent land allocation through a comparison between the base run results and the original data in the case of three farm types (Farm 1, 5 and 9).

Figure 6.5 Farm 1: observed and simulated land allocation.

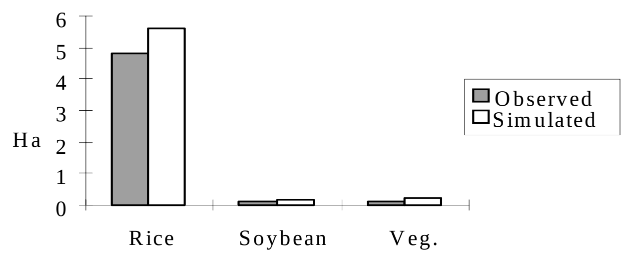


Figure 6.6 Farm 5: observed and simulated land allocation.

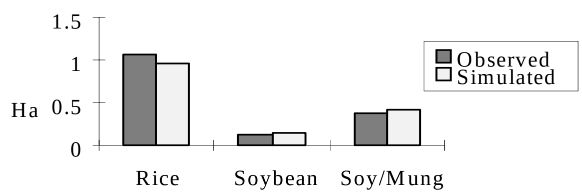
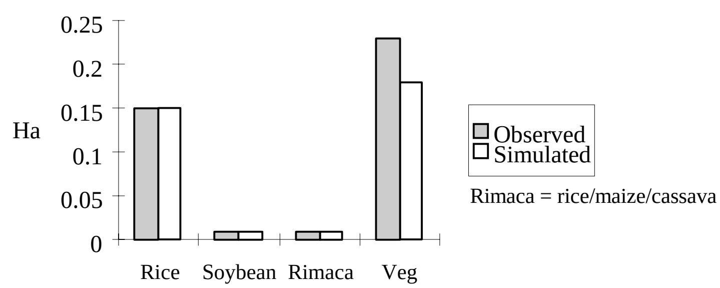


Figure 6.7 Farm 9: observed and simulated land allocation.

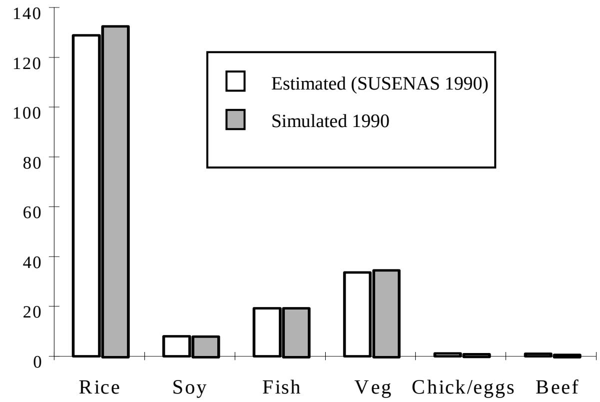


The same exercise has been performed to represent and calibrate the behavior of actors of the processing consumption module. Data used have been presented in Chapter 9 and files can be found in Chapter 8. The nutrient intake simulated and level of consumption from official data fit well for the three groups of consumers (Figure 6.8).

Box 6.2 Base run conditions for the processing/consumer module.

S0 - Base run: expenditures increase 3%

Figure 6.8 Consumption in 1990 for household H2.



The differences between the simulations of the current situation and the observed one are small enough to allow the simulation of other policy options.

7. Impacts of Food Crop Trade Liberalization in Java Lowlands

While GATT and APEC negotiations are under intensive discussion, the strong intervention of government of Indonesia in the agricultural sector is more and more under criticism, both in and outside the country (Pangestu 1995; World Bank 1992). It is thus interesting to try to assess the consequences of a liberalized trade environment for food crops and inputs at regional, consumer and farm levels. Subsidies on inputs have already been progressively removed from 1987 for pesticides and reduced for fertilizers. The changes in fertilizer and pesticide prices have been included in the simulations because the base years of this study are 1989-1990. This permits checking the ability of the model to fit with real evolution after a change in policies.

Thorbecke and Van der Pluijm (1993) point out the importance of a farming systems approach for policy analysis in a country like Indonesia characterized by high diversity. Liberalizing the food crops subsector will lead to changes in prices and variability. The impacts of liberalization of trade will be different according to the number of countries following the deregulation, but there is still great uncertainty concerning the impact on world price levels and instability. According to economic theory, domestic prices will adjust to international prices except if transaction costs are too important or if the domestic production is high enough in comparison with the world production to influence world prices. With respect to rice, Indonesia is a large country facing a small world market, so we consider that Indonesia has no impact on world market rice prices. In the first scenario (S1), domestic prices are assumed to adjust with international prices in terms of level and variability. The adjustment begins in year 2; relative prices considered are those before the devaluation of 1997. Rice prices are stabilized on the domestic market (Chapter 2). Moreover, domestic prices are somewhat higher than international prices. The same may be said for soybean and maize in terms of price variability, while price levels of maize are similar to international prices and the price of soybean is about 50% higher than in the international market (Gonzales et al. 1993).

The change in relative prices and in random coefficients representing their instability is summarized in Box 7.1.

Box 7.1 Conditions of the first scenario (S1).

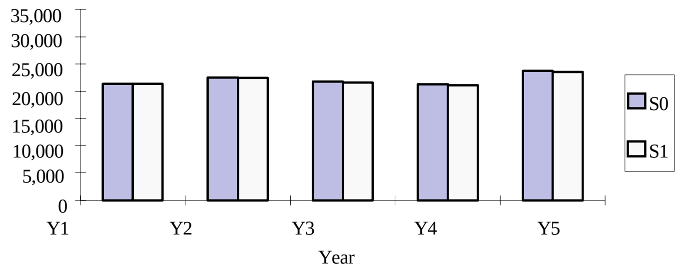
S1-Food crops and input market liberalization:

- input prices increase
- soybean price decreases 40% and rice 20%,
- risk increases for rice and maize

7.1 Results on aggregate performance of food crops production

The main result in regional production is that rice production remains stable after liberalization (Figure 7.1).

Figure 7.1 Impact of liberalization on regional rice production.



In contrast, soybean production decreases sharply in the liberalization scenario (Figure 7.2), while maize production increases (Figure 7.3), stressing the land competition between these crops.

Figure 7.2 Impact of liberalization on regional soybean production.

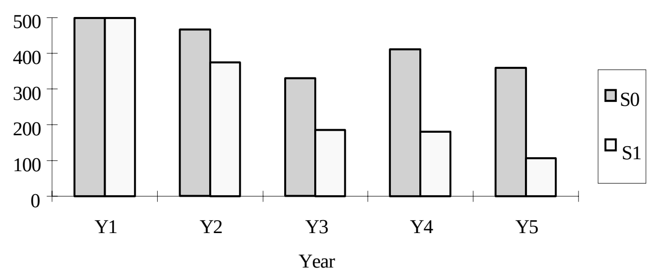
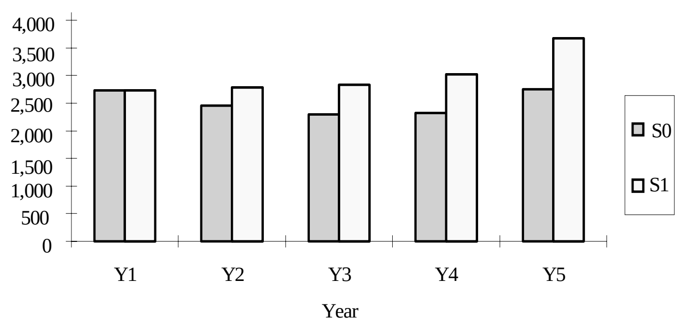


Figure 7.3 Impact of liberalization on regional maize production.



7.2 Impacts on farm incomes and strategies of actors

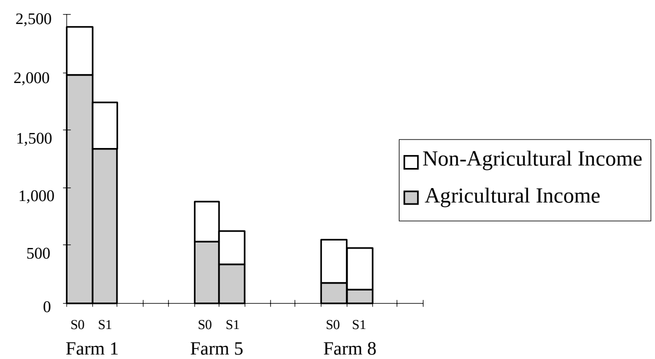
One interesting feature of the MATA model is that it allows deeper analysis of household income and actors' strategies through factor allocation. The decrease of agricultural income after liberalization of the whole food crops subsector is sharp for each farm type (Table 7.1).

Table 7.1 Agricultural income in various scenarios after 4-years simulations ('000 Rp).

Scenario	Technical irrigation with high degree of water control			Simple irrigated with moderate to low degree of water control				Rainfed	
	F1	F2	F3	F4	F5	F6	F7	F8	F9
S0	1,979	664	353	1,279	541	1,586	575	183	61
S1	1,335	441	191	853	336	1,186	428	112	35

The farms which are worst off in the liberalization scenario (S1) are the landless farmers (F3) and the farms in the rainfed area (F8 and F9). The importance of off-farm activities allows them to maintain and not to decrease their total income (Figure 7.4). These three farm types, representing roughly one and a half million households (around 4 million active persons) have very few incentives to stay in agricultural production in the liberalization scenario. However, they are already part-time farmers, and if opportunities for off-farm activities increase their income will go up, thus avoiding incentives for migration.

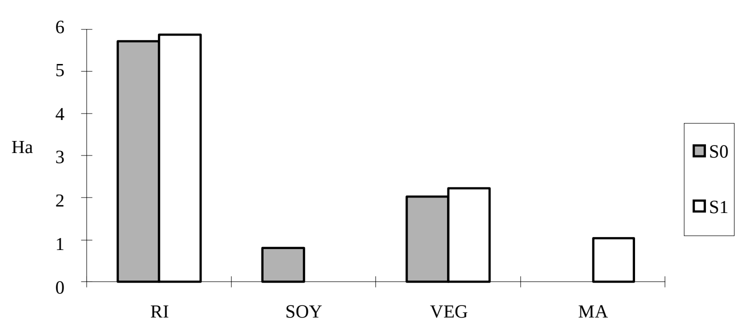
Figure 7.4 Distribution of income after 4-year simulations for three farms.



The analysis of land allocation of Farm 1 confirms the above analysis. This farm type, enjoying a large area under controlled irrigation in good soil conditions, is able to adapt to a liberalized environment in shifting from soybean to maize.

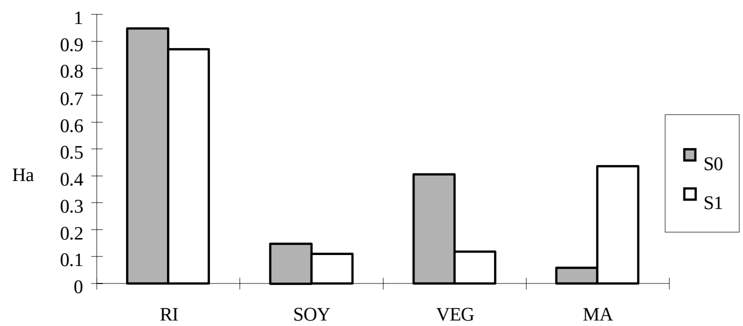
Farm 5 is strongly affected by liberalization. Since soybean is actually the main secondary crop, maize takes its place in S1. The income decreases sharply and thus risk aversion* increases and the liquidity constraint becomes tighter, leading to a reduction of the vegetable area.

Figure 7.5 Yearly land allocation (Farm 1).



* The risk aversion parameter is calculated as A = 1/coef*WH

Figure 7.6 Land allocation (Farm 5).



7.3 Testing the impact of policies on consumption

This scenario of food crop trade liberalization has been applied to the commodity chain module, in order to evaluate the impact on consumer nutrient intake and on activity in processing industries.

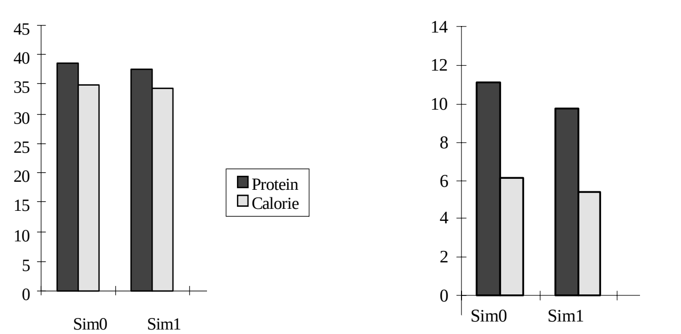
One argument in favor of food crop trade liberalization is the positive impact expected on consumer welfare, especially through the decrease of price of soybean, which is an important source of protein.

Box 7.2

Sim1-Food crops trade liberalization: - soybean price decreases 40% and rice 20%,

Because of the actual satisfactory level of nutrient intake for the middle-high income category (Chapter 5), the analysis of nutrient intakes in various scenarios focuses on the poor and middle-low income group.

Figure 7.7 Deficit in protein and calories.



Poor income group

Middle-low income group

With the scenario of food crop trade liberalization (S1), a positive effect on calorie intake is evident (mainly due to the decrease in the average price of rice) but the deficit in protein remains high (37% for the poor group). The middle-low income group benefits more than the poor income group from this scenario. The effect of food crop trade liberalization on consumption is positive but not very important. At this stage, it should be noted that the basic assumptions of this scenario, adjusting domestic prices to current international prices, at the time of the simulation, lead to a decrease in rice price, which explains the positive impact on calorie intake. In 1997-1998, with the El Nino phenomenon, rice prices will increase and, thus, the impact on consumers' nutrient intake will be negative.

One main conclusion of this simulation is that the positive impact of food crop trade liberalization on protein intake is not as important as is sometimes argued. As this example shows, MATA allows a detailed analysis of consumer behavior, even when the products represent only a small share of total expenditure.

7.4. Liberalization combined with other measures

Given the negative impact of the food crop trade liberalization scenario on actors of the agricultural sector, other simulations combining liberalization with some remaining protection, or optimistic socio-economic contexts such as technical improvement or quick economic growth, are performed to evaluate if they may constitute efficient alternatives to smooth the negative impacts of the food crop trade liberalization scenario. These alternative simulations are divided into two sections: one aiming at improving the economic situation of producers and another aimed at consumers.

7.4.1 Policies aimed at reducing negative impacts of liberalization on producers

Three other scenarios are tested:

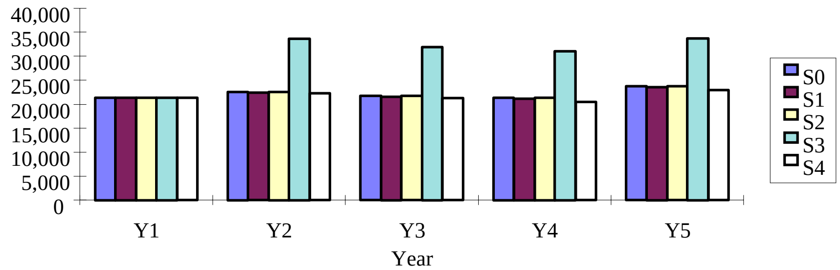
- S2-Food crop and input market liberalization except rice.
- S3-Food and input market liberalization with technical change: S1 combined with increases of 50% in the yields of rice and soybean.
- S4-Fast growth of off-farm activity opportunities: S1 combined with double growth rates of off-farm activities.

The analyses of the simulations are still performed in comparison with the base run reproducing current trends in relative prices and the general economic situation.

7.4.2 Results on aggregate performance of food crop production

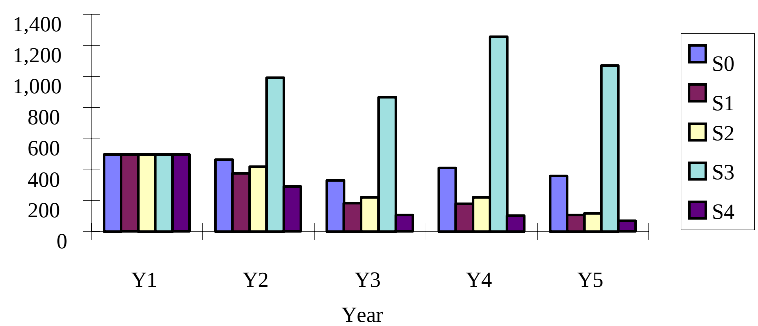
Considering the importance of rice stabilization in Indonesia, the second scenario (S2) excluded this crop from the liberalization process. The impact is important in terms of income, as will be analyzed in the next section, but not on regional production (Figure 7.8).

Figure 7.8 Impact of various scenarios on regional rice production.



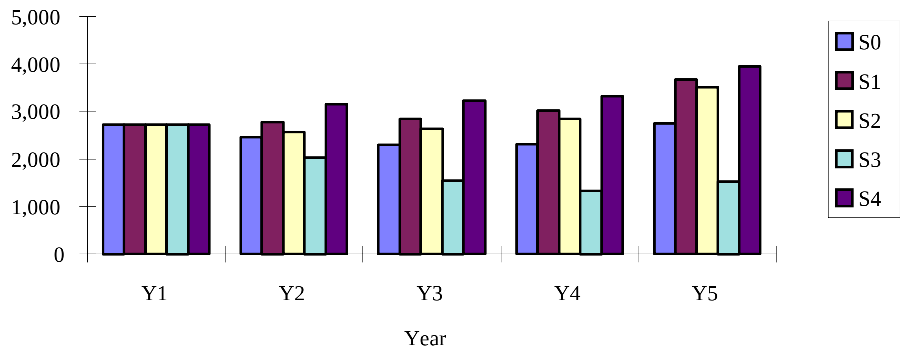
Considering the negative impact on soybean from the liberalization scenario, two technical improvements were included in the third scenario (S3) on rice and soybean (increase of yield of 50% for both crops, with improvement in practice and material). High resources are, indeed, still devoted to research on new varieties, which could allow further increase in yield of rice. For soybean, with an actual yield of 800 kg per ha on average for Java lowlands, the simulated increase will lead to a medium level in comparison with international performance. The supply response is important for these two products (Figure 7.9). The increase in soybean production is higher than the yield increase because more land is allocated to this crop. In fact, the technological improvement over-compensates the loss of profitability induced by trade liberalization. In some areas, the crop becomes more profitable than maize and production of this latter crop decreases.

Figure 7.9 Impact of various scenarios regional soybean production.



Because the Indonesian economy experienced continuously high development before the current economic crisis, the fourth scenario (S4) assumes a quicker increase of off-farm activities in comparison with the base run (10% instead of 5% in the base run). There is a slightly negative impact on rice production, a negative impact on soybean and a positive impact on maize, underlining the low labor requirement of this latter crop (Figure 7.10).

Figure 7.10 Impact of various scenarios on regional maize production.



7.4.3 Results on farm incomes and strategies of actors

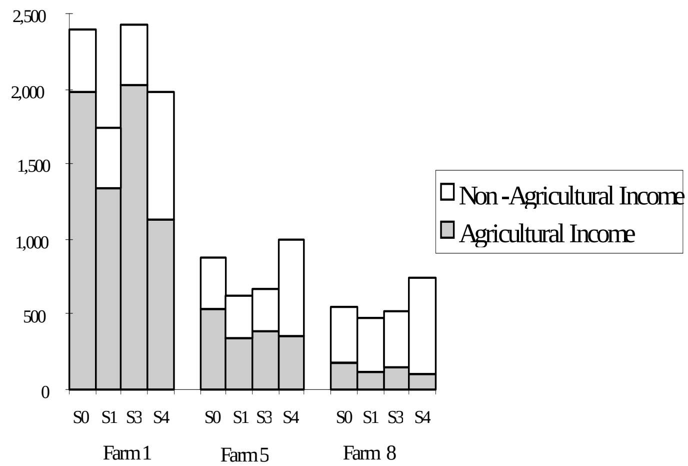
At the farm level, the situation (see Table 7.2 and Figure 7.11) is much better if rice is excluded from the liberalization process (S2).

Table 7.2 Agricultural income in various scenarios after 4-year simulation ('000 Rp).

Scenario	Technical irrigated with high degree water control			Simple irrigated with moderate to low degree of water control				Rainfed	
	F1	F2	F3	F4	F5	F6	F7	F8	F9
S0	1,979	664	353	1,279	541	1,586	575	183	61
S1	1,335	441	191	853	336	1,186	428	112	35
S2	1,726	606	274	1,022	434	1,370	534	146	45
S3	2,018	901	354	945	385	1,451	503	143	52
S4	1,135	384	245	705	358	1,032	408	101	33

The technical innovation scenario (S3) has different impacts from one farm to another. For the farms with a high degree of water control, agricultural income becomes greater than in the base run (S0), because they are highly specialized in rice and positioned to take advantage of the innovation. For farms in the rainfed area, the situation is hardly better than in the liberalized scenario (S1), since the small areas under control do not allow them to take advantage of the technical innovation.

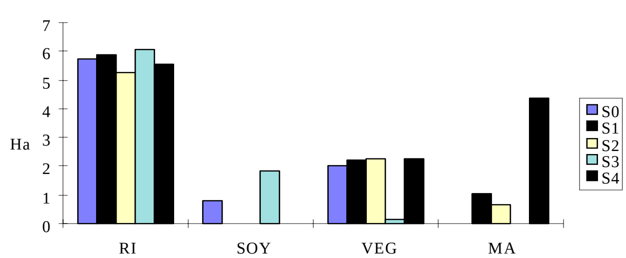
Figure 7.11 Distribution of income after 4-year simulation for three scenarios.



The simulation with the higher increase of off-farm activities (S4) has the worst impact on agricultural income. But, in fact, if the whole income, including off-farm activities, is included, this situation is the most favorable, except for the biggest farm from the high degree of water control area. For this farm, tension on the labor market is very damaging, because it relies highly on hired labor for cultivation. Clearly, for all the other farms, the best way to increase rural income is to promote the development of off-farm activities such as processing and packaging of agricultural products or other small-scale rural industry.

Now looking at actors' strategy, it appears that for Farm 1 (Figure 7.12), the land devoted to vegetables and maize increases in the second scenario, while in scenario 3 more land is devoted to crops under technological innovation (soybean and rice). Because of the difficulty to find hired labor in some periods in the fourth scenario, these farm types shift from soybean and rice to maize.

Figure 7.12 Yearly land allocation in various scenarios (Farm 1).



7.5 Policies aimed at reducing negative impact of liberalization on consumers

In this part the second scenario, excluding rice liberalization has been tested, as well as pessimistic and optimistic scenarios related to economic growth and their impact on income and food expenditure. The scenarios are given in Box 7.3.

Box 7.3 Scenarios (annual %).

S0 - Base run: expenditures increase 3%
S2 - Food crop trade liberalization except rice: soybean price decreases 40% over 4 years
S5 - Slow growth in expenditure: 1% per year
S6 - Quick growth in expenditure: 6% per year

In the scenario of liberalization excluding rice (S2), the nutritional situation improves marginally in Java for the two groups under analysis. Deficits compared to the minimum requirement in protein and calorie decrease from 39% to 38% and from 35% to 34% for the poorest category (Figures 7.13 and 7.14). The deficits of the middle-low income group (Figure 7.14) decrease from 11% to 9.7% for protein and from 6 to 5% for calories.

Figure 7.13 Deficit in protein and calories of the poor income group in various simulations compared to requirements.

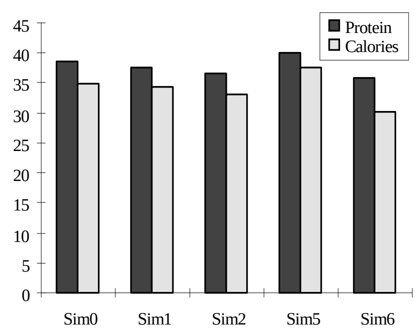
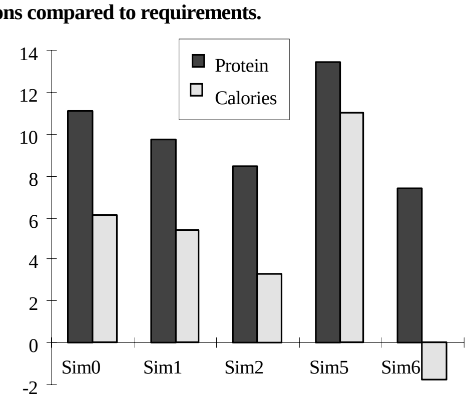


Figure 7.14 Deficit in protein and calories of the middle-low income group in various simulations compared to requirements.



Because of the liberalization of soybean trade and of the decrease in prices associated, the growth of protein intake is quicker at 1.3% instead of 0.9%, and thus seems supportive of long term and marginal improvement in nutrient intake.

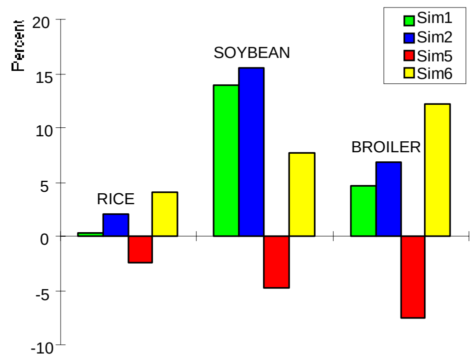
Because the growth rate of food expenditure is related to income growth, and expectations on this variable cover a wide range, two related scenarios have been formulated and tested: two levels of increase in food expenditure, at 1% per year (S5), instead of 3% in the base run, and one larger increase at 6% per year (S6). The impact of income growth on nutrient intake is greater than that of liberalization. The high income growth scenario leads, after a 5 year run, to an excess of calories over the requirement level for the middle-low income group, while the protein deficit remains above 7%. For the low income group, the level of nutrient intake as exhibited by food expenditure is critical in both scenarios, with deficits higher than 30%. It points out the necessity of specific policy focusing on the poorest consumers to improve their nutrient intake.

In the scenario of quick increase of income, vegetable consumption increases faster, while soybean consumption increases slower, compared to the scenario of soybean trade liberalization. These results point out the importance of distinction between categories of households to evaluate policy impact on consumption. In spite of big improvements of nutrient levels in Indonesia as exhibited by average values before the 1997/98 crisis, protein and calorie intakes of the low income population still need to be considered in policy definition.

7.6 Impact on employment in some processing activities

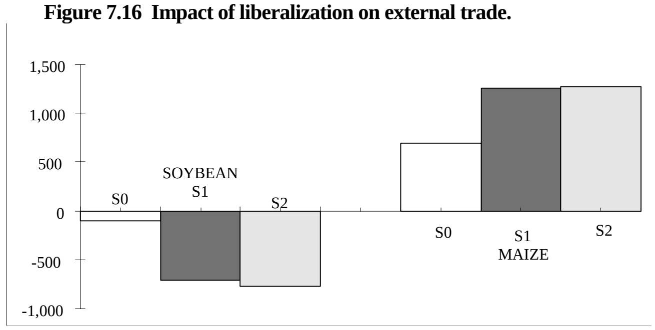
MATA allows the evaluation of employment level in various processing industries. In case of liberalization of food crop trade except rice (S2), employment in the tempe and tahu industry increases quickly at 14% on average. In terms of absolute values, the impact concerns around 40,000 job opportunities. In case of quick increase of growth of private consumption expenditures, the effect on employment is smaller.

Figure 7.15 Employment in processing in several scenarios.



In the sixth scenario, a quick increase of expenditures, the increase in employment in the soybean processing industry is around 8%. It is easily explained if one considers the differences in consumption patterns in scenario 1, trade liberalization, and scenario 6. Meat and vegetables show larger growth in consumption in scenario 6. In this scenario, increase in employment will mainly take place in transportation and marketing. Though not performed here, this impact could be easily evaluated with MATA methodology, if reliable data were available.

Figure 7.16 Impact of liberalization on external trade.



7.7 Conclusions

Various scenarios concerning liberalization of the food crop trade subsector were tested and analyzed in this study. In contrast to previous studies on this topic, the use of a micro-macro sectorial approach enables the evaluation of impacts both at aggregate and at actor levels. The specificities of the tool allow representation in detail of the specific situation of each type of actor, farmer and consumer, taking into account risk and market imperfections in agricultural production, leading to results different from those found with classic partial equilibrium models.

Rice production is very stable with trade liberalization, while soybean production decreases sharply and maize production increases. To counteract this negative impact on soybean production, technical improvements have to be adopted for this crop, allowing compensation for the loss of profitability induced by trade liberalization through yield increase.

At the farm level, impacts are strongly negative on agricultural income. The decrease is less pronounced if rice is excluded from the trade liberalization. Technological improvements for rice and soybean are able to partially compensate the negative impact of trade liberalization on agricultural income. Farms in the irrigated area are even able to get a higher income than in the base run situation. Increased off-farm job opportunities have a strong positive effect on household income except for the largest farm type of the study.

Finally, this study highlights the importance of technical innovations induced by agronomic biotechnological research to maintain rural income in a trade liberalization process. It shows that claims of the positive effects of liberalization for farmers, because of efficiency gains, have to be reconsidered in an imperfect market context, at least in the short term. The liquidity constraint and the existence of risk aversion prevent farmers from specializing in the more profitable crops. It also points out that the development of off-farm activities is necessary to increase rural income. The liberalization of agricultural trade will induce a sharp decrease in income, and for around four million active persons, very few incentives will remain to stay in agricultural production. So, even if the liberalization process leads to a more efficient factor allocation, it could be worth considering defining accompanying policies to minimize adverse impacts during the time of adjustment.

Other policies have been tested, particularly one possibility of boosting soybean production. The main conclusion was that a reinforcement of the price policy would have little impact on soybean production of Java lowlands, but that a subsequent decrease of risk associated with this activity would have an important impact, without hampering consumer welfare (Marty et al. 1997).

On the consumption side, the liberalization of food crop trade has a positive but slight impact on calorie intake. Moreover, this result relies on assumptions of relatively low prices for staple foods. This assumption is consistent with the results of several world trade models, but it will certainly be wrong in 1998 with the drought experienced in several parts of the world and the increase in the cost of living due to the financial crisis. Protein intake remains the main problem for nutrition of the low and middle-low income groups in each simulation. Obviously, the best way to improve nutrient intake is income growth. The impact on employment in soybean-based processing industries is important in the case of food crop trade liberalization. It could create a cumulative effect on nutrient intake, through the income growth related to increase in off-farm job opportunities.

It is worth remembering that, if some shortages occur leading to a sharp increase of international prices, the effect could be an actual increase in domestic prices and the impact on consumer welfare would be counter-intentional. A scenario for such a situation was not studied here.

This presentation of MATA intends to demonstrate the performance of the tool and to explain the main idea governing its logic. In the remainder of this book, the reader will find instructions for performing his own simulations and for making modifications.

Nevertheless, it is still a prototype. Some more detailed analysis needs to be done to feed the model with better data, especially on processing and trade. Impact on environment was not considered due to the lack of time to collect data. Furthermore, if market imperfections are considered, the functioning of markets is still not represented properly. It was impossible to represent a market as complicated as land in Indonesia. A future refinement will be representation of spatial price formation for food crops as a combination of local supply and demand and prices in other markets, domestic and international. Time was too short to overcome the qualitative and statistical analysis of trade and to try to simulate exchange between markets and volume of trade. Imperfections will be removed progressively in other applications.

8. MATA User Guide: Agricultural Production Module

This chapter explains in details how to use the prototype of MATA built for Java lowlands through the interface. First, file framework, contents and utility are described; second, the installation process is described, and third, explanations are given to allow new users to define, analyze and run simulations with the interface.

8.1 Module structure and files

The agricultural zoning for the Java lowlands determined four zones: technical irrigated area (technir), simple irrigated area with soybean dominant (simir1), simple irrigated area with maize dominant (simir2), and rainfed area (rainf). The module contains one independent model for each zone, and each model has the same structure. They can be used separately, to apply a scenario to a specific zone, or simultaneously for the analysis of impacts on the whole region. Figure 8.1 describes the file organization for one zone (zn), and Figure 8.2 shows this for several zones. Table 8.1 provides the list of files for one zone and their contents. Tables 8.2 presents all the files for the different zones of the Java lowlands.

Figure 8.1 Simulation for one zone - production level.

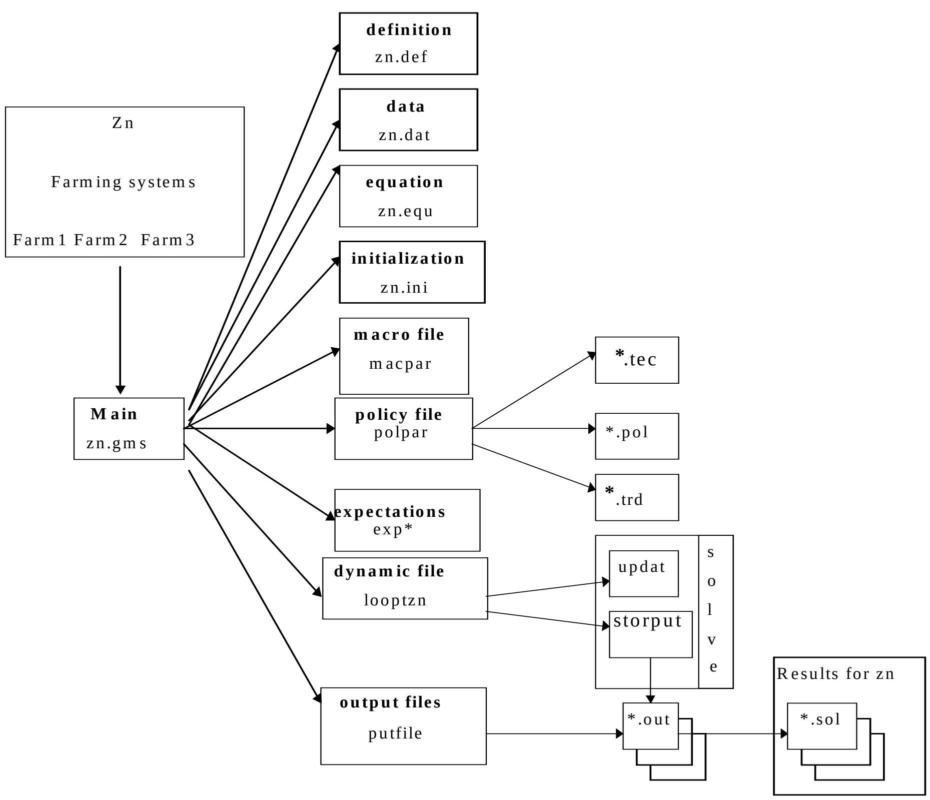


Table 8.1 The files for one zone.

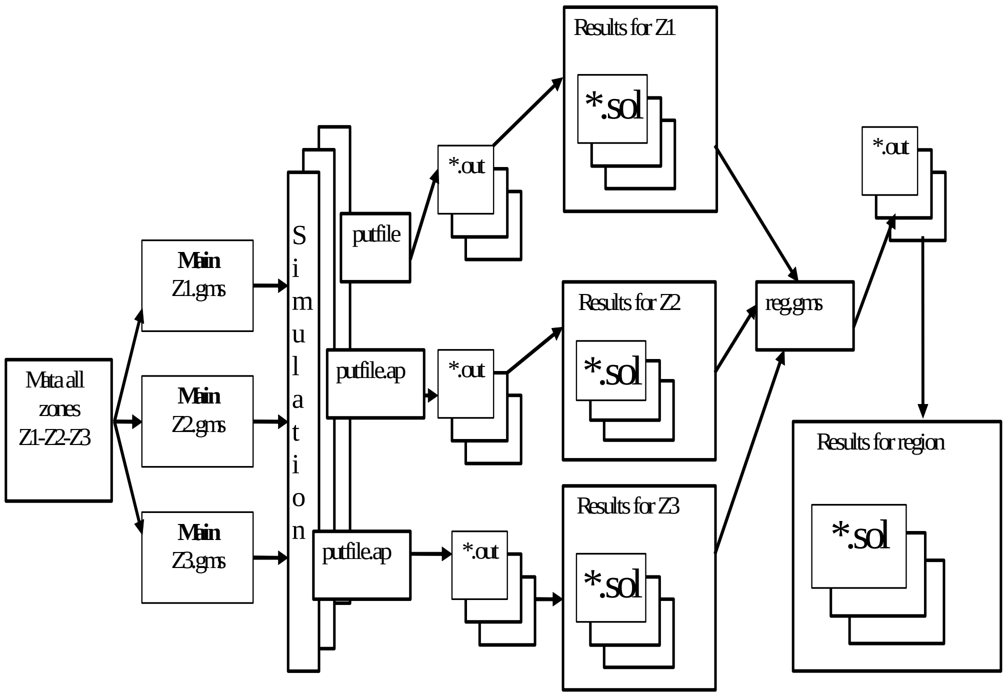
Zone	Zn	Contents
Main	zn.gms	Title and options includes all other files
Definition	zn.def	Definition of sets, parameters, variables and equations
Data	zn.dat	Data by zone for each type of farm
Equation	zn.equ	Equations representing constraints and opportunities at farm and village levels
Initialization	zn.ini	Initial value for main endogenous variables
Macro-economic variables	macpar	Macro-economic data and trends
Policy	polpar *.pol *.tec *.trd	In polpar, scenarios are defined by combination of policy files (*.pol), technical files (*.tec) and trend files (*.trd)
Expectation	exp*	Defines the process of price expectations by farmers
Dynamic	*.dyn updat storput	In the *.dyn file, solutions are performed for each year in a sequential way by a loop instruction. Starting parameters of each year are modified according to past results by the updat file and results are stored by storput
Output	putfile *.out *.sol	In the putfile one file *.out is associated with each variable stored as results. Each *.out file generates *.sol which is in a format suitable for displaying results.

Table 8.2 The files for the four lowland Java zones.

Zone	Z1 Technical irrigated	Z2 Simple irrigated soybean	Z3 Simple irrigated maize	Rainfed	Contents
Farms	F1-F2-F3	F4-F5	F6-F7	F8-F9	contents
Main	technir.gms	simir1.gms	simir2.gms	rainf.gms	title and options includes all other files
Definition	technir.def	simir1.def	simir2def	rainf.def	definition of sets, parameters, variables and equations
Data	technir.dat	simir1.dat	simir2dat	rainf.dat	data by zone for each type of farm
Equation	technir.equ	simir1.equ	simir2.equ	rainf.equ	constraints and opportunities at farm and village levels
Initialization	technir.ini	simir1.ini	simir2.ini	rainf.ini	Initial value for main endogenous variables
Policy	polpar	polpar	polpar	polpar	policy definition
Expectation	exprat, ...	exprat, ...	exprat, ...	exprat, ...	expectation process
Dynamic	technir.dyn updat storput	simir1.dyn updat storput	simir2.dyn updat storput	rainf.dyn updat storput	*.dyn contains solve statement performed for each year in a sequential way by a loop instruction. It includes updat and storput updat to modify the starting parameters of each year according to past results and storput stores the results
Output	putfile putfile.ap *.out *.sol	putfile putfile.ap *.out *.sol	putfile putfile.ap *.out *.sol	putfile putfile.ap *.out *.sol	putfile associated one file *.out with each variable stored as results. Each *.out file generates *.sol which is in a format suitable for displaying results.

Simulations may also be performed on the whole region with aggregation of the results. Figure 8.2 describes the simulation process.

Figure 8.2 Simulations for one region including several zones.



The list of new files is provided in Table 8.3.

Table 8.3 File for regional simulation.

File	Purpose	Contents
MATAall	calls main files of each zone	list of main files
Putfile.ap	allows storage of a new simulation result without deleting the previous one.	same as putfile
Reg.gms	performs aggregation of results at regional level	addition of results

8.2 Installing MATA

The MATA model comes in two parts: MATA Gams files and MATA Interface. The two components must be installed in two different directories. The MATA model requires Gams Program (GAMS is the propriety of Gams Development Corporation, and it must be registered before use).

8.2.1 Description.

MATA Gams files: one 3” disk

MATA Interface: two 3” disks for Windows 3.1 or two 3” disks for Windows 95.

8.2.2 Minimum system requirements

To use MATA Interface for Windows on your computer, make sure you have the following system requirements:

- IBM PC or compatible computer (486/DX or higher).
- Microsoft Windows 3.1 or Windows 95 (32 bit version).
- GAMS 386 version for running under Windows.
- 8 megabytes of RAM.
- Hard disk with 4 megabytes of free space.

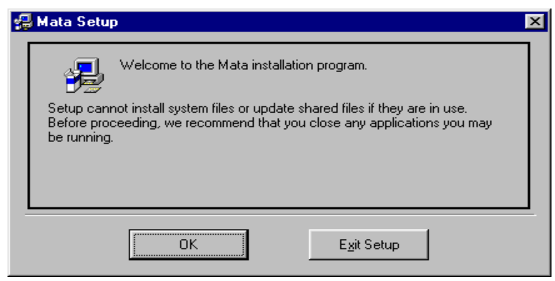
8.2.3 Installing MATA Interface.

Turn on the computer and run Windows 3.1 or Windows 95.
Insert the MATA Interface disk 1 into the appropriate drive.

- For Windows 3.1: From the Program Manager, pull down the **File** menu and choose **Run**. At the Command line field, type *A:\SETUP* (or *B:\SETUP* as appropriate) and click **OK**.
- For Windows 95: From the Control Panel choose **Add/Remove Program**, click **Install**. Follow Windows instructions, click **Next**. At the “Command line for installation program” field, type *A:\SETUP* (or *B:\SETUP* as appropriate) and click **Finish**.

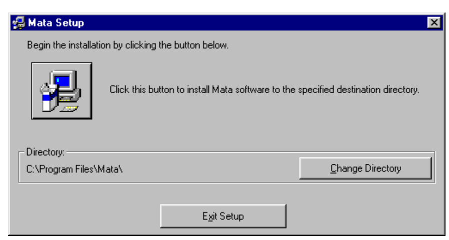
At this step, the MATA Interface Setup program is loading.
Click **OK**.

Mata Setup



On the next screen, the name of the folder/directory to copy the MATA Interface program into is displayed. To use another name, click “Change Directory” and type the new name. Different directory names must be used for the MATA Interface program and for the MATA Model Gams files.

Mata Setup



The Setup program prompts you to insert the MATA Interface disk 2. After this, just use the MATA icon to run the MATA Interface Program. The first time the interface is used, the program must be configured (see below).

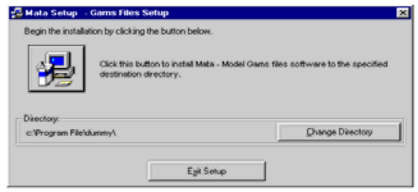
8.2.4 Installing the MATA Model Gams files

Insert the MATA Model Gams files disk into the appropriate drive.

Follow the same instructions described above for installing MATA Interface.

Don't forget to use a different directory name.

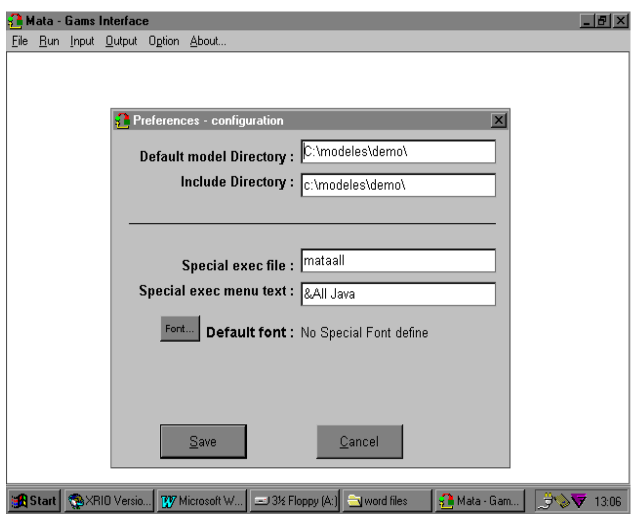
Mata Model - Games Files Setup



8.3 Open files and define scenarios

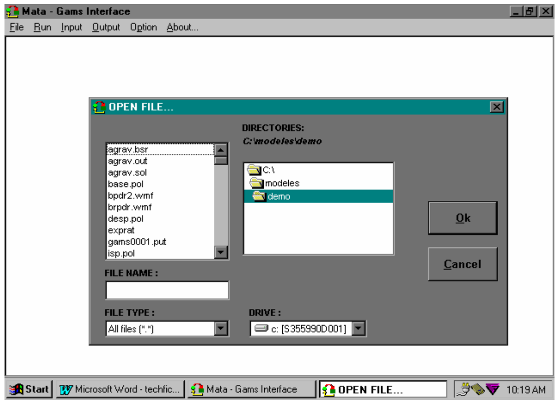
8.3.1 System configuration

Click on the icon of MATA Interface. In the main menu, choose **<option> <configuration>** and indicate the directory where the files are stored as **Default Model Directory**. In the **Include Directory**, repeat it. In the **Special Exec File,** put the name of the file allowing the run of several zones (in this example, MATAall) and in the next window the denomination under which this choice will appear in the menu run (in the example, all Java).



8.3.2 File opening

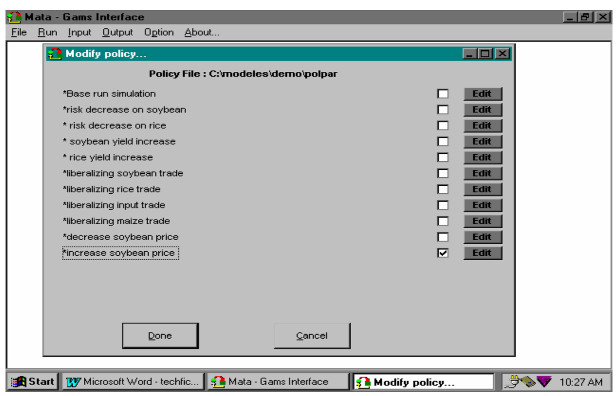
Choose **<file><open>** in the main menu. A window appears with all the files of the directory defined above. Select the file to open. Any existing directory on the hard disk can also be selected.



8.3.3 Scenario definition

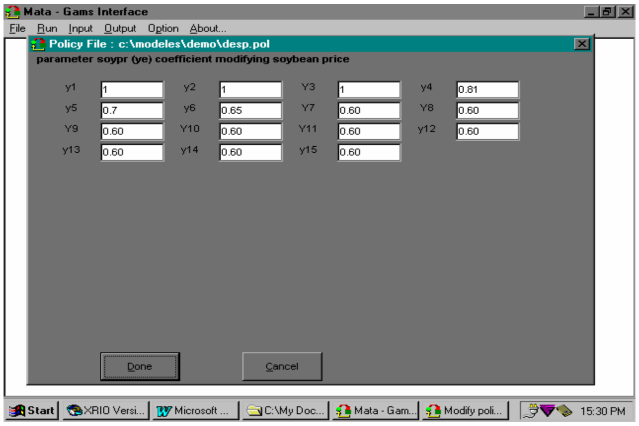
Choose in the menu <**input**> and then <**edit policy**>. A list of predefined policies appears.

Check the policy to be simulated. It is possible to combine policies; in this case choose several options. In the example, a policy increasing soybean price is chosen. In the model, policies are defined by modifying key parameters, for example prices of inputs or outputs. These parameters are multiplied by a coefficient of 1 when the policy is not activated, and of a value defined by the user by pressing edit when the policy is activated. This is called the intensity of the policy.



8.3.4 Intensity

The coefficient which will modify the original parameter of the model appears in the small window, for each year of simulation. It can be modified from this screen by typing in a new value in the corresponding window. In the example, soybean price decreases progressively after 3 years of simulation, by applying a coefficient of 1 for the 3 first years, 0.81 in year 4, 0.7 in year 5, 0.65 in year 6 and 0.6 from year 7 until the end of the simulation period.

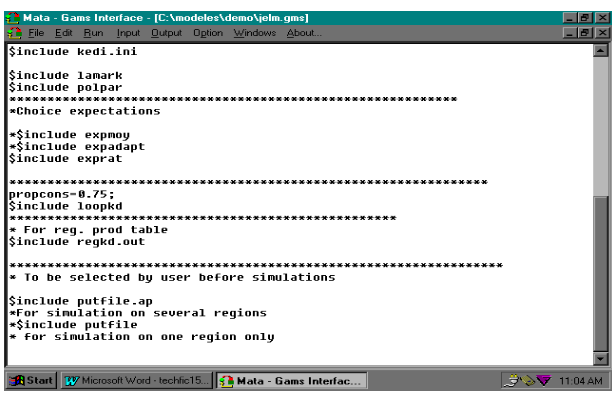


8.3.5 Select regions

Simulation can be performed on one or several regions at the same time, with results aggregated at the national level. If you select <**run**><**Java**> from the main menu, the simulation will be performed on the four zones representing Java. In this case, the putfile statement included by the main files has to be modified for each zone except the first (technir), in order to indicate that results have to be stored after (and not instead) of the preceding results.

Open the main file (from the main menu, choose **<file><open>** and select the *.gms files), go to the end after the instruction ‘to be selected by user before simulations’.

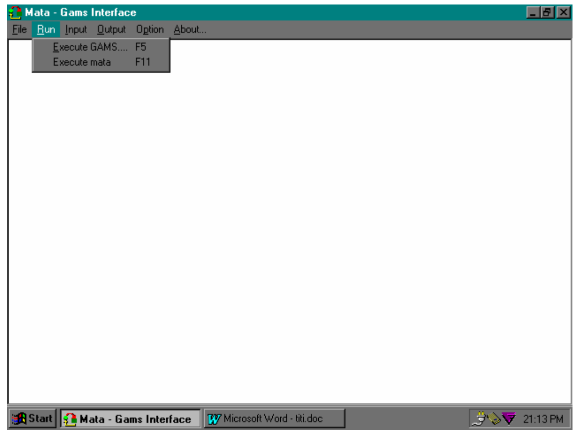
For simulations on several zones, introduce a star in the first column of the line containing the “$include putfile” instruction and erase the one before the instruction “$include putfile.ap”. For simulation on one zone only or for technir.gms (first zone), erase the star in the first column of the line containing the “$include putfile” instruction and reintroduce one before the instruction “$include putfile.ap”.



8.4 Perform simulations and display results

8.4.1 Simulation

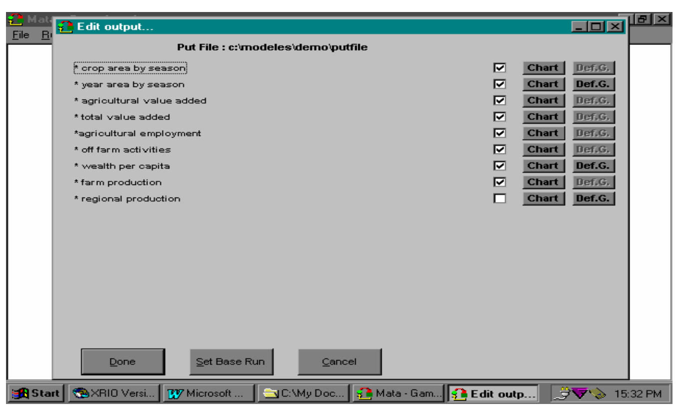
Choose <**run**> in the menu. If the simulation concerns a specific zone, select **<execute GAMS>** and then the main file of the model of the zone (Z.gms). If the simulation covers several zones, select the specific name chosen to call the global run in the configuration menu, **<Java>** (see 8.3.1).



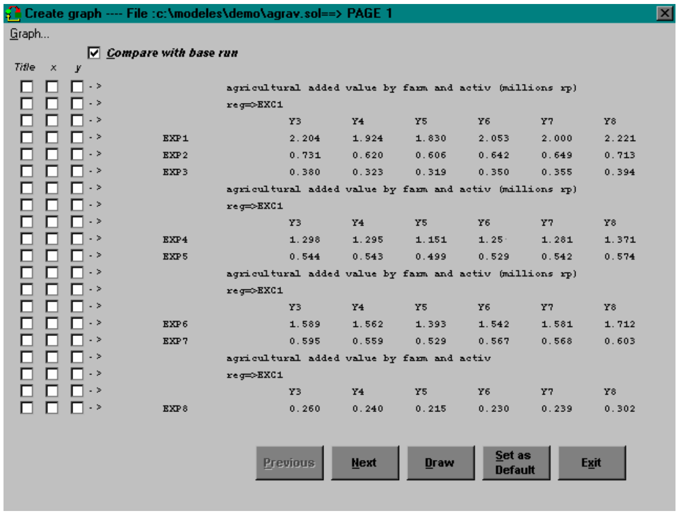
The program shifts automatically to DOS during the time of the simulation and comes back to MATA Interface at the end of the simulation process. During that time, it is possible to perform some other tasks with the model if using Windows 95, but the input and output files, used for the simulation should not be open while GAMS is operating. During the simulation process, **~exec** appears in the window and allows one to control the run, **Finished~exec** indicates that the run is finished.

8.4.2 Display results

Choose <**output**> **<edit solution>** and click <**chart**> in the line corresponding to the information required for display. With the <**Def.G**> button the predefined chart is directly accessed. Also in this screen, values can be assigned to a ‘base run’ by clicking on the button **<Set Base Run>** at the bottom of the page, after having performed this simulation.

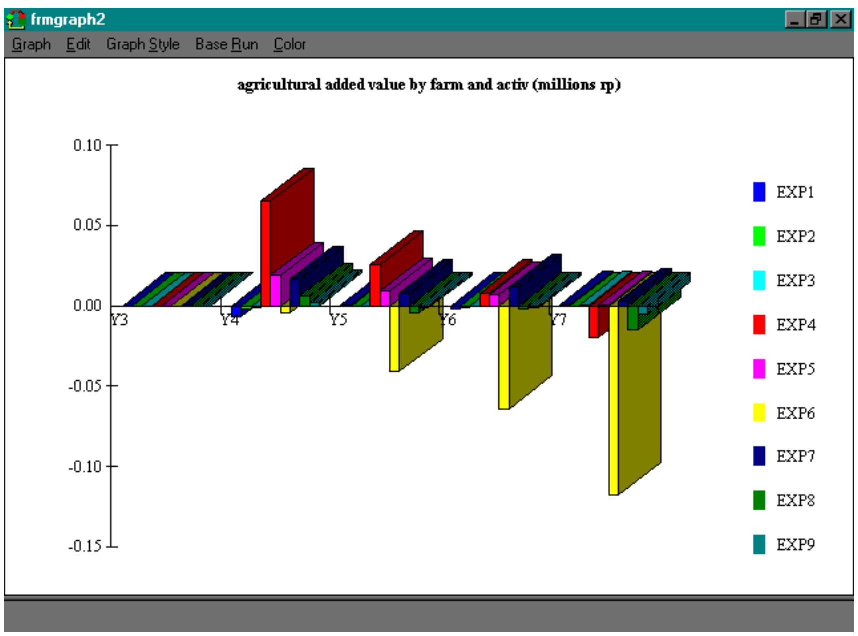


The following window appears. Results are given according to the specification of the variable. Here, agricultural added-value is displayed by farm type, for each year of the simulation. Access to the next or previous page is possible by selecting the button at the bottom of the screen.



8.4.3 Draw chart

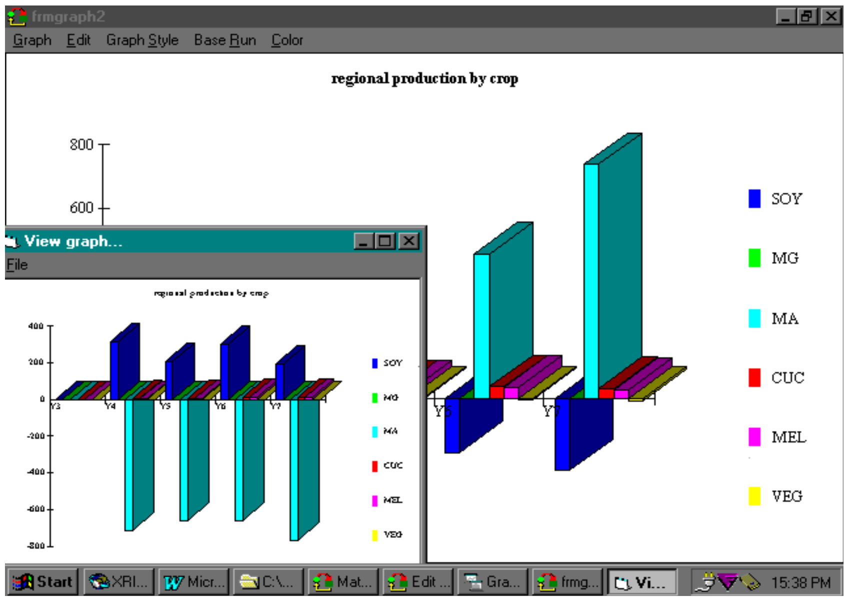
Choose in the previous screen a title, one variable for the X-axis and one or several variables for the Y-axis. Press **<draw>**. The following chart is displayed. Here the agricultural added-value after a scenario is given for nine farms compared to the base run. There are three possibilities of charts in selecting **<Base Run>** in the chart menu: **<hide>** to display only the last simulation; **<compare>** to display the base run and the current graph; **<difference>** to display the differences between the current simulation and base run results.



After displaying a chart, exit either through **<graph> <exit>** or by selecting the cross in the top right of the screen. This leads to the previous screen; by selecting **<set as default>**, the chart format is saved. It can be recovered at any time, by selecting from the main menu

<output> <simulation> and pressing DEF.G. It is also possible to access the **<set as default>** command directly from the chart by selecting **<chart><set as default>** in the window.

In the menu **<graph>**, it is possible to store a chart by selecting **<export image file>** and to save it as an image (format*.wmf). Then the chart can be called back to the screen with the command **<import image file>** which shows the list of graphs already stored.



In the example, the impact on regional production of Java of two different scenarios are shown reducing risk associated with soybean production (in the small window), and increasing soybean price (in the big one). It is easy to compare the effects on regional production: the first policy is much more efficient in boosting Java's soybean production.

From the **<graph>** menu, the chart displayed can also be printed, choose **<Print>**. **<Edit>** allows to copy the picture in the clipboard and to insert it directly in any editor for report. It is possible to modify the chart type by selecting **<graph style>**. The following options appear: line, bar, three dimensional bar. **<color>** contents a choice of greyscale or color.

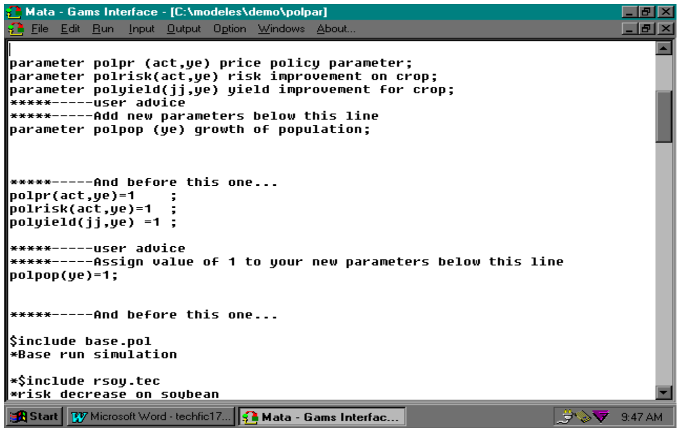
8.5 Define new scenarios

The polpar file must be modified. First, choose **<file> <open>** from the main menu and select POLPAR. At the beginning of this file, instructions are given to modify the list of policies.

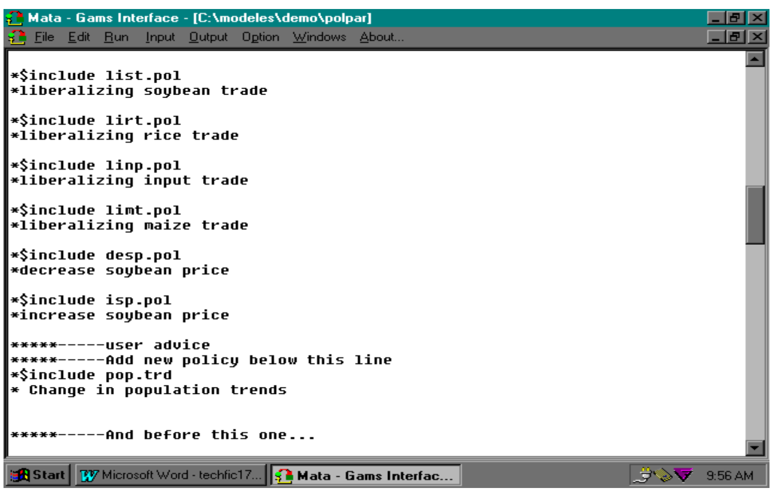
Polpar file is organized in three parts:

i. Definition of parameters that modify existing data to represent scenarios.
ii. Names of files containing policies, shocks or technology changes, to be included in the policy menu considered in the scenario.
iii. GAMS instructions updating the parameters according to policy changes.

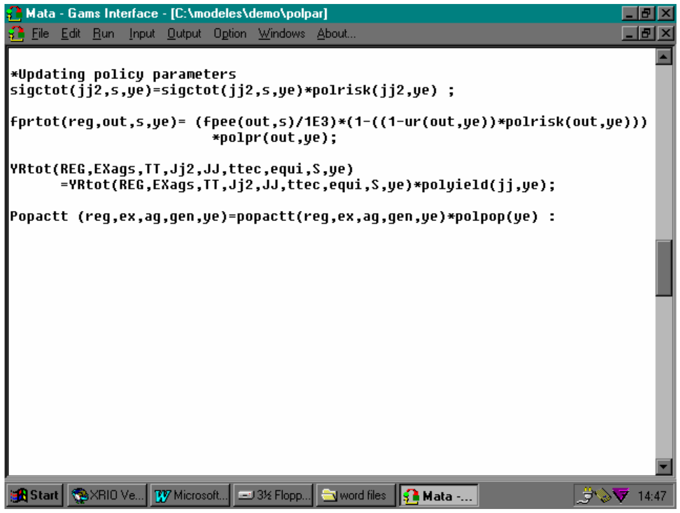
For example, if users want to test the impact of a change in population trend, the scenario should modify the value of POPACTT which represents the number of persons by household. This will be done by multiplying this parameter by a coefficient.



In the first part, new parameters to be modified by scenarios should be defined. In this example, a parameter is defined, POLPOP(ye) which will express the changes by year. The value of 1 is assigned to it. It is done by adding, in the specific places of the file (indicated by 'user advice'), the new parameter definition. The user should write as in the screen:
Parameter Polpop (ye) change in population trend;
Polpop (ye)=1;
Do not forget to add a semicolon";" at the end of both lines.



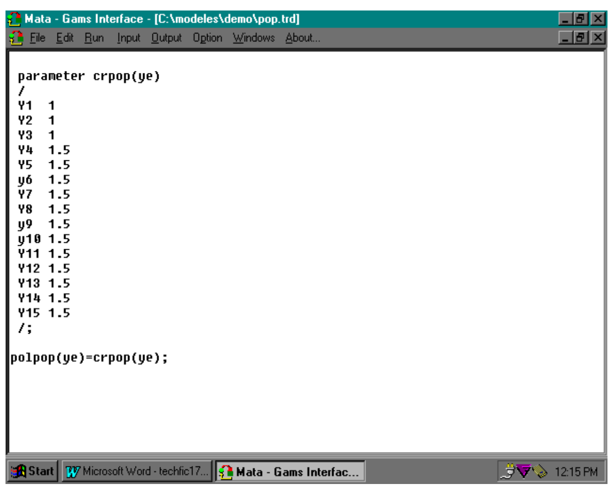
In the second part, two new lines should be added. In the first one, introduce the command $INCLUDE followed by the name of the policy file, which will modify the value of the parameter (in the example, pop.trd). In the second one, the name of the scenario to be displayed on the policy menu (in the example, Change population trend). There is a specific location in the polpar file to put these new lines. Each line has to begin with a star on the first column as in the example:
**$include pop.trd*
**Change population trend*



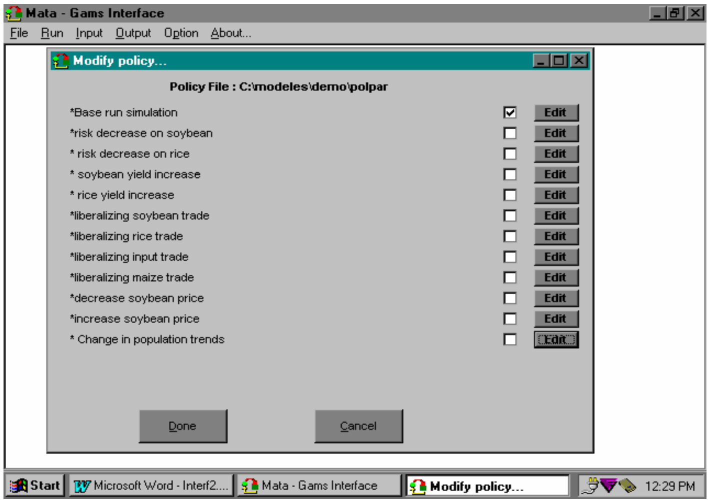
In the third part of the POLPAR file, the values of the original MATA parameters are modified by the policy file. The original parameter in MATA is popactt (reg,ex,s,ag,gen,ye) and the instruction to modify it is:
*popactt(reg,ex,s,ag,gen,ye) = popactt(reg,ex,s,ag,gen,ye) *polpop(ye);*

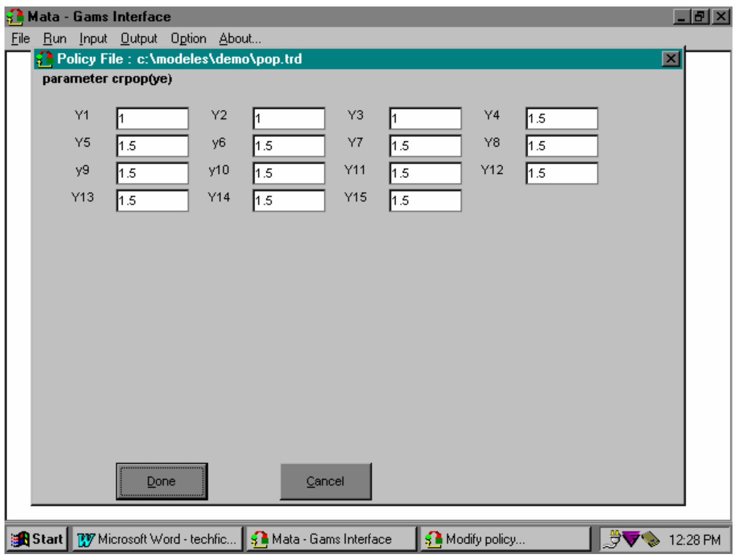
Because the coefficient of polpop is set at 1 by default, it will not modify the original value of the parameter if the pop.trd file is not included.

Then the file with the modification in population trend has to be created. It is done by the command **<file> <new>**. A new parameter is defined (crpop) that represents the change in population growth by year and values are assigned to it for each year of simulation. The last line attributes the values to the policy parameter (polpop, in the example). Save and close the POLPAR file.



From the main menu select **<input> <edit policy>**. If the whole process has been properly followed, a new line appears in the policy menu "Change in population trend" and it is possible, in selecting **<edit>**, to access the small window to modify the trend in population, as in the two screens below.





8.6 Define new variables for output menu

When **<output> <edit solutions>** is selected in the main menu, a screen with preselected output is displayed. It is possible to modify this screen by changing the file PUTFILE. Let us add a new variable to analyze the results on investment.

At the beginning of the put, one file is created for each variable to be displayed as output. To add a new possibility in the display, first create a new file with the same format by adding one line as in the example below.

File inva/invaf.sol/;

```
file result;
file seasa /seasarea.sol/;
file yeara /yeararea.sol/;
file agra/agrav.sol/;
file tota /totav.sol/;
file laba /labagr.sol/;
file labe /labext.sol/;
file wealc /wealcap.sol/;
file prode /prodexp.sol/;
*file prodr /prodreg.sol/;
file inva/invaf.sol/;
*____________________________________________________
scalar LMARG left margin /30/;
scalar TABUL tabulation /10/;
scalar CURS  cursor position /0/;
scalar TOPPRT top print /0/;
scalar TOPPAGE top page /0/;
scalar TOPEXCEL top excel /0/;
*____________________________________________________
** YEAR IN SYSOUT : FIRSTYEAR - LASTYEAR

scalar FIRSTYEAR        /3/;
scalar LASTYEAR         /7/;
*____________________________________________________
put  result;
*____________________________________________________* USE
SYSOUT WITH EXCEL =====> TOPEXCEL = 1
* USE SYSOUT FOR PRINT  =====> TOPEXCEL = 0
*____________________________________________________

TOPEXCEL = 1;

puttl$(TOPEXCEL EQ 0) result   SYSTEM.DATE, @12 ,
SYSTEM.TITLE, @65 'PAGE ', SYSTEM.PAGE  ;

result.PC$(TOPEXCEL EQ 0) = 3;

CURS = LMARG;
put$(TOPEXCEL eq 1) '000000000000000000';
loop    (ye $ (ord(ye) ge FIRSTYEAR and ord(ye) le LASTYEAR and
TOPEXCEL EQ 1),
        put @CURS, '000000000' ;
         CURS = CURS + TABUL);

put$(TOPEXCEL eq 1) /;
```

Then instructions for layout are given. After that, the first and last years of simulation are defined to determine the size of tables. The file contains specific instructions for the put facilities of GAMS. Explanations can be found in the Put Facilities manual.

In the middle of the screen the mention INCLUDE FOR DESIRED SYSOUT indicates the place where new variables for display should be declared. 3 lines have to be added:
put inva;

$include invaf.out
** investment by crop , farm season and year*

```
put seasa;
$include seasarea.out
* area by  crop , farm season and year

put yeara;
$include yeararea.out
* yearly area by farm and crop

put agra;
$include agrav.out
* agricultural added value by farm and year

put tota;
$include totav.out
* total added value by farm and year

put laba;
$include labagr.out
* total agricultural labour by farm and year

put labe;
$include labext.out
* total off-farm labour by household and year

put wealc;
$include wealcap.out
* total wealth by farm and year

put prode;
$include prodexp.out
* production by farm and year

*put prodr;
*$include prodreg.out
* regional production by year

put inva;
$include invaf.out
* investment by  crop , farm season and year
```

The last step is to define and assign a value to the invaf variable. In the TECHNIR file, add to the 'parameters for output':

PARAMETER INVAF

In the storput file, add the calculation of INVAF :

*INVAF(reg,exags,s) .. SUM(me, MAPU.l(reg,exags,s,me)*EP(me))*
*+ SUM(ca, ANPU.l(reg,exags,s,ca)*anp(S,ca))*
*+ SUM((t),LP.l(reg,eXags,t,s)*LPR(reg,t))*
+ SAB.l(reg,exags,s) ;

Do not forget the semi-colon “;” at the end of the line.

The suffix **.L** indicates that the values are the output from the solved statement of GAMS. Investment is defined as the sum of endogenous variables of the model: value of machines, animals and land purchased.

If the whole process has been correctly followed, a new line appears in the screen **<output>** and allows display of yearly investment by farms.

The invaf.out file has to be created. Simply copy another .out file (wealcap.out, for example) and replace wealcap by invaf (2 replacements).

```
*____________________________________________________________
*________________invaf.OUT.________________________________
*____________________________________________________________

putpage$(TOPPAGE eq 1);
TOPPAGE = 1;

CURS = LMARG;

loop    ((reg),
        put /;
        put @20, invaf.TS /;
        put /;
        put  @20, 'reg=>', reg.TL /  ;

        put /;

        loop    (ye $ (ord(ye) ge FIRSTYEAR and ord(ye) le LASTYEAR),
                put @CURS, ye.TL ;
                CURS = CURS + TABUL);
        put /;
        CURS = LMARG;

        loop    ((exags) ,
                put @10, exags.TL, ;
                loop    (ye $ (ord(ye) ge FIRSTYEAR and ord(ye) le LASTYEAR),
                        put @CURS, invaf (reg, exags, ye):<8:3 ;
                        CURS = CURS + TABUL );
                          put /;
                        CURS = LMARG));

PUT /;
```

9. MATA User Guide: Farming System Files for the Technical Irrigated Zone

As explained in the previous chapter, files of each zone have the same organization. In this section, the full contents of each file are provided in text boxes with explanations for the case of the technically irrigated zone. After going through this example, it will be easy for users to understand each file of the Indonesian prototype.

Indications will be given on GAMS syntax but this manual is not intended to substitute for the GAMS User Guide. Reading this book is highly recommended if the user really wants to modify this prototype.

Before going to the first file, the reader is reminded of a few instructions of GAMS:

- A star (*) in the first column of the line indicates that it is a comment and not a line with GAMS instruction.
- The instruction "$include name of a file" includes the designated file.

More explanations will be found in the files.

9.1 Main file: Technir.gms

In MATA, the *.gms file is the main file including all others. It contains four parts:

- In the first part, the title of the model is given after the Gams instruction $TITLE;
- In the second part, GAMS options are used to format output files. The complete list of options available in GAMS is provided in the GAMS User Guide pages 102-106 for options used with solved equations, and pages 112-113 for dollar control directives.
- In the third part, all files constituting the core part of the model, used for calculations, are successively included. The last line of the box below indicates that all the information up to this point constitutes the GAMS model Technir.
- In the fourth part, the dynamic file, which contains the solve instructions and the loop on time as well as saving and updating, is included. The fourth part includes file saving and formatting output.

```
* FILE TECHNIR.GMS
* This is the main file including all others

$TITLE MODEL FOR AGRICULTURAL PRODUCTION -
JAVA LOWLAND TECHNICALY IRRIGATED AREA
*_______________________________________________

$ OFFSYMLIST
$ OFFDIGIT
*$ OFFLISTING
$ OFFSYMXREF
OPTION LIMCOL=0;
OPTION ITERLIM=6000;
OPTION LIMROW=0;
OPTION SOLPRINT=OFF
*_______________________________________________
$INCLUDE TECHNIR.DEF
*definition file
$INCLUDE TECHNIR.DAT
*data file
$INCLUDE TECHNIR.EQU
*equation file
$INCLUDE TECHNIR.INI
*initialization file
$INCLUDE LAMARK
*macro economic context
$INCLUDE POLPAR
*policy definition
$INCLUDE EXPRAT
*rational expectation
*_______________________________________________
MODEL TECHNIR /ALL/
* model definition
```

```
$INCLUDE TECHNIR.DYN
*dynamic file - it contains loop on time for solve - include output files
*_______________________________________________________

*$INCLUDE REGKA.OUT
*stores regional production for aggregation
*_______________________________________________________

*To be modify by user in case of a simulation on several zones
*$INCLUDE PUTFILE.AP
*for regional run
 $INCLUDE PUTFILE
*for running separately this zone
```

9.2 Definition file: Technir.def

The definition file provides the list of sets, parameters, variables and equations of the model.

First, sets are defined. This begins with the GAMS instruction SETS and ends with a semi-colon “;”. For each set the name is given, followed by a comment, then the members of the set are delineated by slashes “/”.

The first set defined in technir.def is the region. The GAMS instructions are:

```
SET
REG region used to calibrate
/
EXC1
/ ;
```

It is equivalent to the mathematical statement REG ={exc1}

```
*FILE TECHNIR.DEF
*------------------------------------
* Definition of sets
SETS
REG region used to calibrate
/
EXC1
/
EX all actors
/
EXP1,EXP2,EXP3
/
EXAGS(ex) agricultural agents
/
EXP1,EXP2,EXP3
/
ACT all activities
/
RI          rice
SOY         soybean
BEEF        beef
SHEEP       sheep
POULTRY     poultry
FALW        fallow
LST         livestock
CUC         cucumber
MEL         melon
MA          maize
/
OUT(act) all productions
/
RI          rice
SOY         soybean
CUC         cucumber
MEL         melon
BEEF        beef
SHEEP       sheep
POULTRY     poultry
MA          maize
/

J(act) all cropping activities
/
RI          rice
SOY         soybean
CUC         cucumber
MEL         melon
LST         livestock
MA          maize
/
```

```
JJ(out) all crop consumed
/
RI          rice
SOY         soybean
CUC         cucumber
MEL         melon
MA          maize
/
JJ2(j) all crops
/
RI          rice
SOY         soybean
CUC         cucumber
MEL         melon
MA          maize
/
VEG(jj2) vegetables
/
CUC         cucumber
MEL         melon
/
TT type of land
/
IRT         irrigated technic
*IRS        irrigated simple
*RAI     rainfed
*DR      dryland
/
TTI(tt) land irrigated
/
IRT    technical irrigation
*IRS   simple irrigation
/
TTEC all technologies
/
TECIR   technical irrigation
*SIMIR  simple irrigation
RAIN    rainfed
*DRY    dryland
/
EQUI type of equipment
/
MAN         manual
TRA         traction
MEC         mechanical
/
TTECI(ttec) irrigation technologies
/
TECIR   technical irrigation
*SIMIR  simple irrigation
/
```

```
S all seasons
/
S1          season 1
S2          season 2
S3          season 3
/
AG range of age
/
ADUL        adults
/
GEN gender
/
MALE        male
/
PRO nourrishment types
/
CALO        calories
PROT        protein
/
ME type of equipment
/
BIG         big equipment
SMA      small equipment
/
OUTWS(out) all production except soybean
/
RI          rice
CUC         cucumber
MEL         melon
BEEF        beef
SHEEP       sheep
POULTRY     poultry
/
CA(out) category of animal
/
BEEF
SHEEP
POULTRY
/
CAV(ca) category of animal fix capital
/
BEEF
/
CAB(ca) category of animal traction
/
BEEF
/
QA forage quality
/
une
/
```

```
INP inputs
/
OTH
PEST
UREA
TSP
KCL
NPK
SEED
MANURE
/
```

```
W type of off farm job
/
SURE
UNSURE
AG
/
```

```
PE periods for prices
/
1*3
/
YE            year
/
Y1*Y15
/
;
```

In the second part, instructions to control possible combinations of sets are given by defining each possibility. The contents of this part are provided in the three text boxes below.

In the left box, the control set JTEC restricts the number of cropping activities (set jj2) according to techniques (ttec) and equipment. Combined with equations, this instruction has the effect of reducing the number of constraints generated to less than that implied by the domain of defining sets. The first set of controls given in the box below, JTEC, reduces the number of possible combinations from 30 to 10, increasing the speed of the run of the model. Possible combinations of the three sets are given on the following lines. The first three lines mean that rice (RI) can be grown with the technical irrigated techniques (TECIR) and with manual (MAN), traction (TRA) or mechanical equipment (MEC). It appears from this set of controls, that in this zone, soybean (SOY) cannot be cultivated with the techniques (TECIR). PTT governs the combination of type of land and techniques; TTRA and TMEC are subsets of JTEC.

The instruction ALIAS is used to give another name to a previously declared set.

```
JTEC(jj2,ttec,equi)
/
RI.TECIR.MAN
RI.TECIR.TRA
RI.TECIR.MEC
SOY.RAIN.MAN
SOY.RAIN.MEC
CUC.RAIN.MAN
MEL.RAIN.MAN
MA.RAIN.MAN
MA.RAIN.TRA
MA.RAIN.MEC
/
```

```
PTT(tt,ttec)
/
IRT.TECIR
IRT.RAIN
/

TTRA(jj2,ttec,equi)
/
RI.TECIR.TRA
MA.RAIN.TRA
SRI.TECIR.TRA
/
```

```
TMEC(jj2,ttec,equi)
/
RI.TECIR.MEC
SOY.RAIN.MEC
MA.RAIN.MEC
SRI.TECIR.MEC
/

 ;

ALIAS(ex,ox);
ALIAS(tt,t);
ALIAS(ttec,tec);
```

In the fourth part, parameters are declared. The list of parameters used to store solutions of simulations (used by putfile) is provided in the box below. Each line begins with the GAMS instruction PARAMETER, followed by the name of the parameter, the domain and documentary text. Each line ends with a semi-colon “;”

*Parameter for putfiles	
PARAMETER AGRAV(reg,exags,ye)	agricultural added value by farm and active person (million Rp);
PARAMETER LABAGR(reg,exags,ye)	yearly days worked by active person in agriculture (days);
PARAMETER LABEXT(reg,exags,ye)	yearly days worked by active person in non agr. Activity (days);
PARAMETER PRODEXP(exags,jj,ye)	yearly farm production (kg);
PARAMETER PRODREG(exags,jj,ye)	regional production (thousand tons);
PARAMETER SEASAREA(reg,exags,jj2,s,ye)	crop area by farm and season (ha);
PARAMETER TOTAV(reg,exags,ye)	added value by farm and active (million Rp);
PARAMETER WEALCAP(reg,exags,ye)	farm wealth per active person (million Rp);

Parameters in GAMS designate data. Values will be assigned in the data file (Technir.dat). The list of data is provided below.

*Parameters for the model	
PARAMETER AGWA(reg,s,act,ag,gen)	agricultural wage;
PARAMETER ALPH(exags)	aversion to risk;
PARAMETER AN(reg,exags,t,act,tec,s)	animal needs;
PARAMETER ANEED(reg,exags,s,ca,qa)	animal need;
PARAMETER ANINI(reg,exags,ca)	animal avail categories;
PARAMETER ANP(s,ca)	animal price purchase;
PARAMETER ANRE(reg,s,cab)	animal rent value;
PARAMETER ANW(s,cab)	bull traction (only);
PARAMETER AP(s,ca)	animal price;
PARAMETER CO(reg,exags,t,act,tec,equi,s,inp)	input use;
PARAMETER CON(ag,gen,pro)	consumption;
PARAMETER CONSMIN(reg,exags)	minimum consumption;
PARAMETER CONSMY(reg,exags)	minimum consumption;
PARAMETER CONSMYT(reg,exags,ye)	minimum consumption;
PARAMETER CREEX(reg,ex,s)	farm credit available;
PARAMETER CRERE(reg,s)	regional credit available;
PARAMETER EP(me)	equipment price;
PARAMETER FOPR(reg,exags,t,act,tec,equi,s,qa)	forage production;
PARAMETER FP(reg,out,s,pe)	fixed price by period;
PARAMETER FPE(reg,out,s)	expected price;
PARAMETER FPETOT(reg,out,s,ye)	expected price;
PARAMETER FPR(reg,out,s)	real price;
PARAMETER FPRTOT(reg,out,s,ye)	total price evolution;
PARAMETER INIC(reg,exags)	initial cash;
PARAMETER INPR(reg,s,inp)	input price;

```
PARAMETER INPRtot(reg,s,inp,ye)                      input price;
PARAMETER LAMAX(reg,exags,s,ag,gen)                  max ag labor;
PARAMETER LAMAXT(reg,exags,s,ag,gen,ye)              max ag labor;
PARAMETER LAVAI(reg,ex,s,ag,gen)                     population availability;
PARAMETER LAVAIT(reg,ex,s,ag,gen,ye)                 population availability;
PARAMETER LMAX(reg,ex,t,s)                           land availability;
PARAMETER LPR(reg,t)                                 land price sale;
PARAMETER LUSE(reg,exags,t,act,tec,equi,s,ag,gen)    labor used ag;
PARAMETER MAD(s,me)                                  days by equipment;
PARAMETER MAXIQ(reg,out,s)                           price max;
PARAMETER MERE(reg,s,me)                             rented equipment price;
PARAMETER MEY(reg,exags,t,act,jj,tec,equi,s)         mean yield;
PARAMETER MINI(reg,exags,me)                         equipment availability;
PARAMETER MINIQ(reg,out,s)                           price min;
PARAMETER MN(reg,exags,t,act,tec,s,me)               machinery needs;
PARAMETER MNAT(reg,out,s)                            imports national;
PARAMETER MNAT(reg,out,s)                            imports;
PARAMETER NAGWA(reg,w,s,ag,gen)                      non agricultural wage;
PARAMETER NDAY(ag,gen)                               number of days worked;
PARAMETER NFA(reg,ex)                                number of farms;
PARAMETER OTOLA(reg,ex,s,ag,gen)                     other employ unsure;
PARAMETER POPACT(reg,ex,s,ag,gen)                    labor availability;
PARAMETER POPACTT(reg,ex,s,ag,gen,ye)                labor availability;
PARAMETER PRFEED(reg,ex,jj,s,qa)                     price feed;
PARAMETER QUAL(out,pro)                              quality by type of food;
PARAMETER R(reg,t,s)                                 land rent;
PARAMETER RAIN(reg,s)                                rainfall for irrigation;
*PARAMETER RR(reg,s)                                 random affecting rainfall;
PARAMETER SARE(reg)                                  coefficient of land sale;
PARAMETER SIGB(ca)                                   risk on animals;
PARAMETER SIGC(jj2,s)                                risk on crops;
PARAMETER SIGCtot(jj2,s,ye)                          risk on crops;
PARAMETER SIGM(me)                                   risk on machine;
PARAMETER SINI(reg,ex)                               savings initial;
PARAMETER SLAND(reg,t)                               percent of land sold due to inheritance;
PARAMETER TOCRST(reg)                                total short term credit;
PARAMETER TOFF(reg,ex,s,ag,gen)                      total sec labor sure;
PARAMETER WAINI(reg,tti)                             initial water availability;
PARAMETER WASPRING(reg,tti,s)                        water from springs;
PARAMETER WPR(out,s)                                 world price;
PARAMETER WR(reg,exags,tti,act,tteci,equi,s)         water requirements;
PARAMETER XNAT(reg,out,s)                            exports national;
PARAMETER YAM(me)                                    years for equip depreciation;
PARAMETER YAP(cab)                                   years for animal depreciation;
PARAMETER YCR                                        years for credit;
PARAMETER YR(reg,exags,t,j,jj,tec,equi,s)            real yield;
PARAMETER YRTOT(reg,exags,t,j,jj,tec,equi,s,ye)      real yield several years;
```

Scalars designate parameters with no domain; they are defined with a scalar statement containing a list of only one element.

The endogenous variables are decision variables of the production units. They are declared in GAMS with a VARIABLES statement. Each variable is given a name, a domain (if it is not a scalar) and explanatory text.

```
VARIABLE

FONC
OT                                   cummuls consumption
OTCONR(reg, exags, s)                real non ag consump
WHR(reg, exags)                      real wealth
CUMCASHR(reg, exags, s)              transfer cash end of the year
CUR(reg, exags, s)                   real cash transfer
PROF(reg, exags, s)                  total profit
PROFA(reg, exags, s)                 agricultural profit
;
```

```
POSITIVE VARIABLES

AAM(reg,exags,cab)                   animal amortizing
ACTS(reg,ex,s)                       actifs sold
AGCRELT(reg,ex,s)                    ag use of credit long term
AGCREST(reg,exags,S)                 ag use of credit short term
AL(reg,exags,t,jj2,tec,equi,s)       land allocation of crops
AM(reg,exags,me)                     equipment amortizing
ANAVA(reg,exags,s,ca)                animal traction transfer
ANFIN(reg,exags,ca)                  animals transfer end of year
ANLOC(reg,exags,s,ca)                animal traction rent out
ANPU(reg,exags,s,ca)                 animal traction bought (days of bulls)
ANRENT(reg,exags,s,ca)               animal traction rent in
ANS(reg,exags,s,ca)                  animals sold decapitalisation
ANSTO(reg,exags,s,ca)                animals transfer
CU(reg,exags,s)                  expected cash transfer
CUMCASH(reg,exags)                   cash transfer at the end of the year
INTRA(reg,exags,s,inp)               input transfer between seasons
INU(reg,exags,s,inp)                 input used
```

```
LA(reg,ex,s,j,ag,gen)            agr labor transfer
LAOFF(reg,ex,s,ag,gen)           off farm labor unsure
LAOFIN(reg,ex,t)                 land at the end of season 3
LAOWN(reg,ex,t,s)                land transfer
LARIN(reg,ex,s,act,ag,gen)       agr labor rented in
LAROUT(reg,ex,s,act,ag,gen)      agr labor rented out
LAS(reg,ex,s,ag,gen              off farm labor sure
LP(reg,ex,t,s)                   land purchased
LRIN(reg,ex,t,s)                 land rented in
LROUT(reg,ex,t,s)                land rented out
LS(reg,ex,t,s)                   land sold
MAFIN(reg,exags,me)              machinery available end of year
MAPU(reg,exags,s,me)             machinery purchased used(days)
MASELL(reg,exags,s,me)           machinery sold
MAV(reg,exags,s,me)              machinery available used
MELOC(reg,exags,s,me)            machinery rent out
MERENT(reg,exags,s,me)           machinery rent in
MS(reg,ex,s)                     savings used for investment
OFEED(jj,s)                      feed total
OTCON(reg,exags,s)               expected non ag consump
OTLA(reg,ex,s,ag,gen)            other labor transfer
PDR(reg,exags,act,s)             real production
PRODUCT(reg,exags,act,s)         expected production
PROPU(reg,ex,out,s)              food purchases
SA(reg,ex,s)                     savings transfer
SAB(reg,ex,s)                    saving bought
SAVS(reg,ex,s)                   savings sell
STCRE(reg,exags)                 cummulated credit short term
TRCRELT(reg,ex,s)                use of credit long term
TRCRST(reg,ex,s)                 use of credit short term
TRLA(reg,ex,s,ag,gen)            transfo labor transfer
WAT(reg,exags,tti,s)             water allocation by farm
WATRA(reg,tti,s)                 water transfer between seasons
WH(reg,exags)                    wealth
;
```

Equations are declared in this file but their definition is in the Technir.equ files. First comes the GAMS keyword EQUATIONS followed by the name, domain and text of the group of equations.

```
* definition of equations of the model
EQUATIONS

ACTSELL(reg,exags,s)                 sell of actifs
AMATR(reg,exags,cab)                 amortizing animals
AMEQ(reg,exags,me)                   amortizing equipement
ANLOTR(reg,exags,s,cab)              traction transfer renting
ANSFIN(reg,exags,ca)                 animal stock end of year
ANTO(reg,exags,s,ca)                 animal balance
BENEF(reg,exags,s)                   expected profit by season to calculate cons
BENEFR(reg,exags,s)                  real profit by season to calculate consumption
CASH(reg,exags,s)                    real agr cash
CASHEXP(reg,exags,s)                 expected agr cash
CONSR(reg,exags,s,pro)               rural consumption
CRST(reg)                            credit short term
EXCRE(reg,exags,s)                   regional credit by farm
FINCASH(reg,exags)                   real cash end of the year
FINCASHEXP(reg,exags)                expected  cash end of the year
FONCTION                         expected utility of wealth
INPUTS(reg,exags,s,inp)              input balance
INV(reg,exags,s)                     investment ag
LABAL(reg,exags,s,jj2,ag,gen)        labor balance
LABOUT(reg,s,act,ag,gen)             labor rented balance
```

9.3 Data file: Technir.dat

The technir.dat file contains all the information necessary to build the MATA model. Three different formats are allowed with GAMS for entering data: tables, direct assignment, and lists.

- Tables: an example of a two-dimensional table is given at the beginning of the file:

TABLE MRIRT1(jj2,jj)   average yields techn. irrig land season 1 (in kg per ha)

	RI	*SOY*	*MA*
RI	*5724*		
SOY		*900*	
MA			*2182;*

This statement assigns values to the variable MIRT1 defined on two sets jj2 (cropping activity) in line and jj (outputs of cropping activities) in column. It has to begin with the instruction “table” and to end with a semi-colon ‘;’

- Direct assignment: an example is given at the end of 1.1

MEY(reg,exags,"irt",jj2,jj,"tecir",equi,"s1")=MRIRT1(jj2,jj);

In the MATA model, in order to preserve autonomy of each file and to make modifications easier, the data entered in tables in this file do not have the same names as parameters used in the equation file. So each table is then used in direct assignment to define the parameters of the technir.equ file.

- Lists: an example of list is given in 1.2.2

```
PARAMETER ANEEDE(ca)    animal requirement for grass (in kg by season)
/
BEEF          2250
SHEEP         1125
POULTRY         90
/;
```

This statement is indicated in the case of parameters of dimension 1. It begins with the GAMS instruction PARAMETER, then the name of the parameter, the domain and explanatory text. Then the list of domain elements and the respective parameter values are written between slashes ”/”. The statement ends with a semi-colon.

Two types of data are used to build the MATA production module: data that are accurate at the agro-economic zone level such as yields, wages, prices and data that are specific to the farming systems determined by the typology (land, labor, etc.).

9.3.1 Data collected at the agro-economic zone level

The lists of the number of cropping seasons, possible crops, animal activities, land types and irrigation techniques in the zone of technical irrigated land are given as SET in the technir.def files. The list of parameters (data necessary to build the model) has also been provided in this file.

9.3.1.1 Production performance

```
* Part 1 Data collected at the agro-economic zone level
*____________________________________________________________

1.1 Average yields for production by type of land and season

TABLE MRIRT1(jj2,jj)   average yields techn. irrig land season 1 (in kg per ha)
           RI       SOY        MA
RI       5724
SOY                 900
MA                            2182 ;

TABLE MRIRT2(jj2,jj)   average yields techn. irrig land season 2 (in kg per ha)
           RI       SOY        MA
RI       4022
SOY                 900
MA                            2182 ;

TABLE MRRAIT3(jj2,jj)   average yields techn. irrig land season 3 (in kg per ha)
        SOY     MEL     CUC      MA
SOY     933
MEL            5727
CUC                    3400
MA                               2182;
* assignement of values to MATA parameters
MEY(reg,exags,"irt",jj2,jj,"tecir",equi,"s1")=MRIRT1(jj2,jj);
MEY(reg,exags,"irt",jj2,jj,"tecir",equi,"s2" )=MRIRT2(jj2,jj);
MEY(reg,exags,"irt",jj2,jj,"rain",equi,"s3")=MRRAIT3(jj2,jj);
```

Average yield in tons per hectare has been collected for each activity, for each type of land, for each type of irrigation, for each type of equipment (manual, animal or mechanical) and for each season. If a crop is grown with two different techniques, such as rice with or without transplanting, it is considered as two activities. If two crops are cultivated together in the same field (multicropping), it is considered as one activity.

The data are organized in tables, with one table for each combination of season, land, irrigation and equipment. In each table, the first column represents the different activities and the first line the output of the activities, as shown in the box below. Here, there is no difference of yield for the different equipment.

Under the tables, assignment lines have been written.These assignments are the links between the parameter MEY and the tables.

Table MRIRT1(jj2,jj) is the data table for season 1 in technical irrigated land for all types of equipment.

The elements of the set that are defined in the table, such as the season, the land and the technigues, are written between " ". The elements that have no influence on the yields (exags, equi) are left unchanged. The assignment line is finished by a semi-colon.

9.3.1.2 Inputs

```
*1.2 Technical coefficients for production

*1.2.1 Input used according to technical itinerary for crops
TABLE IRR1(act,inp)   inputs techn. irrig land season1 (in kg per ha)
        OTH   PEST  UREA   TSP   KCL   NPK   SEED   MANURE
RI      170   40.3   192   184    25     0   14.63       0
SOY       0   50.7   600  74.4  12.5     0       0       0
MA        0    2.8   247    28     7     0     6.1      17 ;

TABLE IRR2(act,inp)   inputs techn. irrig land season2 (in kg per ha)
        OTH   PEST  UREA   TSP   KCL   NPK   SEED   MANURE
RI        0   48.8   232   177    20     0      0        0
SOY       0   34.7   342  49.2    48     0      0        0
MA        0    2.8   247    28     7     0    6.1       17   ;

TABLE RAIT3(act,inp)   coeff. irrig. tech. rain (in kg per ha)
        OTH   PEST  UREA   TSP   KCL   NPK   SEED   MANURE
SOY       0   50.7   161    32    12     0      0        0
CUC       5   23.0   275   101     0    33      0        0
MEL       4   47.1   188   143    13    87    4.3        1
MA        0    2.8   247    28     7     0    6.1       17   ;
* assignment of values to MATA parameters
CO(reg,exags,"irt",act,"tecir",equi,"s1",inp)=IRR1(act,inp);
CO(reg,exags,"irt",act,"tecir",equi,"s2",inp)=IRR2(act,inp);
CO(reg,exags,"irt",act,"rain",equi,"s3",inp)=RAIT3(act,inp);
```

The levels of inputs (in kg/ha) have been collected for each cropping activity, for each type of land, for each type of irrigation, for each type of equipment, and for each season. The data are presented in tables as for the yields but with the first column representing the different activities and the first line the different inputs. Seed, Other and Pest are given in Rp/ha. The fertilizers are in kg/ha.

```
*1.2.2 Input used for animals
PARAMETER ANEEDE(ca)    animal need  of grass (in kg by season)
/
BEEF            2250
SHEEP          1125
POULTRY        90
/;
* assignment of values to MATA parameters
 ANEED(reg,exags,s,ca,"une")=ANEEDE(ca);
```

Animal requirements in kg of feed for each type of animal by season have been collected. Here, there is only one category of feed requirement, grass.

9.3.1.3 Labor requirements

```
*1.2.3 Labor required by technical itinerary
TABLE LABIT(act,equi,s)   Human work per crop in days irrig. tech.
                  S1      S2       S3
RI.MAN          165     156
RI.TRA          131     122
RI.MEC          119     110
SOY.MAN      160       130       147
SOY.MEC      130     100       117
CUC.MAN                           130
MEL.MAN                           131
MA.MAN          98        98        98
MA.TRA          64        64        64
MA.MEC          52        52        52
;
* assignment of values to MATA parameters
LUSE(reg,exags,"irt",act,"tecir",equi,s,ag,gen)=LABIT(act,equi,s);
LUSE(reg,exags,"irt",act,"rain",equi,s,ag,gen)=LABIT(act,equi,s);
```

The level of labour has been collected for each activity, for each type of land (upland, lowland or other), for each type of irrigation (no irrigation, technical irrigation or simple irrigation), for each type of equipment (manual, animal or mechanical), and for each season.

The data are presented in tables as for the yields but with the first column representing the different activities for the different type of equipment (for example RI.MAN is the activity rice with only human labor, RI.TRA is the activity rice with human and animal labor and RI.MEC is the activity rice with human and machine labor) and in the first line the different seasons as shown in the box below.

```
*1.2.3 Traction required by technical itinerary
TABLE ANE(act,s)   (in days)
        S1       S2       S3
RI      16       16
MA      16       16       16
;
* assignment of values to MATA parameters
AN(reg,exags,t,act,tec,s)=ANE(act,s);

*1.2.4 Machines required by technical itinerary
TABLE MNE(t,act,tec,me)  machinery needs   (in days)
               BIG          SMA
RI              4
SOY                          0.5
MA              4
;
* assignment of values to MATA parameters
MN(reg,exags,t,act,tec,s,me)=MNE(t,act,tec,me);
```

Then for the activities that require animal (rice and maize) and mechanical (rice, soybean and maize) labor, the requirements in animal (one type of animal) and machine (2 types of machines BIG and SMA) labor are given.

```
*1.2.5 Animal labor requirements
SCALAR TEMFRE   crop time for one kilo of grass (in days)
/0.011/;
```

Labor requirements are given for each type of animal for each season. In this zone the main animal labor requirement is the time spent by farmers to collect grass on the farm or around the farm (borders of roads).

9.3.1.4 Water requirements

```
*1.2.6 Water required by technical itinerary
TABLE WRE(act,tteci)   water requirement of plants (in m3 per ha per season)
            TECIR
RI          37850
SOY          1040
CUC          1040
MEL          1040
;
* assignment of values to MATA parameters
WR(reg,exags,tti,act,tteci,equi,s)=WRE(act,tteci); for each activity
```

The data for the water requirements in m^3 per hectare of the different crops come from agronomist estimates.

```
*1.2.7 Rainfall per seaon
PARAMETER  RAINE(s)  rainfall by season in m3 per ha per season
/
S1    8603
S2    7808
S3    3450
/;
* assignment of values to MATA parameters
RAIN(reg,s)=RAINE(s);
```

The rainfall, given in mm/month, is converted to m^3 per season per hectare.

9.3.1.5 Prices

All the prices used in this model are those corresponding to the year of the surveys used to build the typology of the farming systems (1992). All the prices are divided by one thousand in order to ease the GAMS runs.

```
*1.3 prices

*1.3.1 Average farm gate output prices at harvest time
TABLE FPEE(out,s)   agricultural product prices (in 000Rp per kg)(cap)
                 S1       S2       S3
RI              0.239    0.239    0.239
SOY             0.950    0.880    0.860
CUC              1        1        1
MA              0.206    0.206    0.230
MEL              0.8      0.8      0.8
BEEF             450      450      450
SHEEP             26       24       30
POULTRY          2.2      2.2      2.2
;
* assignment of values to MATA parameters
FPR(reg,out,s)=FPEE(out,s)/1E3 ;
FPE(reg,out,s)=FPEE(out,s)/1E3 ;
PARAMETER FPRM(reg,out,s,ye ) ;
FPRM(reg,out,s,ye)= FPEE(out,s)/1E3 ;
```

Prices have been collected for each output of activity for each season in Rp/kg.

```
*1.3.2 Input prices:
TABLE INPRE(s,inp)  input prices    (in 000 Rp per kg)
      OTH  PEST  UREA   TSP   KCL   NPK  SEED  MANURE
S1     1     1    0.2   0.25  0.25  0.76   1      0
S2     1     1    0.2   0.25  0.25  0.76   1      0
S3     1     1    0.2   0.25  0.25  0.76   1      0
;
 * assignment of values to MATA parameters
INPR(reg,s,inp)=INPRE(s,inp)/1E3;
INPRTOT(reg,s,inp,ye)=INPRE(s,inp)/1E3;
```

Prices of inputs have been collected for each input (crop and animal inputs) in rupiah/kg. The prices of Seed, Pest and Oth are equal to 1 because the data entered for these three categories in 1.3.2 are in ’000 Rp/ha.

```
*1.3.3 Prices for labour
TABLE AGWAE(s,act) agricultural labor price (in 000 Rp per day)
        RI      SOY  CUC   MEL   LST    MA
S1      4                  2.7     2.5
S2      4                  2.7     2.6
S3           2.2     3.9   2.7     2.7     2.7;

Table NAGWAE(w,s)  off farm wages (in 000 Rp per day)
                  S1      S2       S3
SURE           3.4     3.8      4.2
UNSURE       3.1     2.8      2.8 ;

* assignment of values to MATA parameters
AGWA(reg,s,act,ag,gen)=AGWAE(S,act)/1E3;
NAGWA(reg,w,s,ag,gen)=NAGWAE(w,s)/1E3;
```

Agricultural labor is the price of hired labor for each activity in rupiah/day or hour, while non-agricultural labour is the wage in rupiah/day or hour for regular (SURE) or seasonal (UNSURE) off-farm activities.

```
*1.3.4 Prices of land
PARAMETER LPRE(t) land sale price (000Rp / ha)
/IRT       6500/;

TABLE REE(t,s)  Price of land rented per ha per season (in 000Rp /ha)
        S1      S2       S3
IRT      412     412      412;

* assignment of values to MATA parameters
LPR(reg,t)=LPRE(t)/1E3;
R(reg,t,s)=REE(t,s)/1E3;
```

The price of land to buy and sell and to rent is in rupiah/ha.

```
*1.3.5 Prices and risk for animals
TABLE ANP(s,ca)   animal purchase price (in 000Rp)
       BEEF     SHEEP    POULTRY
S1      450      26      2.2
S2      450      24      2.2
S3      450      30      2.2
;
TABLE AP(s,ca)   animal selling price (in 000Rp)
     BEEF      SHEEP    POULTRY
S1     300       20       1.9
S2     300       20       1.9
S3     300       20       1.9
;
TABLE ANREE(s,cab)   animal rent value (in 000Rp per day)
    BEEF
S1    9.3
S2    9.3
S3    9.3
;
* assignment of values to MATA parameters
AP(s,ca) = AP(s,ca)/1E3;
ANRE(reg,s,cab)=ANREE(s,cab)/1E3;
ANP(s,ca) = ANP(S,ca)/1E3;
```

Animals: the price of animals is for buying, selling and renting animal traction.

```
*1.3.6.Prices for equipment
PARAMETER MEREE(me)   rented equipment price (in 000Rp per day)
/
BIG      25
SMA       4
/;
PARAMETER EP(me)   equipment price (in 000Rp)
/
BIG      3000
SMA       200
/;
* assignment of values to MATA parameters
MERE(reg,s,me)=MEREE(me)/1E3;
EP(me)=EP(me)/1E3 ;
```

9.3.1.6 Risk of different activities

```
*1.4 Risk

*1.4.1 Deviation of gross margins for crops
TABLE SIGCE (jj2,s)   risk on crops
          S1      S2     S3
RI       0.15    0.20   0.70
SOY      0.80    0.80   0.60
CUC      0.60    0.60   2.0
MEL      0.60    0.60   2.0
MA       0.5     0.5    0.5
;
* assignment of values to MATA parameters
SIGC(jj2,s)=SIGCE(jj2,s) ;
SIGCTOT(jj2,s,ye)=SIGCE(jj2,s) ;

*1.4.2 Risk on labor
PARAMETER SIGW(w)   risk on labour wages
/
SURE       0.15
UNSURE   0.3
AG           0.15
/;

*1.4.3 Risk on land
PARAMETER SIGL(t)   risk on land
/
IRT     0.05
/;

SCALAR SIGR   risk on land renting
/
0.01
/;
```

Risk of the activities is calculated as expected percentage of deviation of gross margin for each agricultural activity, for each type of land, for each type of irrigation, for each type of equipment, and for each season.

```
*1.4.4 Risk on animals
  PARAMETER SIGB(ca) risk on animals
/ BEEF         0.20
  SHEEP        0.20
  POULTRY   0.15
/;

*1.4.5 Risk on machine
  PARAMETER SIGM(me)   risk on machine
/ BIG        0.3
  SMA       0.3
/;

* 1.4.6 risk on cash
SCALAR SIGCA   risk on cash
/0.2/;
```

9.3.1.7 Regional scale parameters

```
*1.5 Scale parameters
PARAMETER SCAL (exags)
/
EXP1    240000
EXP2    276000
EXP3    720000
/;
```

The scale parameters were calculated while doing the typology.

9.3.2 Data collected at village and farm levels

9.3.2.1 Data at the village level

```
*Part 2 Data collected at farm or village level
*___________________________________________________________

*2.1 number of farms by type at village level
PARAMETER NFAE(ex)   number of farms
/
EXP1      8
EXP2      9
EXP3     24
/;
 * assignment of values to MATA parameters
NFA(reg,ex)=NFAE(ex);
```

The number of farms at the village level is in the same proportion as the scale parameters. It is used for calculation of the use of common resources (water) as well as for possible exchanges (land, labour, animal traction, machine).

```
*2.2   water availability
PARAMETER WAINIE(tti)   Water coming from dams in m3 per village
/
IRT      3261493
/;

TABLE WASPRINGE(tti,s) Water coming from springs in m3 per season per village
                 S1          S2          S3
IRT               0           0           0
;
* assignment of values to MATA parameters
WAINI(reg,tti)=WAINIE(tti);
WASPRING(reg,tti,s)=WASPRINGE(tti,s);
```

The water is for all the farmers of the village. Technically irrigated land uses water coming from dams, while simply irrigated land uses water coming from springs.

9.3.2.2 Data at the farm level

Data collected at the farm level concerns land, family labour, animal availability, machine endowment, cash saving and borrowing, consumption, and risk aversion.

```
*2.3 Land
TABLE LMAXE(exags,t)   land availability (in ha)
            IRT
EXP1       5.8
EXP2       0.8
EXP3       0
;
* assignment of values to MATA parameters
LMAX(reg,exags,t,s)=LMAXE(exags,t);
```

Here, the land owned by farmers is given. EXP3 covers landless farmers that have to rent all their land, while EXP1 are very big owners.

```
*2.4 Family population and number of active persons
PARAMETER  LAVAIE(ex)   number of members per family (cap)
/  EXP1     5
   EXP2     5
   EXP3     5 /;
PARAMETER POPACTE(ex)  number of active persons available per exploitation (cap)
/  EXP1   3.2
   EXP2   3.2
   EXP3   3.6 /;
 PARAMETER NDAYE(gen)   Number of days worked by one active person per season
/ MALE   90/;
* assignment of values to MATA parameters
LAVAI(reg,ex,s,ag,gen)=LAVAIE(ex);
POPACT(reg,ex,s,ag,gen)=POPACTE(ex);
NDAY(ag,gen)=NDAYE(gen);
PARAMETER LAMAXE(exags) ;
LAMAXE(exags) = POPACTE(exags) * NDAYE( "male") ;
LAMAX(reg,exags,s,ag,gen)=LAMAXE(exags);
```

There is little difference between the farmers with respect to the number of persons in the family and the number of active persons.

```
*2.5 Animals owned
TABLE ANINIE(exags,ca)   animal endowment per exploitation and per category (in numbers)
            BEEF   SHEEP   POULTRY
EXP1         0       1       14
EXP2         0       1        8
EXP3         0       1        5 ;
TABLE ANW(s,cab)   traction given by bull in day per season
     BEEF
S1    40
S2    40
S3    40 ;
PARAMETER YAP(cab)   animal depreciation (in years)
/BEEF    10/;
* assignment of values to MATA parameters
ANINI(reg,exags,ca)=ANINIE(exags,ca);
```

```
*2.6 machine endowment
TABLE MINIE(exags,me)  equipment availability
            BIG     SMA
EXP1    0.125    0.625
EXP2      0       0.25
EXP3    0.08      0.08
;
```

```
TABLE MAD(s,me)   in days by equipment per season
     BIG      SMA
S1   40        40
S2   40        40
S3   40        40
;
PARAMETER YAM(me)   equipment depreciation (in years)
/
BIG     10
SMA      5
/;
 * assignment of values to MATA parameters
MINI(reg,exags,me)=MINIE(exags,me);
```

In the technical irrigated zone, farmers are mechanized and do not use animal traction anymore. Machines are used mainly for traction; BIG is a normal tractor and SMA is a hand-tractor.

```
*2.7Cash saving and borrowing

*2.7.1 Cash at the beginning of the period
PARAMETER INICE(exags)   initial cash (in 000Rp)
/
EXP1    300
EXP2    200
EXP3    900
/;
PARAMETER PROVCASH(exags)   cash provision (in 000Rp)
/
EXP1     300
EXP2     200
EXP3     900
/;
 * assignment of values to MATA parameters
PROVCASH(exags) = PROVCASH(exags)/ 1E3 ;
INIC(reg,exags)=INICE(exags)/1E3;
```

```
*2.7.2 Savings
PARAMETER SINIE(ex) saving initial (in 000Rp)
/
EXP1   46409
EXP2    5914
EXP3     983
/;
* assignment of values to MATA parameters
SINI(reg,ex)=SINIE(ex)/1E3 ;
```

The landless farmers have, of course, less savings.

```
*2.8 Consumption

*2.8.1 Food consumption
PARAMETER CONE(pro)  consumption (per day in cal and g)
/CALO   2360
PROT     52/;
* assignment of values to MATA parameters
CON(ag,gen,pro)=CONE(pro);

*number of days of consumption per season
SCALAR NDC   /120/;

TABLE QUAL(out,pro)  quality per type of food per kg (in cal and g)
              CALO     PROT
RI            3605      68
SOY           3310     350
CUC            120       7
MEL            280       5
BEEF          2070     188
SHEEP         1540     166
POULTRY       3020     182;

*2.8.2 Minimum non food consumption
PARAMETER CONSMINE(exags) min non ag consumption (in 000Rp)
/ EXP1  700
  EXP2  500
  EXP3  350/;
* assignment of values to MATA parameters
CONSMIN(reg,exags)=CONSMINE(exags)/1E3;

*2.8.3 Consumption propensity
SCALAR PROPCONS/0.75/ ;
```

In order to evaluate the consumption of the family, it is necessary to know:

- needs in calories and protein per person per day and the quantity of calories and protein supplied by one kg of product;
- minimal non-food consumption per head which is the amount of money necessary for the survival of the family (health care and school); and
- consumption propensity which it is the percentage of the profit that will be used by the family.

```
*2.9 Initial parameters for risk
PARAMETER COEF(exags);
CF=1;
PC=1;

ALPH("exp1") = 0.030 ;
ALPH("exp2") = 0.050 ;
ALPH("exp3")=  0.070 ;
COEF("exp1") = 0.049 ;
COEF("exp2") = 0.1875;
COEF("exp3") = 0.2134;
```

Farmers' aversion to risk is difficult to estimate. In fact, it is used as a calibrating parameter and then checked for consistency with the qualitative analysis.

9.3.2.3 Market conditions at the village level

Data on market conditions at the village level concern credit, labour and transaction costs.

```
*2.10.1 credit
SCALARS
ICT  /0.3/
YCR /5/
TOCRSTE  /0/
TOCRST(reg)=TOCRSTE/1E3 ;
```

Included are availability of credit, interest rates (short and long term), maximum off-farm labor opportunities for all the farms, and maximum hired agricultural labor for all the farms.

```
*2.10.2 off farm employment opportunities
TABLE TOFFE(ex,s)   labour sure off farm in days
           S1     S2     S3
EXP1      95     80     90
EXP2      68     83     50
EXP3      71     62     45
;
TABLE  OTOLAE(ex,s) labour unsure off farm  (in days)
          S1     S2     S3
EXP1     23      0      0
EXP2      5      4      0
EXP3      7     20     16
;
* assignment of values to MATA parameters
 TOFF(reg,ex,s,ag,gen)=TOFFE(ex,s);
OTOLA(reg,ex,s,ag,gen)=OTOLAE(ex,s);
```

This is only useful when the labor market is limited, which is often the case.

```
*2.10.3 Transaction cost work and land:

SCALAR CTRA transaction cost
/ 0.8 /;
```

9.3.2.4 Random coefficients for yields and prices

In agriculture, there are no certainties on either yields or prices of the products. When a farmer plans his production, he has only an expectation of what the results will be. In this model, the farmer expects the average yields. However the real results that are used to calculate next years endowment, use the average yield multiplied by a random coefficient. A coefficient lower than one can represent bad weather or a pest attack, and a coefficient higher than one perfect climatic conditions.

For prices, farmers during the first year expect the prices given above, but real results are calculated with these prices multiplied by a random coefficient. After the first year, the anticipations of the farmers can follow different patterns.

```
*4.1 Random on prices:

PARAMETER UR1(ye) random coef for rice price
/
Y1    0.945,    Y2   0.970,    Y3   1.071,    Y4    0.913, Y5    1.000,    Y6   1.100
Y7    1.016,    Y8   1.098,    Y9   1.052,    Y10   0.926,Y11   1.016,    Y12  1.098,
Y13  1.052,    Y14   0.926,  Y15   0.913
/;

PARAMETER US (ye)   random coef for soy price
/
Y1    1.056,    Y2    0.864,    Y3   0.900,    Y4    1.068,Y5    0.974,    Y6    0.944
Y7    0.941,    Y8    0.853,    Y9   0.860,    Y10   1.036Y11   1.068,    Y12   0.900,
Y13  1.036,    Y14   0.944,Y15   0.974
/;

PARAMETER UM(ye)   random coef for melon price
/
Y1  0.758,  Y2   1.765,  Y3   1.326,  Y4  0.952,  Y5  0.938,  Y6  0.836
Y7  1.025,  Y8   1.784,  Y9   0.601,  Y10 1.250,  Y11 1.997,  Y12 1.368
Y13 1.987,  Y14  1.643,  Y15  0.696
/;

PARAMETER UC(ye)   random coef for cucumber price
/
Y1  1.460,  Y2   0.739,   Y3   0.875,   Y4  1.503,  Y5   1.153, Y6   1.040
Y7  1.027,  Y8   0.697,   Y9   0.725,   Y10 1.384,  Y11  1.746, Y12  0.846
Y13 1.499,  Y14  1.664,   Y15  0.955
/;
```

```
PARAMETER RMA (ye)   random coef for maize price
/
Y1   1.085,  Y2   0.940,  Y3   0.888,  Y4   1.075,  Y5   0.871,  Y6   0.911
Y7   0.852,  Y8   0.931,  Y9   1.000,  Y10  0.895,  Y11  0.902,  Y12  0.949
Y13  0.945,  Y14  0.947,  Y15  1.139
/;

* assignment of values to MATA parameters
PARAMETER UR(out,ye)   uniform random on output prices;
UR(out,ye)=1;
UR("ri",ye)= UR1 (ye);
UR("soy",ye)= US(ye);
UR("mel",ye)= UM(ye);
UR("cuc",ye)= UC(ye);
UR("ma",ye)= RMA(ye);

FPRTOT(reg,out,s,ye)= (FPEE(out,s)/1E3)*UR(out,ye);


*4.2 Random on yields:

PARAMETER YRS1 (ye)   random on rice yields season 1
/
Y1   0.922,   Y2   1.000,  Y3   0.932,   Y4   1.074,   Y5   0.953,    Y6   0.957,
Y7   1.019,  Y8   1.045,   Y9    1.026,   Y10  0.993, Y11  1.016,   Y12  1.098,
Y13  1.052,   Y14   0.926,Y15  0.913
/;

PARAMETER YRS2 (ye)   random on rice yields season 2
/
Y1   0.965,  Y2   0.847,  Y3   0.926,   Y4   0.819,   Y5   0.935,
Y6   0.873,  Y7   1.058,  Y8   1.024,   Y9   1.108,   Y10  0.919
Y11  1.058,  Y12  0.926,  Y13  0.819,   Y14  1.024,Y15  0.965
/;

PARAMETER YSB(ye)   random on  soybean yields season 2  and 3
/
Y1  1.299,   Y2   1.047,   Y3  1.295,    Y4   1.157,    Y5    0.778,
Y6  1.084,   Y7   0.796,   Y8  0.850,    Y9   1.101,    Y10   0.961,
Y11 1.101,   Y12  1.047,   Y13 0.778,    Y14  1.084,    Y15   0.796
/;
```

```
PARAMETER YCUC (ye)   random on cucumber yields
/
Y1   0.829,    Y2   0.870,   Y3   1.010,  Y4   1.100,    Y5   0.871,
Y6   0.814,    Y7   1.034,   Y8   1.048,  Y9   0.956,    Y10  0.943,
Y11  1.034,    Y12  1.048,   Y13  0.870,  Y14  1.100,Y15  0.829
/;

PARAMETER YMEL (ye)   random on watermelon yields
/
Y1   1.048,    Y2   1.077,    Y3   1.038,    Y4   0.935,    Y5   0.876,
Y6   0.881,    Y7   1.042,    Y8   1.014,    Y9   0.859,    Y10  1.088,
Y11  1.077,    Y12  1.088,    Y13  0.935,    Y14  0.876,Y15  1.042
/;

PARAMETER YRTOT ;

YRTOT(reg,exags,t,"ri",jj,tec,equi,"s1",ye)=MEY(reg,exags,t,"ri",jj,tec,equi,"s1")*YR
S1(ye);
YRTOT(reg,exags,t,"ri",jj,tec,equi,"s2",ye)=MEY(reg,exags,t,"ri",jj,tec,equi,"s2")*YR
S2(ye);
YRTOT(reg,exags,t,"soy",jj,tec,equi,"s3",ye)=MEY(reg,exags,t,"soy",jj,tec,equi,"s3")*
YSB(ye);
YRTOT(reg,exags,t,"ma",jj,tec,equi,"s3",ye)=MEY(reg,exags,t,"ma",jj,tec,equi,"s3")*
YSB(ye);
YRTOT(reg,exags,t,"cuc",jj,tec,equi,"s3",ye)=MEY(reg,exags,t,"cuc",jj,tec,equi,"s3")*
YSB(ye);
YRTOT(reg,exags,t,"mel",jj,tec,equi,"s3",ye)=MEY(reg,exags,t,"mel",jj,tec,equi,"s3")
*YSB(ye);
```

Random coefficients are calculated with the uniform law provided in GAMS with various parameters, according to the variability of yields and prices for each crop. It would be possible to calculate the random value for each year in each simulation. Then, it will be more difficult to discriminate between the effect of the change in policies and the impact of good and bad years as generated by the random function. For this reason, random coefficients have been calculated in separate files and are included here as parameters.

9.4 How to modify a data table

The production module data are organized as a combination of the technir.def and the technir.dat files. The definition file contains the definition of the sets, the parameters and the scalars used in the data file. The two files always have to be modified at the same time. For example, if data are added in the *.DAT file, its name should be added in the *.DEF file.

In order to explain the way data are entered in the data file, an example is taken: there is another activity that is possible such as a combination of soybean and maize. In that case, several lines have to be added in several tables:

-yields
-input requirements
-labor requirements
-water requirements
-risk
-price for agricultural labor
-random for the yields of this activity

But first, some modifications have to be made in the technir.def file. The new activity named, for instance soyma, has to be added in different SETS (act, j, jj2) and in the SETS of

CONTROL (jtec, tmec and ttra). The new statements are written in bold.

```
ACT all activities
/
RI              rice
SOY             soybean
BEEF            beef
SHEEP           sheep
POULTRY         poultry
FALW            fallow
LST             livestock
CUC             cucumber
MEL             melon
MA              maize
SOYMA           soybean-maize
/
```

```
J(act) all main activities
/
RI          rice
SOY         soybean
CUC         cucumber
MEL         melon
LST         livestock
MA          maize
SOYMA       soybean-maize
/
JJ2(j) all crops
/
RI          rice
SOY         soybean
CUC         cucumber
MEL         melon
MA          maize
SOYMA       Soybean-maize
/
```

```
*control of combination of sets

JTEC(jj2,ttec,equi)
/
RI.TECIR.MAN
RI.TECIR.TRA
RI.TECIR.MEC
SOY.RAIN.MAN
SOY.RAIN.MEC
CUC.RAIN.MAN
MEL.RAIN.MAN
MA.RAIN.MAN
MA.RAIN.TRA
MA.RAIN.MEC
SOYMA.RAIN.MAN
SOYMA.RAIN.TRA
SOYMA.RAIN.MEC
/
```

```
PTT(tt,ttec)
/
IRT.TECIR
IRT.RAIN
/

TTRA(jj2,ttec,equi)
/
RI.TECIR.TRA
MA.RAIN.TRA
SOYMA.RAIN.TRA
/

TMEC(jj2,ttec,equi)
/
RI.TECIR.MEC
SOY.RAIN.MEC
MA.RAIN.MEC
SOYMA.RAIN.MEC
/
```

Then lines are added as follows in the technir.dat file:

```
TABLE MRRAIT3(jj2,jj)   average yields techn. irrig land season 3 (in kg per ha)
             SOY     MEL     CUC     MA
SOY          933
MEL                  5727
CUC                          3400
MA                                   2182
SOYMA        534                      850 ;

TABLE RAIT3(act,inp)   coeff. irrig. tech. rain (in kg per ha)
        OTH   PEST   UREA   TSP   KCL   NPK   SEED   MANURE
SOY      0    50.7   161     32    12    0     0       0
CUC      5    23.0   275    101     0   33     0       0
MEL      4    47.1   188    143    13   87    4.3      1
MA       0     2.8   247     28     7    0    6.1     17
SOYMA    0    25.3   203     30    10    0    3.2      6;
```

```
*1.2.3 Labor required by technical itinerary
TABLE LABIT(act,equi,s)   Human work per crop in days irrig. tech.
                    S1      S2      S3
RI.MAN             165     156
RI.TRA             131     122
RI.MEC             119     110
SOY.MAN            160     130     147
SOY.MEC            130     100     117
CUC.MAN                            130
MEL.MAN                            131
MA.MAN              98      98      98
MA.TRA              64      64      64
MA.MEC              52      52      52
SOYMA.MAN                          121
SOYMA.TRA                           82
SOYMA.MEC                           70
;

*1.2.3 Traction required by technical itinerary

TABLE ANE(act,s)   (in days)
             S1      S2      S3
RI           16      16
MA           16      16      16
SOYMA                        10
;

*1.2.4 Machines required by technical itinerary
TABLE MNE(t,act,tec,me)  machinery needs   (in days)
            BIG         SMA
RI           4
SOY                     0.5
MA           4
SOYMA        2          0.5
;
```

```
TABLE WRE(act,tteci)   water requirement of plants (in m3 per ha per season)
             TECIR
RI           37850
SOY           1040
CUC           1040
MEL           1040
SOYMA          890
;

*1.4.1 Deviation of gross margins for crops
TABLE SIGCE (jj2,s)   risk on crops
               S1      S2      S3
RI           0.15    0.20    0.70
SOY          0.80    0.80    0.60
CUC          0.60    0.60    2.0
MEL          0.60    0.60    2.0
MA            0.5     0.5     0.5
SOYMA         0.6     0.5     0.6
;

*1.3.3 Prices for labour
TABLE AGWAE(s,act) agricultural labor price (in 000 rp per day)


       RI    SOY   CUC   MEL   LST   MA    SOYMA
S1     4                 2.7   2.5
S2     4                 2.7   2.6
S3           2.2   3.9   2.7   2.7   2.7    2.5
;

PARAMETER YSOYMA (ye)   random on soybean-maize yields
/
Y1   1.048,    Y2   1.077,    Y3   1.038,    Y4   0.935,    Y5   0.876,
Y6   0.881,    Y7   1.042,    Y8   1.014,    Y9   0.859,    Y10  1.088,
Y11  1.077,    Y12  1.088,    Y13  0.935,    Y14  0.876,Y15  1.042
/;

YRTOT(reg,exags,t,"soyma",jj,tec,equi,"s3",ye)=MEY(reg,exags,t,"soyma",jj,
tec,equi,"s3")*YSOYMA(ye);
```

Then, if we assume that this new activity can be done during the second season with only the water coming from rainfall, other tables will be added in the yields and input parts, without forgetting the assignments lines, and additional data have to be written in other tables (labor, risk):

```
TABLE MRRAIT2(jj2,jj)   average yields techn. irrig land season 2 (in kg per ha)
             SOY       MA
SOYMA     574        950
;
MEY(reg,exags,"irt",jj2,jj,"rain",equi,"s2")=MRRAIT2(jj2,jj);

TABLE RAIT2(act,inp)   coeff. irrig. tech. rain (in kg per ha)
          OTH    PEST   UREA    TSP    KCL    NPK    SEED    MANURE
SOYMA     0       25.3    203     30     10      0      3.2        6
;
CO(reg,exags,"irt",act,"rain",equi,"s2",inp)=RAIT2(act,inp);


*1.2.3 Labor required by technical itinerary
TABLE LABIT(act,equi,s)   Human work per crop in days irrig. tech.
                 S1     S2     S3
RI.MAN          165    156
RI.TRA          131    122
RI.MEC          119    110
SOY.MAN         160    130    147
SOY.MEC         130    100    117
CUC.MAN                       130
MEL.MAN                       131
MA.MAN           98     98     98
MA.TRA           64     64     64
MA.MEC           52     52     52
SOYMA.MAN              131    121
SOYMA.TRA               87     82
SOYMA.MEC               74     70
;
```

```
*1.2.3 Traction required by technical itinerary

TABLE ANE(act,s)   (in days)
           S1     S2     S3
RI         16     16
MA         16     16     16
SOYMA             10     10
;

 *1.3.3 Prices for labour
TABLE AGWAE(s,act) agricultural labor price (in 000 rp per day)

       RI    SOY  CUC   MEL   LST   MA    SOYMA
S1     4                2.7   2.5
S2     4                2.7   2.6           2.5
S3           2.2   3.9  2.7   2.7   2.7     2.5
;

  PARAMETER YSOYM2 (ye)   random on soybean-maize yields
/
Y1   1.048,    Y2   1.077,    Y3   1.038,    Y4   0.935,    Y5   0.876,
Y6   0.881,    Y7   1.042,    Y8   1.014,    Y9   0.859,    Y10  1.088,
Y11  1.077,    Y12  1.088,    Y13  0.935,    Y14  0.876,Y15  1.042
/;

YRTOT(reg,exags,t,"soyma",jj,tec,equi,"s2",ye)=MEY(reg,exags,t,"soyma",jj,tec,eq
ui,"s2")*YSOYMA(ye);
```

9.5 Equation file: Technir.equ

In this file, the decision process of the farmer is represented by a non-linear programming model which optimizes an objective function on a set of constraints and opportunities. Opportunities cover crop and livestock production as well as off-farm activities; constraints concern endowment in land, labor, and capital as well as access to markets.

The objective function represents the objective of the household, the optimization process determines the endogenous variables of the model: labor allocation between on and off-farm activities as well as the land allocation between crops and techniques, savings, investment and so on. After the volume of the output is calculated, the portion of the production commercialised is used to calculate the economic performance of each farm.

All the equations have already been defined in the definition file (Technir.def).

- The GAMS statement for the equation is:
  1. the name of the equation declared in the definition file
  2. the domain
  3. the symbol "..”
  4. left-hand-side expression
  5. relational operator =l= (less than or equal to); =g= (greater than or equal to); =e= (equal to)
  6. the right-hand-side equation
- The standard arithmetic symbols are :
  ** exponentiation
  * / multiplication and division
  + - addition and substraction
- Summation is noted SUM(index of summation, summand).
  For example $\Sigma_i X_{ij}$ is written in GAMS SUM (i,X(i,j)).
  $ operator is used to provide exception-handling capability.

The list of variables and parameters, as well as their domains and meanings, is provided in the definition file where they are defined by type and organized in alphabetic order.

9.5.1 Production

```
*PRODUCTION

PRODU(reg,exags,jj,s).. SUM((jj2,t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
                AL(reg,exags,t,jj2,tec,equi,s)* MEY(reg,exags,t,jj2,jj,tec,equi,s))
                - PRODUCT(reg,exags,jj,s)
                =e= 0;


PRODUR(reg,exags,jj,s).. SUM((jj2,t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
                AL(reg,exags,t,jj2,tec,equi,s)* YR(reg,exags,t,jj2,jj,tec,equi,s))
                - PDR(reg,exags,jj,s)
                =e= 0;
```

The first two equations calculate expected production. Production is determined by land allocation (AL), which is specified according to region (reg), farm (exags), type of land (t), cropping activity (jj2), equipment used (equi) and season (s), multiplied by the level of expected yield (mey). This information is used in the decision process of the farmer. In the second equation, the real level of production is calculated with a value of yields determined by a random generator. This information is used to calculate the economic results of the farm. The dollar operator is used in this equation to restrict the set for the summation to the possible combinations of sets defined in JTEC and PTT. It can be read as an “if”. The sum of variable (Al *mey) will be performed only for the combinations of sets (jj2,tec,equi) which exist in JTEC and of sets (t,tec) which exist in PTT.

9.5.2 Land

```
*USE OF LAND AND LAND BALANCES

LAND(reg,exags,t,s)   ..
                         SUM((jj2,tec,equi) $ JTEC(jj2,tec,equi),
                          AL(reg,exags,t,jj2,tec,equi,s) $ PTT(t,tec))
                         -  LRIN(reg,exags,t,s)
                         + LROUT(reg,exags,t,s)
                         + LS(reg,exags,t,s)
                         -  LP(reg,exags,t,s)
                         -  LAOWN (reg,exags,t,s)
                         =l= 0;
LALIM(reg,exags,t,s)..
                    -  LAOWN (reg,exags,t,s)
                         + LS(reg,exags,t,s)
                         + LROUT(reg,exags,t,s)
                         -  LP(reg,exags,t,s)
                         =l= 0;
LAVAIL(reg,exags,t,s) .. LAOWN(reg,exags,t,s)
                    -  LAOWN(reg,exags,t,s-1)  $(ord(s) gt 1)
                    + LS(reg,exags,t,s-1)$(ord(s) gt 1)
                    -  LP(reg,exags,t,s-1) $(ord(s) gt 1)
                    -  (NFA(reg,exags)*LMAX(reg,exags,t,s))
                    $(ord(s) eq 1)
                    =e= 0;
LANFIN(reg,exags,t)  ..
                         LAOWN(reg,exags,t,"s3")
                    -  LS(reg,exags,t,"s3")
                    + LP(reg,exags,t,"s3")
                    -  LAOFIN(reg,exags,t)
                    =e= 0;
TRANLOUT(reg,t,s) ..
                         SUM(exags, LRIN(reg,exags,t,s))
                    - SUM(exags, LROUT(reg,exags,t,s))
                      =e= 0;
SELLOUT(reg,t,s)  ..
                          SUM(exags, LP(reg,exags,t,s))
                    - SUM(exags, LS(reg,exags,t,s))
                    =e= 0;
CONST(reg,exags,T)..
                         SUM((jj2,tec,equi),
                    AL(reg,exags,t,jj2,tec,equi,"s3")
                         $ PTT(t,tec))
                    + (- LRIN(reg,exags,t,"s2")
                    + LROUT(reg,exags,t,"s2")
                    + LS(reg,exags,t,"s2")
                    -  LP(reg,exags,t,"s2")
                    - LAOWN (reg,exags,t,"s2"))*0.1
                    =l= 0;
```

The first equation LAND expresses the land allocation constrained by the availability (Laown) and the opportunity of renting (LRIN and LROUT), selling (LS) or buying (LR) land.

The second equation LALIM specifies that land rented in cannot be sold. The land sold (LS) and the land rented out must be owned (LAOWN and LP).

The third, LAVAIL, updates the land owned (LAOWN) according to the transactions of the preceding season. LANFIN performs the same operation for the next optimization period. The TRANLOUT and SELLOUT equations express that, because of the spatial characteristics of agricultural activities and transportation costs, exchange of land has to be balanced at the village level. The last equation CONST is a constraint ad hoc, on the possibility of third season cultivation. It should be replaced by the real factor constraining the activity, water in this case.

9.5.3 Inputs and water requirements

```
* USE OF INPUTS
INPUTS(reg,exags,s,inp)..
                          SUM((t,jj2,tec,equi) $( JTEC(jj2,tec,equi) $ PTT(t,tec)),
                               AL(reg,exags,t,jj2,tec,equi,s)*
                            CO(reg,exags,t,jj2,tec,equi,s,inp))
                          -  INU(reg,exags,s,inp)
                          + INTRA(reg,exags,s,inp)
                          -  INTRA(reg,exags,s-1,inp)$(ORD(S) GT 1)
                          =l= 0;

*USE OF IRRIGATION WATER

WATER(reg,exags,tti,s) .. SUM((jj2,tteci,equi) $ JTEC(jj2,tteci,equi),
                          AL(reg,exags,tti,jj2,tteci,equi,s) $ PTT(tti,tteci)*
                             WR(reg,exags,tti,jj2,tteci,equi,s))
                               -  WAT(reg,exags,tti,s)
                               -  WASPRING(reg,tti,s)
                          =e= 0;

WATOT(reg,tti,s)..    SUM((exags),WAT(reg,exags,tti,s))
                               -  WATRA(reg,tti,s-1)$(ORD(S) GT 1)
                               +  WATRA(reg,tti,s)
                               -  WAINI(reg,tti)$(ord(s) EQ 1)
                               -  SUM((exags,jj2,tteci,equi)$ JTEC(jj2,tteci,equi),
                               AL(reg,exags,tti,jj2,tteci,equi,s)$ PTT(tti,tteci))
                               * RAIN(reg,s)
                          =l= 0;
```

Cropping activities require inputs (inp). The level of inputs bought (INU) is determined by a technical coefficient (CO) indicating the requirement according to techniques, the amount to be transferred to the next season (INTRA) and the amount transferred from the previous season.

The water requirement by activity (WR) has to be met by spring (WASPRING) or dam (WAT) or rain (RAIN) water. Water available from the dam at the beginning of the optimization period (WAINI) can be transferred through the seasons (WATRA).

9.5.4 Labor requirements

```
*LABOR

LABAL(reg,exags,s,jj2,ag,gen)..
                    SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)
                    $ (SUM(jj,MEY(reg,exags,t,jj2,jj,tec,equi,s)) gt 0)),
                    AL(reg,exags,t,jj2,tec,equi,s)*
                      LUSE(reg,exags,t,jj2,tec,equi,s,ag,gen))
                    -  LARIN(reg,exags,s,jj2,ag,gen)
                    + LAROUT(reg,exags,s,jj2,ag,gen)
                    -  LA(reg,exags,s,jj2,ag,gen)
                    =e= 0;
LALST(reg,exags,s,"lst",ag,gen)..
                    SUM((ca,qa), (ANSTO(reg,exags,s,ca)
                    -  ANS(reg,exags,s,ca)
                    + ANPU(reg,exags,s,ca))
                      * ANEED(reg,exags,s,ca,qa)*temfre)
                    -  LARIN(reg,exags,s,"lst",ag,gen)
                    + LARout(reg,exags,s,"lst",ag,gen)
                    -  LA(reg,exags,s,"lst",ag,gen)
                    =e= 0;
LTOT(reg,exags,s,ag,gen) ..   SUM (J,la(reg,exags,s,J,ag,gen))
                    + LAS(reg,exags,s,ag,gen)
                    + LAOFF(reg,exags,s,ag,gen)
                    =l= lamax(reg,exags,s,ag,gen)*NFA(reg,exags);

LABOUT(reg,s,act,ag,gen).. SUM(exags, LAROUT(reg,exags,s,act,ag,gen)
                    - LARIN (reg,exags,s,act,ag,gen))
                    =l= 0;
OFFTO(reg,exags,s,ag,gen)..  lAS(reg,exags,s,ag,gen)
                    - TOFF(reg,exags,s,ag,gen)*NFA(reg,exags)
                    =l= 0;
OFFO(reg,s,ag,gen)..     SUM(exags, LAOFF(reg,exags,s,ag,gen)
                    - OTOLA(reg,exags,s,ag,gen)*NFA(reg,exags))
                    =l= 0;
```

Cropping activities require labor (LA) determined by the technical coefficient (luse). Equation LABAL calculates the family labor which should be devoted to cropping activities and takes into account the fact that labour can be hired and that it is possible for the family labor to work on other farms. LALST performs the same calculation for livestock. LTOT expresses the labor constraint at the household level. The workforce (LAMAX) is allocated between agricultural activities (LA) and off-farm activities. Two kinds of off-farm activities are considered: LAS (not risky) and LAOFF (risky).

The LABOUT equation expresses the balance at the village level between labour rented in and out. Off-farm activities are constrained by opportunities at the village level (TOFF and OTOLA).

9.5.5 Animal traction

```
TRAC(reg,exags,s) .. SUM((t,jj2,tec) $ (JTEC(jj2,tec,"tra") $ PTT(t,tec)
                     $ (SUM (jj,MEY(reg,exags,t,jj2,jj,tec,"tra",s))gt 0) ),
                     AL(reg,exags,t,jj2,tec,"tra",s)*
                       AN(reg,exags,t,jj2,tec,s))
                     -  SUM(cab, (aNsto (reg,exags,s,cab)
                     -  ANS(reg,exags,s,cab)
                     + ANPU(reg,exags,s,cab))
                        *anw(s,cab))
                     + SUM(cab, ANLOC(reg,exags,s,cab)
                     -  ANRENT(reg,exags,s,cab))
                     =l= 0;
ANLOTR(reg,exags,s,cab) .. - ANSTO(reg,exags,s,cab) *ANW(s,cab)
                     + ANLOC(reg,exags,s,cab)
                     -  (ANPU(reg,exags,s,cab) *ANW(s,cab))
                     + (ANS(reg,exags,s,cab)   *ANW(s,cab))
                     =l=0;
LOTR(reg,s,cab)  .. - SUM(exags, ANRENT(reg,exags,s,cab))
                     + SUM(exags, ANLOC(reg,exags,s,cab))
                     =e= 0;
ANSFIN (reg,exags,ca).. ANSTO (reg,exags,"s3",ca)
                     -  ANS(reg,exags,"s3",ca)
                     + ANPU(reg,exags,"s3",ca)
                     -  ANFIN (reg,exags,ca)
                     =E= 0    ;
ANTO(reg,exags,s,ca) ..
                     -  ANINI(reg,exags,ca)*NFA(reg,exags)$(ord(s) eq 1)
                     + ANSTO(reg,exags,s,ca)
                     -  ANSTO(reg,exags,s-1,ca)$(ord(s) gt 1)
                     + ANS(reg,exags,s-1,ca)$(ord(s) gt 1)
                     -  ANPU(reg,exags,s-1,ca)$(ord(s) gt 1)
                     =e= 0;
```

The use of animal traction, designed by equipment “tra”, is included here. The technical coefficient representing the number of days of animal labour required by activity “an”, “anw” the conversion coefficient between animal numbers and working days. It is possible to sell animals (ANS) and to purchase them (ANPU), as well as to rent them in (ANLOC) or out (ANRENT). Equation TRAC notes that the use of animals should be lower than the availability defined by the stock at the beginning of the season (ANSTO) and the current transactions.

The stock of animals has to be updated according to purchase and selling for each period and initial endowment (Anini) at the village level (nfa). It is necessary to limit the selling and external renting of animals by the number of head owned at the farm level. If not, the program may lead to selling animals which are rented in.

Renting animals in or out is constrained by the corresponding supply and demand. Qualitative analysis is necessary here to determine if equality or inequality holds, according to the source of supply and demand at village market. Finally, at the end of the optimization period, the stock of animals available for the next year has to be determined.

The similarity of this development with that related to land allocation should be apparent. Equations related to the use of machines follow the same pattern.

9.5.6 Mechanisation

```
*MECANISATION (days)
MECH(reg,exags,s,me) ..
                      SUM((t,jj2,tec) $(JTEC(jj2,tec,"mec") $ PTT(t,tec)
                      $ (SUM (jj,MEY(reg,exags,t,jj2,jj,tec,"mec",s))gt 0)),
                      AL(reg,exags,t,jj2,tec,"mec",s)*
                        MN(reg,exags,t,jj2,tec,s,me))
                      -  MAV(reg,exags,s,me)*mad(s,me)
                      -  MERENT(reg,exags,s,me)
                      + MELOC(reg,exags,s,me)
                      -  MAPU(reg,exags,s,me)*mad(s,me)
                      + MASELL(reg,exags,s,me)*mad(s,me)
                      =l= 0;
MECHAV(reg,exags,s,me) .. MAV(reg,exags,s,me)
                      -  MAV(reg,exags,s-1,me) $(ord(s) gt 1)
                      -  MINI(reg,exags,me)*NFA(reg,exags) $(ord(s) eq 1)
                      -  MAPU(reg,exags,s-1,me) $(ord(s) gt 1)
                      + MASELL(reg,exags,s-1,me) $(ord(s) gt 1)
                      =e= 0;
MECHFIN(reg,exags,me) .. MAV(reg,exags,"s3",me)
                      + MAPU(reg,exags,"s3",me)
                           -  MASELL(reg,exags,"s3",me)
                      -  MAFIN(reg,exags,me)
                      =e= 0;
```

```
MELOTR(reg,exags,s,me) ..  - MAV(reg,exags,s,me)*mad(s,me)
                  + MELOC(reg,exags,s,me)
                  - MAPU(reg,exags,s,me)*mad(s,me)
                  + MASELL(reg,exags,s,me)*mad(s,me)
                  =l=0;
LOMEC(reg,s,me)  ..  - SUM(exags, MERENT(reg,exags,s,me))
                       + SUM(exags, MELOC(reg,exags,s,me))
                       =e= 0;
```

The use of machines for cropping activities is determined by a technical coefficient (mn). In equation MECH, the utilization of machines for cropping activities or for renting out is constrained by current availability (MAV), purchase (MAPU) and selling (MASELL). Mad is a conversion coefficient between the number of machines and the number of days of utilization. Equation MECH calculates the availability of machine days (MAV) by season and MECHFIN updates the number of machines for the next period. Equation MELOTR constrains the renting out and selling of the machines. Equation LOMEC balances exchanges at the village level.

9.5.7 Consumption

```
*CONSUMPTION

CONSR(reg,exags,s,pro) ..
               SUM((ag,gen), LAVAI(reg,exags,s,ag,gen)*
              CON(ag,gen,pro)*NFA(reg,exags)*ndc)
                              - SUM(outws,PROPU(reg,exags,outws,s)*QUAL(outws,pro))
                              =l= 0;
BENEF (reg,exags,s).. propcons*
                              (SUM((jj),PRODUCT(reg,exags,jj,s) * FPE(reg,jj,s))
                              -  SUM((inp), INU(reg,exags,s,inp) * INPR(reg,s,inp))
                              + SUM((act,ag,gen), LAROUT(reg,exags,s,act,ag,gen)*
                                 CTRA*AGWA(reg,s,act,ag,gen))
                              -  SUM((act,ag,gen), LARIN(reg,exags,s,act,ag,gen)*
                                 AGWA(reg,s,act,ag,gen))
                              + SUM((ag,gen), LAS(reg,exags,s,ag,gen)*
                                 NAGWA(reg,"sure",s,ag,gen))
                              + SUM((ag,gen), LAOFF(reg,exags,s,ag,gen)*
                                 NAGWA(reg,"unsure",s,ag,gen))
                              + SUM((t), LROUT(reg,exags,t,s) * r(reg,t,s)*CTRA)
                              -  SUM((t), LRIN(reg,exags,t,s)*r(reg,t,s))
                              + SUM((cab),ANLOC(reg,exags,s,cab)*ANRE(reg,s,cab))
                              -  SUM((cab),ANRENT(reg,exags,s,cab)*ANRE(reg,s,cab)*.9)
                              + SUM((me),MELOC(reg,exags,s,me)*MERE(reg,s,me)*0.5)
                              -  SUM((me),MERENT(reg,exags,s,me)*MERE(reg,s,me))
                              -  SUM((out), PROPU(reg,exags,out,s)*FPE(reg,out,s))
                              -  (ict * AGCREST(reg,exags,s))
                              -  CONSMIN (reg,exags)*NFA(reg,exags))
                              =e= OTCON(reg,exags,s)
                      ;
```

Consumption, in the agricultural production module is divided into three items:

- self consumption of agricultural products to meet minimum calorie and protein needs (PROPU);
- minimum consumption in cash to cover minimal needs at the household level in terms of food, clothes, school expenditures and so on (CONSMIN);
- consumption as a share of profit (OTCON).

PROPU is calculated in equation CONSR, and OTCON in equation BENEF. The profit is calculated as the sum of expected earning (scrap sold, labor on other farms or off-farm activities, earning from renting land, animal or machine) minus the production costs (inputs bought, labor hired from other farms, cost of renting land, animal or machines, financial cost associated with borrowing, and consumption).

9.5.8 Investments and savings

```
* investment , depreciation of equipment, saving , selling active, credit
INV(reg,exag s,s) .. SUM(ME, MAPU(reg,exags,s,me)*EP(ME))
                       + SUM(ca, ANPU(reg,exags,s,ca)*anp(S,ca))
                       + SUM((T),LP(reg,eXags,t,s)*LPR(reg,t))
                       + SAB(reg,exags,s)
                       - MS(reg,exags,s)
                       =l= 0;
AMEQ(reg,exags,me)  .. MAFIN(reg,exags,me)
                            * ep(me)/yam(me) - am(reg,exags,me)
                       =l= 0;
AMATR(reg,exags,cab)  .. ANFIN(reg,exags,cab)
                            * (SUM(s,ap(s,cab)/card(s))/yap(cab))
                            - AAM(reg,exags,cab)
                       =e= 0;
SAVING (reg,exags,s)..
                       SINI(reg,exags)*NFA(reg,exags)$(ORD(S) EQ 1)
                       + SA(reg,exags,s-1)$(ORD(S) GT 1)
                       -  SA(reg,exags,s)
                       -  SAVS(reg,exags,s)
                       + SAB(reg,exags,s)
                       =e= 0;
ACTSELL(reg,exags,s)..
                       SUM(ca, ANS(reg,exags,s,ca)*AP(S,ca)*0.7)
                       + SUM((T),LS(reg,exags,t,s)*LPR(reg,t)*.8)
                       + 0.8*SAVS(reg,exags,s)
                       =e= ACTS(reg,exags,s);
STCRED(reg,exags)..    STCRE(reg,exags)
                       - SUM(s,AGCREST(reg,exags,s))
                        =e= 0;
CRST(reg) ..          SUM((exags,s), AGCREST(reg,exags,s))
                       - TOCRST(reg)
                       =l= 0;
```

Investment covers machines, animals and land purchase. It is funded by cash (MS). AMEQ calculates machine depreciation and AMATR animal depreciation. The amount of goods retained as saving by the household (SA) and the opportunity of buying (SABS) or selling (SAVS) this, is considered in equation SAVING. ACTSELL represents decapitalization, provided in the MATA model as an opportunity to get some extra cash (ACTS). Transaction costs are considered as a penalty on the level of the transaction. EXCRE constrains the total amount of long term credit, CRST limits the amount of short term credit, and STCRED calculates the yearly level of short term credit (STRE).

9.5.9 Cashflow

```
CASHEXP(reg,exags,s) ..
                         SUM((jj),PRODUCT(reg,exags,jj,s-1)*
                           FPE(reg,jj,s-1)) $(ord(s) gt 1)
                         -  SUM((out), PROPU(reg,exags,out,s)* FPE(reg,out,s))
                         -  SUM((inp), INU(reg,exags,s,inp)* INPR(reg,s,inp))
                         + SUM((act,ag,gen), LAROUT(reg,exags,s-1,act,ag,gen)*
                           CTRA*AGWA(reg,s-1,act,ag,gen)) $(ord(s) gt 1)
                         -  SUM((act,ag,gen), LARIN(reg,exags,s-1,act,ag,gen)*
                           AGWA(reg,s-1,act,ag,gen)) $(ord(s) gt 1)
                         + SUM((ag,gen), LAS(reg,exags,s,ag,gen)*
                           NAGWA(reg,"sure",s,ag,gen))
                         + SUM((ag,gen),LAOFF(reg,exags,s,ag,gen)*
                           NAGWA(reg,"unsure",s,ag,gen))
                         + AGCREST(reg,exags,s)
                         -  OTCON(reg,exags,s-1) $(ord(s) gt 1)
                         + SUM((t), LROUT(reg,exags,t,s)*r(reg,t,s)*CTRA)
                         -  SUM((t), LRIN(reg,exags,t,s)*r(reg,t,s))
                         + SUM(cab,ANLOC(reg,exags,s,cab)* ANRE(reg,s,cab)*.8)
                         -  SUM(cab,ANRENT(reg,exags,s,cab)*ANRE(reg,s,cab))
                         + SUM(me,MELOC(reg,exags,s,me)* MERE(reg,s,me)*0.5)
                         -  SUM(me,MERENT(reg,exags,s,me)* MERE(reg,s,me))
                         -  CONSMIN (reg,exags)*NFA(reg,exags)
                         -  MS(reg,exags,s)
                         + ACTS(reg,exags,s)
                         + CU(reg,exags,s-1)  $(ord(s) gt 1)
                         + NFA(reg,exags)*INIC(reg,exags) $(ord(s) eq 1)
                         =e=   CU(reg,exags,s) ;
```

CASHEXP calculates the expected cash at the end of each season. It should be seen as the cashbox of the farmers and all the transactions implying liquidity have to be recorded here at the precise time of occurrence. Here, a difficulty arises related to the continuous feature of time, while the MATA model considers only the starting and ending point of the year as well as the beginning of each season. For example, crops harvested in season 1 are sold at the beginning of season 2 and appear at that time (season 2) in the cashbox. The operations recorded are:

- earnings from selling products of the previous season minus the self consumption for the current season
- input costs (current season)
- earnings from agricultural labor outside the farm (previous season: this assumption has to be adapted according to the type of labor and local rules. Here the payment is in kind after the harvest.)
- cost of agricultural labor hired (previous season)
- earnings from off-farm activities (current season)
- earnings from renting land, machines or animals out and cost from renting them in (current season)
- cost of consumption
- financial cost associated with long term credit
- extra cash from short term credit
- cost of investment
- earnings from decapitalization
- transfer from previous period.

While CASHEXP for s3 calculates the expected cash at the beginning of season 3, FINCASH calculates it at the end of the season.

```
FINCASHEXP(reg,exags) ..
                    SUM((jj),PRODUCT(reg,exags,jj,"s3")*FPE(reg,jj,"s3"))
                    + SUM((act,ag,gen), LAROUT(reg,exags,"s3",act,ag,gen)*
                      CTRA*AGWA(reg,"s3",act,ag,gen))
                    -  SUM((act,ag,gen), LARIN(reg,exags,"s3",act,ag,gen)*
                      AGWA(reg,"s3",act,ag,gen))
                    -  (1+ict) * STCRE(reg,exags)
                    -  OTCON(reg,exags,"s3")
                    + CU(reg,EXAGS,"s3")
                    -  CUMCASH(reg,EXAGS)
                    -  NFA(reg,exags)* PROVCASH(exags)
                    =e= 0;
```

Earnings from the harvest of season 3, earnings and cost related to agricultural labor, reimbursement of short term credit, consumption and transfer from season 3 are considered in this equation. Provision for cash for the next period (PROVCASH) is also included in this equation.

9.5.10 Objective function

```
WEALTH(reg,exags)..
        SUM(S, OTCON(reg,exags,s))
        + 0.9*CUMCASH(reg,exags)
        + PROVCASH (exags) *NFA(reg,exags)
        + SUM(t, LAOFIN(reg,exags,T)* LPR(reg,t))
        + ANFIN(reg,exags,"beef")* AP("s3","beef")*1.2
        - SUM(cab, AAM(reg,exags,cab))
        + ( ANFIN(reg,exags,"poultry")*AP("s3","poultry")*1)
        + ( ANFIN(reg,exags,"sheep")* AP("s3","sheep")*1.1)
        + SUM(me, MAFIN(reg,exags,me)* EP(me))
        - SUM (me, AM(reg,exags,me))
        - SUM(s, AGCRELT(reg,exags,s))
        - WH(reg,exags)
        + 0.9*SA(reg,exags,"s3")
        =e= 0;

WH.LO(reg,exags)=0.00000001 ;

FONCTION..
        SUM ((reg,exags),WH(reg,exags)
        - ALPH(exags)*0.5*
        (SUM((jj,s),(SUM(jj2,( sigc(jj2,s)*
        SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
        AL(reg,exags,t,jj2,tec,equi,s)*
          MEY(reg,exags,t,jj2,jj,tec,equi,s) *  FPE(reg,jj,s)))))**2)
        + SUM((ca), (ANFIN(reg,exags,ca)*
          AP("s3",ca)*sigb(ca))**2 )
        + SUM((ME), (MAFIN(reg,exags,ME)*
          EP(ME)*sigm(ME))**2 )
        + SUM(t, (LAOFIN(reg,exags,T)*
          LPR(reg,t)*sigL(T))**2 )
        + SUM((s,ag,gen),(NAGWA(reg,"sure",s,ag,gen)*
          LAS(reg,exags,s,ag,gen)*sigw("sure"))**2)
        + SUM((s,ag,gen),(NAGWA(reg,"unsure",s,ag,gen)*
           LAOFF(reg,exags,s,ag,gen)*sigw("unsure"))**2)
        + SUM((s,act,ag,gen),(AGWA(reg,s,act,ag,gen)*
          LAROUT(reg,exags,s,act,ag,gen)*sigw("ag"))**2)
        + SUM((t,s),(LROUT(reg,exags,t,s)* r(reg,t,s)*sigr)**2)
        + ((cumcash(reg,exags)* sigca)**2)))
```

The objective function is a maximization of expected utility of wealth. The (WH) is calculated in equation WEALTH determined by the sum of assets owned at the end of the period, multiplied by their values. Some penalities are included to consider transactions costs.

In the equation FONCTION, expected utility of farmers' wealth is calculated. Because of the risks associated with agricultural activities, it is assumed that utility increases with expected wealth and decreases with expected risk. So cropping activities are associated with risk on crops ($sigc_{act,s}$), land with risk on land (sigl), off-farm activities with risk on returns (sigw) and cash with financial risk (sigca). The level of utility (FONC) is determined according to the Von Neumann-Morgenstern representation of decision-taking in risky situations (α) representing the risk aversion coefficient:

$$\text{Max } U(W_F) = E(W_F) - \tfrac{1}{2}\,\alpha\, V(W_F)$$

This equation represents the decision process. It is calculated on the basis of expected prices and yields for each season. At the end of the optimization period, all the decisions of the farmer are known and used in equations below to calculate the real results of the farm with real prices and real yields. Cash transfer to each season is recalculated to get the money available at the end of the year, and consumption of each season is also updated. It is consistent with the idea of the model in the sense that, because consumption is a share of profit of each season, it is adapted by the farmer to the real result as soon as it is known, that is at the end of the season.

All these equations have the same name as the one used in the decision process followed by "r", so equation WEALTH becomes WEALTHR. Exceptions are expected: CASHEXP, which becomes CASH and FINCASHEXP which becomes FINCASH. The equations have the same content as above except that expected prices (FPE) are replaced by real prices (FPR) and expected yields (MEY) by real yields (YR).

9.5.11 Real results

```
*calculations of real results

CASH(reg,exags,s) ..
                SUM(jj, SUM(jj2,
                SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
                AL(reg,exags,t,jj2,tec,equi,s-1)
                  * YR(reg,exags,t,jj2,jj,tec,equi,s-1)))
                  * FPR(reg,jj,s-1))  $ (ord(s) gt 1)
                -  SUM((inp), INU(reg,exags,s,inp)*INPR(reg,s,inp))
                + SUM((act,ag,gen), LAROUT(reg,exags,s-1,act,ag,gen)* CTRA*
                   AGWA(reg,s-1,act,ag,gen)) $(ord(s) gt 1)
                -  SUM((act,ag,gen), LARIN(reg,exags,s-1,act,ag,gen)*
                   AGWA(reg,s-1,act,ag,gen)) $(ord(s) gt 1)
                + SUM((ag,gen), LAS(reg,exags,s,ag,gen)*
                   NAGWA(reg,"sure",s,ag,gen))
                + SUM((ag,gen),LAOFF(reg,exags,s,ag,gen)*
                   NAGWA(reg,"unsure",s,ag,gen))
                -  SUM((out), PROPU(reg,exags,out,s)*FPR(reg,out,s))
                + AGCREST(reg,exags,s)
                -  OTCONR(reg,exags,s-1) $ (ord(s) gt 1)
                + SUM((t), LROUT(reg,exags,t,s)*r(reg,t,s)*CTRA)
                -  SUM((t), LRIN(reg,exags,t,s)*r(reg,t,s))
                + SUM(cab,ANLOC(reg,exags,s,cab)*ANRE(reg,s,cab)*.8)
                -  SUM(cab,ANRENT(reg,exags,s,cab)*ANRE(reg,s,cab))
                + SUM(me,MELOC(reg,exags,s,me)* MERE(reg,s,me)*0.5)
                -  SUM(me,MERENT(reg,exags,s,me)*MERE(reg,s,me))
                -  CUR(reg,exags,s)
                + CUR(reg,exags,s-1) $(ord(s) gt 1)
                + NFA(reg,exags)*INIC(reg,exags) $(ord(s) eq 1)
                + SUM(ca, ANS(reg,exags,s,ca)*AP(S,ca)*0.7)
                + SUM((T),LS(reg,exags,t,s)*LPR(reg,t)*.8)
                -  MS(reg,exags,s)
                + 0.8*SAVS(reg,exags,s)
                -  CONSMIN(reg,exags)*NFA(reg,exags)
                =e= 0;
```

```
FINCASH(reg,exags) ..
                    SUM(jj, SUM(jj2,
                    SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
                    AL(reg,exags,t,jj2,tec,equi,"s3")
                    * YR(reg,exags,t,jj2,jj,tec,equi,"s3")))*  FPR(reg,jj,"s3"))
                    +  SUM((act,ag,gen), LAROUT(reg,exags,"s3",act,ag,gen)*
                       CTRA*AGWA(reg,"s3",act,ag,gen))
                    -  SUM((act,ag,gen), LARIN(reg,exags,"s3",act,ag,gen)*
                       AGWA(reg,"s3",act,ag,gen))
                    -  (1+ict) * STCRE(reg,exags)
                    -  OTCONR(reg,exags,"s3")
                    + CUR(reg,exags,"s3")
                    -  CUMCASHR(reg,exags)
                    -  NFA(reg,exags)* PROVCASH(exags)
                    =e= 0;


BENEFR (reg,exags,s).. propcons*
                     ( SUM(jj,SUM(jj2,
                    SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
                    AL(reg,exags,t,jj2,tec,equi,s)
                    * YR(reg,exags,t,jj2,jj,tec,equi,s)))*  FPR(reg,jj,s))
                    -  SUM((inp), INU(reg,exags,s,inp)*INPR(reg,s,inp))
                    + SUM((act,ag,gen), LAROUT(reg,exags,s,act,ag,gen)*
                      CTRA*AGWA(reg,s,act,ag,gen))
                    -  SUM((act,ag,gen), LARIN(reg,exags,s,act,ag,gen)*
                      AGWA(reg,s,act,ag,gen))
                    + SUM((ag,gen), LAS(reg,exags,s,ag,gen)*
                      NAGWA(reg,"sure",s,ag,gen))
                    + SUM((ag,gen), LAOFF(reg,exags,s,ag,gen)*
                      NAGWA(reg,"unsure",s,ag,gen))
                    + SUM((t), LROUT(reg,exags,t,s)*r(reg,t,s)*CTRA)
                    -  SUM((t), LRIN(reg,exags,t,s)*r(reg,t,s))
                    + SUM((cab),ANLOC(reg,exags,s,cab)*ANRE(reg,s,cab))
                    -  SUM((cab),ANRENT(reg,exags,s,cab)*ANRE(reg,s,cab)*.9)
                    + SUM((me),MELOC(reg,exags,s,me)*MERE(reg,s,me)*0.5)
                    -  SUM((me),MERENT(reg,exags,s,me)*MERE(reg,s,me))
                    -  SUM((out), PROPU(reg,exags,out,s)*FPR(reg,out,s))
                    -  (ict * AGCREST(reg,exags,s))
                    -  (CONSMIN(reg,exags)*NFA(reg,exags))  )
                    =e= OTCONR(reg,exags,s);
```

```
WEALTHR(reg,exags)..
                    SUM(s, OTCONR(reg,exags,s))
                    + 0.9*CUMCASHR(reg,exags)
                    + PROVCASH (exags) *NFA(reg,exags)
                    + SUM(t, LAOFIN(reg,exags,t)* LPR(reg,t))
                    + ANFIN(reg,exags,"beef")*AP("s3","beef")*1.2
                    -  SUM(cab, AAM(reg,exags,cab))
                    + ( ANFIN(reg,exags,"poultry")*AP("s3","poultry")*1.1)
                    + ( ANFIN(reg,exags,"sheep")*AP("s3","sheep")*1.1)
                    + SUM(me, MAFIN(reg,exags,me)*EP(me))
                    -  SUM (me, AM(reg,exags,me))
                    -  SUM(s, AGCRELT(reg,exags,s))
                    -  WHR(reg,exags)
                    + 0.9*SA(reg,exags,"s3")
                    =e= 0;
```

Equation TOTPROF calculates total added value at the farm level (PROF) and equation TOTPROFA agricultural added value.

```
TOTPROF(reg,exags,s)..
        SUM(jj,SUM(jj2,
        SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
        AL(reg,exags,t,jj2,tec,equi,s)
        * YR(reg,exags,t,jj2,jj,tec,equi,s)))
        *  FPR(reg,jj,s))
        -  SUM((inp), INU(reg,exags,s,inp)*INPR(reg,s,inp))
        + SUM((act,ag,gen), LAROUT(reg,exags,s,act,ag,gen)*
        CTRA*AGWA(reg,s,act,ag,gen))
        -  SUM((act,ag,gen), LARIN(reg,exags,s,act,ag,gen)*
        AGWA(reg,s,act,ag,gen))
        + SUM((ag,gen), LAS(reg,exags,s,ag,gen)*
        NAGWA(reg,"sure",s,ag,gen))
        + SUM((ag,gen), LAOFF(reg,exags,s,ag,gen)*
        NAGWA(reg,"unsure",s,ag,gen))
        + SUM((t), LROUT(reg,exags,t,s)*r(reg,t,s)*CTRA)
        -  SUM((t), LRIN(reg,exags,t,s)*r(reg,t,s))
        + SUM((cab),ANLOC(reg,exags,s,cab)*ANRE(reg,s,cab))
        -  SUM((cab),ANRENT(reg,exags,s,cab)*ANRE(reg,s,cab)*.9)
        + SUM((me),MELOC(reg,exags,s,me)*MERE(reg,s,me)*0.5)
        -  SUM((me),MERENT(reg,exags,s,me)*MERE(reg,s,me))
        -  (ict * AGCREST(reg,exags,s))
        =e= PROF(reg,exags,s);
```

```
TOTPROFA(reg,exags,s)..
        SUM(jj,SUM(jj2,
        SUM((t,tec,equi) $ (JTEC(jj2,tec,equi) $ PTT(t,tec)),
        AL(reg,exags,t,jj2,tec,equi,s)
        * YR(reg,exags,t,jj2,jj,tec,equi,s)))
        *  FPR(reg,jj,s))
        -  SUM((inp), INU(reg,exags,s,inp)*INPR(reg,s,inp))
        + SUM((act,ag,gen), LAROUT(reg,exags,s,act,ag,gen)*
        CTRA*AGWA(reg,s,act,ag,gen))
        -  SUM((act,ag,gen), LARIN(reg,exags,s,act,ag,gen)*
        AGWA(reg,s,act,ag,gen))
        + SUM((t), LROUT(reg,exags,t,s)*r(reg,t,s)*CTRA)
        -  SUM((t), LRIN(reg,exags,t,s)*r(reg,t,s))
        + SUM((cab),ANLOC(reg,exags,s,cab)*ANRE(reg,s,cab))
        -  SUM((cab),ANRENT(reg,exags,s,cab)*ANRE(reg,s,cab)*.9)
        + SUM((me),MELOC(reg,exags,s,me)*MERE(reg,s,me)*0.5)
        -  SUM((me),MERENT(reg,exags,s,me)*MERE(reg,s,me))
        -  (ict * AGCREST(reg,exags,s))
        =e= PROFA(reg,exags,s) ;
```

9.6 Initialization file: Technir.ini

In this file, default values are given for the main variables of the model. The extension .L in GAMS assigns a default value to the given variables in order to facilitate the solution process.

```
AL.L("EXC1","EXP1","IRT","RI","TECIR",EQUI,"S1")=19.2;
AL.L("EXC1","EXP1","IRT","RI","TECIR",EQUI,"S2")=19.2;
AL.L("EXC1","EXP1","IRT","SOY","RAIN",EQUI,"S3")=1.28;
AL.L("EXC1","EXP1","IRT","CUC","RAIN",EQUI,"S3")=0;
AL.L("EXC1","EXP1","IRT","mel","RAIN",EQUI,"S3")=0.96;
AL.L("EXC1","EXP2","IRT","RI","TECIR",EQUI,"S1")=13.2;
AL.L("EXC1","EXP2","IRT","RI","TECIR",EQUI,"S2")=13.2;
AL.L("EXC1","EXP2","IRT","SOY","RAIN",EQUI,"S3")=0.84;
AL.L("EXC1","EXP2","IRT","CUC","RAIN",EQUI,"S3")=0.48;
AL.L("EXC1","EXP2","IRT","mel","RAIN",EQUI,"S3")=0.72;
AL.L("EXC1","exp3","IRT","RI","TECIR",EQUI,"S1")=23.75;
AL.L("EXC1","exp3","IRT","RI","TECIR",EQUI,"S2")=21.5;
AL.L("EXC1","exp3","IRT","SOY","RAIN",EQUI,"S3")=2.37;
AL.L("EXC1","exp3","IRT","CUC","RAIN",EQUI,"S3")=0.15;
AL.L("EXC1","exp3","IRT","mel","RAIN",EQUI,"S3")=0.75;
```

9.7 Macro-economic trends: Macpar file

Trends of macro-economic variables are given in this file. In the first part of the file, the population growth (2%) is considered as well as the impact on minimum consumption and minimum cash at the farm level. Trends are assigned through the parameter ye, which represents the period of simulation. Data for the first year given in TECHNIR.DAT as CONSMIN are used to define the total value in the whole simulation period by adding the set ye (CONSMINT). In the second part, the impact of economic growth on labour markets is represented by an increase in off-farm labor opportunities (5%) and an increase in wages (5%).

```
$ontext
file describing trends of macro-economic variables
$offtext
*___________________________________________________________________________
*___________________________________________________________________________

*1. Regional data on population

* Population growth :  2 % per year
PARAMETER CONSMINT(reg,exags,ye)  ;
PARAMETER PROVCASHT(exags,ye)     ;
LAVAIT(reg,ex,s,ag,gen,ye)=LAVAI(reg,ex,s,ag,gen)* (1.02**(ORD(ye)-1));
POPACTT(reg,ex,s,ag,gen,ye)=POPACT(reg,ex,s,ag,gen)*(1.02**(ORD(ye)-1)) ;
LAMAXT(reg,exags,s,ag,gen,ye)=LAMAX(reg,exags,s,ag,gen)*(1.02**(ORD(ye)-1));
CONSMINT(reg,exags,ye)=CONSMIN(reg,exags)*(1.02**(ORD(ye)-1));
PROVCASHT(exags,ye)=PROVCASH(exags)*(1.02**(ORD(ye)-1));

*_______________________________________________________________________
*_______________________________________________________________________
*2. Labor Market

*we assume that economic growth provides increasing opportunities for
*off-farm activities: both sure and unsure increase  5 % yearly
*At the same time tension on labor market implies wages increase for farm (agwa)
*and off-farm activities (nagwa).

 PARAMETER TOFFT(reg,ex,s,ag,gen,ye)  ;
 PARAMETER OTOLAT(reg,ex,s,ag,gen,ye) ;
 PARAMETER AGWAT(reg,s,act,ag,gen,ye) ;
 PARAMETER NAGWAT(reg,w,s,ag,gen,ye)  ;

 TOFFT(reg,ex,s,ag,gen,ye)=TOFFE(ex,s) * (1.05**((ORD(ye)-3)*(ord(ye)>3)));
 OTOLAT(reg,ex,s,ag,gen,ye)=OTOLAE(ex,s) * (1.05**((ORD(ye)-3)*(ord(ye)>3)));
 AGWAT(reg,s,act,ag,gen,ye)=AGWA(reg,s,act,ag,gen) * (1.05**((ORD(ye)-3)*(ord(ye)>3)));
 NAGWAT(reg,w,s,ag,gen,ye)=NAGWA(w,s)  * (1.05**((ORD(ye)-3)*(ord(ye)>3)));
```

9.8 Expectation file: Exprat

Expectations on gross margins constitute one important variable in the decision process of farmers. Several forms of expectations are possible. In this file, the idea of rational expectations is approached through a constant expectation at an average price, representing the production cost (fprm, which had values assigned in the technir.dat file). It is assumed that economic agents are aware of the fact that policy (polpr) and expectations are modified by this parameter.

```
* rational expectations

parameter  FPETOT(reg,out,s,ye);
FPETOT(reg,out,s,ye)=FPRM(reg,out,s,ye)*polpr(out,ye);
```

Other forms of expectations can be defined as adaptive expectations, or expectations calculated as a moving average.

```
*adaptative expectations
 FPETOT(reg,out,s,ye)=FPRTOT(reg,out,s,"y1")$(ord(ye) eq 1)
 +(FPRTOT(reg,out,s,ye-1) $ (ord(ye) gt 1 )) ;

 FPETOT(reg,out,s,ye)=FPRTOT(reg,out,s,"y1")$(ord(ye) eq 1)
 +(FPETOT(reg,out,s,ye-1) $ (ord(ye) gt 1 ))+ 0.5
 *((FPRTOT(reg,out,s,ye-1)-FPETOT(reg,out,s,ye-1)) $ (ord(ye) gt 1))  ;
```

```
*moving average expectations
parameter  FPETOT(reg,out,s,ye)  ;

 FPETOT(reg,out,s,ye)=FPRTOTreg,out,s,"y1")$(ord(ye) eq 1)
  +(FPRTOT(reg,out,s,ye-1) $ (ord(ye) eq 2 ))
  +((( FPRTOT(reg,out,s,ye-1)+ FPRTOT(reg,out,s,ye-2))/2) $ (ord(ye) eq 3 ))
  +((( FPRTOT(reg,out,s,ye-1)+ FPRTOT(reg,out,s,ye-2)
  + FPRTOT(reg,out,s,ye-3))/3)   $ (ord(ye) gt 3 )) ;
```

9.9 Dynamic file: Technir.dyn

The dynamic file includes the loop on time to perform simulations on several years. After the instruction loop, the years for the beginning and the end of simulation are written, then values for the corresponding years are given for the parameters defined with the set ye, then the solution is performed and two files are included: storput and update.

```
* technir.dyn
* dynamic and recursive file
* it performs the loop on time-solve the model- saves and stores results
* reinitialize the variables at the beginning of each year
*________________________________________________________________________

loop(ye $(ord(ye) gt 0 and ord(ye) lt 8),

*________________________________________________________________________
* assign value of parameters for the corresponding year

 sigc(jj2,s)                              =sigctot(jj2,s,ye) ;
 inpr(reg,s,inp)                          = inprtot(reg,s,inp,ye) ;
 fpe(reg,out,s)                          =   fpetot(reg,out,s,ye);
 fpr(reg,out,s)                          =   fprtot(reg,out,s,ye);
 yr(reg,exags,tt,jj2,jj,ttec,equi,s)     =   yrtot(reg,exags,tt,jj2,jj,ttec,equi,s,ye);
 mey(reg,exags,t,j,jj,tec,equi,s)        =   mey(reg,exags,t,j,jj,tec,equi,s)*polyield(jj,ye);
 lavai(reg,ex,s,ag,gen)                  =   lavait(reg,ex,s,ag,gen,ye);
 popact(reg,ex,s,ag,gen)                 =   popactt(reg,ex,s,ag,gen,ye);
 lamax(reg,exags,s,ag,gen)               =    lamaxt(reg,exags,s,ag,gen,ye);
 consmin(reg,exags)                      =   consmint(reg,exags,ye);
 provcash(exags)                         =   provcasht(exags,ye);
 toff(reg,ex,s,ag,gen)                   =   tofft(reg,ex,s,ag,gen,ye)  ;
 otola(reg,ex,s,ag,gen)                  =   otolat(reg,ex,s,ag,gen,ye)    ;
 agwa(reg,s,act,ag,gen)                  =   agwat(reg,s,act,ag,gen,ye)   ;
 nagwa(reg,w,s,ag,gen)                   =   nagwat(reg,w,s,ag,gen,ye)  ;

*________________________________________________________________________

solve technir using nlp maximizing fonc;

*________________________________________________________________________
* store results of the solve
$include storput
*________________________________________________________________________

* updates endogeneous variable for next period

$include updat
*________________________________________________________________________
    );
* end the loop
```

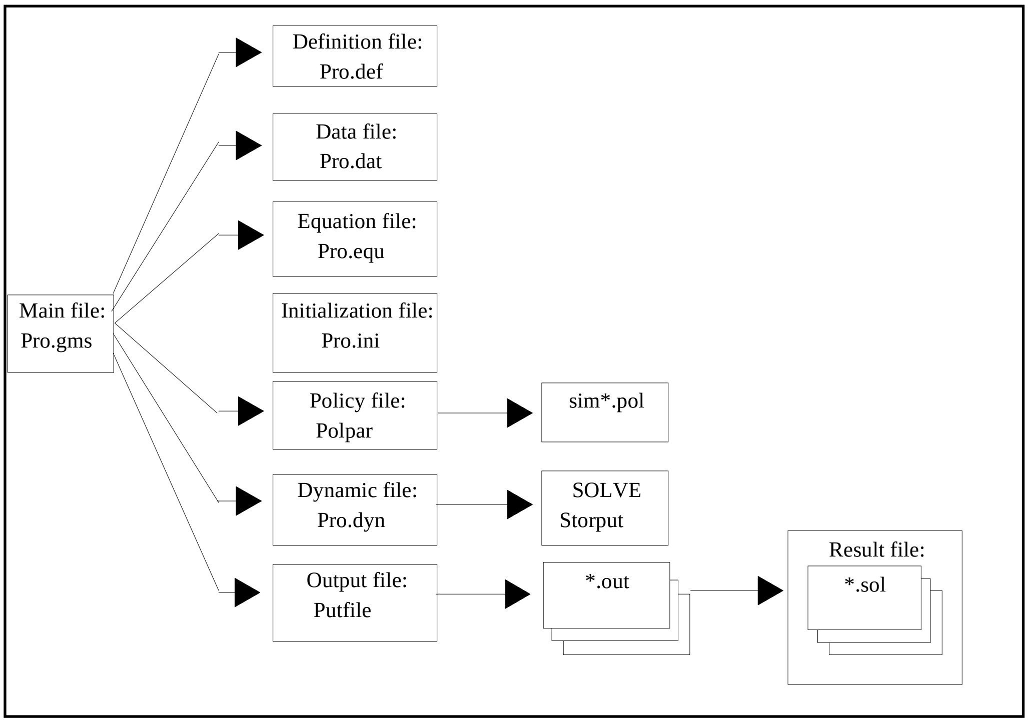
The content of the storput file was explained previously. In the updat file, results of the model are used to calculate starting parameters for the next period. For the initial cash (INIC) a consumption propensity of 0.8 is assumed on the end of period cash. Risk aversion is calculated as a function of wealth with the parameter coef.

```
*FILE UPDAT
*land availability
 LMAX(reg,ex,t,s) = LAOFIN.l(reg,ex,t)/nfa(reg,ex) ;

*________________________________________________________

* initial cash
 INIC(reg,exags) =
(0.2*CUMCASHR.l(reg,exags)/nfa(reg,exags))+PROVCASH(exags) ;
*________________________________________________________

* animal available categories
ANINI(reg,exags,ca) = ANFIN.l(reg,exags,ca)/nfa(reg,exags)  ;

*________________________________________________________

*equipment availability
 MINI(reg,exags,me) = MAFIN.l(reg,exags,me)/nfa(reg,exags)  ;

*________________________________________________________

*  savings initial
 SINI(reg,ex) = SA.l(reg,ex,"s3") /nfa(reg,ex) ;
*________________________________________________________

*    risk aversion
ALPH(exags) = 1/(coef(exags)* WH.l("exc1",exags))   ;
```

10. MATA User Guide: The Commodity Chain Module

In this part the full content of each file of the commodity chain module is provided in text boxes with explanations. The general structure of this module is similar to that of the agricultural production module (Figure 10.1).

Figure 10.1 Files of the commodity chain module.



This module is formatted to be used with the MATA Interface with Windows 3.1 or 95. This manual is not intended to be a substitute for the GAMS User Guide, which is highly recommended if the user really wants to modify MATA.

The reader is reminded of a few GAMS instructions:

- A star (*) in the first column of the line indicates that it is a comment and not a GAMS instruction line.
- The instruction “ $include name of a file” includes the designated file.

More explanations will be found in files.

The maximization of consumer utility leads to quantities consumed and prices of final products. Consumer nutrient intake can be analyzed for each group. The consumer choice between products according to change in price and income is thus represented. The competition for secondary crops between human and feed use is also considered in this model.

This module is far less detailed than the agricultural production module, but it could be more complicated if needed to deal with a policy question. However, it allows one to answer key questions related to agricultural policy such as the impact of policies on nutrient intake of target groups of consumers, impact on activities in trade and processing (investment and employment) and on external trade.

10.1 Main file: Pro.gms

In MATA, the *.gms file is the main one including all others. It contains five parts:

- In the first one, the title of the model is given after the GAMS instruction $TITLE;
- In the second part, GAMS options are used to format output files. The complete list of options available in GAMS is provided in GAMS User Guide pages 102-106 for options used with solved statements, and pages 112-113 for dollar control directives.

```
*File PRO.gms : Main file
$TITLE  Consumption and processing module

OPTION ITERLIM = 20000;
OPTION LIMCOL=5;
OPTION LIMROW=5;
OPTION NLP=CONOPT;
*OPTION SOLPRINT=OFF;
*$ OFFSYMLIST
$ OFFDIGIT
*$ OFFSYMXREF
```

- In the third part, all files are included.

```
$INCLUDE PRO.def
*definition file
$INCLUDE PRO.dat
*definition file
$INCLUDE PRO.equ
*equation file
$INCLUDE PRO.ini
*initialization file
$INCLUDE POLPAR
*policy definition file
_______________________________________________
MODEL PRO/ALL/
```

- In the fourth part, the dynamic file (Pro.dyn), which contains the solve instruction and the loop on time as well as saving is included.
- The fifth, Putfile includes file saving and formatting output.

```
$INCLUDE PRO.dyn
*dynamic file
$INCLUDE PUTFILE
*formatting output file
```

10.2 Definition file: Pro.def

The definition file consists of four parts providing respectively the list of sets, parameters, variables and equations of the model with comments for each.

In the first part, sets are defined. This begins with the GAMS instruction SETS and ends with a semi-colon ";". For each set the name is given, followed by a comment, then the members of the set are delimited by slashes "/".

The first set defines the households considered. The GAMS instructions are:

```
SETS
H   households
/
H1, H2, H3
/ ;
```

This is equivalent to the mathematical statement H ={h1, h2, h3}

The other sets are also presented. Generally speaking, different forms of the same products are considered in this module: the raw agricultural products used as inputs, the final consumption form for humans, and the final form used as feed.

```
*PRO.def file

SETS

H   households
/H1, H2, H3/

YE   years
/Y1*Y10/

COM   all product
/
paddy      paddy
rice       rice consumed
irice      rice feed
soy        soybean
tempe      tempe
tahu       tofu
isoyf      soybean feed
soyim      imported soybean
isoyim     soyim feed
maize      maize
fmaiz      maize consumed
imaizf     maize feed
cass       cassava
cassava    cassava consumed
fish       fish
ffish      fish consumed
iffish     fish feed
oth        other
foth       other consumed
beef       beef
fbeef      beef consumed
chicktd    traditional chicken
fchicktd   chicken consumed
lab        labor
fcost      fix cost
eggs       egg
feggs      egg consumed
sug        sugar
fsug       sugar consumed
veg        vegetable
fveg       vegetable consumed
con        concentrate
icon       concentrate feed
fchickmod modern chicken
*          consumed /

CAR products characteristics
/prot      protein
cal        calorie /
```

```
IOC(com)  final and feed commodities
/rice      rice consumed
tempe      tempe consumed
tahu       tahu consumed
fmaiz      maize consumed
cass       cassava consumed
foth       other consumed
fbeef      beef consumed
fchicktd   traditional chicken cons
feggs      egg consumed
ffish      fish consumed
fsug       sugar consumed
fveg       vegetable consumed
fchickmod  modern chicken cons
isoyf      soybean feed
isoyim     imported soybean feed
imaizf     maize feed
irice      rice feed
iffish     fish feed
icon       concentrate feed /

FC(ioc)   final commodities
/rice      rice
tempe      tempe
tahu       tofu
fmaiz      maize
cass       cassava
foth       other
fbeef      beef
fchicktd   traditional chicken
feggs      egg
ffish      fish
fsug       sugar
fveg       vegetable
fchickmod modern chicken cons/

FC1(fc)   final commodities      except
animal product
/rice      rice consumed
tempe      tempe consumed
tahu       tofu consumed
fmaiz      maize consumed
cass       cassava consumed
foth       others consumed
fbeef      beef consumed
fchicktd   traditional chicken cons
feggs      eggs consumed
ffish      fish consumed
fsug       sugar consumed
fveg       vegetable consumed /
```

```
FEED(ioc)  feed commodities
/isoyf      soybean feed
isoyim     imported soybean feed
imaizf     maize feed
irice      rice feed
iffish     fish feed
icon       concentrate feed/

IIC(com) intermediate or primary commodity
as inputs
/paddy     paddy
soy        soybean
soyim      imported soybean
maize      maize
cassava    cassava
oth        others
chicktd    traditional chicken
beef       beef
eggs       eggs
fish       fish
sug        sugar
veg        vegetables
con        concentrate
lab        labor
fcost      fix cost /

PEC(iic)  primary commodities involvrd in
external trade
/paddy     paddy
soy        soybean
maize      maize/

PCP(iic) primary commodities with
exogenous prices
/paddy     paddy
soy        soybean
soyim      imported soybean
maize      maize
cassava    cassava
oth        other
chicktd    traditional chicken
beef       beef
eggs       egg
fish       fish
sug        sugar
veg        vegetable
con        concentrate
lab        labor
fcost      fix cost/

AN(fc) animal types
/fchickmod modern chicken/ ;
```

Concerning the notation of the elements contained in set, some letters are added before or after the name of the raw product, to distinguish between the products used as:

- input, with the name of the agricultural product,
- products for final human consumption have a name beginning with the letter “f”,
- final products for feed have a name beginning with the letter “i”.

The maize notation is “maize” for input, “fmaiz” for final product for consumption, “imaizf” for final product for feed.

For the rice, the input is “paddy”, the product for consumption is “rice”, the feed “irice”.

For the soybean, the inputs are called “soy” for national production, and “soyim” for imports; the consumed products are “tempe” and “tahu”; the feed is “isoyf” or “isoyim” (imported). Tempe and tahu (or tofu) are processed products from soybean which are very important in Indonesian diets.

For the cassava, the input is called “cassava”, the consumed product “cass”.

For the fish the input is called “fish”, the consumed product is “ffish”, the feed is “iffish”.

The instruction ALIAS is used to give another name to a previously declared set, such as following:

```
ALIAS (fc,fcb);
ALIAS (ioc,iocb);
ALIAS (ye,ya);
ALIAS (feed,fid);
```

In the second part of the definition file, parameters are declared. Each line begins with the GAMS instruction PARAMETER, followed by the name of the parameter, its domain and a documentary text. Each line ends with a semi-colon “;”.

Parameters in GAMS designate data. Values will be assigned in the data file (Pro.dat). The list of data is provided in next paragraph. A list of parameters with exogenous values is provided in the box below.

```
*Parameters (which value are calculated in the module) :

PARAMETER B(h) calculated food expenditure (in thousand Rp);
PARAMETER BY(h,ye) calculated food budget per year (in thousand Rp);
PARAMETER CARCONS(h,car) food characteristics in consumption  per day (g of prot and kcal);
PARAMETER CARCONSY(h,car,ye) food characteristics in consumption  per year (g of prot and kcal);
PARAMETER CACON(h,car,fc) food characteristics in consumption for each product per day (g of prot and
kcal);
PARAMETER CACONY(h,car,fc,ye) food characteristics in consumption for each product per day by year (g
of prot and kcal);
PARAMETER CON(iic) total consumption of raw  material per day (in  million tons);
PARAMETER CONY(iic,ye) total consumption of raw  material per year (in million tons);
PARAMETER CY(h,fc,ye) consumption per year (in kg);
PARAMETER E(h) non engaged expenses (in thousand Rp);
PARAMETER EXTRADE(pec,ye) external trade (in thousand tons);
PARAMETER EY(h,ye) non engaged expenses per year (in thousand Rp);
PARAMETER FUY(an,feed,ye) feed quantities by animal and by year (kg of feed by kg of animal processed);
PARAMETER LABC(ioc) volume of labor in processing sector (in man year);
PARAMETER LABY(ioc,ye) volume of labor in processing sector per year (in man year);
PARAMETER LABTOTY(ye) total volume of labor per year (in man year);
PARAMETER LABS0(ye) volume of labor in scenario 0 (in man year);
PARAMETER LABPERC(ye) percentage of labor compare with labor in scenario 0;
PARAMETER POLP(pcp,ye) price policy parameter;
PARAMETER POPY(h,ye) population for each category of household per year (in billion);
PARAMETER PY(com,ye) price per year (in thousand Rp per kg);
PARAMETER PCARFUY(car,feed,ye) price of feed characteristics per year (in thousand Rp per kg);
PARAMETER PR(pec,ye) representative percentage;
PARAMETER PRODY(pec,ye) production (in thousand tons);
PARAMETER PRODFY(pec,ye) production less seeds and wastes (in thousand tons);
PARAMETER WASE(pec) percentage of seeds self consumption and wastes in total production;
```

```
*Parameters (which value are exogenous) :
*Parameters of which ends by Y are given by year.

PARAMETER RISK(pcp,ye) risk by commodity on price per year;
PARAMETER RISKLIBY(ye) risk on price in case of liberalisation per year;
PARAMETER DA(h) exogenous food expenditures (000 Rp);
PARAMETER DAY(h,ye) exogenous food expenditures per year (000 RP);
PARAMETER POP(h) population for each category of households (in billion);
PARAMETER EP(pcp) actual exogenous prices (in 000 Rp);
PARAMETER PVEG(ye) random vegetable price;
PARAMETER COEFP(ye) random coefficient of paddy price;
PARAMETER COEFS(ye) random coefficient of soybean price;
PARAMETER COEFM(ye) random coefficient of maize price;
PARAMETER COEF(pcp,ye) random coefficient of price for primary commodities with exogenous prices (pcp);
PARAMETER LABVOL(ioc) volume of work including family work (in man year per kg of processed product);
PARAMETER IFE(car,feed) nutrient feed characteristics in kcal(prot) per kg of feed;
PARAMETER ANEED(car,an) food animal needs in calorie and protein per kg of animal;
```

In the third part of the definition file, variables are defined:

```
*Definition of variables :

VARIABLES
U              Producers and consumers utilities
;

POSITIVE VARIABLES
C(h,fc)        Consumed quantities by household (kg per year)
FU(an,feed)    Feed quantities by animal (kg of feed by kg of animal processed)
P(com)         Prices (thousand Rp per kg of product)
;
```

In the fourth part of the definition file, the equations are presented:

```
*Defining equations :

EQUATION UTIL   utility sum of consumers;
EQUATION OPTC(h,fc)   consumers optimality;
EQUATION PFEED(feed)   feed price;
EQUATION OPTPF1(fc1)   excess of costs over prices for fc1;
EQUATION PP(pcp)   primary prices fixed for pcp commodities;
EQUATION FEEDC(an,car)   feed characteristics fill needs;
EQUATION FCHICKMODP(an)   fchickmod price;
EQUATION LIMTEC1(an,feed)   feed technical limits;
EQUATION LIMTEC2(an,feed)   feed technical limits;
```

10.3 Data file: Pro.dat

The data file contains all the information necessary to build the MATA model. Three different formats are allowed with GAMS for entering data: tables, direct assignment and lists.

In the case of parameter of dimension 1, the statement begins with the GAMS instruction PARAMETER, then the name of the parameter, the domain and explanatory text. Then the list of domain elements and respective parameter values is written between slashes “/”. The statement ends with a semi colon.

In case of parameters of dimension above 1, the statement begins with the GAMS instruction TABLE. See the GAMS user guide for more details.

The data are assigned to the parameters according with their domain, defined as SET in the Pro.def file. The list of parameters (data necessary to build the model) has also been provided in this file.

10.3.1 Macro-economic parameters

```
* 3.1 Macro-economic parameters :

PARAMETER DA(h) exogenous food expenditures (in thousand Rp)
/H1 89.061, H2  179.066, H3  369.703/;

PARAMETER POP(h) population for each type of household (in billion)
/H1   0.00165, H2   0.065315, H3  0.040613  / ;

POPY(h,ye)=POP(h)*(1.02**(ORD(ye)-1));
```

The food expenditures have been calculated from CBS (SUSENAS surveys, 1990) data according to the typology of the three consumer categories. Expenditures and prices are given in thousands of rupiah per year. The population data cover Java only.

The assignment of POPY allows an increase of population of 2% each year. This percentage represents the average demographic trend (estimation of CBS and World Bank report sources) used in the base run. It can be modified for simulations.

10.3.2 Prices

```
* 3.2 Prices :
PARAMETER EP(pcp)  actual exogenous prices in 000 Rp
/oth      1
beef      4.365
chicktd   2.28
eggs      1.863
maize     0.221
paddy     0.196
cassava   0.194
lab       1
fcost     1
sug       1.021
veg       0.295
fish      1.673
soy       0.9
soyim     0.55
con       0.7
/;
```

Exogenous prices (average value) are defined in the box above.

```
* 3.3 Random on prices :

 PARAMETER PVEG(ye) random vegetable price
/Y1  0.267,   Y2  0.334,   Y3  0.305,   Y4  0.280,  Y5  0.279
Y6  0.272,   Y7  0.285,   Y8  0.336,  Y9  0.257,   Y10  0.300/;

PARAMETER COEFP(ye)  random coef paddy rice
/Y1  0.934,   Y2  1.069,   Y3  1.010,   Y4  0.960,   Y5  0.958
Y6  0.945,   Y7  0.970,   Y8  1.071,   Y9  0.913,   Y10 1.000/;

PARAMETER COEFS(ye) random coef soy price
/Y1  0.941,   Y2  1.062,   Y3  1.009,   Y4  0.964,   Y5  0.962
Y6  0.950,   Y7  0.973,   Y8  1.064,   Y9  0.922,   Y10 1.000 /;

PARAMETER COEFM(ye) random coef maize price
/Y1  0.915,   Y2  1.089,   Y3  1.013,   Y4  0.948,   Y5  0.946
Y6  0.928,   Y7  0.961,   Y8  1.093,   Y9  0.887,   Y10 1.000 /;

COEF(pcp,ye)=1;
COEF('paddy',ye)=COEFP(ye);
COEF('soy',ye)=COEFS(ye);
COEF('maize',ye)=COEFM(ye);

PY(pcp,ye)=EP(pcp);
PY('lab',ye)=EP('lab')*(1.05**(ORD(ye)-1));
PY('veg',ye)=PVEG(ye);
```

In the box above, random coefficients representing the various exogenous choices not included in the model and able to influence, in any sense, the average prices are defined.

The last lines assign the value of average exogenous prices (EP(pcp)) to each product with an exogenous price (PY(pcp)). Random coefficients will be applied in the file polpar where policies modifying prices are also included.

10.3.3 Data used to calculate output on labor and external trade

```
* 3.4 Data used to calculate output on external trade and labor :

TABLE PR(pec,ye) share of lowland on whole Java prod.

         y1     y2     y3     y4     y5    y6   y7   y8   y9   y10
paddy  0.78   0.85   0.77   1.15   0.89   1    1    1    1    1
soy    0.57   0.54   0.31   0.43   0.43   1    1    1    1    1
maize  0.61   0.61   0.42   0.59   0.64   1    1    1    1    1
;

PARAMETER WASE(pec) percentage of seeds self-consumed and waste in total production
/
paddy    0.07
soy      0.17
maize    0.6
/
;

PARAMETER LABS0(ye) volume of labor in first scenario : base.pol
/
Y1       9466223.364
Y2       9542756.262
Y3       9896255.455
Y4       1.025750E+7
Y5       1.055569E+7
/
;
```

The PR table gives the share of lowland considered in the agricultural production module for all of Java's production.

The WASE parameter represents self-consumption and waste. It is used to calculate the volume available for consumption. In the next version, these data will be included in the macpar file.

10.3.4 Coefficients of the linear expenditure system (LES)

```
* 5  Coefficients of the Linear Expenditures System (LES) :

TABLE BETA   coefficients LES

      RICE     TEMPE      TAHU        FMAIZ        CASS    FFISH    FBEEF
H1    0.142    0.023    1.198280E-4    0.012        0.022   0.037    0.007
H2    0.117    0.012    0.007          0.001        0.002   0.018    0.027
H3    0.076    0.012    0.008        3.012793E-4    0.001   0.019    0.069

 +   FCHICKMOD      FCHICKTD      FEGGS    FSUG    FVEG    FOTH
H1    4.672753E-4   3.072052E-4   0.003    0.018   0.027   0.709
H2    0.001         0.003         0.007    0.022   0.039   0.744
H3    0.007         0.015         0.025    0.024   0.028   0.716
;

TABLE GAMMA  coefficients LES

      RICE      TEMPE    TAHU     FMAIZ    CASS     FFISH    FBEEF
H1     40.137   2.660    0.016    45.214   46.929   5.989    0.191
H2    118.029   4.071    2.622    8.360    19.587   18.674   0.605
H3    152.259   7.611    5.349    4.836    19.803   39.365   2.494

      FCHICKMOD     FCHICKTD      FEGGS    FSUG     FVEG     FOTH
H1    9.472823E-4  6.315215E-4    0.052    2.742    18.021   2.144
H2    0.079         0.093         0.637    6.685    27.081   4.439
H3    0.642         0.634         4.242    13.814   35.642   10.867

;
```

The utility function representing consumer behaviour is a linear expenditure system defined by coefficients beta and gamma. The beta coefficient can be analysed as a preference parameter, weighting each product in the total utility. The gamma coefficient is a committed quantity for each final product (fc).

10.3.5 Processing characteristics

```
* 3.6  Processing characteristics :
TABLE TIO(iic,ioc) raw agricultural material
           rice     tempe    tahu     fmaiz   cass
paddy      1.43
soy                   0.6      0.4
maize                                   1
cassava                                         1
lab        0.01     0.027    0.025
fcost      0.251    0.194    0.282

 +         isoyf    imaizf    irice     iffish    icon    isoyim
soyim                                                       1
soy          1
maize                 1
paddy                           1
fish                                      0.6
con                                                 1
lab
fcost                 0.139     0.129     0.146     0.1     0.1

+       ffish   fchickmod   fsug   fveg
fish      1
sug                           1
veg                                  1
lab               0.07
fcost             0.97

 +         foth     fbeef    feggs    fchicktd
oth          1
beef                  1
eggs                           1
chicktd                                   1
;
```

Table TIO gives the processing coefficients. This table answers the question: how much raw material is needed (kg) to obtain one kg of processed product? The “+” at the beginning of a line indicates that the table was too large to fit nicely on a single line and is continued. The row labels are duplicated, if they have associated data in the new columns. The first column indicates that to produce 1 kg of rice 1.43 kg of paddy is needed, 0.01 units of labor and 0.251 units of fixed cost. As explained above, agri-business in Java is complicated, various scales and production technigues coexist and reliable data are difficult to get. Here the objective was mainly methodological. Technical coefficients are just indications and, for precise results on the commodity chain, more detailed data should be included. The data are in volume (kg) except for labor and fixed cost for which data are in value (in thousand rupiah/day).

```
PARAMETER LABVOL(ioc)   volume of work including  nonpaid family
workers (in man-year per kg of processed product)
/
rice              0.00006
tempe             0.00012
tahu              0.00014
fchickmod         0.00021
/
```

The parameter LABVOL indicates the volume of labor required in the four main agro-processing industries.

10.3.6 Consumption characteristics

```
*Consumption characteristics :

TABLE CARC(fc,car) Consumption characteristics
                  cal            prot
rice             3600             68
tempe            1986            209.4
tahu             1324            139.6
fmaiz            3550             92
cass             1460             12
foth             2025              0
fBeef            2070            188
fchicktd         3020            182
feggs            1620            128
ffish             670            120
fsug             3640              0
fveg              240             14
fchickmod        3020            182
;
```

Protein and calories contained in one kilo of each final product are given in the table above (Food Balance Sheet for Indonesia of Central Bureau of Statistics Jakarta, Indonesia).

10.3.7 Feed characteristics

```
*Feed characteristics :

TABLE IFE(car,feed) nutrient feed characteristics in Kcal(Prot) per kg of feed
               isoyf   isoyim   imaizf   irice   iffish   icon
prot            40.1    40.1      9       11.1     65      41
cal            2290    2290     3340     2314     2500    2500
;

TABLE ANEED(car,an) food animal need for one kg of final product
               fchickmod
prot             53.39
cal            7659.7
;

TABLE LIM1(an,feed) technical limit on feed
               isoyf   isoyim   imaizf   irice   iffish   icon
fchickmod      0.45    0.45     0.6      0.2     0.4      0.4
;

TABLE LIM2(an,feed) technical limit on feed

               icon
fchickmod      0.08
;
```

Table IFE assigns data on calories and protein contained in one kg of the feed products considered. Table ANEED indicates the needs of animals. Some technical constraints on feed requirement are included (Table LIM1 and LIM2).

10.4 How to modify a data table

The data presented above should be improved. In this section, users will find instructions for modifying the file Pro.dat.

The two files Pro.dat and Pro.def always have to be modified at the same time because the definition file contains the definition of the *sets*, the *parameters* and the *scalars*, which are used in the data file. For example, if data are added in the Pro.dat file, the name should be added in the Pro.def file.

In order to explain the way data are entered in the data file, a new type of animal production (shrimps) is considered. The new animal type, named fshrim as the final product for consumption, has to be added in the SETS animal type set (an) and final products (com, ioc, fc). The new statements are written in bold in the three boxes following.

Then in the Pro.dat file several tables have to be modified:

-LES coefficients: tables BETA and GAMMA,
-raw agricultural material: table TIO,
-consumption food characteristics: table CARC,
-feed characteristics: table IFE,
-food animal need: table ANEED,
-technical limits on feed: table LIM1 and LIM2.

Line or row needs have to be be added to enter the new data corresponding to the shrimps animal type. These lines in the data table are added as for the fchickmod commodity.

```
AN(fc) animal types
/
fchickmod     modern chicken
fshrim        shrimps
/

COM   all product
/
paddy     paddy
rice      rice consumed
irice     rice feed
soy       soybean
tempe     tempe
tahu      tofu
isoyf     soybean feed
soyim     imported soybean
isoyim    soyim feed
maize     maize
fmaiz     maize consumed
imaizf    maize feed
cass      cassava
cassava   cassava consumed
fish      fish
ffish     fish consumed
iffish    fish feed
oth       others
foth      others consumed
beef      beef
fbeef     beef consumed
chicktd   traditional chicken
fchicktd  chicken consumed
lab       labor
fcost     fix cost
eggs      eggs
feggs     eggs consumed
sug       sugar
fsug      sugar consumed
veg       vegetable
fveg      vegetable consumed
con       concentrate
icon      con feed
fchickmod modern chicken
fshrim    shrimps/
```

```
IOC(com)   final commodities and feed
/rice      rice consumed
tempe      tempe consumed
tahu       tahu consumed
fmaiz      maize consumed
cass       cassava consumed
foth       others consumed
fbeef      beef consumed
fchicktd   traditional chicken cons
feggs      eggs consumed
ffish      fish consumed
fsug       sugar consumed
fveg       vegetables consumed
fchickmod  modern chicken
fshrim     shrimps
isoyf      soybean feed
isoyim     imported soybean feed
imaizf     maize feed
irice      rice feed
iffish     fish feed
icon       concentrate feed /

FC(ioc)   final commodities
/rice      rice
tempe      tempe
tahu       tofu
fmaiz      maize
cass       cassava
foth       others
fbeef      beef
fchicktd   traditional chicken
feggs      eggs
ffish      fish
fsug       sugar
fveg       vegetables
fchickmod  modern chicken
fshrim     shrimps/
```

10.5 Equation file: Pro.equ

In this file, the utility function of consumers is represented by a linear expenditure system. It is assumed that first order conditions determine an equilibrium under the budget constraints of each type of consumer in prices and quantity consumed. Agri-business is assumed to adapt instantaneously to consumer demand. This assumption seems reasonable in the context of Java. Feed content is determined by cost minimization for a required level of nutrients under technical constraints. Prices of final products are calculated as the sum of the costs of processing. Raw agricultural products have exogenous prices.

The endogenous variables of the model are the quantities of final products consumed by type of household, the feed quantities by animal, and the prices. After the volume of consumption is calculated for final products (raw as well as processed products), some characteristics of the products (protein and calorie intake) are used to calculate the nutrient intake of each consumer category.

All the equations have already been defined in the definition file (Pro.def).

- The GAMS statement for an equation is:
  1. the name of the equation declared in the definition file
  2. the domain
  3. the symbol"..”
  4. left-hand-side expression
  5. relational operator =L= (less than or equal to); =G= (greater than or equal to); =E= (equal to)
  6. the right-hand-side equation
- The standard arithmetic symbols are:
  - ** exponentiation
  - * / multiplication and division
  - + - addition and subtraction
- Summation is noted SUM(index of summation, summand).

For example $\Sigma_i X_{ij}$ is written in GAMS SUM (i,X(i,j)). The $ operator is used to provide exception-handling capability.

The list of variables and parameters, as well as their domains and meanings, is provided in the definition file where they are defined by type and organized by alphabetic order.

The consumer typology permits splitting consumers into homogenous groups in terms of preference, elasticities and budget constraints. The same utility function is then able to represent all the consumers of a category. In this module, the utility function is a linear expenditures system (LES).

```
* 5.1 Consumers Utility Function :

UTIL..
        SUM(h,POP(h)* PROD(fc,(C(h,fc)-
        GAMMA(h,fc))**BETA(h,fc)) ) -U
        =E=0  ;
```

This equation (5.1) determines the variable U, which is maximized. The population (POP) is used to weight the sum of utility by type of household (h). The utility is a function of the quantity consumed (C) of final product, and the parameters of the LES function BETA and GAMMA (see explanation on Pro.datfile).

The first order condition (5.2) allows calculation of the quantity consumed (C) as a function of the non-committed budget (the excedent of committed budget) (∑ GAMMA*P) on food expenditures (DA), the price of final product (P), and the LES parameters (BETA and GAMMA).

```
* 5.2 Consumers Optimality :

OPTC(h,fc)..
        C(h,fc)*P(fc)
        -BETA(h,fc)*(DA(h)-SUM(fcb,GAMMA(h,fcb)*P(fcb)))
        -GAMMA(h,fc)*P(fc)
        =E=0 ;
```

Processing and marketing represent activities that change the form and place of agricultural products, from farm gate to the consumer's basket. They are represented by technical coefficients.

These coefficients describe, for each product and each technical itinerary, how much raw material, intermediate consumption (water, electricity, etc.), labour and capital is needed by unit of output. The table TIO contains all coefficients.

Prices of final consumption products (except animal ones) are calculated as the sum of the cost induced by processing (5.3). These costs are determined by the quantity required (TIO) multiplied by the price of the primary product (P_{pcp}).

```
*5.3 Excess of  Costs over Prices for Final Commodities except for animal :

OPTPF1(fc1)..
          SUM(pcp,TIO(pcp,fc1)*P(pcp))-P(fc1)
          =E=0;
```

For feed products the price is determined as the sum of the cost induced by processing as for final consumption (see 5.4).

```
* 5.4 Feed price :

PFEED(feed)..
          P(feed)=E=SUM(iic,TIO(iic,feed)*P(iic));
```

For broilers, because several combinations can be used for feed, the choice is made by the model in order to meet animal nutrient requirements and to minimize the costs. Technical limits constraining the feed content are also introduced.

The price of animal production is also calculated as the sum of costs (Equations 5.5 to 5.8).

```
* 5.5 Feed Caracteristic Fill Needs :
FEEDC(an,car)..
SUM(feed,FU(an,feed)*IFE(car,feed)) =G=ANEED(car,an);

* 5.6 Feed Technical Limit
Limtec1(an,feed)..
FU(an,feed)=L=LIM1(an,feed)*(SUM(Fid,FU(an,fid)));

* 5.7 Feed Technical Limits
Limtec2(an,feed)..
FU(an,feed)=G=LIM2(an,feed)*(SUM(Fid,FU(an,fid)));

* 5.8 Animal Price
Fchickmodp(an)..
P(an)=E=SUM(iic,TIO(iic,an)*P(iic)) +Sum(feed,P(feed)*FU(an,feed));
```

Feed characteristics determined by quantity of feed consumed (FU) multiplied by nutrient contents (IFE) should meet the needs (ANNEED) of the animals (5.5). Quantity (FU) of feed (feed) by animal (an) is constrained by a maximum and a minimum defined by technology (LIM1, LIM2) (5.6 and 5.7).

10.6 Initialization file: Pro.ini

In this file, default values are given for the main variables of the model. The extension .L in GAMS assigns a default value to the given variables in order to facilitate the solution process.

```
* PRO.ini setting up initial values :

P.lo(com) =0.0001;
P.up(com)=50;
P.l(com)=0.1;

C.up(h,fc)=100*GAMMA(h,fc);
C.lo(h,Fc)=GAMMA(h,fc)+0.0001;
```

```
* PRO.in2 setting up initial values :

P.l('rice')=        0.541;
P.l('tempe')=       0.761;
P.l('tahu')=        0.667;
P.l('fmaiz')=       0.221;
P.l('cass')=        0.194;
P.l('ffish')=       1.673;
P.l('foth')=        1;
P.l('fbeef')=       4.365;
P.l('fchicktd')=    2.28;
P.l('feggs')=       1.863;
P.l('sug')=         1.021;
P.l('veg')=         0.295;
P.l('fchickmod')= 2.312;

C.L('h1','rice')= 46.69;          C.L('h2','rice')= 128.82;       C.L('h3','rice')= 173.36;
C.L('h1','tempe')= 3.43;          C.L('h2','tempe')= 4.89;        C.L('h3','tempe')= 10.06;
C.L('h1','tahu')= 0.02;           C.L('h2','tahu')= 3.15;         C.L('h3','tahu')= 7.07;
C.L('h1','fmaiz ')= 46.52;        C.L('h2','fmaiz ')= 80.6;       C.L('h3','fmaiz ')= 5.04;
C.L('h1','cass ')= 49.72;         C.L('h2','cass ')= 20.15;       C.L('h2','cass ')= 20.64;
C.L('h1','ffish ')= 6.54;         C.L('h2','ffish ')= 19.21;      C.L('h3','ffish ')= 41.03;
C.L('h1','foth ')= 42.3;          C.L('h2','foth ')= 122.8;       C.L('h3','foth ')= 710.5;
C.L('h1','fbeef')= 0.23;          C.L('h2','fbeef')= 0.91;        C.L('h3','fbeef')= 4.86;
C.L('h1','fchicktd')= 0.004;      C.L('h2','fchicktd')= 0.16;     C.L('h3','fchicktd')= 1.62;
C.L('h1','feggs')= 0.09;          C.L('h2','feggs')= 0.82;        C.L('h3','feggs')= 6.28;
C.L('h1','fsug')= 3.19;           C.L('h2','fsug')= 7.77;         C.L('h3','fsug')= 17.33;
C.L('h1','fveg')= 20.3;           C.L('h2','fveg')= 33.66;        C.L('h3','fveg')= 41.622;
C.L('h1','fchickmod')= 0.006;  C.L('h2','fchickmod')= 0.11; C.L('h3','fchickmod')= 1.08;

FU.l(an,feed)=0.1 ;
```

10.7 Policy file: Polpar

The functioning of the polpar file was explained previously.

```
$ontext
 TO MODIFY POLICY
 choose one measure of policy
 erase the star in front of the dollar include command
$offtext

Polp(pcp,ye)=1;
Risk(pcp,ye)=1;

*$include base.pol
*reference scenario, population and income growth

*$include sim1.pol
*food crop markets liberalisation: soybean, rice and maize

*$include sim2.pol
* food crop markets liberalisation except rice.

*$include sim5.pol
* slower growth of food expenditure

$include sim6.pol
*quicker growth of food expenditures

DAY(h,ye)=DA(h)*(INC(h)**(ORD(ye)-1));
PY(pcp,ye)=EP(pcp)*(1-((1-COEF(pcp,ye))*RISK(pcp,ye)))*POLP(pcp,ye);
```

10.8 Dynamic file: Pro.dyn

The dynamic file includes the loop on time to perform simulations on several years. After the instruction loop, the beginning year and end of the simulation period are written. Then values of the corresponding years are given for the parameters defined with the set ye. Then solve is performed and the storput file is included.

```
Pro.dyn
* dynamic and recursive file
* it performs the loop on time-solve the model- saves and stores results
* reinitialize the variables at the beginning of each year
*
LOOP(ye $(ORD(ye) GE 1 and ORD(ye) LT 6),
*_____________________________________________________________________________
* assign value of parameters for the corresponding year

DA(h)=DAY(h,ye);
POP(h)=POPY(h,ye);
EP(pcp)=PY(pcp,ye);

$INCLUDE PRO.in2
*_____________________________________________________________________________

SOLVE PRO USING NLP MAXIMIZING U;
_____________________________________________________________________________
* store results of the solve
$include storput
*_____________________________________________________________________________
* further calculations for final results

PRODFY(pec,ye)=PRODY(pec,ye)*(1-WASE(pec));
EXTRADE(pec,ye)=((PRODFY(pec,ye))/(PR(pec,ye)))-(CONY(pec,ye)*1000);
EXTRADE('soy',ye)=((PRODFY('soy',ye))/(PR('soy',ye)))-
CONY('soy',ye)+CONY('soyim',ye))*1000;
*_____________________________________________________________________________
   );
* end the loop
```

10.9 Storage file: Storput

The contents of the storput file were explained previously. This file also assigns the results of the model for each year to parameters which will be used for formatting output.

```
*STORPUT file :
B(h)=SUM(fc,P.L(fc)*C.L(h,fc));
BY(h,ye)=B(h);
CARCONS(h,car)=SUM(fc,C.L(h,fc)*CARC(fc,CAR))/365;
CARCONSY(h,car,ye)=CARCONS(h,car);
CACON(h,car,fc)=C.l(h,fc)*CARC(fc,car)/365;
CACONY(h,car,fc,ye)=CACON(h,car,fc);
CON(iic)=SUM(h,SUM(fc,TIO(iic,fc)*C.L(h,fc))*POP(h))
    +SUM(h, SUM(an, SUM(feed,TIO(iic,feed)*FU.l(an,feed)*C.l(h,an)*POP(h))));
CONY(iic,ye)=CON(iic);
CY(h,fc,ye)=C.L(h,fc);
E(h) = DA(h) - SUM(fc,P.L(fc)*GAMMA(h,fc)) ;
EY(h,ye)=E(h);
FUY(an,feed,ye)=FU.L(an,feed);
LABC(fc)=LABVOL(fc)*(sum(h,C.l(h,fc)*pop(h)))*1E9;
LABC(feed)=LABVOL(feed)*sum(an,FU.l(an,feed)*sum(h,C.l(h,an)*pop(h)))*1E9;
LABY(fc,ye)=LABC(fc);
LABY(feed,ye)=LABC(feed);
LABTOTY(ye)=SUM(fc,LABY(fc,ye))+SUM(feed,LABY(feed,ye));
LABPERC(ye)=(LABTOTY(ye)/LABS0(ye))-1;
PCARFUY(car,feed,ye)=P.L(feed)/IFE(car,feed);
PY(com,ye)=P.L(com);
WELTOT(h)=pop(h)*1E+9*PROD(fc,(C.l(h,fc)-gamma(h,fc))**beta(h,fc));
WELTOTY(h,ye)=WELTOT(h);
WEL(h)=PROD(fc,(C.l(h,fc)-gamma(h,fc))**beta(h,fc));
WELY(h,ye)=WEL(h);
```

The contents of the putfile and *.sol are explained.

```
file result;
file By1 /BY.sol/;
file DAY1 /DAY.sol/;
file Carcons1 /carconsy.sol/;
file cacon1 /cacony.sol/;
file con1 /cony.sol/;
file cy1 /cy.sol/;
file ey1 /ey.sol/;
file extrad /extrade.sol/;
file pcarfu /pcarfuy.sol/;
file fuy1 /fuy.sol/;
file lab /laby.sol/;
```

11. Concluding Remarks

Free market superiority now seems to be widely accepted all over the world and it motivates intensive negotiations on trade liberalization. However, the framework in which the superiority of free markets is demonstrated, characterized by the existence of markets for all commodities and services as well as all possible time periods, is still far away from the current economic context. As noted by Timmer (1995): "Most of the countries in the developing world, and many transition economies, have not yet created such marketing systems. Especially in their rural economies, many markets are conspicuous by their absence or by very high costs of transacting business. In the poorest countries, or the most backward regions of even the more dynamic economies of the Asian Pacific countries, rural markets for capital, risk, labor and commodities are highly imperfect or nonexistent." Further theoretical developments, aiming at releasing the most unacceptable assumptions of the Arrow-Debreu model in considering imperfect expectations of economic actors, transactions costs, spatial development and economy of scale, lead to interesting approaches but lose the elegant simplicity and the facility of calculation of the standard model. The unity of the harmonious and efficient equilibrium is replaced by a multiplicity of solutions, indetermination and, in dynamic representation, by chaotic behavior of variables such as prices. However, the real economic world is characterized by imperfect information, leading to incorrect decisions and risk. It limits specialization, investment and adoption of new technology. In this context, it is possible that liberalization and globalization do not lead to a better solution for the community and that, at least during adjustment, the reallocation of resources may be largely damaging for some actors.

Progress in computer sciences allows the representation of complex economic decisions. The first purpose of this book was to present such a tentative model for the agricultural sector in the Javanese lowlands. To deal with the diversity of economic conditions, actors are divided into main types. To represent in a pragmatic way the complexity of decisions and market imperfections, opportunities and constraints are listed, price expectations are determined by imperfect information and risk averse behaviours are considered. The model built is still a prototype and some important topics, as price formation when one considers transaction costs, supply lag, and imperfect information, are not yet addressed. Nevertheless, it demonstrates the utility of a careful evaluation at a micro-economic level before claiming that liberalization will benefit all economic agents. In the case presented here, around 40% of the active persons studied face a sharp decrease of income. Very few incentives remain for them to stay in agricultural production and, in a country characterized by under-employment, few opportunities exist in other economic sectors.

The second objective of this project was to provide a tool useful for policy decision advisers and thus a lot of attention has been devoted to friendliness.

The early chapters of this book describe food crop agriculture in Indonesia, laying the foundation for an economic model, MATA, developed to estimate the impacts of various policies.

The MATA user guide describes not only how to use the MATA prototype model built for Indonesia, but also how to operate slight modifications, updating data, adding activities, and performing simulations of policy or external shocks.

Nevertheless, the reader should be warned that while GAMS is a powerful instrument of calculation, syntax or logical errors are likely to appear often. Syntax errors are easy to debug, after some experience, because message errors of GAMS are displayed and they are explicit enough. Logical errors are more difficult to detect. In doing any modification, the user should check carefully what has been calculated by GAMS by displaying variables just before and after modifications.

Also, all the output provided by GAMS should be carefully checked, in particular the shadow prices of variables. To do so, it is of great importance to read the GAMS manual and to erase options which are at the beginning of the main file and minimize the output displayed.

To extend the model to other zones, the user is invited to read the MATA manual for model building.

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