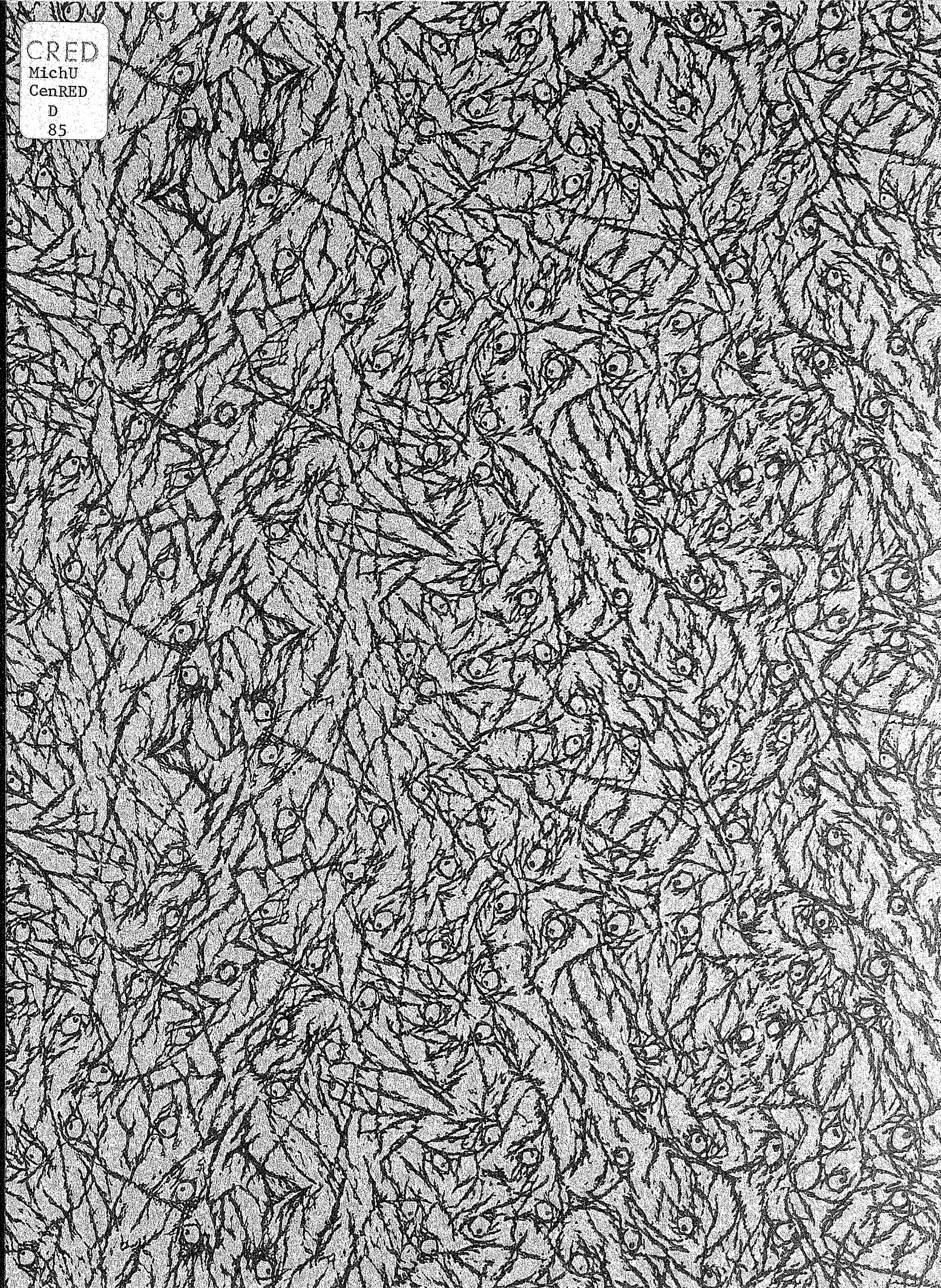

A MODELING OF THE DEMAND AND SUPPLY OF FOOD GRAINS IN SENEGAL

by

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ABSTRACT

In this paper the author estimates demand and supply for principal food grains until the year 2000 in Senegal. These are projected under a variety of assumptions for the hypothesized independent influences -- income, grain prices, population, crop yields, and acreage. The demand for grain is calculated using a range of price, cross-price, and income elasticities. For all sets of assumptions continued rice deficits are derived. With most supply-demand scenaria overall grain deficits also are projected. Finally, possible means to reduce or to eliminate these deficits are considered. Price policy, continued rice imports, and irrigation projects are briefly considered.

SOMMAIRE

Dans ce rapport, l'auteur estime les courbes d'offre et de demande pour les céréales alimentaires principales au Sénégal jusqu'à l'horizon 2000. Ces fonctions sont évaluées pour le futur à partir d'hypothèses variées concernant des facteurs jugés indépendants tels que le revenu, les prix céréaliers, la population, les rendements des cultures, et la superficie cultivée.

Les courbes de demande de grain sont calculées d'aprés une gamme d'élasticités par rapport au prix et au revenu, et d'élasticités croisées. Chaque combinaison d'hypothèses mène à l'estimation d'un déficit en riz. La plupart des combinaisons offre-demande entraine aussi un déficit céréalier total net. Enfin, certains moyens de diminuer ou d'éliminer ces déficits sont éxaminés, ainsi que les conséquences de la politique des prix, de la poursuite des importations de riz et des projets de culture irriguée.

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CHAPTER I - MAJOR OBJECTIVES AND PLAN OF WORK

Attaining and assuring an adequate food supply has generally been a priority of most countries throughout history. Recently the Sahelian countries of West Africa have enunciated the more specific goal of domestic food-grain self-sufficiency. This commitment has been accepted both by the CILSS member countries and various international donor groups.[1] At the outset it should be emphasized that a reliance on domestic food production is not necessarily equivalent to an assurance of food supplies. This is particularly true in the Sahel where variable rainfall patterns imply relatively large risk associated with agricultural production. Finally, it should be noted that food grain supplies can, depending upon contractual, economic, and institutional conditions, be reasonably well assured through international trade, i.e. import.

In Senegal approximately 30 percent of domestic food grain consumption can be classified as imported. Rice (200,000 tons in 1976) and wheat (100,000 tons in 1976) form the near totality of these commercial imports. These imports are primarily financed through export earnings from groundnuts. Essentially Senegal has been pursuing a strategy of comparative advantage and integration with the world economy. While committed to eventual domestic food grain self-sufficiency, the Senegalese recognize that an immediate and total replacement of these imports is unlikely. A gradual reduction in grain imports is to be achieved through national policy affecting both the supply and demand of food grains. Production programs aimed at major increases in domestic rice and maize production, as well as a modest increase in millet production, are incorporated in the Senegalese national plan. Further, a change in the composition of demand towards increased millet and maize consumption with a commensurate reduction in rice consumption is envisioned.

The purpose of this study is to evaluate the probable success of the Senegalese policies to achieve increased self-sufficiency. Such a broad task requires a modeling of Senegalese grain demands and supplies. On the demand side, per capita regional demand equations for grains will be specified; these equations can then be aggregated to project national grain demands.[2] The supply side, due to the inability to specify accurately

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[1] Committee for the fight against drought in the Sahel (CILSS) comprised of the following countries: Senegal, The Gambia, Mauritania, Niger, Mali, Upper Volta, Chad, and the Cap Vertian Islands.

[2] Certain benchmark years like 1985, 1990 and 2000 will be selected.

production functions and producer responses, will be less formally developed. However, as will be explained in Chapter II and tested in Chapter III, some attempt at estimating domestic grain supplies for benchmark years will be made.

From this modeling exercise a number of specific questions can be addressed:

1. Based on current prices, the per capita demand equations, and population estimates, what will national grain demands be in 1985, 1990 and 2000?
2. Without changing the structure of demand, what consumer grain prices would achieve the Senegalese government's per capita grain consumption targets, which incorporate a change in the composition of demand?
3. Assuming a continuation of current agricultural practices and per hectare yields, what will the projected domestic grain supply be in future years?
4. What will be the marginal impact on projected supply from (a) extension efforts which succeed in increasing per hectare yields (b) a change in the relative allocation of resources from groundnut to domestic grain cultivation (c) the planned infra-structure investments (along the Senegal, Gambia, and Casamance Rivers) to increase lands cultivated under irrigation?

Integrating the supply and demand estimates will provide, based on the assumptions selected, projected grain imports, consumer prices needed to equilibrate grain markets, and subsidy expenses needed to achieve government demand targets.[3] Obviously, the above issues can be evaluated with differing combinations of demand and supply assumptions.

There are many benefits to this type of investigation. First, simple projections needed by national planners and donor groups can be generated. Second, the sensitivity of projected demands and supplies to various key parameters like price, price elasticity, rate of population growth, and yield increases, can be assessed. Third, this exercise provides a framework for aggregating the potential effects of the various, regionally decentralized development schemes which have been planned for Senegal.

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[3] A subsidy would be required if the consumer price needed to induce the per capita consumption were less than the required supply price, including all intermediate expenses.

Fourth, potential conflicts in Senegalese planning objectives can be uncovered. Finally, a modeling methodology useful to planners will have been developed. As additional information about the Senegalese agricultural sector becomes available refinements to increase the preciseness of the models' predictions can be made.

The purpose of this exercise is not to promote a particular strategy for achieving food grain security, but rather to provide a framework for analyzing the implications of alternative strategies with various underlying parametric assumptions. Senegalese planners and interested donor groups, after reviewing the implied costs and benefits of these strategies, must devise an agricultural policy for food grain provision.

Chapter II will discuss in greater detail the derivation of the supply and demand components of the model. In Chapter III various empirical estimates of demands and supplies will be presented. Projected grain balances generated from integrating domestic supply and demand under a variety of parametic assumptions will be presented in Chapter IV. The major implications of particular strategies to assure adequate grain supplies (i.e. imports versus domestic production) will be discussed in Chapter V. Finally, in Chapter VI the key recommendations from this study, the needed refinements to the modeling process, and important data deficiencies will all be noted.

CHAPTER II - METHODOLOGY OF THE ANALYSIS

Having established the importance of designing an effective food policy for Senegal, it is now appropriate to present the reader with the methodology used in this study. Essentially, this study aims to construct a framework within which various food policies can be evaluated under a variety of assumptions. These assumptions include those concerning grain prices, income, population growth, and the Senegalese agricultural development effort. Depending on the specification of the model, key effects or impacts on prices, subsidies, grain balances, and nutrition can be estimated. Testing the sensitivity of these results to crucial parameters like price elasticity, income growth, and population growth allows the policymaker to assess the confidence limits within which the results, recommendations, and conclusions of a proposed strategy can be placed.

Section 1 - Derivation of National Grain Demands

The procedure for estimating national grain demands is (1) to partition Senegal into geographic regions based on current grain consumption patterns, (2) to derive per capita grain demand equations for each region and (3) to estimate each region's base population (1976) with a projected annual growth rate. With these data items, regional and national grain demands can be derived for given parametric values and assumptions.

Each of the three components of the demand estimation procedure warrant elaboration.

A. Regional Disaggregation

For the purpose of calculating demands, Senegal is divided into the following four regions:[4]

I. Urban Dakar - which includes the approximate 832,000 (1976) urban residents of Dakar, Pekine, and Rufisque.

II. Groundnut Basin and Rural Cap Vert - which includes the departments of Louga, Thiès, and Diourbel; as well as the major portion of the Sine Saloum.

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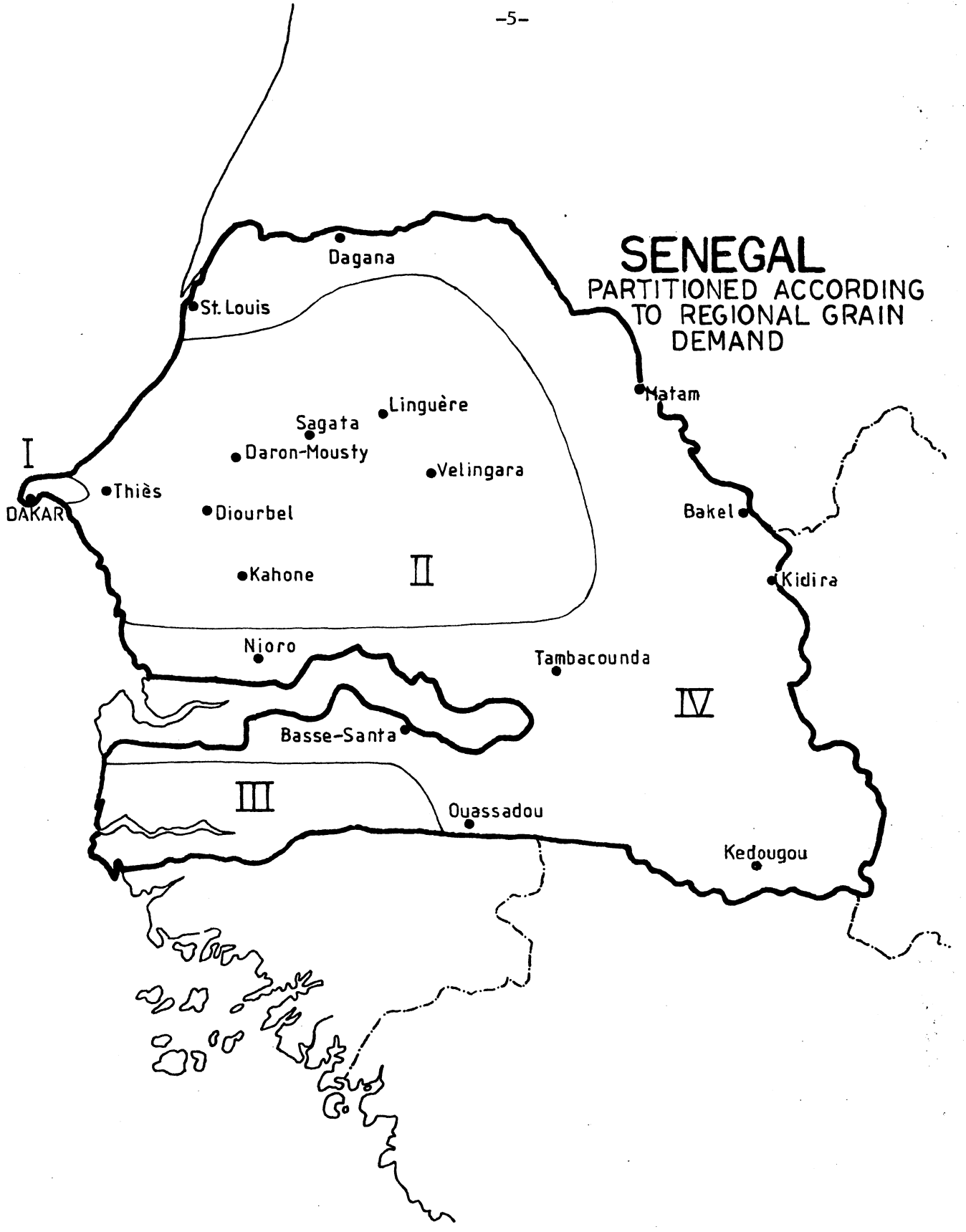
[4] The accompanying map will aid in situating these four regions.


SENEGAL
PARTITIONED ACCORDING TO REGIONAL GRAIN DEMAND
Dagana
St. Louis
Matam
Linguère
Sagata
Daron-Mousty
Velingara
Thiès
DAKAR
Diourbel
Bakel
Kahone
Kidira
Nioro
Tambacounda
Basse-Santa
Ouassadou
Kedougou
I
II
III
IV

III. Casamance Region - which includes all of the Casamance administration region with the exception of an approximate 102,000 residents (1976) who are more properly classified in the Gambia River Basin.

IV. Fleuve and Gambia River Basin - which includes the populations of the Senegal River Basin and the Gambia River Basin (including portions of the Sine Saloum, Casamance, and all of Senegal Oriental).

Disaggregation of Senegal's population is vital, in recognition of the diverse patterns of grain consumption currently observed among the regions.

B. Per Capita Demand Equations

For each principal grain - millet, rice, and maize - and within each of the four regions identified, a per capita demand (KG/year) equation is needed. Each of the 12 grain demand equations has the following independent variables - a constant, own per kilogram price, prices of the other two grains, and per capita income. Thus, each grain demand function has an associated own price, two cross-price, and an income elasticity. The exact formulation of the per capita demand equation is: $Q_{ij}=a_{ij}+\sum_{i=1}^{3} b_{ij}P_{ij}+c_{ij}Y_j$ where

Q_{ij} = quantity demanded of the ith grain in region j (kg/year)

P_{ij} = price of the ith grain in region j (CFA/kg)

Y_j = annual per capita income in region j (CFA)

The coefficients (a's, b's, c's) for these equations were calculated in the following manner:

1. Mean annual (1976) per capita consumption of each grain was estimated by region. These estimates are from the following sources:

Region I - Study of consumer grain demands in Dakar, Senegal.[5]

Region II - Study of producer grain transactions in rural Senegal.[6]

Region III and IV - Gambia River Basin Development Commission work, Casamance River Development work, and SONED study.[7]

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[5] Ross, Clark "Grain Demands and Consumer Preferences, Dakar, Senegal."

[6] Ross, Clark "A Village Level Study of Producer Grain Transactions in Rural Senegal."

[7] SONED, Etude sur la Commercialization des Cereales au Sénégal, Dakar, Senegal 1977.
Unpublished work by the author for the Gambia River and Casamance development projects.

2. Own price, cross-price, and income elasticities at the mean were then estimated. Mean grain prices and incomes in each of the four regions are available from the same sources. The elasticities for Region I are derived when possible from the empirical results of the Dakar grain consumption study. Elasticities in other regions are essentially "best estimates" consistent with those sources of information previously referenced. These latter elasticity estimates, since they generally do not originate from actual budget studies, are undoubtedly subject to error. Assessing the sensitivity of projected grain demands to changes in these elasticity estimates will be done in Chapter III.

Having estimates of the various elasticities, the coefficients for the independent variables, the b's and c's in the above demand equations, can be calculated. Using the mean value for the dependent variable and for the particular independent variable, the following relationship from the definition of elasticity is used to derive the coefficients:

$$(1) \quad \bar{E} = \frac{dY_D}{dY_I} \cdot \frac{\bar{Y}_I}{\bar{Y}_D} \text{ or } \bar{E} = b_I \cdot \frac{\bar{Y}_I}{\bar{Y}_D}$$

$$(2) \quad b_I = \frac{\bar{Y}_D}{\bar{Y}_I} \cdot \bar{E}$$

With estimates for each elasticity (own price, cross-price, and income), all coefficients can be derived. Solving for the constant term in each equation becomes trivial once these coefficients have been calculated. Using mean values for the independent and dependent variables, and the calculated coefficients, the constant is the only remaining unknown in each equation. Having solved for the constant, the demand equation is now expressed in the desired form. These per capita demand equations will be shown in Chapter III.

Thus, for each grain within each region, an annual per capita demand equation has been formulated as a function of each grain price, income, and a constant. To test the predictive power of each equation, various price combinations will be posited and the resulting demands assessed in Chapter III. Also, as stated, the sensitivity of the resulting demands to changes in the assumed elasticities will be evaluated.

C. Regional and National Grain Demand

For any year, regional demand can be estimated by multiplying the projected per capita demand by the assumed regional population. Base year (1976) population estimates are from the recently terminated census of the Senegalese population. Future population estimates were generated on the assumption of a 4.0 percent annual urban growth rate and a 1.9 percent annual rural growth rate. This weighted (at the base year) growth rate of 2.6 percent is that used by Senegalese planners in their Food Investment Strategy for 1977-1985.[8] National demand, of course, is simply the sum of the four regional demands. Within the next chapter projected grain demands until the year 2000 will be presented for a variety of parametric assumptions. It is now appropriate to discuss the procedure for specifying the supply side of the model.

Section 2 - Derivation of Agricultural Supplies

Due to the inability to specify accurately the appropriate agricultural production functions, the derivation of the supply side of the model will be less rigorous than that of the demand side. Seven geographic regions of Senegal, those identified in national planning documents, will be considered. These regions are: Cap Vert, Casamance, Diourbel, Fleuve, Senegal Oriental, Sine Saloum, and Thiès. The sum of crop production from these seven regions will be equivalent to the national domestically produced supply of that crop. To calculate the amount of any crop available for consumption, the domestic supply must be reduced by estimated post-harvest and milling losses.

Production of the ith crop will simply be defined as yield per hectare (Y_i) multiplied by the hectarage cultivated in that crop (H_i). Senegalese planning documents give relatively complete base data for yields and hectarage in each of the seven regions listed above.[9] These data have been accepted for the purposes of this model, and constitute the base from which the future production estimates described below will be made.

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[8] Government of Senegal, Food Investment Strategy, Dakar, Senegal, 1977.

[9] Ministry of Planning, 1976-1980 National Development Plan, Dakar, Senegal, 1977.

A. Autonomous Supply Growth

In this first case both hectarage and yields are assumed to increase over time by a trend factor. For hectarage these increases are between .5 and 2 percent per year, depending on the availability of land in the particular region. Such increases are assumed to be in response to rural population growth. Yield increases will be an important parameter for sensitivity testing. Both unchanging yields per hectare and increases of 2 and 3 percent per annum will be used in this modeling. Thus, production (S) for crop i in year t in region r will be defined as:

$$S^r_{i,t} = \left[Y^r_{i,to} \quad (1 + g_{i,r})^{t-to} \right] \quad X \quad \left[H^r_{i,to} \quad (1 + h_{i,r})^{t-to} \right]$$

where $g_{i,r}$ is the annual growth rate for yield per hectare of the ith crop in region r

h_{ir} is the annual growth rate of hectarage of the ith crop in region r

Y = yield (kg/ha), H = hectares

Summing the regional productions gives the estimated national production of each crop.

B. Senegalese Planned Production

In this case those growth rates envisioned in Senegalese planning documents for yields per hectare and hectarage in each region will be accepted and tested. These rates are considerably more ambitious than those assumed in Part A of this discussion. Yields per hectare for some crops are assumed to increase by as much as 20 percent with hectarage increasing by as much as 30 percent. While this study does not proport to give a definitive assessment of the technical feasibility of these goals for yields and surface, this modeling will give some indication of the reasonableness of these goals, particularly in comparison with the production estimates from Part A.

C. Incorporation of Major Development Programs into Supply

In conjunction with the international donor community, the Senegalese are studying major development of their three river basins, the Senegal, Gambia,

and Casamance. Related projects and programs could range from modest intensification of traditional agriculture to major infra-structure construction including multi-purpose dams for electricity and hydro-agriculture. To estimate accurately future grain supplies, some account must be taken of these planned efforts. More importantly, the aggregate effects of these three potential development projects should be considered and assessed. Each river basin planning agency has essentially been chartered as a decentralized entity, responsible for planning and project coordination in its own basin area. However, it is difficult and grossly inefficient for each of these agencies not to consider potential developments which may emanate from the other basin areas. This study, by considering a range of possible developments in each of these basins, should contribute to a more coordinated planning effort. These major developments will be considered in Chapter V where various strategies for food security are discussed.

Thus, as with the demand side of the model, this study will consider a number of potential supply scenaria. The sensitivity of the domestic supply estimates to yield changes and surface growth can be accommodated with this analysis.

Section 3 - Integration of the Demand and Supply Components

The integration of the demand and supply sub-models, the topics of Chapter IV and V, will provide insight into a number of areas of interest to policymakers. These are mentioned below;

A. Supply/Demand Balances

Projected demands and supplies for grain crops -- millet, maize, and rice -- can be compared under a variety of parametric assumptions. Initially, the now prevailing prices will be used in this analysis; however, the model can incorporate either changes in the grain price level or changes in the relative prices of grains. Initially, this analysis will permit the calculation of projected excess demands and/or supplies for the various grains. Policymakers can then assess the possible means to mitigate problems of excess demand or supply; these could include imports, exports, price policy, or rationing.

B. Price Derivation With an Exogenous Supply

Based on the projected supplies and the hypothesized demand functions, those prices needed to equilibrate individual grain markets can be derived. The implicit assumption here is one of no grain imports; this, of course, can be relaxed to accommodate any exogenous level of imports desired. The policymakers can then assess the economic and political rationality of the calculated prices. For instance, the needed rice price may be at a politically unacceptable level. In contrast, the calculated consumer millet price may be sufficiently low that its associated farm price will not elicit the projected supply without costly national subsidies. Chapter III will now present the data elements used in this analysis and will show, with a minimum of discussion, the major empirical results from the supply and demand sub-models.

CHAPTER III - GRAIN SUPPLY AND DEMAND ESTIMATES

In Section 1 those data elements used in this analysis of Senegalese grain demand and supply will be discussed. In Sections 2 and 3 demand and supply estimates under a variety of parametric assumptions will be presented, with the sensitivity of these estimates assessed.

Section 1 - Derivation of Initial Demand and Supply Components

A. Population

As stated in Chapter II, the Senegalese population has been disaggregated into four geographic regions for this analysis. These regions primarily differ by the composition of the typical grain diet. The estimated current grain consumption within each of these regions is shown in Table II. Table I details the base (1976) population for each region, as well as the estimated populations in 1980, 1985, 1990, and 2000.

Table I - Population of Senegal (000's)

			1976	Annual Growth Rate %	1980	1985	1990	2000
1.	Urban	U	832	4.0	973	1184	1440.7	2132.7
	Dakar	R	0	1.9	0	0	0	0
2.	Groundnut	U	417	4.0	487.8	593.5	722.1	1068.9
	Basin	R	2108	1.9	2272.8	2497.1	2743.5	3374.6
3.	Casamance	U	126	4.0	147.4	179.3	218.2	323.0
		R	513	1.9	553.1	607.7	667.7	821.2
4.	Fleuve and	U	154	4.0	180.2	219.2	266.7	394.8
	Gambia River	R	965	1.9	1040.4	1143.1	1266.3	1544.9
	Basin							
	Country	U	1529	4.0	1788.4	2176	2647.7	3919.4
		R	3586	1.9	3866.3	4247.9	4677.5	5740.7
	Total		5115	2.68[a]	5654.7	6423.9	7325.2	9660.1

Where: U = Urban Sector
R = Rural Sector

a = annual growth rate of total population between 1976 and 2000.

An approximate 90 percent increase in the Senegalese population is envisioned during the 1976 - 2000 period. More importantly, a 150 percent increase in the urban, nongrain producing, population is projected. Such an increase would raise the urban sector's proportion of total population from 30 to 40 percent.

Both the growing total and urban population will further intensify pressures on potential Senegalese food grain deficits. As this analysis will show, either greatly increased domestic food grain production or grain imports will be required to feed this expanding population.

B. Current Per Capita Grain Consumption

Table II shows for each of the four regions the current annual per capita consumption of grains. These data have been derived for regions 1 and 2 from previous studies by the author.[10] Other regional consumption estimates are from Senegalese planning documents.[11]

Table II - 1976 Per Capita Consumption of Milled Cereals (KG/year)

	Millet	Rice	Maize	Total
Region 1	60	103	2	165
Region 2	120	35	4	159
Region 3	75	60	15	150
Region 4	95	45	15	155
Country Mean	99.15	51.37	7.46	157.98

These data demonstrate the relative diversity in the composition of the grain diet among the four regions. In urban Dakar, rice is the most important grain; while in rural Senegal, millet still plays a more dominant

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[10] Ross, Clark "Grain Demands and Consumer Preferences, Dakar, Senegal." "A Village Level Study of Producer Grain Transactions in Rural Senegal."

[11] Government of Senegal, Food Investment Strategy, Dakar, Senegal, 1977.

Table III - Elasticity Estimates for the Independent Variables

	Millet				Rice				Maize			
	P_M	P_R	P_C	Y	P_M	P_R	P_C	Y	P_M	P_R	P_C	Y
Region 1	-.92	.123	.092	.97	.029	-.62	.029	1.22	.75	1.33	-.80	.84
Region 2	-.60	.30	.10	.80	.10	-1.1	.05	1.4	.60	1.40	-.60	.80
Region 3	-.50	.20	.10	.70	.10	-.85	.07	1.3	.60	1.50	-.60	.80
Region 4	-.60	.30	.10	.75	.10	-1.2	.05	1.5	.60	1.50	-.60	.80

where P_M, P_R, and P_C are the prices (CFA/kg) for millet, rice, and maize, respectively.
Y is regional per capita income (CFA). Approximately 215 CFA/$ (1979).

role. It should be noted that rural consumption of purchased rice has become increasingly important in Senegal. Specialization in groundnut cultivation has provided cash incomes to farmers who increasingly have been purchasing rice to supplement and to diversify their diet. Rising rural incomes are likely to intensify this tendency.

C. Derivation of Parameters for the Per Capita Demand Equations

As explained in Chapter II, having estimates of the point elasticity at the mean for the independent variables permits the calculation of the coefficients for the independent variables in each equation. Finally, the constant term in each equation can be solved for, knowing all other parameters in the equation. Table III presents the elasticity estimates for each crop in each region. Table IV shows the mean values for the independent variables used in this procedure. Mean values for the dependent variables, the particular regional grain demands are those shown in Table II.

Table IV - Initial Values for the Independent Variables [a]

	P_M	P_R	P_C	Y
Region 1	60	80	60	60,000
Region 2	40	85	40	35,000
Region 3	40	90	40	25,000
Region 4	40	90	40	20,000

[a] Prices are CFA/kg; Income is annual per capita (CFA). Variables are as defined in Table III.

Following the procedure discussed in Chapter II and using the data elements in Tables II-IV, the regional per capita grain demand equations have those parameters shown in Table V. In each equation the annual per capita grain demand is a function of a constant, each grain price, and regional per capita income.

D. Estimation of 1976 Grain Demands

Using the mean per capita consumption figures in Table II in conjunction

Table V - Coefficients of the Per Capita Grain Demand Equations (a's, b's, c's)

Dependent Variable	Millet (KG/Year)					Rice (KG/Year)					Maize (KG/Year)				
Independent Variable	C	P_M	P_R	P_C	Y	C	P_M	P_R	P_C	Y	C	P_M	P_R	P_C	Y
Region 1	42.3	-.92	.092	.092	.001	41	.05	-.8	.05	.002	-2.32	.025	.033	-.027	.00003
Region 2	50.2	-1.8	.42	.3	.0027	18.97	.088	-.45	.044	.0014	-4.76	.06	.066	-.06	.00009
Region 3	39.97	-.94	.167	.19	.002	25.9	.15	-.57	.11	.003	-20	.23	.25	-.23	.0005
Region 4	41.8	-1.43	.32	.24	.0036	24.36	.11	-.6	.056	.0034	-19.5	.23	.25	-.23	.0006

where C is a constant term; all other variables as defined in Table III.

with the regional population estimates for 1976 (Table I) the estimated 1976 Senegalese grain consumption can be derived. Alternatively, using the values of the independent variables shown in Table IV in conjunction with the per capita grain demand equations (Table V) and the population estimates, will yield identical results for the 1976 estimated grain consumption. These estimates are shown in Table VI.

Table VI - Estimated 1976 Regional Grain Consumption (000's Tons)

	Millet	Rice	Maize	Total
Region 1	49.92	85.696	1.664	137.280
Region 2	303.00	88.375	10.10	401.475
Region 3	47.925	38.340	9.585	95.850
Region 4	106.305	50.355	16.785	173.445
National Total	507.150	262.766	38.134	808.050

E. Estimation of 1976 Grain Supply

As explained in Chapter II, Senegal is being partitioned into seven geographic regions to facilitate estimating national agricultural production. Table VII shows, for each of these regions, the base year (1976) surface, yield per hectare, and resulting production for those agricultural products considered in this study.[12] In this part of the analysis production is simplistically defined as surface (ha.) multiplied by yield (kg/ha). After summing the regional productions shown in the column total, a loss factor and a milling yield are applied to each product and the resulting crop disposition is calculated. In the succeeding section these initial crop dispositions will be compared to the 1976 demand estimates, giving an initial grain balance for Senegal.

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[12] Due to the importance of groundnuts as an export earner for Senegal and the direct trade-off between groundnut and grain production, groundnuts have been included in this supply analysis.

Table VII - Agricultural Supply (1976)

Region	Cap Vert	Casamance	Diourbel	Fleuve	Senegal Oriental	Sine Saloum	Thiès	Total	Loss b Factor	Milling Yield	Disposable Production
Surface a / (000 ha)											
Millet	1.5	100	315	74	85	340	165	1080.5			
Maize	0	15	0	5	25	3.5	0	48.5			
Rice	0	65	0	10	5.6	1.7	0.5	82.8			
Groundnuts	2.2	120	320	6	50	500	155	1153.2			
Total	3.7	300	635	95	165.6	845.2	320.5	2365			
Yields a / (kg/ha)											
Millet	466	850	413	405	588	559	394	510			
Maize	NA	1000	NA	620	800	1000	NA	858			
Rice	NA	1154	NA	1900	1107	529	1000	1227			
Groundnuts	591	1042	731	450	880	880	858	850			
Production (000 tons)											
Millet	.7	85	130	30	50	190	65	550.7	.05	.90	470.9
Maize	0	15	0	3.1	20	3.5	0	41.6	.05	.95	37.5
Rice	0	75	0	19	6.2	.9	.5	101.6	.05	.65	62.7
Groundnuts	1.3	125	234	2.7	44	440	133	980	.10	NA	882.0

Notes: a. The surface and yield estimates are those presented in the Senegalese 1977-1981 development plan.

b. The loss factor includes seed and storage loss. While these estimates are arbitrary and probably too low, the lack of reliable studies of on-farm storage losses precludes more precise estimates.

F. Initial (1976/1977) Senegalese Grain Balance

The results from comparing initial grain demands (Table VI) with the initial domestically produced grain supplies (Table VII) are presented in Table VIII.

Table VIII - Initial Grain Supply/Demand Balance - 1976

	Demand (000T)	Supply (000T)	Difference (000T)[a]	Mean Per Capita Consumption (kg)[b]
Millet	507.150	470.90	-36.250	99.15
Maize	38.134	37.50	-.634	7.46
Rice	262.766	62.70	-200.066	51.37
Total	808.050	571.10	-236.950	157.98

a. A + sign indicates an excess of supply over demand, while a - sign indicates a supply deficit. Any deficit was presumably overcome by imports, food aid, or changes in in-country stocks.

b. A 1976 population of 5,115,000 (Table I) has been assumed.

Certain points emerge from this table. First, domestic grain production in the 1976 reference case only supplies an estimated 71 percent of Senegalese grain consumption.[13] Second, domestic millet production is equivalent to 93 percent of estimated consumption in this base period. Typically, Senegal is nearly self-sufficient in millet production. Millet imports and some sorghum received through donor agencies occasionally supplement domestic production. A shortfall of seven percent, as indicated above, could even be compensated by changes in producer on-farm millet stocks, without resort to commercial imports. As with millet, local maize production is sufficient to satisfy current domestic demand. The relative unimportance of maize in the typical grain diet should be noted. The situation with rice is greatly different. Local rice production accounts for only about twenty-four percent of estimated consumption. Approximately 200,000 tons are annually imported to compensate for this deficit.

From an analysis of those data elements initially used in this modeling of Senegalese grain demand and supply, the dependence on commercial

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13 While not included in this study, wheat imports, primarily destined for bread, currently average 100,000 tons per year.

rice imports to satisfy Senegalese grain demands is evident. The relative self-sufficiency in millet and maize has also been shown. The following sections will discuss the sensitivity of Senegalese grain demands and supplies to the critical parameters of the model. This will permit a comparison of demands and supplies under a variety of assumptions.

Section 2: Sensitivity of Demand Estimates

A. Population

Using those population estimates shown in Table I of this chapter, estimated food grain demands for future years can be generated. The current 4 percent annual growth in the urban population and 1.9 percent growth in the rural population have been applied in this exercise. This results in a compounded annual population growth rate of 2.68 percent between 1976 and 2000. Based on the regional distribution of this population (Table I) and a constant regional per capita ration of each grain (Table II), estimated national grain demands for succeeding years are shown in Table IX.

Table IX - Extension of Current Grain Demands (000's tons)

Year	Population (000)	Millet	Maize	Rice	Total	Percentage Increase of total from 1976
1976	5,115.0	507.15	38.13	262.77	808.05	
1980	5,654.7	558.15	41.81	293.80	893.76	10.6
1985	6,423.9	630.36	46.97	338.65	1,015.98	25.7
1990	7,325.2	714.39	53.03	391.83	1,159.25	43.5
2000	9,660.1	931.27	68.30	531.13	1,530.70	89.4

With the population growth rate assumed and an unchanging regional composition of grain consumption, Senegal's grain demands will sharply increase in succeeding years. By 2000 an 89.4 percent increase from 1976 in total grain consumption is envisioned; this is solely the result of population growth. Since the regional per capita consumption of grains has been held constant, the aggregate grain consumption shown in Table IX only represents 158 kg of grains per capita per annum. Any tendency

for this per capita total to increase would further raise the aggregate national demands in any year. Between 1976 and 2000, assuming the current consumption patterns, national millet, maize, and rice demands will increase by 83.6, 79.1, and 102 percent, respectively. The larger growth rate for rice demand results from the assumption that the urban population, with a more rice intensive diet, will grow at a faster rate than the rural population.

The potential severity of this growth in grain demand can best be seen in the perspective of the 1976 base year domestic supply. That supply, covering an estimated 71 percent of total grain demand, was grossly insufficient to satisfy 1976 rice demand; approximately 200,000 tons of rice were imported to offset this deficit. Assuming the same 1976 domestic supply and the 1985 demand estimates, only 56 percent of domestic grain demand estimates, only 56 percent of domestic grain demand would be satisfied by local production.[14] A shortfall of 444,880 tons would result with rice comprising the bulk of this deficit (275,950 tons). While growth in domestic supply should be forthcoming (See the succeeding section on supply), the magnitude of the estimated growth in demand resulting from population increase poses a serious problem to Senegalese policymakers. Changing the composition of grain demands from rice towards millet and maize could succeed in moderating the costly rice imports.[15] It is unlikely that the annual per capita ration of 158 kg can be substantially reduced. Limiting these projected total grain demands requires some diminution in the growth of population.

In fact, with rising incomes the growth of grain demand may be greater than that assumed in this exercise. The sensitivity of these grain demands to income will be discussed in the next sub-section.

B. Income

As formulated in this model, income is an important factor in the esti-

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[14] A brief review of Senegalese production figures shows little or no growth of domestic grain production during the last 10 years.

[15] The possibility of changing this composition of demand through price policy will be explored in a succeeding sub-section.

mated grain demand equations. Using the particular income elasticities assumed for each region and grain (Shown in Table III), regional per capita income estimates were raised 10 percent and the grain demands recalculated.[16] This exercise permits an evaluation of the sensitivity of the grain demand to the income estimate chosen. Further, assuming the original income estimates are reasonably accurate, this exercise indicates the likely trend of grain demands with rising incomes.

With the 10 percent increase in all per capita regional incomes, per capita national grain consumption increased from 157.98 kg/year to 171.5 kg/yr. This 8.56 percent increase suggests a weighted income point elasticity of .856 for national grain demand. This is consistent with those income elasticity estimates shown in Table III where only rice demand was assumed income elastic at the original mean.

Table X presents those national grain demands in 1976 and 1990 calculated with the original income estimate and with the 10 percent increase.

Table X - Sensitivity of Grain Demands to Income Estimate (000 Tons)

	1976				1990			
	Original Demand	+10% Income	Diff.	% Change	Original Demand	+10% Income	Diff.	% Change
Millet	507.1	547.3	40.2	7.9	714.4	771.2	56.8	8.0
Rice	262.7	288.5	25.8	9.8	391.8	427.6	35.8	9.1
Maize	38.1	41.2	3.1	8.1	53.0	57.3	4.3	8.1
Total[a]	807.9	877.0	69.1	8.5	1,159.2	1,256.1	96.9	8.3

[a] Estimated for entire country - Pop. 1976 = 5,115,000
1990 = 7,325,200

The largest percentage increase in demand is for rice. Particularly in rural areas it had been assumed that rice demand was relatively sensitive to income (See Table III). Peasants have a desire to diversify their diet and rice is viewed as a desirable alternative to millet in rural areas. The

16 All other independent variables retain the values shown in Table IV.

percentage increase in rice demand is less in 1990 than in 1976 due to the faster growth rate of population assumed for the urban sector whose demand for rice is relatively more income inelastic. In absolute magnitude, millet demand registers the largest increase, an additional 56,800 tons in 1990.

If the Senegalese objective of increasing incomes, particularly in rural areas, is achieved, this model shows that national grain demands will be correspondingly affected. The problem of rice imports again must be addressed. With population and income growth combined, projected rice consumption in 1990 would reach 427,600 tons, and increase of 164,900 tons or 63 percent from the estimated 1976 consumption. Without domestic rice production increases or change in the composition of grain consumption, required rice imports would increase from the current 200,066 tons to 364,900 tons. Thus, in projecting future grain demands the effects of increasing incomes must not be ignored.

C. Price Level

The sensitivity of regional and national grain demands to the general grain price level was tested. All grain prices - millet, rice, and maize, were raised 10 percent and the grain demands recalculated. Following this price level increase, estimated national grain demands were only slightly affected. On a per capita basis, the mean annual consumption of all grains only fell by .56 kg from 157.98 to 157.42. The composition of this consumption was only slightly changed, a little more maize (+1.3%) and less millet (-.25%) and less rice (-.8%). This inelasticity of total grain demand with respect to the grain price level can be explained by two factors. First, with the exception of rice in rural areas, own price elasticities had been assumed less than unity. (See Table III) This reflects the relative constancy and importance of grains in the Senegalese diet. Thus, a change in the own price would not greatly modify demand for a particular grain. Second, cross-price responses would tend to raise the demand for each grain as other grain prices were increased. Again, while the magnitude of these responses was assumed low, there would be a tendency to increase consumption of a grain if the prices of the substitute grains were raised. This offsets the tendency for a decrease in demand resulting

from an increase in the own price of the grain.

While the actual estimates generated by this exercise are more indicative than definitive, an important policy point is illustrated by the exercise. Public policy aimed at moderately increasing all grain prices would have little effect on aggregate grain demands. Grain represents the least cost means (in terms of calories per monetary unit) for the Senegalese population to sustain itself. Thus, even in the face of price increases for all grains, little change in aggregate grain consumption occurs. This is consistent with the observed purchasing behavior of grain deficit (particularly urban) households. After receiving the monthly salary, the head of the household immediately purchases a sac or other large quantity of rice, insuring that the household's monthly grain needs are met. With this typical behavior, increases in all grain prices would primarily have distributional effects, the incidence of which depends on the actual government policy tool(s) used to change prices. Thus, rice imports would not be significantly decreased by such a policy. Changing the relative prices for grains may be a more effective means to reduce the demand for rice, which is primarily imported, and increase demand for domesticly produced grains. This will be explored in the succeeding sub-section.

D. Relative Grain Prices

For this exercise differing relative grain prices were postulated and the grain demands recalculated. The purpose of this is to assess the extent to which the composition of grain consumption can be influenced by price policy. These results are presented in Tables XI and XII. In Table XI four different sets of relative prices with their implied regional per capita grain consumption and resulting national consumption are shown. Price combination 1 depicts the current situation, using the mean regional grain prices prevailing in 1976. The per capita and national grain demands are those which were originally calculated and previously presented in other tables. Table XII extends the result of this exercise to show projected changes in rice and total grain consumption associated with each price combination in 1976 and 1990. Such changes are calculated from the "base results" generated with price combination 1.

Table XI - Grain Demands and Relative Prices

A. Prices (CFA/kg)

	Price Comb. 1[a] 1976 Prevailing Prices			Price Comb. 2 Lowering Millet Price			Price Comb. 3 Raising Rice Price			Price Comb. 4 Raising Rice Lowering Millet (3,4)		
	M	R	C	M	R	C	M	R	C	M	R	C
Region 1	60	80	60	50	80	60	50	120	60	80	120	80
Region 2	40	85	40	30	85	40	40	100	40	40	100	30
Region 3	40	90	40	30	90	30	40	110	40	35	95	40
Region 4	40	90	40	30	90	30	40	110	40	35	95	40

a. Where M, R, and C are millet, rice, and maize respectively.

B. Per Capita Consumption (kg/year)[a]

	Price Comb. 1				Price Comb. 2				Price Comb. 3				Price Comb. 4			
	M	R	C	T	M	R	C	T	M	R	C	T	M	R	C	T
R. 1	60	103	2	165	69	103	2	174	73	71	3	147	47	73	3	123
R. 2	120	35	4	159	138	34	3	175	126	28	5	159	123	28	6	157
R. 3	75	60	15	150	83	57	15	155	78	49	20	147	81	56	15	152
R. 4	95	45	15	155	107	43	15	165	101	33	20	154	104	42	15	161
Weighted Mean[b]	99	51	8	158	113	50	7	170	106	39	10	155	101	42	9	152

a. Rounded to nearest kg.

b. Applicable only for 1976 since the regional composition of the projected 1990 population differs slightly from that of 1976.

C. National Demands (tons)

	Millet	Rice	Maize	Total
Price 1 - 1976	507,150	262,766	38,134	808,050
- 1990	714,391	391,827	53,027	1,159,245
Price 2 - 1976	578,363	256,609	36,411	871,383
- 1990	814,914	383,209	50,588	1,248,711
Price 3 - 1976	543,069	197,970	50,314	791,353
- 1990	767,551	293,116	70,094	1,130,761
Price 4 - 1976	518,094	213,379	43,390	774,863
- 1990	725,589	315,057	60,624	1,101,270

Price combination 2, simplistically labeled "lowering millet price" considers the extent to which millet consumption can be raised. Millet consumption increases on a weighted per capita basis (kg) from 99 to 113, or by 14.1 percent. There is, however, only a slight reduction in mean rice and maize consumption. This result is due to the underlying specification of the model where the cross-price response between millet and the other grains was very low, reflecting the belief that the degree of substitutability between millet and rice is quite limited, particularly in urban areas. Consequently, this exercise predicts consumption can be stimulated by a relative price decrease, but not at the expense of other grains, in particular imported rice. The result is simply an increased per capita grain consumption from 158 kg/year to 170 kg/year.

Price combination 3 primarily involves increasing the price of rice in each region. A rather significant decrease in per capita rice consumption results. The weighted mean per capita rice consumption falls from 51 kg/year to 39 kg/year, or by 24 percent. As shown in Table XII such a decrease translates into a significant reduction in national rice consumption and resulting rice imports. In 1990, a reduction of 98,711 tons is predicted by the model. To achieve this reduction, however, the consumer price had to be increased an average of 28 percent with a 50 percent price increase

Table XII - Macro Effects From Changing Relative Prices[a]

(Tons)

	Rice Consumption	Difference	% Diff.	Total Grain	Difference	% Diff.
Comb. 2 - 1976	256,609	-6,157	-2.3	871,383	63,333	+7.8
- 1990	383,209	-8,618	-2.2	1,248,711	89,466	+7.7
Comb. 3 - 1976	197,970	-64,796	-24.7	791,353	-16,197	-2.1
- 1990	293,116	-98,711	-25.2	1,130,761	-28,484	-2.5
Comb. 4 - 1976	213,379	-49,387	-18.8	774,863	-33,187	-4.1
- 1990	315,057	-76,770	-19.6	1,101,270	-57,975	-5.0

[a] The difference for both rice consumption and total grain consumption is calculated by subtracting the projected demand for the indicated price combination from the corresponding demand associated with price combination 1.

in the heavy rice consuming urban Dakar region. The central question posed by this exercise is whether the government of Senegal, in desiring to reduce rice consumption, will have the political will to increase so sharply the consumer rice price. Of interest in this exercise is that total grain consumption was not greatly reduced. The mean consumption of millet and maize increased by 9 kg offsetting 75 percent of the decreased rice consumption.

Price combination 4 sharply raises the rice price but lowers the millet price in regions 3 and 4. The latter was postulated in recognition of the lower than mean grain consumption currently observed in regions 3 and 4. Further, the millet and maize prices were sharply increased in region 1. Again significant savings in projected rice consumption are observed. Total grain consumption in region 1 falls dramatically from 165 to 123 kg/year. Such decreases would represent a 19 percent reduction in national 1976 rice consumption and a 4 percent reduction in total national grain consumption. In this case the brunt of the reduction is borne by the urban Dakar residents (Region 1) and not by the rural residents.

This discussion of relative price changes has shown that policy aimed at changing relative grain prices can succeed in altering the composition, and to a lesser extent the aggregate, of grain consumption. Due to the inelasticity of the postulated own and cross-price elasticities, however, the requisite price changes are quite substantial. It is questionable whether the government of Senegal would or should (from the perspective of equity) increase rice prices to the extent necessary to realize meaningful reductions in rice imports.

E. Own Price Elasticity

Since the elasticities used in this analysis have generally been assumed, rather than derived from actual budget studies, it would be desirable to test the sensitivity of the resulting per capita demands to these elasticity estimates. The own price elasticities assumed for each grain (See Table III and its accompanying discussion) were each increased by 10 percent and the demands recalculated. With these higher own price elasticities, the per capita grain demands would each be somewhat re-

duced reflecting this greater sensitivity to own price.

These new demands, in comparison with the original reference demands, are shown in Table XIII. The estimated per capita annual grain consumption would fall 11 kg to 147 kg, a decrease of 7 percent. For 1990 this represents a reduction of 83,100 tons of grain, 7 percent of the estimated 1990 consumption. The total reduction in grain consumption can be apportioned among millet (54 percent of total) rice (42 percent) and maize (4 percent).

Thus, while the hypothesized own price elasticities affect the resulting per capita demands, the strength of this effect is not overwhelming. The importance of this is that the aggregate projections of Senegalese grain demands are relatively invariant to reasonable changes in the own price elasticities. Consequently, even if the assumed elasticites were subject to 10 - 20 percent error, the major conclusions from this study of grain demands would still be applicable.

F. Summary of Demand Sensitivity

The major findings regarding the sensitivity of Senegalese grain de-

XIII - Changing Own Price Elasticity

Per Capita (kg/year)	Original Demand				Higher Own - Price Elasticity			
	Millet	Rice	Maize	Total	Millet	Rice	Maize	Total
Region 1	60	103	2	165	55	97	2	154
Region 2	120	35	4	159	113	31	4	148
Region 3	75	60	15	150	71	55	14	140
Region 4	95	45	15	155	89	40	14	143
Weighted Mean [a]	99	51	8	158	93	47	7	147
National Demand (000 tons)								
1976	507.2	262.8	38.1	808.1	475.9	238.5	35.8	750.2
1990	714.4	391.8	53.0	1159.2	669.9	356.5	49.7	1076.1

[a] Applicable only for 1976; that of 1990 would slightly differ.

mands to various parameters are listed below.

1. With a continuation of current population growth and an unchanging composition of per capita grain demands, (158 kg/year total), an 89.4 percent increase in national grain consumption between the years 1976 and 2000 is projected.

2. With the income elasticites assumed, a 10 percent increase in income will increase weighted per capita grain consumption by 8.56 percent from 158 kg/year to 172 kg/year.

3. Increasing all grain prices by 10 percent only reduces per capita grain consumption from 158 kg/year to 157.4 kg/year. This relative inelasticity of total grain consumption with respect to the level of grain prices suggests that a policy to increase uniformly all grain prices would not greatly affect total grain consumption.

4. The composition and, to a lesser extent, the aggregate consumption of grains are both sensitive to changes in relative grain prices. For example, a sharply increased rice price relative to prices for other grains would succeed in significantly reducing total rice consumption.

5. Changing the own-price elasticity by 10 percent in each grain demand equation did not substantially alter the projections of the model.

Section 3 - Sensitivity of Supply Estimates

In this section the sensitivity of domestic production or supply to changes in its independent influences will be explored. The gross domestic production of any crop had been simplistically defined as:

$$S_{i,t} = \sum_{n=1}^{7} \left(\left[Y^{r}_{i,to} \ (1+g_{i,r})^{t-to} \right] \left[H^{r}_{i,to} \ (1+h_{i,r})^{t-to} \right] \right)$$

where $S_{i,t}$ = domestic production of crop i in time t

$Y^{r}_{i,to}$ = yield (kg/ha) for crop i in time to in region r

$H^{r}_{i,to}$ = base hectarage for crop i in time to in region r

$g_{i,r}$ = annual growth rate for yield of crop i in region r

$h_{i,r}$ = annual growth rate for hectarage of crop i in region r

Setting t = to and using the original yield and surface estimates for each crop (Table VII) will provide the original gross domestic production estimates.

Projecting domestic production over time necessitates some assumption about changes in hectarage ($h_{i,r}$) and yields ($g_{i,r}$). Table XIV presents the assumptions used in making the future projections which are then shown in Table XV.

Four different sets of projections have been derived. The first three are labeled autonomous growth, defined to include a continuation of government extension efforts to raise crop yields, no significant reallocation of farmers' resources among crops, and no government or donor capital intensive irrigation projects. For this case, surface growth - a function of population growth and land availability - for each crop in each region is shown in Table XIV under 1. Autonomous Growth-Surface. Three different rates of increase for yields, 0, 2, and 3 percent annually are then postulated. The inherent complexity and incertitude of successfully delivering agricultural extension services to the rural sector require using varying estimates for yield growth. Thus, there are three sets of supply projections listed in Table XV autonomous growth, each associated with a different assumption for yield growth.

The fourth set of supply projections, more ambitious than the previous three, represents those growth rates for surface and yields derived from the current Senegalese plan.[17] These projections include (1) a restructuring of agricultural production towards cereal crops particularly maize and rice, and (2) the beneficial effects (surface and yields) of certain projects for which, neither funding nor the ambitious results can be assured. Also, without a substantial change in the groundnut/millet and groundnut/maize relative prices, as well as, policy action addressing the high domestic resource price for rice, the restructuring of agricultural

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17 Ve Plan Quadriennal de Development Economique et Social 1977-1981. Commission 1 - A (Agriculture), Propositions D'Actions (Juillet 1976) pp. 47-60.

Table XIV Changes in Supply Parameters

(Annual Percentage Increase)

	National Total	Cap Vert	Casa-mance	Di-ourbel	Fleuve	Senegal Oriental	Sine-Saloum	Thiès
1. Autonomous Growth								
Surface								
Millet	1.0	.5	1.0	1.0	1.0	1.5	1.0	1.0
Maize	1.2	0	1.5	0	1.0	1.5	1.5	0
Rice	1.0	0	1.25	0	1.0	1.25	.5	0
Groundnuts	1.9	.75	2.0	2.0	1.5	2.0	2.0	2.0
Yields[a]								
2. Government Planned Growth[b] (1976-1981)								
Surface								
Millet	2.0	0	1.0	.6	2.7	2.7	3.7	.9
Maize	12.4	0	10.7	0	19.1	7.0	33.8	0
Rice	8.4	0	2.9	0	30.0	23.6	0	0
Groundnuts	.6	0	3.1	0	0	3.7	.4	0
Yields								
Millet	7.1	1.4	3.0	6.1	4.6	4.5	9.0	9.4
Maize	14.4	0	11.2	0	20.7	12.1	14.9	0
Rice	13.0	0	9.0	0	11.8	20.6	6.9	0
Groundnuts	3.4	1.9	2.9	3.1	5.9	4.2	2.6	3.1

[a] Three uniform annual growth rates (0,2,3) have been tested in this analysis.

[b] Implied annual changes from Government of Senegal planning documents.

production towards cereal crops particularly maize and rice, and (2) the beneficial effects (surface and yields) of certain projects for which, neither funding nor the ambitious results can be assured. Also, without a substantial change in the groundnut/millet and groundnut/maize relative prices, as well as, policy action addressing the high domestic resource price for rice, the restructuring of agricultural production towards cereals crops is unlikely.[18] Further, the yield increases postulated in the

[18] These two issues are discussed more fully in: CRED, Marketing of Food Crops in the Sahel, University of Michigan, August 1977.

Plan are also of questionable realism. These surface and yield growth rates are shown in Table XIV under part 2.

In any case all four sets of domestic agricultural production projections are presented in Table XV. With each set of projections, the 1976 base figures are again shown to facilitate comparison. Both gross production and disposable production (gross production minus storage, milling, and other post-harvest losses) are shown. Results from each set of projections are briefly reviewed.

With projection 1, the original yields per hectare assumed in Table VII are used in future years (i.e. no improvement in yields assumed). Production increases are solely the result of additional lands being cultivated, in response to population growth. Table XIV provides these annual growth rates on a regional basis. As shown in Table XV during the 1976-1980 period the annual growth in production varies between 1 and 2 percent depending upon the crop. The groundnut production increase is the most substantial reflecting the assumption that a slightly larger proportion of additional lands will be placed into groundnut cultivation than into other crops. At current Senegalese agricultural prices the greater profitability per hectare of groundnut cultivation leads to this land allocation assumption.

Table XVI more clearly demonstrates the impact of no growth in yields per hectare. With population growing at 2.68 percent annually, and total domestic grain production at only 1.07 percent, the per capita production of grains steadily falls from the base (1976) of 111 kg/person to 106 kg (1980) to 90 kg (1990). The assumed base year consumption of 158 kg/person was comprised of 111 kg of domestic production and 47 kg of imported grain. Thus, with this scenario of no yield growth grain imports could increase substantially. Of course, the actual level of imports will depend on the per capita grain demands, the variability of which was previously discussed. In Chapter IV various grain demands and supplies will be compared to estimate the required grain imports. Nevertheless, this supply projection based on no change in yields represents a situation where grain imports would continually increase.

In case 2, yields per hectare are assumed to grow at 2 percent per year, as a result of extension efforts and an increased use of inputs -

Table XV Domestic Production (000 tons)

	1976		1980		1985		1990		2000		Annual Per Cent Increase (Gross)	
1. Yield change[a] = 0	G	D[c]	G	D	G	D	G	D	G	D	1976-1980	1976-1990
Millet	551	471	574	491	605	517	637	545	707	605	1.0	1.04
Maize	42	38	44	40	47	42	51	46	59	53	1.2	1.39
Rice	102	63	106	66	113	70	119	74	135	84	1.0	1.10
Groundnuts	980	882	1067	955	1171	1054	1293	1164	1575	1418	2.0	1.99
Grains-Total[b]	695	572	724	597	765	629	807	665	901	742	1.0	1.07
2. Yield change = .02												
Millet	551	471	622	532	723	618	841	719	1137	972	3.08	3.05
Maize	42	38	48	43	57	51	67	61	95	86	3.39	3.37
Rice	102	63	115	71	135	84	158	98	216	133	3.04	3.16
Groundnuts	980	882	1148	1033	1399	1259	1705	1535	2533	2280	4.03	4.01
Grains-Total	695	572	785	646	915	753	1066	878	1448	1191	3.09	3.08
3. Yield change = .03												
Millet	551	471	647	553	789	675	964	824	1438	1229	4.10	4.05
Maize	42	38	50	45	62	56	77	70	120	108	4.46	4.40
Rice	102	63	119	74	147	91	181	112	274	169	3.90	4.16
Groundnuts	980	882	1194	1075	1528	1375	1955	1760	3202	2882	5.00	5.03
Grains-Total	695	572	816	672	998	822	1222	1006	1832	1506	4.00	4.09
4. Government Projections												
Millet	551	471	782	669							9.15	
Maize	42	38	108	98							26.60	
Rice	102	63	234	145							23.10	
Groundnuts	980	882	1132	1019							3.70	
Grains-Total	695	572	1124	912							12.80	

where: G = gross total production, D = disposable production after milling, storage, and other losses.

[a] Yield change = an annual percentage change in yields per hectare.

[b] Grains total is the sum of millet, maize, and rice.

[c] Milling and loss factors are those shown in Table VII.

Table XVI Key Production Indicators

Yields (kg/ha)	1976	1980[a] 1	1980[a] 2	1980[a] 3	1980[a] 4	1985[a] 1	1985[a] 2	1985[a] 3	1985[a] 4	1990[a] 1	1990[a] 2	1990[a] 3	1990[a] 4	2000[a] 1	2000[a] 2	2000[a] 3	2000[a] 4
Millet	510	510	552	574	669	510	610	666	--	510	673	771	--	510	820	1037	--
Maize	858	858	929	966	1411	858	1025	1120	--	858	1132	1298	--	858	1380	1744	--
Rice	1227	1227	1328	1328	2044	1227	1466	1601	--	1227	1618	1855	--	1227	1973	2495	--
Groundnuts	850	850	920	957	956	850	1016	1109	--	850	1121	1286	--	850	1367	1728	--
Net Per Capita Production (kg)																	
Millet	92	87	94	98	118	81	96	105	--	74	98	113	--	63	101	127	--
Maize	7	7	8	8	17	7	8	9	--	6	8	10	--	6	9	11	--
Rice	12	12	13	13	26	11	13	14	--	10	13	15	--	9	14	18	--
Grains	111	106	115	119	161	99	117	128	--	90	119	138	--	78	124	156	--
Groundnuts	172	169	183	190	180	164	196	214	--	159	210	240	--	147	236	298	--
Population (000's)	5115	5655				6424				7325				9660			

[a] 1. Yield change = 0; surface change in Table XIV
2. Yield change = 2%/year; surface change in Table XIV
3. Yield change = 3%/year; surface change in Table XIV
4. Yield and surface changes planned by government (Table XIV)

animal traction, seeders, pesticides, and fertilizer. As shown in Table XVI the per hectare yields in the year 2000 range from 820 kg for millet to 1973 kg for rice. Since the increase in total grain production, 3.08 percent per year, slightly exceeds estimated population growth, per capita domestic grain production increases from 111 kg (1976) to 115 kg (1980), 117 kg (1985), and 124 kg (2000).[19] Again, per capita production does not approach the estimated reference year (1976) consumption of 158 kg/person.

Finally in case 3, a more ambitious yield increase - 3 percent per annum - was assumed. The resulting 4.09 percent growth (1976-1990) in domestic production raises per capita production to 115 kg in 1980 and to a high of 156 in 2000. Assuming no variation in per capita consumption, domestic grain supply would roughly equal the initial per capita consumption by the year 2000. A major problem, however, is the composition of this projected year 2000 domestic supply - 81 percent millet, 7 percent maize, 12 percent rice. In comparison, the 1976 per capita consumption was comprised of 62 percent millet, 6 percent maize, and 32 percent rice. A per capita consumption decrease from 51 kg to 18 kg of rice would be needed to equilibrate the original demand with the projected supply in the year 2000. Since per capita rice consumption has actually been increasing, such a sharp decrease is most unlikely without a sharply increased rice price. This topic will be explored more fully in the following chapter.

It should be emphasized that even with this postulated, sustained 3 percent annual growth in yields, domestic per capita grain production would barely provide sufficient grain to meet assumed nutritional requirements by 2000. Further, the composition of that domestic supply would require a marked change in the grain consumption patterns of the Senegalese population.

Finally, scenario 4 uses government planned growth rates for surface and yields. As shown in Table XIV, such projections, made for the 1976-1981 Five Year Plan, are considerably more ambitious than those postulated in scenaria 1 - 3. While the requisite programs and projects to achieve

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[19] The 3.08 growth represents the compounded and combined effects of surface and yield increases.

such growth rates are referenced in the Five Year Plan, it is highly unlikely that such striking results could be achieved. Nevertheless, scenario 4 presents the projected 1980-81 domestic grain supply using these growth rates.[20] By 1981 the per capita domestic supply of all grains is estimated at 161 kg/capita, slightly in excess of the 158 kg/capita initial demand. Again, however, the incompatability between the composition of demand and supply must be examined. Per capita rice production would be 26 kg/capita compared to a current consumption estimated at 51 kg/capita. Thus, there are two major problems with these government projections: (1) their feasibility and (2) the unacceptable composition of this grain supply.

This section has given some simplistic projections of per capita grain supply; the assumptions for yield per hectare and surface growth differentiate the various supply scenaria. In summary this chapter has derived the initial demand and supply functions for this model and evaluated the sensitivity of these functions to their various independent influences. Chapter IV will compare demand and supply projections under a variety of these assumptions. The resulting grain imbalances with their implied imports and/or surpluses will be noted.

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[20] This exercise was done only until 1980-81, the time frame of the Plan. Continuing with such annual growth rates until 1985 provides production estimates well beyond Senegalese capabilities or needs.

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Table XVII-B - Grain Demand, Supply, and Balance

Year 1985 Population 6,423,900

	Demand	Supply S-1	Supply S-2	Supply S-3	Balance[c,d] - Demand With S-1	Balance[c,d] - Demand With S-2	Balance[c,d] - Demand With S-3
Millet							
National[a]	630.4	517	618	675	-113.4	-12.4	+44.6
Per Capita[b]	98.1	80.5	96.2	105.1	-17.7	-1.9	+6.9
Rice							
National	338.7	70	84	91	-268.7	-254.7	-247.7
Per Capita	52.7	10.9	13.1	14.2	-41.8	-39.7	-38.6
Maize							
National	47.0	42	51	56	-5	+4	+9
Per Capita	7.3	6.5	7.9	8.7	- .8	+ .6	+1.4
Total							
National	1016.1	629	753	822	-387.1	-263.1	-194.1
Per Capita	158.1	97.9	117.2	128	-60.3	-41.0	- 30.2

[a] 000's tons/year

[b] kg/year

[c] (-) deficit, (+) surplus

[d] possible rounding error

Table XVII- C - Grain Demand, Supply, and Balance

Year 1990 Population 7,325,200

	Demand	Supply S-1	Supply S-2	Supply S-3	Balance[c,d] - Demand With S-1	Balance[c,d] - Demand With S-2	Balance[c,d] - Demand With S-3
Millet							
National[a]	714.4	545	719	824	-169.4	+4.6	+109.6
Per Capita[b]	97.5	74.4	98.2	112.5	-23.1	+ .7	+15.0
Rice							
National	391.8	74	98	112	-317.8	-293.8	-279.8
Per Capita	53.5	10.1	13.4	15.3	-43.4	- 40.1	-38.2
Maize							
National	53	46	61	70	-7	+8	+ 17
Per Capita	7.2	6.3	8.3	9.6	- .9	+1.1	+2.3
Total							
National	1159.2	665	878	1006	-494.2	-281.2	-153.2
Per Capita	158.2	90.8	119.9	137.4	- 67.4	-38.3	- 20.9

[a] 000's tons/year

[b] kg/year

[c] (-) deficit, (+) surplus

[d] possible rounding error

Table XVII-D - Grain Demand, Supply, and Balance

Year 2000 Population 9,660.1

	Demand	Supply S-1	Supply S-2	Supply S-3	Balance[c,d] - Demand With S-1	Balance[c,d] - Demand With S-2	Balance[c,d] - Demand With S-3
Millet							
National[a]	931.3	605	972	1229	-326.3	+40.7	+297.7
Per Capita[b]	96.4	62.6	100.6	127.2	-33.8	+4.2	+30.8
Rice							
National	531.1	84	133	169	-447.1	-398.1	-362.1
Per Capita	55.0	8.7	13.8	17.5	-46.3	-41.2	-37.5
Maize							
National	68.3	53	86	108	-15.3	+17.7	+39.7
Per Capita	7.1	5.5	8.9	11.2	- 1.6	+ 1.8	+ 4.1
Total							
National	1530.7	742	1191	1506	-788.7	-339.7	-24.7
Per Capita	158.5	76.8	123.3	155.9	-81.7	-35.2	- 2.6

[a] 000's tons/year

[b] kg/year

[c] (-) deficit, (+) surplus

[d] possible rounding error

A. 1980

By way of comparison, the 1980 grain balance shown in Table XVII-A indicates that the grain deficit could become more severe. Using S-1 and S-2, with a 0 and 2 percent annual change in yields per hectare respectively, both the rice and total grain deficit increases. Moreover there would be a need to import millet to equilibrate domestic millet demand and supply. With S-3 and the associated 3 percent annual growth in yields the total deficit falls to 221,800 tons or 39 kg per capita. Nevertheless, even with S-3 the rice deficit continues to be substantial, 219,800 tons.

The government targets for domestic production are sufficient to eliminate the grain deficit by 1980; in fact a small surplus of 18,200 tons could conceivably be generated. Two major qualifications must be addressed. First, the 12.8 percent annual growth of grain production implied by the government targets is unduly optimistic. The major supporting programs needed for such annual growth are neither organized nor funded. While existing efforts at rural development should succeed in increasing production, a more modest annual growth of 2 or 3 percent (S-2 or S-3) would seem appropriate. It is inconceivable to expect the rapid growth projected by the government in such a short time period.

Second, even if the government targets were reached, serious imbalances in the composition of grain production would result. Using current grain prices the per capita demands for millet and maize would be greatly below the corresponding per capita supplies. In contrast, per capita rice demand (52 kg) would be greatly superior to per capita production (17.3 kg). An excess per capita rice demand of 34.7 kg would presumably exist. Since these three grains are not perfect substitutes, the government would have to initiate some taxing/subsidy scheme to change relative grain prices so that particular grain demands and supplies could be equilibrated. Failing to do that, millet and maize prices would fall dramatically and the rice price would increase drastically. It is highly unlikely however, that farmers would produce the quantities of millet and maize envisioned by the government if producer prices for these grains fell so sharply. With groundnut cultivation as a more profitable alternative, it is even questionable if farmers would produce the projected quantities of millet

and maize at current prices.

Specifically, using the grain demand equations it is possible to solve for those consumer grain prices which equilibrate national demand and the projected government supply. For the Cap Vert area the generated consumer prices are 32.55 CFA/kg (current price 60 CFA/kg) for millet, 123.19 CFA/kg (current price 80 CFA/kg) for rice, and - 82.86 CFA/kg (current price 60 CFA/kg) for maize.[21] In brief, to induce an annual per capita millet consumption of 118.3 kg the millet price in region 1 would have to fall from 60 CFA/kg to 32.55 CFA/kg. This would imply a producer price of 5-10 CFA/kg, much too low to generate any millet production destined for sale. Another possibility would be for the government to subsidize millet production; however, the subsidy expense would be at least (60-32.55 CFA/kg) x (1000 kg/ton) x (167,250 tons) or $21,353,547 at 215 CFA/$. For this exercise only 25 percent of the 669,000 ton millet crop is assumed marketed.

Additionally, to reduce per capita rice consumption to 17.3 kg from the projected 52.0 kg, the consumer rice price must rise 54 percent from 80 CFA/kg to 123.19 CFA/kg. Again, the government would be faced with a difficult problem. The equity effects of this pricing decision, implemented by tax or tariff, would be unfavorable to low income urban consumers who currently depend on rice for a major share of their daily grain intake.[22] To induce the projected 25.6 kg per capita maize consumption, the system of grain demand equations indicates a negative price. While such a price has little economic significance, it demonstrates the relatively inflexible maize demand which currently exists in Senegal.

The conclusion of this discussion is that a very distorting and expensive price policy would be needed to encourage consumers to adopt the per capita consumption levels associated with the government's grain supply targets. Also, it should not be forgotten that these supply targets themselves are unrealistically high.

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[21] Regional price differentials for each grain are those indicated in Table IV; i.e. intermediate marketing expenses and margins were assumed unchanged.

[22] Of course, imports could be permitted and the equilibrium rice price would fall in relation to the magnitude of these imports. The government supply targets, with 161.3 kg of total grain consumption, however, assumed self-sufficiency, i.e. no imports.

B. 1985

For 1985 only the three supply scenaria with autonomous yield growth of 0, 2, and 3 percent are shown. The government planned targets with their 12.8 percent annual growth in total grain production are not continued beyond 1981. With respect to 1980, S-3 represents an improvement on a per capita basis. The annual grain deficit would fall from 39.2 kg to 30.2 kg per capita with S-3. Slight surpluses in millet and maize would compensate for a continually substantial rice deficit in S-3. With S-1, population growth exceeds the growth of grain production and the annual per capita deficit is 60.3 kg. With S-2, growth in domestic grain production slightly exceeds the growth of population.

C. 1990 and 2000

While projections into 1990 and 2000 are rather risky, this analysis indicates that with S-3 the per capita deficit could fall to 20.9 kg in 1990 and 2.6 kg in 2000. The two criticisms directed against the 1980 government projections are relevant to this case. First, achieving near food self-sufficiency in 2000 (2.6 kg per capita deficit) requires annual yield growth of 3 percent for 24 years; i.e. 2000 yields must increase by 103 percent from those of 1976. It is not clear that such continual increases are possible in light of the potential land degradation from the intensive use of agricultural lands projected for Senegal. Second, the composition of the domestic grain supply will differ greatly from the composition of domestic demand. In principle, millet and maize surpluses would roughly compensate for rice deficits. As shown in the previous section, unless a price policy with subsidies and/or taxes were used, the projected millet and maize production will not be forthcoming, since the producer prices for these grains would fall to very low levels.

With S-1 both the per capita and the total grain deficit will increase substantially reaching 81.7 kg and 788,700 tons by 2000. With S-2 some reduction in the per capita deficit is projected between 1990 and 2000 but the total grain deficit would increase from 281,200 tons to 339,700 tons.

D. Summary

Certain points warrant review. First, without any improvement in domestic production, as in the case of S-1, locally grown grains would account for only 48 percent of projected 2000 demand, as compared to 71 percent in 1976. Second, even with a continual 2 percent annual growth in yields per hectare, as premised in S-2, the per capita domestic production only increases from 112 kg (1976) to 123 kg in 2000. Because of population growth, the magnitude of the national deficit increases. Third, annual yield growth of 3 percent is required to achieve local grain production in the year 2000 that is roughly of the same magnitude as projected demand. Such sustained growth will require major commitment of funds and efforts to the rural sector. Finally, the composition of grain demand, a substantial portion of which is rice, will not be well harmonized with the projected composition of domestic supply. Large millet and maize surpluses and rice deficits will result.

As previously discussed a distorting subsidy/tax policy will be required to equilibrate the individual grain demands and supplies.

The succeeding section of this chapter will examine the sensitivity of the derived grain balances to the underlying demand parameters. In Chapter V various strategies to assure adequate grain supplies for Senegal will be discussed.

Section 2 - Sensitivity of Grain Balances to Demand Assumptions

In this section the sensitivity of the derived grain balances to changes in the demand parameters will be assessed.

A. Income

Using those income elasticities posited in Table III, the per capita and national grain demands were re-estimated on the assumption that the 1990 per capita income would be 10 percent higher than that of 1976. These estimated demands were shown in Table X; the corresponding grain balances for these estimates are now shown in Table XVIII.[23]

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[23] Only those balances associated with S-1 (0 percent change in yields) and S-3 (3 percent annual change in yields) are shown. Balances for S-2 would lie between those projected for S-1 and S-3.

As expected, the increased grain demands associated with a higher income level imply large projected grain deficits. In fact, with S-1 only 47 percent (80.5/171.5 kg - See Table X) of projected grain consumption would be satisfied by local production.

This discussion demonstrates a fundamental problem which the Senegalese government must face. Increasing incomes is a stated policy goal as well as increasing food self-sufficiency. Yet, even with a modest rise in income (10 percent) and relatively low income elasticities (Table III) the increase in the grain deficit is quite substantial. This results because every kg of additional demand represents an additional kg of grain deficit. For instance, the projected rice deficits increase by 35,800 or by 11 and

Table XVIII 1990 Grain Balances With Income Increase

	Original (Table XVII)		10% Income Increase	
	S-1	S-3	S-1	S-3
Millet				
National (000 tons)	-169.4	+109.6	-226.2	+52.8
Per Capita (kg)	-23.1	+15.0	-30.8	+7.2
Rice				
National	-317.8	-279.8	-353.6	-315.6
Per Capita	-43.4	-38.2	-48.2	-43.1
Maize				
National	-7	+17	-11.3	+12.7
Per Capita	-.9	+2.3	-1.5	+1.7
Total Grain				
National	-494.2	-153.2	-591.1	-250.1
Per Capita	-67.4	-20.9	-80.5	-34.2

13 percent under S-1 and S-3 respectively. This itself represents an additional $7.16 million of grain imports. Thus, in designing grain policy the government must be aware of potential grain demand increases stimulated by other policy actions aimed at raising rural and urban incomes.

B. Price Elasticity

In Chapter III the sensitivity of the per capita demand estimates to a 10 percent increase in the assumed own price elasticities was assessed.[24] These recalculated demands are now used with S-1 and S-3 to generate grain balances under the assumption of a greater sensitivity of grain demands to own price. Table XIX presents these results for 1990.

Table XIX - 1990 Grain Balances With Higher Own Price Elasticity

	Original (Table XVII)		10% Elasticity Increase	
	S-1	S-3	S-1	S-3
Millet				
National (000 tons)	-169.4	+109.6	-124.9	+154.1
Per Capita (kg)	-23.1	+15.0	-17.1	+21.0
Rice				
National	-317.8	-279.8	-282.5	-244.5
Per Capita	-43.4	-38.2	-38.6	-33.4
Maize				
National	-7	+17	-3.7	+20.3
Per Capita	-.9	+2.3	.5	+2.8
Total				
National	-494.2	-153.2	-411.1	-70.1
Per Capita	-67.4	-20.9	-56.2	-9.6

[24] Since the own price elasticites used in the original demand equations were not all derived from budget studies, it was deemed important to assess the sensitivity of the demand estimate to these elasticities.

If in fact the true own price elasticities are higher than those used in the original model, the projected national grain deficit in 1990 would be less than originally estimated. Nevertheless, the rice deficit continues to be substantial still above 244,000 tons under the most optimistic supply assumption (S-3). Total local grain production under S-3 combined with these decreased demands would satisfy about 93 percent of total grain demand. The problems previously discussed -- (1) the necessity for a compensating price policy to encourage millet and maize consumption and (2) the imbalance between supply and demand for rice -- would have to be confronted with government action before this could be considered a realistic scenario.

While this particular exercise has shown that the actual grain balance is sensitive to the own price elasticity estimate, the two fundamental conclusions emanating from the original derivation of the grain balances are still valid. First, without impressive and sustained growth in the agricultural sector -- with growth in grain production at least surpassing the 2.68 percent annual increase in population -- the total Senegalese grain deficit will continue to increase. Only the ambitious growth assumed in S-3 leads the country towards a domestic grain production sufficient to cover national needs. Second, all combinations of demand and supply indicate a serious and chronic rice deficit. For example, under S-1 and a lower own price elasticity, that rice deficit is projected at 317,800 tons in 1990; under a very optimistic set of assumptions -- S-3 and higher own price elasticities -- the national rice deficit would be 244,500 tons in 1990. Thus, even considering the most pessimistic and most optimistic set of assumptions, a continually increasing rice deficit is projected.

C. Grain Price Level

When all grain prices were raised 10 percent the per capita total grain demand changed by less than one percent. The composition of this new demand was slightly altered, a little more maize (+.3 percent) and less millet (-2.5 percent) and less rice (-.8 percent).

The reason for this relative insensitivity of total grain demand to the grain price level is found in the nature of the demand equations.

Since each particular grain demand is a function of all grain prices, cross-price responses would tend to raise the demand for each grain as other grain prices were increased. This gain, of course, is offset to varying degrees by the decrease in demand from an increase in the own price of the grain.

Consequently, since the resulting grain balances would be little changed from those shown in Section 1 of this chapter, they are not repeated here. The main conclusion is that proportionately changing the price of all grains will do little to affect grain demand and the resulting grain balances. As will be discussed in Chapter V, changing relative grain prices is a more effective, and perhaps necessary, action to equilibrate individual grain demands and supplies.

D. Summary

Section 2 has shown that the main conclusions concerning grain balances derived from Section 1 of this chapter are still relevant when changing demand conditions are assumed. Substantial grain deficits, except in the year 2000 with S-3, will plague Senegal under all combinations of demand and supply considered. The annual rice deficit will continue to be substantial even under those conditions where the total grain deficit is mitigated. In those cases, millet and maize surpluses are present and some policy action to restructure demand will be necessary.

With rising incomes all deficits are proportionately increased. Since raising personal incomes is also a policy goal of the Senegalese, this effect should be considered in any policy proposal. A change in the own price elasticity, such that demands are more sensitive to own grain prices, somewhat reduces the total grain deficit. Annual per capita consumption of grains, however, falls from 158 to 147 kg. Also, the rice deficit continues to exceed 244,000 tons in 1990. This section has shown that the fundamental imbalances in Senegalese grain consumption are relatively invariant to reasonable changes in the demand assumptions.

CHAPTER V - TOWARDS A GRAIN POLICY FOR SENEGAL

This chapter will discuss the principal grain policy options available to the Government of Senegal. Each option will be evaluated in the context of the grain balances derived in Chapter IV. The first section considers a continuation of current trends - a continual grain deficit with substantial imports of rice. Section 2 analyzes the possibility of using price policy to equilibrate demand with domestic supply. Finally, in section 3, major supply initiatives, like the construction of irrigation dams, will be considered.

Section 1 - A Continuation of Grain Imports

As discussed in earlier chapters, a possible means for Senegal to insure adequate grain supplies would be through a continuation of rice imports. Such a strategy, however, would be at variance with Senegal's professed goal of food self-sufficiency. Nevertheless, this strategy is explored here for a number of reasons. First, at a foreseeable range of current world prices for groundnuts and rice, Senegal has a static comparative advantage in groundnut production. Resulting imports of rice would be financed from groundnut export earnings.[25] Second, without a restructuring of domestic agricultural prices and/or major supply initiatives (construction of large irrigation facilities) continued rice imports are inevitable, as shown by the various supply-demand projections in Chapters III and IV. Finally, policymakers can benefit from this projection of the current situation, providing a reference to which other strategies can be compared. For these reasons, an evaluation of continued rice imports is necessary.

For this exercise the initial regional supply parameters - surface, yields per hectare, and production - shown in Table VII of Chapter III are used. For ensuing years changes in surface and per hectare yields are those shown in Table XIV. Finally, in Table XV the resulting domestic production for key years - 1976, 1980, 1985, 1990, and 2000 is shown. These production estimates are considered as domestic supply for the indicated year and used with domestic demand estimates to provide the projected grain balances.

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[25] Jabara, Cathy, "Agricultural Comparative Advantage Under Uncertainty, The Case of Senegal" Unpublished Ph.D. Thesis, Purdue University, May 1979.

Of the four supply scenaria depicted in Table XV the first three are premised on no relative change in the allocation of land and labor among the principal crops. These scenaria are differentiated by varying annual growth rates for yields per hectare (0, 2, 3 percent/annum). Scenario 4, based on Senegal's enunciated National Development Plan, foresees a relative reallocation of production resources from groundnuts to domestic grain crops. In the absence of an effective price policy, it is unclear how the proposed reallocation of resources would be achieved. Also, the government projections are based on yield increases averaging 10 percent/annum for the grain crops. Again, without major commitments of resources and funding, it is unlikely that such yield increases can be achieved.

The national grain demands used in this exercise are those shown in Table IX of Chapter III. They assume a continuation of the current regional per capita ration of grain. In 1976 the national mean was 158 kg/capita, of which 99 kg was millet, 8 kg was maize, and 51 kg was rice. Increased grain demand is solely a function of population growth in this calculation. These are the demand estimates used to calculate the grain balances in section 1 of Chapter IV. (See Tables XVII A - D).

Projected balance of trade accounts using the previously mentioned grain balances are now presented in Table XX.

As Table XX indicates the base year trade surplus of $396,710 is increased under all supply-demand scenaria. Even though required rice imports increase steadily, the growing cost of these imports is more than offset by augmented groundnut production and export receipts. Thus, it is again appropriate to question the wisdom in deviating from a strategy of comparative advantage to one of grain self-sufficiency. Certain qualifications to this analysis do indicate, however, possible reasons for increased domestic production of grains.[26]

(1) The world prices used in this analysis are subject to fluctuation, particularly adverse ones to Senegal. While the argument of world price risk has economic validity, within a foreseeable range of world prices (groundnuts $350 - 650/ton and rice $150 - 350/ton) the strategy of ex-

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[26] An excellent discussion of this issue can be found in Jabara, Cathy, op. cit.

Table XX - Balance of Trade[a]

(000 tons, 000$)

		Groundnuts	Millet	Rice	Maize	Total
1976	tons	+882	-36.25	-200.1	+.634	-
	$	+441,000	-4,350	-40,020	80	+396,710
1980 S-1	tons	+955	-67.2	-227.8	-1.8	-
	$	+477,500	-8,060	-45,560	-200	+423,680
S-2	tons	+1,033	-26.2	-222.8	+1.2	-
	$	+516,500	-3,140	-44,560	+160	+468,960
S-3	tons	+1,075	-5.2	-219.8	+3.2	-
	$	+537,500	-620	-43,960	+420	+493,340
S-4[b]	tons	+1,019	+110.8	-195.8	+103.2	-
	$	+509,500	+13,296	-39,416	+13,416	+497,052
1990 S-1	tons	+1,164	-169.4	-317.8	-7	-
	$	+582,000	-20,300	-63,560	-910	+497,230
S-2	tons	+1,535	+4.6	-293.8	+8	-
	$	+767,500	+550	-58,760	+1,040	+710,330
S-3	tons	+1,760	+109.6	-279.8	+17	-
	$	+880,000	+13,150	-55,960	+2,200	+839,390
2000 S-1	tons	+1,418	-326.3	-447.1	-15.3	-
	$	+709,000	-39,200	-89,400	-1,990	+578,410
S-2	tons	+2,280	+40.7	-398.1	+17.7	-
	$	+1,140,000	+4,880	-79,620	+2,300	+1,067,560
S-3	tons	+2,882	+297.7	-362.1	+39.7	-
	$	+1,441,000	+35,700	-72,420	+5,160	+1,409,440

[a] (1) World Prices/Ton:
Groundnuts - $500
Millet - $120
Rice - $200
Maize - $130
(2) (+) export, (-) import

[b] Government planned projections are only for 1980.

changing groundnuts for rice on the world market is still economically advantageous.

(2) The assumption that 90 percent of the groundnut crop is exported is unrealistic. Considering local groundnut consumption, 90 percent of the recorded crop is not available for export. However, in assessing the potential or economic value of the groundnut crop, the 90 percent estimate is justifiable. Second, a large portion of the groundnut crop is transformed to groundnut oil and exported at a value exceeding the $500/ton for unprocessed groundnuts used in this calculation. Thus, the projected groundnut export receipts are not grossly overestimated.

(3) The import requirements for various crops have not been considered in the calculation. Currently, fertilizer, theoretically needed for all crops, is the major import for the agricultural sector. It could be argued that the import requirements for increased domestic rice and grain crops would exceed their analogues in groundnut production. This is particularly true if large scale irrigation projects, with heavy capital requirements, are introduced.

(4) The analysis has assumed that an export market for the millet and maize surpluses projected in S-2 and S-3 exists. Two of Senegal's neighbors, The Gambia and Mauritania, have chronic food deficits and would probably be willing to import surplus Senegalese grains. Also, the relatively small surpluses with S-2 may be eliminated by market induced declines in the consumer millet and maize prices. It is unlikely, however, that the projected surpluses in S-3 can be eliminated by declines in consumer prices. The requisite consumer millet and maize prices to equilibrate supply and domestic demand would imply a producer price too low to stimulate the projected production. Thus, without export markets for millet and maize their production would decline as resources were transferred into groundnuts. This would actually increase the projected trade surplus as the higher value groundnut crop would be expanded.[27]

Even with the above qualifications a continued emphasis on groundnut production with the resulting rice imports appears to be advantageous to

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[27] In fact, at current producer prices it is unlikely that any maize or millet surplus would exist as producers would quickly respond, within one agricultural season, and produce additional groundnuts.

Senegal. Under all supply scenaria tested, potential groundnut export earnings greatly exceed the expense associated with continued rice imports. A second advantage to continued rice imports is that consumer preferences, with their strong attachment to rice, can be satisfied. The strategy of food self-sufficiency with a heavy reliance on increased millet and maize production implies a major change in consumer grain consumption. Without a distorting and expensive governmental price policy, a shift in the composition of consumer grain consumption will not be forthcoming.

Having assessed the macro-economic effects from a continuation of rice imports as a means to insure adequate grain supplies, the use of price policy to shift grain demand from rice to millet and maize will now be considered.

Section 2 - Price Policy

The section assesses the potential to use price policy to shift national grain consumption from rice to increased millet and maize consumption. Domestic production of millet and maize can be more easily and less expensively increased than domestic rice production. Increased consumer acceptance of millet and maize must accompany the supply increases of these grains. A possible way to stimulate millet and maize consumption would be a price policy lowering the consumer prices for these grains and raising the consumer rice price. Examples of such price policies will be evaluated in this section.

In Table XI of Chapter III per capita grain demands associated with four sets of relative grain prices were derived. Price combination 1 represented the existing relative prices for grains and the per capita demands were those used in the reference year calculations shown throughout this study. Price combinations 2, 3, and 4 were simplistically described as (2) lowering the millet price, (3) raising the rice price, and (4) simultaneously raising the rice and lowering the millet prices. The actual prices used in the exercise, as well as the associated regional per capita grain demands, are shown in Table XI.

Table XXI presents estimates of 1990 national grain demand, the per capita equivalents, and the projected grain balances using both S-1 (no change in per hectare yields) and S-3 (annual growth of 3 percent from 1976 base yields). The regional grain prices are also shown with each

Table XXI - Effects of Price Policy

Grain	Price Comb. 1			Price Comb. 2			Price Comb. 3			Price Comb. 4		
	PC (kg)	ND (000 tons)	Balance (000 tons)	PC	ND	Balance	PC	ND	Balance	PC	ND	Balance
Consumption With S-1												
Millet	99	714.4	-169.4	113	814.9	-269.9	106	767.6	-222.6	101	725.6	-180.6
Rice	51	391.8	-317.8	50	383.2	-309.2	39	293.1	-219.1	42	315.1	-241.1
Maize	8	53.0	-7.0	7	50.6	-4.6	10	70.1	-24.1	9	60.6	-14.6
Total	158	1159.2	-494.2	170	1248.7	-583.7	155	1130.8	-465.8	152	1101.3	-436.3
With S-3												
Millet	99	714.4	+109.6	113	814.9	+9.1	106	767.6	+56.4	101	725.6	+98.4
Rice	51	391.8	-279.8	50	383.2	-271.2	39	293.1	-181.1	42	315.1	-203.1
Maize	8	53.0	+17.0	7	50.6	+19.4	10	70.1	-.1	9	60.6	+9.4
Total	158	1159.2	-153.2	170	1248.7	-242.7	155	1130.8	-124.8	152	1101.3	-95.3

Grain Prices (CFA/kg)	Reg 1	Reg 2	Reg 3	Reg 4	Reg 1	Reg 2	Reg 3	Reg 4	Reg 1	Reg 2	Reg 3	Reg 4	Reg 1	Reg 2	Reg 3	Reg 4
Millet	60	40	40	40	50	30	30	30	50	40	40	40	80	40	35	35
Rice	80	85	90	90	80	85	90	90	120	100	110	110	120	100	95	95
Maize	60	40	40	40	60	40	30	30	60	40	40	40	80	30	40	40
Description:	1976 Prices				Lowering Millet Price				Raising Rice Price				Raising Rice Price Lowering Millet Price			

Where PC = per capita consumption

ND = national demand

price combination.

With price combination 2, a lowering of the millet price to encourage millet consumption, the total national grain deficit is actually increased.[28] The weak substitutability assumed between millet and the other grains accounts for the increased grain deficit. Lowering the price of millet, by the magnitudes in price combination 2, leads to an annual per capita consumption of 113 kg, an increase of 14 kg from the base level in price combination 1. Only a slight decrease in the consumption of rice (-1 kg) and maize (-1 kg) was observed. As a result the per capita annual grain consumption increased from 158 to 170 kg. The important point to this exercise is that simply lowering the millet price will not lead to increased food self-sufficiency for Senegal. The chronic rice deficit will only be slightly affected by the decreased millet price. This is reasonable since a large portion of rice (perhaps as much as 80 percent) is consumed at mid-day when millet, because of its heaviness, is rarely consumed.[29]

Price combination 3 primarily involves an increase in the regional rice prices. The mean national rice price would be increased by 27 percent to 110 CFA/kg. As a result annual per capita rice consumption falls 24 percent from a national mean of 51 kg to 39 kg. Required rice imports fall from a projected 317,800 tons to 219,100 tons. Per capita grain consumption only falls from 158 kg to 155 kg per year, since millet consumption is stimulated from 99 kg to 106 kg. Assuming the most optimistic supply scenario, that of a 3 percent annual growth in per hectare yields, the national 1990 grain deficit is only 124,800 tons. Thus, a price policy sharply raising the consumer price of rice would succeed in greatly limiting rice imports. Further, if accompanying millet production programs succeed, the additional millet consumption can be supported from domestic production. In conclusion, such a combination of price policy and production programs could promote food grain self-sufficiency in Senegal.

It must be mentioned, however, that certain costs and equity effects would be associated with the above strategy. First, urban consumers who

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[28] In regions 3 and 4 the maize price was also lowered.

[29] See: Ross, Clark, "Grain Demand and Consumer Preferences, Dakar, Senegal", CRED, Discussion Paper #80, University of Michigan, June 1979.

rely on rice for 60-65 percent of their grain requirements, would be required to pay 50 percent more for rice. A large proportion of these people can be classified as urban poor and/or unemployed. This distributional effect of the strategy cannot be ignored. Further the middle class, many of whom are civil servants, would strongly resist any significant increase in the rice price. Of course, it is possible that revenues raised through the import duty or sales tax required to increase consumer prices could offset the adverse distributional affects mentioned above.

The rural producer would also be affected by this strategy. First, he would be required to pay an additional premium for rice which he purchases. Second, with the significant increases in millet yields envisioned in the strategy, the producer may simply reallocate land and labor from millet to the more profitable groundnuts. In this case, however, millet demand, stimulated by the increased rice price, could pressure upward the millet producer price and mitigate the desire to reallocate resources from millet.

In conclusion a strategy centered around price combination 3 could serve to advance food self-sufficiency for Senegal. The costs and distributional effects of this strategy, as well as the political feasibility of the strategy, must be carefully considered.

Price combination 4 sharply raises rice prices but lowers the millet price in regions 3 and 4 in recognition of the lower than mean per capita grain consumption currently observed in those regions. Millet and maize prices were raised in region 1. The result in region 1 is a dramatic fall in annual per capita grain consumption from 165 kg to 123 kg. Without the introduction of supplementary food products - fish, vegetables, meats- such a low level of grain consumption would lead to serious problems of malnutrition in the Dakar, region 1, area. Nationally the projected rice deficit in 1990 would be 203,000 tons using supply scenario 3. The total grain deficit would only be 95,300 tons since exportable millet and maize surpluses would exist. While this strategy undoubtedly advances the goal of Senegalese grain self-sufficiency, the adverse equity and efficiency consequences associated with price policy 3, discussed above, would still exist. Further, the strategy is premised on a sharp decline in the level of grain consumption by residents of the urbanized Cap Vert area. It is

unlikely that such a decline could be achieved without seriously jeopardizing the nutritional status of the Dakar population.

In summary this section has shown that price policy can advance food self-sufficiency. A policy of sharply raising rice prices could achieve meaningful reductions in rice consumption. With unchanged millet prices, overall nutritional intake would not be seriously affected. Lowering the millet price is not an effective stimulus to millet consumption if the rice price is left at its current level. Further, a decreased consumer millet price, without costly producer subsidies, would lower the producer price to the point where millet production is not attractive. Finally with the policy of raising rice prices the adverse distributional effects must be considered and some remedies introduced.

Section 3 - Major Supply Initiatives

Up to this point the discussion of grain supplies and the resulting grain balances have been premised on a continuation of current rain-fed agricultural practices. While an upgrading of rain-fed agriculture, to include greater use of animal traction, improved cultivation practices, and ameliorated seeds, is envisioned, no basic change in the structure of small scale compound-oriented agriculture has been assumed.

The government of Senegal has incorporated into its short and long term plans the development of irrigated facilities for rice and maize. Such projects would include both small scale water management schemes along rivers, tributaries, and tidal pools, as well as, the construction of large scale capital structures (generally barrages) for irrigation along the Senegal, Gambia, and Casamance rivers. The supply scenario 3 with its ambitious 3 percent annual growth in yields per hectare has implicitly incorporated some of the effects of the smaller scale projects in its growth assumption. Since some of the land surface on which the small scale developments would be implemented is now under cultivation, an increase in per hectare yields would be attributed to the introduction of small scale water management and control techniques. The larger capital projects and the development of new lands with small-scale perimeter projects have not been considered in the course of this exercise. Having examined the projected supply-demand grain balance under a variety of supply and demand

scenaria, it is now appropriate to consider these planned projects and to assess their potential effects on the grain balances.

Table XXII identifies the planned water management projects for each of the three Senegalese river basins. Hectarage under cultivation and estimated production for 1990 and 2000 have been projected.

In using Table XXII certain cautions must be given. First, the planning documents from which these estimated hectarages and production have been taken generally have made projections only through 1981. In particular, for the Casamance and the Senegal Basins the 1990 projections are essentially those of 1981. This is acceptable since most of these projects have a terminal hectarage corresponding to that given for 1981 in the planning documents. Yields per hectare for 1990 and 2000, however, could be underestimated since improvement in yields from the estimated 1981 level could be expected by 1990 and 2000. Second, this listing of projects is not exhaustive; other projects for the river basins either have been discussed or pre-feasibility activity undertaken. Third, the estimated hectarages for many projects have not been verified by appropriate soil and hydrological suitability studies; thus the estimates are subject to considerable variance. Finally, when adding the projected production from these projects to the estimated production from rainfed agriculture, represented in the three previously discussed supply scenaria, no attempt has been made to net out production which might be lost as resources, particularly labor, are transferred from rainfed to irrigated cultivation. With Senegal's rapidly growing population, however, it is possible that water managed projects can be introduced with no diminution in the rainfed production projected for a given year. Nevertheless, these projections provide a reasonable indication of the possible effects from the principal water management projects.

Part A of Table XXIII shows that projected 1990 supplies of rice and of all grains with no water management projects assumed and with all water management projects of Table XXII included. All three supply scenario for rainfed agriculture are shown in this table. Part B summarizes 1990 projected grain and rice demand using (a) a continuation of current demand trends, (b) a 10 percent projected increase in per capita income, and (c) price policy 3 which sharply raises rice prices. Finally, in part C of

Table XXII - Major Water Management Projects

River Basin Project	Surface 1990(000hs)		Production 1990(000tons)		Surface 2000		Production 2000		Yields Per Hectare[c] (tons/year)	
	Maize	Rice	Maize	Rice	Maize	Rice	Maize	Rice	Maize	Rice
Gambia[a]										
Kekreti[b]	4.4	13.1	22	65.5	7.2	21.8	36	109	5	5
Niokolo Koba	1.5	4.5	7.5	22.5	3.0	9.0	15	45	5	5
Total	5.9	17.6	29.5	88.0	10.2	30.8	51	154	5	5
Casamance[d]										
Nyassia-Guidel		7.6		19.0		7.6		19.0		2.5
Bignona		7.9		19.8		7.9		19.8		2.5
Soungrougrou		1.1		2.8		1.1		2.8		2.5
Baik-Kamobeul		16.0		40.0		16.0		40.0		2.5
Total		32.6		81.6		32.6		81.6		2.5
Senegal[e]										
Dagana		3.2		8.0		3.2		8.0		2.5
Bilor		2.5		6.3		2.5		6.3		2.5
Dieba		2.0		5.0		2.0		5.0		2.5
Diama		20.0		100.0		30.0		150.0		5.0
Total		27.7		119.3		37.7		169.3		4.5
Total All Basins	5.9	77.9	29.5	288.9	10.2	101.1	51	404.9	5	3.7-4.0

[a] See: Development of the Gambia River Basin, Multidisciplinary Multidonor Mission, Draft Final Report.

[b] A barrage built at Sambangalou could provide equivalent hectarage for irrigated cultivation.

[c] Yield per hectare per year is equal to Annual Cropping Rate x Yield/Crop/HA.

[d] See: V[e] Plan Quadriennal de Developpement Economique et Social 1977-1981; Agriculture, p. 66.

[e] See: Cinquieme Plan Quadriennal de Developpement Economique et Social (Senegal) pp. 87-110.

Table XXIII - 1990 Grain Balances with Water Management

A. 1990 - Supply (000 tons)

	No Water Management[a]			With Water Management[b]		
	S-1	S-2	S-3	S-11	S-21	S-31
Rice	74	98	112	243.0	267.0	281.0
All Grains	665	878	1006	850.6	1063.6	1191.6

B. 1990 - Demand - (From Chapter III) (000 tons)

	Projected Demand (D1)	Income + 10% (D2)	Price Comb.3 (D3)
Rice	391.8	427.6	293.1
All Grains	1159.2	1256.1	1130.8

C. 1990 Grain Balance With Water Management (000 tons)

	S-11 D-1	S-11 D-2	S-11 D-3	S-21 D-1	S-21 S-2	S-21 D-3	S-31 D-1	S-31 D-2	S-31 D-3
Rice	-148.8	-184.6	-50.1	-124.8	-160.6	-26.1	-110.8	-160.6	-12.1
All Grains	-308.6	-405.5	-280.2	-95.6	-192.5	-67.2	+32.4	-64.5	+60.8

[a] These three supply scenaria represent a 0, 2, and 3 per cent growth in yields per hectare, respectively, from the 1976 base year levels. See: Chapter III.

[b] For both the maize and rice production shown in Table XXII a 10 per cent post harvest loss factor has been assumed; a 65 per cent rate of transformation for paddy to clean rice has been used.

the table projected rice and grain balances are calculated for various supply and demand combinations.

Of importance is that even with the water management projects the estimated 1990 consumer rice demand cannot be satisfied. Only with the most optimistic supply assumption for rainfed agriculture (S-3) and a price policy which sharply raises the consumer rice price (D-3) can the rice deficit be held below 15,000 tons. In two cases a surplus of total grain in comparison to projected domestic demand is projected. In these cases millet and maize supplies would exceed their domestic demands by a greater amount than the excess domestic demand for rice. It should be emphasized that Table XXIII assumes that all of the previously referenced water management projects will be implemented by 1990 to the extent indicated in Table XXIII. It is of course possible that certain of these projects will not be undertaken or that some underfulfillment of the enunciated targets will occur. In this case the rice deficit as well as the accompanying total grain deficit will be larger than estimated in Table XXIII.[30]

The economic feasibility of these water management projects has not been documented in this study. In fact, for most, if not all, of these rice projects the domestic resource cost of the rice will exceed the world price for the rice currently imported. In such a case the government of Senegal must choose either to subsidize this local rice production or to raise sharply the consumer rice price and limit imports of rice.[31]

In summary this section has shown that, while not assuring self-sufficiency in rice by 1990, the planned water management projects for Senegal can contribute to increased rice supplies. Were the government to combine a price policy which raises sharply the consumer rice price with the water management projects, both grain and rice self-sufficiency could be approached. Of course, economic costs to the domestic economy and to

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[30] If there is a total grain surplus, the surplus would, of course, be reduced.

[31] Since donor assistance is expected for many of these projects, the subsidy expense would undoubtedly be shared by both the relevant donor groups and the Senegalese government. There is also an infinite number of combinations of subsidy and price increases which the government could consider.

particular groups within Senegalese society would accompany this strategy of self-sufficiency. These costs include lost groundnut production from devoting either new or existing resources to additional grain production. With Senegal's comparative advantage in groundnut production this cost could be substantial. Further, the subsidy expense potentially involved with increased millet and rice production will place a substantial burden on the government operating budget. Finally, the distributional effects of this strategy must again be considered. Both the increased consumer rice price and the additional taxes for production subsidies are apt to be regressive in incidence.[32] Chapter V has attempted to assess within the context of this grain supply-demand model the various strategies available to Senegal to insure adequate grain supplies. A continued specialization in groundnuts (Section 1), the potential for using price policy (Section 3) have all been briefly reviewed. To conclude this study Chapter VI will summarize the broad conclusions of this research.

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[32] To encourage domestic millet production the government could lower the producer groundnut price, instead of subsidizing either the production or consumption of millet. This would still be regressive in its final incidence, sharply reducing rural producers' incomes.

CHAPTER VI - SUMMARY OF MAJOR RECOMMENDATIONS

This chapter will attempt to summarize the principal results of this research, focusing on their implications for food self-sufficiency in Senegal. After defining the major objectives of this research in Chapter I, a supply and demand model for millet, maize, and rice was developed in Chapter II. Per capita regional grain demands were estimated as a function of income, all grain prices, and a constant. When aggregated over region and population, these demand functions provided projections of national grain demands for a variety of underlying conditions or assumptions. The domestic supply model was less rigorous than the demand model, essentially assuming that the supply of an agricultural product was equal to hectarage multiplied by yield per hectare. Nevertheless, for given assumptions about hectares and yields domestic supply could be estimated.

In Chapter III the supply and demand model was estimated under a variety of assumptions. Demand was first calculated on the premise of unchanging per capita demands. With the assumed annual rate of population growth, steadily growing national demands for all grains were projected until the terminal year of the study, 2000. The sensitivity of this national demand to per capita income was then shown. Further, the effects of changing relative grain prices was investigated. A major conclusion was that a sharply increased consumer rice price could lead to meaningful reductions in per capita rice demand. Other testing showed that the per capita demands were relatively insensitive to changes in the overall grain price level and to changes in the assumed own price elasticities for the grains. To conclude Chapter III estimates of domestic supply for millet, rice, maize, and groundnuts were generated. Essentially, four supply scenaria were used. The first three were differentiated by the annual rate of growth in yields per hectare, assuming 0, 2, and 3 percent annual growth. There was an invariant growth rate for cultivated surface used with each of these yield growth rates. The fourth supply scenario accepted the Government of Senegal's planned 1977-1981 growth rates for yields per hectare and cultivated surface. Thus, Chapter III provides the empirical estimates of domestic grain supplies and national grain demands needed to calculate the national grain balances.

In Chapter IV grain balances using a variety of supply and demand combinations have been calculated. In the first section continued rice

deficits were projected with supply scenaria 1-3.[33] By the year 2000 these deficits would be, depending upon the supply scenaria used, between 360,000 tons and 447,000 tons. With both supply scenaria 2 and 3 excess supplies of millet and maize were projected. Nevertheless, the estimated rice deficits exceeded these surpluses and Senegal would not be grain self-sufficient. An important conclusion of this exercise is the necessity to consider the composition of grain demand and supply. While grain self-sufficiency can be approached with scenario 3, serious imbalances between individual grain supplies and demands would result. At current relative grain prices, there would be surpluses in millet and maize with continued deficits in rice. Thus, unless complementary price policy schemes accompany the supply increases, problems with excess demands and supplies for individual grains will result.

A further result from the calculations in Chapter IV is that any increase in per capita income will accentuate the grain deficit. This is particularly true for rice which has the highest income elasticity, partially reflecting a desire by the rural population to introduce some diversity into its millet-based diet. Since increasing rural incomes is a priority of the Senegalese government, this conclusion must be recognized in both Senegalese and donor planning. Having shown the likely course of future grain balances in Senegal, the task of Chapter V was to investigate possible means of insuring adequate grain supplies both by domestic production and commercial imports.

Within Chapter V, three principal avenues to insure adequate grain supplies were considered. The first assumed no change in the structure of domestic grain demand or supply. A continued specialization in groundnut production primarily destined for export was assumed. The present composition of grain consumption, with rice playing a significant role, was also hypothesized. Any excess demand for rice was met with commercial rice imports. The hypothetical balance of trade accounts for the agri-

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[33] National grain demands were estimated with unchanging regional per capita demands; increased national demand resulted solely from population growth. The implicit assumption is that relative grain prices per capita income are unchanged.

cultural sector was continually in surplus as the value of groundnut exports greatly exceeded the value of rice imports. Nevertheless, this approach is not one readily accepted by Senegalese authorities, since it does not lead to food self-sufficiency. With both price risk and quantity variance, it can be argued that an optimal degree of domestic grain production, exceeding that implied by a static model of comparative advantage, exists.[34] In recognition of this, two strategies for promoting greater food self-sufficiency were analyzed in Chapter V.

The first of these strategies relies on price policy to shift the composition of grain demand from rice towards more millet and maize. Sharply increased consumer rice prices, as detailed in Chapter V, could succeed in limiting rice demand and stimulating millet and maize consumption. Coupled with traditional extension and training programs which increase per hectare yields Senegal could approach food self-sufficiency. The exact proportion of grain demand satisfied by domestic production will depend on the magnitude of the consumer rice price increase. For those increases considered, in the range of 50 percent, a relatively substantial rice deficit--180,000 - 200,000 tons in 1990--would still exist. The second strategy considered includes the introduction of water management projects to create irrigatable land to reduce further this rice deficit.

The third section of Chapter V analyzes the impact of those water management projects being considered in current Senegalese planning documents. It is shown that food self-sufficiency can be nearly achieved by a combination of a price policy to raise the consumer rice price, productivity increases in rain-fed agriculture, and the successful introduction of the water management projects.[35]

Since both of the strategies reviewed here lead to greater food self-sufficiency, there is a temptation to endorse either of these approaches in light of Senegal's objective of food self-sufficiency. The economic costs and distributional effects of these strategies must also be considered. First, groundnut production, in which Senegal has a comparative

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[34] Jabara, Cathy, "Agricultural Comparative Advantage Under Uncertainty, The Case of Senegal" Unpublished PH.D. Thesis, Purdue University, May 1979.

[35] By 1990 a potential surplus of 60,800 tons of grain could exist. This includes a millet and maize surplus of 72,900 tons and a small rice deficit of 12,100 tons.

advantage, would be reduced below the potential production implied by the resources available to Senegal. Second, the pricing policy needed to stimulate millet production would require either a producer subsidy or a consumer subsidy such that the remuneration of millet production approaches that of groundnut production. Third, the domestic resource cost of rice exceeds the current market price for imported rice. The government will either have to subsidize domestic rice production or have to raise sharply the consumer rice price. In the former case there would be a strain on the limited financial resources available to the Senegalese government. In the latter case there would be adverse distributional effects for low and middle income urban inhabitants who depend on rice for 60 percent of their grain requirements. Thus, it is the obligation of Senegalese policymakers to weigh the relative benefits and costs to any strategy promoting greater food self-sufficiency.

This modeling of Senegalese grain demands and supplies has tried to provide a methodology capable of incorporating the various elements needed to analyze food policy. The demand model provides projections of domestic grain demands for a variety of underlying assumptions. Coupled with estimates of grain supplies, projected grain balances can be derived and various strategies assessed. Policymakers must now refine the model as more accurate data become available, enunciate their objectives with respect to food production, and design a strategy or policy to achieve those objectives.

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