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Normative Study of the Supply Response of Rice in Thailand

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DAE-CARD Sector Analysis Series; No. 13
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FOREWORD

This study is one of a continuing series of empirical research studies that deals with the future production potential of Thailand's agriculture. Because of the important role rice plays in the nation's economy, the study estimates rice producing capacity for Thailand in 1981. More specifically, estimates are made of: (1) the national rice output at a range of prices, (2) the regional pattern of production of rice and other crops, and (3) the regional distribution of employment and farm income.

The empirical analysis summarized in this report is part of a cooperative research effort being carried out by the Division of Agricultural Economics (DAE) of the Ministry of Agriculture and Cooperatives, Royal Thai Government, and the Center for Agricultural and Rural Development, Iowa State University. The cooperative research effort is funded by the Agency for International Development and the Royal Thai Government. This study represents one part of a sector analysis project being undertaken to provide models and empirical analysis which can aid development and policies for agriculture in Thailand.

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NORMATIVE STUDY OF THE SUPPLY RESPONSE OF RICE IN THAILAND

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INTRODUCTION

Thailand's agricultural sector is a major force in this developing nation's economy. In recent years agriculture has contributed almost two thirds of Thailand's exports. It provides employment for more than three fourths of the nation's working population.

Agricultural exports are Thailand's major source of foreign exchange earnings and provide other types of public revenue such as export taxes (premiums).[1] The relatively few commodities accounting for a large portion of the total exports include rice, rubber, tapioca products, maize, jute and kenaf. Rice is currently the most important export commodity and annually accounts for about 21 percent of total export revenue. Exports of maize and tapioca products account for 13 and 8 percent, respectively [Division of Agricultural Economics, 1975]. Thailand is the world's third largest rice exporter after the United States and the People's Republic of China. In 1974 the United States exported 2.2 million metric tons and China exported 1.5 million metric tons of rice. Thailand's 1974 rice exports were .9 million metric tons. The agricultural sector includes 78 percent of the nation's economically active population and their dependents [National Statistical Office, 1974; Division of Agricultural Economics, 1974].

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[1]For an extensive review of rice price policies, see "A history of rice price policies in Thailand," [Siamwalla, 1975].

Even with these large contributions by the agricultural sector, agriculture still accounts for only a quarter of the nation's Gross Domestic Product. Hence, with more than three quarters of the population and only a quarter of the nation's income, an equity problem exists in the level of per capita income in rural areas.

To increase both productivity and efficiency of agriculture, a set of national goals (the Fourth Five Year Development Plan) has been established for the agricultural sector in BE 2520-2524. National agricultural models have been constructed to estimate future production potentials and to supply decision makers with quantitative policy estimates.

This study, one of a continuing series, deals with the future production potential of Thailand's agriculture.[2] Because of the important role rice plays in the nation's economy, this study will estimate rice producing capacity for Thailand in 1981. More specifically, estimates are made of: (1) the national rice output at a range of rice prices, (2) the regional pattern of production of rice and other crops, and (3) the regional distribution of employment and farm income.

AN OVERVIEW OF THAI AGRICULTURE

Because the estimates of the national model used in this study are based on historical and current conditions, the major variables determining consumption, production, and employment are discussed.

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[2]See, for example, Rogers and Itharattana, 1976; Framingham et al., DAE-CARD, 1977; 1977a; and 1977b.

Rice Production

The economy of Thailand traditionally has been dominated by rice. For more than a century the country has produced more rice than needed for domestic consumption. Thailand has been one of the world's leading rice exporters since the early 1960s. Exports have averaged around 25 percent of domestic production and have been an important source of foreign exchange earnings.

Rice, Southeast Asia's staple food, has long dominated agriculture. Even today, with considerable effort to move away from the rice monoculture, rice production retains its important role as a cash crop. During the period of BE 2598-2518, the area planted to paddy increased by 49 percent, an average growth rate of about 2.4 percent per annum (Table 1).[3] Rice area planted is subject to considerable fluctuations from year to year, however. This annual fluctuation in paddy land planted is attributed to a shortage of inputs such as seed or water. The increase in paddy area is attributed mostly to new land developed from forested areas. During the BE 2516 planting season, Thailand planted more than 50 percent of its cropland to rice [Division of Agriculture, 1974b].

Even with the introduction of some new high yielding varieties, fertilizer, and other biological and technical innovations, rice yields in Thailand have increased only modestly over the last 20 years. Yield per rai has been relatively constant since BE 2513 (Table 1). The small yield increase is explained by the acquisition of marginal land for planting rice, unfavorable optimal weather conditions in some instances, and a shortage

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[3]Note that this area does not include upland area planted to rice.

Table 1. Land area, yield and production of rice in Thailand BE 2498-2518

Year	Land Area Planted to Paddy (1,000 rai)	Yield per Rai (Kgs. of Paddy Rice)	Total Production (1,000 metric tons) of Paddy Rice
2498[a]	36,060	247	8,907
2499	37,648	264	9,939
2500	31,726	220	6,980
2501	35,887	240	8,613
2502	37,909	223	8,454
2503	37,012	256	9,475
2504	38,619	256	9,886
2505	41,168	267	10,992
2506	41,299	281	11,585
2507	40,872	278	11,362
2508	40,961	268	10,978
2509	46,454	257	11,947
2510	41,612	231	9,625
2511	45,173	229	10,348
2512	47,400	283	13,410
2513	46,840	290	13,570
2514	47,043	292	13,744
2515	45,931	270	12,413
2516	52,270	285	14,898
2517	49,889	268	13,386
2518[b]	53,243	265	14,091

SOURCE: [DAE, 1975].

[a]The Gregorian calendar year is obtained by subtracting 543 from the Buddhist calendar year.

[b]Second crop production not included.

of inputs. It also is likely that unfavorable price relationships have dampened the use of fertilizer and new varieties.

Rice Varieties and Yields

Rice grown under dryland conditions is known as upland rice. All upland rice is grown on class IV land. Land IV is mainly used for production of crops other than paddy. Paddy is rice grown on land that is either naturally flooded or inundated by human force during most of the growing season. Paddy rice cultivation takes place on land classes I, II, and III as used in this study.

In addition to the different methods of growing rice, there also is a distinction between two major types of rice; namely, glutinous and nonglutinous. This distinction is attributable to the physical consistency of the commodity. A further distinction is possible within each type of grain with respect to physical appearance (long grain, short grain, etc.) or with respect to yield. Thailand currently produces both native (low yielding) varieties and RD (high yielding) varieties of either glutinous of nonglutinous rice.[4]

Nonglutinous rice is the most important of the two crops (Table 2) both for exports and domestic consumption. Glutinous rice makes up only 10 percent of total production. Glutinous rice, although exported in small amounts, is mainly grown for domestic consumption.

Production data from both the Rice Department (for the years 1950-1963) and the Thai National Statistical Office (1963-1974)[5] show that paddy output was relatively stagnant during the period 1950-59 (BE 2493-

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[4]The abbreviation RD indicates Rice Department, the branch of the Ministry of Agriculture and Cooperatives that developed these types specifically for Thai conditions.

[5]The two series are not comparable because difference sampling techniques were used. However, the direction of movement is estimated to be the same

BE 2502), although there were fluctuations in both yields and area because of floods or droughts. Domestic output rose steadily to above 10 million tons between 1959 and 1962. For the next six years output again was stagnant with fluctuations in both yields and area. In 1969 (BE2512), however, yields jumped 24 percent to 283 kilograms per rai. In addition, the area planted increased almost 2 million rai. Since 1969, production has remained around 13 million tons of rice, with a high of almost 15 million tons in the 1973 season because the area planted increased to more than 52 million rai. The higher production of recent years, especially through a greater planted area, is attributed to both favorable weather and higher prices.

Table 2. Exports of glutinous and nonglutinous rice and rice products, BE 2508-2517

Year	Total Exports	White Rice (nonglutinous)	Glutinous Rice
		(1,000 tons)	
BE 2508	1,895,223	1,803,717	91,506
BE 2509	1,507,550	1,419,637	87,913
BE 2510	1,482,272	1,352,441	129,831
BE 2511	1,068,185	964,993	103,192
BE 2512	1,023,064	887,112	135,952
BE 2513	1,063,616	969,377	94,239
BE 2514	1,591,384	1,484,671	106,713
BE 2515	2,112,813	1,987,319	125,494
BE 2516	848,717	813,864	34,853
BE 2517	1,015,620	933,007	82,613

SOURCE: [DAE, 1975].

Yields in Thailand have averaged 275 kilograms per rai in the last five years. Thailand ranks eighth in yields among 13 other major rice-producing nations (Table 3).

The average yield in Thailand for the period 1971-75, 275 kilograms per rai, was only one third of the average yield in Japan over the same period. Japan ranked first in yield among rice-producing countries with an average of 913 kilograms per rai during the 1971-75 period.

Regional Characteristics and Production

Planning in Thailand is oriented around four major regions (North, Northeast, Central Plain, and South) and each includes three or more planning zones. The 1970 population of 24.4 million people was distributed by region as follows: North, 22.7 percent; Northeast, 24.0 percent; Central Plains, 30.9 percent; and South, 12.4 percent [National Statistical Office, 1973]. Each region has a high proportion of the population living in the rural areas except the Central Plain, where the metropolis of Bangkok is located. Because of this high proportion of rural inhabitants, the land base of each region is particularly important and determines how many people living on farms can be sustained by each region. Directly related to this problem is the unemployment rate. Because unemployment is at least 20 percent in all regions, land is the limiting physical resource in the current organization of Thai agriculture.

Because of the year-round availability of water, Land II is capable of double and triple cropping.[6] Land II is productive and profitable.

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[6]Land II is paddyland suitable for production of either broadcast or transplant rice. There also are water management facilities for irrigation. Land I is suitable for only one crop of broadcast rice per year because of a high and unmanageable water supply. Land III is the same as Land II except it does not have potential for irrigation. Land IV is upland with inadequate water supplies for paddy rice to allow supplemental irrigation.

Table 3. Rice area, yield, and production in Thailand and selected countries, 1971-1973

Country	Area Harvested			Average Yield			Production		
	1971	1972	1973	1971	1972	1973	1971	1972	1973
	1,000 rai			kilograms per rai			1,000 tons		
Thailand	44,347	42,375	48,394	310	293	308	13,744	12,413	14,898
Burma	29,775	28,300	30,694	275	260	279	8,175	7,361	8,559
Fed. Malasia	4,438	4,781	5,031	408	385	389	1,809	1,840	1,957
Philippines	20,288	20,644	22,431	251	237	247	5,100	4,898	5,532
China	217,206	210,888	217,219	502	494	513	109,031	104,196	111,520
Japan	16,869	16,500	16,375	839	936	963	14,153	15,440	15,766
Korea Rep.	7,500	7,444	7,625	741	739	767	5,557	5,550	5,849
U.S.A.	4,600	4,600	5,488	846	842	767	3,890	3,875	4,210
Brazil	29,775	30,131	30,625	221	260	243	6,593	7,824	7,448
India	235,988	225,119	231,250	274	257	292	64,602	57,949	67,600
Pakistan	9,100	9,263	9,450	373	376	386	3,393	3,487	3,646
Bangladesh	58,113	60,188	62,219	256	251	294	14,897	15,134	18,291
Indonesia	51,388	49,894	53,550	363	361	379	18,663	18,031	20,321

SOURCE: [DAE, 1975].

The amount of Land II per agricultural resident differs significantly among regions. It is 0.68 in the North, 0.25 in the Northeast, 2.89 in the Central Plain and 0.58 in the South.

The Central Plain is the nation's most productive region, although it has only 22.2 million rai for agricultural production purposes, compared to 44 million rai for the Northeast. Because of the relatively high rice yields of 380 kilograms, the Central Plain is Thailand's largest rice producer. The region is the main producer of sugarcane, maize and cassava. It also has the largest commercial livestock sector in the country. Farm income is highest in the Central Plain because of a combination of high farm and off-farm income. Based on BE 2513 data, the Central Plain was third in onfarm income per farm family. However, it ranks first in off-farm income. The high off-farm income, due most likely to the work opportunities offered by Bangkok industries, places the Central Plain first in total net income per farm family.

The North has the highest net onfarm income. While rice and sugarcane are the most important cash crops, other crops such as cotton, tobacco, soybeans, and oilseeds also are produced. The Northeast produces corn, silk, kenaf, and rice as major crops. However, yields are among the lowest in the country. The Northeast has the largest land base for both rice and upland crop production. The region plants more than 20 million rai to rice (Table 4). Family farm income is much lower in the Northeast than in the other regions. The low productivity of the Northeast soils and the small area of Land II relative to the population are the main reasons for this low income.

Table 4. Rice area planted and yields by region, 1969/70-1974/75

Year	North		Northeast		Central Plain		South	
	Area Planted[a]	Yield[b]	Area Planted	Yield	Area Planted	Yield	Area Planted	Yield
1969/70	10,030	383	20,240	226	13,410	299	3,720	263
1970/71	9,980	408	20,460	241	13,040	285	3,360	256
1971/72	9,203	387	21,471	253	13,170	296	3,199	268
1972/73	9,471	286	21,241	198	14,363	312	3,856	265
1973/74	11,496	347	22,199	209	15,494	352	3,081	268
1974/75	10,390	373	20,683	183	14,980	322	3,836	232

[a]1,000 rai.

[b]Kilogram/rai,

SOURCE: [DAE, 1976a].

The South produces the smallest amount of rice. However, it produces major quantities of cash crops such as rubber, coconuts, palm oil, and coffee. Income to farm families in the region is second highest in the country, because of the high-valued agricultural products grown and opportunities of off-farm earnings in the region [Division of Agricultural Economics, 1972].

ESTIMATING SUPPLY RESPONSE IN THAILAND

Because agriculture accounts for a large part of Thai national income and an even higher proportion of total employment, it is important that the government plan effectively to achieve important economic and social objectives of the rural people. "Planning is necessary when conditions which exist are not those the people want and the conditions they want will not be realized without programs to direct change" [Division of Agricultural Economics, 1976b, p. i.].

A major objective in planning the agricultural sector is to achieve "adequate" income for farmers. At the same time, Thai farmers are expected to produce adequate supplies of food at reasonable prices for the remainder of the economy. Also, Thai agriculture is to supply exports to help achieve equilibrium in the balance of payments [Division of Agricultural Economics, 1976b].

Nature of supply analysis

This study has been made to estimate certain aspects of rice supply potential in Thailand. It is based on a national and interregional

programming model developed for purpose of planning and improving the Thai agricultural sector.

In deciding the kind of model to use for purposes of supply estimation, it is important that certain distinctions are made explicit. Supply might be analyzed by either positive or normative models. A positive analysis might be made by means of an econometric model based on time series data such as that of Behrman [Behrman, 1968]. While a statistically estimated supply function indicates responses of the real world in a past period, it is restrained in ability to estimate what supply might be in the future.

This study is normative in nature in the sense that it is based on a linear programming model of Thai agriculture. The concern in the particular study is that of certain potentials in Thai rice production within the framework to be outlined later. The normative approach is used in this study (a) partly to test the programming model "already in place" for national planning, (b) because output estimates are desired by regions while time series data are insufficient by regions, and (c) the emphasis is on supply potential. Because this study focuses on the potential supply of rice for both the four individual regions as well as the Kingdom, a normative supply model is used that derives the Thailand supply function from the aggregation of normative regional models. The model includes a transportation sector to allow competition among regions and competition among crops for land within a region.

The overall programming model is solved for six different supply prices for nonglutinous rice at Bangkok. Because the model is solved for each price level, there are six solutions referred to respectively as the base, and steps I through V. The rice price used in the base is set at a level indicated by previous model solutions as the minimum supply price necessary to bring forth sufficient rice to fill subsistence and domestic demand. This base price is 600 baht per ton. The upper bound on the rice price has been selected as the price level which will not alter appreciably the quantity of rice produced in Thailand, as indicated by the programming model.

After the base price solution, the price is increased to 1,200 baht per ton of nonglutinous rice for the Step I solution. The 600 baht stepwise increases continue until one of the restraints in the model becomes binding for rice production. This point in the supply function is estimated to occur at a price of 3,600 baht per ton.

Relative to the model, the technologies allowed in it and the restraints imposed on it, Thai agriculture is optimally organized at each level of rice price used. As the rice price is increased, all other input and output prices remain constant. Therefore, higher rice prices cause competition for resources (labor, capital and land) previously used in production of other crops. Competition for land to be used in rice production occurs but only a relatively small amount of land can be used for both rice and upland crops. Rice, alone, is grown on the flooded lands.

Certain assumptions necessary for model construction are based on a plan, Alternative B_2, derived in a previous study.[7] The Alternative B_2 is one of a number of alternatives selected for analysis in the Fourth Five Year Development Plan (BE 2519-2524). Each alternative selected reflects different assumptions about population growth rates, input demands, export demands, and adoption rates of irrigation and high yielding seed varieties in the various regions of Thailand. Some of the alternatives reflect optimism for the years ahead in the Five Year Plan, relative to growth rates. Others are pessimistic about possible rates of growth. The B_2 plan simulates a "middle of the road" supposition of possible growth rates. Thus, the analysis is made under conditions which could prevail given implementation or realization of programs and growth rates as specified in the Alternative B_2.

Alternative B_2 has a population growth rate of 2.5 percent. Medium levels of product exports are assumed for all crops. Rice, maize, kenaf and cassava or tapioca products can be exported in any quantity up to an upper limit imposed upon the model. Based on population and income estimates for this alternative, point demand estimates are calculated for all commodities. Alternative B_2 simulates medium demands for irrigation facilities, high yielding seed varieties and fertilizer use.

In addition, Alternative B_2 also includes a number of farm-income goals. It requires that each region selects, through the linear programming model, a set of production activities that yield an adequate

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[7]For more background information on Alternative B_2 see "Agricultural Development Planning in Thailand" [Framingham, et al., 1977 and DAE, 1976a].

farm income. The Northeast is required to obtain at least 2,000 baht income per family from the production of upland crops on Land IV. Thus, this alternative gives special recognition to the level of farm income, and income redistribution. However, the income constraints have been relaxed for purposes of this study, because they are incompatible with the primary goal of supply estimation.

THE MODEL

The national linear programming model covers 71 changwats of Thailand, aggregated into 19 agroeconomic zones. The agronomic properties of each of the zones are described in Agro-Economics Zones [Division of Agricultural Economics, 1972]. Individual linear programming models were built for each of the 19 agroeconomic zones representing the crop sector. Capital, labor and land restraints are defined for each zone.

Delineation of the Model

The national model is aggregated from the 19 zone models (Figure 1). However, because of restricted computer capacity the national model is smaller than the sum of the 19 zone models. Aggregation was accomplished mainly through the restraints in each of the zone models. Labor constraints which were monthly in the original model were aggregated into the dry season for the months of February through June, but left monthly for the wet season. Capital is included as two restraints for the

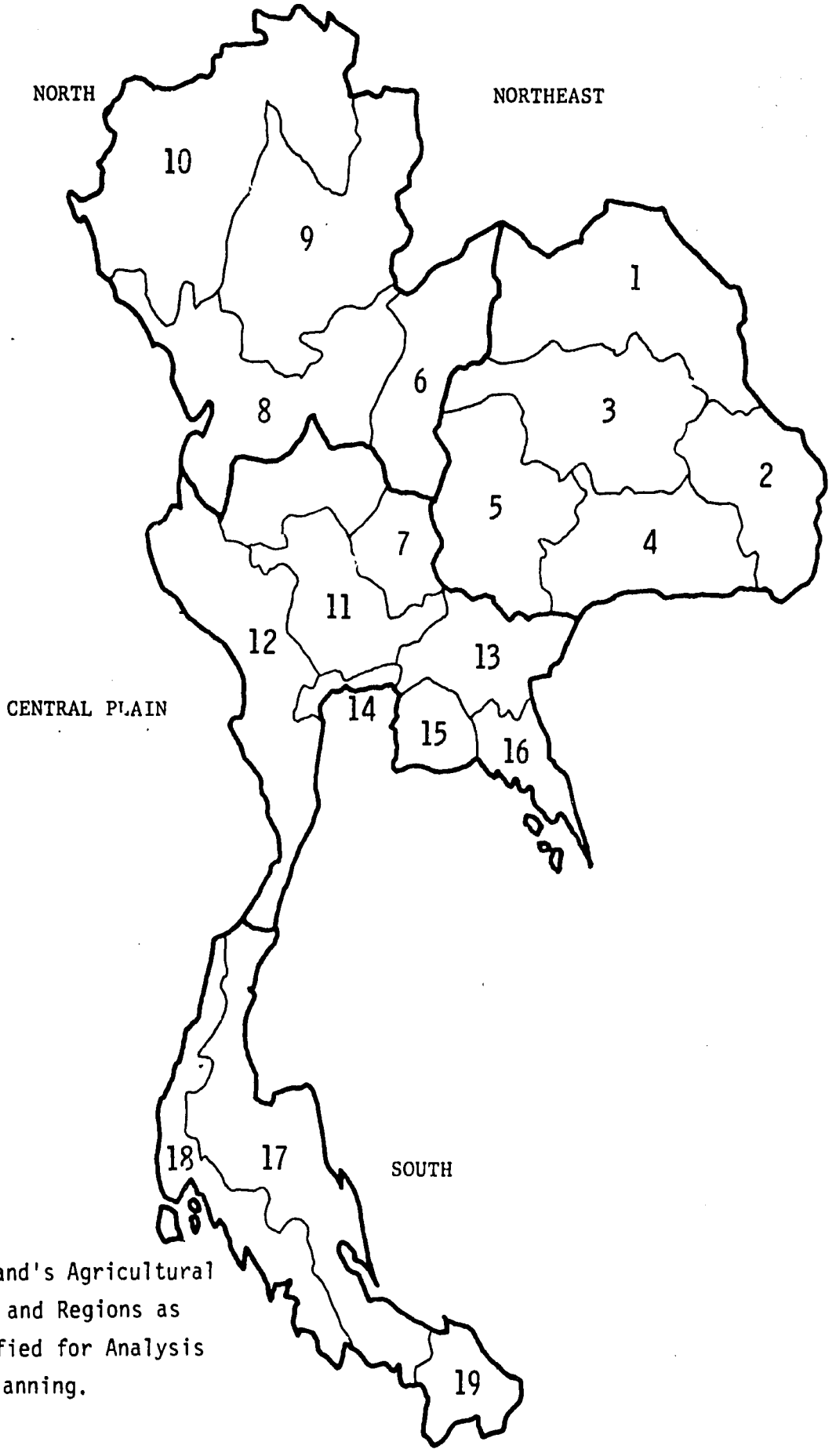

Figure 1. Thailand's Agricultural Zones and Regions as Specified for Analysis and Planning.

dry season and wet season, as compared to monthly in the original model. The model is further aggregated into four demand regions. The demand regions follow zone and changwat boundaries (Figure 1). One explicit demand-supply equation is defined for each distinct commodity at each of the four consumption points.

For the rice supply resource under analysis, the opportunity should prevail for any crop to be produced anywhere in the nation subject to the restraints placed upon the model. Further, transportation of commodities from surplus regions to deficit regions must be possible in order to satisfy the specified point demand For this reason four shipment points are designated, one in each of the four demand regions. These points serve as the final collection points for commodities transported to or from other regions for all crops but glutinous rice. The latter commodity can be transported to or from one agroeconomic zone to any other zone within a region, given a historical transport route that exists or can reasonably be expected to be established as a result of the production pattern in the model. Concurrently, glutinous rice also can be transported among regions. The schematic structure of the model is shown in Figures 2 and 3.

Because the transportation activities of the model allow interzonal and interregional competition, resources are allocated according to the principle of comparative advantage of the various zones and regions. In addition, the model incorporates a set of subsistance demand equations by zone, reflecting production and consumption activities of the farm household. This portion of production is excluded from the market system.

Restraints	Activities for production and capital use in zone 1									Activities for zones 2, 3, 4, and 5			
	Rice	Rice	Rice	GNut	Rice	GNut	GNut	BOic	BOic	ACT2	ACT3	ACT4	ACT5
Bounds	B	B	B	B	B	B	B			B	B	B	B
Objective	-c	-c	-c	-c	-c	-c	-c	-i	-i	-c	-c	-c	-c
Land 1 W	1												
Land 2 W		1											
Land 3 D			1	1									
Land 3 W					1								
Land 4 W						1							
Land 4 D							1						
Labor W 1	a	a			a	a							
Labor W 2	a	a			a	a							
Labor D			a	a			a						
Cap W	a	a			a	a		-1					
Cap D			a	a			a		-1				
Bor. cap.								1	1				
Sub Dem	-y	-y	-y		-y								
Res 2										A			
Res 3											A		
Res 4												A	
Res 5													A
NE rice dem	-y	-y	-y		-y								
NE g. nut dem				-y		-y	-y						
RD max L 2W		a											
RD max L 2D			a										
RD max L 3					a								
FERN	a	a	a		a								
FERP	a	a	a		a								

[a]The Northeast region of the model is linked to the North, Central, and South regions by transportation activities as shown in Figure 7.

Figure 2. Schematic presentation of the Northeast[a] section of the National Crop Production Model (The illustration uses two crops to show detail by land type in zone 1 while matrix notation is used for zones 2, 3, 4, and 5.)

	Production activities in each zone																			Interregional transportation								Export
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	T	T	T	T	T	T	T	T	E
Bounds	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B									
Objective	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	Pe
Resource Z1	A																											
" Z2		A																										
" Z3			A																									
" Z4				A																								
" Z5					A																							
Demand N.E.	-Y	-Y	-Y	-Y	-Y															I	-I				-I	I		
Resource Z6						A																						
" Z8							A																					
" Z9								A																				
" Z10									A																			
Demand North						-Y	-Y	-Y	-Y													I	-I			I	-I	
Resource Z7										A																		
" Z11											A																	
" Z12												A																
" Z13													A															
" Z14														A														
" Z15															A													
" Z16																A												
Demand Central										-Y	-Y	-Y	-Y	-Y	-Y	-Y				-I	I	-I	I	I	-I			I
Resource Z17																	A											
" Z18																		A										
" Z19																			A									
Demand South																-Y	-Y	-Y						-I	I			

Figure 3. Schematic diagram of national crop model with four consuming regions and 19 agroeconomic producing areas

Certain commodities cannot be produced for the market until these subsistence demands have been met.

Nature of the Supply Response

The potential marketed supply of nonglutinous rice is derived under the assumption that producers first satisfy home consumption requirements for nonglutinous and glutinous rice. It is further assumed that total domestic and small export requirements for glutinous rice are also satisfied at all prices for nonglutinous rice. The total output of other crops (but not the location of production) is also assumed to remain constant.

In this study glutinous rice and other crops are treated as nontraded goods. The price of a nontraded good is determined by the opportunity cost of resources used in its production. There is only limited competition between rice and other commodities in production. The export potential for nonglutinous rice is, in fact, severely limited. The consumption of glutinous rice has ethnic origins and there seems to be only limited substitution between glutinous and nonglutinous rice in domestic consumption. The prices of glutinous and nonglutinous rice have been very closely correlated when the small amounts of surplus glutinous rice could be exported to Laos. However, with the recent restriction on Laotian market a modest oversupply of glutinous rice has been shown to push the price of glutinous rice well below the price of nonglutinous rice.

In this study we are interested in the equilibrium allocation of resources in the production of the two types of rice. Farmers are assumed to allocate resources in an efficient manner between the production of glutinous and nonglutinous rice so that an equilibrium differential between

the price of glutinous and nonglutinous rice is maintained. The supply curve of nonglutinous rice derived in this study is similar to that which would result if a price support were implemented for nonglutinous but not for glutinous rice.

Development of Model Coefficients

We now briefly describe the groups of coefficients used for the model. All coefficients and parameters refer to conditions expected for 1981(BE 2525). Solutions also are for 1981.

Variable cost

The variable costs incorporated in the model reflect the variable total of farm inputs. More specifically the variable costs include charges for the following: pesticides, fuel, oil, hired machinery, miscellaneous items, depreciation, value of animal inputs, manure, and food for workers.

Labor

Labor coefficients for each economic activity reflect the total hours of family and hired labor needed to plant, produce and harvest the particular crop. The model distinguishes between dry-season production and wet-season production activities. Specifically, the model aggregates labor for the dry season into one restraint period, whereas it uses monthly labor coefficients for the remainder of the year. The latter disaggregation is used to obtain a better estimate of monthly and peak labor requirements during the planting and harvesting period.

The land base

Thailand has a total land area of 321 million rai. The cropland base as defined in the model for land classes I through IV is approximately 100 million rai (Table 5).

Table 5. Thailand's agricultural land area by class and region in BE 2516-2517

	Cropland Area by Class (Rai)				
Region	Land I	Land II	Land III	Land IV	Total Land by Region
North	2,591,000	3,821,000	8,670,000	7,145,000	22,227,000
Northeast	0	2,333,000	33,623,000	7,690,000	43,646,000
Central Plain	336,000	11,670,000	3,963,000	6,274,000	22,240,000
South	0	1,544,000	3,015,000	7,764,000	12,323,000
Thailand	2,927,000	19,365,000	49,271,000	28,873,000	100,436,000

Agricultural land as used in this study consists of four major types of land: Land I is continuously flooded. It is suited only to production of floating rice. Land II is land where controlled irrigation practices can be employed. It is suitable for double or triple cropping (for both rice and upland crops) since dry season irrigation is possible. Land III permits only rainfed paddy production. Land IV is suitable to produce any endogenous crop except paddy. These four types form the land base for current agricultural production in Thailand. The quantities of each type of land by region are shown in Table 5. Agricultural development planning is limited to the land area classified as above.

As mentioned earlier, agricultural land is a restraining resource in production, given the high rate of underemployment and unemployment in rural areas. Land can be intensively cropped where water is available. In this model only Land II and Land IV can be used for double cropping as upland crops compete for the available land.

All model results are a direct reflection of the model coefficients and especially the types of restraints incorporated in the model. Some of the constraints will be discussed here because of their importance relative to the solution outcomes.

Model restraints

A restriction on paddy area is included for each zone so that the solution reflects the situation as perceived by development planners. The first constraint, WAT, serves to limit the land area in each zone that can be properly irrigated by available water, canals, and leveled land. This type of land is classified as Land II and is the only land type that can have a manageable irrigation system in the dry season.

Current estimates of the amount of land that is actually irrigable during the dry season is based on surveys for the second crop of rice. The maximum area irrigated is slightly over 2 million rai, while there is more than 6 million rai in irrigation districts. The profitability of increasing the land base for cultivation in the dry season will depend solely on water availability and land leveling costs relative to output prices.

Another set of constraints incorporated in the model is the area that can be planted to high yielding rice varieties, the RD_2 and RD_3 constraints. These constraints are defined by agroeconomic zone based on historical data. Expansion of the area is allowed, based on a "learning curve," to prevent farmers from instantly growing RD varieties rather than a mixture of varieties as is actually the case.

A third restriction used in the model is the area fertilized, AFER, for each of the 19 zones. These restraints let a certain number of rai be fertilized in 1981 again based upon an adoption curve developed for this purpose derived from farm historic data.

The constraints discussed above cause Thai agriculture to restrict technological progress within expected bounds and further reflect reality in the model. Without these restraints Thai agricultural capacity would be allowed to make a quantum jump and, the results would give a false impression of real capacity in 1981. Therefore, the results would not fulfill the purpose of the agricultural planners who need to know the short-run output capacity of agriculture.

MODEL RESULTS AND INTERPRETATION

Planning for the future necessitates that certain assumptions be made about conditions likely to occur. Without knowledge of the probability that these conditions will actually come about in the year BE 2524, the analysis is based on the assumption that they do occur. In interpreting the results, therefore, one must keep these assumptions in mind.

Results of each of the six steps of the supply function are presented and discussed in terms of a number of specific objectives: production, exports, employment, and income. The data are presented both at the regional and national levels. Also, each parameter is discussed for all points on the supply function.

The next section presents data on production and distribution of output generated by the model. This section is followed by a

presentation of exportable surplus for selected crops from each of the regions and from the Kingdom. Finally, the impact of increasing rice prices on Thai land rents, agricultural income and employment are analyzed.

Output, Harvested Area, and Yield

Although the linear programming model includes 40 crops and commodities, we discuss only output, harvested area, and yields for a selected subset of crops that are considered to be most important for domestic and export purposed (Tables 6, 7, 8, 9, and 10). The crops discussed are: nonglutinous rice, glutinous rice, maize, cassava, kenaf, rubber, and sugar.

Base Solution, 600 Baht Per Ton for Nonglutinous Rice

By specification of the model, agriculture is forced to produce enough rice to meet subsistence demand. At the base price level 13.8 million tons of rice are produced, 8.1 million tons of which is nonglutinous rice in the Base Solution (Table 6). During the crop year 1970/71 rice production was 13.7 million tons, which then brought a price of 623.63 baht per ton. Data are shown in Table 6 for the 1972/73-74/75 average, the Base Solution, (600 baht), Step I Solution (1200 baht), Step II Solution (1800 baht), Step III Solution (2400 baht), Step IV Solution (3000 baht), and Step V Solution (3600 baht).

The Northeast region produces 30 percent of total rice production with glutinous rice accounting for more than 71 percent of the total (Table 7). The Northeast region is the largest producer of glutinous rice with 3.0 million tons, most of which is consumed locally. With

Table 6. Output, harvested area, and yields of principal crops at different price levels for nonglutinous rice in the Kingdom

Crop	72/73-74/75 Average[a]	Solution					
		Base	I	II	III	IV	V
				Production (000 metric tons)			
Rice nonglutinous	13,565.7	8,098.2	10,417.9	11,409.5	12,102.6	12,415.7	12,535.8
Rice glutinous		5,744.9	5,744.9	5,744.9	5,745.1	5,745.0	5,744.9
Maize	2,077	4,051.3	4,051.4	4,051.3	3,694.3	4,051.3	4,051.3
Cassava	5,869	10,799.2	10,799.2	10,799.2	10,799.2	10,799.2	10,799.2
Kenaf	426.9	409.0	409.0	409.0	409.0	409.0	409.0
Rubber	362.2	417.1	417.1	417.1	417.1	417.1	417.1
Sugar	12,481	13,723.9	13,723.9	13,723.9	13,723.9	13,723.9	13,723.9
				Harvested Area (000 rai)			
Rice nonglutinous	45,534	25,505.6	31,151.5	32,396.6	33,707.6	33,408.0	33,693.2
Rice glutinous		21,993.6	21,584.5	20,585.1	20,033.2	19,623.5	19,336.8
Maize	7,050	14,624.3	14,855.2	14,981.6	14,000.7	15,111.6	15,171.3
Cassava	2,589	4,853.5	5,663.1	4,794.3	4,794.3	4,791.3	4,791.3
Kenaf	2,729.6	2,696.0	2,686.9	2,686.9	2,686.7	2,686.9	2,656.8
Rubber	5,547.3	7,080.2	7,062.8	7,062.8	7,062.8	7,062.8	7,062.8
Sugar	1,561	1,573.1	1,626.0	1,628.7	1,628.7	1,627.5	1,627.5
				Yield (kilogram/rai)			
Rice nonglutinous	274.3	317.5	312.0	352.1	359.0	371.6	372.0
Rice glutinous		261.2	260.6	279.0	286.8	292.7	297.0
Maize	287.0	277.0	272.0	270.4	263.9	268.0	267.0
Cassava	2,267.0	2,225.0	2,216.3	2,252.4	2,252.5	2,253.8	2,253.8
Kenaf	156.4	151.6	152.2	152.2	152.2	152.2	153.9
Rubber	65.3	58.9	59.0	59.0	59.0	59.0	59.0
Sugar	7,995.5	8,723.8	8,440.0	8,426.3	8,426.3	8,432.5	8,432.5

[a]SOURCE: [DAE, 1976a].

Table 7. Output, harvested area, and yields of principal crops at different price levels for nonglutinous rice in the Northeast region

Crop	Solution					
	Base	I	II	III	IV	V
	Production (000 metric tons)					
Rice nonglutinous	1,207.6	1,654.5	1,999.8	2,137.8	2,151.5	2,235.7
Rice glutinous	2,980.6	2,960.2	2,960.2	2,960.2	2,960.2	2,960.2
Maize	277.7	424.8	483.3	485.5	225.6	532.6
Cassava	4,954.6	4,215.2	4,215.2	4,215.2	4,276.5	4,276.5
Kenaf	400.1	400.1	400.1	407.7	407.7	400.0
Rubber	-	-	-	-	-	-
Sugar	648.0	648.0	648.0	648.0	648.0	648.0
	Harvested Area (000 rai)					
Rice nonglutinous	6,767.9	8,654.1	9,752.3	10,307.5	10,307.5	10,731.0
Rice glutinous	14,974.7	14,684.6	13,586.4	13,031.2	13,031.2	12,607.7
Maize	1,093.7	1,818.7	2,161.5	2,175.8	2,150.8	2,467.3
Cassava	2,200.7	2,169.6	1,968.6	1,968.6	1,987.9	1.987.9
Kenaf	2,696.0	2,679.6	2,679.4	2,679.4	2,679.4	2,649.4
Rubber	-	-	-	-	-	-
Sugar	105.9	105.9	105.9	105.9	105.9	105.9
	Yield (kilogram/rai)					
Rice nonglutinous	178.4	191.1	205.0	207.3	208.7	208.3
Rice glutinous	199.0	201.5	217.8	227.1	227.1	234.7
Maize	253.9	233.5	223.6	223.1	223.9	215.8
Cassava	2,251.2	2,237.8	2,141.1	2,141.1	2,151.2	2,151.2
Kenaf	151.6	152.1	152.1	152.1	152.1	153.8
Rubber	-	-	-	-	-	-
Sugar	6,117.0	6,117.0	6,117.0	6,117.0	6,117.0	6,117.0

Table 8. Output, harvested area, and yields of principal crops at different price levels for nonglutinous rice in the North region

Crop	Solution					
	Base	I	II	III	IV	V
	Production (000 metric tons)					
Rice nonglutinous	2,033.1	2,610.5	2,632.9	2,739.1	2,665.4	2,693.3
Rice glutinous	2,451.3	2,411.3	2,474.3	2,474.3	2,664.3	2,664.3
Maize	2,555.1	2,354.4	2,296.8	2,293.3	2,386.9	2,336.0
Cassava	1,278.0	43.2	43.2	43.2	43.2	43.2
Kenaf	-	1.2	1.2	1.2	1.2	1.2
Rubber	-	-	-	-	-	-
Sugar	606.5	4,641.0	6,960.6	6,960.6	7,262.4	7,262.4
	Harvested Area (000 rai)					
Rice nonglutinous	4,687.9	6,931.3	6,757.8	7,492.1	6,431.9	6,289.7
Rice glutinous	5,813.6	5,483.1	5,820.4	5,837.3	6,146.3	6,288.0
Maize	9,692.7	9,151.5	8,938.9	8,925.4	9,111.3	8,854.6
Cassava	564.0	19.1	19.1	19.1	19.1	19.1
Kenaf	-	7.3	7.3	7.3	7.3	7.3
Rubber	-	-	-	-	-	-
Sugar	69.5	531.6	797.3	797.3	831.9	831.9
	Yield (kilogram/rai)					
Rice nonglutinous	433.6	376.6	389.6	365.6	414.4	428.2
Rice glutinous	421.6	439.7	425.0	423.9	433.4	423.7
Maize	263.6	257.2	256.9	256.9	261.9	263.8
Cassava	2,265.5	2,265.5	2,265.5	2,265.5	2,265.5	2,265.5
Kenaf	-	169.9	169.9	169.9	169.9	169.9
Rubber	-	-	-	-	-	-
Sugar	8,726.4	8,730.0	8,730.0	8,730.0	8,730.0	8,730.0

SOURCE: [DAE, 1976a]

Table 9. Output, harvested area, and yields of principal crops at different price levels for nonglutinous rice in the Central Plain

Crop	Solution					
	Base	I	II	III	IV	V
	Production (000 metric tons)					
Rice nonglutinous	4,267.0	5,111.3	6,136.6	6,584.0	6,935.3	6,937.4
Rice glutinous	286.1	346.4	283.5	283.6	93.6	93.5
Maize	1,218.4	1,272.2	1,271.4	915.5	1,182.7	1,182.7
Cassava	4,457.8	5,791.8	6,431.9	6,431.9	6,370.6	6,370.6
Kenaf	-	-	-	-	-	-
Rubber	2.7	-	-	-	-	-
Sugar	12,469.4	8,434.4	6,115.3	6,115.3	5,813.5	5,813.5
	Harvested Area (000 rai)					
Rice nonglutinous	12,249.8	13,592.5	13,907.4	13,917.1	14,686.4	14,688.9
Rice glutinous	1,087.1	1,298.8	1,065.6	1,055.1	336.3	332.9
Maize	3,837.8	3,885.0	3,881.1	2,899.5	3,849.4	3,849.4
Cassava	2,020.2	2,505.8	2,738.2	2,738.2	2,715.9	2,715.9
Kenaf	-	-	-	-	-	-
Rubber	17.4	-	-	-	-	-
Sugar	1,467.1	988.4	725.5	725.5	689.7	689.7
	Yield (kilogram/rai)					
Rice nonglutinous	348.3	376.0	441.2	473.1	472.2	472.2
Rice glutinous	263.1	266.7	265.9	268.8	278.1	280.7
Maize	317.4	327.4	327.5	315.7	307.2	307.2
Cassava	2,206.6	2,311.3	2,348.9	2,348.9	2,345.6	2,345.6
Kenaf	-	-	-	-	-	-
Rubber	152.7	-	-	-	-	-
Sugar	8,499.2	8,533.3	8,429.0	8,429.0	8,429.0	8,429.0

Table 10. Output, harvested area, and yields of principal crops at different price levels for nonglutinous rice in the South region

Crop	Solution					
	Base	I	II	III	IV	V
	Production (000 metric tons)					
Rice nonglutinous	590.5	639.4	640.3	641.7	663.6	669.5
Rice glutinous	27.0	27.0	27.0	27.0	27.0	27.0
Maize	-	-	-	-	-	-
Cassava	108.8	108.8	108.8	108.8	108.8	108.8
Kenaf	-	-	-	-	-	-
Rubber	414.4	417.1	417.1	417.1	417.1	417.1
Sugar	-	-	-	-	-	-
	Harvested Area (000 rai)					
Rice nonglutinous	1,799.9	1,973.6	1,979.1	1,990.9	1,982.1	1,983.5
Rice glutinous	118.0	118.0	112.5	109.6	109.6	108.1
Maize	-	-	-	-	-	-
Cassava	68.4	68.4	68.4	68.4	68.4	68.4
Kenaf	-	-	-	-	-	-
Rubber	7,062.8	7,062.8	7,062.8	7,062.8	7,062.8	7,062.8
Sugar	-	-	-	-	-	-
	Yield (kilogram/rai)					
Rice nonglutinous	328.0	323.9	323.5	322.3	334.7	337.5
Rice glutinous	228.7	228.7	239.9	246.3	246.2	249.6
Maize	-	-	-	-	-	-
Cassava	1,590.0	1,590.0	1,590.0	1,590.0	1,590.0	1,590.0
Kenaf	-	-	-	-	-	-
Rubber	58.6	59.0	59.0	59.0	59.0	59.0
Sugar	-	-	-	-	-	-

prices for nonglutinous rice being higher than glutinous rice, there is a tendency to produce nonglutinous rice, after subsistence requirements for glutinous rice have been met. The 1972/73-1974/75 average annual glutinous rice production of 4.2 million tons is equal to the 1981 estimated production. Farm prices in the 1972/73-1974/75 period were, however, 1,789 baht per ton (Division of Agricultural Economics, 1976).

Yields in the Northeast for nonglutinous rice and glutinous rice are 178.4 kilogram and 199.0 kilogram, respectively. These yields are below the estimated national yields of 317.5 kilograms and 261.2 kilograms. The low yields are mainly due to the lower level of technology in the Northeast region and the low productivity of its land resources compared to other regions.

Estimated rice production in the North under the Base Solution is 2.5 million tons, well below the average 1972/73-1974/75 production of 3.5 million tons. The North is, however, the second largest producer of rice, with nonglutinous rice accounting for about 45 percent of total regional production (Table 8). Glutinous rice production in the North plays an important role for subsistence and local demand. Throughout this analysis, the total quantity of glutinous rice produced in Thailand changes but little among solutions. Only enough glutinous rice is produced to meet subsistence and domestic requirements. The model does not allow exports of glutinous rice.

The Central Plain produces 4.3 million tons of nonglutinous rice in the Base Solution, almost one third of the nation's total output. Conversely, the Central Plain produces very little glutinous rice, 0.3 million tons. One reason for the large nonglutinous rice output of the Central Plain is the large high yielding Land II base, 68 percent of the national Land II base.

The South region does not produce enough rice to meet regional demand for both nonglutinous rice and glutinous rice in the Base Solution. To satisfy total demand the region must import nonglutinous rice from other regions. Rice production totals .6 million tons with less than 5 percent as glutinous rice.

The area harvested, 47.4 million rai, at the national level in 1981 is nearly equal to the 1972/73-1974/75 average of 45.4 million rai (Table 6). One reason for the 2 million rai increase in land area may be because of the low rice price. Within the model, there is a tendency to reduce application of fertilizer and other nonfarm inputs and use more land suitable for rice production to meet domestic and export demands.

At the base price level of 600 baht, Thailand meets domestic demand but exports only .2 million tons of nonglutinous rice. Thus, the supply price of 600 baht per ton is sufficient to bring forth adequate production for the nation's own requirements in 1981, but not nearly enough to satisfy historic export requirements.

At the regional level, the relative importance of glutinous rice in the North and Northeast is emphasized in the area planted to glutinous rice in the North and Northeast is emphasized in the area planted to glutinous rice. More than 55 percent of the harvested area in the two regions is glutinous rice, as compared to the 6 and 8 percent for the Central Plain and South, respectively, (Tables 7, 8, 9, and 10). Yields in the North region are highest for both nonglutinous and glutinous rice, 434 kg and 422 kg, respectively. The Northeast, on the other hand, has the lowest yields, 178 kg and 199 kg for nonglutinous rice and glutinous rice, respectively.

For the remainder of the crops there is less variation among solutions both in area harvested and output because these crops (e.g., rubber, kenaf, cassava, and maize) do not compete for the same land as rice. Moreover, demand for other commodities remains constant throughout the analysis. Too, as the price of rice is increased, rice does not have a chance to compete with some land available to other crops. Output as well as harvested area for other crops, thus, is rather stable across the six solutions.[8]

National production of maize, cassava, rubber and sugar is well above the 1972-73 to 1974-75 national average. Kenaf production remains slightly behind for all solutions (Table 6). Export prices at Bangkok for the export crops (kenaf, cassava, and maize) are constant for all solutions. Domestic demands for rubber and sugar are fixed and remain the same across the various rice price levels. Except for minute variations in yield due to reallocation of land among regions between price levels, output and area harvested hardly change at the national level. Therefore, only significant changes in output or yields of these crops will be discussed at the regional level, if and when they occur.

Step I Alternative, 1,200 Baht Per Ton Nonglutinous Rice

A doubling of the price of rice increases total rice production by 19 percent and nonglutinous rice production by 29 percent. Using the arc

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[8]The model does define upland rice production activities for both nonglutinous rice and glutinous rice. However, it seems that these activities have very little impact on total land included for rice production.

elasticity formula[9] the price elasticity of supply is estimated to be .38 between the Base Solution and Step I Solution. Hence, production is estimated to increase 3.8 percent as price increases by 10 percent. While the arc supply elasticity for the Kingdom is estimated to be .38, the regional elasticities vary between .27 and .12.

The difference in regional and national supply elasticities is in accordance with expectations [Heady, 1962; Tweeten, 1970]. The greater and more diverse resource structure of a whole nation provides for greater substitution possibilities than any region by itself.

As the ratio of rice input prices increases, several adjustments can be made within the model: (1) More land can be put into rice production; (2) Fertilizer application per rai can be increased; (3) The area fertilized can be increased; (4) The proportion of new high yielding seed varieties can be increased; and (5) More land in class II can be planted to rice in the dry season using irrigation facilities through competition with other crops, that become relatively less profitable.

National rice production increases bv 2.7 million to 16.5 million tons under the Step I Solution as compared to the Base Solution. Output in the South increases by only 50,000 tons, while the Central Plain produces nearly a million tons of rice over the base level.

Total harvested area increases by 19 percent to 56.6 million rai, the largest area harvested among all the solutions. This area is about 4

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$$\eta = \frac{x-x1/x+x1}{p-p1/p+p1}$$

where η is the price elasticity of supply, x, and x1 are the quantities supplied, and p and p1 are the prices obtained for the product $x > x1$, and $p > p1$.

million rai more than the historic maximum area planted in 1973/74. In addition, harvested rai for maize increases by 3 million over the Base Alternative, totaling 17.8 million rai. Other crops occupy the same area as in the Base Alternative.

Rice yields decline slightly as production expands into the marginal land areas. Maize yields also decline by about 5 kg as production increases in the Northeast and declines in the North.

Step II Alternative, 1,800 Baht Per Ton Nonglutinous Rice

The elasticity of supply between Step I Alternative and the Step II Alternative declines to .23. This rapid decline results from the manner that Thai agriculture is structured in the model. The supply elasticity is partly a reflection of the constraints included in the model. Except for a relatively small area of Land II, that can be planted to upland crops in the dry season, and a somewhat larger area of Land IV that can be planted to rice, the rice land base if fixed.

Given the bounds on rates of increase on use of new seed varieties, irrigation, and area fertilized, land is the major resource restraint to further increases in production. As the area fertilized increases, the demand for fertilizer increases rapidly (Table 11).

With the price of nonglutinous rice at 1,800 baht per ton, production is estimated to be 11.4 million tons, 10 percent more than under the Step I Solution. Rice production totals 17.4 million tons, over 2.5 million tons of rice more than the historic high of the 1973/74 crop year. As rice production increases, yields also increase as a result of the increased use of fertilizer, high yield RD varieties and irrigation facilities (Appendix tables 1 and 2).

Table 11. Derived fertilizer demand for rice production by region at various farm prices for nonglutinous rice ('000 metric tons)

Region	Rice Price (baht/Ton) 600	1,200	1,800	2,400	3,000	3,600
			Nitrogen 12.26 baht per kg.			
Northeast	23,187.0	23,187.0	37,014.0	44,364.0	45,508.0	52,357.0
North	0	0	833.0	7,182.0	13,521.0	14,832.0
Central Plains	20.0	7.0	37,980.0	63,226.0	71,021.0	71,226.0
South	3,786.0	3,786.0	3,827.0	4,767.0	5,126.0	5,697.0
Kingdom	26,994.0	26,980.0	79,655.0	119,538.0	135,178.0	114,113.0
Region			Phosphorus (12.70 baht/kg P_2O_5			
Northeast	28,983.0	28,983.0	46,268.0	55,455.0	56,885.0	65,446.0
North	0	0	1,041.0	8,977.0	16,902.0	18,541.0
Central Plains	25.0	9.0	47,475.0	79,032.0	88,777.0	89,032.0
South	4,733.0	4,733.0	4,784.0	5,959.0	6,408.0	7,121.0
Kingdom	33,742.0	33,726.0	99,569.0	149,423.0	168,973.0	180,141.0

NOTE: Fertilizer compound is NPK - 16, 20, 0.

Production of nonglutinous rice expands only slightly in the South and North regions. On the other hand, East and the Central Plain regions increased production by 345,000 tons and 1.025 million tons, respectively, over the Step I Solution. As Figures 4, 5, 6, 7, and 8 indicate, the Central Plain and the Northeast have the most elastic supply schedules while the North and the South exhibit extremely inelastic supply behavior for reasons mentioned earlier.

Harvested rice area for the Kingdom increases from Step I by 240,000 rai to a total of 52.9 million rai. As the price of rice increases, land used for rice and the amount of high yielding seed varieties both increase. Also, some upland crops are displaced by rice grown on Land II in the dry season as the rice price is increased. The land area used for production for all crops in each region at each price level is shown in Table 12.

Yields rise considerably as area fertilized quadruples under the Step II Solution and use of RD_2 and RD_3 seed varieties increases. Nonglutinous rice yield is 352 kg, a 13 percent increase over Step I. Glutinous rice yield increases by 7 percent to 279 kg. While rice yields continue to increase as the rice price is incremented, Thailand would have to triple yields to compare favorably in yields with countries such as Japan, Korea, United States, and China. Technology is available to produce similar yields in Thailand.

Step III Alternative, 2,400 Baht Per Ton Nonglutinous Rice

A slightly larger land base and modest increases in yields cause total rice to reach 17.8 million tons in the Step III Solution. The

Table 12. Land area available and used for all commodities by type, season, and region, and percentage used (1,000 rai)

Region		Wet Season Land Type I	Wet Season Land Type II	Wet Season Land Type III	Wet Season Land Type IV	Dry Season Land Type II	Dry Season Land Type IV
				Base Solution			
Northeast	Available land	0	1,878	21,194	11,387	339	11,387
	Land used	0	1,878	19,638	7,002	264	6,904
	% used	0	100	93	61	77	60
North	Available land	2,591	3,200	6,299	6,913	617	6,913
	Land used	1,964	3,200	5,573	6,293	617	6,913
	% used	76	100	88	91	100	100
Central Plain	Available land	366	10,317	3,726	7,595	2,213	7,595
	Land used	0	9,404	2,028	5,755	1,976	5,736
	% used		91	54	76	89	75
South	Available land	0	1,333	685	9,927	73	9,929
	Land used	0	1,333	511	9,729	73	9,928
	% used	0	100	75	98	100	100
Kingdom	Available land	2,927	16,730	35,337	35,824	3,243	35,824
	Land used	1,964	15,186	27,752	28,781	2,931	29,481
	% used	76	91	79	82	90	84

Table 12 (continued)

Region		Wet Season Land Type I	Wet Season Land Type II	Wet Season Land Type III	Wet Season Land Type IV	Dry Season Land Type II	Dry Season Land Type IV
				Step I Solution			
Northeast	Available land	0	1,878	21,194	11,387	339	11,387
	Land used	0	1,878	21,194	7,310	339	7,783
	% used	0	100	100	64	100	68
North	Available land	2,591	3,200	6,299	6,913	617	6,913
	Land used	2,591	3,200	6,299	6,002	617	5,731
	% used	100	100	100	87	100	83
Central Plain	Available land	336	10,317	3,726	7,595	2,213	7,595
	Land used	336	10,028	2,377	5,697	2,213	5,718
	% used	100	97	64	75	100	75
South	Available land	0	1,333	685	9,927	73	9,929
	Land used	0	1,333	685	9,729	73	9,928
	% used	0	100	100	98	100	100
Kingdom	Available land	2,927	17,030	35,337	39,837	3,322	39,837
	Land used	2,927	16,740	33,981	32,753	3,322	33,175
	% used	100	98	96	82	100	83

Table 12 (continued)

Region		Wet Season Land Type I	Wet Season Land Type II	Wet Season Land Type III	Wet Season Land Type IV	Dry Season Land Type II	Dry Season Land Type IV
				Step II Solution			
Northeast	Available land	0	1,878	21,194	11,381	339	11,387
	Land used	0	1,878	21,194	7,301	339	7,932
	% used	-	100	100	64	100	68
North	Available land	2,591	3,200	6,299	6,913	617	6,913
	Land used	2,591	3,200	6,299	6,022	617	5,674
	% used	100	100	100	87	100	78
Central Plain	Available land	336	10,317	3,726	7,595	2,213	7,595
	Land used	336	9,977	2,449	5,698	2,213	5,715
	% used	100	97	66	75	100	75
South	Available land	0	1,333	685	9,927	73	9,929
	Land used	0	1,333	685	9,729	73	9,928
	% used	0	100	100	98	100	100
Kingdom	Available land	2,927	16,730	35,337	35,824	3,243	35,824
	Land used	2,927	16,389	30,628	28,751	3,243	29,250
	% used	100	98	87	81	100	83

Table 12 (continued)

Region		Wet Season Land Type I	Wet Season Land Type II	Wet Season Land Type III	Wet Season Land Type IV	Dry Season Land Type II	Dry Season Land Type IV
					Step III Solution		
Northeast	Available land	0	1,878	21,194	11,387	339	11,387
	Land used	0	1,878	21,194	7,329	339	7,932
	% used	0	100	100	64	100	70
North	Available land	2,591	3,200	6,299	6,913	617	6,913
	Land used	2,591	3,200	6,299	6,015	617	5,657
	% used	100	100	100	87	100	82
Central Plain	Available land	336	10,317	3,726	7,595	2,213	7,595
	Land used	336	9,983	2,443	5,672	2,213	5,686
	% used	100	97	66	75	100	75
South	Available land	0	1,333	685	9,927	73	9,929
	Land used	0	1,333	685	9,729	73	9,929
	% used	0	100	100	98	100	100
Kingdom	Available land	2,927	16,730	35,337	35,824	3,243	35,824
	Land used	2,927	16,395	30,622	28,746	3,243	29,212
	% used	100	98	98	80	100	82

Table 12 (continued)

Region		Wet Season Land Type I	Wet Season Land Type II	Wet Season Land Type III	Wet Season Land Type IV	Dry Season Land Type II	Dry Season Land Type IV
					Step IV Solution		
Northeast	Available land	0	1,878	21,194	11,387	339	11,387
	Land used	0	1,878	21,194	7,336	339	7,983
	% used	-	100	100	64	100	70
North	Available land	2,591	3,200	6,299	6,913	617	6,913
	Land used	2,591	3,200	6,299	6,068	617	5,871
	% used	100	100	100	88	100	85
Central Plain	Available land	336	10,317	3,726	7,595	2,213	7,595
	Land used	336	9,986	2,431	5,628	2,213	5,689
	% used	100	97	65	74	100	75
South	Available land	0	1,333	685	9,927	73	9,929
	Land used	0	1,333	685	9,729	73	9,928
	% used	-	100	100	98	100	100
Kingdom	Available land	2,927	16,398	35,337	35,824	3,243	35,824
	Land used	2,927	16,398	30,610	28,762	3,243	29,423
	% used	100	98	87	80	100	82

Table 12 (continued)

Region		Wet Season Land Type I	II	III	IV	Dry Season Land Type II	IV
					Step V Solution		
Northeast	Available land	0	1,878	21,194	11,387	339	11,387
	Land used	0	1,878	21,194	7,305	339	8,155
	% used	-	100	100	64	100	72
North	Available land	2,591	3,200	6,299	6,913	617	6,913
	Land used	2,591	3,200	6,298	6,159	100	5,820
	% used	100	100	100	89	100	84
Central Plain	Available land	336	10,317	3,726	7,595	2,213	7,595
	Land used	336	9,989	2,428	5,628	2,213	5,689
	% used	100	97	65	74	100	5,689
South	Available land	0	1,333	685	9,727	73	9,929
	Land used	0	1,333	685	9,729	73	9,928
	% used	-	100	100	98	100	100
Kingdom	Available land	2,927	16,730	35,337	35,824	3,243	35,824
	Land used	2,927	16,401	30,606	28,822	3,243	29,594
	% used	100	98	87	82	100	83

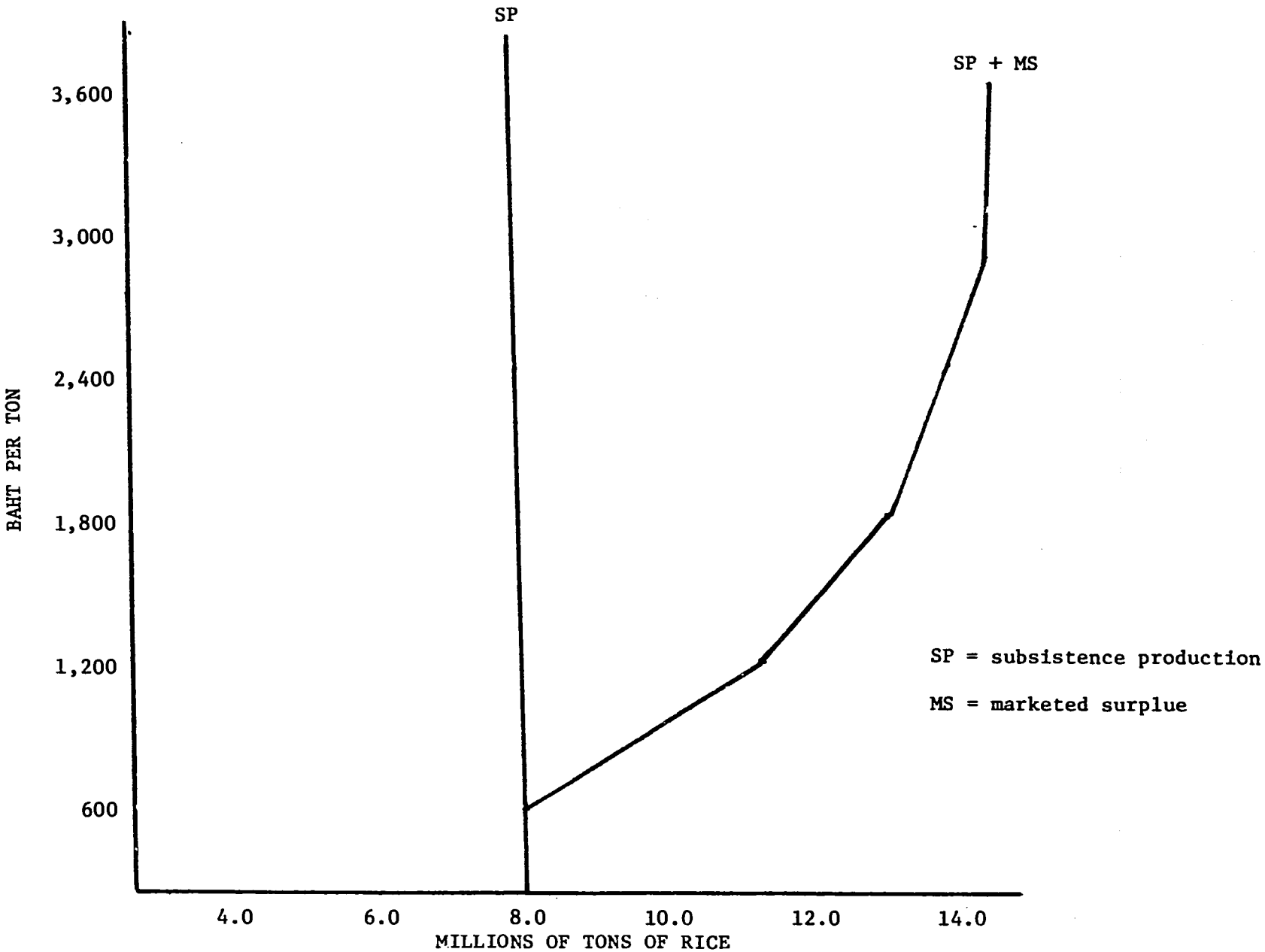

Figure 4. Nonglutinous rice supply schedule for the kingdom

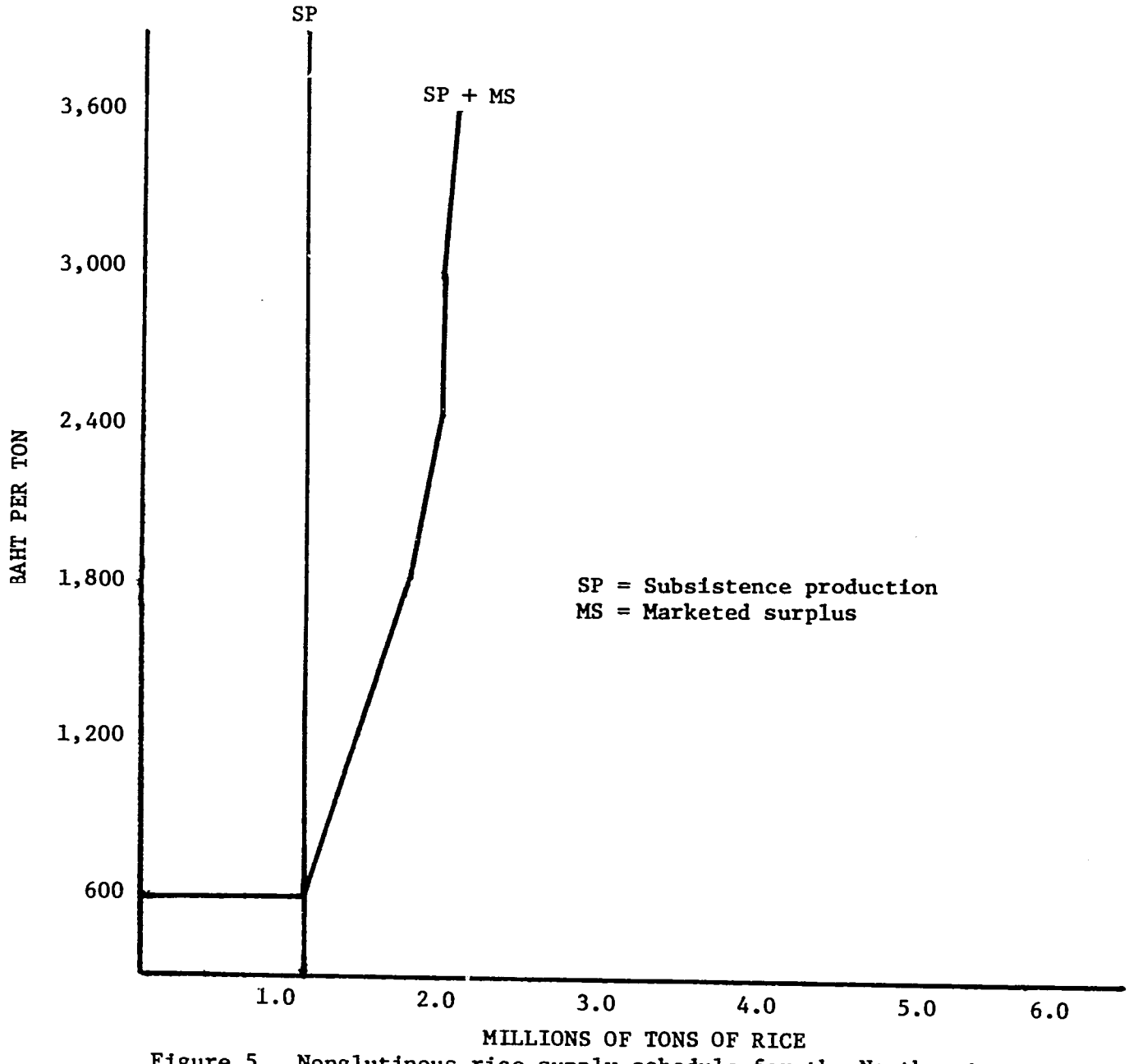

Figure 5. Nonglutinous rice supply schedule for the Northeast.

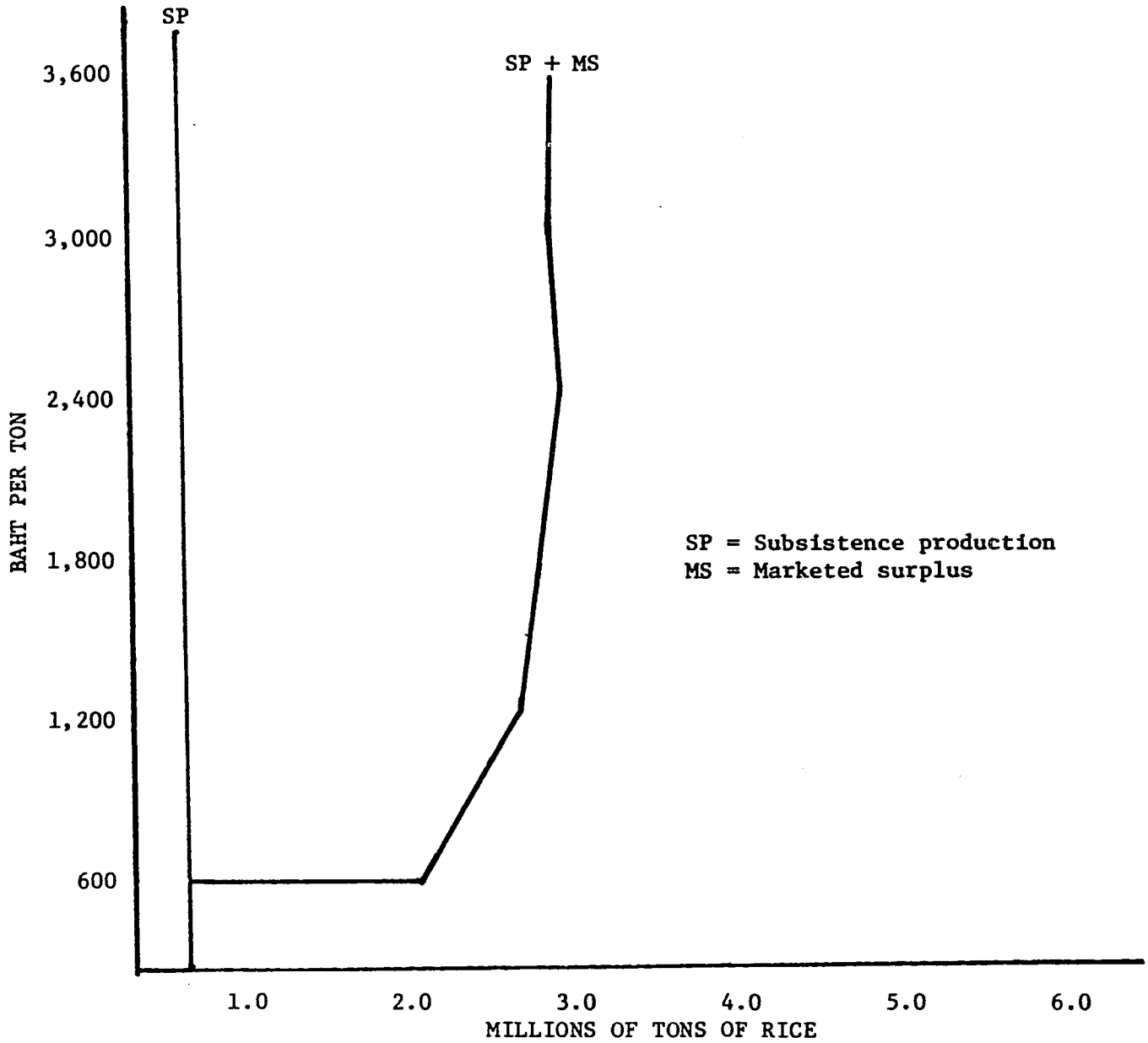

Figure 6. Nonglutinous rice supply schedule for the North.

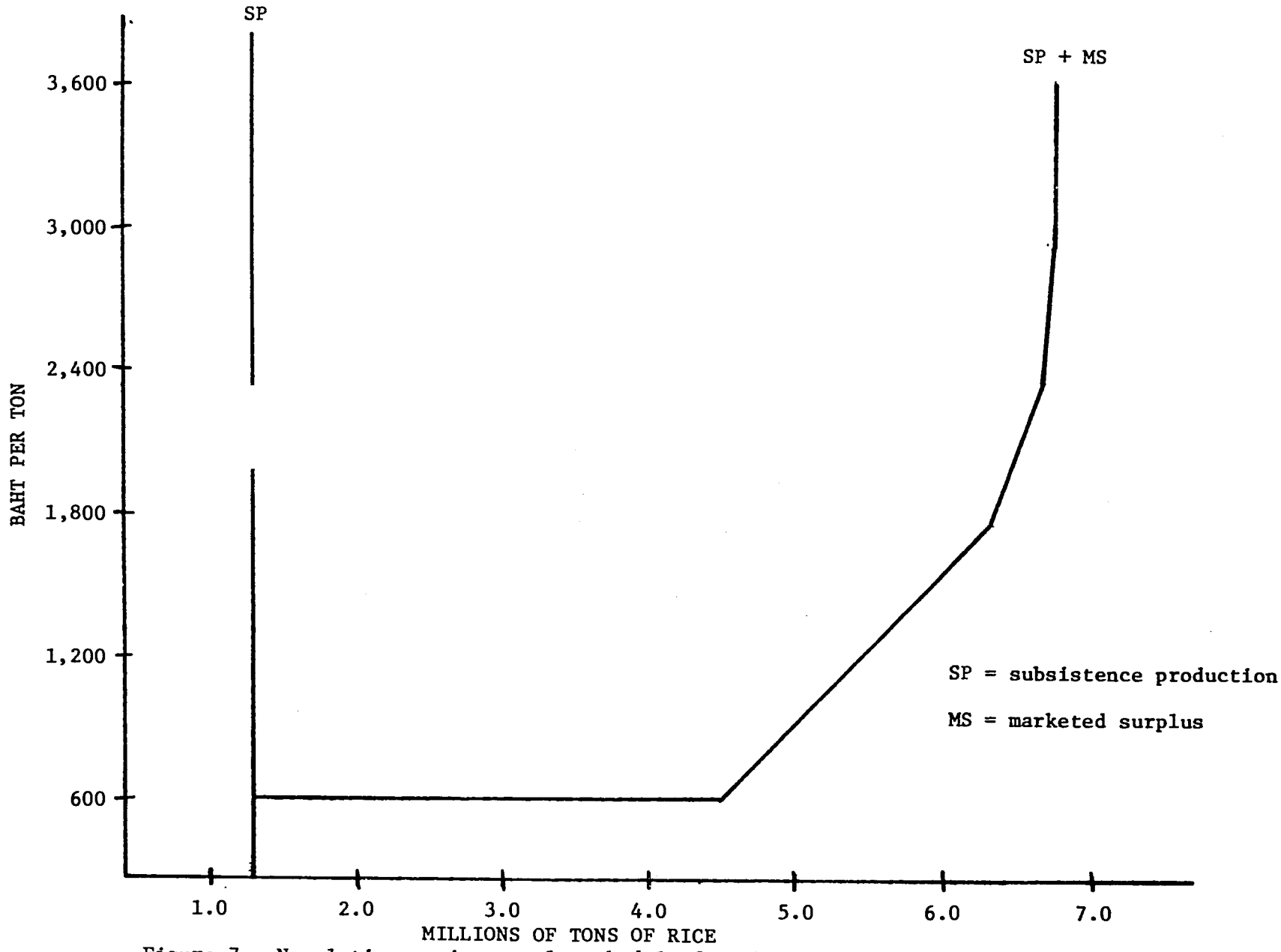

Figure 7. Nonglutinous rice supply schedule for the Central Plains

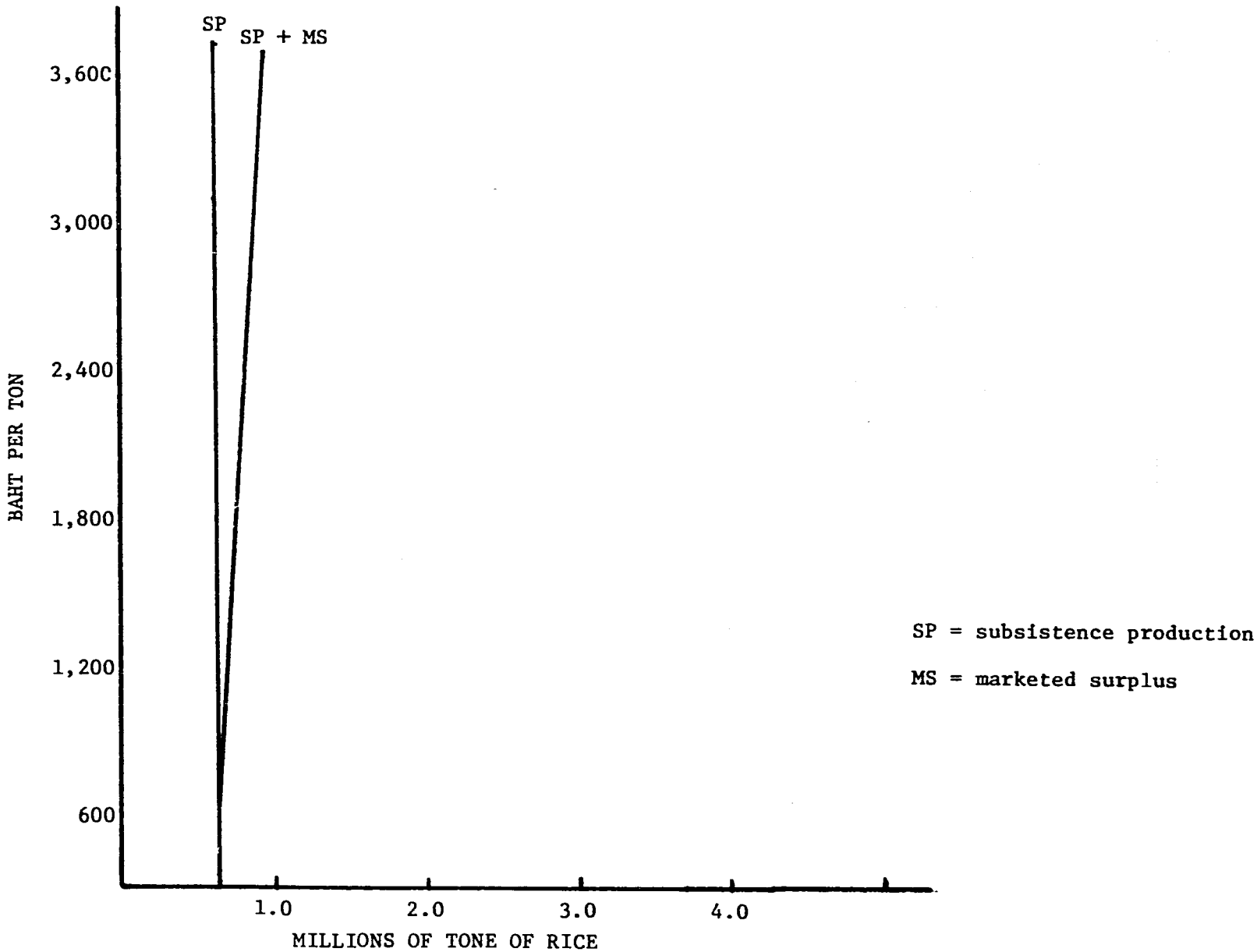

Figure 8. Nonglutinous rice supply schedule for the South

Northeast and the Central Plains regions account for almost all of the increase with 138,000 and 448,000 tons of rice, respectively, over the Step II Solution. Rice yields also are higher as more technological inputs are used for the higher priced output. The Central Plain has the highest rice yields, 473 kg under the Step III Solution. The Central Plain surpasses the North in yields since the former region can grow more rice on Land II and thus, use more RD varieties and fertilizer.

The Central Plain yield for nonglutinous rice increases 36 percent to 473 kg between the Base Solution and Step III Solution. Both the North and South regions have a decline in yields as rice production expands onto the more marginal areas under the Step III Solution.

The area planted to rice in the Central Plain increases only slightly over the range of prices used in this study. The unused rice land in the model is because of labor limitations in zones 13, 15 and 16. The shadow prices associated with these labor limitations are several times the actual wage rate. In such situations the farmers would either hire migrant labor from other zones (which is available) or plant the crop later with a lower expected yield. The model, which was kept small and simple, did not allow for either of these possibilities. The result is that the potential supply of rice is underestimated slightly. With the above options available the land use pattern in the Central Plain would be more like that of the North and Northeast. In the North and Northeast the rice land base increased by over 50 percent as the price of rice increased from 600 to 2,400 baht.

Step IV Alternative, 3,000 Baht Per Ton Nonglutinous Rice

Rice production at the Kingdom level is 18.2 million tons at farm prices of 3,000 baht per ton. The supply elasticity between the Step III and Step IV solutions is .12.

National output increases by only 313,000 tons over the Step III Solution. Most of the increase is produced in the Central Plain. Simultaneously, this region abandons almost all of its glutinous rice production. Conversely, the North region produces more glutinous rice and less nonglutinous rice than under the Step III Solution. The Central Plain has opportunity to grow more high yielding nonglutinous rice in both the wet and dry seasons. The North has a comparative advantage in glutinous rice production.

Step V Alternative, 3,600 Baht Per Ton Nonglutinous Rice

At supply prices of 3,600 baht per ton of nonglutinous rice, the country's rice production reaches a near maximum, given the contraints inherent in the programming model. The supply elasticity declines to 0.5 between solutions for Step IV and Step V. Total output increases by only 120,000 tons. The Northeast and the North regions produce the additional output. The Northeast switches some land from glutinous rice production to nonglutinous rice, while the converse occurs in the North. At this price level, yields range from 374 kg in the Central Plain to 208 kg in the Northeast.

Once the land base is exhausted, use of technological inputs increases. For example, the North region does not use any fertilizer until the rice

price has increased to 1,200 baht per ton (Table 12). At Step II, 883 tons of fertilizer are used. As the rice price increases to 2,400 baht, fertilizer use increases to 7,000 tons at 2,400 baht and to 13,500 tons at 3,000 baht. Although somewhat less pronounced, the same directional movement is true for the other regions.

Fertilizer use increases almost 600 percent between the Base and the Step V Solution. Although is is assumed that Thai agriculture can acquire this amount of fertilizer at the initial price, this assumption may not be realistic relative to government fertilizer import policies, the shortages experienced in the past, and the short-run production capacity of the Thai fertilizer industry. However, the demand for fertilizer could be much larger.

EXPORT SUPPLIES

The export supply of rice, maize, cassava, and kenaf are discussed in this section. The figures in Table 13 have been adjusted for regional consumption. For this reason, a region can have negative exports (imports) for a particular commodity. The rice figures in Table 13 represent net exportable quantities of rice (i.e., regional demands have been subtracted out already). Exports for maize, cassava, and kenaf are possible up to a limit at fixed prices in all solutions. With only limited competition for land among rice and the other commodities endogenous to the model together with an abundance of labor and capital, exports of maize, cassava, and kenaf reach their limit in the Base Alternative.

Table 13. Exports of rice, maize, cassava, and kenaf for various price levels of nonglutinous rice by region (1000 tons)

	Northeast	North	Central Plain	South	Kingdom
			Base		
Rice nonglutinous	-172.4	755.1	479.0	-857.5	204.2
Maize	238.4	2,379.3	567.3	-	3,185.0
Cassava	4,880.2	1,234.7	-1,426.2	85.2	4,773.9
Kenaf	149.5	-	-41.5	-	108.0
			Step I		
Rice nonglutinous	274.5	1,332.5	1,323.3	-808.6	2,121.4
Maize	385.4	2,178.6	621.0	-	3,185.0
Cassava	4,781.0	-0.0	-92.3	85.2	4,773.9
Kenaf	148.3	1.2	-41.5	-	108.0
			Step II		
Rice nonglutinous	619.8	1,354.9	2,348.6	-807.7	3,515.6
Maize	444.0	2,121.0	620.0		3,185.0
Cassava	4,140.9	-0.0	547.8	85.2	4,773.9
Kenaf	148.3	1.2	-41.5	-	108.0
			Step III		
Rice nonglutinous	757.8	1,461.1	2,796.0	-806.3	4,208.6
Maize	446.1	2,117.5	621.4	-	3,185.0
Cassava	4,140.9	-0.0	547.8	85.2	4,773.9
Kenaf	148.3	1.2	-41.5	-	108.0
			Step IV		
Rice nonglutinous	771.5	1,387.4	3,147.3	-784.4	4,521.8
Maize	442.3	2,211.1	531.6	-	3,185.0
Cassava	4,202.2	0.0	486.5	85.2	4,773.9
Kenaf	148.3	1.2	-41.5	-	108.0
			Step V		
Rice nonglutinous	855.7	1,415.3	3,149.4	-778.5	4,641.9
Maize	493.2	2,160.2	531.6	-	3,185.0
Cassava	4,202.2	0.0	486.5	85.2	4,773.9
Kenaf	148.3	1.2	-41.5	-	108.0

Table 14 presents the results of how net export figures are derived from nonglutinous rice production and consumption. To rough out the analysis, the estimates for glutinous rice are provided in Table 15. In this study the assumption is made that there is a ready market for all export commodities.

Exports Under the Base Price

The supply of nonglutinous rice is small at the price level for the Base Alternative. Enough rice is produced to satisfy subsistence and domestic demands. Howver, only 204,000 tons are available for export (Table 13). By comparison average exports during the 1972-74 calendar period were 1.3 million tons.

The South is a deficit region for nonglutinous rice in all solutions, although a small surplus of glutinous is produced. The land base in the South is not large or productive enough to satisfy market requirements for nonglutinous rice. Most of the deficit is imported from the Central Plain and North regions.

Thailand exports 3.2 million tons of maize at 2.37 baht per kg under the Base Alternative. The North accounts for almost 75 percent of the national total maize exports. Cassava exports of 4.8 million tons are substantially above 1972-74 average exports of 1.9 million tons. The Northeast is the nation's most important net exporter of cassava. Due to the large amount of Land IV in the region, the Northeast is the nation's most important net exporter of cassava. The cassava export target of 4.0 million tons of cassava products is substantially above the 1972-74 exports

Table 14. BE2524 production, consumption, and exports for nonglutinous rice by region (million tons)

	Northeast	North	Central Plain	South	Kingdom
			Base		
Production	1.21	2.03	4.27	.59	8.10
Consumption	1.38	1.28	3.79	1.45	7.90
Export	-.17	.75	.48	-.86	.20
			Step I		
Production	1.65	2.61	5.11	.64	10.01
Consumption	1.38	1.28	3.79	1.45	7.90
Export	.27	1.33	1.32	-.81	2.11
			Step II		
Production	2.00	2.63	6.14	.64	11.41
Consumption	1.38	1.28	3.79	1.45	7.90
Export	.62	1.35	2.35	-.81	3.51
			Step III		
Production	2.14	2.74	6.58	.64	12.10
Consumption	1.38	1.28	3.79	1.45	7.90
Export	.76	1.46	2.79	-.81	4.20
			Step IV		
Production	2.15	2.67	6.94	.66	12.42
Consumption	1.38	1.28	3.79	1.45	7.90
Export	.77	1.39	3.15	-.79	4.52
			Step V		
Production	2.24	2.69	6.94	.67	12.54
Consumption	1.38	1.28	3.79	1.45	7.90
Export	.86	1.41	3.15	-.78	4.64

Table 15. BE 2524 production, consumption, and surplus for glutionous rice by region (1000 tons)

	Northeast	North	Central Plain	South
		Base		
Production	2,980	2,451	286	27
Consumption	3,630	2,020	60	20
Surplus (deficit)	(650)	431	226	7
		Step I		
Production	2,960	2,411	346	27
Consumption	3,630	2,020	60	20
Surplus (deficit)	(670)	391	286	7
		Step II		
Production	2,960	2,474	284	27
Consumption	3,630	2,020	60	20
Surplus (deficit)	(670)	454	224	7
		Step III		
Production	2,960	2,474	284	27
Consumption	3,630	2,020	60	20
Surplus (deficit)	(670)	454	224	7
		Step IV		
Production	2,960	2,664	94	27
Consumption	3,630	2,020	60	20
Surplus (deficit)	(670)	644	34	7
		Step V		
Production	2,960	2,664	94	27
Consumption	3,630	2,020	60	20
Surplus (deficit)	(670)	644	34	7

of 1.9 million tons of cassava products. The Northeast is expected to be a main source of the expanded exports with total production divided almost evenly between the Northeast and the Central Plain. Kenaf exports are 108,000 tons under the Base Alternative, compared to 240,000 tons during the 1972-74 period.

Exports Under Steps I Through V

The exportable surplus for all commodities but nonglutinous rice remains the same at the national level as in the Base Alternative in solutions for Step I through Step V. Regional exports vary slightly among steps because of the reallocation of crop production within and among regions and among land classes. For example, cassava is produced on 2.0 million rai of Land IV in the Central Plain in the Base Solution. In the Step I solution, 2.5 million rai of Land IV is allocated to cassava, while the harvested area of sugarcane, groundnuts, and maize decreases by .5 million rai. The Northeast and the North decrease the cassava area in the Step I Solution and increase maize production.

Rice exports increase from .2 million tons in the Base Solution to 4.6 million tons in the Step V Solution. The large increase occurs in the lower portion of the supply function. For example, an increase in the supply price of rice from 600 baht per ton to 1,200 baht causes exports to increase tenfold. Another doubling of the rice price causes rice exports also to double. Exports increase at a decreasing rate between price increments for these reasons: In the initial stage of the supply function, Thai agriculture has sufficient labor and capital to expand rice production and the technological restrictions have not become

effective. As the supply price increases it becomes profitable to apply more of the higher cost technological inputs. However, the main gain from use of more fertilizer and RD varieties are attained with two price increments and the restraints on new technologies eventually become binding. Appendix tables 1, 2 and 3 indicate the steps at which different restraints become binding.

Regional Variations

The North, with .8 million tons, is the nation's largest exporter of rice in the Base Solution. The North also has the highest yields of non-glutinous rice. As the rice price increases to 1,200 baht, exports from the North and Central Plain are almost equal. At higher supply prices, the North quickly reaches its maximum capacity (Appendix tables 1, 2 and 3). For the reasons mentioned earlier, the Central Plain has a more elastic rice supply function. At 3,600 baht per ton for rice, the Central Plain produces 3.1 million tons of rice for export purposes. The North and Northeast each export 1.4 and .9 million tons of rice. The South remains a deficit region throughout the analysis.

Exports of maize shift among the regions in the early steps. The North is the nation's main exporter of maize. It exports almost 2.4 million tons of maize in the Base Solution. As the rice price increases, the relative profitability of maize and cassava decreases. The North is the largest exporter of maize at all price levels.

The Northeast is the major source of cassava exports in the Base Solution. However, the Central Plain is the major source of cassava for

export in the solutions for Step I through Step V. The interaction between the Northeast and Central Plain comes about through labor limitations in zones 13, 15 and 16 and because of additional land that is drawn into production.

FARM INCOME

The price increments used to analyze supply potentials are relatively large. Obviously, net farm incomes should increase accordingly. However, we especially are interested in examining net farm income to determine how it is affected in different regions.

Finally, rice price has a major effect on Thai farm income because it constitutes the major crop. As the rice price increases, those regions with the large and more productive land base suitable for rice will experience the greatest increases in income.

The Base Solution provides unacceptable farm incomes in the Northeast and South regions (Table 16). Even under actual conditions, income is low in the Northeast. As price is increased through the Step V Solution, net farm income per farm increases by over 1,000 percent for Thailand as a whole. It increases by an even larger relative amount in the Northeast but by a relatively smaller amount in the South. While the rate of increase in the North and Central Plain regions is smaller than for the Northeast, the former two regions have a much larger net farm income per farm at the higher price levels. The former two regions are able to increase the absolute amount of net farm income by a greater amount because they possess more rice land on which new technologies have a greater yield response.

Table 16. Estimated BE 2524 net farm income per farm for each step by region[a]

Solution	Net Farm Income (Baht)				
	Northeast	North	Central Plain	South	Kingdom
1970 Actual	952	2,187	1,343	1,784	1,486
Base	170	2,148	2,221	646	1,117
Step I	1,404	5,844	5,356	1,123	2,742
Step II	2,865	9,144	9,603	1,716	5,563
Step III	4,324	12,613	13,859	2,367	7,981
Step IV	5,690	16,146	17,883	3,000	10,313
Step V	7,184	19,717	21,731	3,646	12,665

[a]Farm numbers are projected for 1981 by region: Northeast 2,026,381, North 927,919; Central Plain 1,144,132; South 644,205.

The Level and Distribution of Farm Income as Affected by the Farm Level Price of Rice

There has been considerable discussion about the policies related to the domestic price of rice in Thailand. The history of these policies has been reviewed by Siamwalla [1975]. Much of the discussion has been directed to the effects of the rice price on the transfer of income from the rural to the urban sector as well as the effects of price on production incentives. The potential effects of the price of rice on producer incentives in each region has been examined through the normative supply curves for rice. In this section we wish to examine the effects of alternative prices of rice on the regional distribution of agricultural income.

Rice is grown in all regions of Thailand so net farm income in each region does increase as the price of nonglutinous rice is increased (Table 16). However, regional differences in the rice area per farm and(or) the elasticity of production with respect to irrigation and fertilizer will influence the regional distribution of net farm income. There are three measures of farm income in Table 17. In each case the income from rice production is calculated from the parameterized price of rice in each solution. Two income measures for the value of upland crops are used. In the first measure, upland crops are valued in terms of the opportunity cost of resources used in the production of each crop. The shadow price of each crop is the theoretically correct price to use for income calculations. However, there are reasons to believe the shadow prices arrived at in this study are too low. This is due in part because the models to date have not been able to reflect any trade-off between the utility of income from labor and the disutility of additional work. Unless the total labor supply is limiting, production continues until the marginal value product of labor is driven to zero. Since labor was limiting in only a few zones the imputed wage rate is zero in most cases. Since labor constitutes a major input into crop production, the resulting shadow price for the crop is also low. Another reason is that the upland area in each agroeconomic zone is more heterogenous than was perceived when the models were first constructed. Still another reason is that no discounts have been made for risk and uncertainty. The DAE has research underway to improve the predictive power of the models in the areas mentioned above. For this reason the net value of upland crops has also been calculated by

Table 17. Estimated BE 2524 net farm income per farm for each step by region[a]

Solution	Net Farm Income (Baht)				
	Northeast	North	Central Plain	South	Kingdom
1970 Actual	952	2,187	1,343	1,784	1,486
Price of rice (baht per ton)	Rice and Upland Crops Using Shadow Prices				
600	170	2,148	2,221	646	1,117
1,200	1,404	5,844	5,356	1,123	2,742
1,800	2,865	9,144	9,603	1,716	5,563
2,400	4,324	12,613	13,859	2,367	7,981
3,000	5,690	16,146	17,833	3,000	10,313
3,600	7,184	19,717	21,731	3,646	12,665
	Rice Plus Upland Crops at Constant Prices[b]				
600	1,487	7,512	4,069	8,079	4,789
1,200	2,719	10,392	6,642	8,620	5,969
1,800	3,831	13,762	9,636	9,157	7,898
2,400	5,268	16,778	12,996	9,763	9,913
3,000	6,607	20,171	16,754	10,460	12,233
3,600	7,966	23,098	20,437	10,762	14,316
	Rice Plus Upland Crops and Exogenous Crops and Livestock[c] at Market Prices				
600	2,043	10,639	9,134	9,619	7,641
1,200	3,275	13,520	11,713	9,923	9,263
1,800	4,387	16,890	14,707	10,226	11,197
2,400	5,824	19,906	18,066	10,567	13,294
3,000	7,163	23,300	21,825	10,959	15,532
3,600	8,522	26,226	25,508	11,129	17,616

[a]Farm numbers are projected for 1981 by regions: Northeast 2,025,381; North 927,919; Central Plain 1,144,132; and South 644,205.

[b]Calculated by using Region center prices [DAE, 1977b].

[c]Includes net value of production from exogenous crops, and livestock as used in the Fourth Five Year Plan document [DAE, 1976b].

using actual 1975 farm level prices. It is believed that the actual income from upland crops is closer to the values given by the market prices rather than the shadow prices for the reasons cited above. Market prices are also used to estimate the value net income from crops and livestock which are exogenous to the model. The value of exogenous crops and livestock are included in the income calculations so that the impact of alternative price levels for rice on total farm income can be better approximated.

The question in which regions does the average farm family benefit most from the increased price of rice depnds on the measure used. The income for the average Northeast farm family shows the largest proportionate increase for all the income measures used. The income changes less for the average farm in the South than in other regions. This is because most of the farm income in the South is from upland crops. However, as shown in Table 18, the difference between total farm income for a household in the North or in the Central Plain and the average farm income for a household in the South or in the Northeast increases with the price of rice. The average income per household in the Northeast equals the income of the average household in the South when the price of rice reaches approximately 3,000 baht per ton.

The effect of the alternative prices of rice on the equality or inequality of income distribution for each measure of income is shown in Table 19. The Gini[10] ratios in Table 19 were calculated by assuming that

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[10]Gini coefficients reflect the degree of inequality of income between groups or individuals. If each person has the same income, the Gini coefficient is zero. Conversely, if one person has all the income the Gini coefficient would be one.

Table 18. Effect of alternative rice prices on the regional share of total farm income and the absolute difference in income per household in the Northeast Regions and the remaining regions of Thailand

Price of Rice (Baht Per Ton)	Regional Share of Total Farm Income				Income Per Farm Less Income per farm in the NE		
	North-east	North	Central Plain	South	North	Central Plain	South
	(percent)				(baht/year)		
600	11	29	29	30	6,025	2,756	3,061
1,200	15	29	31	26	7,673	3,923	2,133
1,800	17	29	32	22	9,931	5,805	1,324
2,400	19	29	33	19	11,510	7,728	228
3,000	20	29	34	17	13,564	10,147	-719
3,600	21	29	35	15	15,132	12,471	-1,907

Table 19. Gini ratios measuring the inequality of crop and total farm income between regions of Thailand for alternative farm prices of rice

Farm Price of Rice	Crop Income		Total Farm
	Upland Crops Price at Opportunity Cost	Upland Crops Measured at Market Prices	Rice Plus Upland Crops--Vegetables, Livestock--Measured at Market
	(Gini ratios)		
600	.477	.414	.377
1,200	.339	.280	.312
1,800	.317	.262	.256
2,400	.314	.251	.247
3,000	.310	.247	.246
3,600	.306	.243	.243

all households in each region received the same level of income. The Gini ratios shown here are not the same ratios one would obtain if all households in Thailand were ranked in order of increasing income. The results in Table 19 indicate that the regional distribution of income would move in the direction of greater income equality as the price of rice increased from 600 to 3,600 baht per ton of paddy. However, changes in the Gini ratio are small after the price of rice has reached 1,800 baht. The movement in the direction of greater income equality occurs because of the large proportionate increase in income in the Northeast farm household. Gini ratios reflect proportional increases in income and so there is movement toward greater equality of income even though the absolute difference between, say, the Northeast and the Central Plain household is increasing.

There are several reasons why the income effects of a change in the price of rice vary between regions. At the lower price levels, the RD varieties do not receive any fertilizer and yields are low. As the price of rice increases, more high yielding RD varieties and fertilizer are used on rice at the higher prices. Also, as rice price increases, this crop draws small amounts of land away from other commodities.

The amount of rice produced is a direct function not only of yields but also of the restrictions mentioned previously. These restrictions cause the rice supply schedule of Thailand to be relatively inelastic. The South and Northern regions have a more inelastic supply than do the Northeast and the Central Plain regions. A number of conditions explain this inelastic supply schedule: (a) For the most part, rice is grown on

Land I, II and III, and on only a small portion of upland. No other crops are grown on Land I and II and a rather small area of Land II is utilized for crops other than rice. Upland rice occupies only 2.3 percent of Land IV area. Hence, rice competes only modestly with other crops for land. Further, the supply elasticity is also a function of the restrictions on rate of use of fertilier and RD varieties. Relaxation of the latter restriction would allow supply elasticity to increase somewhat. The inelastic supply schedule for the North in particular reflects the lack of historical use of either fertilizer or RD varieties. With the high proportion of irrigated land the potential supply response in the North is much greater than shown in this study.

Net farm income varies directly with the price of rice. The per unit cost of producing more rice does not increase as fast as the price of the output as the model is solved for the different price levels. Net farm income per farm increases rather dramatically for Thailand as a whole and even for the Northeast region as rice price is set at different levels. However, the Northeast and South regions would still have much lower net farm income per farm than the Central Plain and North regions. The latter two regions have more land adapted to rice production and new technologies and would gain most from the higher rice prices.

Additional rice produced at the higher price levels increased farm labor employment only modestly. Hence, it appears that unemployment and underemployment are two problems that will not vanish with a growing rice export market. Adoption of more labor intensive crops, in a multiple

cropping framework on both land classes II and IV, needs to be encouraged for this purpose. Conversion of land from Land I and III to irrigable land (Land II) could be encouraged.

EMPLOYMENT

Although the employment situation is of secondary concern in this analysis, it continues to be a major problem for Thailand. Thailand has a rapidly growing population and is experiencing an increasing proportion of underemployment and unemployed labor.

Because of the labor intensive nature of Thai agriculture, labor requirements vary widely among seasons (Table 20). Even if Thailand were to have 80 percent of its labor unemployed in the dry season, it needs a majority of these people in the peak labor months of planting and harvesting. If Thailand's agriculture remains labor intensive and adopts new labor intensive technology, labor utilization could increase, but perhaps not enough. Labor use is relatively higher in the Step V Solution than other solutions. However, at the Kingdom level only 16 percent more labor is needed to produce the additional 4.5 million tons of rice in the Step V Solution as compared to the Base Solution.

It does not appear that increased rice production is the solution to Thailand's rural unemployment problems. To solve the employment problem, part of the labor force must be employed outside the sector. Also, agriculture must be directed toward producing more labor intensive crops.

Table 20. Employment situation by step and by region for the dry season and monthly for the wet season (in million hours)

Base Month	Northeast			North			Central Plain			South			Kingdom		
	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used
Dry Season	6,325	548	9	2,723	502	18	1,877	650	35	1,479	616	42	12,404	2,316	19
July	1,254	879	70	540	246	46	372	202	54	291	0	0	2,458	1,327	54
August	1,362	526	39	588	387	66	403	206	51	317	0	0	2,670	1,119	42
September	1,308	88	7	564	181	32	388	212	55	304	145	48	2,564	626	24
October	1,254	213	17	540	228	42	372	23	33	291	197	68	2,457	762	31
November	1,254	226	18	540	205	38	372	142	38	291	100	34	2,457	673	27
December	1,308	636	49	564	349	62	388	202	52	304	178	58	2,564	1,365	53
Step I Solution															
Dry Season	6,325	636	10	2,723	555	20	1,877	716	38	1,479	616	42	13,433	2,669	19
July	1,254	930	74	540	276	61	372	215	58	291	0	0	2,459	1,610	60
August	1,362	525	39	588	422	72	403	208	52	317	0	0	2,670	1,404	49
September	1,308	69	5	564	178	31	388	257	66	304	146	48	2,564	680	24
October	1,254	348	28	540	234	44	372	146	39	291	200	69	2.457	954	36
November	1,254	244	19	540	199	27	372	235	63	291	109	37	2,457	811	30
December	1,308	660	50	564	379	67	388	162	42	304	178	59	2,564	1,580	57
Step II Solution															
Dry Season	6,325	623	10	2,723	584	21	1,877	730	39	1,479	616	42	12,404	2,553	20
July	1,254	927	74	540	288	53	372	211	57	291	0	0	2,457	1,425	58
August	1,363	522	38	588	429	73	403	204	51	317	0	0	2,670	1,155	43
September	1,308	69	5	564	178	32	388	254	66	304	146	48	2,564	647	25
October	1,254	353	28	540	242	45	372	158	42	291	200	69	2,457	953	39
November	1,254	259	21	540	206	38	372	250	67	291	109	37	2,457	823	34
December	1,308	666	51	564	377	67	388	161	41	304	178	59	2,564	138	54

Table 20. Continued.

Base Month	Northeast			North			Central Plain			South			Kingdom		
	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used	Available Labor	Labor Used	% Used
Step III															
Dry Season	6,325	622	10	2,723	583	21	1,877	730	39	1,479	616	42	12,404	2,553	21
July	1,254	921	73	540	576	53	372	421	57	291	0	0	2,457	2,845	58
August	1,363	523	38	588	858	73	403	408	51	317	0	0	2,670	2,310	43
September	1,308	69	5	564	356	32	388	507	65	304	292	48	2,564	1,293	25
October	1,254	359	29	540	485	45	372	316	42	291	399	69	2,457	1,911	39
November	1,254	264	21	540	412	38	372	498	67	291	218	37	2,457	1,650	34
December	1,308	666	51	564	753	67	388	321	41	304	357	59	2,564	2,762	54
Step IV															
Dry Season	6,325	623	10	2,723	585	21	1,877	723	39	1,479	616	42	12,404	2,547	21
July	1,254	922	63	540	288	53	372	203	54	291	0	0	2,457	1,913	57
August	1,363	523	38	588	431	73	403	203	50	317	0	0	2,670	1,156	43
September	1,308	70	5	564	183	32	389	258	66	304	146	48	2,564	656	26
October	1,254	358	29	540	232	43	372	180	48	291	200	69	2,457	969	39
November	1,254	263	21	540	215	40	372	260	70	291	109	37	2,457	846	34
December	1,308	666	51	564	377	67	388	165	42	304	178	59	2,564	1,385	54
Step V															
Dry Season	6,325	623	10	2,723	585	21	1,877	723	39	1,479	616	41	12,404	2,547	21
July	1,254	930	74	540	292	54	372	203	54	291	0	0	2,457	1,924	58
August	1,363	523	38	588	432	73	403	203	50	317	0	0	2,670	1,157	43
September	1,308	64	5	564	197	35	388	258	66	304	146	48	2,564	664	26
October	1,254	386	31	540	232	43	372	180	48	291	200	69	2,457	998	41
November	1,254	266	21	540	211	39	372	260	70	291	109	37	2,957	846	34
December	1,308	652	50	564	377	67	388	164	42	304	178	59	2,564	1,371	53

LAND DEVELOPMENT AND RICE PRICES

As product prices increase, it is expected that imputed prices for inputs also will increase. Thus, as the rice price increases, it is expected that land rents will increase. The magnitude and direction of imputed land rents is given in Table 21.

Rents on Land IV are not affected much by the increase rice prices. A relatively small area of Land IV can be used to grow upland rice. Hence, there is little competition for this land.

In both the North and Central Plain regions, rent for Land I increases from zero baht to over 675 baht per rai. Land II, when cultivated in the dry season has the highest rent or shadow price. In all regions but the Northeast, the shadow price of Land II is over 1,600 baht. The dry season land has higher rents because of the higher yields that are obtained under regulated irrigation.

CONCLUSION

The major purpose of this study is estimation of the potential rice production capacity for Thailand. The model constructed for this purpose is a linear programming model, containing a comparative advantage production sector and a transportation sector [see Framingham et al., 1977]. The model which provides results also at the national level relates to 19 agroeconomic zones and four major regions of Thailand.

Rice price is set at six different levels with solutions made for the linear programming model at each price level. Prices for other

Table 21. Imputed land rents by land class and by region at each price of nonglutinous rice (in baht)[a]

Region	Solution					
	Base	Step I	Step II	Step III	Step IV	Step V
Northeast						
Land I	0	0	0		0	0
Land IIW	257.0	317.2	394.4	473.4	619.0	764.3
Land IID	343.3	322.6	398.3	483.5	634.0	792.0
Land III	438.7	255.6	321.8	390.6	418.4	571.0
Land IVW	21.1	7.3	12.3	3.9	3.9	4.7
Land IVD	5.4	7.3	25.9	17.5	21.3	21.2
North						
Land I	18.5	140.1	273.6	364.7	544.7	676.5
Land IIW	76.8	229.4	453.2	812.5	930.5	1,145.1
Land IID	67.0	380.4	306.0	880.3	1,343.0	1,662.2
Land III	68.8	164.1	350.8	549.8	748.3	933.1
Land IVW	64.0	125.5	112.4	132.1	68.8	69.1
Land IVD	23.4	73.9	79.0	72.0	45.6	51.2
Central Plain						
Land I	0	126.0	263.3	399.9	540.8	675.4
Land IIW	87.8	165.6	378.1	467.1	585.7	753.2
Land IID	105.3	385.6	679.3	985.1	1,294.6	1,611.6
Land III	109.1	157.7	295.8	236.4	404.3	394.8
Land IVW	148.3	170.4	257.3	138.9	85.7	134.2
Land IVD	100.0	187.8	190.2	108.3	97.7	96.4
South						
Land I	539.8	566.4	620.6	638.0	695.4	858.5
Land IIW	1,378.6	1,378.6	1,415.2	1,378.6	1,389.7	1,684.4
Land IID	490.6	356.7	333.4	419.8	622.1	639.5
Land III	0.0	23.4	23.6	0.0	5.3	5.0
Land IVW	25.4	18.2	17.4	11.5	20.5	14.7
Land IVD						

[a]The land values include the value of restrictions on planted RD area, dry season irrigation water, and area fertilized.

commodities are not changed. Solutions of the linear programming model, thus, provide a normative model indicating how much rice could be produced under stated conditions. Land is divided into four classes for the study and land in each class serves as a restriction on production. Rice and 39 other crops are allowed to compete for use of land, labor, and capital supplies. Restraints also are placed on the rates at which new technologies such as RD varieties and fertilizer will be used. All solutions are for the year BE 2524 (1981).

The study suggests that Thai agriculture can substantially increase its rice output even with available technologies. Under the highest prices of the study, Thailand could export more than 4.5 million tons of nonglutinous rice, 300 percent more than 1972-74 average exports. This finding is of utmost importance to Thailand's farm income, public revenue and foreign exchange earnings.

REFERENCES

Behrman, J. R. Supply Response in Underdeveloped Agriculture. North
1968 Holland/American Elsevier, Amsterdam, The Netherlands.

Division.of Agricultural Economics. Agro-Economic Zones for Agricultural
1972 Development. Office of the Under Secretary of State, Ministry of Agriculture and Cooperatives, Bangkok, Thailand.

_____. 1973 General Farm Survey. Office of the Under Secretary of
1974a State, Ministry of Agriculture and Cooperatives, Bangkok.

_____. Agricultural Statistics of Thailand, Crop year 1974-1975.
1974b Agricultural Statistics No. 25. Office of the Under Secretary of State, Ministry of Agriculture and Cooperatives, Bangkok.

_____. Agricultural Statistics of Thailand, Crop year 1974-1975.
1975 Agricultural Statistics No. 33. Office of the Under Secretary of State, Ministry of Agriculture and Cooperatives, Bangkok.

_____. Agricultural Statistics of Thailand, Crop Year 1974-1975.
1976a Agricultural Statistics No. 41. Office of the Under Secretary of State, Ministry of Agriculture and Cooperatives, Bangkok.

_____. Thailand's Fourth Five-Year Agricultural Development Plan
1976b BE 2524--Guidelines. Office of the Under Secretary of State, Ministry of Agriculture and Cooperatives, Bangkok.

_____. Third Annual Report: Agricultural Sector Analysis in Thailand.
1977a DAE-CARD Sector Analysis Series No. 6. Iowa State University, Center for Agricultural and Rural Development, Ames.

_____. In cooperation with the Center for Agricultural and Rural
1977b Development. Singapore Symposium, Agricultural Sector Analysis in Thailand. DAE-CARD Sector Analysis Series No. 7. Iowa State University, Center for Agricultural and Rural Development, Ames.

Falcon, W. P. Farmer response to price in an underdeveloped area--A case
1962 study of West Pakistan. Unpublished Ph.D. dissertation. Department of Economics, Harvard University, Cambridge, Mass.

Food and Agriculture Organization. Production Yearbook 1973. Food and
1978 Agriculture Organization, United Nations, Rome.

Framingham, C. F., A. L. Stoecker, K. Kathikarn, S. Sriplung, and E. O.
1977 Heady. Agricultural development planning in Thailand: Some supporting analysis. DAE-CARD Sector Analysis Series No. 4. Iowa State University, Center for Agricultural and Rural Development, Ames.

Goodwin, J. W., J. S. Plaxico, and W. F. Lagrone. Aggregation of normative
1963 micro supply relationships for dryland crop farms in the rolling plains of Oklahoma and Texas. Technical Bulletin T-103. Oklahoma State Experiment Station, Stillwater.

Heady, E. O. Agricultural Policy Under Economic Development. Iowa State
1962 University Press, Ames.

_____, C. B. Baker, H. O. Dieselin, S. W. Kehrberg, and S. D. Staniforth,
1961 eds. Agricultural Supply Functions. Iowa State University Press, Ames.

Mellor, J. W. The Economics of Agricultural Development. Cornell
1966 University Press, Ithaca, New York.

National Statistical Office. Population and Housing Census. Office of
1973 the Prime Minister, Bangkok.

Rogers, K. D. and P. Itharattana. Agricultural employment and migration
1976 in Northeast Thailand: Application of a regional planning model. DAE-CARD Sector Analysis Series No. 1. Iowa State University, Center for Agricultural and Rural Development, Ames.

Siamwalla, A. A history of rice price policies in Thailand, in Essays in
1975 Honor of Kuhnying Suparb Yossurdara, Prateep Sondy Suvan, ed. Sompong Press, Bangkok, pp. 141-165.

Tweeten, L. Foundations of Farm Policy. University of Nebraska, Lincoln.
1970

Appendix Table 1. RD variety maximum area allowed and RD variety actual area used by region and land type (BE 2524)

	Land Used (1000 rai)	Northeast		North		Central Plain		South	
		Land 2	Land 3	Land 2	Land 3	Land 2	Land 3	Land 2	Land 3
Base	Available area	320	3,572	1,499	3,520	5,328	1,710	415	214
	Area used	168	1,686	1,499	3,520	1,206	1,085	297	214
	% used	52.5	47.2	100	100	22.6	63.5	71.6	100
Step I	Available area	320	3,572	1,499	3,520	5,328	1,710	415	214
	Area used	246	3,020	1,499	3,520	4,973	1,333	415	214
	% used	76.9	84.6	100	100	93.3	78.0	100	100
Step II	Available area	320	3,572	1,499	3,520	5,328	1,710	415	214
	Area used	246	3,020	1,499	3,520	4,967	1,553	415	214
	% used	76.9	84.6	100	100	93.2	90.8	100	100
Step III	Available area	320	3,572	1,499	3,520	5,328	1,710	415	214
	Area used	297	3,020	1,499	3,520	4,969	1,558	415	214
	% used	92.8	84.6	100	100	93.3	91.1	100	100
Step IV	Available area	320	3,572	1,499	3,520	5,328	1,710	415	214
	Area used	297	3,020	1,499	3,520	5,103	1,550	415	214
	% used	92.8	84.6	100	100	95.8	90.6	100	100
Step V	Available area	320	3,572	1,499	3,520	5,328	1,710	415	214
	Area used	320	3,572	1,499	3,520	5,104	1,550	415	214
	% used	100	100	100	100	95.8	90.6	100	100

Appendix Table 2. Irrigated area available and acres actually irrigated by region for each step (BE 2524)

	Northeast			North			Central Plain		
	Available	Used	% Used	Available	Used	% Used	Available	Used	% Used
Base	334	259	88	409	236	58	2,211	1,935	88
Step I	334	334	100	409	409	100	2,211	2,181	99
Step II	334	334	100	409	409	100	2,211	2,211	100
Step III	334	334	100	409	409	100	2,211	2,211	100
Step IV	334	334	100	409	409	100	2,211	2,211	100
Step V	334	334	100	409	409	100	2,211	2,211	100

	South			Kingdom		
	Available	Used	% Used	Available	Used	% Used
Base	73	73	100	3,029	2,505	83
Step I	73	73	100	3,029	2,998	99
Step II	73	73	100	3,029	3,029	100
Step III	73	73	100	3,029	3,029	100
Step IV	73	73	100	3,029	3,029	100
Step V	73	73	100	3,029	3,029	100

Appendix Table 3. Land use by class for selected crops by region (1000 rai)

Base

Crop	Northeast Land Class I	Northeast Land Class II	Northeast Land Class III	Northeast Land Class IV	North Land Class I	North Land Class II	North Land Class III	North Land Class IV	Central Plain Land Class I	Central Plain Land Class II	Central Plain Land Class III	Central Plain Land Class IV
Nonglutinous rice	0.0	636.0	6,041.4	90.3	828.4	1,633.5	2,225.8	0.0	0.0	10,552.8	1,697.0	0.0
Glutinous rice	0.0	1,502.1	13,325.4	147.1	1,135.5	1,500.6	3,035.3	142.1	0.0	755.8	331.3	0.0
Maize (feed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3,552.9
Maize (human)	0.0	3.2	0.1	140.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4
Groundnuts	0.0	1.4	0.2	382.5	0.0	77.3	0.0	1.9	0.0	8.6	0.0	58.1
Kenaf	0.0	0.0	0.0	2,655.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jute	0.0	0.0	0.0	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cassava	0.0	0.0	0.0	2,200.7	0.0	0.0	0.0	564.0	0.0	0.0	0.0	2,020.2
Sugarcane	0.0	0.0	0.0	105.9	0.0	0.0	0.0	1.0	0.0	30.5	0.0	1,436.6
Other	0.0	3.2	271.8	252.1	0.0	302.9	312.6	65.6	0.0	0.0	6.0	137.1

Crop	South Land Class I	South Land Class II	South Land Class III	South Land Class IV	Kingdom Land Class I	Kingdom Land Class II	Kingdom Land Class III	Kingdom Land Class IV
Nonglutinous rice	0.0	1,406.5	393.4	0.0	828.4	14,228.9	10,357.3	90.3
Glutinous rice	0.0	0.0	118.0	0.0	1,135.5	3,758.6	16,810.1	289.3
Maize (feed)	0.0	0.0	0.0	0.0	0.0	1.1	0.0	12,809.4
Maize (human)	0.0	0.0	0.0	47.7	0.0	3.2	0.1	225.9
Groundnuts	0.0	0.0	0.0	175.9	0.0	87.4	0.2	618.6
Kenaf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,655.3
Jute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6
Cassava	0.0	0.0	0.0	68.4	0.0	0.0	0.0	4,853.5
Sugarcane	0.0	0.0	0.0	0.0	0.0	30.5	0.0	1,542.6
Other	0.0	0.0	0.0	1,552.1	0.0	306.2	590.4	2,007.0

Appendix Table 3. (continued)

Step I

Crop	Northeast Land Class I	Northeast Land Class II	Northeast Land Class III	Northeast Land Class IV	North Land Class I	North Land Class II	North Land Class III	North Land Class IV	Central Plain Class I	Central Plain Class II	Central Plain Class III	Central Plain Class IV
Nonglutinous rice	0.0	804.5	7,759.1	90.3	1,984.0	1,806.0	2,956.6	184.5	336.0	11,210.1	2,046.4	0.0
Glutinous rice	0.0	1,409.2	13,128.2	147.1	606.9	1,598.8	3,029.9	247.3	0.0	967.4	331.3	0.0
Maize (feed)	0.0	0.0	0.0	1,818.7	0.0	0.0	0.0	7,621.6	0.0	1.1	0.0	3,600.1
Maize (human)	0.0	0.0	0.0	140.8	0.0	0.0	0.0	16.9	0.0	0.0	0.0	20.4
Groundnuts	0.0	1.4	0.2	451.9	0.0	3.1	0.0	145.5	0.0	0.0	0.0	31.8
Kenaf	0.0	0.0	0.0	2,644.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jute	0.0	0.0	0.0	35.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0
Cassava	0.0	0.0	0.0	2,169.6	0.0	0.0	0.0	19.3	0.0	0.0	0.0	2,505.8
Sugarcane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	30.5	0.0	957.9
Other	0.0	3.2	307,2	252.1	0.0	204.7	312.6	172.5	0.0	0.0	6.0	112.6

Crop	South Land Class I	South Land Class II	South Land Class III	South Land Class IV	Kingdom Land Class I	Kingdom Land Class II	Kingdom Land Class III	Kingdom Land Class IV
Nonglutinous rice	0.0	1,406.5	567.1	0.0	2,320.0	15,606.1	15,142.2	314.2
Glutinous rice	0.0	0.0	118.0	0.0	606.9	3,975.5	18,219.7	415.9
Maize (feed)	0.0	0.0	0.0	0.0	0.0	1.1	0.0	15,990.5
Maize (human)	0.0	0.0	0.0	47.7	0.0	3.2	0.0	236.5
Groundnuts	0.0	0.0	0.0	175.9	0.0	4.5	0.0	875.4
Kenaf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,644.5
Jute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.3
Cassava	0.0	0.0	0.0	68.4	0.0	0.0	0.0	5,663.1
Sugarcane	0.0	0.0	0.0	0.0	0.0	30.5	0.0	958.0
Other	0.0	0.0	0.0	1,552.1	0.0	207.9	625.9	2,112.7

Appendix Table 3.(continued

Step II

Crop	Northeast Land Class I	Northeast Land Class II	Northeast Land Class III	Northeast Land Class IV	North Land Class I	North Land Class II	North Land Class III	North Land Class IV	Central Plain Class I	Central Plain Class II	Central Plain Class III	Central Plain Class IV
Nonglutinous rice	0.0	670.5	8,991.3	90.3	1,366.7	1,992.5	3,066.1	332.3	336.0	11,450.5	2,120.9	0.0
Glutinous rice	0.0	1,543.2	11,896.0	147.1	1,224.2	1,412.3	2,920.4	263.3	0.0	737.2	328.4	0.0
Maize (feed)	0.0	0.0	0.0	2,161.5	0.0	0.0	0.0	1,408.9	0.0	1.1	0.0	3,596.2
Maize (human)	0.0	0.0	0.0	140.8	0.0	0.0	0.0	16.9	0.0	0.0	0.0	20.4
Groundnuts	0.0	1.4	0.0	443.4	0.0	3.1	0.0	145.5	0.0	0.0	0.0	32.3
Kenaf	0.0	0.0	0.0	2,644.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jute	0.0	0.0	0.0	35.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0
Cassava	0.0	0.0	0.0	1,968.6	0.0	0.0	0.0	19.0	0.0	0.0	0.0	2,738.2
Sugarcane	0.0	0.0	0.0	105.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	725.5
Other	0.0	3.2	307.2	252.1	0.0	204.7	312.6	172.5	0.0	0.0	6.0	112.6

Crop	South Land Class I	South Land Class II	South Land Class III	South Land Class IV	Kingdom Land Class I	Kingdom Land Class II	Kingdom Land Class III	Kingdom Land Class IV
Nonglutinous rice	0.0	1,406.5	572.6	0.0	1,702.7	15,520.0	14,751.0	422.7
Glutinous rice	0.0	0.0	112.5	0.0	1,224.2	3,692.9	15,257.4	410.5
Maize (feed)	0.0	0.0	0.0	0.0		1.1	0.0	13,166.7
Maize (human)	0.0	0.0	0.0	47.7		3.2	0.1	225.9
Groundnuts	0.0	0.0	0.0	175.9		4.5	0.2	797.2
Kenaf	0.0	0.0	0.0	0.0				2,644.4
Jute	0.0	0.0	0.0	0.0				42.3
Cassava	0.0	0.0	0.0	68.4				4,794.3
Sugarcane	0.0	0.0	0.0	0.0				813.5
Other	0.0	0.0	0.0	1,552.1	0.0	207.9	625.9	2,089.4

Appendix Table 3. (continued)

Step III

Crop	Northeast Land Class I	Northeast Land Class II	Northeast Land Class III	Northeast Land Class IV	North Land Class I	North Land Class II	North Land Class III	North Land Class IV	Central Class I	Central Class II	Central Class III	Central Class IV
Nonglutinous rice	0.0	670.0	9,546.6	90.3	2,733.4	3,976.5	6,133.9	647.7	672.0	22,909.4	4,243.1	0.0
Glutinous rice	0.0	1,543.5	11,340.7	147.1	2,448.5	2,833.2	5,839.2	526.7	0.0	1,471.7	649.0	0.0
Maize (feed)	0.0	0.0	0.0	2,175.8	0.0	0.0	0.0	14,804.4	0.0	0.0	0.0	3,596.2
Maize (human)	0.0	3.2	0.1	140.8	0.0	0.0	0.0	33.9	0.0	0.0	0.0	20.4
Groundnuts	0.0	1.4	0.2	471.2	0.0	6.3	0.0	291.1	0.0	0.0	0.0	6.2
Kenaf	0.0	0.0	0.0	2,644.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jute	0.0	0.0	0.0	35.0	0.0	0.0	0.0	14.6	0.0	0.0	0.0	0.0
Cassava	0.0	0.0	0.0	1,968.6	0.0	0.0	0.0	38.1	0.0	0.0	0.0	2,738.2
Sugarcane	0.0	0.0	0.0	105.9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	725.5
Other	0.0	3.2	307.2	252.3	0.0	409.4	625.2	345.1	0.0	0.0	6.0	112.6

Crop	South Land Class I	South Land Class II	South Land Class III	South Land Class IV	Kingdom Land Class I	Kingdom Land Class II	Kingdom Land Class III	Kingdom Land Class IV
Nonglutinous rice	0.0	2,813.0	1,148.2	0.0	3,405.4	31,[illegible]0.0	30,063.3	845.5
Glutinous rice	0.0	0.0	222.1	0.0	2,448.5	7,391.5	29,947.2	821.1
Maize (feed)	0.0	0.0	0.0	0.0	0.0	2.3	0.0	26,339.7
Maize (human)	0.0	0.0	0.0	95.5	0.0	6.5	0.3	451.9
Groundnuts	0.0	0.0	0.0	351.8	0.0	9.1	0.4	1,596.0
Kenaf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,288.8
Jute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.7
Cassava	0.0	0.0	0.0	136.8	0.0	0.0	0.0	9,588.7
Sugarcane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,663.1
Other	0.0	0.0	0.0	3,104.3	0.0	415.9	1,251.8	4,179.2

Appendix Table 3. (continued)

Step IV

Crop	Northeast Land Class I	Northeast Land Class II	Northeast Land Class III	Northeast Land Class IV	North Land Class I	North Land Class II	North Land Class III	North Land Class IV	Central Plain Class I	Central Plain Class II	Central Plain Class III	Central Plain Class IV
Nonglutinous rice	0.0	670.5	9546.6	90.3	1,548.0	1,908.8	2,642.6	332.3	336.0	11,922.9	2,369.9	58.0
Glutinous rice	0.0	1,543.2	0.0	147.1	1,043.0	1,496.0	3,343.0	263.3	0.0	274.6	61.7	0.0
Maize (feed)	0.0	0.0	0.0	2,150.8	0.0	0.0	0.0	7,927.6	0.0	1.1	0.0	3,230.1
Maize (human)	0.0	3.2	0.1	140.8	0.0	0.0	0.0	16.9	0.0	0.0	0.0	20.4
Groundnuts	0.0	1.4	0.2	477.6	0.0	0.0	0.0	145.5	0.0	0.0	0.0	0.8
Kenaf	0.0	0.0	0.0	2,644.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jute	0.0	0.0	0.0	35.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0
Cassava	0.0	0.0	0.0	1,987.9	0.0	0.0	0.0	19.0	0.0	0.0	0.0	2,715.0
Sugarcane	0.0	0.0	0.0	105.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	689.7
Other	0.0	3.2	307.2	252.3	0.0	204.7	312.6	172.5	0.0	0.0	6.0	112.6

Crop	South Land Class I	South Land Class II	South Land Class III	South Land Class IV	Kingdom Land Class I	Kingdom Land Class II	Kingdom Land Class III	Kingdom Land Class IV
Nonglutinous rice	0.0	1,406.5	575.6	0.0	1,884.0	15,908.4	15,134.8	480.8
Glutinous rice	0.0	0.0	109.6	0.0	1,043.0	3,313.9	14,856.0	410.5
Maize (feed)	0.0	0.0	0.0	0.0	0.0	1.1	0.0	13,308.6
Maize (human)	0.0	0.0	0.0	47.7	0.0	3.2	0.1	225.9
Groundnuts	0.0	0.0	0.0	175.9	0.0	4.5	0.2	799.9
Kenaf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,644.5
Jute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.3
Cassava	0.0	0.0	0.0	68.4	0.0	0.0	0.0	4,791.3
Sugarcane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	795.7
Other	0.0	0.0	0.0	1,552.2	0.0	207.9	625.9	2,089.8

Appendix Table 3. (continued)

Step V

Crop	Northeast Land Class I	Northeast Land Class II	Northeast Land Class III	Northeast Land Class IV	North Land Class I	North Land Class II	North Land Class III	North Land Class IV	Central Plain Class I	Central Plain Class II	Central Plain Class III	Central Plain Class IV
Nonglutinous rice	0.0	670.5	9,970.1	90.3	1,548.0	2,264.4	2,144.8	332.3	336.6	11,924.9	2,369.9	58.0
Glutinous rice	0.0	1,543.2	10,917.2	147.1	1,043.0	1,140.4	3,841.2	263.3	0.0	274.6	58.2	0.0
Maize (feed)	0.0	0.0	0.0	2,467.3	0.0	0.0	0.0	7,670.8	0.0	1.1	0.0	3,230.1
Maize (human)	0.0	3.2	0.1	140.8	0.0	0.0	0.0	16.9	0.0	0.0	0.0	20.4
Groundnuts	0.0	1.4	0.2	477.6	0.0	3.1	0.0	145.5	0.0	0.0	0.0	0.5
Kenaf	0.0	0.0	0.0	2,614.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jute	0.0	0.0	0.0	35.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0
Cassava	0.0	0.0	0.0	1,967.9	0.0	0.0	0.0	19.0	0.0	0.0	0.0	2,715.9
Sugarcane	0.0	0.0	0.0	105.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	689.7
Other	0.0	3.2	307.2	252.1	0.0	204.7	312.6	172.5	0.0	0.0	6.0	112.6

Crop	South Land Class I	South Land Class II	South Land Class III	South Land Class IV	Kingdom Land Class I	Kingdom Land Class II	Kingdom Land Class III	Kingdom Land Class IV
Nonglutinous rice	0.0	1,406.5	577.0	0.0	1,884.0	12,266.5	15,061.9	480.8
Glutinous rice	0.0	0.0	108.0	0.0	1,043.0	2,958.3	14,924.9	410.5
Maize (feed)	0.0	0.0	0.0	0.0	0.0	1.1	0.0	13,368.3
Maize (human)	0.0	0.0	0.0	47.7	0.0	3.2	0.1	225.9
Groundnuts	0.0	0.0	0.0	175.9	0.0	4.5	0.2	799.6
Kenaf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,614.4
Jute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.3
Cassava	0.0	0.0	0.0	68.4	0.0	0.0	0.0	4,791.3
Sugarcane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	795.7
Other	0.0	0.0	0.0	1,552.1	0.0	207.9	625.9	2,089.4

Appendix Table 4. Capital used and capital bound by region for each step

	Northeast	North	Central Plain	South
		Base		
Capital Available	798,141.896	424,481.186	1,115,396.390	171,785.892
Capital Used	764,296.351	424,481.186	737,857.088	171,785.892
% Used	95.8	100.0	66.2	100
		Step I		
Capital Available	798,141.896	424,481.186	1,115,396.390	171,785.892
Capital Used	772,981.582	424,481.186	795,409.404	171,785.892
% Used	96.9	100	71.3	100
		Step II		
Capital Available	798,141.896	424,481.186	1,115,396.390	171,785.892
Capital Used	798,141.896	424,481.186	882,707.071	171,785.892
% Used	100	100	79	100
		Step III		
Capital Available	798,141.896	424,481.186	1,115,396.390	171,785.892
Capital Used	798,141,896	424,481.186	937,922.352	171,785.892
% Used	100	100	84	100

Appendix Table 4.(continued)

	Northeast	North	Central Plain	South
		Step IV		
Capital Available	798,141.896	424,481.186	1,115,396.390	171,785.892
Capital Used	798,141.896	424,481.186	945,686.070	171,785.892
% Used	100	100	85	100
		Step V		
Capital Available	798,141.896	424,481.186	1,115,396.390	171,785.892
Capital Used	798,141.896	424,481.186	947,413.904	171,785.892
% Used	100	100	85	100

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