IRRIGATION INVESTMENT IN INDONESIA: TREND AND DETERMINANTS

Effendi Pasandaran[1] and M.W. Rosegrant[2]

Abstrak

Penurunan produksi padi di Indonesia akhir-akhir ini mendorong para penentu kebijaksanaan untuk kembali membicarakan tentang sumber-sumber pertumbuhan produksi padi dan diversifikasi tanaman pada masa yang akan datang. Topik utama dalam diskusi tersebut adalah peranan irigasi. Tulisan ini mengkaji kebijaksanaan irigasi alternatif dalam konteks penyediaan dan permintaan tanaman pangan di Indonesia pada masa yang akan datang. Hasil kajian dipresentasikan dalam model perilaku investasi irigasi pemerintah di Indonesia. Skenario investasi irigasi alternatif diuji dengan proyeksi dan model kebijaksanaan, selanjutnya dibahas mengenai implikasi kebijaksanaan investasi dan manajemen irigasi.

Key words: irrigation, rice, production, Indonesia.

INTRODUCTION

The agricultural sector in Indonesia has grown rapidly over the past decade. From 1978 to 1988, the rate of growth of this sector was over 4 percent in real terms, with a slightly higher rate of growth, 4.3 percent, in the food crop sector. The fastest growth in this sector has been in rice production, which has been achieved in significant part due to government policies, including investment in irrigation and research, extension programs for new technologies and inputs, and favorable input and output pricing policies. The irrigation investment program has included not only construction of new systems, but large investments in the rehabilitation of existing systems, and in development of tertiary distribution systems within existing irrigation schemes. The combination of research, investment, and pricing policies has led to rapid growth in use of modern varieties and fertilizer and impressive gains in rice yields per hectare.

In recent years, however, there has been a considerable slowdown in the rate of growth in rice yields, from over 5 percent per year in the late 1970's and early 1980's, to about 1.5 percent per year since 1984. The slowdown in yield growth is due to near completion of the spread of modern varieties and intensified production programs, declining marginal productivity of fertilizer due to high rates of use, a

[1] Director of the Center for Agrosocio-economic Research (CASER)
[2] Researcher of the International Food Policy Research Instituute (IFPRI)

less favorable price environment, and a sharp reduction in irrigation investment and in the completion of new and rehabilitated areas (CBS, 1970 - 1985).

The combination of rapid growth in rice production followed by a dramatic slowdown has reopened a debate among Indonesian policy makers over the future sources of growth in rice production. A key element in the debate is the role of irrigation in the growth of rice production, particularly the appropriate level and allocation of future irrigation investment in this changing rice production environment. This paper assesses alternative irrigation investment policies in the context of future food crop supply and demand in Indonesia. Past trends in irrigation sector development are first discussed; recent developments in the government financial investment program and physical area completions in irrigation are presented; and results are presented as a model of government irrigation investment behavior in Indonesia; and alternative irrigation investment scenarios are examined in a projections and policy model.

METHODOLOGY

Determinants of Irrigation Investment in Indonesia

The Indonesian government has attempted to meet a number of sometimes conflicting objectives through its agricultural investment and pricing policies. Among the major objectives have been maintenance of relatively low and stable consumer prices for rice and other staples, maintenance of incentives for rapid growth in domestic food production, growth in farm income, and reductions in the level of imports of rice and of the foreign exchange costs of rice imports. In attempting to meet these objectives, the government must make allocated fund between agricultural and non-agricultural investments. The funds provided to agriculture must also be allocated among a wide range of alternative investments, including input subsidies, price supports, extension programs and irrigation development. The allocation of funds among these investments is constrained by the availability of public revenues and foreign exchange. Given the competition for scarce investible funds among alternative public investments, it is hypothesized here that the government will take into account: (a) the relative cost-effectiveness of the alternative investments, and in particular, the returns to investment in irrigation, and (b) the availability of public resources and foreign exchange, when determining the level of investments in irrigation. In order to test this hypothesis, a series of regression analyses is made to explain the level of annual expenditures on construction of new irrigation systems in Indonesia.

Model specification

The model-to-be-tested hypothesizes that the annual expenditures on construction of new irrigation systems in Indonesia are a function of factors which determine the profitability or cost-effectiveness of new irrigation systems, and factors which affect the availability of public resources and foreign exchange. The variables tested in alternative regression specifications of the irrigation investment model which affect the profitability of irrigation are (a) the real world price of rice; (b) a rice yield index defined as the yield of rice relative to the average yield of corn, cassava, and soybean; (c) real gross revenues for rice, defined as the world price of rice times the rice yield index; and (d) the real capital cost per hectare for developing new irrigation systems. The variables which are assumed to influence the availability of public resources and foreign exchange are; (e) the real gross national product; and (f) the real world price of oil. This latter variable is included because of its strong influence on government revenues and foreign exchange. Additional variables tested in model specification are; (g) the imports of rice; and (h) the imports of rice as a percentage of domestic production. These latter variables are included to see if the government goal of reduction in level and cost of imports has a significant impact on investments, independent of the goals for cost-effectiveness in investments.

Specification of the irrigation investment functions also requires a specification of the lag structure between the independent and dependent variables. Lags in the irrigation development process include lags between project appraisal and approval, between approval and initiation of construction, and between initiation and completion (Svendsen and Ramirez, 1990). These lags can vary greatly from project to project. In Indonesia, which has a substantial pipeline of irrigation projects, the lags can also be compressed or lengthened substantially over time due to changes in government priorities or resources. A number of alternative lag structures were tested, and based on goodness-of-fit, the results reported here utilize a four-year lag between measures of irrigation investment profitability (rice price, revenue and yield and capital costs) and their impact on irrigation investment expenditures. Variables reflecting the government's resource and foreign exchange position (GNP and the price of oil) are specified with no lag, i.e., they have an immediate impact on the level of irrigation investment expenditures.

Data sources and definition of variables

The variables utilized in the various specifications of the regression model are defined in Table 1. The sources for the basic data are as follows: (a) DGWRD, Ministry of Public Works for real annual expenditures on new irrigation construction and real capital costs per hectare for new construction; (b) CBS for real gross national product, crop yields, rice imports, and rice production; and (c) the World Bank for the real world price of rice and the real world price of oil. The data covers the period 1969-1988 (1965-1984 for those variables specified with four year lags), for Indonesia as a whole.

Table 1. Definition of variables for estimation of irrigation investment functions. All variables are on an annual basis, 1969-1988 (1965-1984 for lagged variables).

Variable	Definition
IRREXP	Real expenditures on new irrigation construction, thousand US$, 1985 prices.
WPRICE	Real world rice price, Thai 5 percent broken, FOB Bangkok, US$/mt, 1985 prices.
COSTHA	Real capital costs per hektar for new irrigation construction, thousand US$/ha, 1985 price.
POIL	Real price of oil, Saudi Arabian OPEC Market Crude, US$/barrel, 1985 prices.
GNP	Gross national product, million US$, 1985 prices.
IMPORT	Rice imports, 1000 mt, milled equivalent.
PCTIMP	Rice imports as a percentage of domestic rice production.
YRICE	The ratio of paddy rice yield to the average yield of corn, cassava and soybean.
REVRICE	Gross rice revenue (WPRICE times YRICE).

Multi-market Supply/Demand Model of the Indonesian Food Crop Sector

In this sector, the multi-market food crop demand/supply model is briefly presented. A detailed description of the structure and operation of the model is given in Rosegrant, *et al.* (1987), Chapter 5. The key components of the model are:

¤ ***Supply.*** Total production of five food crops, rice, corn, cassava, soybeans, and sugar, is determined by fertilizer demand functions, yield response functions, and are response functions estimated for Java and off-Java. Fertilizer demand for each crop is estimated as a function of expected crop price; fertilizer price; technology shift variables, such as percentage use of modern varieties, percentage of area irrigated, and percentage of area under intensification programs; and trend, which represents the effect of unmeasurable technological shift variables. Crop yields are estimated as a function of fertilizer use, technology shift variables, and lagged yield. Area harvested is estimated as a function of expected crop revenues, expected revenues of competing crops, and lagged area. Specification and estimation of response function for the five food crops are discussed below.

- *Demand.* Per capita demand or food crops is estimated as a function of per capita consumption expenditures, the own prices of the crops and the prices of complementary and substitute food commodities. Demand functions are estimated for different income classes and regions. Demand functions for corn and soybean for feed, and a demand function for consumption of home corn production are also specified.
- *Government policy.* The impact of government pricing and investment policies on area, yield, production, consumption, supply/demand balances, farm revenue, food expenditures, and import expenditures are assessed by specifying the level of investment in irrigation, price policies, and government fertilizer subsidies. Under any specified set of policies, annual food crop production, consumption, and supply/demand balances can be projected to the year 2005. Data and estimation procedures are presented in the Appendix 1.

TRENDS IN IRRIGATED AREA IN INDONESIA

This section reviews trends in irrigated area development in Indonesia. For earlier reviews of issues and developments in the irrigation sector, see Booth (1977a, 1977b), and Nyberg and Prabowo (1982). The two main sources of data on irrigated area in Indonesia are the Central Bureau of Statistics (CBS) and the Directorate General of Water Resources Research (DGWRD) of the Ministry of Public Works.

CBS reports two types of data on irrigated area: (a) irrigated and wetland paddy area harvested; and (b) area of wetland by type of irrigation and number of paddy plantings per crop year. The first of these sources overstates irrigated area harvested, because it includes wetland, non-irrigated paddy in the same reporting category as irrigated paddy area. The latter data provide better detail, but because they are reported on an area planted basis as compared to area harvested, they are not directly comparable to the other sources. Therefore, the former data series are used to provide a basis for comparison of trends with the data provided by DGWRD, which reports irrigated area on a physical service area basis. Detailed estimates presented below attempt to reconcile the CBS and DGWRD data for 1985, a year for which supplementary data exists.

The CBS data on area harvested for irrigated and wetland paddy, dryland paddy, and total paddy, and yield and production of paddy in Indonesia, 1969-93, are given in Appendix Table 1. Total irrigated and wetland area harvested has grown at a rate of just under 1.7 percent per year since 1969. The rate of increase has been about 1.3 percent on Java and 2.2 percent off-Java. The rate of growth in irrigated and wetland area has been relatively steady throughout this period, with nearly equal rates of growth during the first and second halves of the period. Irrigated and wetland area occupied 82 percent of total paddy are harvested in 1969, and 89 percent in 1987. As noted above, these figures overstate the actual proportion of irrigated area, because they include rainfed lowland areas and tidal and inland swamp irrigation. If the latter areas are deducted from irrigated and wetland areas, irrigated area represented about 68 percent of total paddy area harvested in 1985 (see also Appendix Table 3).

Appendix Table 2 presents physical service area in Public Works irrigation systems as compiled by DGWRD. These data exclude the irrigated service area in village systems, which amounted to about one million hektar in 1985 (see also Appendix Table 3). Time series data on the area irrigated in village systems is not available. Total irrigated service area increased at a rate of 1.5 percent per year from 1969-71 to 1985-87. The growth rate in service area was very rapid off-Java, 3.7 percent per year, compared to only 0.5 percent on Java. This is not surprising given the relatively high level of irrigation development already existing on Java in 1969.

As shown in Appendix Table 2, diversion and reservoir systems in Indonesia are classified as technical, semi-technical, and simple systems. Technical systems have permanent canals, control structures, and measuring devices, and the government controls water distribution up to the tertiary canals. Semi-technical systems have permanent canals but few control or measuring devices, and the government generally controls only the source and the main canal. Simple or sederhana systems have few permanent control and distribution structures, and are usually farmer-managed.

Virtually all of the apparent growth in irrigated service area is attributable to growth in technical irrigation systems, which grew at a rate of 2.5 percent per year. Total semi-technical irrigated service area declined gradually through the mid-seventies and began a slow growth after that. This increase was due to growth in semi-technical area off-Java, which outfaced the steady decline in area on Java. Total simple irrigated service exhibited the opposite pattern, first growing, then slowly declining until recovering in recent years. The general pattern of increase in technical service area accompanied by stagnation in combined semi-technical and simple service area until recent years has been largely due to the rehabilitation and upgrading of existing semi-technical systems to technical levels, and simple systems to semi-technical or technical levels. Although there has been substantial investment in new construction of semi-technical and simple systems, conversion of order systems to technical levels has resulted in little net increase in area devoted to these types of systems.

STATUS OF IRRIGATED AREA, YIELD, AND PRODUCTION, 1985

Appendix Table 3 summarizes estimated service area, cropping intensity, area harvested, yield, and production by type of paddy land in 1985. Total irrigated area harvested, excluding the relatively low-yielding swamp irrigation, represents 68 percent of total paddy area harvested, and producer 83 percent of total paddy. Public Works systems, with 3.1 million hektar of actual irrigated service area, account for 78 percent of actual irrigated service area and 80 percent of irrigated area harvested, 54 percent of total paddy area harvested, and 68 percent of total paddy production. Technical systems account for about 54 percent of total Public Works systems, semi-technical for 27 percent, and simple systems for 19 percent. Estimated average yields for Public Works systems range from 4.50 mt/hectare for simple systems to 5.15 mt/hectare for technical systems, and average paddy cropping intensities from 1.59 to 1.81.

Village irrigation systems, generally small systems which are managed by farmers, cover about 850,000 hectare of actual service area, accounting for over 20 percent of actual irrigated service area, 14 percent of total paddy area harvested, and just over 15 percent of total paddy production.

Tidal and inland swamp and valley irrigation account for another 1.2 million hektar of service area. Swamp systems rely on flood irrigation, with few water control structures, and often have problem soils. Swamp irrigation achieves average yields of about 1.75 mt/hectare on just one paddy crop per year, so although it accounts for 12 percent of paddy area harvested, it is responsible for only 5 percent of paddy production.

Unirrigated wetland paddy is estimated to cover 748,000 hectare, achieving average yields of about 3 mt/ha, and accounting for about 8 percent of paddy area harvested and 6 percent of paddy production. Dryland paddy covers about 12 percent of total paddy land, accounting for 5 percent of production.

IRRIGATION DEVELOPMENT EXPENDITURES AND PHYSICAL AREA COMPLETIONS

Annual irrigation development expenditures, 1969/70 to 1993/94, are presented in Appendix Tables 4 and 5, and annual area completions in Appendix Table 6. The annual data are summarized by Repelitas, or five-year development plans, in Appendix Tables 7 and 8. The irrigation investment program grew dramatically through the first three Repelitas. Real expenditures in the third plan were more than four times larger than in the first plan. However, expenditures declined by almost 20 percent between Repelita III and Repelita IV. The decline in actual expenditures in the fourth plan, despite higher planned expenditures, is discussed below.

As shown in Appendix Table 7, rehabilitation receives the largest share of expenditures in the first plan, more than 40 percent of the total. Although declining in relative importance, rehabilitation expenditures increased substantially in absolute terms through the third plan, before a reduction in the fourth plan. Over the course of the first three plans, expenditures on construction of new irrigation systems increased rapidly and received the largest aggregate share of expenditures, averaging 38 percent of expenditures during the first three Repelitas. Real expenditures on new construction increased nearly ten-fold between the first and third plans. The swamp and tidal irrigation development program, which received nearly 30 percent of expenditures in the first Repelita, has declined in relative importance to about 5 percent, but has received a nearly constant level of expenditures in real terms. After a modest initial program, river and flood control received about 30 percent of expenditures over the last three plans.

The completion of physical areas by type of development over the first four Repelitas is shown in Appendix Table 8. Area rehabilitated totaled 950,000 hectare in the first plan, and declined steadily thereafter to 150,000 hectare in the latest Repelita. Completions of new irrigated area construction more than doubled between the first and third plans, to 436,000 ha, before declining to 198,000 hectare in the fourth plan. Swamp and tidal irrigation peaked at 450,000 hectare completed in the third plan, before also declining sharply. Areas brought under river and flood control followed a pattern of completions similar to that of swamp and tidal irrigation.

Appendix Tables 9 and 10 show the planned and actual irrigation development expenditures and planned and actual area completions in Repelita IV. As shown in these tables, the sharp drop in expenditures and area completions between the third and fourth plans was not contemplated when Repelita IV was developed. Planned expenditures in Repelita IV were nearly double those in Repelita III in real terms, and physical targets were equal to or larger than in the third plan across all programs.

The actual Repelita IV program was cut back by nearly two-thirds compared to planned levels. The cutback has been made fairly evenly across programs, ranging from 57 percent on rehabilitation to 69 percent on new system construction (Appendix Table 9).

Physical area completed has declined by a similar order of magnitude compared to planned targets. About 200,000 hectare of new irrigation system construction was completed, compared to the original planned area of 600,000 hectare. Other programs have experienced cutback of similar proportions (Appendix Table 10).

A number of factors have contributed to the reduction in the irrigation investment program in Repelita IV. The government suffered large losses in revenues due to declining oil prices, necessitating major cutbacks in all development programs. The sheer size of the on-going irrigation program caused logistical problems in implementation. Finally, the successes of the rice production program, coupled with declining world rice prices and increasing cost of new irrigation investment, have led to a reassessment of priorities. This reassessment has resulted in increased priority given to efficient management, operation and maintenance of existing systems, and reduced priority for investment in new irrigation.

The reorientation of management policies which has been initiated during the last few years include a gradual turnover of the government managed, small-scale systems of less than 500 hectares to the water users' associations, assessment of the sources of funding for operation and maintenance, introduction of irrigation service fees, and institutional strengthening. While these programs have expanded quickly, it is too early to assess the overall effectiveness of the programs.

IRRIGATION INVESTMENT FUNCTIONS

The estimated irrigated investment functions are presented in Tables 2-4. The equations in Table 2 utilize the world price of rice and capital costs per hectare for new irrigation construction as the independent variables indicating cost-effectiveness of irrigation investment. Table 3 gives the equations utilizing gross revenues for rice and capital costs per hectare, while Table 4 presents the results utilizing the world rice price, rice yield, and capital costs per hectare as indicators of cost-effectiveness.

The results strongly support the hypothesis that investment in new irrigation construction is a function of both the profitability or cost-effectiveness of new irrigation systems, and of the availability of government resources and foreign exchange. The lagged world price of rice and lagged rice revenues both have a significant and strong positive influence on new irrigation investment (Table 2 and Table 3). The addition of a separate variable for rice yield, however, does not add to the explanatory power of the investment function (Table 4). Lagged capital costs per hectare, as expected, have a highly significant negative impact on new irrigation investment.

The price of oil and level of real GNP, as hypothesized, have a highly significant positive impact on new irrigation investment. As with the price, revenue, and capital cost variables, the estimated impacts of the oil price and GNP variables are robust across alternative specifications. The import variables, however, do not have a significant impact on new investment. Although the signs on these variables are in the right direction, the estimated parameters are statistically insignificant, and inclusion of these variables does not improve the overall fit of the equations.

The model is thus quite successful in explaining changes in public investment in new irrigation construction over time as a function of the relative profitability of irrigation investment and the availability of government resources and foreign exchange. The analysis in the next section assess future prospects for investment in new irrigation system construction following the recent cutbacks in investment. The analysis uses a multi-market food crop supply/demand model to examine the impact of alternative irrigation investment scenarios on projected food supply, demand and trade balances. The food crop supply/demand model is briefly described and then applied to assess the effect of alternative investment scenarios.

Table 2. Irrigation investment functions with world price of rice and capital costs per hectare as indicators of cost-effectiveness. Dependent variable: IRREXP (real expenditures on new irrigation construction).

Independent Variable	Equations		
	(1)	(2)	(3)
Constant	-10176.20	-91530.40	-104802.40
	(-1.41)[a]	(-1.23)	(-1.46)
$WPRICE_{t-4}$	213.32	185.98	171.91
	(2.52)	(1.98)	(2.83)
$COSTha_{t-4}$	-111.78	-119.57	-119.61
	(3.81)	(-3.77)	(-3.94)
$POIL_t$	10196.00	8702.16	8199.33
	(5.94)	(3.24)	(3.14)
GNP_t	4.83	5.18	5.49
	(2.91)	(2.95)	(3.08)
$IMPORT_{t-4}$		26.86	
		(0.73)	
$PCTIMP_{t-4}$			548313.0
			(1.01)
Adj. R^2	0.77	0.77	0.77
Durbin Watson	1.67	1.67	1.59

[a] t-statistics in parentheses.

Table 3. Irrigation investment functions with gross revenues from rice and capital costs per hectare as indicators of cost-effectiveness. Dependent variable: IRREXP (real expenditures on new irrigation construction).

Independent Variable	Equations		
	(1)	(2)	(3)
Constant	-88586.12	-80657.98	-94964.74
	(-1.32)[a]	(-1.17)	(-1.41)
$REVRICE_{t-4}$	287.29	251.54	233.29
	(2.56)	(2.04)	(1.88)
$COSTha_{t-4}$	-110.87	-118.82	-118.83
	(-3.79)	(-3.76)	(3.93)
$POIL_t$	10371.79	8842.71	8346.56
	(6.08)	(3.30)	(3.19)
GNP_t	4.45	4.86	5.19
	(2.73)	(2.79)	(2.92)
$IIMPORT_{t-4}$		27.02	
		(0.74)	
$PCTIMP_{t-4}$			546653.00
			(1.02)
Adj. R^2	0.78	0.77	0.78
Durbin Watson	1.67	1.67	1.59

[a] t-statistics in parentheses.

IMPACT OF ALTERNATIVE IRRIGATION INVESTMENT SCENARIOS

In this section, the food crop supply/demand model is used to assess the impact of alternative irrigation investment scenarios on food crop production, consumption, trade balances, farm revenue, and net trade and food consumption expenditures. A useful standard of comparison of alternative irrigation investment scenarios is whether they permit balanced long term growth in domestic rice production and demand at stable prices. This standard of comparison is adopted both as being consistent with expressed government objectives, and on economic grounds.

Analysis of comparative advantage in rice production in Indonesia indicates that Indonesia is efficient in import substitution but does not have a comparative advantage in the export of rice (Rosegrant, *et al.*, 1987, Chapter 4). Divergences from a balanced supply/demand growth path may have particularly large costs because Indonesia is a major actor (or potential actor) of the world rice market. Shortfalls in production relative to demand growth which generate large import demand drive up the world price of rice, imposing additional economic costs. If production growth outstrips demand growth, the main strategies for surplus management are accumulation of expensive stocks, disposal of surpluses on the export markets with costly subsidies, or reduction in domestic farm prices of rice to reduce production incentives.

Table 4. Irrigation investment function with world price of rice, yield index of rice, and capital costs per hectare as indicators of cost-effectiveness. Dependent variable: IRREXP (real expenditures on new irrigation construction).

Independent Variable	Equations		
	(1)	(2)	(3)
Constant	-12345.80	-112958.60	-124229.80
	(-0.47)[a]	(-0.420)	(-0.47)
$WPRICE_{t-4}$	215.82	188.45	174.17
	(2.34)	(1.85)	(1.71)
$YRICE_{t-4}$	327.97	323.14	293.03
	(0.09)	(0.08)	(0.08)
$COSTha_{t-4}$	-111.27	-119.06	-119.14
	(-3.59)	(-3.56)	(-3.71)
$POIL_t$	10318.51	8823.17	831.28
	(4.54)	(2.81)	(2.71)
GNP_t	4.68	5.04	5.36
	(1.96)	(2.03)	(2.15)
$IMPORT_{t-4}$		26.80	
		(0.70)	
$PCTIMP_{t-4}$			547902.8
			(0.98)
Adj. R^2	0.76	0.75	0.76
Durbin Watson	1.67	1.67	1.59

[a] t-statistics in parentheses.

Table 5 present indicative investment scenarios for three levels of irrigation development. The medium irrigation investment scenario assumes an annual increase in irrigated paddy area harvested of 80,000 hectare, of which 24,000 hectare are on Java and 56,000 hectare off-Java. The implications of these area harvested figures for completions of physical service area depend on assumptions regarding achievable paddy cropping intensities. It is assumed in developing the indicative investment plans that newly constructed irrigation systems can achieve average annual paddy cropping intensities of 1.80 on Java and 1.65 off-Java, a weighted national average of about 1.70. This is higher than the average of 1.38 for all Public Works systems in 1985. A higher cropping intensity is used based on the assumption that the primarily technical new systems can achieve higher rates than the average of existing systems, which include lower technology and deteriorated systems; and because higher than average cropping intensities are required to attain adequate internal rates of return to new systems. If significantly lower cropping intensities are attained in new systems, internal rates of return would not justify project development. If cropping intensities in new systems are nevertheless lower than assumed, the necessary service area completion to achieve a given harvested area would, of course, be higher.

Under the cropping intensity assumption used here, the medium rate of annual increase in irrigated paddy area can be generated by an investment program in new construction and rehabilitation nearly the same in physical area completions as the average actual area for Repelita IV. The medium level base area completions are 30,000 hectare for rehabilitation and 43,800 hectare for service area from new construction annually. This compares to average completions for Repelita IV of 30,340 hectare of rehabilitated area and 39,500 hectare of new irrigated service area. At estimated average 1986 real construction costs, the total annual investment cost of rehabilitation and new construction is Rp. 264.8 billion (Table 5).

The low irrigation investment scenario assumes that 40,000 hectare of new irrigated paddy area harvested will be generated annually. This scenario can be generated by rehabilitation area and new construction of about 20,000 hectare each annually comparable to the projected levels of 1988/89, the final year of Repelita

Table 5. Indicative irrigation investment programs for alternative investment scenarios in the food crop supply/demand model.

	Medium Irrigated Investment			Low Irrigated Investment			High Irrigated Investment		
	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total
Annual increase in irrigated paddy area harvested ('000 ha)	24.0	56.0	80.0	12.0	28.0	40.0	36.0	95.2	131.2
Area rehabilitated[a] ('000 ha)	15.0	15.0	30.0	10.0	10.0	20.0	30.0	30.0	60.0
New service area construction[b] ('000 ha)	11.7	32.1	43.8	5.6	15.8	21.4	16.7	54.0	70.7
Rehabilitation cost[c] (Rp billion)	2.22	27.1	49.3	14.8	18.1	32.9	44.4	54.3	98.7
New construction cost[d] (Rp billion)	51.9	163.6	215.5	27.7	80.2	107.9	74.0	275.4	349.4
Total annual investment cost (Rp billion)	74.1	190.7	264.8	42.5	98.3	140.8	118.4	329.7	448.1

[a] Average increase in cropping intensity from rehabilitaion is 0.20.
[b] Average cropping intensity of 1.80 for new construction on Java, 1.65 for off-Java.
[c] Average cost of rehabilitation $900/hectare on Java, $1,100/hectare off-Java.
[d] Average cost of new construction $2,700/hectare on Java, $3,100/hectare off-Java.

IV. This program would cost about Rp.140.8 billion at estimated 1986 construction costs (Table 5).

The final, high investment scenario, assumes a 50 percent increased in annual irrigated paddy area harvested on Java and a 70 percent increase off-Java, compared to the base investment scenario. The total new paddy area harvested under irrigation increases by about 131,000 hectare per year, under this scenario. The high irrigation investment option would require completion of 60,000 hectare of rehabilitated area, and 71,000 hectare of service area from new construction, at a cost of Rp.448.1 billion.

The results reported in Table 6 include base year (1989), 1995 and 2000 projections for domestic wholesale price of rice, paddy production, other crop production, and net rice imports. The years specified are the middle years of three-year averages. As shown in Table 6, the medium irrigation scenario, approximately equivalent to the actual Repelita IV program, is sufficient to maintain balanced growth in rice production and demand, with small exports of rice in 1995 and 2000 and a slight decline in rice price from the base year (average of 1988-90) price of Rp. 529/kg. Paddy production increases by 2.0 percent per year and

Table 6. Summary of key results from irrigation investment scenarios, with no decline in irrigated service area from urban industrial development, 1990 and 1995 projections. Flexible domestic rice price.

	Medium Irrigation	Low Irrigation	High Irrigation
1989			
Domestic wholesale rice price (Rp/kg)	529	529	529
Paddy production ('000 mt)	45,186	45,159	45,214
Other crop production ('000 mt)[a]	26,907	26,907	26,907
Rice imports ('000 mt)	47	63	31
1995			
Domestic wholesale rice price (Rp/kg)	509	515	503
Paddy production ('000 mt)	51,289	50,915	51,595
Other crop production ('000 mt)[a]	30,398	30,315	30,479
Rice imports ('000 mt)	-152	-113	-348
2000			
Domestic wholesale rice price (Rp/kg)	516	527	504
Paddy production ('000 mt)	56,019	55,394	56,656
Other crop production ('000 mt)[a]	34,673	34,490	34,850
Rice imports ('000 mt)	-45	-17	-247

[a] Total production of corn, cassava, soybeans, and sugar.

production of other crops (corn, cassava, soybeans, and sugar) by 2.3 percent per year.

The impact on paddy yields and production of a cutback to low irrigation investment is moderate. In 2000, yields are 2 percent lower, and production declines by 625,000 mt, or 1.1 percent relative to the medium irrigation investment scenario. The direct effect on production on a cutback in irrigation investment is partially offset by the increase in rice prices caused by higher rice imports. The increase in rice prices induces an increase in paddy area harvested which reduces the net effect on production of the cutback in irrigation investment. The increase in the price of rice also reduces domestic demand, further moderating the impact of investment cutbacks on imports. The increase in the price of rice also causes a small shift in area from other crops to rice, resulting in a slight loss of production in these crops.

The high irrigation investment policy has opposite effects of similar magnitude relative to medium irrigation. The domestic rice price declines slightly, there is an increase in paddy production of 637,000 mt and generation of 247,000 mt of rice exports in 1995. Production of other crops increases slightly (Table 6).

The analysis of alternative irrigation investment scenarios using the food crop supply/demand model suggest that the reduction in investment in new irrigation systems in Repelita IV was an appropriate response to the changing economic environment of irrigation. However, further reductions in investment in new systems to below these levels do not appear appropriate. The results show new irrigation area harvested of 60,000-80,000 hectare per year would be adequate to maintain balanced growth of domestic rice production and demand at stable rice prices. If average paddy cropping intensities of 1.60-1.70 can be attained in newly constructed systems, these rates of growth in irrigated area harvested can be generated by construction of new service area of 35,000-50,000 hectare per year. This level of investment is consistent with the average annual completion rates in Repelita IV.

CONCLUSIONS AND POLICY RECOMMENDATIONS

The irrigation development program has been a major factor in the growth of rice production in Indonesia since last two and a half decades. The program grew rapidly in the first three Repelitas, before a considerable slowdown in the rate of investment and completion of area targets since Repelita IV.

Irrigation investment strategy in the past was also geared toward supporting sustainable growth and rice self-sufficiency. The long-term strategy of irrigation development is based on two premises. First, the performance of existing irrigation facilities needs to be improved and protected from external disturbances. Second, additional irrigated land resources are needed as a source of income and food security.

A policy issue related to investment decisions is the institutional and organizational adjustment needed to implement programs effectively and efficiently. For example, effective adjustment is needed to integrate various processes such as irrigation and land development in new irrigation systems and also to link various processes from infrastructure development to dissemination of technology in reclaimed tidal-swamp areas.

Reorientation of management policies has been initiated during the last few years. These include a gradual turnover of the government managed, small-scale systems of less than 500 hectares to the water users' associations, assessment of the sources of funding for operation and maintenance, introduction of irrigation service fees, and institutional strengthening.

Although appropriate policy instruments are still being formulated, these policy objectives are conductive to promotion of crop diversification if implemented properly. Turning over government systems to local communities will internalize water-allocation policy within the irrigation system. This enables local communities to set their own criteria and make their own decisions in choosing an irrigated crop mix suitable to local conditions.

The introduction of irrigation service fees in larger government irrigation systems can be used to improve irrigation performance that is responsive to external stimuli. However, due to limitations in system facilities and the physical delivery of water, the irrigation pricing policy is unlikely to have a large impact on water allocation. Rather, it is primarily designed to raise finances to support efficient operation and maintenance of irrigation systems.

Introduction of diversified cropping within existing irrigation systems poses additional management complexities. There are at least three important constraints to supporting diversified crops in irrigation systems: system design, technical information, and production technologies. The operational policy to deal with these constraints requires integration of activities at the system level between agencies concerned -- for example, the program to promote the capacity of the water users' associations to relax existing constraints.

The policy to promote crop diversification in irrigated areas requires flexibility on the part of the farmers to choose crops suitable to their own decision making criteria. This flexibility, however, is influenced to a certain extent by the performance of irrigation systems. As most irrigation systems in Java are in an advanced stage of development, it is reasonable to expect that farmers in Java will be more responsive in selecting a wider range of crops to be grown.

The most important nontraditional irrigation alternative that might be developed in Indonesia is the use of groundwater. This is particularly true for the eastern part of Indonesia, where rainfall is limited and erratic. In western parts of Indonesia it is necessary, however, to explore the feasibility of the conjunctive use of ground and surface water in existing irrigation systems.

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Appendix Table 1. Irrigated and wetland area, dryland area, and total area, yield, and production of paddy in Indonesia, 1969- 1993

Year	Irrigated & wetland Area			Dryland area			Area			Yield			Production		
	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total
	'000 ha									mt/ha			'000 ha		
1969	3933	2611	6544	345	1124	1469	4278	3735	8014	2.57	1.88	2.25	11003	7010	18013
1970	3947	2732	6679	341	1115	1456	4288	3847	8135	2.70	2.01	2.38	11580	7744	19324
1971	4037	2856	6893	365	1066	1431	4402	3922	8324	2.81	1.99	2.42	12389	7793	20182
1972	3992	2610	6602	326	970	1296	4318	3580	7898	2.76	2.09	2.45	11896	7490	19386
1973	4226	2838	7064	331	1009	1340	4557	3847	8404	2.86	2.20	2.56	13016	8465	21481
1974	4434	2906	7340	285	884	1169	4719	3790	8509	2.94	2.27	2.64	13853	8611	22464
1975	4379	2955	7334	264	896	1161	4644	3851	8495	2.95	2.24	2.63	13701	8630	22331
1976	4203	3026	7229	249	890	1139	4452	3916	8369	3.15	2.37	2.78	14031	9270	23301
1977	4115	3087	7202	245	913	1158	4360	4000	8360	3.00	2.57	2.79	13080	10267	23347
1978	4447	3251	7698	284	947	1231	4731	4198	8929	3.29	2.43	2.89	15551	10221	25772
1979	4393	3282	7675	217	912	1129	4610	4194	8804	3.40	2.53	2.99	15655	10627	26283
1980	4503	3316	7824	253	933	1186	4756	4249	9005	3.86	2.66	3.29	18358	11294	29652
1981	4763	3428	8191	266	324	1190	5029	4352	9382	4.07	2.83	3.49	20478	12296	32774
1982	4488	3385	7873	247	868	1115	4735	4253	8988	4.39	3.00	3.74	20806	12778	33584
1983	4479	3508	7987	291	885	1176	4770	4393	9162	4.53	3.12	3.85	21595	13707	35303
1984	4852	3695	8547	350	867	1217	5202	4562	9764	4.55	3.17	3.91	23666	14471	38136
1985	4965	3704	8669	307	855	1162	5272	4559	9832	4.59	3.25	3.97	24217	14808	39025
1986	4986	3827	8813	345	831	1176	5331	4658	9989	4.59	3.50	4.08	24459	16297	40756
1987	4971	3866	8837	214	871	1085	5185	4737	9922	4.73	3.24	4.04	24544	15535	40079
1988	4860	4065	8925	348	865	1213	5208	4930	10138	4.82	3.36	4.11	25088	16588	41676
1989	5099	4276	9375	350	807	1157	5449	5083	10532	4.96	3.49	4.25	27011	17714	44725
1990	5063	4314	9377	355	769	1124	5419	5084	10503	5.02	3.54	4.30	27177	18001	45178
1991	4848	4313	9161	336	777	1113	5814	5090	10904	5.09	3.59	4.10	26393	18296	44689
1992	5159	4640	9799	394	911	1305	5553	5551	11104	5.09	3.60	4.34	28274	19966	48240
1993	4486	3332	7818	346	762	1108	4832	4094	8926	5.16	3.64	4.45	24784	14912	39696

Source: Central Bureau of Statistics, 1969-1993.

Appendix Table 2. Potential irrigated service area in Public Works Systems, by type of system, Indonesia, 1969-1993

Year	Total Irrigated Service Area			Technical irrigated service area			Semi-technical irrigated service area			Simple irrigated service area		
	Java	Off-Java	Indo.	Java	Off-Java	Indo.	Java	Off-Java	Indo.	Java	Off-Java	Indo.
	'000 ha											
1969	2.506	882	3.388	1.172	298	1.470	973	301	1.274	361	283	644
1970	2.513	923	3.436	1.240	309	1.549	918	330	1.248	355	284	639
1971	2.506	982	3.488	1.291	281	1.572	664	342	1.003	554	359	913
1972	2.513	1.004	3.517	1.380	295	1.675	583	352	935	550	357	907
1973	2.518	1.028	3.546	1.446	309	1.755	524	359	883	548	360	908
1974	2.552	1.135	3.657	1.518	233	1.751	430	447	877	574	455	1.029
1975	2.521	1.236	3.757	1.522	269	1.786	431	504	935	568	468	1.036
1976	2.555	1.289	3.844	1.557	313	1.870	467	473	940	531	503	1.034
1977	2.557	1.385	3.942	1.563	318	1.881	435	516	951	559	551	1.110
1978	2.581	1.437	4.018	1.575	340	1.915	459	530	989	547	567	1.114
1979	2.592	1.470	4.063	1.604	357	1.961	441	587	1.028	548	520	1.074
1980	2.608	1.500	4.107	1.642	365	2.007	427	639	1.066	539	496	1.035
1981	2.623	1.529	4.152	1.680	373	2.053	414	690	1.104	529	466	995
1982	2.637	1.558	4.195	1.717	381	2.099	401	741	1.142	519	436	956
1983	2.656	1.586	4.241	1.752	393	2.145	390	790	1.180	514	403	916
1984	2.735	1.670	4.405	1.807	424	2.231	338	811	1.149	590	435	1.025
1985	2.696	1.717	4.413	1.808	429	2.237	363	839	1.202	525	449	974
1986	2.698	1.924	4.622	1.861	544	2.405	305	864	1.169	532	516	1.048
1987	2.970	2.388	5.358	2.069	691	2.760	314	1.032	1.346	587	665	1.252
1988	2.523	1.792	4.315	1.370	345	1.715	455	459	914	698	988	1.686
1989	2.535	1.553	4.088	1.383	378	1.761	461	178	639	691	997	1.688
1990	2.536	1.912	4.448	1.389	413	1.802	459	507	966	688	992	1.680
1991	2.547	1.886	4.433	1.426	409	1.835	439	411	950	682	966	1.648
1992	2.573	1.929	4.502	1.465	448	1.913	427	499	926	681	982	1.663
1993	2.586	2.012	4.598	1.492	530	2.022	420	486	906	674	996	1.670

Source: Ministry of Public Works, DGWRD, 1969-1993.

Appendix Table 3. Service area, cropping intensity, area harvested, yield, and production by type of paddy land, Indonesia, 1985.

Type of paddy land	potential service area	Actual service area	Area harvested	Cropping intensity[a]	Yield	Production
	'000 hectare				(mt/ha)	('000 mt)
Irrigated						
Technical	2,237	1,650	2,988	1.81	5.15	15,388
Semi-technical	1,202	850	1,434	1.69	4.87	6,984
Simple	974	584	929	1.59	4.50	4,182
Village	1,036	851	1,353	1.59	4.37	5,913
Total Irrigated	5,449	3,935	6,704	1.70	4.84	32,462
Swamp/Valley	1,167	1,167	1,217	1.04	1.75	2,130
Rainfed	673	673	748	1.11	3.11	2,330
Dryland	1,163	1,163	1,163	1.00	1.80	2,098
TOTAL	**8,452**	**6,938**	**9,832**	**1.42**	**3.97**	**39,025**

[a] Area harvested divided by actual service area.

Sources: Estimated from data from CBS; DGWRD; Rekapitulasi Buku Pintar Daerah Irigasi P.U., Direktorat Irigasi I; CAER; The Sederhana Assessment Study, P.T. Exsa, March 1985.

Appendix Table 4. Irrigation development expenditures at current prices, Indonesia, 1969/70-1993/94

Year	New system construction	Swamp and tidal	Rehabilitation	River and flood control	Total expenditure
			million Rupiah		
1969/70	5,335	5,826	7,603	1,942	20,706
1970/71	4,566	6,336	7,865	901	19,668
1971/72	4,739	6,475	9,192	920	21,326
1972/73	5,394	7,041	11,011	1,383	24,829
1973/74	5,000	7,400	14,300	1,200	27,900
1974/75	14,635	74,352	11,876	17,416	118,279
1975/76	27,387	15,736	19,684	35,445	98,252
1976/77	36,874	8,512	25,990	43,530	114,906
1977/78	50,272	10,638	36,287	53,543	150,740
1978/79	68,180	13,047	53,732	69,928	204,887
1979/80	93,269	20,404	70,173	83,143	226,989
1980/81	133,750	25,008	97,737	93,317	349,812
1981/82	161,516	21,373	126,965	118,603	428,696
1982/83	194,516	27,713	139,275	114,108	475,612
1983/84	176,498	15,210	122,139	73,272	387,119
1984/85	141,200	34,800	177,300	163,600	516,900
1985/86	240,300	27,500	149,200	145,200	562,200
1986/87	190,700	16,400	70,900	94,200	372,200
1987/88	234,400	23,700	183,700	163,200	505,000
1988/89	161,000	12,800	69,400	95,100	338,300
1989/90	383,766	50,335	198,580	330,235	962,916
1990/91	483,347	58,880	206,854	353,095	1,102,176
1991/92	531,582	43,906	314,396	292,465	1,182,349
1992/93	667,586	116,008	256,021	353,434	1,393,049
1993/94	705,075	66,066	330,643	454,572	1,556,356

Note: 1993/1994 data are budgeted expenditures.
Source: DGWRD (1969-1994).

Appendix Table 5. Irrigation development expenditures at 1975/76 prices, Indonesia, 1969/70-1993/94

Year	New system construction	Swamp and tidal	Rehabilitation	River and flood control	Total expenditure
	million Rupiah				
1969/70	10,066	10,993	14,345	3,664	39,068
1970/71	7,739	10,739	13,331	1,527	33,336
1971/72	7,180	9,881	13,927	1,394	32,312
1972/73	7,289	9,515	14,880	1,869	33,553
1973/74	6,024	8,917	17,229	1,446	33,616
1974/75	15,737	4,680	12,770	18,727	51,914
1975/76	27,387	15,736	19,684	35,445	98,252
1976/77	35,800	8,264	25,233	42,262	111,559
1977/78	46,983	9,942	33,913	50,040	140,878
1978/79	59,807	11,445	47,133	61,340	179,725
1979/80	63,020	13,787	47,414	56,178	180,399
1980/81	72,297	13,518	52,830	50,442	189,087
1981/82	75,941	10,034	59,608	55,682	201,265
1982/83	81,387	11,595	58,274	47,744	199,000
1983/84	65,370	5,633	45,237	27,138	143,378
1984/85	50,791	12,518	63,777	58,849	185,935
1985/86	77,416	8,871	48,129	46,839	181,354
1986/87	57,440	4,940	21,355	28,373	112,108
1987/88	60,733	6,141	21,687	42,285	130,845
1988/89	34,211	2,720	14,747	20,208	71,886
1989/90	100,988	13,245	52,257	86,902	253,392
1990/91	113,676	13,840	48,623	82,999	259,079
1991/92	107,971	8,918	63,857	59,403	240,149
1992/93	125,258	21,766	48,037	66,314	261,375
1993/94	127,160	11,915	59,631	81,982	280,687

Appendix Table 6. Area completed under irrigation development programs, Indonesia, 1969/70-1993/94

Year	New system construction	Swamp and tidal	Rehabilitation	River and flood control	Total area
	million Rupiah				
1969/70	43,153	21,059	210,330	73,259	347,801
1970/71	24,379	25,000	171,549	62,406	283,334
1971/72	46,400	14,905	134,754	57,045	254,104
1972/73	45,834	61,562	172,444	55,875	335,715
1973/74	31,480	56,140	263,469	40,853	391,942
1974/75	20,684	8,154	108,956	79,278	217,072
1975/76	88,522	34,368	105,143	140,122	368,155
1976/77	63,435	26,190	116,893	114,934	321,452
1977/78	41,157	27,246	112,015	130,484	310,902
1978/79	112,144	83,244	84,833	148,907	429,128
1979/80	122,541	71,226	95,133	139,984	428,884
1980/81	113,124	117,321	111,803	137,079	479,327
1981/82	118,006	108,690	94,413	141,037	462,146
1982/83	57,128	124,024	69,142	121,005	371,299
1983/84	25,391	33,244	24,160	39,363	122,158
1984/85	48,000	60,500	43,560	61,200	213,260
1985/86	44,100	33,400	29,040	54,500	161,040
1986/87	43,700	4,800	24,700	34,100	107,300
1987/88	40,100	16,600	34,400	72,100	163,300
1988/89	22,000	5,000	20,000	34,000	76,500
1989/90	102,849	135,144	171,714	73,637	483,344
1990/91	83,455	43,912	236,852	78,284	450,783
1991/92	77,309	60,365	262,075	118,266	518,015
1992/93	64,182	n.a.	282,448	91,000	437,630
1993/94	98,740	155,662	212,208	93,445	560,055

Note : 1993/1994 data are targeted areas.
n.a. = data not available.
Source : DGWRD (1969-1994).

Appendix Table 7. Total irrigation development expenditure by type of development, Repelita I through Repelita IV.

Five-Year development plan/type of development	Current cost Rp billion	Real cost[a] Rp billion	Percented distribution
Repelita I (1969-73)	114.4	171.9	100.0
Rehabilitation	50.0	73.7	42.3
New construction	25.0	38.3	22.3
Swamp/Tidak	33.1	50.0	29.1
River and flood control	6.4	9.9	5.7
Repelita II (1974-78)	617.1	582.3	100.0
Rehabilitation	147.6	138.8	23.8
New construction	197.3	185.7	31.9
Swamp/Tidak	152.3	50.1	8.8
River and flood control	219.9	207.8	35.7
Repelita III (1979-83)	1,908.2	913.1	100.0
Rehabilitation	556.3	263.4	28.8
New construction	759.8	358.0	39.2
Swamp/Tidak	109.7	54.6	6.0
River and flood control	482.4	237.2	26.0
Repelita IV (1984-88)	2,294.6	748.2	100.0
Rehabilitation	550.5	179.5	24.0
New construction	967.6	315.5	42.2
Swamp/Tidak	115.2	37.6	5.0
River and flood control	661.3	215.6	28.8

Note: [a] Constant 1975/76 rupiah.
Source: Ministry of Public Works, DGWRD, 1988.

Appendix Table 8. Physical area completed, by type of development, Repelita I through Repelita IV.

Type of development	Repelita I 1969-73	Repelita II 1974-78	Repelita III 1979-83	Repelita IV 1984-88
	'000 hectare			
Rehabilitation	953.5	527.8	394.7	151.7
New construction	191.2	325.9	436.2	197.9
Swamp/Tidal	178.7	179.2	454.5	120.3
River and flood control	289.4	613.7	578.5	256.0

Source: Ministry of Public Works, DGWRD, 1988.

Appendix Table 9. Irrigation development expenditures by type of development, planned and actual Repelita IV.

Type of development	Plan	Actual					
	1984/85-1988/89	1984/85	1985/86	1986/87	1987/88	1988/89	Total
		Rp billion					
Rehabilitation	1,265.0	177.3	149.2	70.9	83.7	69.4	550.5
New constructure	3,131.4	141.2	240.3	190.7	234.4	161.0	967.6
Swamp/Tidal	271.5	34.8	27.5	16.4	23.7	12.8	115.2
River and flood control	1,665.6	163.6	145.2	94.2	163.2	95.1	661.3
Total	6,333.5	516.9	562.2	372.2	505.0	338.3	2,294.6

Source: Ministry of Public Works, DGWRD, 1989.

Appendix Table 10. Physical area planned, completed and projected, by type of development, Repelita IV.

Type of Development	Plan	Actual					
	1984/85-1988/89	1984/85	1985/86	1986/87	1987/88	1988/89	Total
		Rp billion					
Rehabilitation	360.0	43.6	29.0	24.7	34.4	20.0	151.7
New constructure	600.0	48.0	44.1	43.7	40.1	22.0	197.9
Swamp/Tidal	460.0	60.5	33.9	4.8	16.6	5.0	120.3
River and flood control	500.0	62.2	54.5	34.1	72.2	34.0	256.0

Source: Ministry of Public Works, DGWRD, 1989.

Appendix 1. Data and estimation procedures

Provincial area, yield, technology, and price data from the Central Bureau of Statistics, for the years 1969-85, were aggregated on an eight region basis, including East, Central, and West Java, North Sumatera, other Sumatera, South Sulawesi, other Sulawesi, and other Indonesia. Provincial fertilizer use for total food crops was taken from PUSRI. Allocation of total fertilizer use to individual crops was based on the annual Survey of Agriculture.

The time series data for the three regions on Java were then pooled, as were the data for the five regions off-Java. Regional dummy variables were included in the area and yield functions, and the functions were estimated using ordinary least squares.

Many studies of food demand parameters in Indonesia have been completed. This study therefore did not undertake a full-fledged attempt to econometrically estimate a complete set of demand parameters. Instead, the model relies largely on a synthesis of existing studies to develop a set of own and cross price and income elasticities for rice, corn, soybean, cassava, sugar, and wheat.

The elasticities of demand for rice are based on econometric estimates using the 1981 SUSENAS data. These estimates of rice demand parameters from cross sectional data represent long-run elasticities. The estimated elasticities for rice were thus adjusted downward to obtain short-run elasticities appropriate for the model.

For other crops, already completed demand studies were reviewed. The relationships between rice demand parameters and non-rice demand parameters from these studies were then used to make proportional adjustments from the rie demand parameters to develop estimates of the demand parameters for the other crops.

The model also accounts for Indonesia's impact on the world rice market. The small country assumption does not hold for Indonesia in the world rice market. The size of Indonesia's imports (or exports) affects world rice prices (Timmer, 1986). The model therefore incorporates a long-run world price flexibility coefficient with respect to Indonesian net imports. The long-run world price increases as Indonesian net imports increase.

The model can be operated assuming either fixed domestic rice prices, or flexible domestic rice prices which are adjusted as long-run world rice prices change due to Indonesia's import position. In the analysis presented here, the flexible domestic rice price policy is utilized. Prices of other commodities and inputs are assumed to remain constant in the simulations.