A LINEAR PROGRAMMING ANALYSIS OF THE EMPLOYMENT, INCOME AND PRODUCTIVITY OF THE SMALL FARM AND RICE PROCESSING SECTORS OF SIERRA LEONE

By

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CHAPTER 1

INTRODUCTION

Agriculture is the largest sector in the economy of Sierra Leone, employing approximately 75 percent of the population in 1972 and accounting for over 30 percent of gross domestic product.[1] But though the national economy has grown at an estimated 4.3 percent rate in the last decade, the agricultural sector is estimated to have grown only 1.6 percent per year.[2] The government of Sierra Leone, recognizing the importance of the agricultural sector and the need to develop policies to encourage its growth, has set a goal of increasing the growth rate of the sector to 4.6 percent per annum.[3]

Central to the overall agricultural development plan is the emphasis on increased rice production. Rice is the staple food in Sierra Leone, grown by over 80 percent of the farmers.[4] To achieve self-sufficiency in rice

[1]Government of Sierra Leone (1974).

[2]Government of Sierra Leone (1972).

[3]Government of Sierra Leone (1974).

[4]Spencer et al. (1976).

production, the government has attempted to formulate policies which would both increase rice production and improve efficiency in rice processing.

Recent studies of the small farms and the rice processing industry in Sierra Leone have shed considerable light on the operation of these sectors with respect to employment, income generation, and output. In a study of small farms by Spencer and Byerlee (1977), a detailed description and analysis of farming systems, land use, and employment is carried out based on data collected in an extensive survey conducted in Sierra Leone in 1974/75.[1] A study of the rice processing industry by Spencer, May-Parker and Rose (1976) describes the economies of alternative rice processing techniques and, using data from the above survey, constructs a linear programming model to assist in comparison of these techniques and evaluation of government policies influencing industry performance.

To further explore the impact of certain government actions on the employment, income and productivity of the small farm and rice processing sectors, this paper develops a one period linear program linking the previously reported rice processing model with a model of the small farm

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[1]Other research based on this survey includes work by Linsenmeyer (1976), fisheries; Byerlee, Tommy and Fatoo (1976), migration; Liedholm and Chuta (1976), small-scale industry; Byerlee and King (1976), consumption; for a description of the survey, see Spencer and Byerlee (1977).

sector which was constructed based on the above mentioned small farm study.

The objectives of this paper are:

1. To describe a linear programming model which can be used in evaluating the effects of certain government policies on the small farms and rice processing industry in Sierra Leone.
2. To use the model to predict:
    a. employment, incomes and output of small farms and the rice processing industry under conditions projected for 1980;
    b. the effect on these variables of alternative government policies with respect to:
        i. rice prices,
        ii. credit,
        iii. small farm input subsidies,
        iv. change of small farm production technology.
3. To interpret the model results and draw conclusions regarding the impact of the alternative policies.

This paper draws heavily upon the work done in the two studies mentioned above. For each of eight resource regions in Sierra Leone (Figure 1) Spencer and Byerlee (1977) have defined representative farms based on cropping patterns and production techniques. The small farm component of the model is built around these "typical"

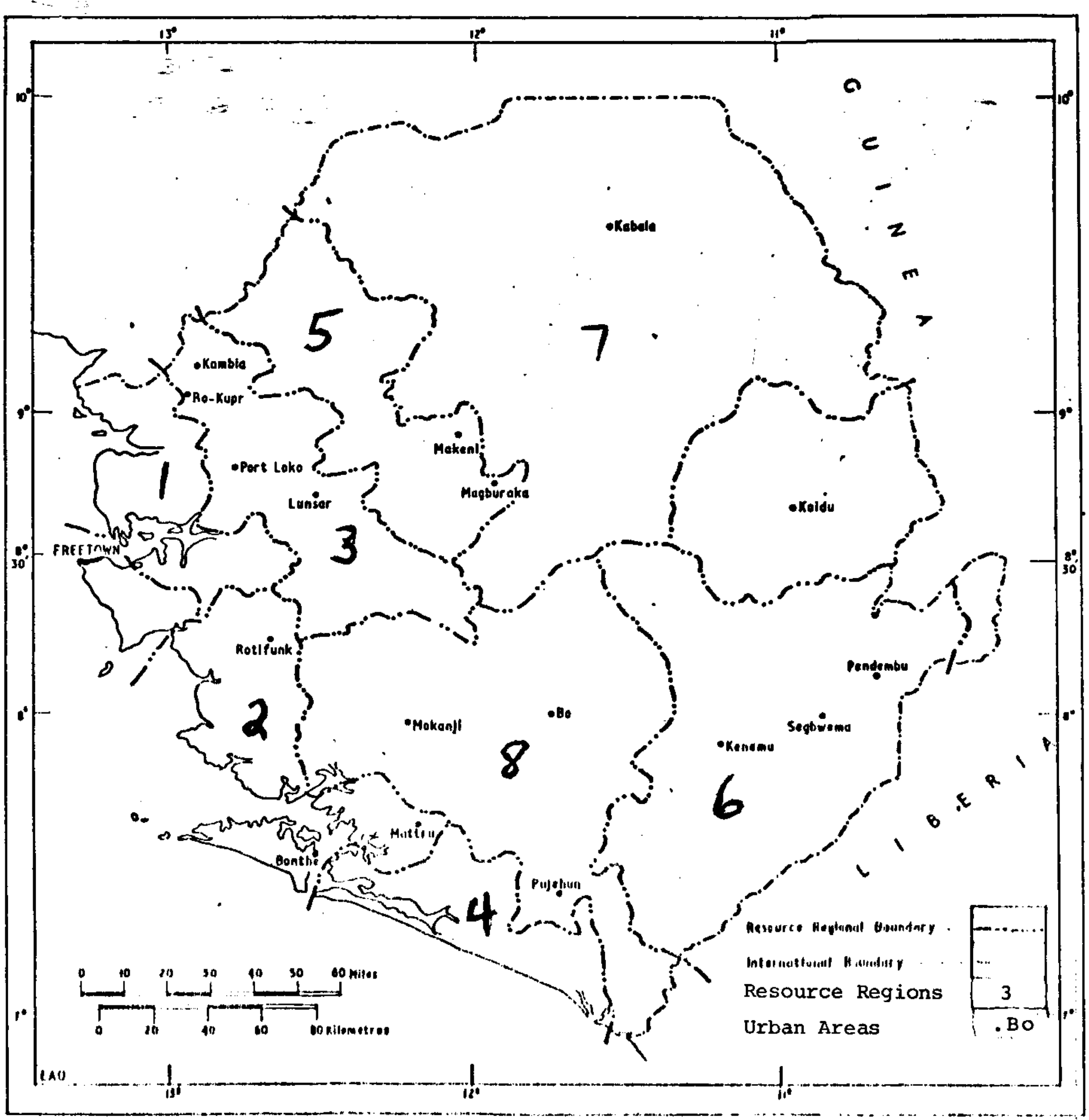

Figure 1.1. Resource Regions[1] and Urban Areas in Sierra Leone.

[1]As defined by Spencer and Byerlee (1977).

farms.[1] The rice processing component specifies five alternative processing technologies which (in numbers determined by the optimal solution of the model) may be located in any of the eight resource regions or in two large urban areas. A transportation subcomponent moves the rough rice from the small farms to the processing centers and after processing, takes the clean rice to demand.[2] By linking these two components in a linear program framework, the interactions between the two sectors can be studied in the context of small farm labor, land and output demand constraints and alternative input and output pricing policies.

The model will be described in detail in the following chapter. In Chapter 3, the ten policy runs of the model will be explained and evaluated. Finally, the results of the study will be summarized and conclusions presented in Chapter 4.

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[1]The representative farms will be described briefly later in this paper. For a complete description of the farms as well as the eight resource regions see Spencer and Byerlee (1977).

[2]The five rice processing technologies and the rice transportation activities will be discussed later. A detailed description is given in Spencer et al. (1976).

CHAPTER 2

THE MODEL

2.1. Model Equations

The equations of the model are as follows:

Maximize:

$$Z = \sum_j P_j^P X_j^P + \sum_{ij}\sum \alpha_i Y_{ij}^{P*} - \sum_{ij}\sum L_{ij} R_{ij} - \sum_i L_i^I V_i - \sum_{ij}\sum N_{ij}^{F*} W_{ij}^{F*}$$

$$- N^{F**} W^{F**} + \sum_j N_j^S W_j^S - \sum_i K_i^F - P^F F^F - P^M M^M - \sum_j P_j^S S_j$$

$$- \sum_{ij}\sum C_{ij} M_{ij} - \sum_{ij}\sum T_{ij}^H X_{ij}^H - \sum_{ij}\sum T_{ij}^C X_{ij}^C - \sum_{ij}\sum N_{ij}^m W_{ij}^m$$

$$- \sum_i \beta_i K_k^m + \sum_j A_j^E X_j^E - \sum_j A_j^I X_j^I + \sum_{ij}\sum \gamma_i Y_{ij}^E - \sum_i \delta_i Y_i^I$$

$$+ a({F_E}^E - {F_E}^R) \qquad (2.1)$$

Maximize value of husk rice production + value of non-rice small farm production - land rent paid - extension costs of new technology - wages paid to hired small farm (non-processing) labor - wages imputed to small farm processing labor + wages received by small farm family members for labor sold out - small farm annual capital cost - fertilizer cost - cost for mechanization services - cost of rice seed - variable cost of husk rice processing - husk rice assembly costs to mills - clean rice distribution costs to demand centers - wages paid to mill labor - annual mill investment cost + rice export receipts - imported clean rice costs + non-rice export receipts - cost of non-rice imports + (-) foreign exchange earnings (cost).

Subject to:

$$L_{ij} \leq LAND_{ij} \qquad i = 1,\ldots,9 \quad j = 1,\ldots,8 \tag{2.2}$$

(Acres of type i land used in region j does not exceed availability.)

$$N^F_{ij} \leq LABOR^F_{ij} \qquad i = 1,\ldots,12 \quad j = 1,\ldots,8 \tag{2.3}$$

(Person hours of small farm labor [farm production and rice processing] employed in month i in region j does not exceed availability.)

$$\Sigma N^F_{ij} \leq LABOR^{F*}_j \qquad j = 1,\ldots,8 \tag{2.4}$$

(Person hours of small farm labor [farm production and rice processing] employed annually in region j does not exceed availability.)

$$Y^P_{ij} = Y^{P*}_{ij} + Y^E_{ij} \qquad i = 1,\ldots,16 \quad j = 1,\ldots,8 \tag{2.5}$$

(Total value of small farm production of good i [non-rice] in region j equals the total value of that good produced for domestic consumption plus the total value exported.)

$$X_i^{P*} = \sum_j X_{ij}^H \qquad i = 1,\ldots,8 \qquad (2.6)$$

(Quantity of husk rice transferred from small farms in region i equals the quantity shipped from production in region i to mills.)

$$\sum_i \rho_i M_{ij} = \sum X_{ij}^H \qquad j = 1,\ldots,10 \qquad (2.7)$$

(Quantity of husk rice processing in region j equals the quantity sent to processing units in the region.)

$$\sum_i \mu_i M_{ij} = \sum X_{ji}^C + X_j^E \qquad j = 1,\ldots,10 \qquad (2.8)$$

(Quantity of clean rice output from processing units equals the quantity shipped to domestic demand plus the quantity exported.)

$$\sum_i X_{ij}^C + X_j^I = \mathrm{DEMAND}_j^X \qquad j = 1,\ldots,17 \qquad (2.9)$$

(Quantity of clean rice shipped from processing units to demand center j plus imports of clean rice shipped to demand center j equals total demand.)

$$\sum_j \alpha_i Y_{ij}^{P*} + Y_i^I = \mathrm{DEMAND}_i^Y \qquad i = 1,\ldots,16 \qquad (2.10)$$

(Value of good i [non-rice] available for domestic consumption plus the value of imports equals national demand.)

On certain runs of the model, mill numbers are constrained as follows:

$$M_{ij} \leq MILL_{ij} \tag{2.11}$$

(The number of type i mills in region j does not exceed the maximum number allowed.)

The following rows transfer land, labor, capital, and foreign exchange requirements and earnings to the objective function for costing:

$$L_{ij} - 1 \left[T_R^{L_{ij}} \right] = 0 \qquad i = 1,\ldots,4 \quad j = 1,\ldots,8 \tag{2.12}$$

(Transfer of total annual use of upland, swamp, improved upland and improved swampland by region.)

$$N_{ij}^{F*} - 1 \left[T_R^{N_{ij}^{F*}} \right] = 0 \qquad i = 1,\ldots,12 \quad j = 1,\ldots,8 \tag{2.13}$$

(Transfer of monthly regional farm production labor.)

$$N^{F**} - 1 \left[T_R^{N^{F**}} \right] = 0 \tag{2.14}$$

(Transfer of national processing small farm labor.)

$$N_j^S - 1 \left[T_R^{N_j^S} \right] = 0 \qquad j = 1,\ldots,8 \tag{2.15}$$

(Transfer of region small farm labor sold out.)

$$N_{ij}^m - 1 \left[T_R^{N_{ij}^m} \right] = 0 \qquad i = 1,\ldots,4 \quad j = 1,\ldots,11 \tag{2.16}$$

(Transfer of the four classes of regional mill labor use.)

$$K_i^F - 1 \left[T_R^{K_i^F} \right] = 0 \qquad i = 1,\ldots,6 \qquad (2.17)$$

(Transfer of the six types of small farm capital use.)

$$K_i^m - 1 \left[T_R^{K_i^M} \right] = 0 \qquad i = 1,2,3 \qquad (2.18)$$

(Transfer of the three types of mill investment.)

$$F^F - 1 \left[T_R^{F^F} \right] = 0 \qquad (2.19)$$

(Transfer of national fertilizer use.)

$$M^M - 1 \left[T_R^{M^M} \right] = 0 \qquad (2.20)$$

(Transfer of mechanized acreage use.)

$$S_j - 1 \left[T_R^{S_j} \right] = 0 \qquad j = 1,\ldots,8 \qquad (2.21)$$

(Transfer of regional seed use.)

$$F_E{}^E - 1 \left[T_R^{F_E{}^E} \right] = 0 \qquad (2.22)$$

(Transfer of total foreign exchange earnings.)

$$F_E{}^R - 1 \left[T_R^{F_E{}^R} \right] = 0 \qquad (2.23)$$

(Transfer of total foreign exchange requirements.)

National husk rice production (less 10 percent for on-farm wastage) is also transferred to the objective function for valuing at the farm gate before it is processed.

$$X_j^P - 1 \left[\frac{X_j^P}{T_R} \right] = 0 \qquad j = 1,\ldots,8 \qquad (2.24)$$

In addition, the following accounting rows are used:

$$\text{Total rice imports} = \sum_j X_j^I \geq 0 \qquad (2.25)$$

$$\text{Total rice exports} = \sum_j X_j^E \geq 0 \; . \qquad (2.26)$$

where:

Q_{ij} = representative small farm type i in region j

P_j^P = farm gate price of husk rice in region j (Le./bu.)[1]

X_j^P = <u>bushels</u> of husk rice available for use in region j (= production less 10 percent wastage)

X_j^{P*} = <u>10 ton units</u> of husk rice sent to processing units by small farms in region j (= production less 10 percent wastage and seed requirements)

Y_{ij}^P = value of good i (non-rice) produced on small farms in region j (Le.)

Y_{ij}^{P*} = value of good i (non-rice) produced on small farms in region j for domestic consumption (Le.)

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[1]Le. = Leone. Le 1.00 = $1.10 U.S. (approximately)

α_i = spoilage factor for good i

L_{ij} = acres of type i land use in region j

R_{ij} = rent of type i land in region j (Le./acre)

L_i^I = acres of land type i on which improved cultivation methods are used

V_i = cost of new technology needed in practicing improved cultivation methods on land type i (Le./acre)

N_{ij}^F = total person hours of small farm labor employed in month i in region j

N_{ij}^{F*} = person hours of small farm labor employed in nonprocessing activities in month i in region j

N^{F**} = man days of small farm labor employed in processing activities nationally

W_{ij}^{F*} = wage in month i of small farm (nonprocessing) labor in region j (Le./person hour)

W^{F**} = wage of small farm processing labor (Le./man-day)

N_j^S = person hours of small farm labor sold out in region j

W_j^S = wage of small farm labor sold out in region j (Le./person hour)[1]

K_i^F = annual value of capital type i used on small farms nationally (Le.)

P^F = price of fertilizer (Le./bag)

F^F = number of bags of fertilizer used nationally

P^M = cost of mechanization services (Le./acre)

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[1] $W_j^S = \frac{1}{12} \sum_i W_{ij}^{F*}$

M^M = acres of land mechanized nationally

P_j^S = price of rice seed in region j (Le./pound)

S_j = pounds of rice seed used in region j

C_{ij} = total variable milling costs for the quantity of husk rice milled by mill type i (including hand pounding) in region j

M_{ij} = number of type i processing units in region j

T_{ij}^H = transport cost of shipping husk rice from supply in region i to a mill in region j (Le./10 tons)

X_{ij}^H = quantity (10 ton units) of husk rice shipped from production in region i to mills in region j

T_{ij}^C = transport cost of shipping clean rice from a mill in region i to demand in region j (Le./10 tons)

X_{ij}^C = quantity (10 ton units) of clean rice shipped from a mill in region i to demand in region j

N_{ij}^m = man days of mill labor type i employed in region j

W_{ij}^m = wage paid to mill labor type i employed in region j (Le./man-day)

β_i = capital recovery factor for mill type i

K_i^m = investment or rehabilitation cost of type i mills nationally

A_j^E = export bonus (export price less transport costs from region j to Freetown of clean rice milled in region j (Le./10 tons)

X_j^E = exports (10 ton units) of clean rice milled in region j

A_j^I = cost of importing and transporting clean rice to demand center j (Le./10 tons)

X_j^I = imports (10 ton units) of clean rice shipped to demand center j

γ_i = factor to account for the margin by which foreign exchange received for export commodity i (non-rice) is less than that received for domestic sales of commodity i[1]

Y_{ij}^E = value (in domestic price terms) of exports of commodity i (non-rice) from region j (Le.)

δ_i = factor to account for the margin by which import price exceeds domestic price of commodity i (non-rice)

Y_i^I = value (in domestic price terms) of imports of commodity i (non-rice) (Le.)

a = factor to adjust for under/over valuation of Leone (i.e., a = shadow exchange rate ÷ official exchange rate)

${F_E}^E$ = foreign exchange earnings (Le.)

${F_E}^R$ = foreign exchange requirements (Le.)

$LAND_{ij}$ = acres of land type i available for farm use in region j

$LABOR_{ij}^F$ = person hours of small farm labor available for employment in month i in region j

$LABOR_j^{F*}$ = person hours of small farm labor available for employment <u>annually</u> in region j

ρ_i = husk rice input (tons) of mill type i

μ_i = clean rice output (tons) of mill type i

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[1]For example, on some runs, it is assumed that due to various marketing, tariff and other changes, a commodity when exported earns for the small farm sector only 80 percent of the amount it earns when it is sold on the domestic market and does not incur these charges. In this case, $\gamma = .8$.

$DEMAND_j^x$ = demand for clean rice in demand center j (tons)

$DEMAND_i^y$ = national demand for good i (non-rice) (Le.)

$MILL_{ij}$ = mill constraint applying to type i mills in region j (certain runs)

T_R^i = transfer of total factor i use to the objective function

P^{EXP} = rice export price (Le./10 tons)

P^{IMP} = rice import price (Le./10 tons)

The matrix schema is presented in Figure 2.1.

2.2. Small Farm Production Activities

Within each of the eight production regions, Spencer and Byerlee (1977) have constructed between two and five representative farm types based on cropping combinations and labor allocations characteristic of regional enterprises (Table 2.1).[1] For each of the representative farms so defined land, monthly and annual labor, annual capital and foreign exchange requirements as well as annual output have been specified.

Output of rice, fundi, groundnuts, cassava, onions, peppers and tomatoes, other vegetables, fruits and other tree crops, palm oil, palm kernels, cocoa, coffee, hunting and gathering, animal products, fish, small scale

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[1]This paper will define additional representative farms later for use in runs exploring the effect on the small farm sector of the introduction of new types of farming technology.

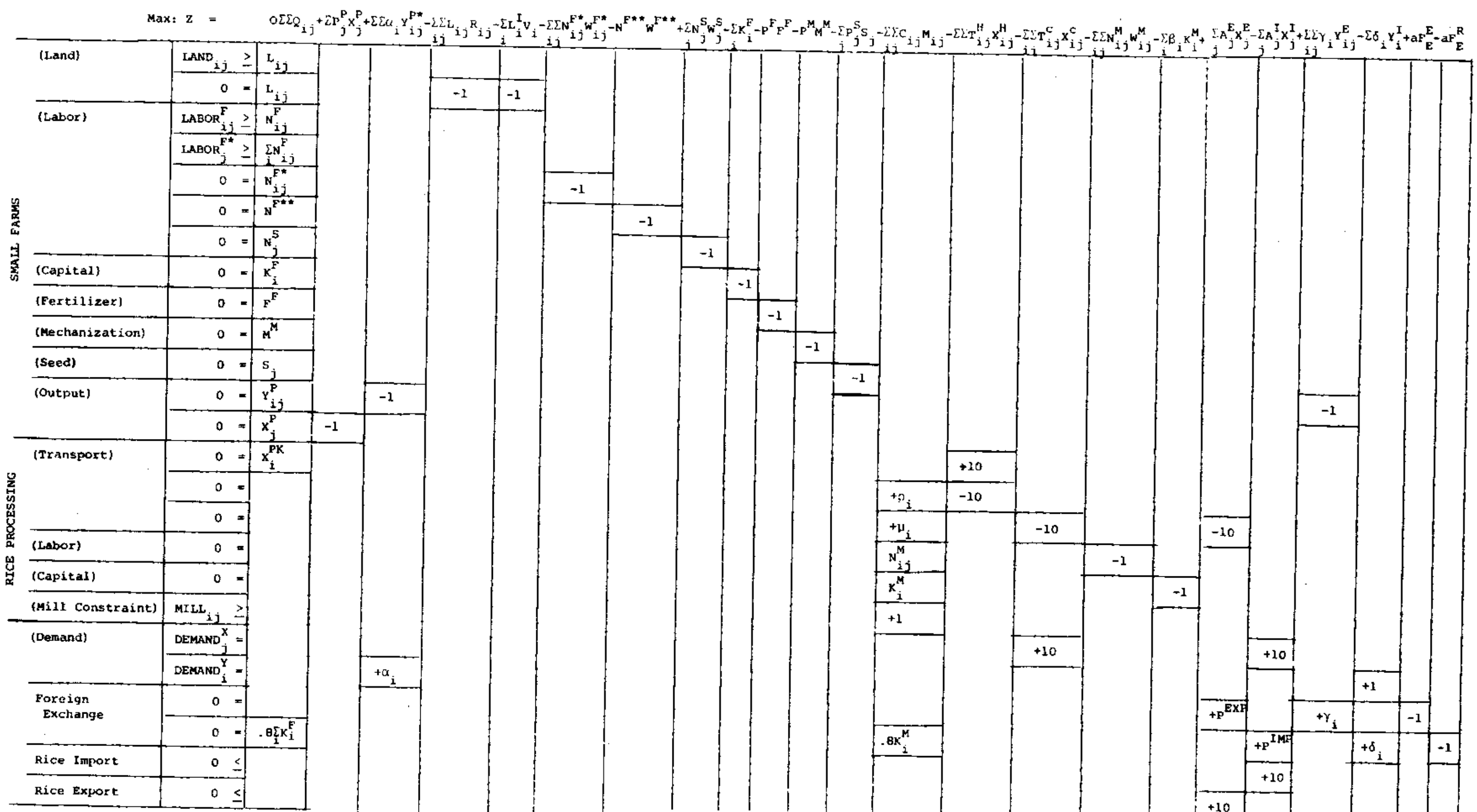

Figure 2.1. Matrix Schema of Linear Programming Model

TABLE 2.1

PHYSICAL CHARACTERISTICS OF RESOURCE REGIONS AND REPRESENTATIVE FARM TYPES

Resource Region	Area (Square Miles)	Mail Political Districts	Elevation (Feet)	Rainfall (Inches Per Year)	Vegatation	Soils	Representative Farms	Number of Farms in Sample
1. Scarcies	981	Kambia Port Loko	<50	120	Chesmapodium grass Mangrove swamps Inland swamps	Reddish to yellow brown Laterite	11. Upland rice 12. Vegs./inland swamp rice 13. Vegs./fishing	21 12 7
2. Southern Coast	1,320	Moyamba Bonthe	<50	130	Secondary bush Mangrove swamps Inland swamps	Laterite Lithosols Alluvial	21. Upland rice/groundnuts 22. Upland rice/wild oil palm 23. Mangrove swamp rice/upland rice	24 24 12
3. Northern Plains	2,227	Kambia Port Loko	50-500	100	Lophita Grass savannah Secondary bush	Laterite	31. Upland rice/inland swamp 32. Fundi/oil palm 33. Improved inland swamp rice 34. Upland rice/others	9 3 8 25
4. Riverain Grasslands	1,065	Bonthe Pujehun	<50	160	Grasslands Secondary forest	Alluvial	41. Mech. riverain rice/coffee 42. Upland rice 43. Hand riverain rice 44. Improved oil palm	10 32 4 2
5. Bolilands	1,781	Bombali Tonkolili	50-500	115	Savannah Swamp grasslands Secondary bush	Infertile Laterite	51. Upland rice/groundnuts 52. Mixed hand/mech. boliland rice 53. Mech. boliland rice 54. Hand boliland rice 55. Inland swamp rice	19 10 6 3 9
6. Upper Moa Basin	4,633	Kenema Kailahun	500-1,000	120	High bush	Laterite	61. Upland rice/coffee/cocoa 62. Upland rice/cocoa/coffee/ inland swamp rice	36 13
7. Northern Plateau	10,155	Koinadugu Tonkolili Bombali	1,000	90	Savannah	Reddish brown Laterite	71. Upland rice/cattle 72. Upland rice/inland swamp rice 73. Upland rice/wild oil palm 74. Upland rice	12 11 14 15
8. Southern Plains	4,475	Bo Moyamba Pujehun	50-500	130	Secondary forest	Laterite	81. Upland rice 82. Upland rice/coffee	24 14

Source: Spencer and Byerlee (1977).

industrial products, other nonfarm products and minor upland crops enter the model. Each representative farm's production of the sixteen non-rice commodities is measured in value terms. This output is aggregated into regional production rows and transferred to regional domestic demand or exports. Since there is no effective domestic demand for palm kernels,[1] cocoa or coffee, total production of these commodities is exported. For all commodities except palm oil, palm kernels, cocoa, coffee, small-scale industrial and other nonfarm output, an allowance is made for 10 percent wastage resulting from on-farm storage. Therefore, for each unit of these goods that is taken from the production rows, a unit enters both the objective function for valuation as domestic demand or exports, and the demand rows to contribute to the satisfaction of domestic consumption needs.

Rice output is in physical units. Regional production, measured in bushels, is aggregated and total output less 10 percent wastage is valued in the objective function at the regional farm-gate price. The 1974 regional husk rice prices are given in Table 2.2. In 1980, the prices are expected to be 10 percent lower and thus were adjusted down in the runs simulating the expected 1980 situation. The amount of husk rice production which is processed is

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[1]A palm kernel mill is in operation in Sierra Leone but its output is exported and therefore palm kernel production is regarded as an export.

TABLE 2.2
1974 REGIONAL FARM GATE PRICE OF HUSK RICE

Region	Price (Le/bushel)
1	4.19
2	4.42
3	4.71
4	2.49
5	4.36
6	5.32
7	5.16
8	4.38

Source: Spencer and Byerlee (1977).

equal to total output less wastage and seed requirements. Therefore, net husk rice production which is available for processing, is aggregated regionally (in 10 ton units) and is drawn upon by the processing activities. Rice enters the demand rows after transport and processing--not directly from the farm.

Part of the output of each representative farm is labor sales. Total person hours of labor sold out is summed regionally and transferred to the objective function for valuation at the regional wage rate.

2.3. Land

Seven categories of agricultural land are defined in the model: upland annual, upland tree, inland swamp, mangrove swamp, riverain, hand cultivated boliland and mechanized boliland.

About 75 percent of all rice produced in Sierra Leone is grown on upland.[1] Fertility is maintained on this land by using a "bush fallow system" in which an area is farmed for one or two years before the land is allowed to return to the bush. It is then cultivated again several years later. Other grains, vegetables, and tree crops are also grown on this land.

There are five types of swampland considered in the model. Inland swamps, found throughout the country, grow primarily rice and vegetable crops. Mangrove swamps are found along the coast where tidal action causes flooding and subsequent draining of the area. The riverain grasslands are located mainly along the southern coast. These grassy plains were formed from silt deposited by rivers flooding extensive areas of the south. Bolilands are low, swamp grasslands in the north and central part of Sierra Leone on which both mechanical and hand cultivation is practiced.

In runs of the model exploring the effect of technology change, "improved" upland and "improved" inland

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[1] Spencer (1971).

swamp land are defined (These latter classifications will be discussed later).

Table 2.3 presents the land constraints used in the model. The 1974 levels were computed by weighting the acreage of different land types by the estimated number of households represented by each farm type. The 1980 projected supply was set by estimating the total acreage of the various land types available for farm use and converting this to annual availability based on the length of the fallow period.[1]

For the 1980 model runs, there is no upland tree crop constraint per se. Instead, based on the length of the fallow period for each region the upland tree crop acreage use is combined with the upland annual acreage use, creating a regional "annual crop equivalent," the level of which is constrained regionally.[2]

To compute the cost of land, upland annual and upland tree acreage are combined and transferred to the objective function to be charged the regional upland rent, and the remaining five land categories are summed and costed at the regional swamp land rental rate. Regional

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[1]For example, if 80 acres are available for use and the regional fallow period is 10 years, eight acres are available for annual use.

[2]For example, if the fallow period is 10 years, the total annual regional tree crop acreage is multiplied by .1 and added to the total regional upland annual crop acreage to give that region's annual crop equivalent.

TABLE 2.3

AMOUNTS OF SEVEN LAND TYPES USED IN SIERRA LEONE IN 1974 AND PROJECTED 1980 LAND SUPPLY (ACRES)

	1974 Estimate	1980 Projected Supply[a]
Region 1 (Scarcies)		
Upland - Annual crops	47,500	
- Tree crops	13,600	
- Total[b]	49,064	58,800
Inland swamp	10,600	20,000
Mangrove swamp	14,700	40,000
Region 2 (Southern Coast)		
Upland - Annual crops	74,000	
- Tree crops	10,700	
- Total[b]	75,070	75,070
Inland swamp	8,700	20,000
Mangrove swamp	9,700	20,000
Region 3 (Northern Plains)		
Upland - Annual crops	110,000	
- Tree crops	46,300	
- Total[b]	116,899	180,400
Inland swamp	8,500	15,000
Mangrove swamp	8,200	12,300
Region 4 (Riverain Grasslands)		
Upland - Annual crops	48,400	
- Tree crops	21,300	
- Total[b]	50,530	51,900
Inland swamp	1,300	10,000
Riverain	12,000	100,000
Region 5 (Bolilands)		
Upland - Annual crops	49,200	
- Tree crops	8,500	
- Total[b]	50,050	80,000
Inland swamp	9,200	20,000
Boli - Hand cultivated	30,400	50,000
- Mechanized	57,900	75,000
- Total	88,300	100,000
Region 6 (Moa Basin)		
Upland - Annual crops	213,200	
- Tree crops	164,900	
- Total[b]	233,318	262,100
Inland swamp	20,500	280,000
Region 7 (Northern Plateau)		
Upland - Annual crops	206,700	
- Tree crops	70,100	
- Total[b]	213,710	325,000
Inland swamp	35,300	120,000
Region 8 (Southern Plains)		
Upland - Annual crops	232,100	
- Tree crops	56,300	
- Total[b]	238,631	268,700
Inland swamp	13,300	290,000

[a]See text for basis of projection.

[b]Annual crop equivalent, i.e., tree crop acreage adjusted to acreage of annual crops which could be cultivated using the appropriate fallow period for the region (see text).

rents calculated by Spencer and Byerlee (1977) are given in Table 2.4.

2.4. Small Farm Labor

Small farm labor (family and hired labor), including that used in rice processing, is constrained monthly and yearly. Initially, annual regional labor supply constraints measured in person hours[1] are set at the estimated levels of labor use in 1974. Monthly constraints are set at the estimated quantity used during the month of peak labor demand in each region. Agricultural labor use is highly seasonal. In Sierra Leone, the labor requirement is highest in most regions in the wet season of May to September when harvesting and planting are done. Labor is used in the slack season for such activities as tree crop maintenance and brushing. The formulation used in the model forces the farms to use labor within actual yearly limits but permits seasonal variation of labor use and monthly labor use up to the maximum amount available. In projecting the 1980 labor constraints, a 1.7 percent growth in the small farm labor force is assumed (equivalent to the 2.2 percent annual growth rate projected for the

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[1] Spencer and Byerlee use weights reflecting relative wage rates to compute person hours of labor: 1 person hour = 1 man-hour = 1 1/3 woman-hours = 2 child-hours.

TABLE 2.4

REGIONAL LAND RENTS PAID BY SMALL FARMS--1974

Region	Upland	Swamp Land
1	.10	2.34
2	2.33	2.99
3	1.32	1.22
4	.12	1.70
5	.30	.40
6	0	0
7	.13	.05
8	.27	.11

Source: Spencer and Byerlee (1977).

whole population less a 0.5 percent rural-urban migration rate).[1] Table 2.5 shows the labor constraints used.

Small farm labor used for hand pounding of rice is separated from that used for non-processing purposes for costing in the objective function. Non-processing labor is aggregated regionally by month and transferred to the objective function for costing at the wage rates given in Table 2.6. Annual hand pounding labor is aggregated nationally in person-day units and valued at Le 0.39 per person-day.[2] This is the mean wage paid by rural households in Sierra Leone for female labor hired during the 1974/1975 crop season.[3] Since women dominate the hand-pounding activity, this figure is taken to be a good indication of the opportunity cost of hand pounding labor.

2.5. Small Farm Capital

Six categories of capital--farm tools, animal equipment, non-rice processing equipment, non-farm equipment, livestock and tree crop costs--enter the model in animal value terms and are transferred directly to the objective function.

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[1] Byerlee et al. estimate that about 1.4 percent of the rural population depart for urban areas each year although because of return migration, the net flow is only .5 percent of the rural population. See Byerlee, Tommy and Fatoo (1976).

[2] Six hour days.

[3] Spencer and Byerlee (1977).

TABLE 2.5

LABOR USE ON SMALL FARMS IN SIERRA LEONE[1]
-PEAK MONTH AND ANNUAL REQUIREMENTS-
(PERSON-HOUR EQUIVALENTS)[2]

Region	1974 Estimated			1980 Projection[3]	
	Peak Month		Annual	Peak Month	Annual
	Month	Million Hours	Million Hours	Million Hours	Million Hours
1	August	9.75	73.10	10.79	80.89
2	July	7.77	81.52	8.56	90.20
3	August	22.49	165.76	24.88	183.31
4	June	5.35	41.10	5.92	45.47
5	August	12.43	99.60	13.76	110.20
6	July	33.13	278.43	36.66	308.07
7	October	42.51	336.42	47.04	372.23
8	May	30.51	260.98	34.09	288.76

[1]Includes production and processing labor

[2]1 person-hour = 1 man-hour = 1.3 woman-hours = 2 child-hours.

[3]Projected using annual small farm population growth rate of 1.7 percent.

TABLE 2.6
WAGE RATE OF SMALL FARM LABOR IN SIERRA LEONE (LEONES PER PERSON-HOUR)[1]

Month and Year	Region							
	Scarcies 1	Southern Coast 2	Northern Plains 3	Riverain 4	Bolilands 5	Moa Basin 6	Northern Plateau 7	Southern Plains 8
May 1974	.16	.10	.06	.11	.07	.12	.05	.10
June 1974	.18	.08	.05	.09	.05	.07	.04	.10
July 1974	.15	.08	.07	.08	.06	.08	.03	.12
August 1974	.10	.08	.07	.10	.07	.07	.04	.13
September 1974	.09	.05	.05	.06	.06	.08	.09	.11
October 1974	.20	.07	.05	.05	.04	.09	.01	.09
November 1974	.07	.05	.05	.10	.07	.08	.06	.07
December 1974	.11	.08	.10	.10	.07	.09	.07	.10
January 1975	.11	.07	.08	.06	.07	.08	.03	.16
February 1975	.24	.09	.09	.06	.13	.08	.07	.11
March 1975	.09	.07	.11	.08	.09	.06	.08	.11
April 1975	.14	.10	.18	.09	.07	.09	.10	.11
Weighted Mean	.13	.08	.07	.08	.07	.08	.08	.11

SOURCE: Field survey.

[1] 1 person-hour = 1 man-hour = 1.33 woman-hours = 2.0 child-hours.

2.6. Fertilizer, Machinery, and Rice Seed

In initial runs, fertilizer is priced at Le 2.30 per bag, machinery services at Le 7.00 per acre, and rice seed at 20 percent higher than the regional farm gate price, to reflect an assumed higher value of rice seed relative to rice used for human consumption. The fertilizer and mechanization costs are subsidized by the government and in some runs, the subsidies will be removed. Seed prices will be lowered in runs of the 1980 projects situation since 1980 rice prices are expected to drop from 1974 levels. Fertilizer use (bags) and mechanized acreage are aggregated nationally and seed use (pounds), regionally, for transfer to the objective function.

2.7. Rice Processing and Transportation Activities

Husk rice is moved from the farms to the processing centers via a transportation network discussed fully in Spencer et al. (1976). There is provision in the model for processing to be carried out by five milling technologies, described in detail in the rice processing study:

1. Traditional hand pounding
2. Small rubber roller mills
3. Small steel cylinder mills
4. New large rubber roller mills
5. Existing large disc sheller mills

The hand pounding of husk rice is done on the small farms within the resource region in which the rice is produced. Therefore, transport cost from the farm to the hand pounding activity is zero.

The small rubber roller, small steel cylinder and large rubber roller mills may be located in any of the eight resource regions, or in Freetown or Kono. The number, type, and location of the mills in a given run is determined by the optimal solution to the model. Husk rice may be transferred from the farms to mills located within the same region or in a different region.

There are currently three large disc sheller mills in Sierra Leone, located at Kissy (Freetown), Mambolo (Region 1), and Tormabum (Region 4). These mills were in a broken-down condition in 1973-1975 and the Sierra Leone Rice Corporation which manages the mills was considering rehabilitating them. In the first run simulating the 1974 situation, these mills were kept out of solution by using a constraint set equal to zero. In subsequent runs the constraint was set less than or equal to one, permitting them to be activated. Husk rice from any production region may be shipped to these mills for processing.

After milling, clean rice is transported to domestic demand centers or is exported by clean rice transportation activities. Hand pounded rice is assumed distributed to rural demand within the same region at zero transport cost and to the regional urban center and interregionally according to the estimated transport cost schedule computed by Spencer et al. (1976). Rice processed at the mills may be transported to any of the demand centers at the appropriate transport cost.

Large rubber mills of varying specifications were programmed in different model runs in the rice processing study. In the present study, these mills are programmed to operate at 67 percent of theoretical capacity and at 70 percent milling recovery rate in all runs but one, in which the recovery rate is set at 72 percent. The latter percentage might be achieved by more efficient mills, and, if so, it would have an impact on some of the variables studied here. These mills are assumed to have a six year life.

In the initial run of the model, which simulates the 1974 situation, the number of small mills is constrained by region to be less than or equal to the number operating in 1974. Of these, small rubber mills are constrained to being less than or equal to 30, the number operating in 1974.[1] These numbers are given in Table 2.7. In other runs, there is no maximum constraint on small mill operation.

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[1]Spencer et al. (1976).

TABLE 2.7

REGIONAL DISTRIBUTION OF SMALL MILLS IN SIERRA LEONE[1]

Region	Number of Rice Mills
1	53
2	6
3	14
4	15
5	37
6	42
7	14[2]
8	64
Freetown	19
Kono	4[2]
Sierra Leone	268

[1]Spencer et al. (1976).

[2]Four of the Region 7 mills operated in the Kono urban area, as defined in Spencer et al. (1976).

2.8. Milling Labor

Hand pounding labor draws on the regional small farm labor constraints (Table 2.5) monthly and annually as described earlier.

Four classes of labor are required to operate the mills:

1. Skilled labor--small mills
2. Unskilled labor--small mills
3. Skilled labor--large mills
4. Unskilled labor--large mills

This labor is assumed to come from off-farm sources and hence does not draw on the small farm labor constaints. Its use is unconstrained. Wage rates (Le/person-day) received by each labor class vary by location as follows: for small mills outside Freetown and Kono, unskilled Le 0.60, skilled Le 0.99; for small mills in Freetown and Kono, unskilled Le 0.99, skilled Le 1.20; for large mills at all locations, unskilled Le 0.99 and skilled Le 1.50.[1] As indicated previously, hand pounding labor is paid its estimated opportunity cost of Le 0.39 per person-day.

Labor use of each type is aggregated regionally and transferred to the objective function for valuation according to the respective wage rate.

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[1]Spencer et al. (1977).

2.9. Mill Capital

Total costs of constructing new rice mills and old mill rehabilitation are summed in the mill capital rows and annual capital costs are obtained in the objective function by multiplying these costs by the appropriate capital recovery factor, determined by the assumed interest rate and expected life of the mills. In most runs of the model, a 10 percent interest, the rate charged by financial institutions in Sierra Leone,[1] is assumed.

2.10. Demand

Clean rice demand is specified regionally as in the rice processing study. The milled rice may be used to satisfy demand of the rural area in which the mill is located, demand of the urban area of the same region, demand in the rural and urban areas of the other seven regions,[2] and demand in Freetown and Kono. Thus seventeen demand centers are specified. The 1974 clean rice demand and the 1980 projection are given in Table 2.8. The 1980 demand is projected at a population growth rate of 2.2[3]

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[1]Spencer et al. (1977).

[2]Region 4 is assumed to have no urban demand. Urban locations are defined in Spencer et al. as those that in 1963 had more than 2000 people and more than 50 percent of the working population in non-farm activities.

[3]Byerlee et al. (1976).

Table 2.8

DOMESTIC CLEAN RICE DEMAND IN SIERRA LEONE
(tons)

Region	1974[1]		1980 Projection[2]	
	Rural Demand	Urban Demand	Rural Demand	Urban Demand
1	17,034	1,886	17,698	1,960
2	10,303	1,945	10,705	2,021
3	24,717	4,692	25,681	4,875
4	6,144	0	6,384	0
5	18,700	3,454	19,429	3,589
6	50,626	9,950	52,600	10,338
7	53,815	3,678	55,914	3,821
8	34,989	8,136	36,914	8,453
Freetown	--	34,137	--	35,468
Kono	--	12,218	--	12,695

[1] Spencer et al. (1976)

[2] $Demand_{1980} = Demand_{1974}(1+d)^6$

$d = p + ny$

p = annual population growth rate = .022
n = expenditure elasticity of demand = .85
y = annual per capita income growth rate = .021

percent, an expenditure elasticity of .85,[1] and a per capita income growth rate of 2.1 percent.[2]

Table 2.9 presents the 1974 and 1980 national demand figures used in the model for the non-rice commodities. The 1974 levels represent estimated production (less 10 percent allowance for wastage) for all goods except palm kernels, coffee, and cocoa which are not consumed domestically. An estimate was made of the number of each representative farm type based on the field survey data and the model was run with the representative farms forced in at these levels to obtain the quantity of each commodity produced and available for consumption. This approach was used rather than one based on average propensities to consume computed by Byerlee and King (1977) first because that study of consumption was conducted only among rural households and therefore average propensities do not reflect urban demand and secondly because rural demand computed from that study would include demand for rural output produced in non-farm sectors (e.g., marine fishing and small-scale industrial production[3]). Therefore, the 1974 figures in Table 2.9 represent domestic production by the small scale agricultural sector which is available for

[1]Byerlee and King (1977).

[2]Government of Sierra Leone (1975).

[3]See Linsenmeyer (1976); and Chuta (1976).

TABLE 2.9

ESTIMATED 1974 DEMAND, EXPENDITURE ELASTICITIES AND PROJECTED 1980 DOMESTIC DEMAND[1] FOR NON-RICE AGRICULTURAL COMMODITIES IN SIERRA LEONE

Commodity	1974 Demand[2] (Million Leones)	Expenditure Elasticities[3]	1980 Demand[4] (Million Leones)
Fundi	1.22	1.37	1.63
Groundnuts	2.83	1.37	3.79
Cassava	2.69	1.37	3.60
Green Vegetables	2.32	1.08	3.00
Onions, Peppers, Tomatoes	2.22	1.08	2.87
Fruits	2.49	1.08	3.22
Palm Oil	6.93	1.52	9.44
Palm Kernels	0.00	--	0.00
Coffee	0.00	--	0.00
Cocoa	0.00	--	0.00
Hunting and Gathering	0.63	1.41	0.84
Animal Husbandry	1.27	1.41	1.71
Fish	5.03	0.72	6.25
Small-scale Industry	1.83	1.47	2.83
Other Non-farm	3.27	1.47	4.44
Minor Upland Crops	1.28	1.37	1.72

[1]Consumer demand after allowing for wastage.

[2]Domestic production by small-scale agricultural sector which is available for domestic consumption (see text).

[3]Computed from Byerlee and King (1977). Where no figures were reported by Byerlee and King for the specific commodity group, figures for the closest substitute have been used.

[4]Projected using annual population growth of 2.2 percent and per capita income growth at 2.1 percent. See Footnote 2 of Table 2.8 for projection formula.

domestic consumption. The 1980 demand figures are projected using the same assumed population and per capita income growth rate as above and the expenditure elasticities given in Table 2.9.

The model forces demand to be met exactly (i.e., the demand rows have = signs) for all commodities except for hunting and gathering output, fish, small scale industrial and other non-farm products. These rows are set '≥ 0' since hunting and gathering output supplements consumption rather than satisfying any predetermined demand, while demand for fish and small scale industrial output is partly supplied by sectors not specified in this model (Linsenmeyer and Chuta[1] have constructed models of these sectors).

2.11. Imports

Provision is made in the model for importation of seven commodities--rice, groundnuts, cassava, onions, peppers and tomatoes, other vegetables, palm oil and animal products. Rice imports move as needed to the seventeen demand centers described earlier. In the 1974 model runs the rice import cost is assumed to be Le 407.10/ton (1974 C.I.F. Freetown price) plus Le 4.50/ton transfer cost to the warehouse. To this is added the transport cost from Freetown to each demand center to obtain the appropriate objective function cost. In 1980, international rice

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[1]Ibid.

prices are expected to be about 60 percent of 1974 prices. Therefore in runs modeling the 1980 situation an import price of 246.50/ton is used. Since rice importation uses foreign exchange, the import price is also entered into the national foreign exchange requirements row.

Non-rice imports feed directly into the national demand rows. Since there is no readily available world market price data, the import prices used are 120 percent of the domestic price. This assumes that world market prices are above domestic prices or that import tariffs and distribution costs account for the higher import cost. These imports use foreign exchange equal to the import price per unit.

2.12. Exports

The model permits exports of rice, groundnuts, cassava, onions, peppers and tomatoes, other vegetables, palm oil, animal products, palm kernels, cocoa and coffee.

Only rice processed by new large rubber roller mills is assumed to be of appropriate quality for export.[1] Therefore clean rice may be exported from ten milling locations. To allow for domestic port handling and marketing costs, the export price is assumed to be 80 percent of the import cost. Thus the 1974 and 1980 export prices are Le 325.68/ton and Le 197.20/ton respectively. The

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[1] See Spencer et al. (1976)

objective function coefficient is this export price less transport costs from the mills to Freetown, the port for export shipments. Foreign exchange is generated (the export price) and is entered into the foreign exchange earnings row.

Non-rice export commodities are disaggregated regionally and, except for palm kernels, cocoa, and coffee, are assumed to earn an export price of 80 percent of the regional domestic price. This assumes that marketing costs and tariff policies will ensure that farm gate export prices for these commodities will be lower than farm gate domestic prices. Palm kernels, cocoa, and coffee, whose domestic demand is virtually zero, are assumed to earn a farm gate export price which is the same as the farm gate domestic price. Therefore the objective function coefficient for these crops is 1.0. The 1980 price of coffee is expected to be 40 percent higher than the 1974 price and this coefficient becomes 1.4 in the 1980 runs. These export prices are entered in the foreign exchange earnings row.

2.13. Foreign Exchange

Foreign exchange is used in three ways in the model. First, foreign exchange requirements for each farm type are assumed to be 80 percent of the total capital needs. Second, it is assumed that 80 percent of the initial investment costs in small and large mills is foreign exchange cost. Finally, imports require foreign exchange. As discussed above, the national foreign exchange requirement row is incremented by the import price with the import of each ton of rice. Import of a non-rice commodity adds 120 percent of that commodity's domestic value to the row. These needs are accumulated and transferred to the objective function.

Foreign exchange is earned by exports. The national foreign exchange earnings row accumulates the additions made by rice exports (the export price received per ton) and the other commodities (80 percent of the commodities' domestic value) and transfers the total to the objective function.

Foreign exchange could be shadow priced to account for any under- or over-valuation of the Leone by specifying the appropriate objective function coefficient. No such adjustment is made in the model runs to date.[1]

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[1] i.e., the objective function coefficient is zero in all runs.

CHAPTER 3

MODEL RUNS

3.1. Introduction

The model is used to determine the effects of certain government policies on the output, employment and income of the small farm and rice processing sectors of Sierra Leone. The first run simulates the actual 1974 situation with respect to number of mills in operation, land and labor availabilities, demand requirements and prevailing prices. Two additional 1974 runs are done to determine the mix of mill technologies which maximizes the objective function under two different assumptions regarding rice recovery rates. Labor, land and demand are then projected to 1980 and seven model runs are carried out to study the performance of the two sectors operating in 1980 under different government pricing, interest rate, subsidization and technology transfer policies.

Table 3.1 gives the specifications of the ten model runs. Tables 3.2 through 3.6 present the results of the runs.

TABLE 3.1

PARAMETER SPECIFICATIONS IN ALTERNATE RUNS OF THE LINEAR PROGRAMMING MODEL

Constraints	Run 1		Run 2		Run 3		Run 4		Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
	Sign[1]	Level	Sign[1]	Level	Sign[1]	Level	Sign[1]	Level	Sign Level	Sign Level	Sign Level	Sign Level	Sign Level	Sign Level
Land	LE	Estimated 1974 Use[2]	LE	(As Run 1)	LE	(As Run 1)	LE	Projected 1980 Requirements[2]	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Labor (monthly)	LE	Estimated 1974 Peak Month Use[3]	LE	(As Run 1)	LE	(As Run 1)	LE	Projected 1980 Peak Month Requirements[2]	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Labor (annual)	LE	Estimated 1974 Annual Use[3]	LE	(As Run 1)	LE	(As Run 1)	LE	Projected 1980 Annual Requirements[2]	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Demand--Rice	E	Estimated 1974 Demand[4]	E	(As Run 1)	E	(As Run 1)	E	Projected 1980 Demand[4]	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
--NonRice[5]	E	Estimated 1974 Production[6]	E	(As Run 1)	E	(As Run 1)	E	Projected 1980 Demand[6]	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Mills--Small	LE	1974 Mill Numbers[7]	GE	0	GE	0	GE	0	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
--Large Rubber	E	0	GE	0	GE	0	GE	0	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
--Large Disc	E	0	LE	1	LE	1	LE	1	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Large Rubber Mill Recovery Factor		n.a.[10]		.70		.72		.70	.70	.70	.70	.70	.70	.70
Interest Rate		.10		.10		.10		.10	.35	.10	.35	.10	.10	.10
Domestic Rice Prices		1974 Levels[8]		1974 Levels[8]		1974 Levels[8]		1974 Levels[8]	1974 Levels[8]	Expected 1980 Levels	Expected 1980 Levels	Expected 1980 Levels	Expected 1980 Levels	Expected 1980 Levels
Imports[9]		Rice		Rice		Rice		Rice; groundnuts; cassava; onions, peppers, tomatoes; other vegetables; palm oil; animal products	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Exports[9]		Rice; palm kernels; cocoa, coffee		(As Run 1)		(As Run 1)		Rice; groundnuts; cassava; onions; peppers, tomatoes; other vegetables; palm oil; palm kernels; cocoa, coffee; animal products	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)	(As Run 4)
Rice Import Price (C.I.F. Freetown, Le)		407.10		407.10		407.10		407.10	407.10	246.50	246.50	246.50	246.50	246.50
Rice Export Price (F.O.B. Freetown, Le)		325.68		325.68		325.68		325.68	325.68	197.20	197.20	197.20	197.20	197.20
Fertilizer & Mechanization Cost		Subsidized		Subsidized		Subsidized		Subsidized	Subsidized	Subsidized	Subsidized	Non-subsidized	Subsidized	Non-subsidized
Improved Technology Cost		n.a.[10]		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	subsidized	non-subsidized

[1] LE: Less than or equal to
E: Equal to
GE: Greater than or equal to

[2] See Table 2.3

[3] See Table 2.5

[4] See Table 2.8

[5] Including all non-rice production except fish, small-scale industrial output, other nonfarm output, and hunting and gathering output, on which demand is set ≥ 0.

[6] See Table 2.9

[7] See Table 2.7

[8] See Table 2.2

[9] The model contains provision for import and export of these commodities though some activities are never activated (See Table 3.2)

[10] n.a. = not applicable

TABLE 3.2

PROFIT AND SMALL FARM OUTPUT IN ALTERNATE RUNS OF THE LINEAR PROGRAMMING MODEL

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Objective Function (Million Leones)	15.46	18.62	18.92	50.12	48.60	34.47	33.33	31.12	41.39	35.88
Net Foreign Exchange (Million Leones)	+10.38	+10.19	+10.34	+26.54	+27.03	+17.42	+18.69	+17.42	+21.20	+21.20
Rice Imports (000, Tons)	5.43	0	0	0	0	0	0	0	0	0
Rice Exports (000, Tons)	0	5.24	9.30	78.22	76.75	67.56	64.78	67.56	91.29	91.29
Other Imports (Million Leones)										
Groundnuts	na[1]	na	na	.32	.32	.33	.33	.33	.34	.34
Cassava	na	na	na	.99	.99	.92	.92	.92	.95	.95
Onions, Peppers, Tomatoes	na	na	na	1.99	1.99	1.31	1.31	1.31	1.32	1.32
Green Vegetables	na	na	na	.91	.91	.94	.94	.94	.97	.97
Palm Oil	na	na	na	.84	.84	.73	.73	.73	.81	.81
Other Exports (Million Leones)										
Palm Kernels	10.03	10.04	10.04	9.20	9.20	9.02	9.02	9.02	8.99	8.99
Coffee	5.04	4.93	4.93	6.30	6.20	6.20	6.20	6.20	6.15	6.15

TABLE 3.2 (CONT.)

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Cocoa	4.18	4.07	4.07	5.38	5.28	5.38	5.28	5.28	5.23	5.23
Animal Products	na	na	na	.75	.75	.65	.65	.65	.64	.64
Unconstrained Commodities[2] (Million Leones)										
Fish	4.35	3.90	3.90	3.64	3.64	6.13	6.13	6.13	6.11	6.11
Small-scale Industrial Products	1.96	1.95	1.95	2.31	2.31	2.23	2.23	2.23	2.21	2.21
Other Non-farm Products	3.15	3.14	3.14	3.51	3.51	3.53	3.53	3.53	3.52	3.52
Hunting and Gathering	.61	.62	.62	.59	.59	.57	.57	.57	.57	.57

[1]na = activity not allowed in this run.

[2]For these commodities, demand is set ≥ 0.

TABLE 3.3

SMALL FARM LAND USE IN ALTERNATE RUNS OF THE LINEAR PROGRAMMING
(Acres, 000)

Region	Run 1	Runs 2 & 3	Runs 4 & 5	Runs 7 & 8	Runs 9 & 10
1 Upland[1]	43.9	37.0	19.0	2.8	2.8
Inland Swamp	10.6[2]	10.6[2]	1.3	4.9	4.9
Mangrove Swamp	14.7[2]	14.7[2]	40.0	40.0[2]	40.0[2]
2 Upland[1]	75.0	75.0	75.0[2]	75.0[2]	75.0[2]
Inland Swamp	8.7[2]	8.7[2]	12.2	12.2	12.2
Mangrove Swamp	7.7	8.4	20.0[2]	20.0[2]	20.0[2]
3 Upland[1]	96.0	100.8	60.5	60.5	60.5
Inland Swamp	8.5[2]	8.5[2]	15.1[2]	15.1[2]	15.1[2]
Mangrove Swamp	8.2[2]	8.2[2]	12.3[2]	12.3[2]	12.3[2]
4 Upland[1]	43.4	45.2	51.9[2]	51.9[2]	51.9[2]
Inland Swamp	0.9	1.0	2.4	1.4	1.8
Riverain	12.0[2]	12.0[2]	30.7	16.7	22.8
5 Upland[1]	47.0	47.0	10.3	4.6	6.5
Inland Swamp	9.2[2]	9.2[2]	20.0[2]	8.7	12.3
Boli-Hand	30.4[2]	30.4[2]	50.0[2]	50.0[2]	50.0[2]
Boli-Mechanical	57.9[2]	57.9[2]	50.0	50.0	50.0
6 Upland (traditional)[1]	230.9	231.1	262.1[2]	262.1[2]	256.8
Upland (improved)	n.a.	n.a.	n.a.	n.a.	36.0[2]
Inland Swamp (traditional)	13.5	15.0	8.6	8.6	19.7
Inland Swamp (improved)	n.a.	n.a.	n.a.	n.a.	12.0[2]
7 Upland (traditional)[1]	205.7	213.3	258.0	272.0	263.9
Upland (improved)	n.a.	n.a.	n.a.	n.a.	25.3[2]
Inland Swamp (traditional)	34.5	35.0	57.9	52.3	57.6
Inland Swamp (improved)	n.a.	n.a.	n.a.	n.a.	6.0[2]
8 Upland[1]	235.1	235.1	268.7[2]	268.7[2]	268.7[2]
Inland Swamp	13.1	13.1	15.0	15.0	15.0
Sierra Leone					
Upland (traditional)[1]	977.0	984.5	1005.5	997.6	986.1
Upland (improved)	n.a.	n.a.	n.a.	n.a.	n.a.
Inland Swamp (traditional)	99.0	101.1	132.5	118.2	138.6
Inland Swamp (improved)	n.a.	n.a.	n.a.	n.a.	18.0[2]
Mangrove Swamp	30.6	31.3	72.3[2]	72.3[2]	72.3[2]

TABLE 3.3 (CONT.)

Region	Run 1	Runs 2 & 3	Runs 4 & 5	Runs 6 7 & 8	Runs 9 & 10
Sierra Leone					
Riverain	12.0[2]	12.0[2]	30.7	16.7	22.7
Bolilands	88.3[2]	88.3[2]	100.0[2]	100.0[2]	100.0[2]
Total	1206.9	1217.2	1341.0	1304.8	1399.0

[1]Annual crop plus tree crop acreage

[2]Maximum acreage constraint

TABLE 3.4

SMALL FARM EMPLOYMENT IN ALTERNATE RUNS OF THE LINEAR PROGRAMMING MODEL
(Percent of Available Supply Employed)

Region		Run 1	Runs 2 & 3	Run 4	Run 5	Runs 6 & 8	Run 7	Runs 9 & 10
1	Annual	100.0	88.0	69.3	69.3	75.9	75.9	75.9
	Peak Month	96.3	85.9	100.0	100.0	100.0	100.0	100.0
2	Annual	99.0	95.0	89.2	92.7	89.2	92.7	89.2
	Peak Month	99.4	95.7	94.0	97.1	94.0	97.1	94.0
3	Annual	99.8	98.3	91.9	91.9	91.9	91.9	91.9
	Peak Month	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	Annual	98.5	98.8	100.0	100.0	99.4	99.4	99.9
	Peak Month	100.0	100.0	99.5	99.5	100.0	100.0	100.0
5	Annual	97.7	87.7	69.1	69.1	51.1	56.4	57.0
	Peak Month	100.0	93.3	75.8	75.8	60.0	63.5	65.1
6	Annual	98.7	94.3	91.8	96.9	91.8	96.9	96.0
	Peak Month	99.5	96.2	96.5	100.0	96.5	100.0	100.0
7	Annual	100.0	99.9	100.0	100.0	100.0	100.0	100.0
	Peak Month	98.8	100.0	92.2	92.2	95.5	95.5	96.2
8	Annual	84.4	79.6	82.2	82.2	82.2	86.0	82.2
	Peak Month	79.8	76.4	78.9	78.9	78.9	81.6	78.9

[1]Includes production and rice processing activities.

[2]Labor availability given in Table 2.5.

TABLE 3.5

SIZE AND LOCATION OF RICE PROCESSING ESTABLISHMENTS IN ALTERNATE RUNS OF THE LINEAR PROGRAMMING MODEL

Region	Number of Establishments							
	Run 1	Run 2	Run 3	Run 4	Run 5	Runs 6 & 8	Run 7	Runs 9 & 10
1 Hand Pounding	2816	0	0	0	0	0	0	0
Small Steel Mills	53[2]	0	0	0	0	0	0	0
Small Rubber Mills	0	55	52	113	113	108	108	108
Large Rubber Mills	0	0	0[4]	0	0	0	0	0
Large Disc Mills	2128	0	0	0	0	0	0	0
2 Hand Pounding	2128	0	0	0	1769	0	1769	0
Small Steel Mills	6[2]	0	0	0	0	0	0	0
Small Rubber Mills	0	47	32	61	28	61	28	61
Large Rubber Mills	0	0	1	0	0	0	0	0
3 Hand Pounding	3810	0	0	0	0	0	0	0
Small Steel Mills	14[2]	0	0	0	0	0	0	0
Small Rubber Mills	0	186	76	150	150	155	155	155
Large Rubber Mills	0	0	10	12	12	12	12	12
4 Hand Pounding	0	0	0	0	0	0	0	0
Small Steel Mills	15[2]	0	0	0	0	0	0	0
Small Rubber Mills	0	21	19	20	20	19	19	19
Large Rubber Mills	0	1	2	5	4	2	2	3
Large Disc Mills	--	0	0	0	0	0	0	0
5 Hand Pounding	5526	0	0	0	0	0	3211	0
Small Steel Mills	37[2]	0	0	0	0	0	0	0
Small Rubber Mills	0	133	57	143	143	139	77	140
Large Rubber Mills	0	0	7	0	0	0	0	0
6 Hand Pounding	8368	0	0	0	8668	0	8668	0
Small Steel Mills	29	0	0	0	0	0	0	0
Small Rubber Mills	0	169	155	176	12	176	12	221
Large Rubber Mills	0	0	1	0	0	0	0	0
7 Hand Pounding	5268	0	0	0	0	0	0	0
Small Steel Mills	7[3]	0	0	0	0	0	0	0
Small Rubber Mills	7[3]	103	0	105	105	105	105	122
Large Rubber Mills	0	0	9	0	0	0	0	0
8 Hand Pounding	6873	0	0	0	0	0	6009	0
Small Steel Mills	64[2]	0	0	0	0	0	0	0
Small Rubber Mills	0	195	197	177	181	182	76	119
Large Rubber Mills	0	0	7	4	4	4	3	9

TABLE 3.5 (CONT.)

Region	Number of Establishments							
	Run 1	Run 2	Run 3	Run 4	Run 5	Runs 6 & 8	Run 7	Runs 9 & 10
Freetown								
Small Steel Mills	0	0	0	0	0	0	0	0
Small Rubber Mills	19[2]	0	0	0	0	0	0	0
Large Rubber Mills	0	0	0	0	0	0	0	0
Large Disc Mills	--	0	0	0	0	0	0	0
Kono								
Small Steel Mills	0	0	0	0	0	0	0	0
Small Rubber Mills	4[2]	0	0	0	0	0	0	0
Large Rubber Mills	0	0	0	0	0	0	0	0
Sierra Leone								
Hand Pounding	34789	0	0	0	10437	0	19657	0
Small Steel Mills	225	0	0	0	0	0	0	0
Small Rubber Mills	30[2]	909	498	945	752	945	580	945
Large Rubber Mills	0	1	37	21	20	18	17	24
Large Disc Mills	--	0	0	0	0	0	0	0

[1]Numbers of processing units are rounded to nearest integer.

[2]Maximum constraint on small mill numbers.

[3]Maximum constraint on small mill numbers (rubber plus steel).

[4]A fractional mill was activated here.

TABLE 3.6

MILL EMPLOYMENT AND WAGES IN ALTERNATIVE RUNS OF THE LINEAR PROGRAMMING MODEL[1]

Region	Run 1		Run 2		Run 3		Run 4		Run 5		Runs 6 & 8		Run 7		Runs 9 & 10	
	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)	Man Days (000)	Wages (Le) (000)
1 Unskilled	.53	.32	.54	.33	.68	.47	1.13	.68	1.13	.68	1.08	.65	1.08	.65	1.08	.65
Skilled	13.25	13.12	13.62	13.49	13.28	13.25	28.25	27.97	28.25	27.97	27.04	26.77	27.04	26.77	27.04	26.77
2 Unskilled	.06	.04	.47	.28	1.40	1.26	.61	.37	.28	.17	.61	.37	.28	.17	.61	.37
Skilled	1.50	1.40	11.77	11.66	9.36	10.01	15.34	15.19	6.94	6.87	15.34	15.19	6.95	6.87	15.34	15.19
3 Unskilled	.14	.08	1.86	1.12	8.49	8.11	11.45	10.75	11.45	10.75	11.16	10.45	11.16	10.45	11.16	10.45
Skilled	3.50	3.47	46.60	46.13	29.39	34.41	50.89	57.23	50.89	57.23	51.64	57.74	51.64	57.74	51.64	57.74
4 Unskilled	.15	.09	1.34	1.24	1.49	1.40	3.83	3.71	3.83	3.71	2.21	2.11	2.21	2.11	2.92	2.81
Skilled	3.75	3.71	6.86	7.56	6.47	7.30	9.80	12.20	9.80	12.20	7.62	8.93	7.62	8.93	8.57	10.36
5 Unskilled	.37	.22	1.33	.80	5.88	5.60	1.43	.86	1.43	.86	1.39	.83	.78	.47	1.39	.83
Skilled	9.25	9.16	33.31	32.98	21.50	24.84	35.67	35.32	35.67	35.32	34.64	34.29	19.39	19.20	34.97	34.62
6 Unskilled	.29	.17	1.69	1.02	2.54	1.91	1.76	1.06	.12	.07	1.76	1.06	.11	.07	2.21	1.32
Skilled	7.14	7.07	42.37	41.94	40.16	40.44	44.07	43.63	2.91	2.88	44.07	43.63	2.91	2.88	55.16	54.61
7 Unskilled	.14	.08	1.03	.62	7.18	7.11	1.05	.63	1.05	.63	1.05	.62	1.75	.63	1.22	.73
Skilled	3.50	3.47	25.67	25.41	9.69	14.53	26.29	26.02	26.29	26.02	26.14	25.88	26.14	25.88	30.38	30.08
8 Unskilled	.64	.38	1.95	1.17	7.17	6.68	4.90	4.21	4.67	3.92	4.66	3.91	3.01	2.68	8.41	7.87
Skilled	16.00	15.84	48.63	48.15	35.06	38.90	48.50	50.20	49.20	50.68	49.23	50.70	22.03	23.36	39.48	44.06
Freetown																
Unskilled	6.46	6.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skilled	4.75	5.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kono																
Unskilled	1.36	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skilled	1.00	1.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sierra Leone																
Unskilled	10.14	9.13	10.21	6.58	34.83	32.54	26.16	22.27	23.96	20.79	23.92	20.00	19.68	17.23	29.00	25.03
Skilled	63.64	64.23	228.83	227.32	164.91	183.68	258.81	267.76	209.95	219.17	255.72	263.13	163.72	171.63	262.58	273.43
Total	73.78	73.36	239.04	233.90	199.74	216.22	284.97	290.03	233.91	239.96	279.64	283.13	184.40	188.86	291.58	298.46

[1] Labor is assumed to come from off-farm sources.

3.2. Run 1--1974 Situation

Run 1 simulates the 1974 situation. Labor and land use are constrained to be less than or equal to estimated 1974 levels and demand is constrained to be equal to the 1974 consumption estimates (with the exceptions explained previously). The number of small mills is constained to be less than or equal to the 1974 regional numbers given in Table 2.7 and since neither type of large mill operated in 1974, these constaints are set equal to zero. The interest rate is 10 percent, the rate charged by most financial institutions in Sierra Leone. Prices prevailing in 1974 are used. Imports of rice and exports of rice, palm kernels, cocoa and coffee are permitted.

Table 3.2 shows the predicted profits, foreign exchange earnings, and output. As required, demand for all commodities is satisfied but about 5000 tons of rice is imported to meet demand. All palm kernel, coffee and cocoa production is exported (as specified). Fish output in Run 1 is 14 percent lower than the 1974 estimates of small-farm production given in Table 2.9 but the output of small-scale industrial, other non-farm and hunting and gathering output closely approximate the 1974 estimates.

Tables 3.3 and 3.4 give the regional land and small farm labor use. Inland swamp land is constraining in Regions 1, 2, 3, and 5, mangrove swamp land is constraining in Regions 1 and 3, all the riverain grasslands in Region 4 and the bolilands in Region 5 is used. Labor use reaches its peak month maximum in Regions 3, 4, and 5 in August, June and July respectively. Annual labor availability is completely used in Regions 1 and 7. Region 8 is an area of slack labor, 84 percent of annual and 80 percent of peak month being used.

Table 3.5 shows the number and location of processing units in the optimal solution. Of the 268 small mills operating in 1974, 255 enter solution, 30 of these are small rubber mills, the maximum allowed to enter. The small mills have been programmed to operate at 70 percent capacity,[1] though they actually operated at a somewhat lower capacity utilization in 1974. This could account for the lower number of mills in the solution.

Table 3.5 indicates a total of 35,000 hand processing facilities (person-years[2]), distributed among all regions except Region 4, an area with a tight labor situation.

Labor use at the mills, shown in Table 3.6, totals 10,000 man-days of unskilled labor and 64,000 man-days of skilled labor.

Compared to the analogous run of the rice processing linear program, there are 115 more small mills and a drop in hand pounding activity of 6,000 facilities.

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[1]Spencer et al. (1976).

[2]A hand pounding activity uses 300 person-days of labor per year (six hour days). Ibid.

This is due to the fact that hand pounding draws on the small farm labor availability here whereas labor was not a constraint in the earlier model. Thus, to meet the farm output demand constraints, small farm labor is required in production activities in this model leaving less available for processing.

Run 1 provides a base against which further runs, with different parameters, can be compared. To the extent that the linear program does not model the variables exactly as they relate to each other in the real world, runs of the model will not precisely reflect real world conditions. However, since Run 1 reasonably approximates the 1974 situation, the model will be used to study inter-sectoral adjustments with respect to employment, income and productivity under certain labor, land, demand, mill efficiency, interest rate, rice pricing, subsidy, and small farm technology conditions.

3.3. Run 2--Competitive Position of New Large Mills

In Run 1, small mills were constrained to their 1974 numbers. The large mills were not allowed to enter solution since none operated in 1974. In Run 2, the constraints on the two types of small mills and the large rubber mills are set greater than or equal to zero, permitting any number of them to be activated. This will allow the model to determine the profit maximizing mix of mill technology, and to discover whether the large rubber mills can compete with existing processing methods. Similarly, constraints on each of the three large disc mills are relaxed to be less than or equal to one which permits these mills to be reactivated if they are competitive.

Other parameters are the same as Run 1. One large rubber mill and 909 small rubber mills are activated[1] replacing all of the hand pounding facilities. The large rubber mill enters in Region 4 and this mill processes 43 percent of regional rice output; the remainder goes to 21 small rubber mills. In the other seven regions, all regional output is shipped directly to small rubber mills located in the same region. There are no mills activated in the larger urban areas of Freetown and Kono. Thus clean rice to satisfy these two heavy demand centers is milled in Regions 3 and 8 respectively. No small steel mills or large disc mills enter solution, lending further support to the rice processing study conclusion that these mills are relatively less efficient. Mill employment and wages (Table 3.6) reflect the increase in mill operation.

All of the output of the large rubber mill, over 5,000 tons, is exported and this results in the higher

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[1]The numbers of processing units in this study have been rounded to the nearest integer. A continuous linear programming algorithm is used and it is felt that, for purposes of this paper, the marginal cost of greater accuracy with respect to numbers of processing facilities exceeds the marginal gain.

objective function value in spite of the large increase in capital costs required for mill construction. Contributing to the increase in clean rice availability is the advantage in milling efficiency which the mills have over hand pounding. (The mills operate at a 70 percent milling rate while the hand pounding rate is 68.4.)

With the freeing of hand pounding labor, farm production adjusts, increasing rice cultivation somewhat in total but modifying most non-rice production only marginally. Fishing output declines by Le 450,000 with Regions 1 and 7 primarily affected.

Region 1 is influenced the most by the mill activation. Upland use declines by 7,000 acres and much of the labor is unemployed. Given the proximity of Region 1 to Freetown, this result suggests that a policy promoting extensive use of rice processing mills may encourage migration from Region 1 to the nearby urban area. Small farm labor is used less intensively nationally but Regions 3, 4, and 7 still have used labor to the maximum availability in the month of peak requirement (August, June, and October respectively). More land is used in Regions 2, 3, 4, 6, and 7 while there is no change from Run 1 in Regions 5 and 8. The same land categories have reached their upper bound in this run as in Run 1.

Under conditions specified in this run, both types of rubber roller mills are shown to be more efficient than the other types of processing facilities but the consequences of total reliance on these technologies for rice processing can be seen primarily in the slack created in the small farm labor situation. With small farm unemployment particularly high in Regions 1 and 8, the rural-urban migration rate could conceivably increase, exacerbating the problems associated with this discussed in Byerlee et al. (1976). Self sufficiency in rice, a major government policy, is achieved in this run but the trade-offs implied by a comparison of the two model runs must be carefully weighed by decision makers.

3.4. Run 3--Effect of Increased Recovery Rate

It was shown in the rice processing study that the model was very sensitive to the assumption regarding recovery rate of large rubber roller mills. When a 70 percent rate was used (the specification in this model), instead of 72 percent, the number of large mills in the optimal solution declined drastically. To provide a consistency check with the earlier study, the model is run with the large mill recovery factor specified at 72 percent.

As expected, the number of large rubber roller mills increased sharply to 37. The number of small rubber roller mills fell to 498. This corresponded to 36 large and 498 small rubber roller mills activated in the rice processing model. Hand pounding again was not in solution. As in Run 2, all the rice production from a given region is milled in the same region. The increase in large mills and the decrease in small mills in each region reflects the advantage in efficiency large mills now have over the small mills. The large mills do not completely replace the small mills because of their higher capital and labor costs. Overall mill labor requirement and wages decline.

The impact of the higher recovery rate on the small farm sector is nil. Land and labor use and production are exactly the same as in Run 2. Because of the higher milling efficiency, more clean rice is available for exports, which increases 4,000 tons. This offsets the higher mill capital requirements, resulting in little change in the objective function.

Runs 4 through 10 use the 70 percent recovery factor which is a more reasonable expectation of mill performance.

3.5. Run 4--Projection of 1974 Policies to 1980

The first three runs have been done under 1974 conditions with respect to price, land, labor and demand. In Run 4, land, labor and demand constraints are set at their projected 1980 levels, given in Tables 2.3, 2.5, and 2.8 and 2.9 respectively. Prices continue to be specified at the 1974 level. To allow for an expansion of international trade, the import and export activities indicated in Table 2.9 have been added.

The objective function in Run 4 rises to Le 50 million. With the increased labor and land availability, small farm production of rice, groundnuts, palm oil, animal products, coffee, cocoa, small-scale industrial and other non-farm output has risen from Run 2. Output of the other commodities has declined somewhat. Import of five commodities is required to meet domestic demand and animal products are exported in addition to the three export crops. Rice production increases markedly and 78,000 tons is exported.

Overall land use increases with all available mangrove swamp and boliland used. Upland in Regions 2, 4, 6, and 8 and inland swamp land in Regions 3 and 5 are used up to the maximum constraint. Upland use actually drops in Regions 1, 3, and 5 and inland swamp use declines in Regions 1 and 6. Even though peak month labor availability is a constraint in Regions 1 and 3, these results may indicate a lower relative profitability of cultivation of these land types. In other regions, the labor situation seems somewhat looser than Run 2 but Regions 4 and 7 hit annual constraints.

Twenty-one large rubber roller mills enter solution (compared to one in Run 2). All output from these mills is exported. The 945 small rubber roller mills (909 in Run 2) supply clean rice for domestic demand. Mill employment and wages are much higher, reflecting this increase in mill numbers.

Run 4 predicts that if the high rice prices of 1974 are maintained in 1980 total profit for the two sectors will increase substantially. Significant mill investment is required with the result that a considerable amount of small farm labor is unemployed. Regions 1, 5, and 8 are predicted to use just 69.3, 69.1, and 82.2 percent of available annual labor respectively. To the extent that this underutilization does exist in 1980, the migration problem alluded to earlier may be aggrevated.

3.6. Run 5--Effect of Shadow Pricing Capital in Run 4

The interest rate used in the first four runs to compute the capital cost for the rice mills is 10 percent, the rate charged by financial institutions in Sierra Leone. The authors of the processing study, suspected that this rate does not represent the true cost of capital to the economy and on several runs of the processing model used a shadow cost of capital of 35 percent.[1] To assess the impact of this higher rate on the combined sectors studied here, Run 5 is done using a 35 percent interest but with other parameters unchanged from Run 4.

Small farm production does not change, and land use is exactly the same as Run 4. As expected, the main

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[1]Linsenmeyer (1976) found that fishing households pay a 43.25 percent effective rate of interest on medium term loans. Assuming that rice mills require capital for a slightly longer period, the 35 percent figure was used (Spencer et al., 1976).

impact is on the composition of the rice processing activities. Large mill numbers drop by one (there is one less mill in Region 4), small mills decline by 193 and hand pounding is done in Regions 2 and 6, areas where land is constraining and labor is available for non-production activities. As expected, Table 3.4 shows farm labor in these two regions to be more fully utilized but there is no change in other regions.

Some small mills have dropped out of solution in Regions 2 and 6, where they are replaced by hand pounding, increased by four in Region 8, and remain at the same levels elsewhere. Small mills are more sensitive to the higher capital cost than the large mills since the latter are able to earn foreign exchange by exporting their output thus offsetting the increased investment cost.

Thus, on the basis of Run 5 results, higher interest rates may be expected to result in a lower level of milling activity nationally with hand pounding having an advantage in certain areas. Realistic valuation of the cost of capital leads to the same conclusion.

3.7. Run 6--Effect of 1980 Expected Prices

In Runs 1 through 5, prices have been fixed at 1974 levels. Run 6 is designed to trace the effects of introducing the prices expected in 1980. Import and export prices for rice are adjusted downwards following long run projections of the international situation which indicate that these prices in 1980 will be about 60 percent of 1974 levels (Table 2.9). Further, in 1976, the domestic support price for rice was lowered to 90 percent of the 1974 level. Assuming that domestic prices will remain at this level in 1980, regional rice prices are dropped 10 percent in this run.[1] Coffee prices are increased 40 percent, following expectations, while other import and export prices remain the same. Other parameters are as in Run 4.

The objective function value drops by Le 16 million in comparison to Run 4. Rice production is down in Regions 1, 4, 5, and 7 and the same in all other regions. This drop affects large mill numbers which decline by three in Region 4. Again all large mill output is exported, 11,000 tons less than in Run 4. Though total national small mill operation is identical to Run 4, the distribution is somewhat different. Small mills decline by five in Region 1, one in Region 4, and four in Region 5 and increase by five in Regions 3 and 8. To illustrate the kinds of adjustments that account for this redistribution: In Run 4, Region 1 processes all of the rice it produces and supplies all of its own demand as well as all of the Region 3 urban and part of the Freetown demand. With the production drop in Run 6, Region 1 does not produce enough rice to supply Region 3 urban demand and Region 3 must activate five

[1]Rice seed prices are assumed to decline similarly.

additional small mills to process sufficient rice to meet this need. Some of the Region 3 rough rice production that previously went to the large mills in Region 3 for processing now is diverted to the new small mills, and the supply from Region 3 to the export market drops.[1]

Non-rice small farm production is adjusted somewhat with the most significant change being an increase in fishing output from Le 3.6 million to Le 6.1 million. Most of this increase comes from greater fishing activity in Region 1, an endeavor that has become relatively more profitable with the lower rice prices. Coffee output is unchanged since the acreage of coffee trees is constrained at the 1974 level and no yield increasing technology is programmed.

Overall land use is slightly lower than Run 4. Mangrove swamp and boliland are again used to their maximum, and other types in each region which are at their upper bound in Run 4 are similarly constraining now, with the exception of inland swampland in Region 5. Upland use has declined in Regions 1 and 5 and increased in Region 7. Inland swampland drops in Regions 2, 5, and 7 and rises slightly in Region 1.

Small farm labor use is unchanged in Regions 2, 3, 6, and 8 and is used more fully in Regions 1 and 7.

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[1]This change in large mill capacity is not evident in Table 3.5 due to rounding.

Region 5 labor is less intensively used while Region 4 adjusts marginally, still employing nearly all available labor.

On the basis of this run, some readjustment of labor use might be expected if lower rice prices obtain in 1980. Region 5 may be an area of significantly higher farm unemployment. The model predicts 51 percent of annual labor availability will be used in 1980.

3.8. Run 7--Effect of Shadow Pricing Capital in Run 6

Capital is again priced at its estimated opportunity cost to explore the combined effect of the lower prices and the higher capital cost. Mill numbers drop as they did in Run 5, i.e., small mills decline significantly more than large mills. Only one large mill drops from solution (Region 8) compared to Run 6, whereas 365 fewer small mills enter solution. Hand pounding replaces 33 small mills in Region 2, 62 small mills in Region 5, 164 small mills in Region 6, and 106 small mills in Region 8. Accordingly, a larger percentage of available farm labor is used in these four regions.

Land use and production are unchanged from Run 6. A slightly lower objective function reflects the export drop of 3,000 tons caused by the decline of large mill numbers.

3.9. Run 8--Effect of Removal of Fertilizer and Mechanization Subsidies in 1980

In all runs so far, fertilizer has been priced at Le 2.30 per bag and mechanization services used by farmers in Regions 4 and 5 have been priced at Le 7.00 per acre. Spencer and Byerlee (1977) point out that these inputs are highly subsidized by the government and suggest the actual costs are Le 10.26 per bag for fertilizer and Le 50.00 per acre for mechanization services. In Run 8, these actual costs are used to trace the effects of removing the subsidies on these inputs in 1980. Other parameters are the same as Run 6.

The only change from Run 6 is a Le 3.35 million drop in the objective function. The mix of processing facilities in solution is exactly the same as Run 6. Likewise there are no changes in land or small farm labor use, even in Region 5 where greatest use of these inputs occurs. The explanation may lie in the computations by Spencer and Byerlee (1977) which indicate that small farms in this area operate with high margins and can thus absorb the increased operating costs.

3.10. Run 9--Effect of Improved Technology

In the first eight runs of the model, the only small farm technologies considered are those occurring in the 1974/75 survey of farm households described by Spencer and Byerlee (1977). To compare these traditional systems with improved systems currently being introduced in Regions 6 and 7, Runs 9 and 10 add to the model two new technologies, upland rice cultivation using fertilizer and improved seed, and inland swamp rice cultivation using improved seed, fertilizer and a simple water control system.

Two agricultural development projects are currently under way to introduce these new technologies. The Eastern Area Project (EAP) was established in Region 6 in 1973 and emphasized improved biological-chemical technology for the production of swamp rice. The Northern Area Project (NAP) began in 1976, emphasizing both upland and swamp rice cultivation. Participating farmers in each project receive credit, improved seed and tools as well as extension advice on constructing water control facilities. By 1980, development of 36,000 acres of upland and 12,000 acres of inland rice is planned for the EAP while the NAP plans development of 24,250 acres and 6,000 acres respectively. These projects are expected to cost the government about Le 8.85 million between 1976 and 1980 to be financed mainly by a World Bank loan. This is about Le 103 per crop acre developed (including acreage of oil palm plantations and other crops). By assuming that the investment cost will be paid off in 25 years at 8 percent interest, approximating the World Bank terms, the costs amount to about Le 9.60 per acre developed. This is the estimated level of subsidy to these schemes.

Three new representative farms have been defined to incorporate improved upland rice technology. One new Region 6 farm, 63, is the same as existing farm 61 (Region 6) as described by Spencer and Byerlee (1977) and two new Region 7 farms, 75 and 76, are the same as the previously defined Region 7 farms, 73 and 74, with the following changes derived from Spencer (1975). On farm 63, rice yeild is increased 60% and minor upland crop yield is increased 30%. On farms 75 and 76, rice yield is increased 80% and minor upland crop yield by 40%. On all three new farms, labor use for rice harvesting is assumed to increase 40 percent and fertilizer input is 2 cwts. per acre. A maximum of 36,000 acres in Region 6 and 25,250 acres in Region 7 is allowed to adopt the new technology.

Data for the improved inland swamp technique were obtained from the field survey in the EAP discussed in Spencer and Byerlee (1977). Table 3.7 shows the input-output relationships programmed for new farms 64 (Region 6) and 77 (Region 7), which represent the improved inland swamp system. The figures shown reflect a level of performance achieved by the top third of the farmers studied in the field survey since it is expected that overall farmer performance will improve as they become more experienced in using the new technique. Yields programmed are 50 percent higher than those of the traditional farms in the respective regions. Maximum acreages of improved

TABLE 3.7

INPUT-OUTPUT RELATIONSHIPS IN IMPROVED INLAND SWAMP RICE FARMING IN REGIONS 6 AND 7 OF THE LINEAR PROGRAMMING MODEL
(Average Per Farm)

	Farm 64	Farm 77
Inland swamp (acres)	2.5	2.5
Labor use (person-hours)		
January	214	214
February	263	263
March	413	413
April	645	645
May	541	541
June	238	238
July	94	94
August	203	203
September	344	344
October	81	81
November	26	26
December	31	31
Total	3,164	3,164
Farm tools (Le.)	6.33	6.33
Seed (lbs.)	135.0	135.0
Fertilizer (cwts.)	6.8	6.8
Rice output (bu.)	131.0	91.0

SOURCE: Field survey.

inland swamp is set at 12,000 acres in Region 6 and 6,000 acres in Region 7.

Besides the addition of the five new representative farm activities, the parameters used in Run 9 of the model are the same as those in Run 6 (i.e., expected 1980 labor, traditional land, demand and pricing policies).

The objective function value increases from Le 34.47 million to 41.39 million as greater rice production in Regions 4, 5, 6, and 7 leads to 24,000 tons more clean rice export. All of the two improved land types is used in both regions. Traditional land use is exactly the same in Regions 1, 2, 3, and 8. In Region 4, upland use is still at its upper bound, and inland swamp and riverain land use rises. In Region 5, all of the available boliland is still used and both upland and inland swamp land use increases. In both regions in which new technology is employed, traditional upland acreage declines and traditional inland swamp acreage goes up slightly. Though numbers of traditional representative farms decline in both regions, the fact that the newly defined upland farms cultivate some inland swamps in addition to the improved land, accounts for this small rise in traditional swamp land use.

The labor situation is the same as Run 6 in Regions 1, 2, 3, and 8 since land use is unchanged. Labor is tighter in the other four regions as might be expected with the higher land use.

Non-rice output changes marginally. The mix of mill technologies is identical to Run 6 in Regions 1, 2, and 3. Small mill numbers remain the same in Region 4, rise in Regions 5, 6, and 7 and fall in Region 8. Nationally, the number of small mills in solution is unchanged. Large mills rise by one in Region 4, and five in Region 8. Clean rice sent to the export market from Regions 4 and 8 therefore rises substantially.

The main effect of these new rice technologies is to increase income and small farm employment. The increase in income is due to a large increase in rice production which adds foreign exchange via the export market. The mills are still relied on for all of the rice processing. The new cultivation systems appear to be more profitable relative to the traditional methods since all the acreage of these improved land types enters the optimal solution. This result suggests that farmer resistance to these new technologies, based on the profitability criteria, would be small.

3.11. Run 10--Effect of the Removal of Input Subsidies from the New Technologies

In this run, fertilizer and mechanization subsidies are removed as in Run 8. Further, farmers adopting the new upland and inland swamp technologies are now programmed to pay Le 4.80 per acre and Le 9.60 per acre respectively. This is the estimated amount that the government must spend to provide extension and other services necessary for the development of the new farming systems. It is assumed that the cost of extension and other services to upland rice farmers is half the cost incurred by the government,[1] while the full cost is required to provide these services to the swamp rice farmer. This is because the swamp rice farmers must be taught how to construct and use water systems, in addition to learning how to apply fertilizer, whereas the upland rice farmers require only the latter instruction.

The only change from Run 9 is the decreased objective function value. Thus it may be concluded from Run 10 that the subsidies result in higher farm incomes but production and labor use are unaffected by their removal.

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[1]Computed earlier, Run 9.

CHAPTER 4

SUMMARY AND CONCLUSIONS

A continuous linear programming model has been used to trace the possible effects of alternative government policies on the small farm and rice processing sectors. Run 1 simulates the 1974 conditions, Run 2 permits the model to choose the mix of processing technologies which maximize the objective function in 1974, while Run 3 does the same with large rubber roller mills programmed to run more efficiently. Runs 4 and 5 model the 1980 situation under 1974 prices with interest rates first set at 10 percent and then at 35 percent. Runs 6 through 8 model the 1980 situation under the expected (lower) 1980 prices, first under conditions of 10 percent interest and input subsidy, then 35 percent interest with subsidies and finally with 10 percent interest and no subsidies. The last two runs, 9 and 10, include new farming technologies, first under subsidized and then under unsubsidized conditions.

Under the specifications of the model and the conditions programmed, the following conclusions can be drawn:

1. Under either the high rice prices prevailing in 1974 or the lower prices which are expected, self-sufficiency in rice production, a major government goal, appears likely by 1980. Production patterns could be expected to be somewhat different depending on the price level with rice production declining under lower prices and non-rice production adjusting somewhat. Fishing output seems quite sensitive to level of rice prices in Region 1 where lower prices encourage fishing activity. Overall incomes drop sharply with low prices and to the extent that the government controls rice prices, policy can have a major impact on this variable.

2. Production of groundnuts, cassava, onions, peppers, and tomatoes, and other vegetables may not keep up with demand by 1980 since the model shows imports of these commodities.

3. Removal of fertilizer and mechanization subsidy appears to have minimal impact on land use, farm or mill employment, processing technology or production. Farm income, though, is eroded with the subsidy removal.

4. Cost of capital is shown to have an important effect on the rice processing activity. With an interest rate higher than that charged by financial institutions, mill numbers drop and hand pounding becomes more competitive. Small rubber roller mills are more sensitive to higher interest rates than large rubber roller mills since the latter are able to offset their highest investment

cost, by producing clean rice suitable for export and earning foreign exchange.

5. The conclusions reached in the processing study with respect to choice of processing technique are borne out here. Large and small rubber roller mills dominate the other processing activity nationally even when capital is charged a high interest. The efficiency with which the large rubber roller mills operate is again a critical factor, with many more large mills activated when the recovery rate is 72, rather than 70, percent. The large disc sheller mills are not competitive and should not be reactivated under the criteria set out in the model.

6. The choice of mill technology for rice processing impacts heavily on small-farm employment. Building more mills would likely result in lower small farm employment levels as hand pounding activity is replaced by the mills. Regions 1, 5, and 8 are consistently high small farm unemployment areas and appear to be the areas which are the most sensitive to reliance on mills for processing.

7. The introduction of new rice cultivation technologies in Regions 6 and 7 is likely to result in greater rice production, higher farm incomes, and greater small farm employment. To process the added rice output, further mill activation (the model chooses large mills) appears to result in the highest overall profits. Even when subsidies are removed, all the available improved land is used, indicating the profitability of the new systems.

The model has proven useful in determining the type and direction of responses to alternative government pricing , credit, input, subsidization and technology diffusion policies. It is in a form which could easily be linked with the other models developed from the overall Sierra Leone study or which could be modified and used independently for evaluation of such things as shadow pricing of foreign exchange, demand satisfaction through product substitution , additional types of improved technologies and changing wage rates. It could also be useful as a component of a systems formulation, modelling dynamic interactions in the agricultural economy.

BIBLIOGRAPHY

BIBLIOGRAPHY

Byerlee, Derek, Joseph L. Tommy and Habib Fatoo. "Rural-Urban Migration in Sierra Leone: Determinants and Policy Implications." African Rural Economy Paper No. 13, MSU, 1976.

Byerlee, Derek and Robert King. "Factor Intensity of Rural Consumption Patterns in Sierra Leone." African Rural Economy Working Paper, MSU (forthcoming).

Chuta, Enyinna. "A Linear Programming Analysis of Small Scale Industry in Sierra Leone." Unpublished Ph.D. dissertation, MSU, 1976.

Liedholm, Carl and Enyinna Chuta. "The Economics of Rural and Urban Small Scale Industries in Sierra Leone." African Rural Economy Paper No. 14, MSU, 1976.

Linsenmeyer, Dean A. "Economic Analysis of Alternative Strategies for the Development of Sierra Leone Marine Fisheries." African Rural Economy Working Paper No. 18, MSU, 1976.

Sierra Leone, Government of. "National Accounts of Sierra Leone, 1965/66-1970/71." Central Statistics Office, Freetown, Sierra Leone, June 1972.

________. "National Development Plan, 1974/75-1978/79." Central Planning Unit, Ministry of Development and Economic Planning, Freetown, Sierra Leone, 1974.

________. Agricultural Statistical Survey of Sierra Leone, 1970/71, Central Statistics Office, Freetown, Sierra Leone, 1975.

Spencer, Dunstan S. C. "Rice Production and Marketing in Sierra Leone." Paper presented at the Conference on "Factors of Agricultural Growth in West Africa," Legon, Ghana, March 1971.

Spencer, Dunstan and Derek Byerlee. "Small Farms in West Africa: A Descriptive Analysis of Employment, Incomes and Productivity in Sierra Leone." African Rural Economy Working Paper No. 19, MSU, February 1977.

Spencer, Dunstan, Ibi I. May-Parker and Frank S. Rose. "Employment, Efficiency and Income in the Rice Processing Industry of Sierra Leone." African Rural Economy Paper No. 15, MSU, 1976.