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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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THE IMPACT OF SMALL FARM MECHANIZATION ON THE INDONESIAN RICE ECONOMY: A SIMULATION ANALYSIS

By

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IMPACTS OF SMALL FARM MECHANIZATION ON INDONESIAN RICE ECONOMY: A SIMULATION ANALYSIS*

Thammanun Pongsrikul and Bart Duff**

Introduction

Despite the persistent decrease of the agricultural share in the gross domestic product (GDP), agriculture has been the dominant sector in the Indonesian economy. Within this sector, food crops have been the largest subsector (Table 1 in Appendix). Rice is the most important crop among food crops because it is the major staple food of the Indonesians. The annual per capita consumption of rice in 1978 was approximately 123.4 kilograms, and over 60 percent of total calories came from rice consumption (Table 2 in Appendix). Even though rice production in Indonesia increases averaging 5 percent a year over the 10 years of the first two economic development plans (Repelita I and II, 1968/69 - 1978/79), Indonesia's rice imports consistently increases and has reached about 2 million tons a year since 1977 (Table 4 in Appendix). This marks Indonesia as one of the major rice importers in the world (Pongsrikul, 1983).

The high expenditure on rice imports causes the Indonesian government to set the self-sufficiency in rice consumption as the national goal since 1959. To achieve the objective, the government implements both intensification and extensification programs to stimulate domestic rice production. The intensification program, through the BIMAS (Bimbingan Massel-mass guidance), provides for extension devices and a package of input improvement of seed, fertilizer and pesticide uses, spraying equipment on credits, and a cash balance for a cost of living allowance. The extensification is implemented through the expansion of rice planted area resulting from irrigation improvements. To enable farmers to cultivate more land and to have the secondary crop, farm mechanization becomes attractive under the extensification program. Tractors were first introduced to only the outer islands which were the less populated and labor shortage areas, and they were later introduced to both inner and outer islands.

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Broad introduction of farm mechanization, however, creates a lot of controversial issues. The most lively controversy is that the mechanization provides the adverse influence on agricultural employment, since the tractorization displaces farm labor and consequently generates high unemployment to the sector. The negative effect implies demand for farm labor shifting down, and the fall in demand will lead to lower wage rates as supply of labor remained the same. The lower wage implies a lower income for agricultural hired labor which mostly consists of landless and small farmers. Furthermore, the phenomina also worsens the income distribution since incomes are distributed toward tractor owners who are either rich investors or large farmers. The decline in the purchasing power of the majority will be detrimental to economic strength in the future since it will directly affect the agricultural sector and indirectly hurt other related sectors.

On the other hand, the alternative view argues that Indonesian agriculture is not homogeneous. Some area may have labor surpluses while others may be facing a labor shortage, and even in some areas in West Java do face labor shortage problem during the peak season of harvesting and land preparation for the secondary crop (Collier, et.al, 1981). Without tractorization, it is almost impossible to have a multiple crops because time for land preparation between crops is short. Furthermore, the use of HYV requires precise timing in transplantation which is a short period. Therefore, it depends on the degree of labor displacement and an increase in total cultivated land resulted from farm mechanization. If the mechanization leads to a vast increase in planted areas and multiple crops, the total employment and income of farmers tend to increase because of more demand for farm labor and other employment opportunities. In 1979, Rijk pointed out that there were different types of farm mechanization each of which has different effects on employment and income. The introduction of appropriate mechanization would give positive effects to the area. Another aspect is whether farm mechanization increases yield per hectare. Different studies have different conclusions, but none of them concludes that farm mechanization reduced yield. The most difficult is to measure the additional yield.

Obviously, self-sufficiency in rice consumption is essential to Indonesia, but it has never been successful. To achieve such goal, there are many factors involved and it takes time. Therefore, the general objective of this study is to determine the period of self-sufficiency resulted from the implementation of various types of mechanization under a given set of agricultural policies. The specific objectives will be focussed on total rice output, employment and its pattern, income and income distribution, trade volume, and total policy costs.

From the given set of objectives, one may hypothesize that self-sufficiency can be achieved by simulating domestic production and curbing the high domestic demand. The domestic demand should be reduced through a reduction in population growth. An introduction of the appropriate mechanization will increase total of rice output. If farm mechanization leads to high total employment and yield, the proportion of hired labor to total employment and incomes of farm workers will increase. The more governmental distortion and the faster self-sufficiency will always associate with higher costs to the government.

The Economic Structure of Indonesia

Indonesia is situated on 17° of latitude and 47° of longitude which is in the tropical zone. The country consists of 13,667 islands which stretched out for 5,110 kilometers (km) from East to West and 1,888 km from North to South covering the total land area of 200 million hectares (ha). Out of the total land approximately 60 million ha is potentially suitable for agricultural development. The wide spread of land area indicates the variations in climates, soil composition, environment, and socio-economics. Therefore, the Indonesian agriculture is not homogeneous. To understand the differences in key economic variables, this part will be devoted for brief descriptions on South Sulawesi, West Java, and Indonesia as a whole. South Sulawesi and West Java, two of the 27 provinces in Indonesia, are selected for this study because they are major areas of rice production with high degree of mechanization, but much difference in population densities and some socio-economic aspects.

1. Population and Density

South Sulawesi is a province on the outer island which consists of 23 districts, 169 sub-districts, and 1,170 villages. The total land area of this province is 72,781 square km (Maamun, 1981). The total population in 1981 was 6.12 millions, or 4.1 percent of the total population in Indonesia. The population density was only 84 persons per square km which was very low compared to 500 persons per square km in Java (Table 5 in Appendix). The majority of population and labor force in South Sulawesi are engaged in agriculture. More than 70 percent of population in 1976 lived in the rural areas, and about 63 percent of the labor force in 1973 worked in the agricultural sector (Maamun, 1981). Similar to South Sulawesi, the majority of population in West Java lived in agriculture, and approximately 70 percent of labor force worked in this sector (Saefuddin, 1981). Total population of West Java in 1981 was 28 millions, or about 19 percent of the total population in Indonesia. Since the total area of West Java is only 46,300 square km, the population density in the same year is 604 persons per square km which is considerably high compared to

only 74 persons per square km of the national average (Table 5 in Appendix). The high density in West Java was due to high population growth, for example, the average population growth of West Java during 1971-1981 was 2.69 percent while the population growth of South Sulawesi and Indonesia were only 1.72 and 2.31 percent respectively.

2. Paddy Area and Production

Approximately 88 percent of the total area in South Sulawesi comprises forest, mountains, rivers, swamps, and homelots. The remaining 12 percent is the cultivated area which consists of 512,919 ha of wetland and 407,222 ha of dryland. In 1976, 92.8 percent of total wetland in South Sulawesi was devoted for rice production, and about 95.8 percent of the total harvested paddy area (wetland and dryland areas) in 1976 was the wetland area (Table 6 in Appendix). Furthermore, about 20 percent of the paddy wetland area was double crops (Maamun, 1981), and about 63.94 percent of the net harvested area in 1976 was irrigated (Table 6 in Appendix). On the other hand, sixty-three percent of total land area in West Java is for agricultural production which consists of 1.8 million hectares of wetland and about one million hectares of dryland area (Saefuddin, 1981). More than 90 percent of the total wetland area in 1976 was used to grow rice. In the same year about 94.3 percent of the total harvested paddy area was irrigated. The percentage of the irrigated paddy areas to total harvested area consistently increases because of the large spending on irrigation projects during the three economic development plans, totalled 661 billion Rupiahs. The irrigation projects were heavily emphasized on Java, especially in the East and West Java.

West Java has been known as the rice granary of Indonesia because it has the largest share in Indonesia's rice production. During 1971 to 1981 the province accounted for 22-24 percent of the nation's total rice output. Yield of rice production in West Java is relatively high compared to the yield of Indonesia as a whole, e.g., its yield in 1981 was 3.28 tons per hectare (Table 8 in Appendix) which was about 6 percent higher than the national average. The high yield was due to the low percentage of crop failure (Saefuddin, 1981) and the large irrigation projects taken place in Java, particularly in West and East Java, during the three economic development plans. Furthermore, the high yield also resulted from the implementation of intensification programs. The growth rate of paddy production in West Java during 1971-1981 was 4.8 percent. Even though this province has the largest share in rice production, it is still a rice shortage area. Table 9 indicates that in 1976 the milled rice deficit in West Java was 139,000 tons. The deficit in 1978, however, declined to 40,000 tons, and the shortage was supplied by the rice surplus from Jakarta through the shipment of BULOG (Table 10 in Appendix).

In contrast, yield of paddy production in South Sulawesi in 1981 was 2.84 tons per hectare, approximately 7.8 percent lower than the national average. The relatively low yield may result from the relatively high percentage of crop failure (Maamun, 1981). The paddy production grew at 2 percent a year for 1971-1981 period. Even if the province's share of rice production in 1981 was only 6.4 percent of the nation's total rice output, this province is one of the major rice surplus area. Its annual reports to other provinces was 1.2 million metric tons of grain (Maamun, 1981). According to the 1976 BULOG's estimation, the province's crude milled rice surplus was 121,000 tons (Table 9 in Appendix). All of rice surplus in South Sulawesi in 1978 were shipped by BULOG to East Nusa Tengara, West and East Kalimantan, Maluku, and Southeast and Central Sulawesi (Table 10 in Appendix). The majority of rice surplus in 1978 was sent to Southeast and Central Sulawesi, East Kalimantan, and Maluku.

3. Farm Mechanization Status

Farm mechanization has been introduced to Indonesian agriculture since early 1950s. The initial attention was given to the big four-wheel tractors and crawlers, but it has been changed toward the Japanese small tractors since 1960s. Not until 1970 that farm machines have been broadly introduced to small farmers in Indonesia (Bagyo, 1981), and the uses of farm machines become very popular since then. The total investment of farm machines reached 180.5 billion Rupiahs in 1978, and it accounted for 12.6 percent of total farm power. The principal farm machines used in Indonesia in 1978 are shown in Table 11 in Appendix.

Power tillers increased from 670 units in 1970 to 2,360 units in 1978, and the number is projected to reach 24,075 units in 1983/84. Even if the number of power tiller increased more than the number of small four-wheel tractors, the latter had the higher average growth rate during 1970-78, 23 percent per year compared to only 17 percent a year of the former. The small tractors increased from 268 units in 1970 to 1,410 units in 1978, or increased by 1,412 units, and it is expected to reach 12,290 units in 1983/84. The large increase is due to the government's credit subsidy on the purchase of small tractors. For the 1970-78 period, the number of manual weeders/cultivators increased by 509,000 units, the highest increase in numbers. In the same period, the hand sprayers increased by 134,675 units which was second to only the manual weeders, and the population is projected to be 465,990 units 1983/1984. The irrigation pumps during this period increased only 1,409 units, or have 7 percent growth rate. The power thresher increases its popularity. The population increased from 124 units in 1970 to 1,343 units in 1978, or a 35 percent annual increase, and the number is expected to be 8,365 units in 1983/84.

The machine density in this study is defined as the numbers of machinery available per one thousand hectares of cultivated areas. According to Table 11, the manual weeders had the highest machinery density, about 121.79 units per 1,000 hectares in 1978. The machinery density of hand sprayers in the same year was 17.16 units per 1,000 hectares, second to only the manual weeders. Among tractors, power tiller had the highest machinery density because its price was relatively lower than other types of tractors, but small four-wheel tractors had the highest increase in density. The fertilizer applicator and large four-wheel tractor are among the lowest machinery density. The latter had low density because of its high price, and poor farmers who are the majority population can not afford to buy it.

There are three major types of ownerships found in Indonesia, namely, individual ownership, joint ownership, and other form of ownership. The last type of machinery ownership includes governmental services, hiring, and machines in leasing contracts. The joint ownership of farm machinery in Indonesia is also found in the form of cooperatives and farmer groups. Each unit of farm machines can serve up to 3 to 6 farmers. Table 11 indicates that about 60 percent of small tractors in 1978 was under individual ownership, which was the highest percentage among different types of tractors. Farmers bought their own small tractors because the government gives credit subsidy to the purchase of this type of tractors. Approximately 87 percent of manual weeders/cultivators was under individual ownership. The high percentage was due to the frequent uses and the low price of the machine. Interestingly, seventy percent of irrigation pumps in 1978 was under the joint ownership. This is because one pump can provide water to more than one farmer at one time.

Both South Sulawesi and West Java have higher machinery densities than the national average. According to Table 12, all machinery densities of West Java are higher than that of Indonesia as a whole. It is also true for South Sulawesi except hand sprayers. In general, South Sulawesi has higher machinery densities than West Java except hand sprayers and power threshers. The densities of all tractors in South Sulawesi are higher than West Java because the former has low population density. Therefore, more tractors have been used for land preparation in South Sulawesi than in West Java.

The estimated prices of the six types of farm machines are shown in Table 13.

4. Mechanization Policies

There are two major mechanization policies in Indonesia:

a. Credit subsidy policy

Presently, the government provides a soft credit through the government's bank or agency by charging the farmers only 12 percent interest rate. The maximum credit under this policy is five million Rupiahs for a maximum repayment of five years.

b. Fuel price policy

This policy sets a uniform price for fuel used in farm mechanization as follows:

- The price of gasoline is 150 Rupiahs per litre.
- The price of diesel oil is 52.50 Rupiahs per litre.
- The price of kerosene is 50 Rupiahs per litre.

According to the estimation of Wiryosumarto, the market prices at the Jakarta market in September 1981 are as follows: for gasoline 152.4 Rupiahs per litre, for diesel oil 57.15 Rupiahs per litre, and for kerosene 51 per litre.

5. Subsidy equivalent

To determine the impacts of overall subsidy, it is necessary to calculate subsidy equivalent for the following cases.

a. The credit subsidy policy

The total subsidy is defined as:

$$S = \sum_{t=1}^{n} (\gamma) \{ LF_t - P_t \} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where S = total subsidy

= rate of implicit subsidy, which is the difference between market rate and policy rate of interest

LF_t = amount of loan at time t.

P_t = principal payment in period t.

b. Fuel price subsidy

This policy affects the variable cost of using the machine. It is simply defined as.

$$S_t^i = (MP_t^i - PP_t^i) \times Q_t^i \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where: S_t^i = Subsidy on i^{th} commodity at period t.

MP_t^i = market price of ith commodity at period t

PP_t^i = policy price of ith commodity at period t

Methodology

1. Theoretical framework

This study employs a partial equilibrium analysis to evaluate impacts of self-sufficiency and agricultural development policies, particularly the farm mechanization, on Indonesia's rice economy. Basically, a policy adoption will affect domestic production and consumption, trade volumes, and social welfare. The relationships are shown in Figure 1. For simplicity, a small country assumption will be imposed here. The world price of rice is determined by the intersection of world supply S^w and word demand D^w in the world market at which is point E^w in the panel (a). The world price of rice facing Indonesia is the horizontal line OP_o. The initial equilibrium in the domestic market is at E_1, where the original domestic demand D^d intersects domestic supply S^d. The domestic price P_o is determined in domestic market, as in panel (b). The corresponding quantity of domestic production and consumption is OR_o units. In this case, the social welfare is determined at point E_1, the tangency between the budget line Y_1R_3 and the community indifference curve IC_o in panel (c).

Suppose, real income increases from Y_1R_3 level to Y_2R_4 level. The domestic demand for rice will shift from D^d to $D^{d'}$, and the new domestic price of rice becomes OP_1 level. Without government's interventions, the country will import R_oR_2 units of rice, since domestic consumption is OR_2 units while domestic production is only OR_o units. Consequently, the country's welfare will be on indifference curve IC_2, which is higher than IC_o. If

the government wants to maintain the self-sufficiency by prohibiting rice imports, the country will produce and consume OR_1 units of rice. As a result, the country's welfare will shift from indifference curve IC_2 to IC_1, in which implies a lower social welfare for the country. The shift causes consumer's surplus to fall by the area of $P_1P_oE_3E_2$, but the producer's surplus increases by the area of $P_1P_oE_1E_2$. The area of triangle $E_1E_2E_3$, the differential area of consumer's and producer's surpluses, is the excess burden or social welfare cost to the society resulted from the self-sufficiency policy. In the long-run, the self-sufficiency can be achieved by imposing the intensive and extensive agricultural development policies to increase domestic production fast enough to match the high domestic demand. If this is the case, the domestic supply will shift from S^d to S^d. The country will produce and consume OR_2 units of rice, and the corresponding social welfare will be on the indifference curve IC_2. There will be no welfare loss.

2. Model description

The IRRI's prototype rice policy model, initially developed by Dr. R.W. Herdt and et al, will be used to trace overtime impacts of various mechanization policies on economic variables and policy costs to the government of Indonesia. This type of model is basically a quantitative accounting model that its development bases on the rice policies on Southeast Asia's projects; namely, buffer stocks and international trade policies, fertilizer demand and supply policies, irrigation investment and its productivity policies, and demand and consumption analysis on rice (Herdt and Webster, 1982).

The model primarily consists of supply and demand sides. The supply side includes domestic production, imports or exports, and buffer stock. The demand side is the total domestic consumption of five economic classes. For a better understanding, the model will be described as follows:

a. Production side

Rice production is carried out on large and small farm lands. Sum of output from these farms are total production of rice at a given year. Rice output depends on total land area of each quality, fertilizer uses, farm mechanization and labor requirement.

The rice land consists of eight qualities each of which is differentiated by the degree of water control (Table 14 in Appendix). Even though the total amount of rice land is fixed, the proportion of various qualities of land depends upon government's investments in irrigation. The higher investment will improve quality of land and

yield. In addition to irrigation, the uses of high yield varieties of rice and fertilizer also increase rice yield. The supply of fertilizer is determined by government's policies, while the demand is determined by the productivity of fertilizer on the eight type of land each of which has different yield responses to fertilizer. The response functions take the form:

$$Y_{ij} = a_i + b_i FERT_{ij} + C_i (FERT_{ij})^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

where a_i, b_i and c_i are parameters in the yield response on the ith land quality, which j is the subscript denoting farm class. $FERT_{ij}$ is the amount of fertilizer application on i^{th} land quality by j^{th} farm class.

The values of these parameters, shown in Table 15, are estimated by the regression technique. The fertilizer response function, together with relative price and availability of fertilizer, determines the rice yield and fertilizer uses on each quality of land. The available fertilizer is optimally distributed among various land qualities by using the marginal productivity principle to determine the fertilizer application rates. When the amount of fertilizer used on each quality of land is known, yield on each type of land can be obtained from the expression (3). The total output on each land quality is the product of its yield and planted area, or

$$q_{ijl} = A_{ijl} \cdot Y_{ijl}$$

where q_{ijl} = rice output of the ith quality of land ijl produced by the jth farm class in l^{th} season.

Y_{ijl} = rice yield of ith quality of land produced by j^{th} farm class in l^{th} season.

A_{ijl} = total planted area of ith quality of land produced by j^{th} farm class in l^{th} season.

The total rice output of the economy is determined by the expression (4) as below:

$$Q_l = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} q_{ijl} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where Q_1 = total rice output without mechanization

The model treats farm machinery as having possible impacts on yield. The total area under mechanization is the product of the number of machines available and the machine's capacity; or

$$A_{kl} = N_{kl} \cdot C_{kl} \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

where A_{kl} is the total area under k machine operation in l^{th} season.

N_{kl} and C_{kl} are the number of k machine and capacity in lth season.

The total change in rice output resulted from mechanization is the product of total area under k mechanization and additional yield resulted from k machine; or

$$q_{kl} = A_{kl} \cdot Y_{kl} \quad \ldots\ldots\ldots\ldots\ldots \quad (6)$$

where q_{kl} and Y_{kl} are additional rice output and yield of rice resulted from k machine.

The effects of mechanization on total rice output of each farm class is determined as:

$$q_{kjl} = q_{kl} \cdot R_{kjl} \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

where q_{kjl} is the change in rice output resulted from k machine in j^{th} farm class in l^{th} season.

R_{kj} is the percentage of k machine owned by j^{th} farm class in l^{th} season.

The effects of mechanization on total change in rice output resulted from mechanization can be obtained from the expression (8).

$$Q_2 = \sum_{k=1}^{m} \sum_{j=1}^{2} \sum_{l=1}^{2} q_{kjl} \quad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

where Q_2 is the change in total output resulted from k machine implementation.

q_{kjl} is the change in output resulted from k machine in j^{th} farm class and in l season.

The total output of rice production in the economy is defined as:

$$Q = Q_1 + Q_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

where Q is the total rice output.

Labor used in this model consists of family labor and hired labor. The total labor used without the existence of farm mechanization is defined as:

$$Tl_1 = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} (A_{ijl} \cdot L_{ijl})\ (h_{ijl} + f_{ijl}) \quad \ldots\ldots\ldots \quad (10)$$

where, Tl_1 is total labor uses

A_{ijl} is total area of ith quality of land used by j^{th} farm class in l^{th} season.

L_{ijl} is the labor required per hectare in i^{th} land quality by j^{th} farm class in l^{th} season.

h_{ijl} and f_{ijl} are respective percentages of hired and family labor to total labor uses imployed in i^{th} land quality and by j^{th} farm in l season.

In addition to yield, the mechanization also has impacts on labor uses. The effects of farm mechanization on labor uses is defined as:

$$Tl_2 = \sum_{k=1}^{m} \sum_{j=1}^{2} \sum_{l=1}^{2} (N_{kjl} \cdot C_{kjl})(h_{kjl} + f_{kjl}) \quad \ldots\ldots\ldots \quad (11)$$

where: Tl_2 is the change in total labor uses resulted from farm mechanization

N_{kjl} is the number of k machine used by j^{th} farm l^{th} season.

C_{kjl} is the capacity of kth machine used by j^{th} farm in l^{th} season.

h_{kjl} and f_{kjl} are respective percentages of hired and family labor affected by k machine in j^{th} farm class in l^{th} season.

The total employment is defined as:

$$TL = Tl_1 + Tl_2 \quad \ldots\ldots\ldots\ldots\ldots \quad (12)$$

where: TL is total labor use in a given year

b. Consumption side

The demand for rice is a function of its price and per capita income, and the demand function is the Cobb-Douglas' sort which takes the form:

$$DMRICE = A_g . PRICE^{Eg} . INCOME_g^{Ng} \quad \ldots\ldots\ldots \quad (13)$$

where: DMRICEg is the quantity of demand by g^{th} economic class.

A_g is intercept

PRICE is the domestic market price of rice.

E_g is price elasticities of demand for rice of gth class.

INCOMEg is per capita incomes of g^{tl} class.

N_g is income elasticities of demand for g^{th} class.

A_g, E_g, and N_g are parameters that are estimated by the regression technique (Table 16 in Appendix).

In general, rice prices may be determined by demand and supply within the model through an iterative procedure to search for the price that clears domestic market. There will be no trade in this case. Alternatively, prices may be defined exogenously and fixed. The excess demand and supply in this case will be offset by imports and exports of rice, respectively. The consequence leaves the market price of rice invariably affected. The assumption of fixed price is not too unrealistic to the case of Indonesia, since BULOG attempts to stabilize the domestic price of rice.

The model assumes that incomes flow to the owners of resources and of rice output. There are four types of income in the model; labor income, rental income, farm income, and non-farm income. Five groups of population classes are also assumed, landless farmers, small farmers, large farmers, urban, and non-farm rural, each of which may receive income from one or more sources.

The labor income obtains from wage paid, and for each population group, YLg, is defined as:

$$YL_g = \sum_{i=1}^{8} \sum_{j=1}^{2} (A_{ij}.L_{ij}.h_{ij})\, W_j + \sum_{k=1}^{m} \sum_{j=1}^{2} (N_{kj}.C_{kj}.h_{kj})W_j \quad \ldots\ldots \quad (14)$$

where Wj is wages paid by j^{th} farm class.

The rental income is derived from the ownership of land. It is the product of rent paid to each land quality and the area of land that each class holds. The rental income for each population group, YRg, is as

$$YR_g = \sum_{i=1}^{8} \sum_{j=1}^{2} (A_{ij}.P_{ij}.R_{ij}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

where P_{ij} is the proportion of ith land quality used by j^{th} farm class.

R_{ij} is rent paid for land quality i by j^{th} farm class.

Farm income is the income from rice production. The farm income of population group g, YFg, is defined as:

$$YFg = P^d.Qg - TCg \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

where: P^d is palay prices

Qg is total production of gth group.

TCg is total cost of production of gth group, which consists of fertilizer, machine, rent, wage and other cost.

The non-rice income is exogenously determined. The total income of each population group, Yg, is

$$Yg = YLg + YRg + YFg + YOg \quad \ldots\ldots\ldots\ldots \quad (17)$$

where: YOg is non-rice income of gth group.

c. Foreign trade

Trade volumes are defined as the difference between domestic production and consumption of rice at a given period. If domestic consumption is greater than domestic production, it will be the case of imports and vice versa.

d. Policy instruments and costs

The current version includes policy instruments in four areas; fertilizer, irrigation, farm mechanization, and population control. Each policy instrument has associated it with a cost.

The fertilizer policy consists of two policy instruments. The first policy instrument is the fertilizer price. Its cost, the difference between world and local prices of fertilizer, is calculated by the model. The second instrument is the rate of growth in fertilizer availability. It is impossible to measure the cost of this policy instrument unless the policy procedure is known such as free fertilizer to farmers.

Two irrigation policy instruments are included in this model; new irrigation and rehabilitation. The new irrigation investment upgrades land from rainfed to different qualities of irrigated land, while the rehabilitation investment on the other hand improves the dry season irrigated land.

The policy instrument in the population program is the control of population growth rate. To blend the current rate to the target rate involves costs, and the greater the difference between the two rates leads to the greater cost of the population program.

The farm mechanization affects both yield and employment. For example, tractors decrease the use of family labor and increase the use of hired labor. The mechanization policies involves two policy variables; a direct subsidy on farm machinery and the rate of increase in the machinery numbers. The direct subsidy includes subsidy on capital cost and fuel price. It is easy to measure the policy costs of the first instrument, since it is a direct cost to the government.

Perhaps, the flowchart in Figure 2, shows the flow of prototype rice policy model, can provide a better understanding how the model works better. The equilibrium may be disturbed by a shift in demand or supply. An increase in income or population, or the combination of both, will raise domestic demand and price of rice. In the short-run, the excess demand will be offset by imports or the buffer stock of rice. In the medium-run, the equilibrium can be restored by encouraging an

intensive use of fertilizer, provided that irrigation and mechanization are well developed. In the long-run, rice output can be increased by implementing the sufficient fertilizer, irrigation, and farm mechanization policies, to accommodate the high domestic demand. The higher output implies higher rice income. Higher income will result in an increase in domestic demand and supply in the second round. The adjustment will continue until the equilibrium is achieved.

Suppose, the government implements the agricultural policies to improve the uses of fertilizer, irrigation, and machinery to increase domestic output through production and a disequilibrium price. The exports of rice surplus, however, will restore the equilibrium price. The incidence of higher output also leads to higher rice income and domestic demand of rice. Again, the higher demand will signalize higher price and output in the second round, and so on. The adjustment will stop when the equilibrium price is regained.

3. The Computer Program for the Model Calculation

The program is, initially written by Dr. J.P.G. Webster in a Microsoft basic*, stored in a series of chained program because it is too large to fit in the TRS-80 as a single program. The whole program consists of 12 segments each of which is identified by REM statement.

1. Set up initial data segment will initialize all data variables except those contained in the 'Policy Specification' segment.

2. Main program is designed to control the operation of the program in accordance with the choice of program operation (Figure 3).

3. Rice output segment will compute output of rice for a given amount of fertilizer and land qualities. The sequence of the computation is depicted in Figure 4.

4. Mechanization segment incorporates the effects of alternative mechanization policies on rice output and employment. The computational sequence appears in Figure 5.

5. Price formation segment calculates a market-clearing price for rice anc calculates the imports/exports needed to satisfy current demand at a given price. The sequence of computing market price of rice is shown in Figure 6.

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*Another version developed by Dr. R. W. Herdt and Ms. Linda Castillo is available in Agricultural Economics Department, IRRI, Los Banos, Laguna.

6. Income generation segment computes per capita incomes for each of the five population groups. Figure 7 shows the sequence of computation.

7. Data listing on screen segment provides information on the current status of the model variables.

8. Update resource segment changes the proportion of population groups, the areas of land, and the fertilizer supply in line with policy decisions. The sequence is shown in Figure 8.

9. Policy specification segment allows the user to enter rates of change of population, land areas, and fertilizer supplies, and the fertilizer price. The computing sequence is shown in Figure 9.

10. Computation of policy costs segment computes the matrix (POLCST) of policy costs.

11. Write headings segment will print policies and table headings for printed output.

12. Data listing on printer will print matrix per capita income showing sources of income (labor, rental, rice income, other income) and total income.

The program can be run either for one year or ten years simulation, since it is a year-by-year simulation program.

4. Data Collection and Assumptions

Publications of the Central Bureau of statistics, Indonesia, are the major sources of informations used in this study. Informations also obtain from many theses, dissertations, working papers, books, and statistics published by various international organizations. The collections in IRRI's main library and economic section of the Agricultural Engineering Department are primary facilities for searching the information. The computation of the study is primarily done in the economic section, agricultural engineering department, IRRI.

The strength of the prototype model is that its development bases on rice policies of the Asia's countries, in which provides a broader perspective on policy impacts. The disaggregation of the model requires a great deal of detailed information on resource allocation and income/output distribution. The unavailability of some details forces the study to impose assumptions as follows:

a. Total land and ownership

Total land is fixed and entirely used to grow rice in the wet season. The agricultural land consists of eight qualities each of which has different yield response to fertilizer applications as shown in table 14. The qualities 1 through 4 are wet season land while qualities five through eight are dry season land. Total land consists of large and small farms. Farms that are smaller than 3 hectares are classified as small farms, and any farms that are larger than 3 hectares are classified as large farms. Approximately 60 percent of the rice land in Indonesia are small farms, while only 55 percent of rice land in South Sulawesi are small farms. Small farms in West Java accounted for 61 percent of rice land. The technical and semitechnical land are identified as the best irrigated land, while the second best irrigated land is the moderate irrigated land. For Indonesia as a whole, approximately 50 percent of them are controlled by small farmers and the other 50 percent belongs to large farmers. The small farmers in South Sulawesi and West Java control only 45 percent of the irrigated land. The large farmers control the good rainfed land more than the small farmers, but the small farmers control this type of land in the second season more than the large farmers.

About 40 percent of small farm land in Indonesia and West Java are owned by smaller farmers. Large farmers own 75 percent of the large farm land and 35 percent of the small farm land. The rural non-farm and urban class own the rest of the farm land. For South Sulawesi, small farmers own about 50 percent of small farm land, while large farmers own about 80 percent of the large farm land and 25 percent of the small farm land. The rest of farm land belongs to the rural non-farm and urban class.

b. Rent and other cost of production

According to Saefuddin's estimation, average land rent for the wet season of West Java is 105,332 Rp/ha or 878 kg/ha, and the rent of the dry season is 107,340 Rp/ha or 894 Rp/ha. They are assumed to be the rent of good rainfed land which is 10 and 5 percent lower than the rent of best and moderate irrigated land, respectively. The poor rainfed land is about 25 percent lower than good rainfed land. Rents in South Sulawesi and Indonesia as a whole are assumed to be lower than that of the West Java. For simplicity, there is no rent descrimination.

Other costs of rice production are obtained from publications of Central Bureau of Statistics in 1979 named production of food crop in Indonesia. The other cost of production in Indonesia is about 4286 Rp/ha or 36 kg/ha; in West Java is 5642 Rp/ha or 47 kg/ha; in South Sulawesi is 4767 Rp/ha or 40 kg/ha. The other costs of production in the dry season is 5 percent higher than that of the wet season. The better quality of land leads to low cost, and large farmers have higher cost than small farmers (Table 16 in Appendix).

c. Labor requirement

Average labor requirement for wet and dry seasons in West Java are 153 and 134 manday per hectare, respectively (Saefuddin, 1983). They are assumed to be the labor requirements of the moderate irrigated land, and requirements of other soil type are shown in Table 17. The labor requirements of large farms are assumed to be 5% smaller than that of the small farms due to the economy of scale. Higher population density always associates with higher labor requirements per hectare.

Labor requirements in the prototype model consist of hired and family labor. Different farm sizes require different proportions of hired and family labor. In general, the large farms have higher proportion of hired labor than small farm. The proportion of hired labor is fixed over the simulation periods.

d. Economic class and demand function

Changes in total and proportion of each population group will affect demand for rice size each of which has different preference as shown in Table 18. The model divides population into five categories; landless, small farmers, large farmers, rural non-farms, and urban. The first three, classified as farmer class, are both rice producers and consumers but the last two are rice consumers. The prototype model also takes the rural migration to urban into consideration by assuming that the percentage of urban population in the total increases by 1.5 percent a year. Furthermore, the percentage of large farmers, small farmers and landless in the total each is assumed to decline by 0.3 percent per year while the percentage of rural non-farm population in the total declines by 0.4 percent a year.

Landless and small farmers accounted for more than 40 percent of the total population while it is only 12 percent for the large farmers. The rural non-farm has 11 percent share in the total population but the urban has 31 percent.

Empirical Analyses

The easiest method to determine the impacts of farm mechanization is to simulate the model with and without mechanization by holding other policies constant. The difference of the two simulations will be the impacts of mechanization. In this study, we hold the policies on population, fertilizer, and land constant study, (see Table 21 and 22 Appendix). To achieve the study's objectives, the IRRI Rice Policy Model will be used to simulate for three cases; Indonesia, South Sulawesi, and West Java. Table 21 to 26 are the computer print-outs of given policies and simulated results. The first part of these tables shows the policy summary on population, fertilizer, land, and

mechanization, while values of the output variables over the ten years of the simulation appear in the second part. Empirical analysis consists of three cases as follows:

(1) Indonesia as a whole

With the given set of policies and agricultural conditions, rice output increases at increasing rates even without the implementation of mechanization policies. The law of diminishing return, however, has taken place since the sixth year of the simulation. This is because the service life of mini tractor and power tiller has only six years span. Since domestic demand increases faster than domestic supply, Indonesia has to import more than five million tons of rice in the first year of the base run. The achievement of self-sufficiency in rice consumption, however, finally arrives after the fifth year. Indonesia has almost two million tons of rice surplus by the fifth year, and the surpluses have increasing trends afterwards (Table 21 in Appendix). Per capita incomes of all economic classes increase, but the incomes are unequally distributed. Incomes of the landless farmers have the slowest increasing trends because they own no rice field. Furthermore, the wage rates in the model are exogenously determined and fixed throughout the simulation. On the contrary, per capita incomes of small and large farmers have a very fast increasing trends since they own the majority of rice land and farm machinery. Even though the urban class owns more rice land than the rural non-farm class, the increasing trends of their per capita incomes are almost identical. This is because the migration of population from rural areas to urban is incorporated into the model. Total employment increases very fast during the first seventh years and slows down afterward. Hired labor has the same pattern of changing trends. The slow increase in employment after the seventh year also causes incomes of landless farmers to remain almost the same. The policy costs to the government have a large decline after the sixth year, and rise slowly since then (Table 21 in Appendix).

Presently, Indonesian government gives subsidies on the purchase of small tractors and on fuel prices. Only power tillers and small tractors are currently subsidized. With the given numbers and projected growth rates of various farm machines in Table 22, the trend values of rice output are higher than that of the case without mechanization by averaging a little more than six million tons a year, or almost 2 percent higher. The increase leads to a faster achievement of self-sufficiency in rice consumption. With farm mechanization, Indonesia achieves the self-sufficiency in the third year of the base run, instead of the sixty year as in the preceeding case. Furthermore, the higher output also implies higher yield and crop intensity because total land is fixed.

Farm mechanization improves incomes but worsens the income distribution. As fas as per capita incomes are concerned, the trend values of urban and rural non-farm groups remain unchanged because they own no farm machine. The trend values of landless' per capita incomes more or less remain the same. On the other hand, the trend values of small and large farmers' per capita incomes increase by averaging 763 and 2,900 Rupiahs a year, respectively. That is, income distribution has a bias toward small and large farmers.

Trend values of both total employment and hired labor employment are lower than that of the case without mechanization. The former declines by averaging 6.87 percent a year but the latter increases by averaging only 408 percent annually. As a result, the percentage of hired labor to total labor (employment) increases averaging almost 2 percent a year. It implies that farm machinery displaces family labor more than hired labor. The subsidies on mechanization also create higher policy costs to the government by averaging 142 million Rupiahs a year, but the policy-cost ratios are lower than the case without mechanization by 4,260 Rupiahs per ton of rice, or 13.41 percent reduction. Therefore, mechanization reduces policy cost per unit output. The mechanization lowers the labor-output ratio averaging 6.1, or 19 percent a year. In other words, each ton of rice produced uses 6.1 mandays less than the case without mechanization. It implies higher labor production as well.

(2) South Sulawesi

Table 23 shows that the cost of population policy in South Sulawesi is zero, because the current and target ratio are identical. With the given population growth and the absence of mechanization, rice output increases at increasing rates until the seventh year; and the province enables to supply almost two million tons of its output in the first year of the base run to the rice shortage areas in Indonesia. Per capita incomes of all eocnomic classes have increasing tends, but incomes of small and large farmers increse at higher proportion than the rest. Total employment and employment of hired labor have increasing trends. Policy costs to the government, on the other hand, have the decreasing trends and have a big drop after sixth year. Farm mechanization increases rice output and trade volumes averaging 6.8 and 12.5 percent a year, respectively, but it has no effect on per capita incomes of urban and rural non-farm groups. Little effect appears on the per capita incomes of the landless farmers. Alternatively, per capita incomes of large and small farmers increase averaging 3.4 and 2.58 percent, respectively. Unlike the case of Indonesia as a whole, farm machines displaces the hired labor more than the family labor, since the employment of hired labor falls by 2.1 percent but the total employment declines only 1.1 percent. The consequence also leads to higher labor-output ratios which implies higher labor productivities (see Table 28).

(3) West Java

In general, pattern changes of simulated values of West Java are similar to that of South Sulawesi and Indonesia as a whole except the trend values of policy costs. Even though the policy costs of West Java have rising trend, its policy cost-output ratios are lower than two preceeding cases. This is because rice output in West Java increases at incresing rates throughout the simulation period. Farm mechanization raises total output and surplus by 1.08 and 1.04 million tons, respectively. Per capita incomes of small and large farmers increase more than other income groups (Table 26). Family and hired labor are equally displaced by the mechanization. The higher labor-output ratios implies higher labor productivities.

The simulation output of rice production, total employment, trade, labor-output ratios, and policy cost-ratios, are plotted in Figure 10, 11, 12, 13 and 14, respectively. According to Figure 10, farm mechanization has very little effects on rice production of Indonesia as a whole. On the other hand, effects on employment in South Sulawesi and West Java are small, but greater effects appear in the case of Indonesia as a whole. Farm mechanization significantly improves Indonesia's foreign trade and leads to higher inter-provincial trade. West Java supplies rice surplus to the shortage areas more than South Sulawesi (Figure 12). Unlike the cases of South Sulawesi and Indonesia, the policy cost-output ratios of West Java gradually falls (Figure 13). Finally, Figure 14 shows that labor-output ratios of South Sulawesi are lower than that of West Java. It implies that labor productivities in the former are higher than that in the latter. However, the case of Indonesia as a whole has the lowest labor-output ratios and the highest labor productivity.

Conclusions and Remarks

This study employs the prototype model to evaluate impacts of population and agricultural development policies on rice production, employment, trade, incomes and income distribution of Indonesia. The study consists of three cases; Indonesia, South Sulawesi, and West Java. Their empirical results have similar trend values. With given economic policies on population, fertilizer, and irrigation, farm mechanization increases total rice output and yields. The increase improves Indonesia's foreign trade and leads to a faster achievement of self-sufficiency in rice consumption. Furthermore, higher outputs of South Sulawesi and West Java also enlarge the inter-provincial trade, since both provinces can provide more surpluses to rice shortage areas in Indonesia. Higher output leads to higher rice incomes, but the income distribution has a bias toward employment of both family and hired labor. Both types of labor are equally displaced by the implementation of farm machines, but it displaces hired labor more than family labor in South Sulawesi. In the case of Indonesia, family labor

are displaced more than hired labor. However, labor productivities improve, since the labor-output ratios are lower when mechanization is implemented. Mechanization has the largest effects on labor productivities in the case of Indonesia as a whole. Labor productivities of South Sulawesi are higher than that of West Java. As far as policy cost-output ratios are concerned, the case of West Java has the lowest trend values and South Sulawesi has the highest ratios.

In general, policy recommendation base on the national goals. Suppose that high yield varieties, fertilizer uses, and irrigation system are well adopted. If self-sufficiency in rice consumption is the primary concern, Indonesian government should subsidize four-wheel tractors, hand sprayers, and power threshers. Tractorization enables farmers to prepare in time for the second crops, while hand sprayers and power thresher will improve production's efficiencies. This measure, however, creates higher unemployment in the agricultural sector. If the displaced farm labor can find jobs in other sectors/industries, this policy is desirable. Given this, total output should be increased through West Java, because its policy cost per unit output is lower than South Sulawesi. Alternatively, if the primary concern focusses on only well-being of landless farmers, the government should subsidize on the hand sprayers since employment increase and relative income of landless to small and large farmers improved.

Bear in mind that the conclusions in this study are based on results computed from the model with a priori built-in restrictions/assumptions. In addition to insufficient datas, the fixed wage rates and fixed proportion of owners on land and machinery may mislead the conclusions on incomes and income distribution. The model, however, can be improved in many ways, e.g., incorporating a mechanism into the model to determine wage rates and ownership. The substitution between machineries and labor should be endogenously determined by relative prices of capital and labor. Nevertheless, the model provides broader perspectives on policy impacts and is realistic, since its development bases on the existing agricultural policies in Asian countries.

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Table 1. Percentage distribution of gross domestic product (GDP) at current market price by industrial origin.

Sector	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1. Agriculture, livestock, forestry and fishery	44.8	40.2	40.1	32.7	31.7	31.1	31.1	30.5	29.8	28.7
a. Farm food crops	26.2	23.5	23.3	19.6	20.2	19.7	19.3	18.2	17.5	16.8
b. Farm non food crops	5.3	5.0	4.8	3.6	2.8	3.1	4.0	3.6	3.6	3.5
c. Estate crops	2.9	2.6	2.2	1.7	1.5	1.4	1.7	1.8	2.0	2.0
d. Livestock and products	3.4	3.0	2.6	2.1	2.4	2.2	1.6	2.1	1.8	1.7
e. Forestry	3.9	3.8	5.3	3.9	3.3	3.3	2.8	3.0	3.1	3.0
f. Land and marine fishery	3.1	2.4	1.9	1.7	1.5	1.4	1.7	1.8	1.8	1.7
2. Mining and qurrying	8.0	10.8	12.3	22.2	19.7	18.9	18.5	17.6	16.9	15.3
3. Manufacturing industries	8.4	8.0	9.6	8.3	8.9	9.4	9.5	9.9	9.2	10.1
4. Electricity, gas and water supply	0.5	0.4	0.6	0.5	0.5	0.6	0.6	0.5	0.4	0.4
5. Construction	3.5	3.8	3.9	3.8	4.7	5.3	5.4	5.7	6.0	6.1
6. Wholesale and retail trade	16.1	16.8	16.5	16.6	16.6	16.5	18.1	15.7	18.3	18.4
7. Transport and communication	4.4	4.0	3.8	4.1	4.1	4.3	5.2	4.5	4.5	4.6
8. Other financial intermed	1.2	1.2	1.2	1.1	1.2	1.3	1.2	1.8	2.1	2.3
9. Services	4.9	4.3	3.9	3.5	3.7	3.5	3.2	3.0	2.7	2.9
10. Others	8.1	8.6	8.1	7.3	8.9	9.0	10.2	10.7	10.1	11.2
Total (%)	100	100	100	100	100	100	100	100	100	100
(Rp. billion)	3,672	4,564	6,753	10,708	12,643	15,467	19,011	21,967	30,661	43,765

Source: Central Bureau of Statistic (CBS), Statistical Pocketbook of Indonesia, various years 1975-80.

Asian Development Bank, Key Indicators, various issues.

Table 2. Food and calories balance sheet of slected food consumption, Indonesia, 1968-1978.

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Annual per capita food consumption (kilograms/capita/year)											
1. Rice	96.5	106.0	108.6	108.0	108.3	118.0	115.6	114.2	116.2	120.9	123.4
2. Cassava	64.5	56.5	51.2	47.9	48.1	56.6	59.0	60.8	76.0	75.7	74.0
3. Corn	26.2	17.4	20.8	18.7	16.7	26.5	20.7	20.6	18.3	21.5	27.2
4. Sweet potatoes	19.1	17.9	16.9	16.7	15.3	17.2	17.4	16.8	16.0	16.2	13.4
5. Wheat	3.3	2.6	3.5	4.7	3.0	3.6	4.9	4.0	5.1	4.0	4.1
Average calories from selected food (10^3 Kcal/cap/year)											
1. Rice	359	388	399	403	395	432	425	414	432	450	460
2. Corn	99	67	81	74	67	99	81	81	64	78	102
3. Cassava	64	55	50	47	47	56	58	60	78	76	74
4. Sweet potatoes	18	17	16	16	14	16	16	16	15	15	12
5. Wheat flour	10	10	10	14	10	14	18	14	18	14	14
Total starchy staples	550	537	556	554	533	617	598	598	607	633	662
Rice as percentage of starcy staples	65	72	72	73	74	70	71	69	71	71	69

Sources: Central Bureau of Statistics, Food Balance Sheet of Indonesia, 1968/77, 1979.
Central Bureau of Statistics, Food Balance Sheet of Indonesia, 1978, 1980.

Table 3. Total and distribution of population and labor force in Indonesia, 1971-78.

Year	Indonesia's population			Labor force			
	Total numbers (million)	Growth rates (%)	Percentage in agriculture	Total number (million)	Percentage in agriculture	Percentage in manufacture[a]	Percentage in other sectors[a]
1971	118.8		65.1	42.2	63.2	7.5	29.3
1972	121.61	2.36	64.5				
1973	124.4	2.30	63.8				
1974	127.3	2.33	63.0				
1975	130.3	2.36	62.5	47.0	62.3	8.2	29.5
1976	133.3	2.30	61.4	47.9	61.5	8.4	30.1
1977	136.3	2.25	61.3	49.1	61.4	8.6	30.0
1978	139.6	2.42	60.5	50.3	60.9	7.5	31.6
1979	142.9	2.36	60.1	50.6	60.5		
1980	146.0	2.17	58.5	51.8	59.6		
1981	149.08	2.11	56.6	52.9	59.1		

Source: CBS, Statistical Pocketbook of Indonesia, various years.
FAO, Production yearbook, various years.

[a] ADB, Key Indicators, various years.

Table 4. Domestic rice production, quantity and share of rice imports to domestic consumption, Indonesia, 1961-1980.

Year	Production		Imports	
	Quantity (million tons) (1)	Percentage change (million tons) (2)	Quantity (million tons) (3)	Percentage to domestic consumption (4)
1961	9.58		1.06	11
1962	10.28	7.3	1.02	10
1963	9.16	-10.9	1.04	11
1965	10.24	6.6	0.20	2
1966	10.75	5.0	0.31	3
1967	10.40	-3.2	0.35	4
1968	11.67	12.2	0.63	6
1969	12.25	5.0	0.60	5
1970	13.14	7.3	0.96	8
1971	13.72	4.4	0.49	4
1972	13.18	-3.9	0.73	6
1973	14.61	10.8	1.66	11
1974	15.28	4.6	1.07	7
1975	15.18	-0.6	0.67	5
1976	15.84	4.3	1.28	8
1977	15.88	0.2	1.96	12
1978	17.52	10.3	1.85	11
1979	17.87	2.0	1.95	10
1980	20.25	13.3	2.05	10

Source: Central Bureau of Statistics, Indonesia, Statistical Pocketbook of Indonesia, various years.

Table 5. Total population and density by selected provinces, Indonesia, 1971-1981.

Year	Total population			Percentage to total population[a]		Population density[a]		
	Indonesia	S. Sulawesi	W. Java	S. Sulawesi	W. Java	Indonesia	S. Sulawesi	W. Java
	(thousand persons)			(percentages)		(persons per km^2)		
1971	118,810	5,158	21,436	4.34	18.04	59	70	463
1972	121,550	5,247	22,015	4.32	18.11	60	72	475
1973	124,400	5,338	22,604	4.29	18.17	61	73	488
1974	127,310	5,430	23,219	4.26	18.24	63	75	501
1975	130,290	5,524	23,846	4.24	18.30	64	76	515
1976	133,340	5,620	24,490	4.21	18.37	66	77	529
1977	136,460	5,717	25,151	4.19	18.43	67	78	543
1979	142,920	5,916	26,528	4.16	18.49	69	80	558
1980	145,000	6,019	27,244	4.14	18.56	71	81	573
1981	149,080	6,121	27,988	4.10	18.77	74	84	604
Average population growth	2.31	1.72	2.69					

Source: Population 1971-81 was interpolated using census 197 and 1981 from CBS.

Notes: [a] Calculation.

Table 6. Utilization of net harvested wetland of paddy, and wetland paddy production, Indonesia, 1970-1976.

Year	% of harvested wetland area to total harvested paddy area			% of harvested wetland to total wetland		% of irrigated paddy area to total harvested paddy area			% of wetland paddy production to total paddy production		
	Indonesia (1)	S. Sulawesi (2)	W. Java (3)	S. Sulawesi (4)	W. Java (5)	Indonesia (6)	S. Sulawesi (7)	W. Java (8)	Indonesia (9)	S. Sulawesi (10)	W. Java (11)
1970	81.6	90.3	88.7	89.0	79.5	NA	NA	NA	91.3	96.0	94.7
1971	82.8	92.0	89.0	92.3	85.4	45.36	48.47	55.20	92.1	96.3	95.5
1972	83.6	74.1	90.5	66.6	84.3	NA	NA	NA	92.3	97.6	95.4
1973	84.0	92.4	91.4	84.1	93.0	NA	NA	NA	92.2	96.5	96.2
1974	86.3	95.0	93.2	81.6	95.1	49.08	54.00	55.93	93.7	97.8	96.9
1975	86.3	96.3	94.2	95.8	95.2	NA	NA	NA	93.4	98.0	97.2
1976	86.4	95.8	94.3	92.8	91.9	66.55	63.94	61.39	93.6	98.1	97.4

Sources: Central of Bureau of Statistics, Statistical Pocketbook of Indonesia, and also in A. Lains, Regional Concentration in Expansion of Rice Production in Indonesia, 1978.

Table 7. Total areas and expenditures on irrigation development during three economic development plans, Indonesia, 1969/70 - 1983/84.

Years	Type of development				Expenditures on development				
	Rehabilitation	Expansion	River/flood control	Swamp/tidal development	Rehabilitation	Expansion	River flood control	Swamp/tidal development	Total expenditure
	hectares				billion rupiah				
Pepelita I	953,546	191,246	248,585	178,666	50.0	25.0	6.3	33.1	114.4
1969/70	230,330	43,153	73,259	21,059	7.6	5.3	1.9	5.8	20.7
1970/71	171,549	24,379	62,406	25,000	7.9	4.6	0.9	6.3	19.7
1971/72	135,754	46,400	57,045	14,905	9.2	4.7	0.9	6.5	21.3
1972/73	172,444	45,834	55,875	61,562	11.0	5.4	1.4	7.0	24.8
1973/74	263,469	31,480	40,858	56,140	14.3	5.0	1.2	7.4	27.9
Pepelita II	526,769	273,198	-	272,034	144	195.7	196.7	-	546.6
1974/75	108,956	20,684	71,124	8,154	10.7	14.3	10.1	-	36.2
1975/76	105,143	88,522	97,688	51,134	16.8	26.1	36.8	-	81.8
1976/77	112,011	63,435	16,248	55,549	26.5	36.2	37.6	-	102.3
1977/78	112,015	41,157	n.a.	62,099	36.2	50.2	46.8	-	135.6
1978/79	88,644	59,400	n.a.	95,098	53.7	68.8	65.4	-	190.8
Sub-total	1,480,315	464,444	433,645	450,700	194.0	200.7	103.0	-	661.0
Pepelita III (1979/80-1983/84) Target	813,865	766,140	-	535,000					
Grand total	2,294,180	1,230,584	433,645	985,700	194.0	220.7	103.0	-	661.0

Source: Indonesia, Directorate General of Water Resources Development, also in Status and Performance of Irrigation in Indonesia and the Prospects to 1990 and 2000, by Albert J. Nyberg and Dibyo Prabowo, 1982.

Table 8. Distribution of areas, production, and yield of paddy in Indonesia, 1971-1981.

Year	Net harvested areas of paddy			Total production in Indonesia	Percentage to total production in Indonesia		Yield of paddy		
	Indonesia	S. Sulawesi	W. Java		S. Sulawesi	W. Java	Indonesia	S. Sulawesi	W. Java
	thousand hectares			1,000 tons	percentage		ton per hectare		
1971	8,324	524	1,772	21,392	7.0	22.0	2.57	2.93	2.66
1972	7,898	468	1,718	20,357	5.5	22.2	2.58	2.95	2.60
1973	8,404	475	1,878	21,091	6.8	23.4	2.51	3.10	2.71
1974	8,508	446	1,885	22,464	5.9	23.3	2.64	2.98	2.77
1975	8,495	519	1,864	22,331	7.1	23.9	2.63	3.07	2.86
1976	8,364	505	1,803	23,301	6.6	23.6	2.79	2.76	3.05
1977	8,388	524	1,751	23,347	6.0	21.7	2.79	2.66	2.89
1978	8,629	535	1,800	25,772	5.9	22.3	2.99	2.82	3.03
1979	8,849	550	1,866	26,350	6.2	22.2	2.98	2.75	3.14
1980	8,999	560	1,897	26,998	6.3	22.3	3.00	2.80	3.25
1981	9,207	575	1,920	28,330	6.4	22.4	3.08	2.84	3.28

Sources: Central Bureau of Statistics, Indonesia, Statistical Yearbook of Indonesia, various years.
Central Bureau of Statistics, Production Food Crops in Indonesia, various years.
Central Bureau of Statistics, Statistical Pocketbook of Indonesia, various years.

IRRI, World Rice Statistics, various years.

Table 9. Crude milled rice surplus or deficit of selected provinces in Indonesia, 1976.

	Jakarta	W. Java	Central Java	E. Java	N. Sumatra	S. Sumatra	S. Sulawesi	Indonesia
Net rice production (000 tons)	19	3,333	2,259	2,701	892	442	833	14,121
Midyear population (000 persons)								
Rural	0	21,451	21,084	23,391	6,189	2,928	4,599	110,287
Urban	5,940	3,039	2,534	3,961	1,281	1,083	1,021	23,054
Total	5,490	24,490	23,618	27,352	7,470	4,011	5,620	133,340
Average consumption (kg/cap/yr)								
Rural	0	145	91	77	145	144	123	114.2
Urban	112	119	101	98	115	154	134	115.3
Total	112	142	92	80	138	146	125	114.4
Consumption requirements from SUSENAS (000 tons)								
Rural	0	3,110	1,919	1,801	897	421	566	12,595
Urban	615	362	256	388	147	167	146	2,658
Total	615	3,472	2,175	2,189	1,044	588	712	15,253
Net Surplus (+) or deficit (-) (000 tons)								
conversion*	-596	-139	+84	+512	-152	-146	+121	-1,132
conversion**	-596	-26	+156	+599	-123	-132	+151	-679
Net deficit using disappearance (000 tons)								
conversion*								-1,746
conversion**								-1,196

Source: Leon A. Mears, The New Rice Economy of Indonesia, 1981, page 493.

Notes: *Conversion 0.5042 stalk paddy to milled rice.
**Conversion 0.52 stalk paddy to milled rice.

Table 10. Inter-provincial shipments of river by BULOG and Authorized Private Firms, Indonesia, 1978.

Provinces of origins	Organizations	Provinces of Destination											
		W. Java	E. Nusa	Yogyakarta	S. Sumatra	Other Sumatra	West Kalimantan	East Kalimantan	Maluku	Sulawesi	Jambi	Others	Total
		(tons)											
Jakarta	Bulog	40,000	500	-	-	3,200	2,950	-		-	18,075	5,000	69,725
	Private Co.	-	-	-	8,500	-	7,650		55	-	-	3,502	19,707
													89,432
Central Java	Bulog	-	-	12,000	-	-	7,550	-	-	-	-	5,000	24,550
	Private Co.	-	-	-	2,000	-	14,500	-	-	-	-	5,500	22,000
													46,550
East Java	Bulog	-	24,025	24,000	5,000	-	-	2,000	2,000	750	-	20,100	77,875
	Private Co.	-	1,000	-	6,000	1,000	3,500	4,500	5,500	11,500	-	1,075	34,075
													111,950
North Sulawesi	Bulog	-	-	-	-	-	-	-	10,500	18,500	-	-	29,000
	Private Co.	-	-	-	-	-	-	-	-	-	-	-	-
													29,000
South Sulawesi	Bulog	-	2,000	-	-	-	3,000	12,373	10,250	18,435	-	-	46,058
	Private Co.	-	-	-	-	-	-	-	-	-	-	-	-
													46,058
Bali	Bulog	-	7,400	-	2,050	-	-	4,863	-	-	-	12,400	26,713
	Private Co.	-	-	-	-	-	-	-	-	-	-	-	-
													26,713
Others	Bulog	-	7,053	-	-	-	-	3,800	-	-	-	14,875	25,728
	Private Co.	-	-	-	1,650	-	850	-	-	-	-	1,500	4,000
													29,728

Sources: BULOG, and also in Leon A. Mears, The New Rice Economy of Indonesia, 1981.

Table 11. Farm mechanization status in Indonesia, 1970-1978[a]

Types of farm machines	1970		1975		1978		Increased numbers during 1970-78	Annual growth rate 1970-78 (percent)	1983/84[b] projection (number)	Types of ownership in 1978[c]		
	Numbers	Density/ 1000/ha	Numbers	Density/ 1000/ha	Numbers	Density/ 1000/ha				Individual	Joint (percent)	Others
Power tillers	670	0.04	961	0.05	2,360	0.13	1,690	17	24,075	50	20	30
Small tractors (under 20 HP)	268	0.02	392	0.02	1,410	0.08	1,142	23	12,290	60	20	30
Large tractors (over 30 HP)	147	0.01	190	0.01	331	0.02	184	11	3,760	22	37	41
Manual weeders/ cultivators	1,632,000	92.83	1,825,000	103.81	2,141,000	121.79	509,000	3	NA	87	10	3
Power weeders/ cultivators	42	0.002	270	0.02	350	0.02	308	30	NA	64	12	24
Hand sprayers	166,930	9.50	199,875	11.76	301,605	17.16	134,675	8	465,990	39	42	19
Power sprayers	12,215	0.69	25,420	1.44	44,441	2.53	32,226	18	82,230	16	59	25
Manual dusters	687	0.04	723	0.04	905	0.05	218	4	NA	67	20	13
Power dusters/ mist blower	3,420	0.19	5,023	0.29	5,615	0.15	2,195	6	NA	83	15	2
Fertilizer applicator feeders	-	-	56	0.003	229	0.01	173	42	NA	62	10	28
Irrigation pump	2,015	0.12	2,732	0.16	3,424	0.19	1,409	7	5,340	20	70	10
Manual threshers	1,108	0.06	1,215	0.07	1,579	0.09	471	4	12,545	33	43	24
Power threshers	124	0.01	338	0.02	1,343	0.08	1,219	35	8,365	28	23	39
Grain dryers	46	0.003	176	0.01	375	0.02	329	30	5,475	4	19	17

Source: 1. Sub-directorate of Agricultural Mechanization, Directorate General, Food Crops Production Development, Ministry of Agriculture, also in Bodianto and Mulyoto, 1981.

2. Central Bureau of Statistics, Statistical Yearbook of Indonesia, 1980.

Notes: [a]Including all farm machines owned not only by farmers but also by cooperatives.

[b]Projected by the sub-directorate of Agricultural Mechanization, Directorate of Food Crop Production.

Table 12. Comparative statistical information on farm mechanization: Indonesia, South Sulawesi and West Java, 1978.

Types of farm machines	Indonesia		South Sulawesi		West Java	
	Number	Density per 1,000 ha	Number	Density per 1,000 ha	Number	Density per 1,000 ha
Power tillers	2,360	0.13	300	0.41	504	0.33
Small tractors	1,410	0.08	282	0.38	371	0.24
Large tractors	331	0.02	78	0.10	85	0.06
Hand sprayers	301,605	17.16	1,212	1.64	31,803	20.87
Irrigation pumps	3,424	0.19	174	0.24	283	0.18
Power threshers	1,343	0.08	210	0.28	531	0.35

Source: Sub-directorate of Agricultural Mechanization, Directorate General of Food Crops, Ministry of Agriculture, Jakarta.

Table 13. Estimated prices of some commodities in Jakarta market as of September 1981.

Price in Rupiahs Types of machine	Price in US$	= 631.25[a]	= 925[b]
Power tiller	3,600	2,272,500	3,330,000
Large tractor	19,200	12,120,000	17,760,000
Small tractor	9,100	5,744,375	8,417,500
Manual sprayers	80	50,500	74,000
Irrigation pump	400	252,500	370,000
Power threshers	600	387,750	555,000

Source: Estimation of J. Budianto and Mulyoto, "Indonesia", a paper in APO Symposium on Farm Mechanization, Tokyo, 1981.

Note: is the foreign exchange rate.

[a] the foreign exchange rate as of June 1981.

[b] the present foreign exchange rate.

Table 14. Coefficients of yield response function for fertilizer by land qualities, and seasons in South Sulawesi, West Java, Indonesia.

Coefficients and land qualities	Indonesia		South Sulawesi		West Java	
	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
Land quality 1.						
a_i	3613.48	3957.35	3812.9	4208.60	3887.7	4242.66
b_i	22.30	19.024	23.35	22.30	19.8	34.31
c_i	-0.056	-0.016	-0.072	-0.052	-0.06	-0.0421
Land quality 2.						
a_i	4193.05	3843.43	4260.0	3886.30	3508.6	4421.90
b_i	16.77	23.91	41.00	19.70	18.11	54.91
c_i	-0.016	-0.049	-0.30	-0.118	-0.03	-0.21
Land quality 3.						
a_i	3795.18	3836.49	3367.53	4045.01	4545.8	3759.19
b_i	22.79	13.99	14.42	19.90	16.53	18.66
c_i	-0.056	-0.038	-0.028	-0.059	-0.06	-0.05
Land quality 4.						
a_i	4100.82	2539.54	3393.18	2404.86	3058.6	2227.90
b_i	15.32	10.011	19.36	8.79	15.9	12.85
c_i	-0.022	-0.131	-0.04	-0.031	-0.05	-0.118

Source: A report in the Staff Meeting, May 29-30, 1972, Central Research Institute for Agriculture, Ministry of Agriculture.

Note: The grain yield of all experiments are made on the Alluvial soil.

Table 15. Rice land by land qualities and farm sizes of Indonesia, South Sulawesi and West Java.

Farm size and type of land	Indonesia		South Sulawesi		West Java	
	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
Total harvested land	8,849	4,248	572	275	1,866	896
Upland rice land	1,186	137	25	1	117	11
Rice land with assured water supply	5,681	2,743	282	231	1,164	521
Technical and semi-technical irrigated land	2,376	1,207	96	66	678	386
Moderate irrigated land[a]	2,100	1,101	77	66	328	135
Rainfed land	1,205	435	109	0	161	0
Small farmers - total	5,309	2,549	343	165	1,138	538
Best irrigated land	820	604	43	36	305	193
Moderate irrigated land	1,050	551	84	36	148	70
Good rainfed land	566	261	50	0	75	0
Poor rainfed land	712	100	20	1	70	11
Large farmers - total	3,540	1,699	229	110	728	358
Best irrigated land	820	603	53	30	373	193
Moderate irrigated land	1,050	550	102	30	180	65
Good rainfed land	639	174	59	0	86	0
Poor rainfed land	474	37	5	0	41	0

Source: Various publications of the Central Bureau of Statistics, Indonesia.
Nyberg and Prabowo, Status and Performance of Irrigation in Indonesia and the Prospects to 1990 and 2000, 1982.

Notes: [a]Moderate irrigated land includes simple and other irrigated land.

Table 16. Land rent and other cost of production, by land quality, and season, 1979.

Items	Indonesia		South Sulawesi		West Java	
	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
				(kg/ha)		
Land rent:						
Best irrigated land	957	968	955	967	966	983
Moderate irrigated land	910	924	911	923	922	939
Good rainfed	870	880	868	879	878	894
Poor rainfed	652	660	651	659	658	671
Other costs:						
Small farmers:						
Best irrigated land	32	34	36	39	42	44
Moderate irrigated land	34	36	38	40	45	47
Good rainfed land	36	38	40	42	47	49
Poor rainfed land	45	48	50	53	59	61
Large farmers:						
Best irrigated land	41	42	45	48	52	55
Moderate irrigated land	43	45	48	50	55	58
Good rainfed land	45	47	50	53	58	61
Poor rainfed land	56	59	63	66	73	76

Source: Central Bureau of Statistics, Product of Food Crops in Indonesia, 1979.

Table 17. Labor requirements by group, soil type, and season.

Items	Indonesia		South Sulawesi		West Java	
	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
	(mandays/ha)					
Large farmers:						
Best irrigated land	139	129	138	128	142	132
Moderate irrigated land	150	131	148	130	153	134
Good rainfed land	159	141	157	140	162	144
Poor rainfed land	173	155	172	153	177	158
Small farmers:						
Best irrigated land	146	136	145	135	149	139
Moderate irrigated land	158	138	156	137	161	141
Good rainfed land	167	148	165	146	170	151
Poor rainfed land	182	163	180	161	186	166

Source: Calculation.

Table 18. Population and coefficients of demand functions, prototype model.

Population	Population	Price elasticity	Income elasticity	Population	Price elasticity	Income	Population	Price elasticity	Income elasticity
	(10^6)			(10^6)			(10^6)		
Landless	37.2	-.33	.35	1.35	-.30	.37	7.56	-.3	.38
Small farmers	32.8	-.23	.30	1.28	-.20	.30	7.00	-.21	.30
Large farmers	14.9	-.22	.32	0.92	-.30	.32	2.80	-.23	.28
Urban	47.7	-.20	.23	1.90	-.21	.28	8.96	-.25	.29
Rural non-farm	16.4	-.30	.35	0.67	-.32	.25	2.52	-.30	.33

Table 19. Effects of mechanization on employment and yield, 1980.

Types of machine	Labor (manday/ha)				Yield (kg/ha)	
	Wet season		Dry season		Wet season	Dry season
	Family L.	Hired L.	Family L.	Hired L.		
Power tiller[a]	-11.1	+14.1	-11.1	+14.1	0	2,000
Small tractor[b]	-11.3	+ 7	-11.3	+ 7	0	2,000
Large tractor[a]	-11.7	+ 2.6	-11.7	+ 2.6	0	2,000
Irrigation pump[a]	+ 4.8	+ 7.2	+11.0	+17.0	+1520	+3,380
Manual sprayers[b]	+11	+11	+13	+13	+480	+480
Power thresher[b]	- 6	+ 4	- 6	+ 4	+ 40	+ 40

Note: [a] Herdt, R.W., and J. P. Webster, 1982. A Dynamic Framework for Analyzing Rice Policies (A draft).

[b] Estimation.

Table 20. Machinery capacity, ownership, and service life of machinery.

Item	Capacity (ha)		% of ownership		Life of machiner (yrs)
	Dry season	Wet season	Small farms	Large farms	
Power tiller[a]	10	8	.50	.50	6
Small tractor[a]	31	26	.45	.55	8
Large tractor[a]	92	88	0	1.00	10
Irrigation pump[b]	10	10	.30	.70	8
Hand sprayer[b]	15	15	.5	.5	4
Power thresher[b]	50	35	.4	.6	7

Note: [a] Herdt, R.W. and J.P. Webster, 1982. A Dynamic Framework for Analyzing Rice Policies. (A draft).

[b] Estimation.

Table 21 Absence of mechanization, Indonesia.

I.R.R.I. Rice Policy Model

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Policy summary:

-Population: present growth rate = 2.30%; growth rate in 10 years = 2.00%;
government cost = 0.05 million rupiahs per annum

-Fertilizer: starting supplies =602.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = %57095.00 rupiahs

-Land: depreciation rate = 5.00% pa;
rehabilitation rate =443000 ha pa, costing 131053 rupiahs per ha.
new irrigated land =289000 ha pa, costing 275939 rupiahs per ha.

-Mechanisation policies:

Power tiller
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

LARGE Tractor
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

MANUAL SPRAYERS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

Irrigation Pump 4pi
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

POWER THRESHER
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

MINI TRACTOR
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

Results summary:

Yr	Popln m.	Fert '000t	Yield m t	Export m t	- Per Capita incomes - LL	SF	LF	UR	RNF	Totlab million	HireLab mandays	GovtCost m.rupiahs
0	-	-	-	-	9900	25000	94000	100000	10000			-
1	149.00	602.00	29.54	-5.08	9913	32577	122878	101204	11090	1009.4	645.85	172174.00
2	152.38	632.10	31.65	-4.91	9913	35302	125345	101241	11208	1076.3	686.76	173893.00
3	155.80	663.71	33.97	-3.44	9914	37846	128881	101285	11348	1151.0	732.24	175697.00
4	159.24	696.89	36.45	-1.82	9915	40551	132651	101332	11508	1231.6	781.26	177592.00
5	162.71	731.73	39.09	-0.05	9915	43428	136576	101380	11693	1317.6	833.38	179581.00
6	166.21	768.32	41.86	1.85	9916	46432	140724	101428	11905	1408.4	888.36	181670.00
7	169.73	806.74	44.45	3.57	9917	49893	143631	101472	12137	1492.3	937.37	46060.70
8	173.28	847.07	44.78	3.03	9917	50078	144630	101405	12251	1492.8	937.63	48363.80
9	176.85	889.43	45.11	2.75	9917	50279	145713	101343	12386	1493.2	937.89	50781.90
10	180.44	933.90	45.46	2.48	9916	50514	146844	101284	12549	1493.7	938.14	53321.00

Table 22 Existing of Mechanization, Indonesia,

I.R.R.I. Rice Policy Model
****

Policy summary:

-Population: present growth rate = 2.30%; growth rate in 10 years = 2.00%;
government cost = 0.05 million rupiahs per annum

-Fertilizer: starting supplies =602.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = %57095.00 rupiahs

-Land: depreciation rate = 5.00% pa;
rehabilitation rate =443000 ha pa, costing 131053 rupiahs per ha.
new irrigated land =289000 ha pa, costing 275939 rupiahs per ha.

-Mechanisation policies:

Power tiller
numbers in use = 2,360 projected rate of increase = 15 %, subsidy per machine = 29542 rupiahs.

LARGE Tractor
numbers in use = 1,741 projected rate of increase = 7 %, subsidy per machine = 0 rupiahs.

MANUAL SPRAYERS
numbers in use =301,605 projected rate of increase = 16 %, subsidy per machine = 0 rupiahs.

Irrigation Pump 4pi
numbers in use = 10,000 projected rate of increase = 10 %, subsidy per machine = 0 rupiahs.

POWER THRESHER
numbers in use = 1,434 projected rate of increase = 12 %, subsidy per machine = 0 rupiahs.

MINI TRACTOR
numbers in use = 2,000 projected rate of increase = 21 %, subsidy per machine = 64677 rupiahs.

Results summary:

Yr	Popln	Fert	Yield	Export	- Per Capita incomes -					Totlab	HireLab	GovtCost
	m.	'000t	m t	m t	LL	SF	LF	UR	RNF	million	mandays	m.rupiahs
0	-	-	-	-	9900	25000	94000	100000	10000			-
1	149.00	602.00	33.10	-1.51	9912	32968	124349	101204	11090	965.5	628.37	172174.00
2	152.38	632.10	35.65	-0.97	9913	35748	127021	101241	11208	1025.3	666.74	173963.00
3	155.80	663.71	38.45	0.97	9913	38354	130793	101285	11348	1091.8	709.31	175781.00
4	159.24	696.89	41.48	3.14	9914	41131	134835	101332	11508	1163.0	754.97	177692.00
5	162.71	731.73	44.74	5.52	9915	44090	139075	101380	11693	1238.0	803.21	179701.00
6	166.21	768.32	48.21	8.12	9915	47188	143586	101428	11905	1316.1	853.73	181813.00
7	169.73	806.74	51.60	10.63	9916	50758	146914	101472	12137	1385.2	897.58	46231.50
8	173.28	847.07	52.84	10.99	9915	51068	148402	101405	12251	1368.6	891.90	48567.70
9	176.85	889.43	54.21	11.73	9915	51414	150052	101343	12386	1349.3	885.29	51025.70
10	180.44	933.90	55.74	12.62	9915	51815	151843	101284	12549	1326.8	877.60	53612.50

Table 23 Absence of Mechanization, South Sulawesi.

I.R.R.I. Rice Policy Model
****

Policy summary:
-Population: present growth rate = 1.70%; growth rate in 10 years = 1.70%;
government cost = 0.00 million rupiahs per annum
-Fertilizer: starting supplies =100.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = %95810.00 rupiahs
-Land: depreciation rate =10.00% pa;
rehabilitation rate = 30000 ha pa, costing 131053 rupiahs per ha.
new irrigated land = 50000 ha pa, costing 275939 rupiahs per ha.
-Mechanisation policies:

POWER TILLERS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

LARGE TRACTORS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

MANUAL SPRAYERS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

Irrigation Pump 4pi
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

POWER THRESHER
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

MINI TRACTOR
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

Results summary:

Yr	Popln m.	Fert '000t	Yield m t	Export m t	- Per Capita incomes - LL	SF	LF	UR	RNF	Totlab million	HireLab mandays	GovtCost m.rupiahs
0	-	-	-	-	7900	21000	90000	100000	10000	-	-	-
1	7.82	100.00	4.00	1.74	7957	36695	93555	105579	11228	125.9	83.62	27309.50
2	7.95	105.00	4.26	1.74	7960	38759	101398	105598	11333	132.2	87.95	27788.60
3	8.09	110.25	4.53	1.94	7963	40800	109187	105628	11448	139.1	92.62	28291.60
4	8.23	115.76	4.81	2.14	7966	42817	116957	105666	11573	146.4	97.62	28819.70
5	8.37	121.55	5.09	2.36	7969	44813	124731	105709	11710	154.1	102.92	29374.30
6	8.51	127.63	5.39	2.59	7973	46788	132526	105755	11858	162.3	108.51	29956.60
7	8.65	134.01	5.69	2.82	7977	48745	140357	105804	12019	170.9	114.38	12839.50
8	8.80	140.71	5.70	2.77	7977	48216	140691	105502	12056	171.0	114.46	13481.40
9	8.95	147.75	5.71	2.75	7977	47641	140844	105222	12097	171.1	114.53	14155.50
10	9.10	155.13	5.72	2.73	7977	47011	140764	104962	12142	171.3	114.60	14863.30

Table 24 Existence of Mechanization, South Sulawesi.

I.R.R.I. Rice Policy Model
****

Policy summary:
-Population: present growth rate = 1.70%; growth rate in 10 years = 1.70%;
government cost = 0.00 million rupiahs per annum
-Fertilizer: starting supplies =100.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = %95810.00 rupiahs
-Land: depreciation rate =10.00% pa;
rehabilitation rate = 30000 ha pa, costing 131053 rupiahs per ha.
new irrigated land = 50000 ha pa, costing 275939 rupiahs per ha.
-Mechanisation policies:
POWER TILLERS
numbers in use = 300 projected rate of increase = 15 %, subsidy per machine = 29542 rupiahs.
LARGE TRACTORS
numbers in use = 178 projected rate of increase = 7 %, subsidy per machine = 0 rupiahs.
MANUAL SPRAYERS
numbers in use = 1,212 projected rate of increase = 16 %, subsidy per machine = 0 rupiahs.
Irrigation Pump 4pi
numbers in use = 137 projected rate of increase = 10 %, subsidy per machine = 0 rupiahs.
POWER THRESHER
numbers in use = 220 projected rate of increase = 12 %, subsidy per machine = 0 rupiahs.
MINI TRACTOR
numbers in use = 400 projected rate of increase = 21 %, subsidy per machine = 64677 rupiahs.

Results summary:

Yr	Popln m.	Fert '000t	Yield m t	Export m t	- Per Capita incomes - LL	SF	LF	UR	RNF	Totlab million	HireLab mandays	GovtCost m.rupiahs
0	-	-	-	-	7900	21000	90000	100000	10000			-
1	7.82	100.00	4.19	1.93	7957	36810	104991	105579	11228	125.4	82.48	27309.50
2	7.95	105.00	4.47	1.92	7960	38884	112990	105598	11333	131.6	86.67	27802.00
3	8.09	110.25	4.77	2.15	7962	40935	120953	105628	11448	138.3	91.18	28307.70
4	8.23	115.76	5.08	2.39	7966	42962	128916	105666	11573	145.5	95.99	28839.00
5	8.37	121.55	5.40	2.64	7969	44968	136904	105709	11710	153.2	101.07	29397.40
6	8.51	127.63	5.74	2.91	7972	46953	144936	105755	11858	161.2	106.42	29984.20
7	8.65	134.01	6.09	3.19	7976	48920	153030	105804	12019	169.6	112.01	12872.60
8	8.80	140.71	6.16	3.19	7976	48401	153654	105502	12056	169.6	111.76	13521.20
9	8.95	147.75	6.23	3.24	7976	47835	154127	105222	12097	169.5	111.47	14203.20
10	9.10	155.13	6.31	3.30	7976	47212	154403	104962	12142	169.4	111.11	14920.60

Table 25 Absence of Mechanization, West Java.

I.R.R.I. Rice Policy Model
****

Policy summary:

-Population: present growth rate = 2.60%; growth rate in 10 years = 2.00%;
government cost = 0.38 million rupiahs per annum

-Fertilizer: starting supplies =346.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = %95050.00 rupiahs

-Land: depreciation rate =10.00% pa;
rehabilitation rate = 50000 ha pa, costing 131053 rupiahs per ha.
new irrigated land = 42000 ha pa, costing 275939 rupiahs per ha.

-Mechanisation policies:

POWER TILLERS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

LARGE TRACTORS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

MANUAL SPRAYERS
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

Irrigtion ump 4pi
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

POWER THRESHER
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

MINI TRACTOR
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 rupiahs.

Results summary:

Yr	Popln m.	Fert '000t	Yield m t	Export m t	- Per Capita incomes - LL	SF	LF	UR	RNF	Totlab million	HireLab mandays	GovtCost m.rupiahs
0	-	-	-	-	8100	21000	91000	99500	10000	-	-	-
1	31.39	346.00	12.06	2.59	8126	40653	88390	104056	11819	397.5	290.62	51029.80
2	32.19	363.30	12.43	2.00	8127	41192	91497	103906	11924	408.1	298.58	52674.10
3	32.99	381.46	12.82	2.15	8127	41755	94780	103768	12044	419.1	306.84	54400.70
4	33.78	400.54	13.22	2.30	8127	42342	98220	103641	12182	430.5	315.36	56213.60
5	34.58	420.57	13.62	2.47	8127	42951	101810	103524	12342	442.3	324.16	58117.20
6	35.38	441.59	14.04	2.64	8128	43578	105549	103416	12528	454.4	333.22	60115.90
7	36.17	463.67	14.46	2.83	8128	44223	109439	103316	12748	466.8	342.54	62214.60
8	36.96	486.86	14.89	3.03	8129	44882	113487	103224	13011	479.7	352.12	64418.20
9	37.74	511.20	15.33	3.24	8129	45556	117700	103140	13330	492.9	361.97	66732.00
10	38.52	536.76	15.78	3.46	8129	46241	122088	103062	13724	506.4	372.09	69161.50

Table 26 Existence of Mechanization, West Java.

I.R.R.I. Rice Policy Model
****

Policy summary:

-Population: present growth rate = 2.60%; growth rate in 10 years = 2.00%;
government cost = 0.38 million rupiahs per annum

-Fertilizer: starting supplies =346.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = %95050.00 rupiahs

-Land: depreciation rate =10.00% pa;
rehabilitation rate = 50000 ha pa, costing 131053 rupiahs per ha.
new irrigated land = 42000 ha pa, costing 275939 rupiahs per ha.

-Mechanisation policies:

POWER TILLERS
numbers in use = 804 projected rate of increase = 15 %, subsidy per machine = 29542 rupiahs.

LARGE TRACTORS
numbers in use = 285 projected rate of increase = 7 %, subsidy per machine = 0 rupiahs.

MANUAL SPRAYERS
numbers in use = 31,803 projected rate of increase = 16 %, subsidy per machine = 0 rupiahs.

Irrigtion ump 4pi
numbers in use = 283 projected rate of increase = 10 %, subsidy per machine = 0 rupiahs.

POWER THRESHER
numbers in use = 531 projected rate of increase = 12 %, subsidy per machine = 0 rupiahs.

MINI TRACTOR
numbers in use = 930 projected rate of increase = 21 %, subsidy per machine = 64677 rupiahs.

Results summary:

Yr	Popln m.	Fert '000t	Yield m t	Export m t	- Per Capita incomes - LL	SF	LF	UR	RNF	Totlab million	HireLab mandays	GovtCost m.rupiahs
0	-	-	-	-	8100	21000	91000	99500	10000			-
1	31.39	346.00	12.63	3.16	8126	40851	99879	104056	11819	394.5	287.32	51029.80
2	32.19	363.30	13.08	2.60	8126	41415	103182	103906	11924	404.6	294.83	52704.30
3	32.99	381.46	13.55	2.83	8127	42006	106688	103768	12044	415.0	302.57	54436.80
4	33.78	400.54	14.04	3.08	8127	42625	110384	103641	12182	425.7	310.50	56256.70
5	34.58	420.57	14.56	3.36	8127	43271	114270	103524	12342	436.7	318.62	58168.80
6	35.38	441.59	15.11	3.67	8127	43940	118350	103416	12528	447.8	326.90	60177.60
7	36.17	463.67	15.69	4.01	8128	44633	122635	103316	12748	459.2	335.32	62288.50
8	36.96	486.86	16.29	4.38	8128	45347	127140	103224	13011	470.8	343.88	64506.70
9	37.74	511.20	16.93	4.78	8128	46083	131883	103140	13330	482.5	352.54	66838.00
10	38.52	536.76	17.61	5.23	8129	46841	136889	103062	13724	494.4	361.31	69288.60

Table 27. Impacts of mechanization on policy costs-output ratios of Indonesia, South Sulawesi, West Java.

Year	Indonesia			South Sulawesi			West Java		
	Without mech.	With mech.	Changes[a]	Without mech.	With mech.	Changes[a]	Without mech.	With mech.	Changes[a]
1	5158	5158	0	6518	6518	0	4021	4021	0
2	4898	4842	- 56	6245	6220	- 25	4027	4008	- 19
3	4644	4536	-108	5979	5934	- 45	4039	3991	- 48
4	4402	4251	-151	5775	5677	- 98	4047	3976	- 71
5	4177	3986	-191	5563	5444	-119	4061	3960	-101
6	3966	3742	-224	5368	5224	-146	4076	3943	-133
7	951	889	- 62	2184	2114	- 70	4093	3927	-166
8	990	911	- 79	2289	2195	- 94	4111	3909	-202
9	1031	932	- 99	2399	2280	-119	4132	3890	-242
10	1074	951	-123	2515	2364	-151	4154	3869	-285

Source: Simulation.

Note: [a] The difference between policy costs-output ratio with and without mechanization.

Table 28. Labor-output ratio and percentage of hired labor to total labor of Indonesia, South Sulawesi, and West Java.

	Indonesia	South Sulawesi	West Java
Total labor-output ratio	31.6	30.2	31.56
Hired labor-output ratio	19.9	20.2	23.2
Percent of hired labor to total labor	63	67	73

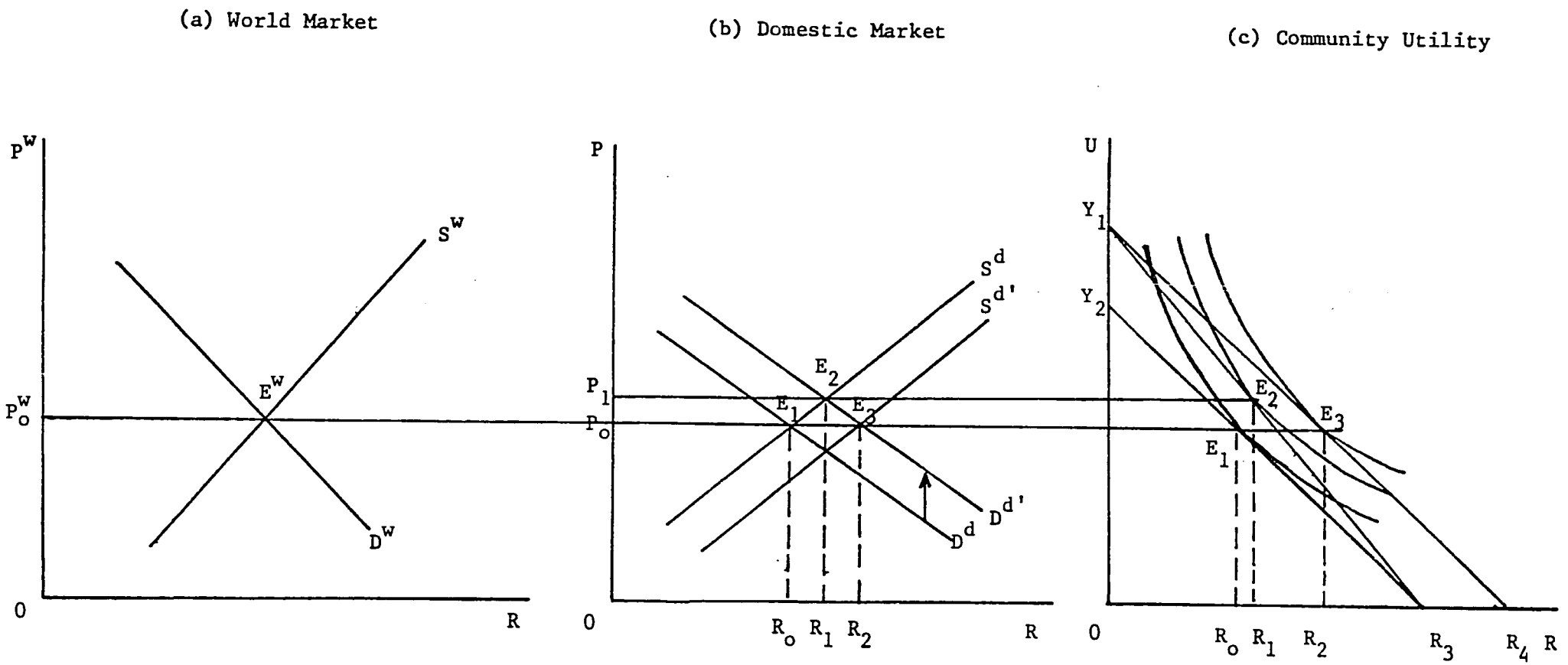

Figure 1 The Relationship among Self-Sufficiency, Imports, and Socail Welfare.

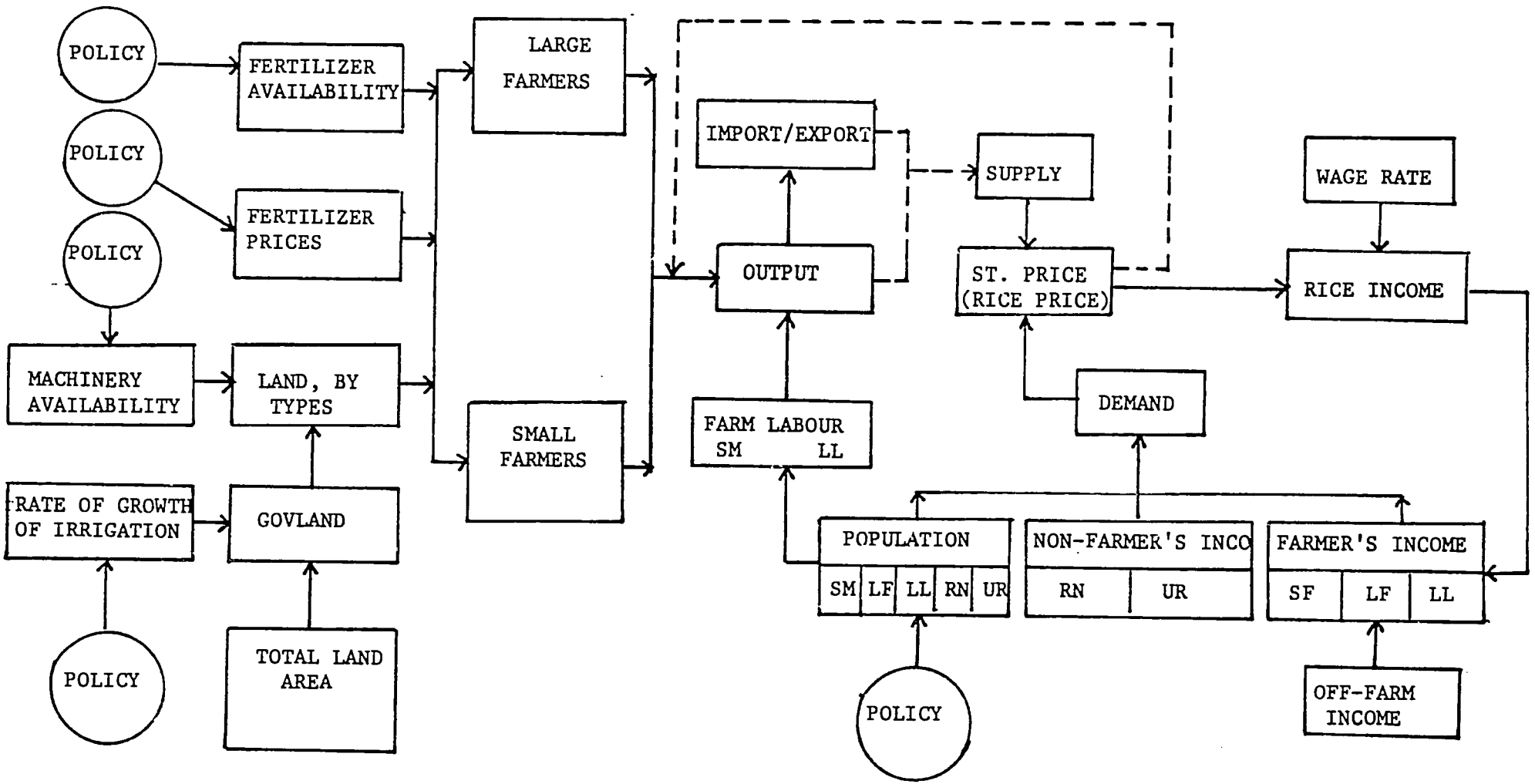

FIGURE 2 PROTOTYPE RICE POLICY MODEL

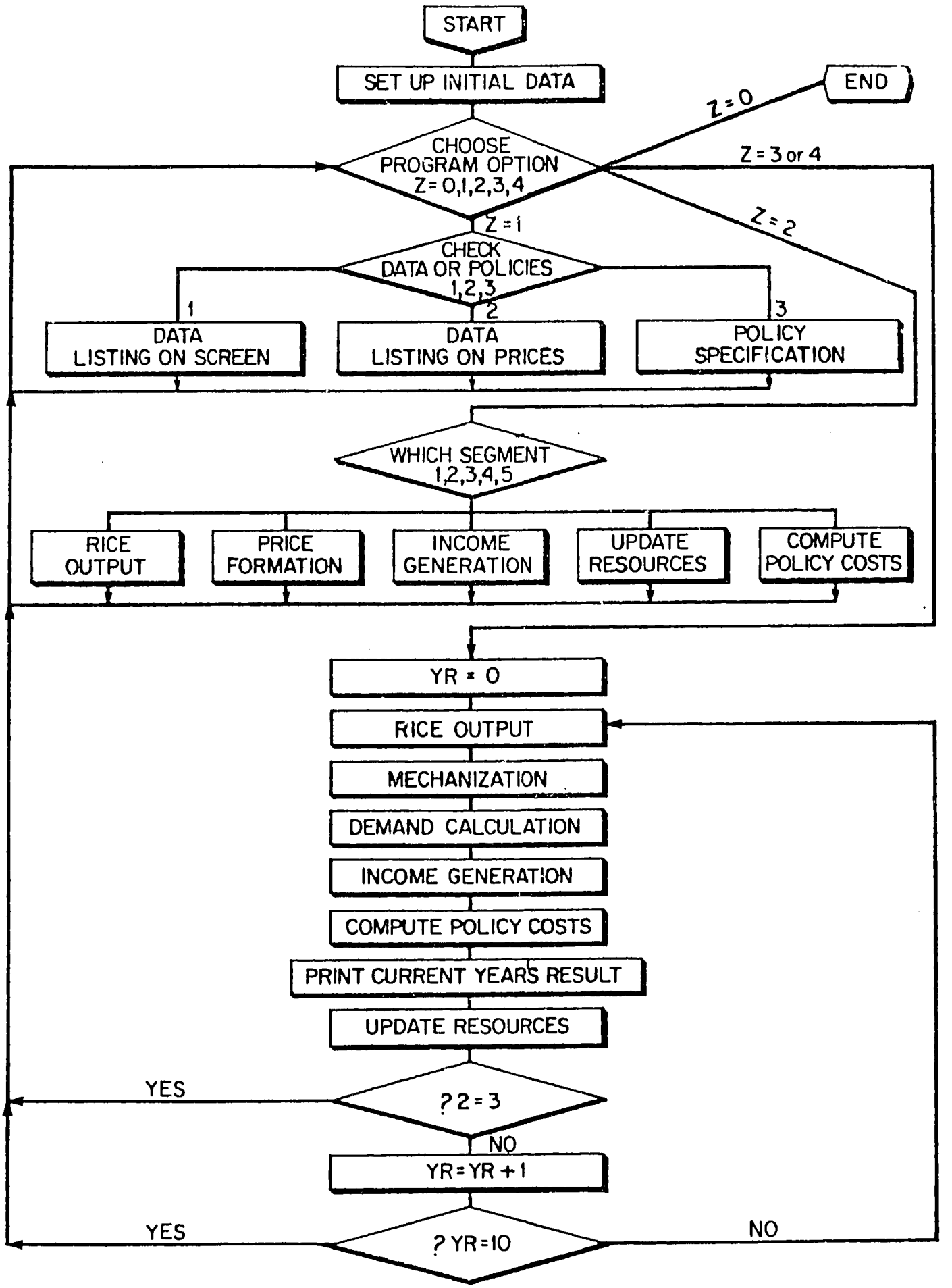

Fig 3 Flowchart for main program.

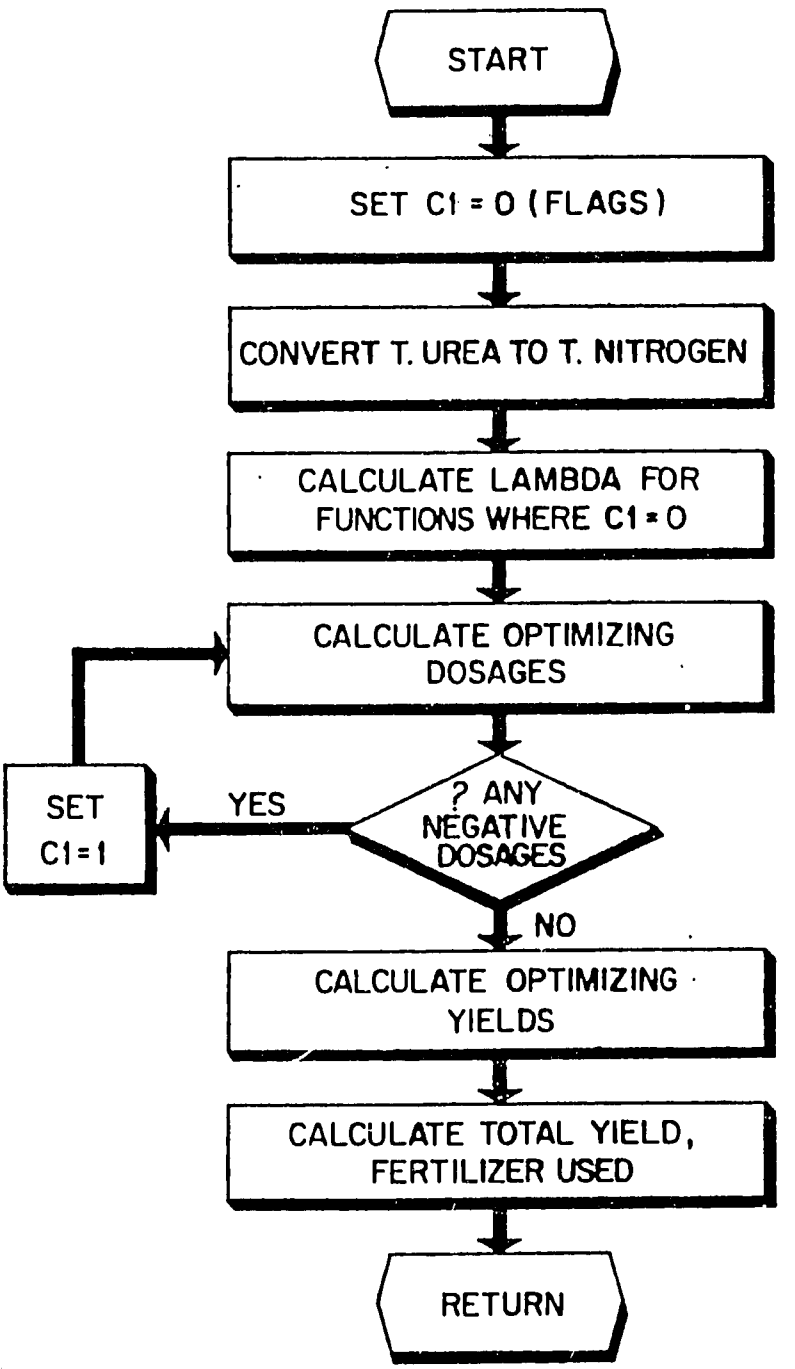

Fig. 4 Flowchart for rice output segment.

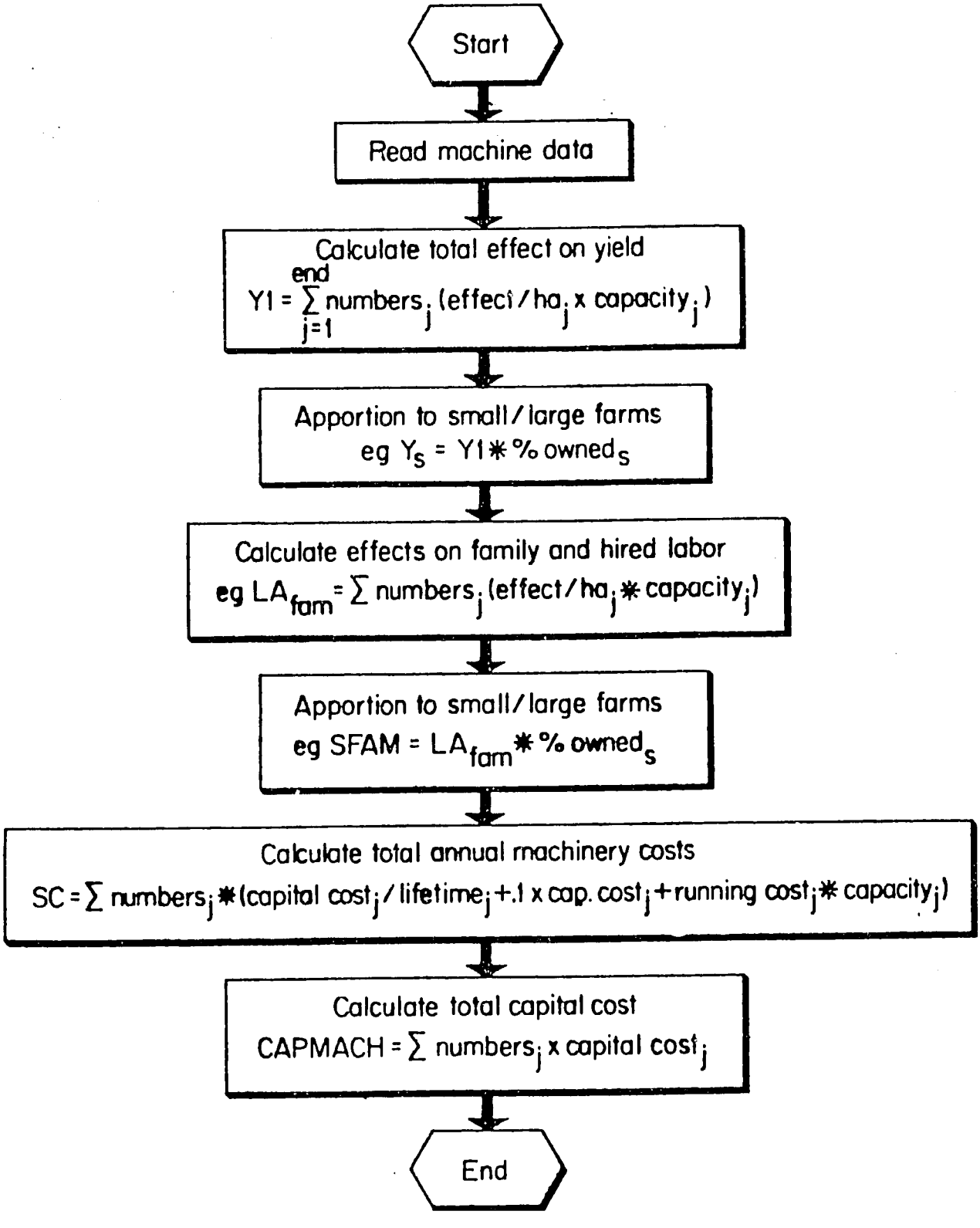

Figure 5 Flowchart for program MECH.

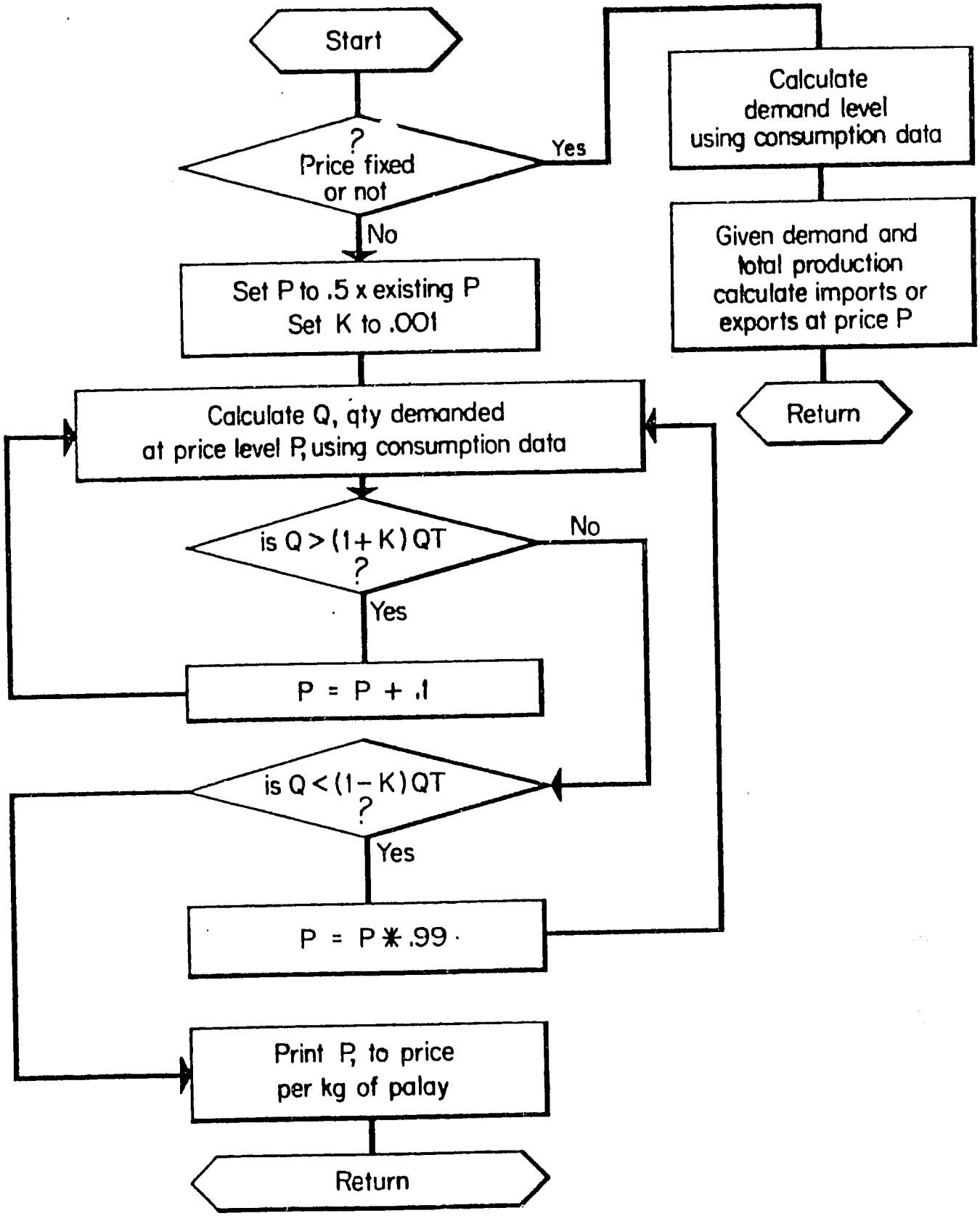

Fig 6 Flowchart for price formation segment.

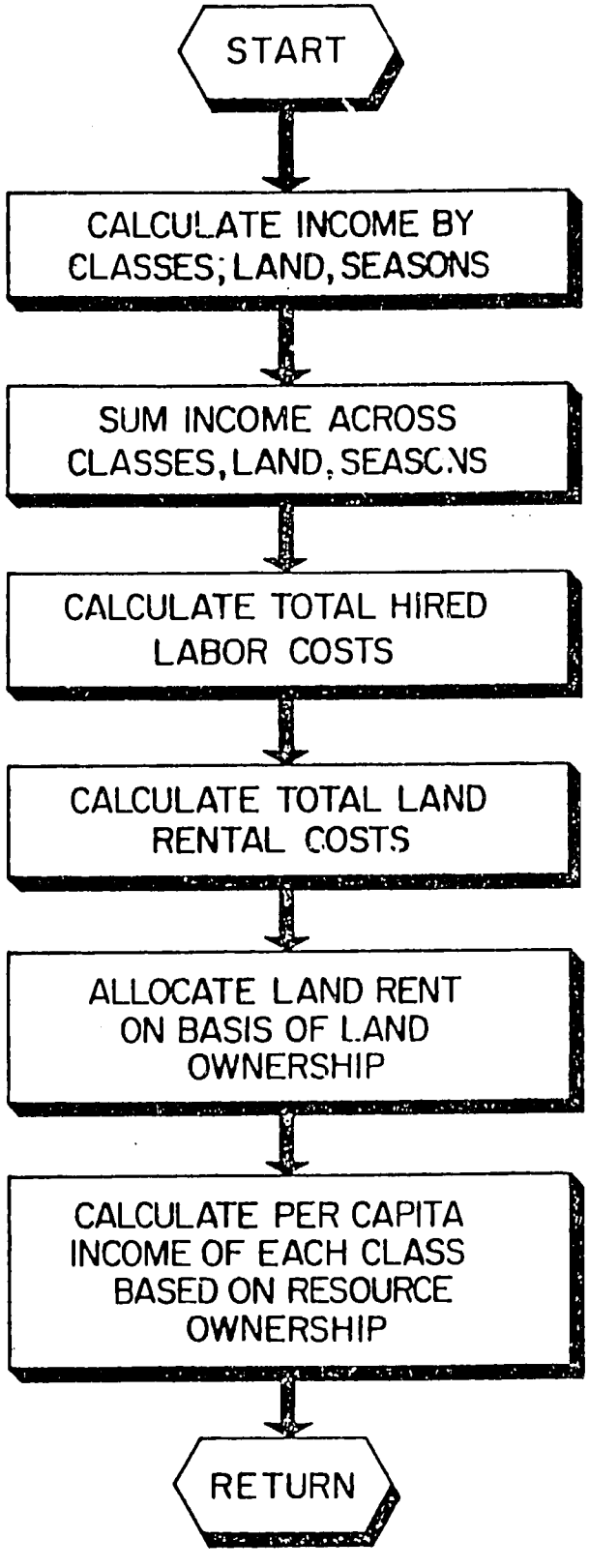

Fig. 7 Flowchart for income segment.

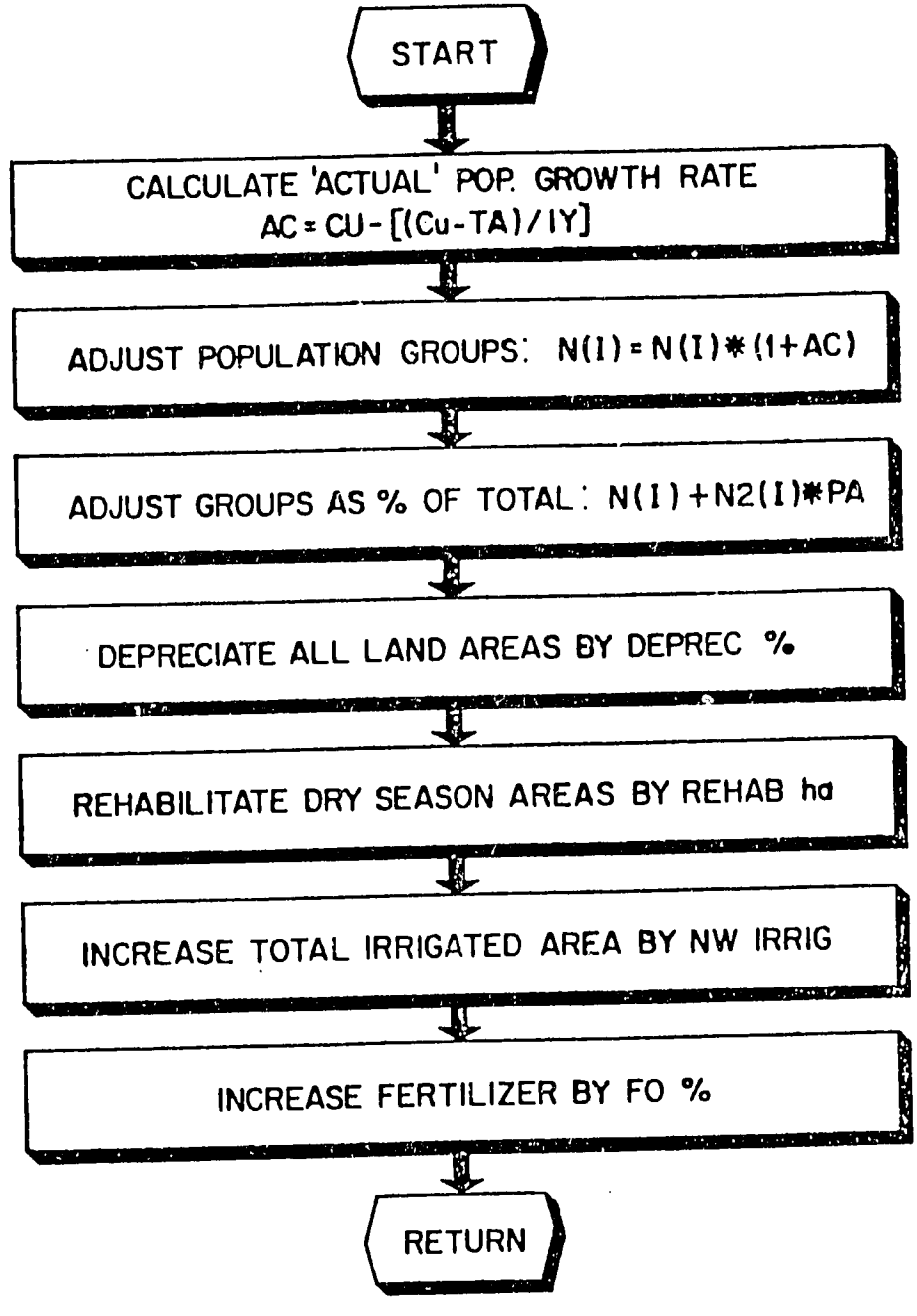

Fig. 8 Flowchart for update resources segment.

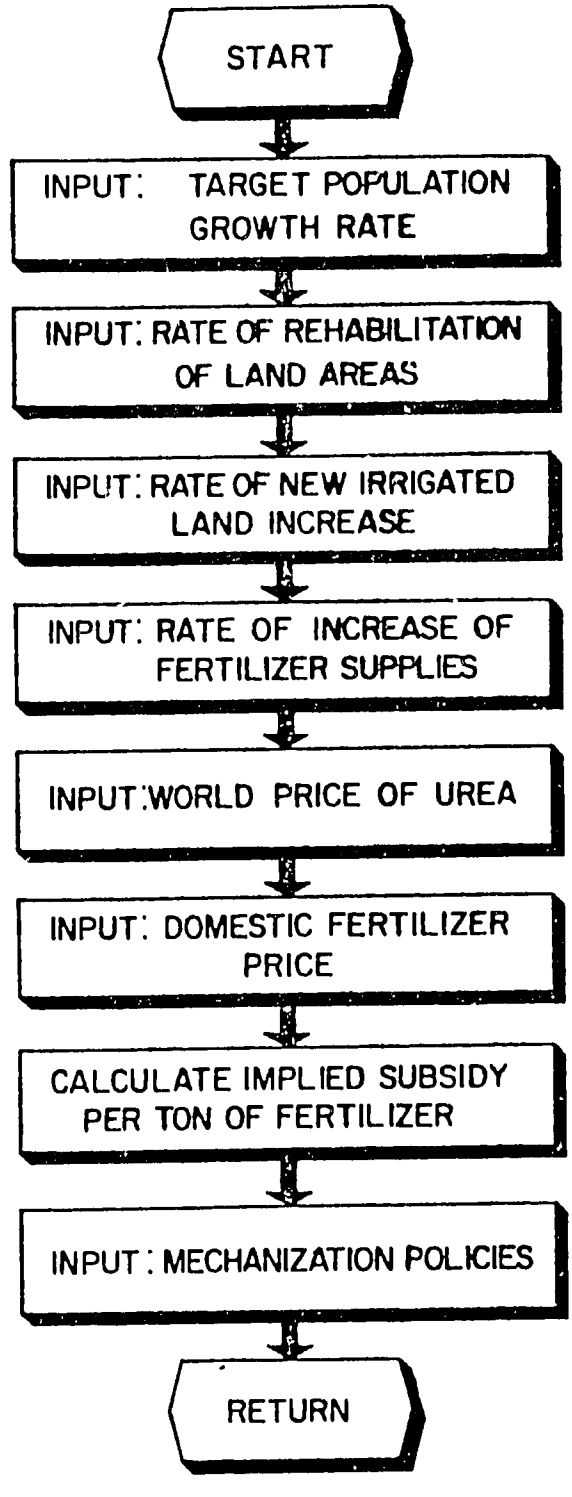

Fig. 9 Flowchart for policy specification.

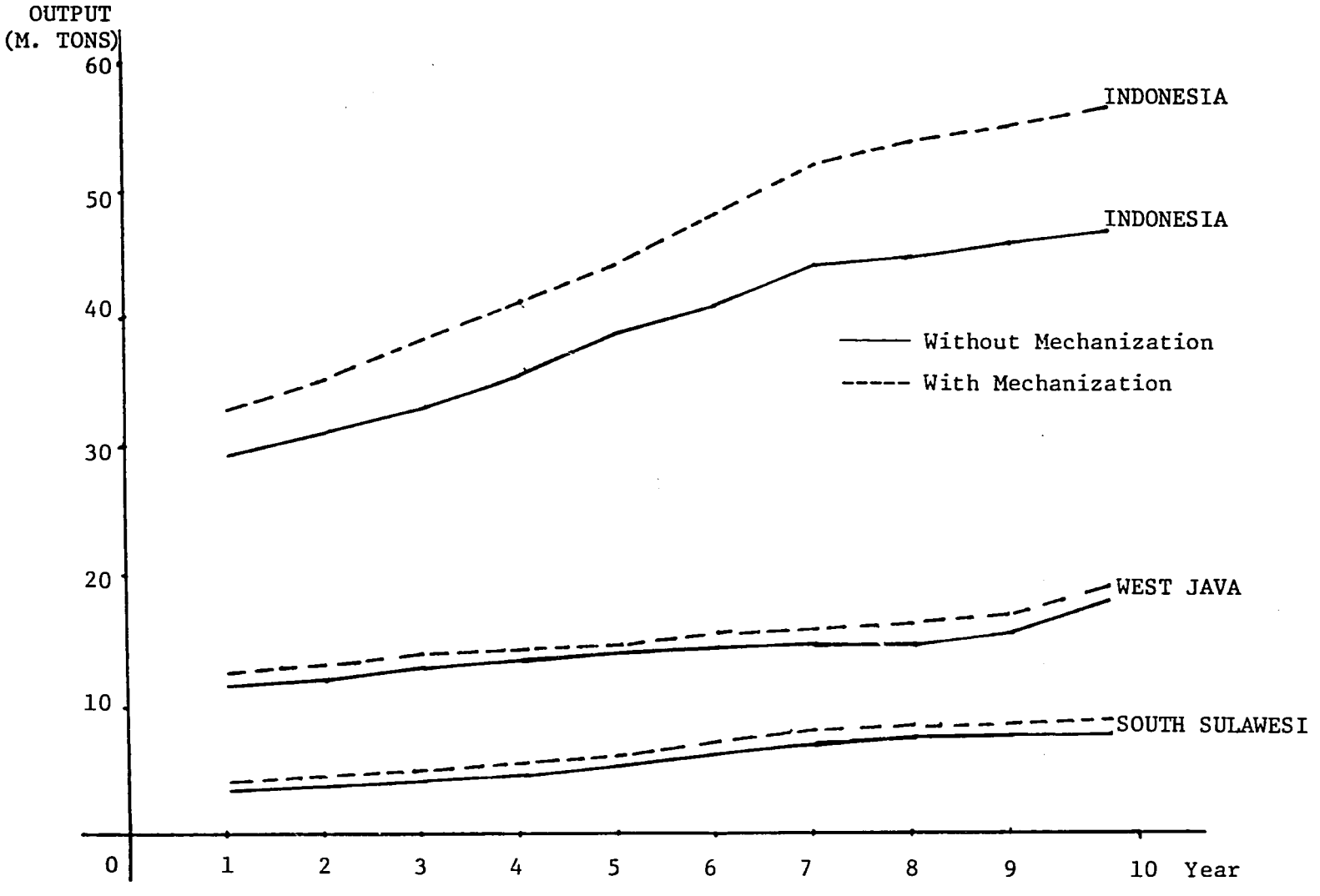

FIGURE 10 Effects of Mechanization on Rice Production, Indonesia, South Sulawesi, and West Java.

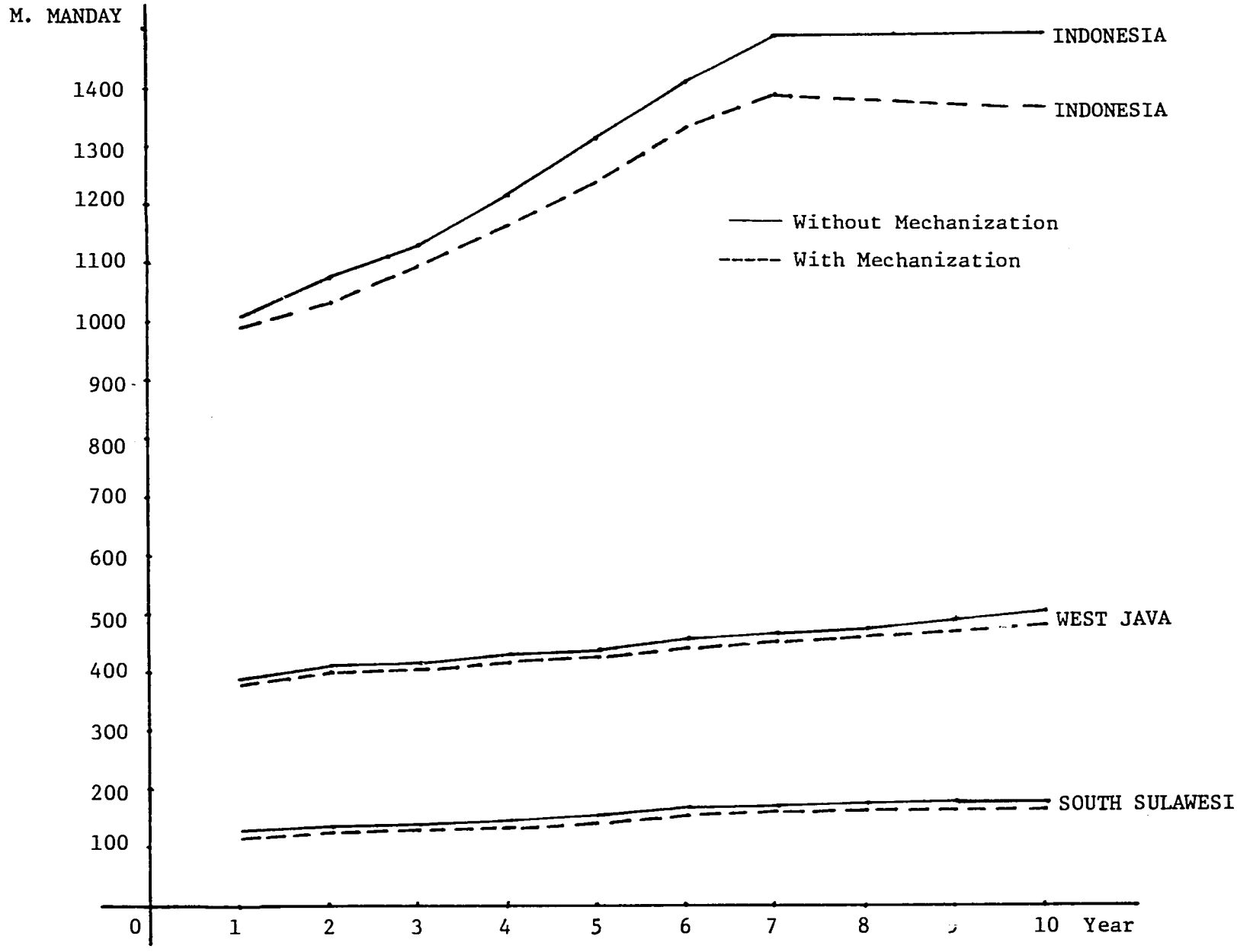

FIGURE 11 Effects of mechanization on total employment, Indonesia, South Sulawesi, and West Java.

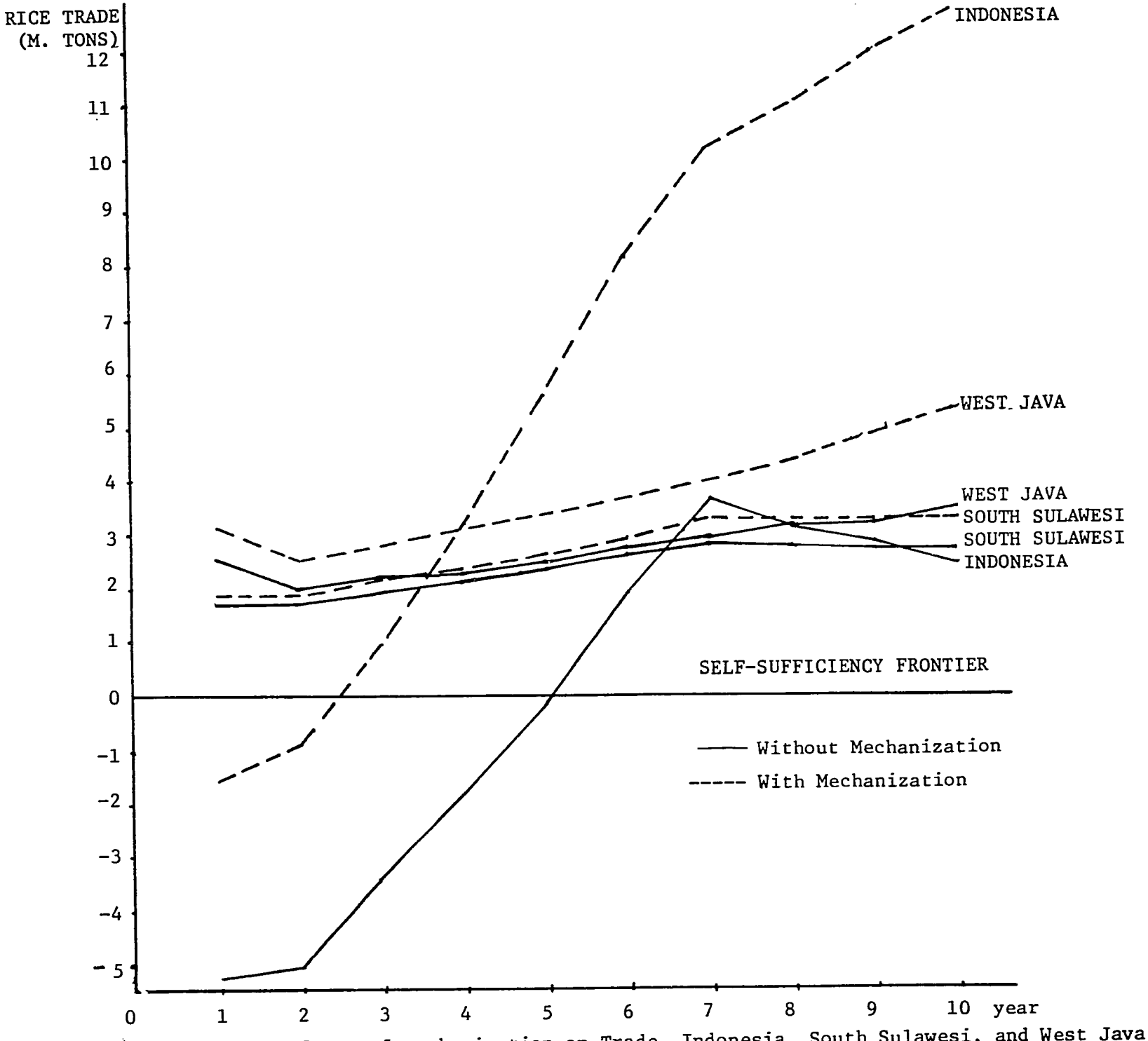

FIGURE 12 effects of mechanization on Trade, Indonesia, South Sulawesi, and West Java.

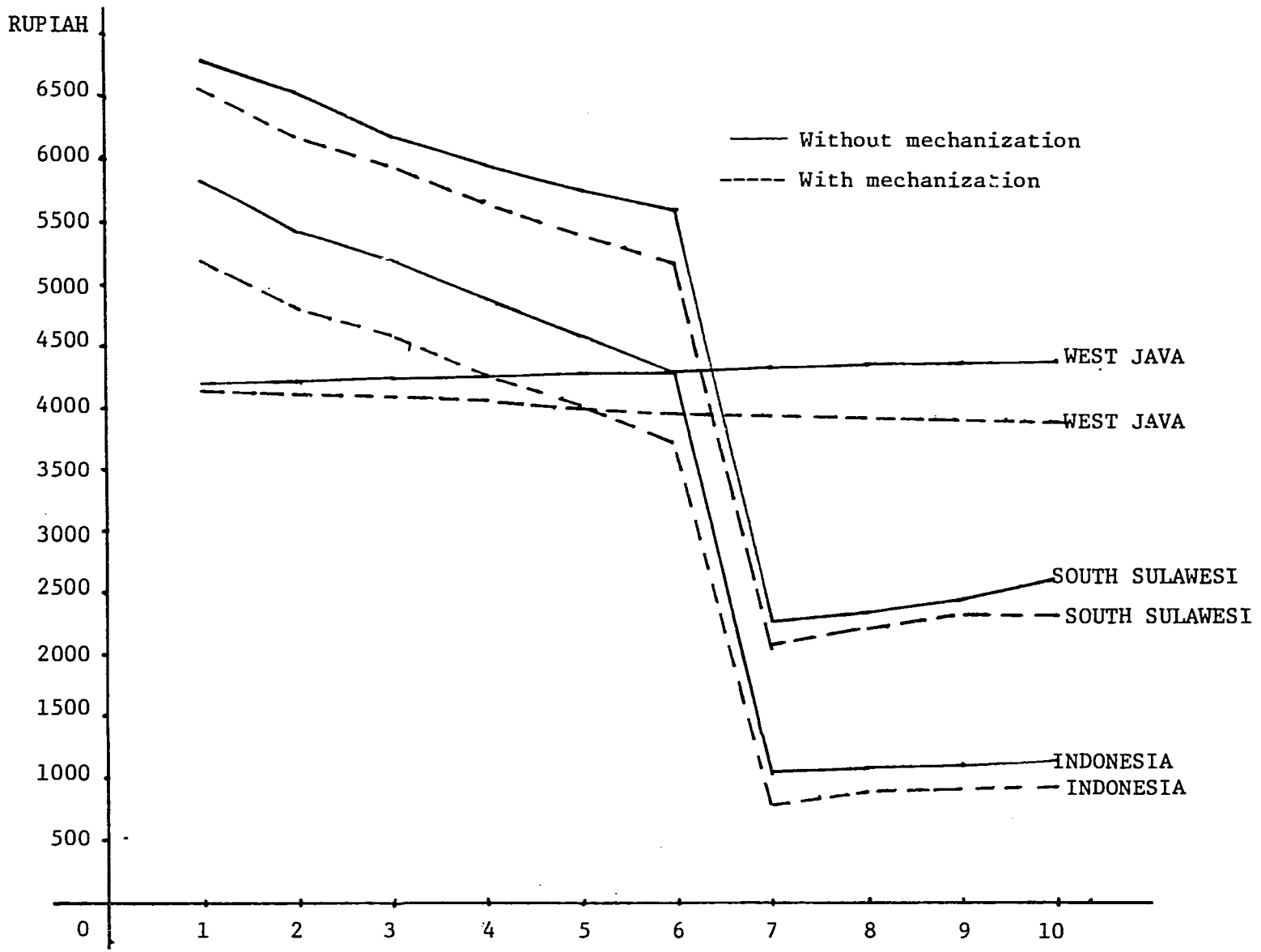

FIGURE 13 Effects of mechanization on policy cost-output ratios, Indonesia, South Sulawesi, and West Java.

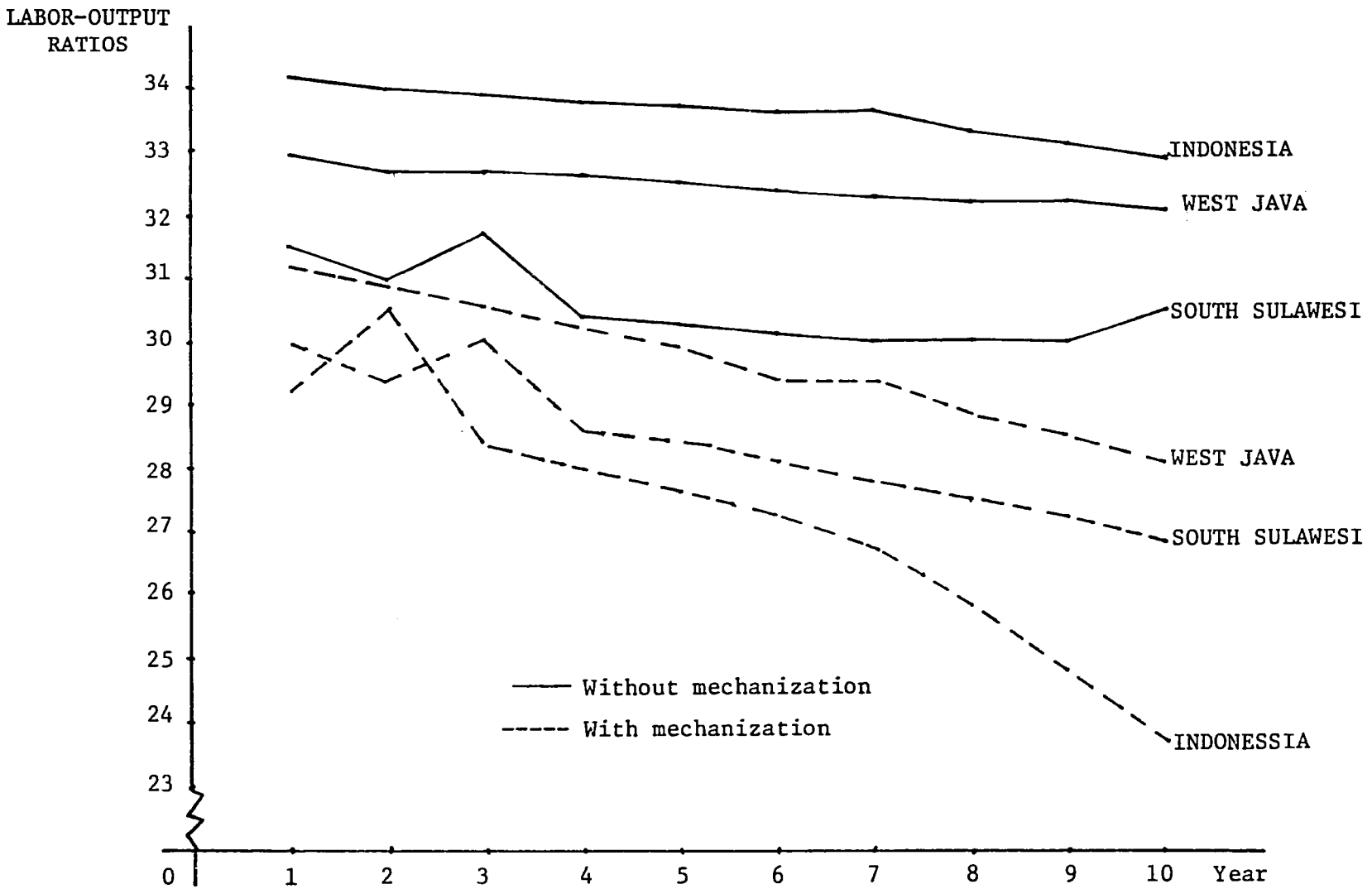

FIGURE 14 Effects of mechanization on labor-output ratios, Indonesia, South Sulawesi, and West Java.