Rice Buffer Stocks for Indonesia: A First Approximation

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by

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THE PROBLEM

Indonesia has had to import large and growing amounts of rice and other cereals throughout the 1970s. In 1973-74 short supply pushed world prices of rice and other cereals to very high levels. Since then, internationally traded supply has eased considerably, and prices have returned to more normal levels. At the same time, production of rice in Indonesia appeared to have stabilized in the 1975-77 period, although in 1978 good weather and low incidence of insect attack helped production to reach record levels.

Since 1967-68, political and economic stability appears to have been the priority objective of the Indonesian government.[1/] For food policy this goal has geen approached through legislation of minimum farm-gate paddy prices and maximum wholesale rice prices. The Grain Stock Authority (BULOG) has the task of providing rice supplies to assure that the rice price does not rise above the ceiling level and to purchase rice through regional offices and cooperatives to protect the floor price. BULOG is the sole importer of rice for Indonesia and distributes rice to personnel in the army and civil service regularly. It also provides rice for disaster relief. In general, with domestic prices established within a narrow range, imports and rice stocks become the means of equating supply and demand in Indonesia.

1/ For a discussion of goals in food policy for Indonesia, see: Soetatwo Hadiwigeno and Douglas D. Hedley, "Issues in Food Policy During Indonesia's Third Five Year Plan," paper prepared for the International Association of Agricultural Economists Meetings, Banff, Canada, September 3-12, 1979.

PURPOSES OF THE STUDY

The history and experience of the institutional structures involved with rice stocks, demand, production, and distribution are of particular importance in conditioning possible scenarios for rice reserve stocks for Indonesia. So the paper begins with a review of the historical development of programs and policy actions, prices, production, and trade in rice for Indonesia. Management of rice supplied, both domestically produced and imported, is discussed in relation to national objectives and consumer demands.

A small linear expenditure system (LES) is developed and presented to portray the demand for cereals in Indonesia. This demand is disaggregated by region and into its rural and urban parts to enable sources of demand growth in Indonesia to be explored. On the supply side this paper draws on the area and production projections by Prabowo and Nyberg[2/] which, when coupled with demand projections, can provide estimates of import demand for Indonesia. The instability of production in Indonesia is addressed at length, out of which a model of reserve stock is generated.

The specific objectives of the study are to review the history of the rice stock and import program, to develop and present a model of demand for cereals, to utilize long-term projections of domestic production to assess import requirements of rice, and to define the variability of annual domestic production in rice and use this to assess the application of a rice reserve stock.

2/ Dibyo Prabowo and A. J. Nyberg, "Status of Irrigation in Indonesia as of 1978 and Prospects for 1990 and 2000," paper prepared for the International Food Policy Research Institute/International Fertilizer Development Center Workshop on Food Policy for Southeast Asian Countries, Los Banos, Philippines, May 22-25, 1979.

TRENDS IN PRODUCTION, CONSUMPTION, PRICES, AND TRADE

Virtually all of the material in this section has been described and presented in detail somewhere else. It is only reviewed here.

Table 1 gives area harvested, production, and yield of milled rice, 1953-77, for Indonesia. Simple time-trend analyses of areas harvested and yields are presented in Table 2. Total area of rice harvested in Indonesia expanded by about 43,000 hectares each year during the 1970s, a 0.52 percent rate of growth. This growth represents a 1.32 percent annual growth in sawah (diked rice land) and a 3.46 percent annual decline in ladang (upland rice) harvested. Area harvested of ladang grew consistently during the 1950s and 1960s by 40-43,000 hectares each year (3.0-3.4 percent annually). The area harvested of sawah has grown by about 93,000 hectares each year in the 1970s, up sharply from the growth demonstrated during the previous two decades.

Annual yield increases in Indonesia are now about 3 percent, up substantially from less than 1 percent in early years. This growth in area and yield during the 1970s represents the massive investments in irrigation begun in the first and second five-year development plans (Repelita I and Repelita II, 1969/70-1978/79) as well as the new varieties and associated inputs introduced to Indonesia in 1968. The programs of credit and extension throughout Indonesia, particularly since 1968, have also contributed to the increase of rice yields. The location of rice production has remained stable; during the 1953-57 period, 61.3 percent of Indonesian rice was grown in Java-Madura, whereas during 1973-77, 60.4 percent of the total was grown there. Consequently, growth rates in production are roughly similar in central and outer islands, even though yields off Java are considerably below those of Java-Madura (1.64 tons milled rice compared to 2.13 tons in 1977).

Wetland rice (sawah) harvest is highest in April and May in all four provinces of Java; upland rice harvest usually peaks somewhat earlier (Table 3). The pattern of harvest through the year appears to be changing slightly, with a less pronounced and earlier peak of harvesting. New shorter duration varieties, more intensive cropping of rice, and irrigation improvements probably account for this change, which has been detectable since about 1973.3/

Rice prices are monitored throughout the country. By and large, prices in the major cities of Indonesia move together seasonally (see

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3/ For more discussion see Douglas D. Hedley, "Some Aspects of the Supply of Rice in Indonesia," paper presented at the Western Economics Association Meetings, Honolulu, Ha., June 1978.

Table 4),[4/] so prices for Jakarta only are shown in Table 5. Prices for 25 percent broken white rice (f.o.b. Bangkok) are also shown as a comparison. The domestic rice price was amply protected from the rice in world rice prices in 1974 and 1975. With the exception of 1976, domestic prices are well below international prices. This implies that the government subsidizes all rice imports. With the November 15, 1979 devaluation of the rupiah, world prices are again well above domestic prices.

Seasonal prices for rice closely follow the harvest periods and are tempered by the minimum and maximum prices established by government. Table 6 gives monthly price indexes for selected cities of Indonesia. Prices are low at harvest time, then slowly climb to reach their annual heights just before the early harvesting period. The variation from high month to low month varies considerably from one region to another.

Figure 1 shows annual production and imports of milled rice in Indonesia for 1953-78. The growth in imports through the mid-1950s and early 1960s reflected the political instability of the time. While production expanded slowly, demand ran well ahead of domestic supply. In the 1963-64 period imports increased sharply in anticipation of a ban on imports in the following year. By 1967-68 new policies and opportunities to encourage production and an expansionary economy accelerated both production and imports. Imports increased throughout the 1970s despite spectacular production gains.

The prices, also shown in Figure 1, demonstrate the steady rise in money prices for rice since 1966 and, equally, the almost constant real price for rice for this period.[5/]

4/ Hedley, "Some Aspects of Rice." Low correlations among eastern Indonesian cities are indicative of the low levels of trade among them.

5/ The price for medium-quality rice in Jakarta was deflated by the index of nine basic commodities with rice removed from the index.

Table 1--Area, yield, and production of rice in Indonesia, 1953-77

Year	Total Area	Total Production	Total Yield	Sawah Area	Sawah Production	Sawah Yield	Ladang Area	Ladang Production	Ladang Yield
	(million hectares)	(million tons)	(tons/ hectare)	(million hectares)	(million tons)	(tons/ hectare)	(million hectares)	(million tons)	(tons/ hectare)
1953	6.47	7.31	1.13	5.38	6.58	1.22	1.09	0.73	0.06
1954	6.61	7.78	1.18	5.47	6.54	1.20	1.14	0.89	0.78
1955	6.57	7.55	1.15	5.52	6.80	1.23	1.05	0.75	0.71
1956	6.70	7.60	1.13	5.70	6.92	1.21	1.00	0.68	0.68
1957	6.80	7.63	1.12	5.75	6.89	1.20	1.05	0.77	0.73
1958	6.99	7.98	1.14	5.91	7.22	1.22	1.08	0.74	0.68
1959	7.15	8.29	1.16	5.94	7.36	1.24	1.22	0.90	0.74
1960	7.28	8.77	1.20	5.97	7.74	1.29	1.31	1.03	0.79
1961	6.86	8.27	1.21	5.58	7.25	1.30	1.27	1.02	0.80
1962	7.18	8.90	1.22	5.84	7.72	1.32	1.45	1.17	0.81
1963	6.73	7.94	1.18	5.33	6.93	1.30	1.40	1.01	0.72
1964	6.98	8.42	1.21	5.48	7.27	1.33	1.50	1.15	0.77
1965	7.33	8.88	1.21	5.88	7.78	1.32	1.45	1.09	0.75
1966	7.69	9.03	1.17	6.01	8.07	1.34	1.68	1.27	0.76
1967	7.52	9.05	1.20	5.99	7.96	1.33	1.52	1.09	0.72
1968	8.02	10.17	1.27	6.36	8.94	1.41	1.66	1.22	0.74
1969	8.01	10.64	1.33	6.54	9.56	1.46	1.47	1.08	0.74
1970	8.14	12.17	1.50	6.68	11.07	1.66	1.46	1.10	0.76
1971	8.32	13.72	1.65	6.89	12.64	1.83	1.43	1.08	0.76
1972	7.90	13.18	1.67	6.60	12.17	1.84	1.30	1.01	0.78
1973	8.40	14.61	1.74	7.06	13.47	1.91	1.34	1.14	0.85
1974	8.51	15.23	1.80	7.34	14.32	1.95	1.39	0.96	0.69
1975	8.50	15.18	1.79	7.33	14.18	1.93	1.17	1.01	0.86
1976	8.36	15.84	1.88	7.23	14.71	2.04	1.16	1.00	0.86
1977	8.36	15.88	1.90	7.20	14.83	2.06	1.16	1.05	0.90
1978		17.50[a]							

Source: Data obtained from the Biro Pusat Statistik (Central Statistical Office), Jakarta.

Note: All rice is in milled rice form. Conversion from "dry stalk paddy" to milled rice is 100:52. "Sawah" refers to diked rice land; "ladang" refers to upland rice. Methods of computing area harvested, production, and yield changed substantially between September 1969 and January 1970. No attempt has been made to adjust for this difference. For a discussion of this see: Alfian Lains, "Regional Concentration of Rice Production in Indonesia" (Ph.D. dissertation, University of the Philippines at Diliman, 1978).

a/ Preliminary.

Table 2--Time-trend analyses of area harvested and yields of rice in Indonesia, 1953-77

Years	Constant	Percent Annual Growth Rate	S	R^2
		Area Harvested (Sawah Plus Ladang)		
1970-77	43.60	0.52	28.77	0.277
1953-69	83.57	1.17	11.88	0.768
1953-67	67.17	0.96	13.00	0.673
		Area Harvested (Sawah Only)		
1970-77	92.95	1.32	29.52	0.623
1953-69	43.76	0.75	12.70	0.442
1953-67	23.98	0.42	13.20	0.203
		Area Harvested (Ladang Only)		
1970-77	-45.00	-3.46	9.70	0.782
1953-69	39.81	3.03	4.68	0.828
1953-67	43.19	3.37	5.23	0.840
		Yield (Sawah Plus Ladang)		
1970-77	0.0520	2.99	0.0057	0.933
1953-69	0.0082	0.69	0.0017	0.602
1953-67	0.051	0.44	0.0016	0.458
		Yield (Sawah Only)		
1970-77	0.0495	2.60	0.0068	0.898
1953-69	0.0137	1.06	0.0014	0.859
1953-67	0.0111	0.87	0.0013	0.854
		Yield (Ladang Only)		
1970-77	0.173	2.14	0.0085	0.409
1953-69	0.026	0.35	0.0029	0.101
1953-67	0.039	0.52	0.0026	0.149

Note: Sawah refers to diked rice and ladang refers to upland rice. For area harvested, the numbers represent thousands of hectares growth in area annually. For yield, the numbers represent tons per hectare change in yield annually. The associated standard error(s) represents thousands of hectares and tons per hectare.

Percent annual growth rate is measured as the mean of the area harvested or yield for the years included in the trend.

Table 3--Monthly indexes of area harvested of rice in the province of Java-Madura, 1972-77

Month	West Java			Central Java			Yogyakarta			East Java		
	Sawah	Ladang	Total	Sawah	Ladang	Total	Sawah	Ladang	Total	Sawah	Ladang	Total
January	25	76	28	35	296	44	57	375	149	14	148	21
February	37	287	53	66	342	76	56	417	159	23	398	41
March	97	462	123	141	263	146	124	233	156	96	335	109
April	202	277	210	201	107	197	219	154	200	328	206	323
May	235	77	223	208	63	203	185	1	131	320	70	307
June	126	10	118	139	7	135	102	...	72	128	11	122
July	64	5	59	114	3	110	71	6	81	54	2	51
August	82	1	75	107	2	103	88	...	60	40	3	58
September	116	1	107	88	3	85	112	...	82	53	2	50
October	105	1	97	48	1	45	75	...	33	60	2	57
November	63	1	59	33	9	32	58	...	42	44	12	42
December	39	5	37	27	105	30	54	19	44	23	11	22

Source: Adapted from Douglas D. Hedley, "Some Aspects of the Supply of Rice in Indonesia," paper presented at the Western Economics Association Meetings, Honolulu, Ha., June 1978.

Table 4--Simple correlations among indexes of monthly moving average prices for rice in selected cities of Indonesia, 1971-77

	Java			
	Jakarta	Bandung	Semarang	Yogyakarta
Bandung	0.91	1.00		
Semarang	0.86	0.93	1.00	
Yogyakarta	0.86	0.91	0.97	1.00
Surabaya	0.85	0.92	0.95	0.94

	Kalimantan			
	Pontianak	Banjarmasin	Balikpapan	Samarinda
Banjarmasin	0.62	1.00		
Balikpapan	0.83	0.51	1.00	
Samarinda	0.86	0.53	0.93	1.00
Jakarta	0.67	0.68	0.57	0.55
Surabaya	0.65	0.54	0.57	0.54

	Sumatera						
	Banda Aceh	Medan	Padang	Palembang	Jambi	Bengkulu	Lampung
Medan	0.83	1.00					
Padang	0.69	0.59	1.00				
Palembang	0.51	0.44	0.70	1.00			
Jambi	0.67	0.60	0.70	0.49	1.00		
Bengkulu	0.58	0.56	0.80	0.73	0.75	1.00	
Lampung	0.56	0.45	0.72	0.57	0.77	0.77	1.00
Jakarta	0.50	0.45	0.66	0.36	0.77	0.66	0.61

	Other Islands					
	Menado	Ujung Pandang	Denpasar	Mataram	Kupang	Ambon
Ujung Pandang	0.17	1.00				
Denpasar	0.12	0.03	1.00			
Mataram	0.57	0.34	0.57	1.00		
Kupang	0.66	0.20	0.20	0.36	1.00	
Ambon	0.36	0.06	0.24	0.29	0.45	1.00
Jakarta	0.69	0.30	0.30	0.55	0.58	0.05
Surabaya	0.71	0.40	0.46	0.73	0.58	0.11

Source: Douglas D. Hedley, "Some Aspects of the Supply of Rice in Indonesia," paper presented at the Western Economics Association Meeting, Honolulu, Ha., June 1978.

Table 5--Prices of medium-quality rice in Jakarta and white rice, 25 percent broken, f.o.b. Bangkok, 1968-78

Year	Jakarta (Medium-Quality Rice)			Bangkok (White 25 Percent Broken)	
	Current Rupiah	Deflated Rupiah a/	Dollars b/		
	(Rp/kilogram)	(Rp/kilogram)	(US$/ton)	(Baht/ton)	(US$/ton) c/
1968	39.44	160.15	125.21	4,788.60	233.59
1969	30.71	98.75	97.49	4,010.40	195.63
1970	35.59	103.01	112.98	3,101.40	151.29
1971	31.86	84.13	75.86	2,307.00	112.54
1972	36.92	91.38	87.90	2,505.60	122.22
1973	57.09	105.38	135.93	3,556.20	173.47
1974	61.04	75.86	145.33	9,861.00	481.02
1975	77.68	95.74	184.95	6,182.34	301.58
1976	93.22	105.78	221.95	4,444.00	216.78
1977	92.42	95.34	220.05	n.a.	n.a.
1978 d/	95.90	95.90	228.33	n.a.	n.a.

a/ An index of eight basic commodities (not including rice) is readjusted so that 1977 = 100 and then used to deflate monthly rice prices. These prices are then averaged for each year.

b/ An exchange rate of US$ 1.00 = Rp 420 is used for 1971-78; for earlier years the rate is US$ 1.00 = Rs 315.

c/ Any exchange rate of US$ 1.00 = Baht 20.5 is used.

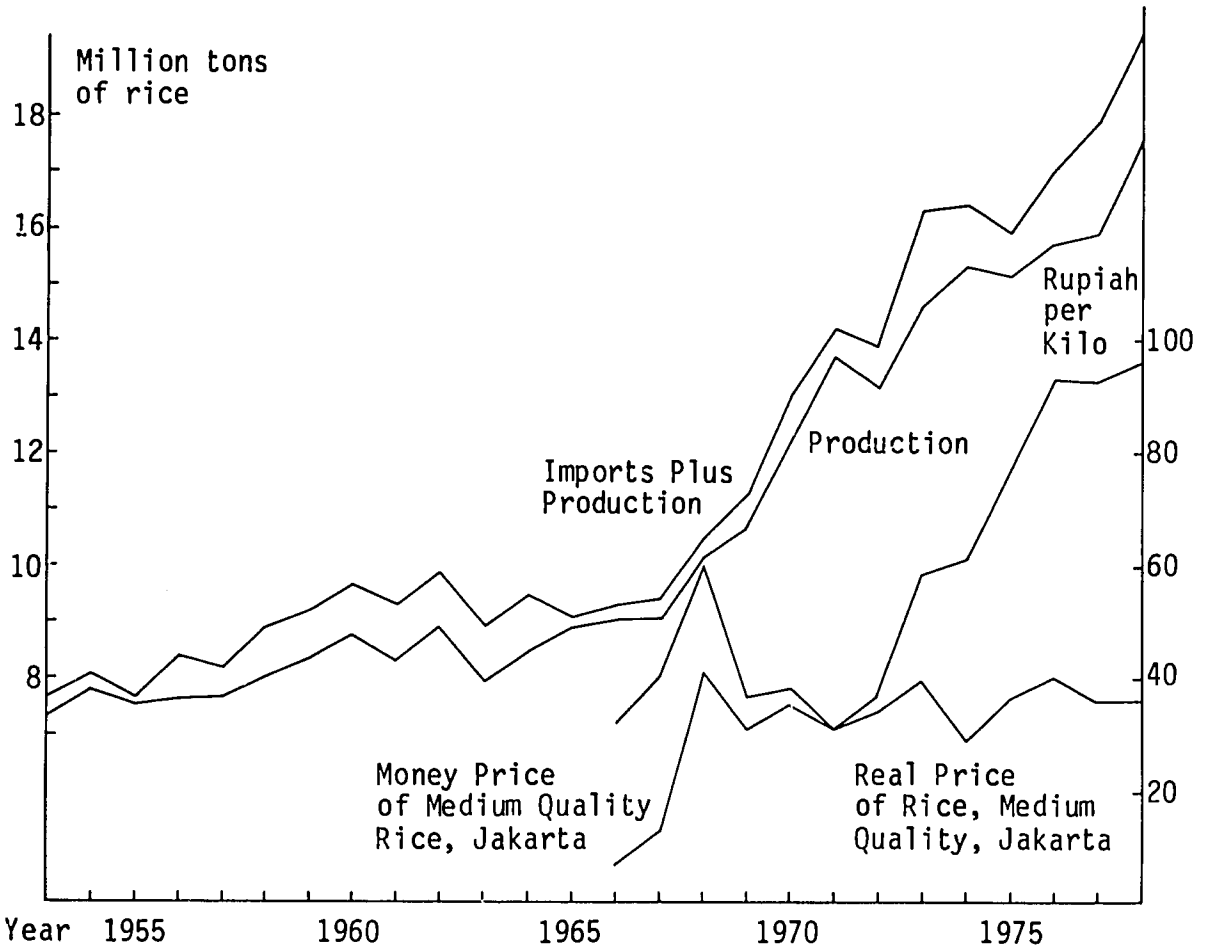
d/ First nine months only.

Table 6--Average monthly indexes of rice prices in selected cities, Indonesia, 1968-72 and 1974-77

City	January	February	March	April	May	June	July	August	September	October	November	December
Jakarta	106.7	105.4	104.0	99.2	94.6	91.0	92.6	94.9	97.9	98.2	103.5	107.8
Semarang	106.1	102.9	99.8	92.9	91.0	91.0	92.8	95.3	98.7	100.6	107.2	112.2
Yogyakarta	107.7	104.9	99.0	91.5	89.2	90.5	93.5	95.1	96.7	102.0	109.9	112.1
Surabaya	107.5	105.7	103.1	92.8	89.0	89.7	93.1	94.8	100.9	101.9	106.0	108.3
Banda Aceh	109.6	99.1	96.9	94.8	95.6	94.7	92.3	94.4	102.6	102.4	104.7	106.9
Medan	101.9	96.7	90.5	94.9	97.9	97.5	99.3	100.0	102.8	105.6	104.2	104.3
Padang	106.0	107.1	99.8	104.6	103.1	98.9	97.5	97.9	94.4	92.7	95.4	100.8
Palembang	98.7	104.8	103.4	101.7	101.2	99.7	99.0	104.8	102.3	97.2	93.1	92.0
Lampung	107.3	106.0	100.6	94.5	93.6	90.6	93.3	102.1	103.5	100.6	100.1	107.3
Pontianak	100.5	98.7	98.7	96.0	97.8	96.6	98.5	100.0	101.2	101.0	105.4	105.3
Banjarmasin	99.4	111.4	109.3	108.2	106.4	105.7	106.0	88.7	82.2	86.7	90.6	97.3
Balikpapan	103.7	101.0	98.6	99.1	97.0	96.0	97.2	98.2	100.1	104.2	104.0	102.8
Samarinda	101.9	101.0	99.9	98.9	97.8	95.7	95.4	99.2	104.8	104.7	105.3	102.7
Ujung Pandang	105.7	104.6	102.5	101.5	97.4	92.8	100.5	100.0	98.6	99.3	95.0	100.7
Denpasar	101.0	103.9	101.1	103.0	99.6	93.3	92.2	93.7	98.6	102.9	102.4	99.8

Source: Douglas D. Hedley, "Some Aspects of the Supply of Rice in Indonesia," paper presented at the Western Economics Association Meetings, Honolulu, Ha., June 1978.

Figure 1--Production, imports, and prices of rice, Indonesia, 1953-78.



DEMAND

The Indonesian government has maintained a ceiling price for rice throughout the country since the 1960s. To implement this policy, BULOG stands ready to sell rice in urban markets if prices reach this maximum acceptable price. The general result is that imports are used to equalize supply and demand within an acceptable range of prices. The market is not allowed to establish imports and prices simultaneously.

The reluctance to use product price to clear markets over the past decade can be attributed to the massive implications for distribution of changes in rice prices within the country. To examine the impact of a change in cereal prices on the expenditure patterns in Indonesia, a small LES was estimated for Java and off Java, broken down by rural and urban populations. The model is described in Appendix 1. The LES was estimated using aggregate data from the SUSENAS (Household Expenditure Survey) conducted by the Central Bureau of Statistics, Jakarta, in 1976. The data are drawn from Round II covering the period of May-August 1976. Earlier estimates derived from Round I (January-April 1976) based on aggregate data gave results in accord with a priori evidence. For example, the overall expenditure elasticity for cereals in Round II is about 0.55, whereas for Round I the estimate is 0.68, above even the 1960 estimate derived by Timmer.7/

Following Mellor's method,8/ the income effect a 10 percent increase in cereal price has on spending in each of the commodity categories is explored in Table 7. However, unlike in Mellor's analysis the cross elasticities of demand between the commodity categories and cereal price are not assumed to be zero. These cross elasticities are presented in Table 10. To account for these cross elasticities, the net change in each expenditure category is calculated for a 10 percent increase in cereal prices (Table 8). In effect, this shows the rearrangement of money expenditures resulting from the increase. Table 9 presents the expenditure elasticities derived from the LES model for each commodity category and by location in Indonesia. Unfortunately, the expenditure elasticities cannot as yet be broken down by income class. The differences in mean incomes between locations can, however, provide some insights into the change in elasticities as income rises.

7/ C. Peter Timmer, "Estimating Rice Consumption," Bulletin of Indonesian Economic Studies 7 (July 1971).

8/ John W. Mellor, "Food Price Policy and Income Distribution in Low Income Countries," Economic Development and Cultural Change 27 (October 1978): 1-26.

In urban Java the income effect of a 10 percent rise in cereal prices is borne about equally between food and nonfood expenditures. However, for all others in Indonesia, food expenditures absorb most of this income effect. Cereal expenditures decline sharply outside Java and in rural Java and change little in urban Java. Expenditures of urban consumers appear to be most deeply affected in the protein food (meat, fish, milk, and eggs) and housing categories. The largest declines in the expenditures of rural consumers are in food commodity groups. The decline of expenditures for rural groups is proportionally larger than for urban groups.

A tentative conclusion from the tables is that nutrition is likely to worsen as cereal prices rise. This effect will be most pronounced in rural areas. It will be softened, however, by the increase in farm prices that is likely to accompany an increase in consumer prices. The issue becomes how much of the rural population will have their real incomes increase if the price of cereals increases? It is an exceedingly difficult question to answer. Clearly, only the incomes of net producers of rice will increase if the price of rice increases. The difficulty is in trying to determine what proportion of the rural population produces a marketable surplus and identifying the changes that occur. Booth and Sundrum show that farm size has declined in Java and Sumatera and increased elsewhere.[9/] White suggests that landlessness is probably increasing as tenant sharecroppers are denied access to land.[10/] These trends suggest that benefits of an increase in rice price will go to an ever smaller group of producers in the rural sector unless resources are redistributed. Soejono notes that farm incomes appear to have been becoming more evenly distributed over the 1968-74 period.[11/] However, his survey covers only "farmers," presumably those who own or control land. Another point he makes is that nonfarm income is doing more to make income distribution equitable than is the return from paddy production. This is an important point for policymakers concerned with using the price of rice as a redistributional tool.

Returning to consideration of the urban groups, Sundrum points out that income distribution is worsening in urban areas of Java.[12/] Further, the data he presents suggest that the incomes of the poorer 80 percent of the urban population of Java increased at a rate lower than the average for urban Java between 1970 and 1976.

Cereal imports to Indonesia through BULOG have been the subject of almost continuous political debate in the 1970s. In effect,

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9/ Anne Booth and R. M. Sundrum, "The 1973 Agricultural Census," Bulletin of Indonesian Economic Studies 12 (July 1976).

10/ B. White, "Political Aspects of Poverty, Income Distribution and Their Measurement: Some Examples from Rural Java," Development and Change 10 (January 1979).

11/ I. Soejono, "Growth and Distributional Changes of Incomes in Paddy Farms in Central Java, 1968-74," Bulletin of Indonesian Economic Studies 12 (July 1976).

12/ R. M. Sundrum, "Changes in Consumption Patterns in Urban Java," Bulletin of Indonesian Economic Studies 13 (July 1977).

imports have been the means of balancing supply and demand for cereals in Indonesia within the price ranges prescribed by the government. Some crude projections of demand can be made for Indonesia based on the demand model estimated above.

Mears estimates consumption of rice for 1978 to be 121 kilograms per capita.[13/] His estimate is based on the disappearance of rice calculated as production plus imports less BULOG stock changes less seed and losses. Of this amount of rice consumed, 14 kilograms per capita came from imports.

To maintain imports at the 1978 level, about 2 million tons, production must increase annually by at least 6.5 percent and possibly as much as 7.0 percent.[14/] This is substantially above the 3.77 percent rate at which production grew during the last decades. Lower rates of growth imply sharp increases in imports or prices.

It is of interest to examine the amount the price of rice must increase to lower the quantity demanded so that imports can be held constant. The retail price elasticity of demand found from the LES model is -0.73. Production growth between 1968/69 and 1977/78 was 3.77 percent annually. At this rate of growth, it is estimated that 21.9 million tons will be produced in 1984. After adjusting for imports of 2 million tons, losses, and feed use, it is estimated that consumption will be 21.6 million tons or 136 kilograms per capita (at an annual population growth rate of 2.1 percent). To reach this level of quantity demanded, the price would have to rise by about 25 percent. This price increase is, in all likelihood, unacceptably large for policymakers in Indonesia. It can be noted that, while the overall demand elasticity is -0.73, there are sharp differences between regions and classes of the population.[15/] Urban consumers appear to resist changing rice consuming response to a large price rise.

13/ Leon Mears and Sidik Moeljono, "Food Policy," November 1978. (Mimeographed.) The losses are estimated to be 6.5 percent of production. Mears also presents information on a loss rate of 4.5 percent. He uses the same basic methodology shown here, although his projections of demand are lower.

14/ This rate is the annual growth rate in production to reach total demand less imports plus seed use on a projected 9 million hectares (38.286 kilograms per hectare), adjusted by 6.5 percent loss and 1.5 percent annual feed use. This method is suggested in Mears and Moeljono, "Food Policy."

15/ Direct price elasticities of demand (quantity) for cereals can be found from the first line of Table 10, as one minus the price elasticity for cereals (expenditures).

Table 7--Decrease in per capita monthly expenditures by commodity because of the income effect of a 10 percent increase in cereal prices, Indonesia, 1976

Commodity	Java-Madura		Off Java-Madura	
	Urban	Rural	Urban	Rural
Cereals	4.68	21.89	13.18	30.93
Meat, fish, milk, eggs	22.01	17.77	29.06	26.20
Vegetables, pulses, fruit	10.43	13.12	15.84	17.79
Other food	16.43	18.37	22.15	24.86
Tobacco	5.59	8.49	7.69	8.92
Housing, light, fuel, water	27.12	9.59	29.59	9.60
Clothing	4.19	5.76	5.97	8.09
Durables	4.75	8.96	6.47	7.90
Festivals	0.61	3.53	0.45	3.44
Miscellaneous	20.89	8.95	18.07	8.14
Total food	59.14	79.64	87.93	108.69
Total nonfood	57.56	36.79	60.88	37.17
Total	116.70	116.43	148.47	145.86
Per capita monthly expenditures	6,939.99	3,479.37	6,504.03	4,753.68
Population proportion	0.1144	0.5168	0.0658	0.3030

Source: The data are from the Biro Pusat Statistik, Jakarta.

Note: The values in the table are products of the expenditure proportions and the expenditure elasticity of each commodity category, the mean expenditure on cereals, and the proportionate rise in cereal prices. Monthly per capita expenditures on cereals were 1,166.86 in urban Java-Madura; 1,164.27 in rural Java-Madura; 1,484.73 in urban areas off Java-Madura; and 1,459.51 in rural areas off Java-Madura. The expenditure elasticities were estimated using a linear expenditure system (LES) model applied to data from Indonesia, Biro Pusat Statistik, Survey Sosial Ekonomi Nasional (SUSENAS), Round II, May-August 1976 (Jakarta: Biro Pusat Statistik). (See Table 3.)

Table 8--Net change in per capita monthly expenditures by commodity because of a 10 percent increase in cereal prices, Indonesia, 1976

Commodity	Java-Madura		Off Java-Madura	
	Urban	Rural	Urban	Rural
Cereals	88.26	47.61	83.13	38.15
Meat, fish, milk, eggs	-17.34	-8.95	-18.29	-8.69
Vegetables, pulses, fruit	-8.22	-6.61	-9.97	-5.90
Other food	-12.95	-9.25	-13.94	-8.25
Tobacco	-4.40	-4.27	-4.84	-2.96
Housing, light, fuel, water	-21.37	-4.83	-18.63	-3.19
Clothing	-3.30	-2.90	-3.75	-2.68
Durables	-3.74	-4.51	-4.07	-2.62
Festivals	-0.48	-1.78	-0.28	-1.14
Miscellaneous	-16.46	-4.51	-11.37	-2.70
Per capita monthly expenditures	6,939.99	3,479.37	6,504.03	4,753.68
Population proportion	0.1144	0.5168	0.0658	0.3030

Source: The data are from the Biro Pusat Statistik, Jakarta.

Notes: The values in the table are found from the product of the expenditure on a commodity, the cross-elasticity (quantity) of demand with respect to price of cereals, and the proportionate change in cereal prices. The elasticities were estimated using a linear expenditure system (LES) model, applied to data from Indonesia, Biro Pusat Statistik, Survey Sosial Ekonomi Nasional, Round II, May-August, 1976 (Jakarta: Biro Pusat Statistik). (See Table 4.)

Table 9--Expenditure elasticities by commodity, Indonesia, 1976

Commodity	Java-Madura		Off Java-Madura	
	Urban	Rural	Urban	Rural
Cereals	0.2385	0.5618	0.3889	0.6903
Meat, fish, milk, eggs	1.3381	1.6561	1.1828	1.2392
Vegetables, pulses, fruit	0.8563	1.0236	1.1123	1.0977
Other food	0.9404	0.8839	0.9949	0.9510
Tobacco	0.8846	1.2411	0.9440	1.0813
Housing, light, water, fuel	1.2499	0.9746	1.2857	1.0451
Clothing	1.0465	1.2891	1.1029	1.1762
Durables	1.9307	2.4816	2.0739	1.9240
Festivals	1.0551	1.6553	0.7479	1.6207
Miscellaneous	1.3126	1.4339	1.3678	1.1444
Food	0.8209	0.8835	0.8526	0.9326
Nonfood	1.2889	1.3993	1.3351	1.2642

Source: The data are from Biro Pusat Statistik, Jakarta.

Note: The elasticities were derived from a linear expenditure system (LES) model estimated using data from Indonesia, Biro Pusat Statistik, Survey Sosial Ekonomi Nasional, Round II, May-August 1976.

Table 10--Cross-elasticities of demand with respect to price of cereals by commodity, Indonesia, 1976

Commodity	Java-Madura		Off Java-Madura	
	Urban	Rural	Urban	Rural
Cereals a/	0.7564	0.1653	0.2613	0.2614
Wheat, fish, milk, eggs	-0.1773	-0.2791	-0.1699	-0.1262
Vegetables, pulses, fruit	-0.1135	-0.1725	-0.1598	-0.1118
Other food	-0.1246	-0.1489	-0.1429	-0.0969
Tobacco	-0.1172	-0.2092	-0.1355	-0.1102
Housing, fuel, light, water	-0.1656	-0.1642	-0.1847	-0.1064
Clothing	-0.1386	-0.2170	-0.1584	-0.1198
Durables	-0.2561	-0.4183	-0.2979	-0.1959
Festivals	-0.1388	-0.2790	-0.1074	-0.1650
Miscellaneous	-0.1739	-0.2417	-0.1965	-0.1166

Source: The data are from Biro Pusat Statistik, Jakarta.

Note: The elasticities were derived from a linear expenditure system (LES) model estimated using data from Indonesia, Biro Pusat Statistik, Survey Sosial Ekonomi Nasional, Round II, May-August 1976.

a/ The elasticity reported in this row is the direct price (cereals) elasticity of demand (expenditure). This is calculated as one minus the direct price (cereals) elasticity of demand (quantity).

RICE SUPPLY

The supply of rice from domestic production in Indonesia rose steadily during the 1970s. Growth of production can be attributed to several factors, including the expanded and refined programs of extension and supervised credit, the expansion of irrigation facilities, and the stability of prices. However, these factors cannot satisfactorily explain rice production in Indonesia.

In most places where water control exists, whether fully irrigated or rainfed only, rice will be grown. The new varieties of shorter stature and maturity can be cropped more intensively where a supplementary water supply permits a second crop. In general rice is grown whenever there is a reasonable assurance that a crop can be harvested. In the past, rice generated the highest net income per hectare for producers when water was available. Other crops can yield an equally high net income, though usually during drier parts of the year. The result is that rice production tends to expand as the factors of production expand as technology permits. Additionally, year-to-year variations in domestic production are generated largely by differences in rainfall and the incidence of insects and diseases.

A careful appraisal of rice production in the provinces and regions of Indonesia reveals no significant response to price between 1968 and 1978. Several formulations of the "adaptive expectations" supply function failed to yield significant coefficients of real prices for seasonal and annual models. A significant coefficient associated with the money price of rice can be found, but this results more from the upward trend of inflation in rice prices coupled with an upward trend in production and area rather than from a cause-and-effect relationship between the production and price of rice.

One might argue that with governmental control over the prices of rice in Indonesia farmers are not responding in an "adaptive expectations" manner. Farmers may respond to current prices alone rather than to a weighted sum of current and past prices. Again, virtually no correlation between current real prices and production or area of rice is to be found.

Two authors have attempted to estimate supply functions using a price variable taken in relation to other crops. Pitt assembled a relative profitability index for rice to display the net income of rice in relation to the most competitive crop alternative.[16/]

16/ M. Pitt, "Economic Policy and Agricultural Development in Indonesia," (Ph.D. dissertation, University of California at Berkeley, 1977).

Between 1956 and 1972 he found that area responded significantly to profitability in a Schiller lag formulation of the supply curve for both sawah and ladang rice. He found that area planted with sawah responded significantly and negatively to a rainfall variable measured as actual rainfall in the July-September period divided by mean rainfall for this period in central Java. For ladang his rainfall coefficient is positive and significant.

More recently Lains used a double logarithmic formulation of the "adaptive expectations" model to estimate a supply function for rice.17/ His price variable is the ratio between the price of rice and the price of a competing crop in the preplanting period. Price coefficients estimated for the 1966-76 period show no significance by province for wetland or dryland rice. However, his rainfall variable (the amount of rainfall in the three months before planting) is positive and significant for wetland rice but positive and not significant for dryland rice.

The evidence suggests that the price of rice alone cannot explain variations in production, but that these variations may be partly explained by a price variable representing the competitiveness of rice compared to the competitiveness of other crops. The lack of significance in Lain's work may be caused by the form of its functions (double log, disaggregated to provinces) rather than by the variable chosen. Preplanting rainfall increases production, whereas Pitt's work indicates that higher-than-normal rainfall following the peak harvest season decreases production of sawah and increases production of ladang.

Following Pitt and Lains, an attempt was made to utilize the price ratio of rice and corn as an explanatory variable in a supply model. Unfortunately, since 1968 the price of corn has risen more slowly, albeit unsteadily, than the price of rice so that any linear model formulation yields a negative coefficient for the variable of the ratio of rice and corn prices. A simple geometrically lagged supply function for the 1953-67 period does yield a correct sign for the price coefficient, confirming in a rough way the supply function estimated by Pitt with a "crop profitability index" in place of price for the 1956-72 period.18/ Attempts made to introduce other variables into the equation for the 1968-77 period were not successful.

Some success was found by extending the number of years under observation. For the 1967-77 period a positive coefficient corresponding to the ratio of rice and corn prices was found. However, many problems occur in trying to interpret the model. Clearly, the supply responses can be assumed to be different for the years before 1967 than those following because of the chaotic conditions of the time. Additionally, the new high-yielding varieties with the associated inputs and extension began in 1968, thus trans-

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17/ Alfian Lains, "Regional Concentration of Rice Production in Indonesia" (Ph.D. dissertation, University of the Philippines at Diliman, 1978).

18/ Mark Pitt, "Regional Concentration."

forming the entire supply framework. Consequently, the correct sign of the coefficient seems to be based on the inclusion of the earlier years and not on basic tendencies in the data.

Using a rainfall variable to explain regional or national rice production in Indonesia introduces many conceptional difficulties. First of all, Pitt and Lains use different variables to describe weather--one for the preplanting and the other for the postharvest period. Second, Lains uses many weather stations across Java, while Pitt confines his observation to central Java. The area from which weather data is chosen could determine the significance of the result. Third, as in Te's work, a dummy variable for weather can be constructed to include those years in which major storms affected production.19/ However, the major rice-growing areas of Indonesia are not affected by severe storms and typhoons. The only way to distinguish "bad weather years" and "good weather years" is by knowing the size of the rice crop. This becomes the proxy, as it were, for judgments about the weather. The result is circular logic, assuring that a statistically significant result will be found, if Te's approach is followed. As an example, in Figure 1 the weather in 1972 and 1975 is judged to be "dry" because of the smaller rice crop in those years. This logic creates some difficulty for using Te's approach for Indonesia, as poor and good weather years are not readily identifiable if rice crop production is not known. Nonetheless, weather is the major influence causing variations in rice production away from a steady upward trend.

An alternative to directly developing a supply function for rice is to derive the supply function from a production function. Large volumes of micro-level data are just becoming available in Indonesia about the production of rice and other crops. One set of data is generated from the annual sample survey of agriculture. Also, the Biro Pusat Statistik carries out a survey each year of farmers whose fields have been used for yield estimation ("crop cutting survey"). These data as yet have not yielded a reasonable production function for rice, and contain some anomalies. For example, yields produced with no fertilizer appear to be about equal to those produced with large quantities of fertilizer--both nitrogen and phosphate. Also, yields of farmers using insecticide appear to be equal to or smaller than the yields of farmers not using insecticide. Clearly, use of insecticide indicates that a past infestation required an insecticide to thwart it, even though some yield loss resulted. Finally, use of these data in highly aggregated form yielded estimates of production elasticities for fertilizer ranging from zero to about 0.15. The higher elasticities came from the smallest farms on rainfed and simply irrigated land outside of the regular extension programs (BIMAS and INMAS). Clearly, these data need to be carefully examined before an acceptable production function can be found.

19/ Amanda Te, "An Economic Analysis of Reserve Stock Program for the Philippines," International Rice Research Institute, Los Banos, Philippines, no date. (Mimeographed.)

Nyberg and Prabowo provide a thorough review of irrigation resources in Indonesia.[20] There appears to be a strong argument for believing that land with the associated water availability is the most important limitation on expanding rice supply. Their careful analysis of available expansion and the associated projections of supply are in very close accord with trend projections of supply expansion. Table 11, presenting their supply projections through 1990 and projections of demand and imports, provides possible scenarios for the coming six years. Their second estimate of imports under a regime of slightly rising real rice prices seems the most reasonable. Even so, projected imports for 1985 are nearly 4 million tons, half of world traded supply. However, if the thesis that supply can expand only as rapidly as irrigation and yield technology permit is correct, then imports must reach this level or the real price of rice must rise more than the suggested 12 percent in six years.

A third projection, like the second, assumes that total demand in Indonesia will reach 140 kilograms per capita by 1984. Thereafter, policies would limit demand to that amount, which is more than adequate. Considerable attention, however, would be needed to assure adequate rice supplies to the lower-income groups. Interestingly, even though per capita demand would be fixed after 1984, imports in substantial quantities would be required. Imports would begin to fall after 1984, but at a progressively slower rate. Even under this stringent regime, projected imports would remain large through the next decade.

In summary a conventional supply function for rice probably cannot be constructed for the most recent period in Indonesia. The recovery of slack in the economy, technological improvements, improved management practices, irrigation systems, and the like have combined to expand rice supply at a rate limited only by factors of production--subject to the uncertainty of weather. Rice has traditionally been planted in preference to other crops when water is available. Price increases have not stimulated production in recent years as real or deflated prices have been stable.

20/ Prabowo and Nyberg, "Status of Irrigation."

Table 11--Projections of production, demand, and imports of rice, Indonesia

Year	Production Estimates		Demand Projections			Import Projections		
	High	Low	A	B	C	A	B	C
			(million tons)					
1978[a/]	17.50	17.50	16.93	16.93	16.93	1.97	1.97	1.97
1979	18.10	18.01	18.07	17.80	17.80	1.76	1.49	1.49
1980	18.69	18.53	19.25	18.69	18.69	2.40	1.84	1.84
1981	19.29	19.04	20.49	19.59	19.59	3.08	2.18	2.18
1982	19.88	19.55	21.77	20.50	20.50	3.82	2.55	2.55
1983	20.48	20.07	23.12	21.43	21.43	4.62	2.93	2.93
1984	21.07	20.58	24.52	22.37	22.06	5.48	3.33	3.02
1985	21.67	21.09	25.98	23.32	22.50	6.38	3.72	2.90
1986	22.27	21.61	27.51	24.30	22.95	7.36	4.15	2.80
1987	22.86	22.12	29.09	25.27	23.41	8.40	4.58	2.72
1988	23.46	22.63	30.74	26.25	23.88	9.50	5.01	2.64
1989	24.05	23.15	32.46	27.25	24.36	10.67	5.46	2.57
1990	24.65	23.66	34.24	28.24	24.85	11.90	5.90	2.51

Notes: Production estimates are based on a linear trend from 1978 to 1990 of the production projections made by D. Prabowo and A. J. Nyberg, "Status of Irrigation in Indonesia as of 1978 and Prospects for 1990 and 2000," paper prepared for the International Food Policy Research Institute/International Rice Research Institute/International Fertilizer Development Center Workshop on Food Policy in Southeast Asian Countries, Los Banos, Philippines, May 22-25, 1979.

Demand projections are described in Appendix 2. Projection A assumes an expenditure elasticity of 0.55 for 1976, declining by 0.01 per year thereafter. It is also assumed that prices are constant, population grows 2 percent annually, and expenditures increase 5 percent annually. Projection B has the same assumptions as Projection A except that real price of rice is assumed to increase 2 percent annually. Projection C is identical to Projection B until a per capita demand of 140 kilograms is reached. Thereafter demand growth is limited to population growth and per capita consumption is constant.

Import projections are described in Appendix 2. All projections are based on the three demand projections taken in order plus seed demand (0.34 million tons) less production adjusted by feed use (1 percent), water loss, and shrinkage (6.5 percent).

a/ Preliminary figures from Biro Pusat Statistik, Jakarta.

BUFFER STOCKS FOR RICE IN INDONESIA

BULOG: The National Grain Stock Authority

The predominant objective of rice stock policy in Indonesia, administered by BULOG, has been to maintain seasonal stability of prices at farm and wholesale levels.21/ A second and politically important activity is to provide rice to government employees and the armed forces and to provide rice during emergencies or disasters. A third activity of BULOG is maintaining a buffer stock to reduce price variations between years. This latter stock is not held separately from seasonal stocks; the level of the buffer or "iron stock" rose slowly during the 1970s as BULOG became more and more adept at handling the seasonal price variation. The buffer stock concept has existed for many years, though because of the instability of the 1960s, efforts were concentrated on seasonal instability.

The difference between farm and wholesale minimum prices was established in 1968. That difference provided a return large enough to encourage private traders to hold rice for approximately five months each year. For many reasons22/ this margin in real terms has declined over time. So it now discourages private traders from holding supplies--and contributes to the seasonal price stability desired by the government. Also, BULOG has been forced to hold larger and larger stocks to maintain timeliness of supplies in many locations and to preserve the minimum and maximum prices.

21/ For the history, antecedents, and operations of BULOG, see Saleh Affif and C. Peter Timmer, "Rice Policy in Indonesia," Food Research Institute Studies in Agricultural Economics, Trade and Development 10 (No. 2, 1971); Indonesia, Badan Urusan Logistik (BULOG), "Special Country Studies on National Rice Policies: Indonesia," (submitted by the Secretariat of the Food and Agriculture Organization of the United Nations, Rome), BULOG, Jakarta, Indonesia 1976; Bustanil Arifin, "The Indonesian Economy," Indonesia, BULOG, March 1976; C. Peter Timmer, "The Political Economy of Rice in Indonesia," Food Research Institute Studies 15 (No. 3, 1975); Leon Mears, Rice Marketing in Indonesia (Jakarta, Indonesia: University of Indonesia, 1961); Moeljono and Mears, "Food Policy;" Indonesia, BULOG, "The Problem of Stock-Size in the Indonesian Rice Stock Policy," BULOG, Jakarta, Indonesia, 1975.

22/ See Hedley, "Some Aspects," and Anne Booth and Bruce Glassburner, "Survey of Recent Developments," Bulletin of Indonesian Economic Studies 11 (March 1975).

BULOG has grown both in magnitude and operations. In 1972 the BUUD and KUD 23/ programs began, providing a means of attaining BULOG objectives of price stability and implementing other production programs (BIMAS, for example). In 1974 a regional rice storage program began in some 300 locations across the country. Table 12 gives a review of rice imports, domestic procurement, stocks, and distribution. Figure 2 shows how the amounts of rice stocked, imported, and procured changed between 1953 and 1978.

Reserve Stocks for Rice in the Indonesian Setting

Several reservations must be made before any discussion of reserve stocks for rice in Indonesia. Reserve stocks are assumed in this paper to be intended as a buffer against seasonal variations of prices. This aspect was a small part of BULOG's operations in the past. Stocks of rice held by BULOG in the 1970s were larger than the stocks of the late 1960s, not as an attempt to build a seasonal grain reserve, but to stabilize prices better. As the margin between floor and ceiling prices in Indonesia has shrunk, private traders have stopped holding seasonal rice stocks. This increasingly leaves the task of assuring a market throughout the country to BULOG. Yet the expansion of BULOG's stocks does provide some year-to-year stability, not entirely intentionally. Even though BULOG stocks replace those of the private trade, the private trade is unable to hold stocks more than a few months since private interest rates are about 5 percent per month. BULOG, on the other hand, maintains a year-round inventory to assure supplies and stable prices. The result is that the shift in stockholding for seasonal price stability from private trade to BULOG automatically provides some stability for prices from year to year.

The shift to BULOG in stockholding has another implication. As the BULOG system has grown since the mid-1970s, more rice is required to fill the ever-increasing size of the "pipeline." As a result, part of the increase in BULOG stock can be regarded as simply the "working stock" and not a contribution to seasonal stability. Another phenomenon leading to higher stocks of rice in BULOG was the policy of keeping prices stable during the national and presidential elections of 1977-78. To be more certain of accomplishing this, BULOG attempted to maintain larger stocks of rice throughout the country. These stocks eased the pressures on prices.

Indonesian storage capacity for rice is primarily in the form of relatively small, low throughput godowns spread throughout the country. The ratio of throughput to storage capacity will probably average one or less each year. Terminal grain storage capacity has not been developed in Indonesia. Indeed, with seasonal price stability as the primary objective, central or terminal capacity (20-30,000 tons for each location, for example) has not been established. Yet this is the type of capacity expected to be used for long-term storage in operating a reserve stock program. Since reserve stocks of

23/ Badan Usaha Desa and Koperasi Unit Desa.

rice would be used primarily to maintain price objectives in urban areas there seems little need to expand the network of small godowns across the country. Instead, central storage facilities would need to be constructed. This would be a major investment.

Finally, Indonesia is already the largest importer of rice in the world, taking about one third of the world trade supply. Projections shown earlier suggest that if real rice prices in Indonesia continue to be held constant, the need for imports will double, probably within the next five to six years. One consequence is that attempts by Indonesia to acquire a reserve stock large enough to offset variations in domestic supply will increase already massive Indonesian purchases of rice in the world market. Yet even with these stocks, Indonesia will have a growing import requirement. In short, the imports of rice required to meet the expected gap between demand and production and to acquire a buffer stock may not be available at reasonable prices.

A Buffer Stock Model

A model of a buffer stock of rice for Indonesia can only be designed with restrictive assumptions. While it may be unrealistic, the assumption must be made that development of a buffer stock of rice for Indonesia will leave international rice prices and supplies unchanged. This is the small country assumption. Indonesia's importance in world rice trade makes this assumption quite unrealistic. To deny this assumption at the outset, however, commits the researcher to development of a complete world trade model for rice with linkages to the other grains, such as wheat and corn. The size of this paper forbids such an exercise.

A second assumption is that a buffer stock for rice in Indonesia is designed only to offset annual variations in production. Specifically, it is expected and assumed that imports will continue to grow as production, expanding as rapidly as the available factors of production permit, falls behind growth in demand. Table 11 presents three scenarios for imports under two different price regimes.

A third assumption is that an important objective of the Indonesian government is the maintenance of stable price levels or, possibly, modest real increases in prices for rice. Such an objective will continue to be served by using imports to equate demand and supply at previously established domestic prices.

A fourth assumption is that, since supply growth is assumed to be limited by availability of production factors, particularly land and water, supply does not respond significantly to the price of rice within the range of prices projected through 1990.

Regarding supply variability, it is assumed that the 1967-78 period represents a "normal" period of supply instability, whereas in earlier periods the level and instability of supply were the results of different conditions. Demand is assumed to expand without a random component.

If buffer stocks are explicitly disassociated from rice imports to Indonesia, then variations from year to year are generated

entirely from variations of supply. The projected import levels shown earlier assume that supply grows at a constant rate, somewhat less than its rate of growth between 1976 and 1978. Thus the variability in supply is measured as the variation around the trend of a given period. The sole purpose of the buffer stock then is to cover shortfalls in production below the assumed trend in domestic production so that imports for all years are normal or expected.

Mathematically this model can be expressed as an equilibrium condition:24/

$$D_t = P_t + I_t - S_t - A_t ,$$

where:

D_t = domestic consumer demand;

P_t = domestic production;

I_t = normal levels of imports;

S_t = change in buffer stock levels;

A_t = seed use, feed use, shrinkage, and loss adjustments.

Demand (D_t), adjustments (A_t), and imports (I_t) are assumed to be measured without a stochastic component. A random component occurs only for production (P_t) and change in buffer stocks (S_t). By rearranging, this variability can be expressed as:

$$\text{Variance } (D_t - P_t - I_t + A_t) = \text{Variance } (S_t).$$

Since D_t, I_t, and A_t have no random component,

$$\text{Variance } (P_t) = \text{Variance } (S_t).$$

Again, this variance of production is measured around the trend in production.

A final assumption is that with normal imports each year, the buffer stock is drawn down in those years in which production falls below the trend and buffer stocks are built during years in which production exceeds the trend. As a result:

$$\sum_{t=1}^{T} S_t = 0$$

and $E(S_t) = 0$ for all t.

24/ See Appendix 2 for the methodology used to derive demand and import projections.

An estimate of variance around the production trend can be interpreted as the variance of stock change, S_t. Since cumulative stock changes are needed, the variance of

$$\sum_{t=1}^{T} S_t$$

can also be found from the joint probability distribution. From this joint distribution, the buffer stock required to meet cumulative shortfalls in production for various probabilities can be determined.

Costs and Benefits of the Stocks

The costs and benefits of the buffer stock model presented above are described in qualitative terms. The most significant change for rice from having a buffer stock in Indonesia is that the random component associated with production is borne entirely by the buffer stock and not by imports. This assumes, of course, that the objective of keeping prices stable or allowing only modest real increases is the objective of Indonesian policymakers. A significant benefit then is that Indonesia can keep imports stable. In other words, the variation in Indonesian production is not transmitted to the international market for rice. Without a model of international rice prices, it is difficult to assess how significant this benefit is. It can be noted that in 1973 Indonesia paid nearly US$ 500 per ton for rice and still did not fulfill import demands when a domestic shortfall in production coincided with world-wide shortages in internationally traded grains. As a result, experience suggests that in some years benefits could be substantial.

It is assumed that the Indonesian government bears the entire cost of the scheme. With price objectives within Indonesia being met, the producer and consumer of Indonesia are unaffected--so long as the buffer stock is large enough to cover shortfalls in production. The real cost of the program is paid from taxes. While a progressive income tax scheme exists, the bulk of federal revenues stem from indirect taxes and royalties.

Finally, by letting all variation in Indonesian production of rice be absorbed by the Indonesian buffer stocks of international rice, prices may be made more stable. This may benefit other rice importers or rice exporters.

Buffer Stock Analysis

The discussion about the supply of rice in Indonesia makes it clear that variations in production appear to be largely caused by weather variations. Rather than attempting to construct a representative weather index to capture part of these variations, the full variation in production around a trend can be measured directly. The standard error of estimation from a time-trend regression gives the

variability in production throughout the country. The simple trend regression for annual rice production between 1967 and 1978 is:

$$Y_t = 9.0130 + \underset{(0.0527)}{0.7059}\, T_t \qquad R^2 = 0.9473$$
$$S = 0.6296 \qquad n = 12$$
$$d = 1.4193$$

where:

Y_t = annual (calendar year) production of milled rice in million tons;
T_t = time variable with 1967=1 and 1978=12;
d = Durban-Watson statistic; and
s = the standard error of estimation.

The residuals are nonautogressive. One can therefore assume that residuals from one year to the next are independent. The residuals from this regression represent the shortfall (if negative) or oversupply (if positive) in relation to the trend of production. As noted above, these residuals are the required stock change to operate the scheme, S_t. The reserve stock required to offset shortfalls in production can be represented as the most negative accumulation of residuals which could occur. More simply, if the residuals are normal, then the probability in any one year of falling one standard error (0.63 million tons) or more below the trend is 0.16. However, this does not take into account the possibility of production shortfalls in two or more consecutive years.

Since the residuals are nonautoregressive, each residual can be treated as an independent random variable of mean zero and standard error 0.6296. Then the sum of these random variables will have mean zero and variance equal to ns^2 or a standard error of $s\sqrt{n}$. This represents the distribution of the accumulated residuals over time.

For any given 12-year horizon, one can then calculate the accumulated deviations from trend and the probability of a deviation. It is then possible to calculate the size of a buffer stock needed to achieve a specific probability of satisfying a shortfall or series of shortfalls in production. Table 13 gives the buffer stock sizes for various probabilities over any specific 12-year horizon. With 3 million tons in reserve, for example, Indonesia could be 90 percent certain of meeting cumulative shortfalls in production during a specific 12-year horizon. It is important to recognize that this stock estimate does not include normal operating stocks, sufficient stocks to dampen seasonal price variations, or supplies to offset the expected increases in imports.

The cost of holding the stock varies with price and the interest rate chosen. Taking investment in storage and rice as sunk costs, annual interest charges would be US$ 60-126 million for interest rates between 10 and 14 percent and prices of US$ 200-300 per ton of rice.

One variation of the above model is to examine what happens when the buffer stock is not large enough to meet cumulative shortfalls in

production. As an example, suppose Indonesia maintained a 2-million-ton buffer stock assuring adequate protection about 82 percent of the time. If the cumulative shortfall was 3 million tons, 1 million tons more than available stocks, Indonesia would face two choices: to permit domestic prices to rise, or to purchase an additional 1 million tons in the international market. If prices are allowed to rise, the domestic price of rice would increase between 3 and 4 percent.[25/] The international market for rice may indeed be more inelastic than the domestic market: an additional 1 million tons sought internationally may increase international prices considerably more than in the domestic market. Indeed, in a practical sense, knowledge by traders that the Indonesian buffer stock was empty would stimulate upward price movements even before Indonesia entered the market to buy.

It was noted above that it was impossible to estimate the effect of an Indonesian rice buffer stock on international prices within this paper. Yet the foregoing suggests that it would be more interesting to assess the costs and benefits of a reserve stock caused by international prices. A fixed rice price policy gives all costs and benefits to the government and has no direct effect on producers or consumers. With a trade model, one could investigate how the variance in production is shared by buffer stocks and imports over a specific period.

25/ The demand elasticity for rice is assumed to be -0.73.

Table 12--Rice imports, domestic procurement, stocks, and distribution in Indonesia, 1967-78

Calendar Year	Opening Stocks	Imports	Domestic Procurement	Distribution			Closing Stocks
				Budget Group a/	Market Operations b/	Other, Including Losses c/	
			(million tons of rice)				
1967	176.2	353.8	520.2	681.0	139.4	78.8	151.0
1968	151.0	628.4	597.6	697.0	72.8	110.9	496.3
1969	496.3	604.2	203.9	687.7	126.5	191.3	261.9
1970	261.9	955.6	493.3	710.5	228.9	188.0	530.4
1971	530.4	489.9	616.7	677.4	225.8	186.1	530.7
1972	530.7	734.5	160.3	650.6	418.6	141.6	168.0
1973	168.0	1,656.7	262.8	660.8	703.5	87.1	586.9
1974	586.9	1,070.8	530.4	657.5	315.1	245.0	879.7
1975	879.7	672.7	539.3	663.7	423.2	212.8	390.1
1976	390.1	1,280.6	391.5	662.0	887.5	166.7	541.0
1977	541.0	1,964.1	423.9	635.0	1,702.8	180.2	511.6
1978 d/	511.6	1,850.0	865.8	640.4	1,250.6	191.6	1,144.8

Source: Unpublished data from Badan Urusan Logistik (BULOG), Jakarta, 1979. BULOG kindly provided this table because alternative sources gave different figures for most of its components.

a/ Purchases through BULOG and the DOLOG system.

b/ Distribution to Armed Forces and Civil Servants.

c/ Sales by BULOG in selected urban markets at wholesale prices to maintain the prescribed price ceiling.

d/ Preliminary.

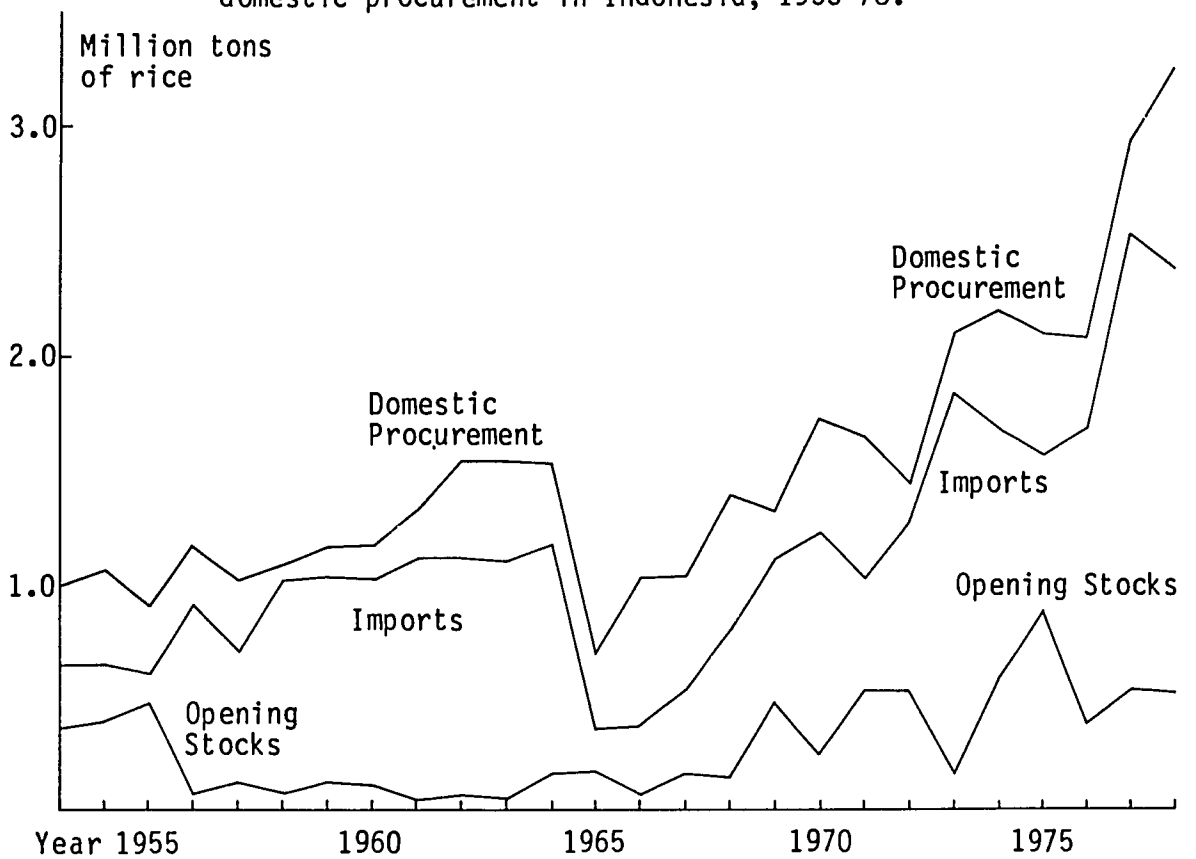
Table 13--Size of the buffer stocks Indonesia requires to achieve specific probabilities of covering shortfalls in rice production over a 12-year period

Probability of Covering Production Shortfalls	Size of Stocks
(percent)	(million tons)
50	0.00
60	0.55
70	1.13
75	1.46
80	1.83
85	2.27
90	3.01
95	3.58

Notes: A production shortfall refers to a deviation from the trend of production, and not to a gap between production and demand.

The estimates of stocks do not include normal operating stocks or the stocks necessary to meet any seasonal price stability objectives. Nor do they include stocks to offset the upward trend in imports.

Figure 2--Government rice balances: cumulative stocks, imports, and domestic procurement in Indonesia, 1953-78.



Sources: Indonesia, Badan Urusan Logistik (BULOG), Seperempat Abad Rergulat Dengen Putir-Butir Beras (Jakarta Indonesia: BULOG, 1971); and unpublished data provided by BULOG.

SUMMARY AND CONCLUSIONS

Projections of demand are developed in this analysis that, when combined with supply projections from another source, can generate projected imports under alternative assumptions. An acceptable supply function could not be developed, so supply projections were based on the expansion of available resources. Because real prices were stable during the past decade, no interaction with supply could be found.

The "small country" assumption is unrealistic because Indonesia imports a significant proportion of traded rice. A model of international prices, however, cannot be developed in a paper of this size. Without such a model the budgetary implications of a buffer stock for Indonesia cannot be fully assessed.

A small buffer stock model is developed in such a way that annual variations in production around a trend can be compensated for by the rice buffer stock. This model assures that all production variation in Indonesia remains isolated from world rice trade. Only an expected or "normal" level of imports to Indonesia is envisaged.

It is suggested that 3 million tons of rice is sufficient to cover shortfalls in Indonesia's production with about 90 percent security. The principle benefit of such a scheme is that the international price of rice would be much more stable. Since normal imports are expected to continue, variations in projected demand have no effect on the size of the buffer stock needed.

APPENDIX 1

THE LINEAR EXPENDITURE SYSTEM MODEL

The Linear Expenditure System (LES) model used to develop the expenditure, price, and cross-price elasticities for each expenditure category for Indonesia is adapted from the LES of Rubin and Klein.[26/] The Rubin and Klein model for demand can be presented as:

$$Q_{ij} = \delta_j + (I_i - \Sigma_j P_j \delta_j) \beta_j / P_j \qquad (1)$$

$$\text{for } j = 1, 2, \ldots M$$

where:

- Q_{ij} = the quantity of commodity j demanded for the ith observation;
- I_i = total income of the ith consuming unit;
- P_j = the price of good j;
- i = 1, 2, ..., N (the number of consuming units observed);
- j = 1, 2, ..., M (the number of commodities); and
- δ_j = (usually) the minimum amount of commodity j that the consumer regards as necessary.

The expenditure form of the LES can be derived by multiplying the equation by P_j (prices are assumed constant across consuming units), yielding:

$$P_j Q_{ij} = P\delta_j + \beta_j (I_i - \Sigma^j P_j \delta_j) \qquad (2)$$

This expenditure model is used to derive the elasticities described below. The expenditure elasticity of the jth goods:

$$\eta_j = \frac{\beta_j}{W_j} = \beta_j \frac{P_j Q_{ij}}{\Sigma_j P_j Q_{ij}} \qquad (3)$$

26/ Lawrence Robert Klein and H. Rubin, "A Constant Utility Index of the Cost of Living," Review of Economic Studies 15 (No. 2, 1978): 84-87.

W_j is the expenditure proportion of the jth good; $\Sigma P_j Q_{ij}$ is total consuming unit expenditure, assumed to be equal to total income. (Saving is assumed to be zero or ignored.)

The price elasticity of demand for the jth good is:

$$e_{jj} = -1 + \frac{(1+\beta_j)\ P_j \delta_j}{P_j\ Q_{ij}}. \tag{4}$$

The cross price elasticity of demand is:

$$\frac{\beta_k (P_j \delta_j)}{P_k\ Q_{ik}}. \tag{5}$$

To evaluate these elasticities at their means and to simplify their presentation, let

$P_j\ \delta_j = \lambda_j$;

$P_j\ Q_{ij} = E_j$ (mean expenditure on good j); and

$\sum_j P_j\ Q_{ij} = E$ (total consumer expenditure).

Then equation (3) becomes

$$\eta_j = \frac{\beta_j\ E_j}{E} \tag{6}$$

equation (4) becomes

$$e_{jj} = -1 + \frac{(1+\beta_j)\ \lambda_j}{E_j} \tag{7}$$

and equation (5) becomes

$$e_{k_j} = \frac{\beta_k \lambda_j}{E_k}. \tag{8}$$

The model can be estimated as

$$E_{ij} = \lambda_j + \beta_j\ E_i + u_{ij}\ , \tag{9}$$

where

e_{ij} = the expenditure by consuming unit i on good j; and

E_i = the total expenditure by consuming unit i.

The minimum expenditure necessary can be taken to be the lowest observed expenditure in the sample, that is, E_0 for total expenditure and E_{0j} for each commodity.

Then

$$P_j \hat{\delta}_j = E_{0j} = \lambda_j + \hat{\beta}_j E_0 \qquad (10)$$

Substituting in the equation (9) above:

$$E_{ij} = P_j \delta_j + \hat{\beta}_j (E_i - E_0) + u_{ij} \qquad (11)$$

Equation (11) is the original model presented in equation (2). Thus, LES can be utilized by estimating equation (9) above. All other values can be obtained from $\hat{\lambda}_j$ and $\hat{\beta}_j$.

In using the SUSENAS data, only aggregated results are available. The mean expenditures by expenditure class are presented. These aggregated data used with ordinary least squares lead to a heteroskedastic disturbance. Thus, a weighted regression was developed to account for the differences in the numbers of observations comprising each expenditure class. In addition to heteroskedasticity due to the unequal sizes of groups, there is most likely heteroskedasticity across expenditure classes, that is, the variance of the distrubance term increases as the expenditure level rises.27/ As a result, a generalized least squares approach is taken to estimate equation (9) above. Using G, a grouping size matrix:

$$G_Y = G\, X\beta + G\epsilon \qquad (12)$$

$$\text{for } G = \begin{bmatrix} \sqrt{n_1} & 0 & \cdots & 0 \\ 0 & \sqrt{n_2} & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & & \sqrt{n_G} \end{bmatrix} \qquad (13)$$

$$E\,(G\epsilon\epsilon G') = \delta^2\, \Omega \text{ and define:} \qquad (14)$$

and then,

$$\hat{\beta} = (X'\, G'\, \Omega^{-1}\, G\, X)^{-1}\, (X'\, G'\, \Omega^{-1}\, X'\, Y) \qquad (15)$$

27/ See Boediono, "A Linear Expenditure System for Indonesia," Gadjah Meda University, Yogyakarta, Indonesia, 1978. (Mimeographed.)

APPENDIX 2

PROJECTIONS

Demand Projections

To generate demand projections, account is taken of increases of population and per capita expenditures. Per capita demand for period t, (PC D_t), is calculated as:

$$PC\ D_t = \left[\{[(1+r_1)^t - 1.00] + \eta\ (1+r_2) + 1.00\} + 1\right] PC\ D_0, \quad (16)$$

where:

- PC D_t = per capita demand for rice (in kilograms) in year 1978 + t;
- PC D_0 = per capita demand for rice in year 1978 (preliminary estimate of 121 kilograms per capita used);28/
- r_1 = the rate of population growth;
- r_2 = the rate of per capita expenditure growth; and
- η = expenditure elasticity (taken as 0.54 - 0.01).

Total rice demand (D_t) for Indonesia under a constant price regime is derived from:

$$D_t = [PC\ D_t\ (1+r_1)^t \cdot POP_0] \div 100, \quad (17)$$

where:

- D_t = total rice demand in million tons for the year 1978 + t,
- POP_0 = population in Indonesia (millions) in 1978 (midyear estimate).

To calculate total demand for rice in any year t under a change in price:

$$D_t \left\{[PC\ D_t\ (1+r_1)^t \cdot POP_0] \div 1{,}000\right\} (\epsilon_0 \cdot \Delta + 1), \quad (18)$$

where:

- D_t = price elasticity of demand for rice,
- Δ = proportionate change in price between 1978 and 1978 + t.

28/ This estimate is from Mears and Moeljono, "Food Policy."

To calculate the total demand for rice when per capita consumption is constant:

$$D_t = \left\{[(1+r_1)^t \ POP_o] \ k\right\} - 1{,}000,$$

where

D_t, POP_o, and t are defined above; and

k = the desired constant per capita consumption in kilograms per capita.

Import Projections

Import projections are based on production projections made by Prabowo and Nyberg[29/] and the demand projections shown above.

$$I_t = D_t - [PROD_t(1.00-r_3-r_4)] - SD_t,$$

where

D = total rice demand in millions of tons in year 1978 + t;

$PROD_t$ = total production of rice in millions of tons;

r_3 = the proportion of production for shrinkage, loss, and waste;

r_4 = the proportion of production for feed use, and

SD_t = seed use of rice (0.34 million tons throughout).

29/ Prabowo and Nyberg, "Status of Irrigation."

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