بسم الله الرحمن الرحيم

RICE POLICIES AND PRIORITIES IN MAURITANIA

By

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To my beloved fiancée, Mattie S. Jamison.

I dedicate this work.

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LIST OF ACRONYMS

BDPA: Bureau pour le Developpement de la Production Agricole

BMDC: Banque Mauritanienne pour le Developpement et le Commerce

CAA: Commissariat a` l'Aide Alimentaire

CIF: Costs-Insurance-Freight (meaning all these costs of the good at destination)

CNFVA (also CFVA): Centre National de Formation et de Vulgarisation Agricole

CNRADA: Centre National de Recherche Agronomique et de Developpement Agricole

FAC: Fond d'Aide et de Cooperation

FAO: Food and Agriculture Organization

FED: Fond Europeen de Developpement

FOB: Free-on-Board (meaning costs from the shipment point or origin)

OMC: Office Mauritanien des Céréales

OMVS: Organisation pour la Mise en Valeur du Fleuve Senegal

RAMS: Rural Assessment Manpower Survey

SONADER: Société Nationale de Developpement Rural

SONIMEX: Société Nationale d'Imporations et d'Exportations

UM: Unité Monétaire (read: OUGUIYA): $1 = 55 UM (at the ongoing exchange rate)

USAID: United States Agency for International Development

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CHAPTER 1

INTRODUCTION

If there is an economic crisis in Sub-Saharan Africa, as is now generally accepted by the worldwide community, Mauritania falls in the category of most severely affected countries (World Bank report of 1981).[1] The most severe consequence of the crisis has been the death of thousands of people from starvation, in Mauritania and elsewhere. Domestic policy issues have been singled out by Eicher in his "Africa's Food Crisis" (1982) as being at the heart of the problem. In search of solutions, governments have failed to consider population growth and "agrarian socialism" as possible sources of their problem. Based on the conclusions of most reports, the governments' search procedure for courses of actions might best be described as one of "tatonnement," or trial-and-error experimentation. The colonial legacy, the drought cycle and migration are cited in the literature as the major causes of the African economic crisis. Whether these arguments hold or not, a famine has occurred in much of Western Africa, and that is a fact. How the famine came about and how it has been perpetrated is still subject to investigation.

Overall, the intellectual community seems to agree upon the existence of a self-sustaining agriculture on the eve of the

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[1] In Table 25 (p. 167 of the World Bank report (1981), annual growth of agriculture (food) is reported as -1.3%, and the growth rate of total production is reported as -4.0% per year, the lowest figures in the low-income semi-arid group.

independence era. This agriculture was characterized as rudimentary, but granaries were never empty. Rarely in the past did people starve. Why should the post-independence period be distinguished by so many failures:

- a negative growth rate of agricultural production,
- an increasing foreign exchange deficit,
- desertification and general environmental degradation.

A glance at selected economic indicators suggests that the negative trends will continue if appropriate actions are not taken at once. For examples, Tables 1.1, 1.2, 1.3 and 1.4 indicate a negative growth rate of agricultural production in Mauritania, a budget deficit which increased thirty times from 1973 to 1979, substantial foreign debt, and the highest ranked average annual growth rate of expenditure on public administration among the African countries.

1.1 The Problem

Naturally, the food crisis problem is vast. To keep this study manageable, the issue is addressed from the angle of food shortage, where rice is viewed as a predominant part of the problem. A shortage, as can be seen in Figure 1.1, can be resolved either through: (1) a shift (decrease) in demand to point A, (2) a shift (increase) in supply to point B, (3) a combination of both demand and supply shifts to point C, or (4) an increase in price to P_F to reflect an equilibrium situation at E. Indeed, given a hypothetical price level P_H below the market equilibrium price, a shortage is derived from the difference between total quantity demanded and total quantity supplied. A shift of the supply curve S to S' or a shift of the demand curve D to D' would bring about an equilibrium in the market at P_H. The aim of

Table 1.1

Growth rates of agricultural production

1969-71 to 1977-79

(average annual growth rate in volume as a percentage)

4+	3-4	2-3	1-2	0-1	<0
Kenya	Cameroon	Benin	Botswana	Ethiopa	Angola
Malawi	Ivory Coast	Burundi	Chad	Gabon	Congo
Swaziland	Rwanda	Cent.Africa	GuineaBissau	Gambia	Ghana
		Liberia	Lesotho	Guinea	Mauritania
		Upper Volta	Madagascar	Somalia	Mozambique
		Zambia	Mali		Togo
		Zimbabwe	Mauritius		Uganda
			Niger		
			Nigeria		
			Senegal		
			Sierra Leone		
			Sudan		
			Tanzania		
			Zaire		

Source : IBRD, 1981, table 5.5, p.50

Table 1.2

Recent budgetary trends(million $)

	1973	1974	1975	1976	1977	1978	1979	1980
Taxes	43.9	56.4	65.1	81.0	84.0	77.8	96.7	105.6
Domestic revenues	61.9	86.4	87.2	108.7	102.7	119.8	128.9	137.8
Expenditures	61.7	76.0	94.7	173.8	190.2	230.8	206.7	191.1
Current deficit	- 0.2	-10.4	7.5	65.1	87.5	111.0	77.8	53.3
Capital expendit.	8.3	17.6	61.4	175.7	88.3	80.6	71.1	128.9
Overall deficit	8.1	7.2	68.9	240.8	175.8	191.6	148.9	182.2
Domestic borrowing	0.5	-22.6	0.5	3.1	37.7	10.4	6.7	35.6
For.budget support	0	0	0	52.0	34.6	94.8	70.0	40.0
For.budget grants	0	0	36.0	27.4	22.3	9,3	6.7	8.9
For.projects loans	4.6	11.8	18.2	138.0	55.8	50.4	51.1	75.6
Total foreign assist	4.6	11.8	54.2	217.4	112.7	154.5	127.8	124.5
External bank	2.9	18.0	14.3	20.4	25.4	26.6	14.4	22.2

Source : "Mauritania : Country Development Strategy Statement FY 83", USAID, January 1981.

Table 1.3

Comparison between domestic and foreign financial resources

	1973	1974	1975	1976	1977	1978	1979	1980
Total expenditures	70.0	93.6	156.1	349.5	278.5	311.4	277.8	320.0
Less debt amortization payments	2.4	5.3	22.8	19.5	23.0	34.1	21.8	17.8
Total expenditures	67.6	88.3	133.3	330.0	255.5	277.3	256.0	202.2
Tot.domestic revenues	61.9	86.4	87.2	108.7	102.7	119.8	128.9	137.8
Tot.commercial borrow	3.4	- 4.5	14.8	23.5	63.2	37.1	21.1	57.8
Tot.foreign assist.	4.6	11.8	54.2	217.4	112.7	154.5	127.8	124.5
Total domestic rev. less amortization payments	59.5	81.1	64.4	89.2	79.7	85.7	107.1	120.0
Domestic revenues as % of total expendit.	88	92	48	27	31	31	42	40
Total foreign assistance as % of total expenditures	7	13	41	66	44	56	50	41

Source : "Mauritania : Country Development Strategy Statement FY 83", USAID, January 1981.

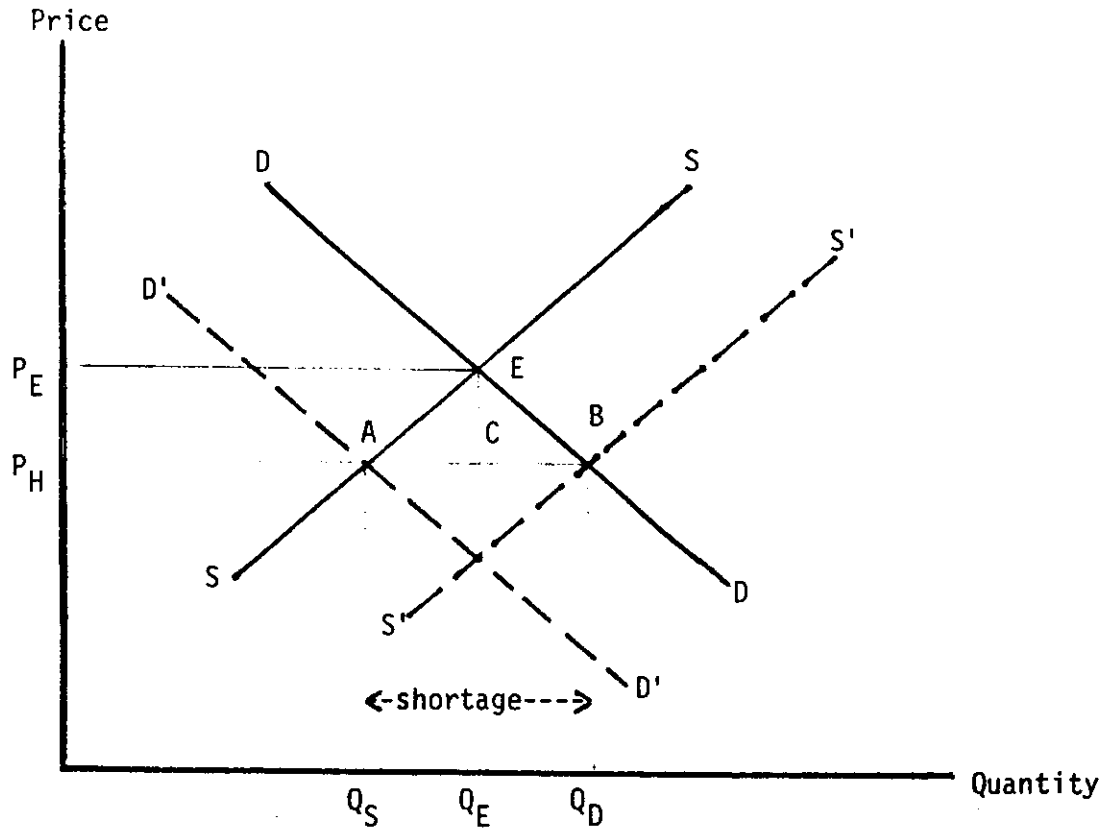
Table 1.4

The growth of public administration and defense relative to GDP

Countries	Expenditure on public administration and defense as % of GDP(annual average, 1970-79)	Average annual growth rates,1970-79		
		expenditure on public administration and defense	relative to GDP	expenditure on public administration
Mauritania	18.0	13.9	1.8	12.1
Kenya	17.1	8.4	6.5	1.9
Sudan	16.1	4.5	4.3	0.2
Tanzania	14.9	10.2	4.9	5.3
Chad	14.2	6.1	-0.2	6.3
Somalia	13.7	6.5	3.1	0.2
Congo	12.7	2.3	2.9	-0.6
Botswana	12.1	16.3	13.5	0.5
Madagascar	11.5	0.2	0.3	-0.1
Benin	11.0	4.8	3.3	1.5
Rwanda	10.3	6.5	4.1	2.4
Lesotho	9.2	3.3	7.0	-3.7
Upper Volta	9.1	6.2	-0.1	6.3
Uganda	9.1	5.9	-0.4	6.3
Sierra Leone	8.3	9.6	1.6	8.0
Ivory Coast	8.1	8.9	6.7	2.2
Liberia	8.0	6.7	1.8	4.9
Cameroon	7.1	6.2	5.4	0.8
Nigeria	6.4	13.3	7.5	5.8
Mean (unweighted)	9.9	7.4	3.9	3.3

Source : World Bank, 1981, table 4-2,p.41

Figure 1-1. Food Shortage Representation



most countries' food policies is to meet consumer demand, reducing the issue to one of supply management. In other words, the problem is to increase food supply, or in the case of Mauritania rice supply. Exclusion of other commodities is intentional to keep the study as simple as possible since, as will be seen, the data do not permit a complete investigation.

Facing an ever-decreasing supply of sorghum and millet due to annual low levels of rainfall, Mauritanian farmers are progressively shifting to rice production, for auto-consumption and to satisfy market demand. Although the government has promoted this shift, it has not responded to farmers' needs for production incentives. The lack of incentives appears to be valid argument from the farmers' standpoint, whereas the government claims that a lack of capital and foreign exchange earnings prevents it from providing inputs to farmers and/or commodities to consumers. The international community has intervened with aid (grants and loans), with no noticeable effect on production.

1.2 The Purpose

Based on the objective of meeting the basic needs of the Mauritanian consumers and producers alike, an attempt is made in this study to evaluate the determinants of supply and demand for rice. Policy recommendations are sketched out based on the results. Since rice subsector policy is part of an overall agricultural or rural sector policy which evolved along with an industrialization policy, an overview of the macroeconomics of the Mauritanian economy is presented prior to the policy recommendations.

1.3 The Objectives

The objectives of the study may be classified into two categories, the overall objectives and the specific objectives.

1. The overall objectives include:
   a. a summary of the history of development policies pursued in Mauritania (from 1960 to 1981);
   b. an analysis of agricultural policies, especially those affecting rice.
2. The specific objectives include:
   a. identification of the theories of agriculture development, not only those that evaluate past policies but essentially those that guide future policy formulations and implementation (Chapter 2);
   b. description of the rice industry (Chapter 3);
   c. establishment of the functional relationships between factors affecting demand and supply respectively, and estimation of the parameters upon which future actions can have some effects (Chapter 4);
   d. recommendations of policies needed to induce more rice production (Chapter 5).

1.4 The Data

The data used in this study are secondary data, both time series data and cross-sectional data from household surveys. The sources are diverse, ranging from international or foreign institutions (FAO, IBRD, IMF, Ministère Francais de la Coopération, USAID, etc.) to domestic

publications and surveys. Among all of these, RAMS[2] constitutes the basic source from which most of the information was collected. However, in selecting the data the author's familiarity with the sector was used where differing data were available from different sources.

The figures are annual averages for the entire nation, and this presents some drawbacks in accuracy because of considerable regional differences in prices, yields, etc. Concerning the quality of these data, we quote Shearer and Vu Thi from "Food and Agriculture Sector Assessment" (January, 1983), a study which evaluated the RAMS reports:

Shearer's article on "Economic Issues" (p. 1)

> "An analysis of the Mauritanian economy on the basis of quantitative measurements of indicators is quite futile. Only very rough approximations exist even for such fundamental variables as crop acreages and volume of crops. . ."

Vu Thi's article on "The Social Aspects of the Mauritanian Rural Sector" (p. 1)

> "The main problem encountered with all the social studies is the lack of reliable quantitative data. Thus, statements tend to be qualitative value judgements rather than documented analysis. . ."

1.5 Plan of the Study

Several agriculture development models are introduced in Chapter 2. The discussion is useful in explaining the role and functions of the agricultural sector within the overall economy. Mauritanian agriculture is described in more detail in Chapter 3, where rice is taken as

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[2]RAMS (Rural Assessment Manpower Survey) is a USAID project in Mauritania that had among other objectives to assemble and generate data so as to analyze the economic setting and to formulate consequently some macro-policies for the government of Mauritania.

a commodity model. Rice is, indeed, an important source of food consumption (40% of family expenditure), and until recently it was the only imported food commodity. Chapter 4 lays out the fundamentals of some analytical tools to help analyze the rice commodity in the whole economy. An econometric model of supply and demand equations has been estimated. Chapter 5 lists some of the alternatives to bring about an equilibrium of supply and demand based on the results of the econometric estimations and recommends some reforms or alternations in policies and priorities needed to launch a rice development program capable of inducing surpluses in the near future. Finally, each chapter includes an introductory statement and a summary.

CHAPTER 2

GENERAL THEORETICAL DESCRIPTION OF AGRICULTURE DEVELOPMENT MODELS (MACRO ECONOMIC)

Most of the enthusiasm of economists and social scientists in general for writing on the subject of development in Africa is justified both by a remarkable potential for theory testing and by the surge after the independence era of worldwide concerns about growth of the new nations. The interest in accelerated development put the academic community to work, and today several growth models are available. Most African countries have used more than one model in the history of their economic development. Mauritania, for example, witnessed a radical shift in emphasis from an industrial-based economy to an agricultural-based economy. The industrial impetus died off rather quickly because of its failure to generate enough employment for the masses it attracted and displaced from the farms. Agriculture then substituted for industry, but at a time when people of the rural sector were discovering the "charm" of the cities and feeling the need to flee from the hard work of the farm.

This situation of rural exodus could not be stopped without recreating an appropriate atmosphere for living in the rural areas. With this goal in mind, the government searched for alternative courses of action. The conditions favored the development of irrigated rice. Though the general strategy seems sound, the results were disappointing. Prior to suggesting a different set of policies, it is advisable to examine the commodity subsector discussed in the next two chapters. This chapter, hence, aims at tracing historical attempts in Mauritania

to develop rice production, with an emphasis on the induced innovation and vent-for-surplus (or frontier) models described respectively by Hayami and Ruttan (1972) and Myint (1958). The theory of comparative advantage will also be discussed briefly, as this concept has relevance in evaluating whether importation of rice or domestic production will be more profitable for the country.

2.1 Mauritanian Agricultural Development in Historical Perspective

This section draws on Vernon Ruttan's article on agricultural development (1980), a comprehensive descriptive piece of work on the different strategies and approaches that have been tried.[3] At first, increasing food production was believed to be contingent on opening up new lands for production. Later, and primarily as a result of the "green revolution," technology came to be regarded as the primary force in increasing food production.

In Mauritania, the first attempt to open up new lands for agricultural production goes back to 1965 when BDPA, a French development agency, launched under the auspices of the French cooperation a rice irrigated perimeter at Dar El Barka. The experiment was a success, and as late as in 1966 the villages of Bakao and Vinding were declared beneficiaries. The strategy of the French government was viewed as a frontier approach, inasmuch as new areas were to be planned for rice production. As Ruttan pointed out (p. 62):

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[3]Beckford, G. L. (1972) in his comment of Ruttan and Hayami's paper raised some interesting issues as regards to the appropriateness of this model to development of agriculture in LDCs. The major reservation of the critic is to qualify the model as principally one of agriculture growth and not of development.

> "Throughout most of history, expansion of the area cultivated or grazed has represented the dominant source of increase in agricultural production."

Also, (p. 62),

> "Where soil conditions were favorable as in the great river basins and plains, the new villages gradually intensified their system of cultivation. Where soil resources were poor, as in many of the hill and upland regions, new areas were opened up to shifting cultivation or nomadic grazing."

These statements accurately describe rice cultivation in Mauritania, where uplands (non-flooded areas) have traditionally been withheld from use in agriculture for years and upon which forests hence developed. The climatic disturbances that followed the drought beginning in 1968 opened up these lands for rice cultivation. The pioneer villages attracted more people, and soon an extension of the village perimeters boundaries was requested. However, the land tenure system was quite rigid, and the French field supervisors were advised to shift toward the conservation approach. This approach typically follows from soil exhaustion and consequently emphasizes: (1) the evolution of a hand-labor cropping system, (2) the production and use of organic manure, (3) labor-intensive devices of drainage and irrigation for a more efficient use of scarce land and water resources. The approach was quite easy to implement, because most of the farmers were also herders and highly disciplined by the structure of their social system. The HODH-EL-CHARKI "operation charrue"[4] of 1967 was a good example of the government's attempt to carry out the conservation model.

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[4]Animal traction project which was launched principally in the HODH-EL-CHARKI (also Néma) Region but also in the axis of Boutilimit-Néma. The project failed because of management and supervision problems.

From 1969 to 1973, the government orientation was an industrialization program which would stimulate agriculture development by expanding the demand for farm products (sugar cane for instance), by supplying the industrial outputs needed to improve agricultural productivity (fertilizer), and by drawing away surplus labor from agriculture. This approach has been described as the urban-industrial impact model. The drawback of this model was rapidly to siphon youngsters from the farm and simultaneously to create overpopulated urban centers and underemployment.

In 1974, following a sharp decrease in cereals production, the government was inspired by the example of ASSABA Region to launch a vast vegetable production program in which the northern Regions could participate with their oases. This program was supported by a large component of extension and communication-dissemination aimed at bridging the differences in productivity among farmers and regions. Hundreds of cooperatives were created, extension agents were dispatched around the country, and a national extension policy was for the first time institutionalized in order to coordinate farmer education programs. The CNFVA, a school for agriculture, hosted several seminars where farmers were exposed to new ideas and techniques of production and organization. This approach described by the diffusion model failed, however, to generate rapid growth of agricultural output.

The preceding models can all be grouped under the vent-for-surplus framework, which is based on the implicit assumption of unused capacities in the system. As the argument of Myint goes, without altering subsistence production there is a potential for increasing export production by putting into use the underutilized resources. In

Mauritania's case the immediate objective is an increase in food production rather than in exports. There appears explicitly or implicitly in every model some underutilized resources (land, labor, or capital) which can be exploited to increase output: the frontier model assumes idle lands; the conservation model implies a higher payoff of capital, as does the urban-industrial impact model; the diffusion model in turn is built upon obstacles to information dissemination and hence implies a not-fully-utilized human cognitive capacity.

The high-payoff input model, which addresses the technical knowledge to be generated by research institutions, the technical inputs to be produced by the industrial sector, and farmers' faculty to adopt new techniques and use new inputs, was accepted in Mauritania as a logical approach to increase productivity in agriculture while developing an industrial base for the country. However, since research and education components are not included in the model, the prescriptions set forth by the approach were incomplete. Ruttan points out (p. 3):

> "It (the model) does not explain how economic conditions induce the development and adoption of an efficient set of technologies for a particular society."

It is this limitation that led Ruttan and Hayami to develop a new model, the induced innovation model, in which technical change is treated as endogenous. To avert the limitations of the model as identified by Beckford (1972), the induced innovation model from which Moris derived a version (1981) that encompasses a larger breadth, called rural induced development model, shall be described as if the public sector operates in a politically directed economy. The concern here is with what Hicks (1982) calls labor-saving and land-saving technologies

in agriculture. This taxonomy refers to those mechanical devices that displace labor and to the biological (crops varieties) or chemical (fertilizers, pesticides, etc.) technologies that permit a higher yield response. For example, in introducing more machinery, more land is needed and less labor is required; alternatively, a biological technology saves on land and needs more labor. This trade-off is illustrated in the simplified Figure 2.1.

In Mauritania, several new mechanical technologies have been introduced into the village perimeters, such as water-pumps and irrigation technology supplies. In the larger state-farm perimeters, heavier equipment was introduced, including tractors to plow the soil, and hulling material, all of which would cut on labor requirements. It is not clear to what extent this technology succeeded in saving labor, but according to Sparling (1981) there is reason to believe that this heavy equipment contributed to the low rate of return of large-scale perimeters.

Biological technology is improving, but at a slow pace. Fertilizers are being used, although with insufficient dosages, while crop varieties are still at the experimental stage. The creation in 1972 of the CNRADA, the national agriculture research center, was the first attempt to internalize the process of technical innovation. However, there is no provision in the program of CNRADA for mechanical research, nor is the biological research component ready to provide varieties that may outperform the existing ones. It is not clear that the research center is even equipped with appropriate research instruments.

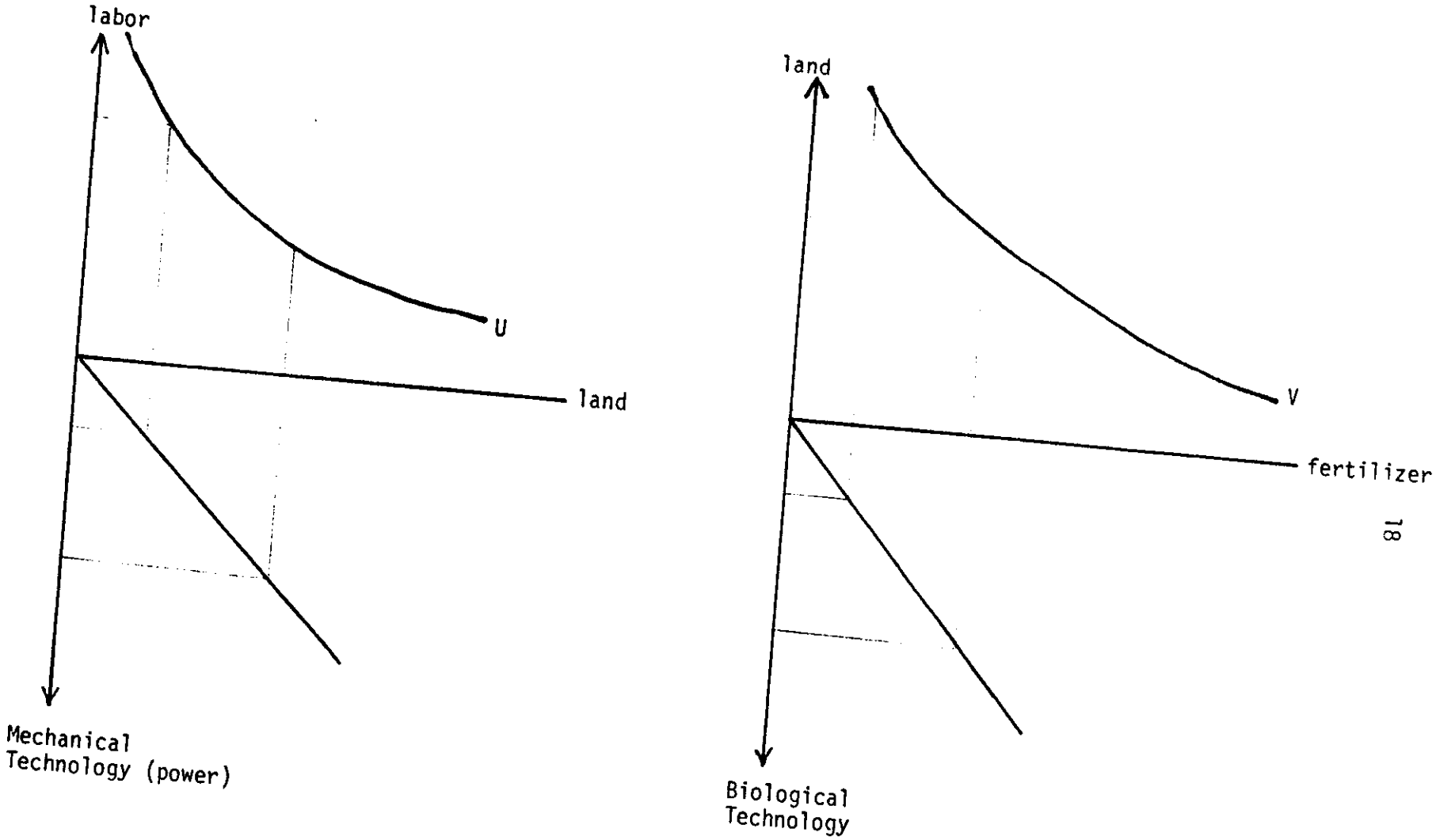

Figure 2-1. Technologies and Factors Inputs

Rural inducement programs, to comply with Moris' version, have been launched not only by the government but also by numerous international institutions. With the help of these institutions, CNRADA and other state or parastatal agencies have been brought into existence, and new areas have been opened up to production. These institutional innovations occurred in much the same way described by Ruttan (p. 141):

> "Neither this process, nor its impact, is confined to the agricultural sector. Changes in relative prices in any sector of the economy act to induce innovative activity, not only by private producers but also by scientists in public institutions. . ." and (p. 141),
>
> ". . . the institutions that govern the use of technology or the 'mode' of production can also be induced to change to enable both individuals and society to take fuller advantage of new technical opportunities under favorable market conditions."

2.2 An Assessment of Comparative Advantage of Rice Supply Sources

Rice has been produced for over 10 years, and still imports have not diminished. Perhaps, one might suggest, the Mauritanian ought to pause and ask whether it is more profitable to keep producing rice locally or to import it instead. In this context, the criterion of comparative advantage can provide a framework for analysis. Since this objective is of secondary nature, no formal exercise will be performed to generate a benefit-cost analysis of domestic rice production. The Heckscher-Ohlin version relies on a rule of thumb which will suffice for this discussion. The rule of thumb states that a country where consumption is not biased towards certain commodities should export domestically produced commodities and import those whose production at home requires more of its scarce resources.

To determine which goods use more of the scarce resources, the "Bruno Ratio," or equivalently domestic resource costs (DRC), may be used to measure the domestic currency costs of a foreign exchange saving to net foreign exchange saving. Then, the rule is to compare the resulting ratio to the computed shadow exchange rate (SER).[5] If SER is higher than DRC, this would signify that an imported metric ton price (CIF) is higher than the domestic costs, and therefore the domestic production should be encouraged.

However, this procedure of comparing import to domestic production costs would seldom come to the mind of politicians, and in a sense it is a deficient prescription because it fails to account for the indirect benefits of the domestic alternative, such as backward and forward linkages, consumption multipliers, etc. Yet, valuable resources may actually be wasted in domestic production of rice. Only a detailed study on this subject can give the adequate answer as to which, between import and domestic production, is the optimum source of rice supply. But if domestic production turns out to be the chosen alternative and an import-substitution policy is followed, then high tariff and non-tariff barriers may be institutionalized, as was the case for the match industry. The well-known "infant industry" argument may also have relevance, because farmers may be facing higher costs per unit of output compared to similar farmers elsewhere (especially at imports sources). In this case, Mauritanian farmers need protection against foreign competition until they can establish themselves.

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[5]Here SER refers to units of foreign exchange worth to the economy.

Figures compiled by RAMS show domestic production as very competitive with imports outside Nauakchott market (see Table 2.1). However, we know that agricultural inputs are subject to heavy subsidies, as is transport to and from the interior. The government seems to be unable to do anything except to perpetrate these distortions in the market in the name of agrarian socialism (Eicher, 1982, p. 41-44).

2.3 Summary

Successful achievement of sustained growth in a developing country is necessarily a function of the resource endowments and involves a continuing adjustment to changing agricultural technology. Failure to be adaptive to new technical alternatives may lead to backwardness. The frontier model, the conservation model, the urban-industrial impact model, the diffusion model, the high-payoff input model, and the induced innovation model each has some amount of explanatory power.

Table 2.1

Comparative cost for one ton of domestic versus imported rice

IMPORTED RICE : 1980 prices	broken	long-grain
Cost (CIF) in US $	$ 325	$ 400
Cost in UM	14625 UM	18000 UM
Buying costs	292 UM	626 UM
Shipping and handling	1500 UM	1500 UM
General costs	2683 UM	3202 UM
Taxes	493 UM	604 UM
Margin	294 UM	354 UM
Costs at Nouakchott	20206 UM	24714 UM
Subsidized* transport to interior	3000 UM	3000 UM
Price including subsidy	23206 UM	27714 UM
Price excluding subsidy	25206 UM	29714 UM

DOMESTIC PRODUCT : 1980 prices	in UM
Producer price (paddy)	11 000
Milling	1 800
Labor and bagging	500
Transport	2 000
Storage	500
Subtotal	15 800
Conversion factor	.65
Price of white rice	24 500
Less price of by-product	-1 800
Farmgate price	22 700
Price including subsidy on transport	25 700
Price excluding subsidy on transport	27 700

Source : RAMS, June 1981.

* Transport costs without subsidy amount to 5 000 UM

CHAPTER 3

MAURITANIAN AGRICULTURAL SECTOR: The Case of Rice

A recent USAID study (January 1981) reports that agriculture in Mauritania has grown little since independence and that there has been a decrease in productivity. Cereal production during the last five years has averaged less than 50,000 metric tons annually, against an overall need of 180,000 metric tons, requiring the government to rely upon foreign donors for assistance in financing the necessary grain imports. This situation is attributable to several factors. Weather conditions seem to dominate. The recurring drought has influenced several other areas of stagnation in the agricultural sector: rural migration, animal losses, desert advancement, etc. The most dramatic consequence of the climatic imbalance has been the decline of the traditional rainfed-recessional culture (sorghum) that constituted the major source of food for human consumption (see Table 3.1). Decreasing sorghum production has paralleled a growing interest in irrigated crops (principally rice).

This brief summary sets forth a basis for discussion of demand and supply of rice, as well as the mechanisms by which these are determined in the market. Demand is analyzed in terms of consumption and marketing systems, while supply is broken down into domestic production and imports. In sum, this chapter addresses the political economy of rice, i.e. production and consumption activities that fall within the scope of governmental policy and the passivity of the private sector.

Table 3.1

Cultivated areas[a], rainfall[a], flooding[a], and cerals production[b]

Years	Rainfall (mm)	Flooded areas (Ha)	Cultivated areas (Ha)	Cereals production		
				sorghum (tons)	maize (tons)	wheat (tons)
1964	382	766000	245000	90000	3400	200
1965	502	123000	123000	100000	4000	300
1966	359	117000	117000	90000	3000	300
1967	393	140000	140000	100000	2000	200
1968	267	86000	86000	50000	4000	300
1969	403	95000	95000	100000	4000	300
1970	256	393000	110000	82000	800	200
1971	772	350000	101700	50000	4200	200
1972	252	219300	87200	37500	2000	200
1973	224	NA	NA	25000	1500	100
1974	229	NA	NA	40000	4600	200
1975	377	NA	NA	32000	3100	300
1976	249	NA	NA	21000	3200	400
1977	224	NA	NA	30000	3300	300
1978	224	NA	NA	43500	4800	400
1979	227	NA	NA	21200	5000	200
1980	192*	NA	NA	31000	4400	200

Sources: a.RAMS, 1981

b.Martin, 1982

NA - Not Available
* - predicted figure

3.1 Demand for Rice

The most recent available surveys of Mauritania's economic and social situation are summarized in the RAMS report, which concludes that an estimated 43% of the expenditures on cereals is allocated to purchases of rice for consumption. However, this percentage may be misleading without a closer examination of the marketing system and consumption patterns. To what extent does this figure of 43% reflect economic distortions, such as food aid, government subsidies, and monopoly power in the market? Closer examination of the marketing system will shed light on the price determination mechanism and help answer this important question.

3.1.1 The Marketing System

Marketing functions are performed primarily by the government and its affiliated agencies. The private sector (merchants and shop owners) competes with the government only within short distances around the production centers. To prevent merchants from cheating consumers, the State subsidizes SONIMEX (a commercial parastatal enterprise) transport costs so that it can supply the consumption centers all year.[6] However, producers still face the bargaining power of the merchants, who exchange their goods at high prices for commodities which at harvest time command a very low price. This barter system involves mostly sorghum and millet commodities, rice being a relatively new crop. In rice SONIMEX has monopoly status, being the only agent permitted

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[6]Martin (1982, p. 192 and 193) estimates the subsidy on domestic rice at 5.8UM per kg, and on imported rice at 4 UM at Nouakchott and 6.5 UM in the provinces (or interior).

to buy and sell both locally produced and imported rice. OMC is a State agency which deals in rice; theoretically OMC provides a domestic price support program in building reserve stocks, although historically its main contribution has been to store donated grains. SONADER, a state enterprise which is mainly in charge of crop production, has created its own marketing department to deal with the grains repaid by farmers for the services and inputs costs contracted during the crop season.

Imported rice is assembled at Nouakchott harbor and put in sacks of 60 or 100 kg. Grading is restricted to separating the long-grain varieties from broken rice. Handling is done by longshoremen called "dockers." Transport to the interior is either on government trucks or through private transporters. In both cases transport costs are subsidized through a "système de péréquation" (an equalizing scheme) that permits transporters to charge 3 UM/kg regardless of the destination points.

Import prices are maintained within a certain range. The acquisition costs (CIF) of a metric ton of rice is estimated at $325 and $400 for the broken and long-grain, respectively. A cost comparison with domestically produced rice is reproduced from the RAMS report in Table 2.1. The domestic variety requires an additional marketing function, processing; indeed, in its raw form (called paddy) this variety cannot be consumed. A milling operation must take place to separate the grain from the hull. A conversion factor of 65% from paddy to rice is a well established norm in the region; i.e., out of 100 kg of paddy, 65 kg of grain are obtained, and the by-product or hull is used to feed animals or used as manure.

Table 2.1 indicates how important these marketing costs are in determining the metric ton costs of both domestic and imported rice.

Aid is a third source of rice. CAA, which is a State enterprise responsible for securing and distributing donated food to indigent families, has been functioning in close association with OMC. CAA operates a relief program that distributes both food and medicine; it intervenes only in states of emergency, such as in periods when production drops substantially and there is a chance of starvation, or when an epidemic is delcared. In these cases, food is distributed free of charge to the recipients.

As pointed out earlier, marketing costs are high. A brief look into the industries that perform the various marketing functions will clarify why this is so.

a. Transportation

Mauritania is one of the many countries in Africa which has a poor road network. The costs of transporting goods by cargo carrier are prohibitively expensive, and river navigation is now blocked by sand filling up the river bottoms. Two cities, Nouakchott and Nouadhibou, are situated on the Atlantic coast and have harbors of limited capacity, and three major urban concentrations lie along the Senegal River. Several other cities are located inland.

The paved road network is restricted to two axes, one of 500 km going from Rosso to Atar passing through Nouakchott, and the other over 1,000 km long connecting Nouakchott to Néma via Aleg, Kiffa, and Aioun. Of the 6,000 km road system, over 2,500 km are still sand and dirt

tracks, and approximately 2,000 km are gravel roads in very poor conditions. Another characteristic of the road system is the high incidence of sand dunes which can totally block the road in less than one hour during wind storms. Moving dunes have traditionally discouraged the development of paved roads.

The most common means of transportation are trucks, boats, and animals (camels, oxen, donkeys). The government and its affiliated agencies participate only in the truck-hauling industry, although a big share is left to the private sector. The trucks are "Mercedes" and "Berliet" models of 5 or 10 metric tons capacity. Losses associated with this mode of transportation are high compared to water navigation or animal loading. Trucking charges are fixed by the Ministry of Transport, but little control is exercised over private transporters. River navigation, despite being slow, is cheaper than truck-hauling. The river connects the four major production areas; Rosso, Boghé, Kaedi, and Selibaby, and navigation may occur throughout the year if the river is sufficiently deep. This is in sharp contrast to truck-hauling, which must be discontinued during the rainy season months on most non-paved roads. OMVS, a consortium for the development of Senegal River basin grouping Mali, Mauritania, and Senegal, plans to dredge the Senegal River and to construct dams at Diama and Manantalli so as to ease water transportation in the future.

Animals were the traditional means of transportation for nomads and merchants. Using camels in the North, oxen and donkeys in the South, crops were shipped at a very low price. These animals have the advantage of reaching regions to which trucks and boats have no access,

and they are cost-effective. Naturally, animals are slow and provide no adequate protection to the transported goods.

b. Telecommunication

The telephone system is just beginning to gain acceptance among small businesses. Transaction costs are tremendously reduced in Mauritania with a good telephone system, due to the long distances between cities and the risk associated with travel.

c. Handling

Labor availability is unlikely to pose a problem among handlers of agricultural commodities. Mauritania continues to suffer unemployment problems, especially among longshoremen or "dockers." Adult literacy is at 17%, indicating that there are unskilled workers who are likely going to keep the unemployment rate high and to guarantee labor for the handling function. This situation, implies that the wages will remain low as long as an excess supply of dockers characterizes the market.

d. Storage

With low production, storage facilities are predictably scarce. Traditional granaries made of mud and branches surround every village. Their construction is not resistent to termites, and storage losses due to insect damage consequently are considerable. In these traditional granaries, the product is conserved in bulk, while in more modern warehouses it is generally bagged. Problems with insects and moisture render the costs of storage quite high; these costs increase the further South the warehouse is located.

SONIMEX and OMC own storage facilities in limited capacities and numbers. Management of these facilities requires skilled personnel

whose salaries represent a significant cost in addition to the high cost of pesticides used to treat the silos. New storage technologies were introduced in 1977 by USAID; the new granaries are cheaper, but little is known of their efficacy in resisting insects and moisture damage.

3.1.2 Consumption

Extensive analysis of consumption patterns is provided by RAMS; only some of the results will be mentioned here. The RAMS team in its study of income patterns and consumption concluded that there is great risk attached to rural income, which explains the income elasticity of demand for food of about 0.96 (and 0.44[7] for cereals). After conducting a cross-sectional survey of urban-rural differences and ethnic groups' preferences for consumption, the team estimated at 133 kg and 118 kg of cereals consumption for urban and rural consumers respectively, and a scale for expenditures on each category of food. Expenditures for rice ranks first in the urban areas, while it places second (after sorghum) in the rural area. This classification is based on households' cash expenditures, and therefore it should be of no surprise because in rural areas most farmers do not have to buy rice. In terms

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[7] This 0.44 elasticity figure for cereals suggested by the RAMS study indicates that for 1980, consumption was near the saturation level. For RAMS, this is equivalent to saying that there was no demand for more consumption. A similar study conducted for other food shows elasticity coefficients for:

Fruits and vegetables = 0.47
Tea = 0.61
Sugar = 0.79
meat = 0.50
milk = 1.03

In other words, this implies that the country was adequately supplied with cereals, and fruits-and-vegetables but not with enough milk. (See RAMS, 1980, p. 98).

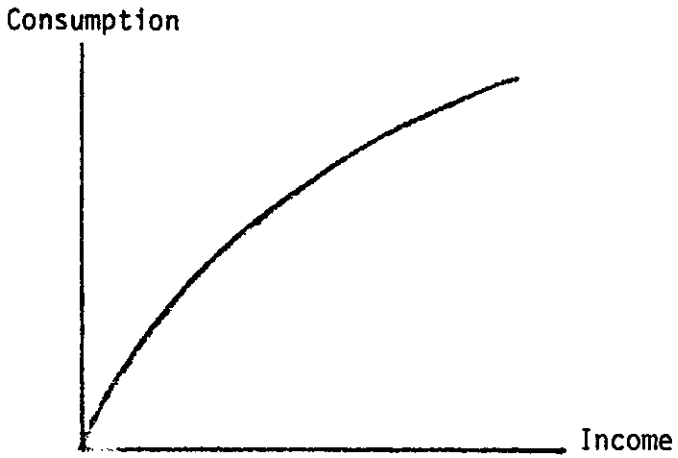
of preferences, sorghum requires processing before consumption; this feature makes rice very attractive in the Moorish consumption centers. The taste criterion has not been addressed by the RAMS survey.

The Mauritanian population totals approximately 1.5 million, of which 1/3 inhabit the cities. The income distribution between urban and rural population, as points out Martin (1982, p. 23), is quite skewed towards the urban population.

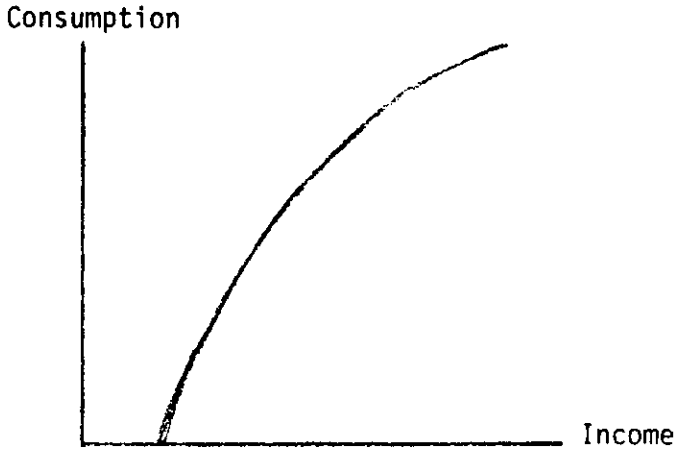
Relating income to consumption, an FAO study (1967) provides an extensive discussion of the types of the demand functions encountered in LDCs, reproduced in Figure 3.1. According to the FAO study, the case of Mauritania would logically fall into the group of log inverse functions, which the study associated with the countries consuming staple foods (cereals and starchy roots). The log-log inverse form implies an increase in per capita consumption up to a maximum intake, followed by a decline thereafter as income rises. For commodities other than staples, a semi-log or double-log functions was found appropriate. This result is not out of line with the income elasticity of 0.96 previously mentioned; it would signify that consumption is still very responsive to income change, or alternatively, that the saturation level is still far out of reach.

Consumption is also influenced by price policy. The government policy has been to keep market prices deliberately low to make food affordable to the poor. It is therefore a government pricing system that dictates in the market the levels of consumption. SONIMEX sets the market price in collaboration with the Ministry of Commerce and compensates its resulting losses on rice accounts with government subsidies and profits on sugar and tea, for which it also has monopoly

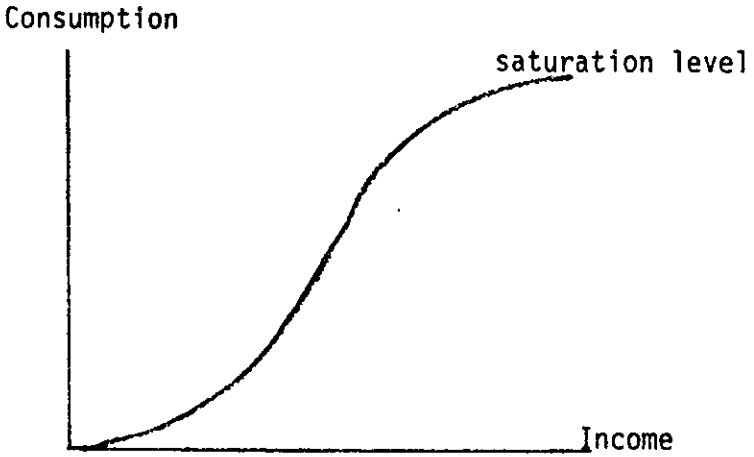
Figure 3-1. Nature of Demand Functions



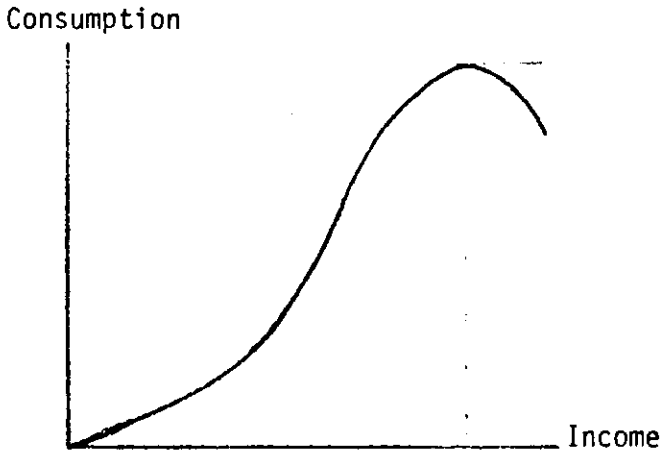
Logarithmic : log C = a + b log Y



Semi-log : C = a + b log Y



Log inverse : log C = a - b/Y



Log-log inverse : logC= a-b/y-clogY

Source: FAO, 1971.

power. RAMS found this consumer protection especially favorable to the urban consumer and disastrous for (1) production, (2) farm employment, and (3) the "welfare recipient's mentality" that would develop in the rural community, which believes that a free cereal distribution is guaranteed by the government. The way the government has been able to keep market prices low is through subsidy. Shearer (1983, p. 10) points out that prices of both domestic and imported rice are subsidized, just as are the prices of wheat, maize, and sorghum.

3.2 Supply of Rice

In some respects, the RAMS survey on irrigated agriculture constitutes a substantial piece of information which does not need to be duplicated. However, to supplement the RAMS study, an overview of the rice commodity subsector will be presented here. As mentioned earlier, three different sources of supply will be distinguished: domestic production, imports, and aid.

3.2.1 Domestic Production

The history of locally produced rice, as related in Chapter 2, goes back to mid-60's when BDPA first initiated the perimeters of DARELBARKA, BAKAO, and VINDING. The success of these first experiments, combined with declining production trends in the Oualo, established in the mind of the local authorities the soundness of an agricultural development policy. In 1971, 10 more perimeters were created, and from then on the number kept growing.

Rice production schemes can be divided into two classes: (1) small-scale (at village level) irrigated perimeters, or 25 ha on

average and (2) large-scale perimeters, over 1,000 ha. Sparling (1981), in his survey of Sahelian irrigation projects, arrived at cost efficiency estimates for small-scale perimeters as compared to large ones and concluded that small-scale perimeters are more profitable. Several reasons are cited to sustain this conclusion. Three large-scale perimeters are currently operated in Mauritania under direct government supervision. Only one private large-scale perimeter exists (at Tekane). By contrast, village perimeters are numerous along the Senegal River, and nearly every village is currently planning to construct one.

Two approaches have been tried by SONADER to launch village perimeters. In one approach, SONADER would select the site, undertake all the preliminary preparation of the perimeter, provide the necessary equipment (water-pumps, irrigation material, etc.) and supervisory personnel. The other approach, which we call the private village perimeters approach, refers to the villages perimeters without a prior feasibility study. Under this last alternative, SONADER and other international organizations (WAR & WANT, FAC, FED, etc.) provide the technical assistance and occasionally material equipment. The large-scale perimeters of GORGOL, BOGHE, and MPOURIE have mechanization and heavy equipment made possible through a project budget which involves foreign assistance. Within the compounds of the large-scale perimeters, a State-farm is usually managed alongside a people's perimeter under the same irrigation system. Most of the perimeters, when they are not State-farm, are managed and organized under a village cooperative.

Government intervention covers a wide range of activities, from providing inputs to planning the superstructure of the perimeter,

technical assistance, training, etc. Inputs are acquired and distributed by SONADER; these range from fertilizers to pesticides, seeds, and hydraulic equipment. Often agricultural inputs are exempt of taxes at import; even the fuel destined to rice fields is tax-exempt. The private village perimeters and other private perimeters owners benefit from some of these subsidies, since they may acquire credit facilities at the development bank (BMDC) and order inputs supplies from the various agencies.

Rice varieties used are all imported (IKP, IR8, TATSHU MOSHI, etc.) and may yield from 2 to 6 metric tons per hectare with fertilization. Double-cropping systems have been quite successful on an experimental basis but are not widespread due to competition with sorghum cultivation. Crop diversification has been encouraged, and most villages have found in irrigated sorghum a reliable substitute. The research system is working hard to establish its identity in developing better yielding varieties and appropriate technologies for irrigation. CNRADA is the single national research institution. CNFVA is an agriculture school aimed at training extension agents and serves a bridge between farmers and research. In every perimeter, there is at least one extension agent trained at CNFVA.

The main factors of production - land, labor, and capital - are not equally distributed in the production areas. While in the South-West land is fairly abundant, it is scarce in the area of Selibaby. Tenure is subject to opposing opinions, and a land reform has recently been decided upon by the government. Labor is probably the most controversial factor. Indeed, the literature has evolved from dealing with the problem of migration at the eve of independence

to a more complex concept of shadow price[8] and labor surpluses (Eicher, 1982, p. 33 and 99-105). Capital is the most limiting factor. To grow rice under irrigation requires a certain amount of equipment such as water-pumps, hydraulic equipment, etc., but also money to purchase fertilizers, seeds, etc. Both at the government level and at the level of private farms, this factor has been an impediment to the development of rice. Foreign assistance has been tremendously helpful in this respect, as in the example of COSOC at Rosso, CARITAS FED, FAC in between NDiago and Maghama.

3.2.2 The Foreign Sector

The foreign sector interacts with supply in two ways: directly through imports, and indirectly through the resource gap (current national deficit). Imports are relevant for their major contribution to total supply. Prior to 1970, imports were the major source of the marketed rice supply. Volume of imports has kept rising despite rising domestic production. A substantial unrecorded amount also flows into Mauritania every year from neighboring countries, because of either lower market prices abroad or family ties. The major source of imports is Thailand. The world price, represented in this case by the Thai export price (FOB), indicated drastic fluctuations, as illustrated by the sudden increase in 1980 of $80/metric ton. This unexpected increase has dangerous effects on the resource gap.

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[8] In Appendix B-1, there appears a graphical representation of how a shadow rate in the factor (labor) market is used to determine the optimum level of employment, and also what return (subsidy) the employer must receive in order to hire above the market rate.

Mauritania relies principally upon the foreign exchange earnings from iron ore exports to finance rice and other imports. The world price of iron exhibited a downward trend over the last decade.[9] In face of this declining foreign earnings figure, the resource gap registered a real increase[10] by a factor of 30 over the period 1973-1979 (from 321 to 8,911 millions of ouguiyas). Therefore, financial support support was sought and obtained from various foreign governments and agencies to bridge the gap.

3.3 Summary

At present, the agricultural sector in Mauritania is attracting the interest of both the government and a large number of international agencies. Their common objective is to raise productivity at the farm level and to increase total supply of the various commodities, especially rice. Meeting the demand of rice has been shown to be dependent upon production as well as upon marketing institutions and channels. For that reason, numerous government enterprises have been created to assist farmers to produce more and to assure an adequate distribution of the product to consumers. However, the transportation network is still disorganized and not well managed.

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[9]Table 15 (p. 157) of the World Bank report (1981) shows these annual averages of growth rates for Sub-Saharan Africa:

	Volume (%) for 1970-79	Price (%) for 1970-80
Copper	-.3	-18.7
Iron ore	-3.9	-13.0

[10]Deflated with GDP deflator.

Increasing consumption of rice and the shift away from indingenous food crop is just one example of an acculturation process that is taking place and in which "western" habits are being adopted. Economically, this shift is rationalized though through a tremendous decrease in sorghum production. In order to offset the decline in sorghum intake; rice production has had to increase. The government perceived this situation and therefore launched a vast program of rice production by opening new opportunities to farmers and providing limited assistance. Since the domestic supply still lags behind consumption, the government has had to import rice and to seek foreign aid. Indeed, in importing goods the country has used up a great deal of foreign exchange, more than what iron ore exports have been able to generate.

This chapter has provided a macro-level overview of the rice industry. In the next chapter, analytical tools will be examined that will enable us to look further into the industries, sectors, and factors relationships.

CHAPTER 4

QUANTITATIVE ANALYSIS OF MAURITANIA'S RICE SUBSECTOR

Although experienced farmers tend to rely on judgement in making decisions, government policy makers prefer to supplement their judgement with quantitative studies. A wide range of quantitative methods can be used for subsector analysis, including both partial and general equilibrium techniques. Several common quantitative mehtods are introduced in this chapter, with particular emphasis on econometric regression analysis. Because of inadequate data relating to the Mauritanian economy, no attempt is made actually to apply most of these methods. Rather, they are surveyed briefly to determine how they might be useful toward establishing linkages in the Mauritanian food system if more complete data were available. These methods include input-output analysis (IO), linear programming (LP), and computable general equilibrium models (CGE).

An econometric model is described in greater detail. The model has been developed to explore the potential usefulness of econometric techniques for providing insights into the rice subsector in Mauritania.

Description of the econometric model is preceded by a general discussion of the theory of supply and demand. The model was estimated using data from the period 1970-1980. The results are presented and discussed.

4.1 Input-output Models (IO)

Input-output analysis is based on a matrix representing amounts of goods and services that flow between sectors of an economic system.

This matrix provides a consistency check based on a series of material balance equations describing flows of resources or products. The basic (or static) IO matrix indicates how much of a resource or product from one sector is needed in all other sectors, as well as the resulting expenditures (or payment) in each sector on that resource or product. Therefore, the framework highlights the interdependence of the various productive spheres of an economy. For example, in the case of rice, IO analysis can indicate the quantity of rice by-products (e.g. hulls) needed for the livestock industry, the quantity of grain required for human consumption, the amount of manure to be purchased from the livestock subsector; etc.

The dynamic input-output model differs from the static model in that it embodies dynamic equilibrium and hence is viewed as a useful tool for determining long-run equilibrium growth paths. The characteristic feature of many dynamic IO models is that they endogenize investment.

However, due to the aggregated nature of available data on Mauritanian economic sectors, IO models could not be of any use to this study. Also, IO models alone cannot satisfy the objectives described at the outset of this analysis, the IO approach would undoubtedly have to be supplemented by some other techniques, such as LP and/or econometric models.

4.2 Linear Programming Models (LP)

Linear programming typically deals with the problem of allocating limited resources among competing activities in the best possible (i.e., "optimal") way. The technique is "linear" because all the mathematical

functions in the model are required to be linear functions (or approximatable by linear functions), and "programming" because it has to do with planning. In other words, LP involves planning activities to obtain "optimal" results, or results which maximize the specified objective among all feasible solutions.

Although input-output models have no endogenous mechanism for choosing among alternative feasible solutions, linear programming introduces this feature through inequality constraints. LP also permits calculation of "shadow prices" (also "shadow multipliers," or "scarcity indicators") which measure the importance of the constraints to which they are attached. The great flexibility of LP in permitting the addition or deletion of constraints permits experimentation with different variants of a basic model. Indeed, it is often possible to add or subtract equations and/or constraints without upsetting the overall consistency of the system or the ability to obtain a solution.

Linear programming techniques have tremendous versatility. Applications can range from micro-level problems (e.g. maximization of one farm's rice production subject to factor costs and resources availability) to macro-level problems (e.g. maximization of national rice consumption subject to import and domestic production constraints).

Despite its advantages, especially for a country like Mauritania where agricultural resources are limited and require a great deal of management, LP modeling was considered inappropriate for this study due to the limited availability of data.

4.3 Non-linear, Computable General Equilibrium (CGE) Models

Computable general equilibrium models may be thought of as combinations of input-output and linear programming models in which endogenously

determined prices adjust so as to equilibrate the results of individual optimizing behavior by actors in the economy. The main distinction between CGE and IO models is that the cells of CGE matrix[11] express the final demand vector for the entire economy, while IO matrix expresses an intermediate-demand (or sectorial demand) vectors. The main difference between CGE and LP models is that there is no link in LP models between the final demand vector and the factor incomes implicit in the solution, and there is therefore no feedback mechanism that would require an adjustment in prices (see Dervis, 1983, p. 136).

CGE models are sometimes called price-endogenous models, because all prices must adjust until the decisions made in the productive sphere of the economy are consistent with the final demand decisions made by households and other autonomous decision-makers. The solution in a CGE model reduces to that of finding a set of commodity prices (weights in the objective function in a linear programming model) such that market clearance takes place. There exist no arbitrary prices capable of equating supply and demand decisions. Prices that are generated from the basic matrix [12] are fed back to the final demand vector. It is this feedback element that makes CGE dynamic in nature and more appealing for planning purposes than any of the other techniques alone.

However, CGE models are not entirely appropriate for this study, since CGE models endogenous price and quantity variables are allowed

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[11]CGE models use a SAM (social-accounting matrix) framwork, a version of the IO matrix; there is no such thing as a CGE matrix.

[12]The basic matrix refers to inter-industry inputs values.

to interact so as to simulate the workings of the system. This allowance does not reflect what actually happens in a command-type economy such as the Mauritanian economy, where prices are determined as a result of both endogenous forces, but it could provide a standard for comparison.

4.4 An Econometric Estimation of Rice Supply and Demand Functions

Econometric models are designed to estimate parameters that describe functional relationships between the variables in an economic system. Econometric models can often be used to forecast the levels of endogenous variables and to calculate elasticities and/or flexibilities useful for policy decision-making. Several estimation procedures are available, depending on the structural relationship of the variables and the quality of the data.

Before the econometric model developed by the author is described, it will be useful to recall the general theory of supply and demand.

4.4.1 Theory of Supply and Demand

a. Demand

Neoclassical demand theory assumes that the individual consumer has an infinite number of wants and only a limited income with which to satisfy these wants. Therefore, the consumer is continuously confronted with a choice among many alternatives, and it is his or her goal to maximize total satisfaction (utility) by purchasing appropriate quantities of commodities.

The demand for a good is defined as a function representing the maximum quantities of a good that the consumer stands ready to buy at

various prices levels, ceteris paribus. Represented graphically, the demand curve is downward sloping. As more and more of the good is consumed, however, the amount of satisfaction derived from additional amounts of consumption declines. The willingness of the consumer to pay for additional amounts consequently falls. Therefore, increasing amounts of the good will be purchased only at a lower price.[13]

Change in demand is to be distinguished from change in quantity demanded. Change in demand indicates a shift of the whole demand curve in response to changes in factors such as population size, income, prices of substitutes and/or complements, or tastes and preferences. When income rises people may purchase more goods at a given price; in this case the good is said to be a normal good. However, if consumption declines in face of a rise in incomes, the good is said to be an inferior good. Price changes among complementary and substitute goods also shift the demand schedule for a good: the price of a substitute moves in the same direction as the quantity purchased of the good, while the price of a complementary product moves in the opposite direction to the quantity purchased of the good. Change in quantity demanded refers to a movement along the demand curve caused by a change in price.

The price elasticity of demand is the percentage change in quantity purchased that results from a 1% change in price; it measures the reaction of consumption to price changes and is calculated by the formula: price elasticity of demand = $\frac{\partial Q}{\partial P} * \frac{P}{Q}$ for any P, Q on the demand function. Price flexibility is the percentage change in price that results from

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[13]Alternatively, the downward sloping demand curve can be explained through substitution and income effects as follows. One may take more of a good if: (1) the price of the good decreases and no change in prices of substitutes takes place; (2) the good is important in the consumer's budget, and a decrease in its price leads to a real income increase which in turn allows the consumer to buy more of the good.

a 1% change in quantity demanded. When there is no substitute for a product or when the cross-elasticity with other goods is zero, the reciprocal of the flexibility is a good approximation of the elasticity.

If the absolute value of the elasticity coefficient is greater than one, demand is said to be elastic, meaning that the percentage change in quantity demanded is greater than the corresponding percentage change in price. If the absolute value of the coefficient is less than one, demand is inelastic. When the elasticity coefficient is equal to -1, demand is said to be of unitary elasticity. Demand is perfectly elastic when elasticity is infinite, or when the curve is totally horizontal, and perfectly inelastic when elasticity is zero, or the curve is vertical.

Price elasticities are of interest to producers, since a price fall will cause total revenue to increase along the elastic portion of the demand curve, to remain constant along a unitary elastic portion, and to fall along the inelastic portion.

The income elasticity of demand is a measure of the percentage change in quantity purchased arising from a 1% change in income. Normal goods have positive income elasticities. The price flexibility of income is the percentage change in price in response to a 1% change in income, other factors remaining constant. The flexibility of income is typically expected to be positive; a higher income implies a higher demand, which in turn suggests a higher price for a constant quantity.

A special case in this relationship of income-price-and quantity applies to the giffen case, where a lower price is associated with a

smaller quantity demanded. It follows that the price elasticity has a reversed sign (positive rather than negative). The giffen case arises when income effect is large enough to offset the substitution effect as a consequence of a price increase or decrease.

Market demand is the summation of consumers' individual demands (or the "average" demand times total population). Any increase in population would shift the demand curve to the right, i.e., a greater quantity demanded at a given price level.

b. Supply

Whereas in the case of demand the consumer attempts to maximize satisfaction (or utility), in the case of supply the producer attempts to maximize net returns. A supply function can be derived from a knowledge of input-output relationships and prices. The supply curve shows the maximum quantities of a given commodity producers will be willing to offer for sale (per unit of time) at various prices, ceteris paribus. The supply curve should slope upward and to the right. To induce producers to put forth more effort to produce a greater supply, a greater reward must be offered in the form of higher output price.

As in the case of demand, it is important to distinguish between movements of the supply curve itself and movements along a fixed supply curve.

Factor costs (land, labor, and capital) and technological innovations are the principal shifters of the supply curve. Rises in factor prices tend to shift the supply curve to the left, increasing supply price at constant quantity, while technological innovations which reduce production costs shift it to the right, lowering supply price

at each quantity. Additional shifters of the supply curve include: changes in returns of substitutes in production, weather, off-farm employment opportunities, changes in prices of joint-products (or by-products), and institutional constraints. When these variables are not held constant but are allowed to move, then the curve relating output response to price changes is called a "response relation." Unlike the simple supply curve, the supply response relation is not reversible, e.g. if price increases and then decreases, quantity does not return to the original level.

The price elasticity of supply expresses the percentage change in quantity supplied in response to a 1% change in price, ceteris paribus. An increase in quantity supplies is normally associated with a rise in price. Just as in the case of the demand function, the elasticity coefficient varies in magnitude along the supply function, unless the function is linear and passes through the origin or is non-linear, as in the example of a logarithmic function where the elasticity coefficient may be constant along the entire function. An elastic supply is characterized by an elasticity greater than one; an inelastic supply is characterized by an elasticity ranging between zero and one; and a zero elasticity means that supply is fixed or perfectly inelastic. Supply elasticities are relevant for forecasting purposes, because they make possible prediction of the production increases or decreases likely to result from price changes.

4.4.2 The Price Analysis[14] of Rice in Mauritania

4.4.2.1 The Economic Model Specification

Based on the above theoretical discussion, the factors affecting supply and demand for rice in Mauritania can now be identified.

Three main variables are hypothesized to determine consumption levels: population, income, and price.

Changes in population have a direct influence on market demand relations. At all ages, rice is consumed in one form or another. As far as ethnic groups are concerned, rice consumption patterns differ; due to the lack of accurate figures, no attempt will be made to differentiate the impact on demand by ethnic groups. The author will be content with aggregate figures reported by the World Bank Study (1981, p. 176), e.g. total population of 1.5 million, and annual average growth rate of 2.7% (For a more detailed discussion of population influence on demand, see the RAMS study entitled "Rural Sector Consumption Patterns in Mauritania," 1980). To reduce multicollinearity problems between population, income, and consumption (i.e., correlation between these explanatory variables), consumption figures were all converted to a per capita basis.

Income is another important demand shifter, as explained in the theoretical discussion. Like population, income can be examined from different perspectives: in its structure, income is not the same in the urban sector as compared to the rural sector; in each group,

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[14]Price analysis here refers to the quantitative study of demand-supply-price relationships.

sources of income generation are distinctive, and the distribution varies, as indicated by different Gini coefficients[15] (index of income concentration). Furthermore, budgetary surveys by RAMS show dissimilar patterns of expenditures, the rural nomad purchasing less cereals and consuming more milk and dairy products. These patterns are described in the Table on annual consumption patterns in Appendix A-II. From the same table, rice is shown to take 43% of the family budget expenditures on cereals in the urban sector, as contrasted to 50% spent on sorghum. In the rural sector, auto-consumption satisfies 51% of cereals consumption needs, suggesting that little cereal is bought in the market; no further indication of disaggregated consumption expenditures is given concerning individual food preferences. A more complete coverage on this subject figures in RAMS surveys on income and consumption. Based on the available evidence, income is expected to be positively related to quantity demanded (case of a normal good).

Price is related to quantity demanded. The direction of causality is yet to be established. The pricing system in Mauritania probably does not reflect market behavior alone. In recent years, there seems to have been an insurgence of small traders attempting to recapture a segment of the market following government attempts to exercise monopoly power in the name of socialism. Traders and merchants are personally acquainted with consumers and are able therefore to create

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[15]The Gini for the sedentary sector has been estimated as R = 0.46 and for the nomadic sector as R = 0.41. The Lorenz curve shows 70% earning 35% of total income; see RAMS, 1980 for details.

a more permanent and stable influence on their clients,[16] while the government from a distance dictates its laws and decrees with little or no direct control. Unfortunately, the only reliable price figures that can be analyzed here are those for which an official record is kept, and those are the government prices. The government influences prices at two levels. Through SONIMEX, official prices are set to local producers. In recent years, the official producer prices have not even covered production costs when government subsidies are netted out (see Appendix A-III for a further discussion about production costs under traditional farming and modern farming for single crop versus double crop, and different yield hypotheses). Consumer prices are also set by the SONIMEX marketing board.

Producer price and consumer price are related by a marketing margin, which for purposes of this study is assumed constant for the period under investigation. Actual marketing margins were relatively constant during the 1974-80 period. The government also influences rice prices by subsidizing transport and deliberately commanding SONIMEX to maintain prices low. In the case of donated rice, which is provided to the government by foreign donors free of charge or at concessionary prices (e.g. to cover transport costs), free distribution has been promoted for indigent people, who as a result have developed a taste for rice.

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[16] RAMS findings provide evidence of this; these findings indicate (p. 46): (1) on regional markets consumer prices were higher than official prices, (2) prices varied from region to region, and (3) seasonal price variations within a single region were high.

The retail price of rice is hence considered to be a predetermined variable, set by government agencies. The price which is given in Table 4-1 is essentially determined by acquisition costs of imported rice, to which SONIMEX adds its marketing margin. Figure 4-1 shows the marketing channels of rice as viewed by Martin. The confederation of employees and artisans represents all types of merchants who assure middlemen functions between SONIMEX and the consumers; these merchants in turn add a margin to their costs. The higher these margins, the higher the retail price and the lower the quantity demanded. Price is therefore expected to be negatively related to quantity demanded (if rice is a normal good).

The question of deflating arises often in model specification. When prices and income increase (or decrease) at approximately the same rate and demand remains unchanged, then econometric theory suggests deflating. However, when changes in the general price level appear to have an "illusion effect" on the demand for a product (meaning the demand for the product changes in response to nominal prices, even though real prices have not changed), then including a price index, e.g. the CPI, is more advisable (see Tomek and Robison, 1981, p. 319-322).

A CPI increase may mean an increase in prices of substitutes, and that in turn suggests a higher quantity demanded of the product. In this case a positive relationship is expected between CPI and consumption. CPI may also be meant to capture trends; that is, through time per capita consumption increases. Yet, if rice were important in CPI composition (for which there is no information available) then there would be a high correlation with consumer price.

Table 4-1. Consumer Price of Rice

Years	Nominal Price in UM/kg	CPI (1975 = 100)
1970	5.9	63.3
1971	5.2	68.2
1972	4.9	73.7
1973	9.4	79.4
1974	14.9	89.4
1975	16	100
1976	16.4	114.4
1977	17.4	126.2
1978	18.6	135.1
1979	19.4	147.5
1980	20	163.4

Source: RAMS surveys.

The supply of rice in Mauritania consists of domestically produced rice, imported rice, and rice donated in the form of food aid. Domestic production can be calculated as the product of total hectarage planted to rice times yield.

Yield can be thought to vary mainly as a function of input costs, technology, product profitability, climate, and time. Technology includes biological technology as this is defined in Chapter 2 (e.g. varietal improvement) and cultural technology (e.g. improvements in cultivation methods). Climate refers mainly to temperature levels and amounts of precipitation, which together have a tremendous influence on yield in a country as arid as Mauritania. Inputs costs and product price can be hypothesized to have an indirect effect on yield, inasmuch as they affect expected net revenue. Product price here refers to market price, which the farmer will obtain by selling rather than consuming. The amount of fertilizer purchased by the farmer depends on the potential profit. Referring back to rice marketing (Figure 4-1), farmers seek this higher price from traders, thus opening avenues to parallel markets. Yield is also expected to change over time; long term trends reflect gradual changes such as soil depletion, etc., as exacerbated by the double crop system (see difference in yields in Appendix A-III).

Area or hectarage is assumed to be under the direct control of the farmer, who will expand or contract production independently of SONADER depending on the profitability of rice cultivation.[17] Area

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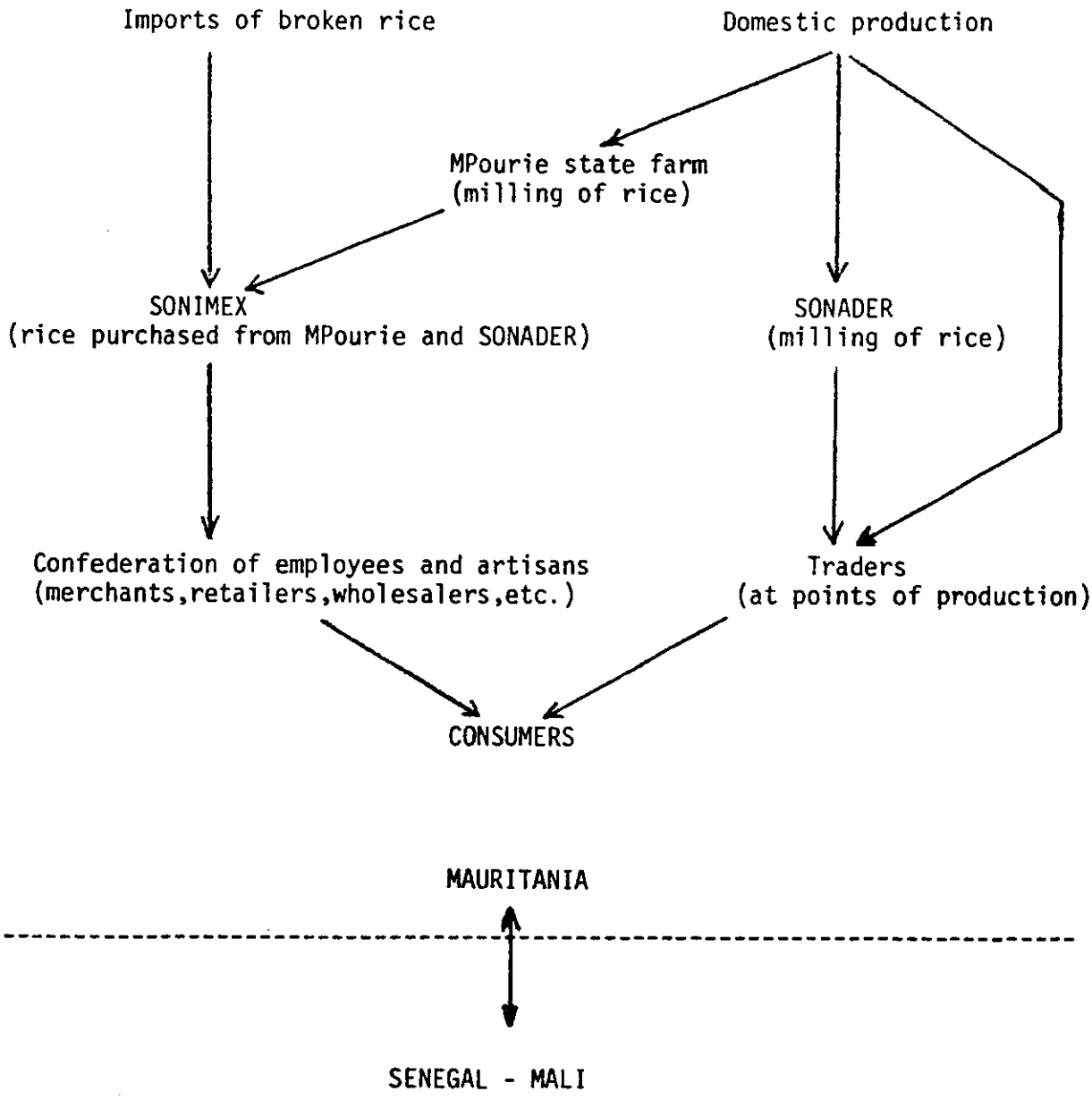
[17]This is not an unreasonable assumption, provided SONADER maintains the terms of the contract in turning over management of the perimeters to farmers as soon as they prove themselves capable.

Figure 4-1. Rice Marketing



Source: adapted from Martin, 1982, p.42

planted to rice can be thought to vary mainly as a function of producer price of rice, area currently under rice production, inputs costs, prices of substitutes in production (sorghum), and technology. Producer price but not market price is actually what the farmers expect to obtain for their crops if the government exercises a rigid control in the market.

The area currently planted to rice will influence the farmer's decisions about next year's planting due to asset fixity, profitability of the current crop, and soil depletion.

Technology is an important determinant of area. The more tractors, water pumps, and equipment the farmer has, the more likely he/she will expand area.

Increasing profitability of complementary products or by-products is likely to play a role in influencing the farmer to grow more rice. In contrast, increasing profitability of substitutes and drought are expected to have a negative influence on the farmer's decision to expand area.

Imports are another source of rice supply and are assumed to be a function of the world price, foreign exchange earnings (or credit-worthiness of Mauritania abroad), and profitability of rice substitutes in consumption. While world price is expected to be negatively related to quantity imported, foreign exchange earnings are likely to positively influence imports. A higher price of a rice substitute (in consumption) would indicate a lower supply of that substitute (provided it is a normal good), which in turn calls for more imports of rice; the relationship is hence expected to be positive.

4.4.2.2 Statistical Model Specification

The complete model appears below:

- Demand:

CONSUP = f (CPRT, INC1, CPI, DV2)

- Supply:

Yield = f (CPRT, TECHNO, _ _ _ _ _)

Hectarage = f (PPRT, DV1, _ _ _ _ _)

Imports = f (FOREX, SPT, _ _ _ _ _)

DQPR = Yield * Hectarage (by definition)

TOTSUPPLY = DQPR + Imports (by identity)

where: Hectarage in '000 Ha, Yield in tons/Ha, and Imports in '000 tons

CONSUP = Per capita annual consumption (in kg)

INC1 = Per capita GDP at market prices used as proxy for per capita annual income (in UM)

CPRT = Consumer price of rice (in UM/kg)

PPRT = Producer price of rice (in UM/kg)

SPT = Sorghum price (in UM/kg)

FOREX = Foreign exchange earnings (in millions UM)

DQPR = Domestic quantity produced of rice (in '000 tons)

TOTSUPPLY = Total supply (in '000 tons)

CPI = Consumer price index (1975 = 100)

TECHNO = Technology = 1 for 1973-80 and zero elsewhere representing investment in technology to offset drought effects

DV1 = Dummy variable = 1 for 1973-75 and zero elsewhere representing the drought effects

DV2 = Dummy variable = 1 for 1975 and zero elsewhere, representing an unusual drop in consumption of rice in 1975 only.

(see Appendix A-I for complete listing of data and data sources)

The practice of government price fixing in Mauritania made it questionable to use price as the endogenous variable in the demand equation, since price is thus predetermined. Therefore, a quantity-dependent specification was chosen based on Waugh's arguments (1964).

In 1975, the import figure dropped considerably (from 32,000 to 8,000 tons); the world price cannot be blamed, because world price for that year was lower than in 1974. Probably the decrease in imports was related to the foreign exchange earnings decrease of about 55%, combined with the country's need for arms arising from the Western Sahara conflict, which occurred the same year. A dummy variable (DV2) was used to account for the unusual circumstances associated with 1975.

DV1 refers to the drought years of 1973-75, in which severe ecological disturbances caused people to starve, animals to disappear, and desertification to progress. Agricultural production was seriously depressed. Area cultivated decreased drastically during this period. The government and especially foreign donors invested important amounts of effort and funds to equip the farmers with what in the model has been called "technology." Technological changes are represented by a dummy variable and are included in the yield equation to account for change in yield per unit of area, as was anticipated in Chapter 2 by the conservation model.

Gross domestic product (GDP) at market prices was used as a proxy for income, which was not available for the entire period under investigation.

All equations were specified in linear form, implying a constant slope over the range of the data. Logarithmic specifications were also tested, with no significant improvement in the results (see Appendix B-II for alternative specifications results). The ordinary-least squares (OLS) estimation procedure was used owing to its desirable properties: lack of bias, efficiency, minimum MSE, and consistency if the usual assumptions hold. Demand and supply equations were estimated independently and not as a simultaneous system because price is exogenously determined.

- Omitted Variables:

To ensure simplicity, to improve statistical tests, and to prevent statistical problems, several variables were deleted from the equations.

In the demand equation, income was converted to per capita basis, as opposed to the alternative of including population as an independent variable, which might have led to multicollinearity problems.

On the supply side, several lagged variables in both yield and hectarage equations were tested and later omitted. A commodities price ratio (sorghum-to-rice) was tried in both the yield and area equations, but failed the statistical tests. Rainfall figures were not available for the entire period, and in any case the rice crop is irrigated, which make it less vulnerable to precipitation. World price of rice was also deleted from the import equation due to poor statistical results, as can be seen in Appendix B-II.

- The Data

Two sets of data are available describing the Mauritanian economy. One consists of government estimates used by different sources such as the IMF, the Ministry of Economy and Finance reports, FAO, FAC, etc.

The other is derived from surveys conducted by RAMS using the polling method. Organizational handicaps, survey personnel quality shortfalls and financial constraints are the main reasons cited by RAMS (p. 4) for choice of the polling method. Data were hence obtained from "polling surveys" conducted on random samples of villagers (on the basis of 1 person per 1,000).

Shearer (1983, p. 1), in an evaluating mission of RAMS studies, points out:

> "RAMS made a valiant effort to plug some of the gaps but could obviously not advance very far during the project's limited duration."

Commenting on the difficulty in Mauritania of obtaining reliable data, Shearer says (p. 1):

> "Not only are there few qualified statisticians and analysts in the central administrations; there are no trained data gatherers in the field and there is little or no confidence among the rural population in the motives of public employees, (or foreign researchers) asking questions about land, production, livestock numbers and ownership, incomes, and consumption."

The reticence of the rural population to cooperate with RAMS enumerators was based on fear of higher taxation and fear of removal from the list of indigent people who receive quarterly assistance in form of food aid. Therefore, income and consumption are likely to have been underestimated, and the number of budgetary units (defined as the number of household dependents) overestimated (since respondents wanted to be eligible for higher amounts of aid).

Government data, which are usually reported by such institutions as IMF, FAO, the World Bank, FAC, etc., have the same fantasy feature built-in. Indeed, the data are derived from government personnel reports. These reports are drawn upon figures that are generated by

government officials in the interior. However, in the interior the civil servants' tendency to exaggerate numbers is well known; even a well-intentioned agent would be handicapped by the lack of financial means and by the lack of training from engaging in reliable work.

4.4.2.2 Estimation Results

Only the best equations are reported herein.[18]

a. Demand equation:

(1) CONSUP = 5.8 - .004 INC1 + 1.39 CPRT + .62 CPI - 16.43 DV2

t-statistic = 4.59** 3.57** 5.7** -5.45**

R^2 = .98 D.W. = 1.64

Mean CONSUP = 26.57

Mean INC1 = 15102.5

Mean CPRT = 13.46

b. Supply equations:

(2) Yield = 1.09 + .22 CPRT + 1.24 TECHNO - .018 CPI

t-statistic = 1.8* 1.48 -1.35

R^2 = .91 D.W. = 2.47

Mean Yield = 3.02

Mean CPRT = 13.46

(3) Hectarage = .575 + .172 PPRT - .425 DV1

t-statistic = 4.74** -2.06*

R^2 = .82 D.W. = 2.04

Mean Hectarage = 1.55

Mean PPRT = 6.36

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[18] See Appendix B-II for other estimated equations, including some variables not described above.

(4) Import = 4.35 + .956 SPT + .161 FOREX

t-statistic = 2.2* 2.03

R^2 = .74 D.W. = 2.04

Mean Import = 30.73

Mean SPT = 17.36

Mean FOREX = 60.54

*Significant at 10% level or better

**Significant at 5% level or better

4.4.2.3 Discussion of Results

In appraising the results (and recalling the quality of the data), a level of significance α = .10 is specified unless indicated otherwise.

a. Demand

- Coefficients:

The coefficients in the demand equation are estimates of the net relationship between the respective explanatory variables and the quantity demanded; each represents the change in the dependent variable associated with a one-unit change in the particular independent variable, ceteris paribus.

In constructing the model, it was stated that a positive sign was expected for income and CPI coefficients, while a negative sign was expected for the coefficients on price and on the dummy variable (DV2). The results suggest that the coefficients on income and price are not consistent with the logic of the model. These results would appear to indicate that rice in Mauritania is an inferior good. Furthermore, price is related positively to quantity demanded, meaning that rice may even illustrate the case of a giffen good.

The magnitude of the coefficients is a function of the units (e.g. kg or tons) used to measure the variables. For example, the coefficient on income represents a decrease by .004 kg per person per year in consumption as a response to a one-unit (UM) increase in income, ceteris paribus. In other words, one more ouguiya added to the consumer's income would lead to a decrease in consumption of rice of .004 ton (or 4 kg) per year and per person. This result is hard to believe compared to other studies, which found a positive sign on the coefficient. The student's t-statistics, which are calculated as the ratio of the individual estimated coefficients to the estimated standard errors, are relevant to test whether or not the estimated coefficients are significantly different from 0 at the specified level of significance. Equivalently, a confidence interval can be constructed from the coefficient and its standard error to provide a range of values which are likely to contain the true regression parameters. With every confidence interval there is a level of statistical significance. The t-statistic shows that each variable has a coefficient significant at the stated α level.

- $\underline{R^2}$:

The coefficient of determination (R^2) gives a measure of the degree of linear association between the dependent variable and the collective independent variables. $\bar{R}^2$ is the coefficient of determination corrected for the degrees of freedom (i.e., number of explanatory variables). The .98 level indicates a strong association; the independent variables are associated with 98% of the variation in the quantity demanded.

- D.W. test:

When error terms in a time series regression model are correlated with one another, there exists serial correlation which affects the efficiency of OLS regression estimators. The Durbin-Watson statistic is a good indicator of possible serial correlation. From the formula

$$D.W. = 2\ (1 - \hat{\rho})$$

(which is used instead of a test using the statistical tables because of a degrees-of-freedom problem) and given the value of D.W. = 1.64 for the demand equation, rho may be approximated to be .18, which is relatively low (not far from zero), indicating little or no serial correlation.

b. Supply

b.1 Yield

- Coefficients:

The coefficient on consumer price in the yield equation was expected to be positive, and likewise the coefficient on technology. The results show that the estimated coefficients are consistent with this logic. The coefficient on CPI, which was included to capture the trend on general prices, turns out to be negative, as could have been anticipated. Indeed, a general price increase lowers farmer's real revenue, thus decreasing purchases of farm inputs such as fertilizer.

The magnitude of the coefficient on consumer price is .22, indicating that a one-unit change in the price, or an additional ouguiya per kg, is associated with an additional .22 units in yield (i.e., .220 tons/ha or 220 kg/ha).

-t-statistics:

The test indicates that only the coefficient on consumer price is significant at the specified level of significance. Yet, the author feels strongly that technology and consumer price index influence productivity or yield, as explained above.

-R^2:

With R^2 = .91, a strong association is indicated between the independent variables and the yield variable.

-D.W.:

D.W. = 2.47 implies an estimated rho of -.23, which is still relatively low and indicates little or no serial correlation.

b.2 Hectarage:

-Coefficients:

The coefficient on producer price was expected to be positive, while the coefficient on the dummy variable (representing the drought period) was expected to be negative. The results are consistent with expectations.

The coefficients indicate the size of the response of area cultivated to a one-unit change in producer price. A one-unit change in producer price (or an additional ouguiya per kg to the farmer) is associated with an increase of hectarage units by .172 (or 172 ha).

-t-statistics:

Indicate that both coefficients of producer price and of DV1 are individually significant at the specified α.

-R^2:

A relatively strong association is demonstrated by R^2 = .82 between the explanatory variables and the dependent variable.

-D.W.:

The estimated rho is approximately .02, as derived from the D.W. = 2.04, indicating no serial correlation.

b.3 Imports:

-Coefficients:

All coefficients were expected to be positive, and the results are in concordance with the logic.

The magnitudes of the coefficients show an increase of about 956 tons and 161 tons respectively in response to a change of one-unit in sorghum price (1 UM/kg) and one-unit in foreign exchange earnings (1 million UM).

-t-statistics:

The t-statistics indicate significance of the coefficients at the specified α.

-R^2:

With an R^2 = .74, there appears to be considerable association between the included variables and the import variable.

-D.W.:

An estimated rho of approximately .02 is implied, with a D.W. = 2.04, indicating no serial correation.

c. Elasticities

Computations of estimated elasticities appear below, and an appraisal and comparison with elasticities in other published studies follows. The price elasticity of demand of 0.7 (computed at the arithmetic means) can be interpreted as the percentage change in quantity demanded as a response to a 1% change in consumer price, other factors held constant. Since the slope is positive, the

calculated elasticity is rendered ambiguous however; the finding suggests a positive response of quantity demanded to price increase, which is inconsistent with economic theory if rice is a normal good. If this result were to hold, then there is some reason to believe that rice may be illustrating the case of a giffen good.

Elasticities Calculations:*

- Price elasticity of demand at the means =

$$\frac{\partial\ CONSUP}{\partial\ CPRT} * \frac{CPRT}{CONSUP} = 1.39 * \frac{13.46}{26.57} = \underline{.70}$$

- Income elasticity of demand at the means =

$$\frac{\partial\ CONSUP}{\partial\ INC1} * \frac{INC1}{CONSUP} = -.004 * \frac{15102.5}{26.57} = \underline{-2.27}$$

- Yield elasticity or price elasticity of yield at the means =

$$\frac{\partial\ Yield}{\partial\ CPRT} * \frac{CPRT}{Yield} = .22 * \frac{13.46}{3.0} = \underline{.98}$$

- Hectarage elasticity, or price elasticity of area, at the means =

$$\frac{\partial\ Hectarage}{\partial\ PPRT} * \frac{PPRT}{Hectarage} = .172 * \frac{6.36}{1.55} = \underline{.70}$$

where: CONSUP = per capita consumption

CPRT = consumer price of rice at t

INC1 = per capita income

*The domestic supply elasticity computation appears in Appendix B-III.

The income elasticity of -2.27, computed at the means, suggests that a 1% increase in income would lead to a 2.27% decrease in rice consumption. This result is indicative of a good that is inferior.

These results are perplexing, yet they are difficult to compare with previous studies, especially RAMS surveys and Martin, since those were calculated from data aggregated across all cereals. Furthermore, the RAMS figures and Martin's figures of elasticities are similar;

this must not be a surprise, because Martin used the same figures as RAMS in most cases. RAMS surveys indicate an income elasticity of .5 for cereals. The price elasticity of demand specifically for rice was not available, and an aggregated figure for cereals of .44 is reported. Martin, without providing a figure, states (p. 59) that the demand for cereals is kinked and very inelastic at the minimum consumption requirement. Since the yield and hectarage equations are based on different price series, a net price elasticity of supply, or production response to a market price change, is computed and discussed in Appendix B-III. However, supply response must be broken down into a yield response to changes in CPRT and a hectarage response to changes in PPRT. Yield response of .98 is close to unitary, while area response is inelastic. (.70). The price elasticity of yield indicates a percentage in yield of .98 in response to a 1% change in consumer price. The price elasticity of hectarage, .70, is the percentage change in hectarage in response to a 1% change in producer price. Given that many Mauritanian farmers seem eager to increase production, this evidence that they apparently do respond fairly well to price increases (with a total elasticity with respect to market price above 1.0) seems to indicate that higher production may be obtained if appropriate incentives (especially prices) are provided and external constraints (i.e., non-price) are removed.

d. Assessment of the Results

The results obtained from the model are generally disappointing. Estimates for the most part do not conform to expected figures, and they in fact are difficult to believe.

If these results do not reflect reality, then the problem may be attributed primarily to the data. Only 11 observations were available, and they are of poor quality. SONADER representatives may exaggerate yield figures just to make themselves look good. Estimates of production are probably underestimated, because government purchases do not include cross-boundaries sales, local sales (to traders), and auto-consumption.

Market structure is too unstable to yield good results. Considerable institutional changes have occurred in recent years, and this has led to poor statistical results.

Specification error is another possible source of problems. For example, some illegal activities have not been accounted for in the model, such as smuggling and illegal sales at non-official prices. Also, there may be collinearity between several independent variables.

4.5 Summary

Different quantitative approaches have been sketched to indicate their potential usefulness in analyzing the Mauritanian rice subsector. An econometric model was developed in an attempt to understand the economics of rice in Mauritania.

The results of this estimation of supply and demand functions highlighted some relationships which, if they are to be believed, may provide policy-makers with useful parameters on which to focus in order to achieve higher production figures. The results may even provide evidence that rice in Mauritania has the characteristics of an inferior good. The results were obtained by regressing on the demand side per capita consumption on price, income, the price index, and a

dummy variable for drought. On the supply side, domestic production (defined as yield times hectarage) was added to import and aid. Yield was regressed in turn on consumer price, CPI, and technology; hectarage was regressed on producer price and a dummy variable representing drought; and import was regressed on foreign exchange earnings and sorghum price.

The best estimates of each function have been presented, and their statistical soundness discussed. Coefficients of income and price in the demand function have signs which contradict economic theory if rice is a normal good and which suggest that rice is not only an inferior good, but also a giffen good.

Elasticities figures have been computed. Questions must be raised concerning the estimated elasticities, which do not seem to conform with those estimated in other studies.

However, the quality of data is questionable and the length of the data series short, all conclusions must be considered tentative and judged in relation to other studies and future work. For example, it would be useful to try to better understand the tastes and preferences of urban consumers in order to determine if there is a logical possibility that rice is a giffen good.

CHAPTER 5

RICE POLICIES AND PRIORITIES

The World Bank report, Accelerated Development in Sub-Saharan Africa, (1981), classifies Mauritania in the lowest group of countries in terms of growth rate of agricultural production during the period 1969-79. Within the lowermost group, Mauritania is ranked last, with an average annual growth rate of -1.4%. Of course, this rate refers to agricultural production in general; as the data indicate elsewhere (see RAMS), rice production marked a clear upward trend. The present concern should be to understand why this increase in rice production has not been much greater. Symptoms of the low rate of increase in rice production have been laid out in the preceding chapters. The discussion that follows in Chapter 5 is intended to address the problem of how surpluses in rice can be generated to satisfy not only the current demand for the commodity, but also to overcome the increasing food shortages created by the persistent decrease in sorghum production.

With this objective in mind, the substance of the findings is first reviewed, and then some tentative policy recommendations are formulated. The chapter is organized so as to make a clear distinction between demand and supply treatments, with a focus on the latter, for which more intelligible results were obtained. Critical research studies needed for future policy work are also identified.

5.1 Policies and Priorities in Regard to Demand for Rice

5.1.1 Substantive Results of the Model

Three fundamental points have been suggested by the results of the demand equation:

(1) a positive relationship exists between prices and quantity demanded of rice;

(2) a negative relationship exists between income and quantity demanded of rice;

(3) a positive relationship exists between the consumer price index and quantity demanded of rice.

The first two points would appear to suggest that rice in Mauritania is an inferior good, perhaps even having the properties of a giffen good (which could only hold, if at all, over a limited range of prices). The third point would appear to indicate that as a result of a rise in the general price levels relative to the price of rice, people will buy more rice.

In the eyes of the author, (i.e., based on personal observations) rice in Mauritania is not an inferior good. Indeed, it has been a tradition in rural Mauritania to express good hospitality by slaughtering a sheep and to bestow a rice-based meal. Consumption in rural areas has almost certainly been increased as a result of the use of rice in the urban areas, which serve as models to the rural villages. However, the results, obtained during the present study cast doubt on this belief. The apparent contradiction between the author's expectations and the results suggests that too little is known about actual demand relationships. The growing scarcity of sorghum and other traditional crops may

be partly responsible for this misconception about the superiority of rice; perhaps people's tastes and preferences are undergoing modifications. Several other hypotheses can be developed to explain this contradiction, but more formal studies with improved data are likely to lead to greater insights.

5.2 Policies and Priorities in Regard to Supply of Rice

5.2.1 Substantive results of the Model

The results on the supply side generally conform to expectation and seem to indicate:

(1) yield decisions and area decisions are made on the basis of different prices,

(2) yield and area are relatively sensitive to price changes, and

(3) total domestic supply is elastic.

5.2.2 Recent Government Rice Policies

Based on recent empirical evidence (e.g. low producer price during the period 1970-80), we surmise that the objective of government policy has been to encourage auto-consumption in rural areas and at the same time to discourage domestic production for sale in Nouakchott, the major consumption center (12% of total demand in 1980) because imports are cheaper there. The hypothesis of encouraging auto-consumption in production areas is supported by the government's policy of subsidizing inputs (fertilizer, seed, and machinery) even though little or no credit is made available to the farmers to enable expansion of farms to commercial sizes. Total demand for rice in the producing areas is quite high

(42% of total demand in 1980), so that it makes sense to encourage auto-consumption whenever locally produced rice is cheaper than imported rice.

5.2.3 Policy Issues to Achieve Higher Production Objectives

Two questions concerning rice policy should be raised at this point:

(1) Could the government use various policies to increase production incentives (since this study seems to indicate a positive although supply response) and then distribute the resulting surpluses to major population centers in the interior?

(2) Could domestic production costs be lowered sufficiently to make domestic rice competitive with imports even in Nouakchott?

In reference to the first question, imports are definitely a cheaper source of supply in Nouakchott because there are no overland transport costs, but presumably in the South, South-East, and East domestically produced rice is less expensive than imports. What is needed then is: (a) to identify production incentives (which will be addressed in the next sub-section), and (b) to undertake comparative studies of the economics of distributing domestic rice versus imports to the major interior cities (see Table 5-1 and map for population decomposition and locations of cities).

In regard to the second question, a priority in the government agenda should be to determine whether domestic research institutions are well equipped to address research on technological innovations and to reduce production costs.

Table 5.1

Population decomposition in 1980

(in '000 inhabitants)

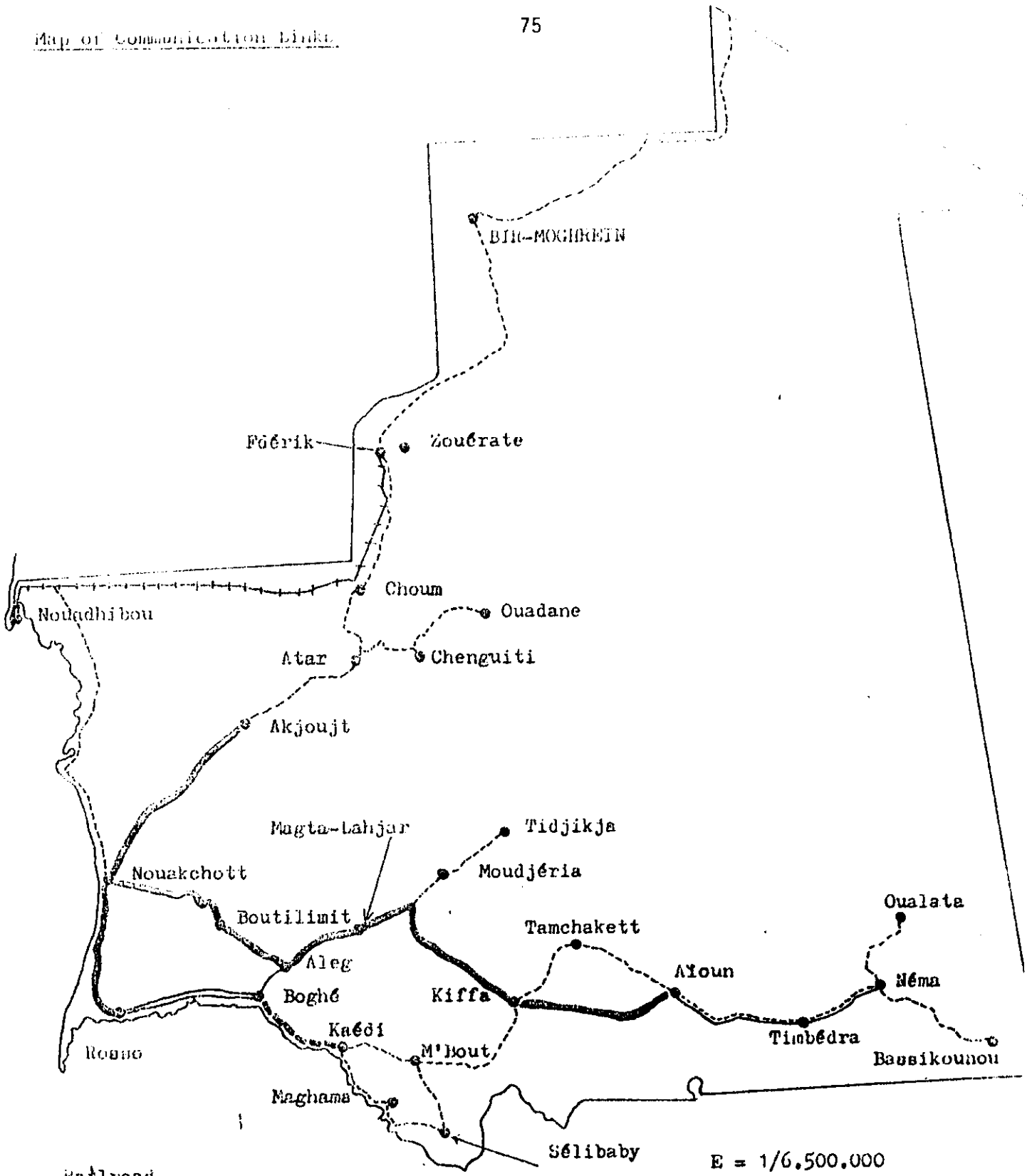
Regions	Nomads	Sedentary	Urban	Total
0.Nouakchott			173	173
1.Hodh El Charki 2.Hodh El Gharbi 3.Assaba	181	216	35	432
4.Gorgol	16	119	23	158
5.Brakna 10.Guidimaka	48	179	22	249
6.Trarza	102	95	27	224
8.Nouadhibou	-	4	26	30
7.Adrar 9.Tagant 11.Tiris-Zemmour 12.Inchiri	62	67	48	117
Total	409	680	354	1443
%	28	47	25	100

Source : Martin, 1982, p.133

Note :

RAMS total population figure differs by about 100,000 from IMF data in appendix A-I.(3),illustrating the discrepancy in the data which was referred to earlier.

Map of Communication Links



Railroad

Paved Road

Road Under Study

Dryweather Track

Prepared Paved Road

Improved Tracks (under construction)

Towns

Source : RAMS, 1980

5.2.4 Specific Policy Tools and Their Implications

Given that increasing production and lowering production costs are desirable policy objectives, an interesting question would be to ask, what specific policy tools should the government consider? Three main policy areas that are under the control of the government must be considered:

(a) incentive structures,

(b) institutional changes, and

(c) expanding agricultural research and extension capabilities.

a. Incentive Structures

Farmers' enthusiasm for increasing production can be mobilized only voluntarily, i.e., when proper stimuli are provided and external constraints removed. The World Bank report (1981, p. 55) indicates that seven out of nine projects implemented under favorable prices achieved or surpassed their production objectives; and 13 of the 18 under unfavorable prices failed to do so. The present study has shown (in Chapter 4) that a higher producer price has a positive but modest effect on area planted, and also that market price influences yield in the same way. As suggested earlier, assuming present non-price constraints on production are lifted, these supply responses might improve dramatically. From the cost tables of rice cultivation under single and double cropping (see Appendix A-III) it becomes clear that double cropping under traditional management practices (i.e., low inputs levels) has the potential to provide more rice, but also at cheaper cost than under high-inputs management. Thus, not only is double-cropping on small, traditionally-farmed perimeters economically efficient, but it is also socially desirable in the sense that a much larger number of rice farmers will participate in increasing production (i.e., as compared to expansion only of large state-owned perimeters).

How can the government determine the optimum level at which to set producer prices? A CGE (Computable General Equilibrium) study might be useful to indicate how the optimum price might be determined within the system without government price controls, subsidies on transport, or inputs tax exemptions. If the result of a revised price policy is to raise producer prices so as to more closely reflect market prices, presumably producers will base both yield and area decisions on producer prices alone. This would increase the ability of the government both to control production and to predict future supply of rice, and it would discourage illegal sales on parallel black markets.

Some rice varieties tested at the research stations produce up to 10 tons/ha, as compared to the national average yield of about 5 tons/ha. Although the "yield-gap" is well-known throughout the world, the size of this discrepancy in Mauritania is large, indicating that production can probably be increased via on-farm yield increases.

b. Institutional Changes

Farmers need to be involved in the decisions that affect them, and they need to be taught effectively as well as given the means to take over the management of their perimeters. Under the present system the small village perimeter cannot be expanded without the permission and the help of SONADER. Yet, the successes of many private perimeters have proven that the farmers have the necessary skills and capabilities to run their own show. This would seem to indicate that it is time to give more freedom to farmers in making production decisions. Naturally, such a transition must be well prepared. The most crucial condition for its success is a viable credit system, which would allow farmers to acquire cash, fertilizers, machinery,

and other inputs supplies in the quantities necessary for commercial farming. BMDC, the development bank, has failed to assist farmers in the south to boost production, and SONADER credit services are of a very limited capacity and available only to small village perimeters.

c. Expansion of Agricultural Research and Extension Capabilities

Agriculture research findings must move from the compounds of agricultural experiment stations to the perimeters. Yield in the perimeters averages only 50% of on-station yields. CNRADA and CNFVA, the research center and school of agriculture respectively, have failed to serve as bridging institutions between research stations and farmers. The "cooperative-school" at Boghé, in charge of educating villagers in cooperative systems and developing management skills, is still in its infancy.

5.3 Suggestions for Further Research

A priority must be given to the collection of better quality data. This study suffered from this aspect; likewise, no other research can count on good results before a good data base is assured. To guarantee better statistical data, the government must avoid some of the pitfalls of bureaucracy which characterize the current tendency of the civil service agents in the interior to report just anything. A more rigorous discipline in this matter should be stressed by the President himself, and instructions must be given to the administration in general to impose sanctions against faulty reports. The public institutions should be aware of the control and verification that may ensue each data set or report released. The Ministry of Control or the Ministry of Planning can be put in charge of this appraisal task. Besides

this institutional change, a sub-sector data collection program can also produce improvement in data quality.

In order to design effective policy tools, additional research is necessary. In terms of price policy, further econometric studies are needed to focus on the one hand on the demand for rice and on the other hand on the supply of rice. A useful framework to employ in conducting these studies would be a sub-sector level approach.

In the inputs supply area, more studies are needed in the domain of credit servicing. Past experiences of "operation charrue" in 1965 and of the SONADER credit system have indicated that lack of accountability is a serious obstacle to credit servicing in Mauritania, but no attempt has yet been made to determine the causes of its failure.

Institutional designs of better supervision of perimeters or extension services network may be very useful to relieve the farmers from the cumbersome bureaucracy to which they are subjected. An investigation of the causes of the "yield gap" may very well lead to an identification of both the potential for increased yields on the basis of current technology and the quality of the extension service.

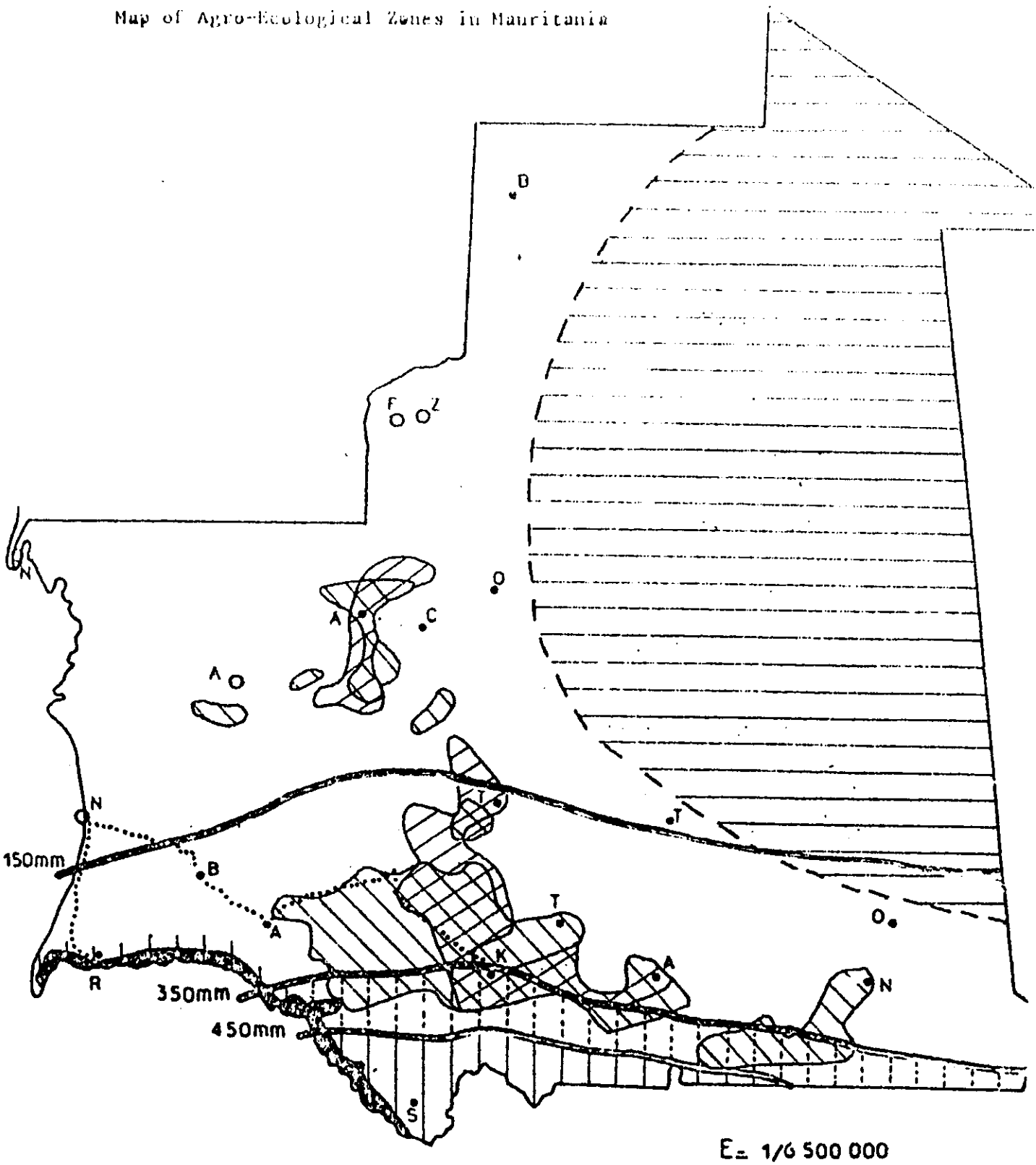
The list of needed research studies is, of course, incomplete and can extend endlessly because of the meager amount invested from the beginning in the agricultural sector and its outlets. There exist, undoubtedly, several other important areas about which more accurate information is needed.

5.4 Summary

While on the demand side little could be suggested because of the questionable findings of the econometric study, several policy areas

APPENDIX A-I : BASIC DATA

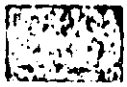
Map of Agro-Ecological Zones in Mauritania



E= 1/6 500 000

SOURCE: R AMS 1980

1. Agro-ecological Zones



1. Senegal River Valley

350 mm +0 450 mm

450 +0 650 mm

2. Rain-fed cultivation

3. Oued floodland cultivation

4. Palm - groves (oasis)

5. Pastoral zone

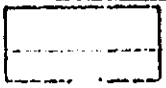
Overlapping zone

1. Oued floodland cultivation and Palm Groves

2. Oued floodland cultivation and rain-fed cultivation (between 350 mm & 450 mm)

3. Intermixing of 3 zones - Palm groves
- Oued floodland cultivation
- Rain-fed cultivation (between 350 mm & 450 mm)

2. Special ecological zone



Majabat Al Koubra

3. Other non-ecological zones

○ Modern urban zones

..... Transitional zones: recently paved roads.

A-I.(1) Domestic rice production and utilization

Years	Production (tons)	Yield (ton/Ha)	Hectarage (Ha)	Seed (tons)	Feed (tons)	Waste (tons)	Food (tons)
1970	1 372	1	1 098	128	97	367	786
1971	1 370	1	1 500	160	94	356	760
1972	2 500	1	2 000	80	188	708	1 524
1973	3 000	3	1 000	80	326	809	1 785
1974	3 000	4	1 000	83	326	808	1 783
1975	3 840	4	1 036	95	406	1 050	2 289
1976	3 960	4	1 187	128	416	1 075	2 341
1977	6 500	5	1 600	136	375	973	2 116
1978	7 100	4.5	1 700	160	363	937	2 040
1979	8 300	4.5	2 000	160	417	1 098	2 345
1980	10 000	5	3 000	NA	NA	NA	NA

Source : RAMS, June 1981

Note :

Yield times hectarage does not equal production for some years. There is no indication in the RAMS study whether the discrepancy is justified or not. In turn, rice uses do not sum up to production; a wide margin exists. Also, seeding quantities do not always seem to conform with the amount normally needed per hectare.

A-I.(2) Commodities prices

Years	Prices of rice		Sorghum consumer price
	producer price(UM)	Consumer price(UM)	
1970	5	5.9	10
1971	5	5.2	11
1972	5	4.9	11
1973	5	9.4	19.5
1974	5	14.9	12.5
1975	5	16	12
1976	5.3	16.4	15
1977	5.6	17.4	15
1978	6.1	18.6	35
1979	10	19.4	19
1980	13	20	31

Source : RAMS, 1980

A-I.(3) Gross Production Figures and Population

Years	GDP at market price (millions of $)	CPI (1975=100)	Population (millions)
1970	251.8	63.3	1.1607
1971	269.4	68.2	1.1865
1972	286.3	73.7	1.2128
1973	287.1	79.4	1.2398
1974	370.2	89.4	1.2673
1975	457.7	100	1.2954
1976	535.7	114.4	1.3242
1977	555.5	126.2	1.3536
1978	553.5	135.1	1.3861
1979	617.9	147.5	1.4194
1980	705	163.4	1.4534

Source : International Finance Statistics Yearbook 1982,IMF.

A-I.(4) Foreign Sector Figures

Years	Rice Import[a] ('000 tons)	World price[b] (Thai,UM/ton)	Exchange rate[c] (UM/$)	Foreign exchange earnings (millions UM)
1970	11	143.4	55.2	3.8
1971	16.6	129.4	52.2	5.8
1972	20	148.2	51.2	10.3
1973	28	288.9	47	38.6
1974	32	542.9	43.3	101.4
1975	8	364	45.1	45.7
1976	27.9	255	43.6	80.6
1977	42.6	276	46	49.3
1978	51	369	46.1	78.6
1979	50	334	45.8	112
1980	51	433	46	139.9

Sources : a- Martin, 1982

b- FAO Production Yearbook, 1982

c- International Finance Statistics Yearbook 1982, IMF

APPENDIX A-II

Annual Bulk Consumption Patterns

ITEMS	PER CAPITA ANNUAL CONSUMPTION	
Food items	Nomad	Sedentary
Cereals[+]	84 kg	135 kg
Fruits and vegetables	5 kg	24 kg
Meal[++]	5 kg	33 kg
Fish	-	10 kg
Milk and dairy products	166 liters	29 liters
Tea	1.27 kg	1.75 kg/adult
Sugar	7 kg	13.6 kg
Nonfood items		
Toiletry (soap)		4.6 kg
Energy products		
- kerosene(for lamps)		0.8 liters
- wood	445 kg	538 kg
Tobacco		140 grams
Clothing	245 UM	

[+] Cereal consumption patterns :

Millet / Sorghum	50 %
Rice	43 %
Wheat	6 %
Other	1 %

[++]Meat consumption patterns :

Beef	47 %
Sheep	18 %
Goat	3 %
Camel	29 %
Poultry and other	3 %

Source : RAMS, 1980.

APPENDIX A-III

Categories of Farms and Production Systems

(a) Relative size of surface areas by method of operation

Method	Surface area (Ha)	Percent (%)
Small village perimeters	1 796	41.5
Large perimeters	1 806	42.0
Private perimeters	589	13.5
Others (Research)	120	3.0
Total	4 311	100.0

Source : RAMS survey

(b) Cost Price of a Ton of Rice (in UM)

Yield hypothesis per hectare of rice	Traditional farming		Modern farming	
	single crop	double crop	single crop	double crop
3 tons/Ha	14	11.3	14	12
4 tons/Ha	10.5	8.4	10.5	9
5 tons/Ha	8.4	6.7	8.4	7.2
6 tons/Ha	7	6.7	7	7.2

Source : RAMS, 1980.

(c) Cultivation of one hectare of rice(single crop)

Operation	Traditional farming		Modern farming	
	Quantity	Cost in UM	Quantity	Cost in UM
Preparation of land	40 days	6 000	8h*400 UM	3 200
Sowing(selected seeds)	150 kg*30 UM	4 500	150kg*30	4 500
Weeding	20 days	2 400	20 days	2 400
Irrigation	20 days	2 400	20 days	2 400
Fertilizer	200 kg	3 600	200 kg	3 600
Harvest & transport	34 days	4 080	6h*1200	7 200
Amortization(motorpump, spare parts,repairs)		4 000		4 000
Diesel fuel		1 280		1 280
Amortization(improvements to land)		10 000		10 000
Other		3 826		3 858
Total		42 086 UM		42 438 UM

Average yield = 5 tons/Ha

Average production cost per kg = traditional farming = 8.4 UM

modern farming = 8.4 UM

Note : These calculations were based on data from Mlaiga farm (Tekane) for modern farming and Dar El Barka for traditional farming.

Source : RAMS, 1980.

(d) Cultivation of one hectare of rice (double crop)

Operation	Traditional farming		Modern farming	
	Quantity	Cost in UM	Quantity	Cost in UM
Preparation of land	60 days	7 200	12h	4 800
Sowing	300 kg*30	7 000	300kg*30	9 000
Weeding	40 days	4 800	40 days	4 800
Irrigation	40 days	4 800	40 days	4 800
Fertilizer	400 kg	7 200	400 kg	7 200
Harvest & transport & threshing	68 days	8 160	12h*1200	14 400
Amortization(motorpump, spare parts,and repairs)		8 000		8 000
Diesel fuel		2 560		2 560
Amortization(improvements to land)		10 000		10 000
Other		6 172		6 556
Total		67 892 UM		72 116 UM

Average yield = 9 tons for double crop

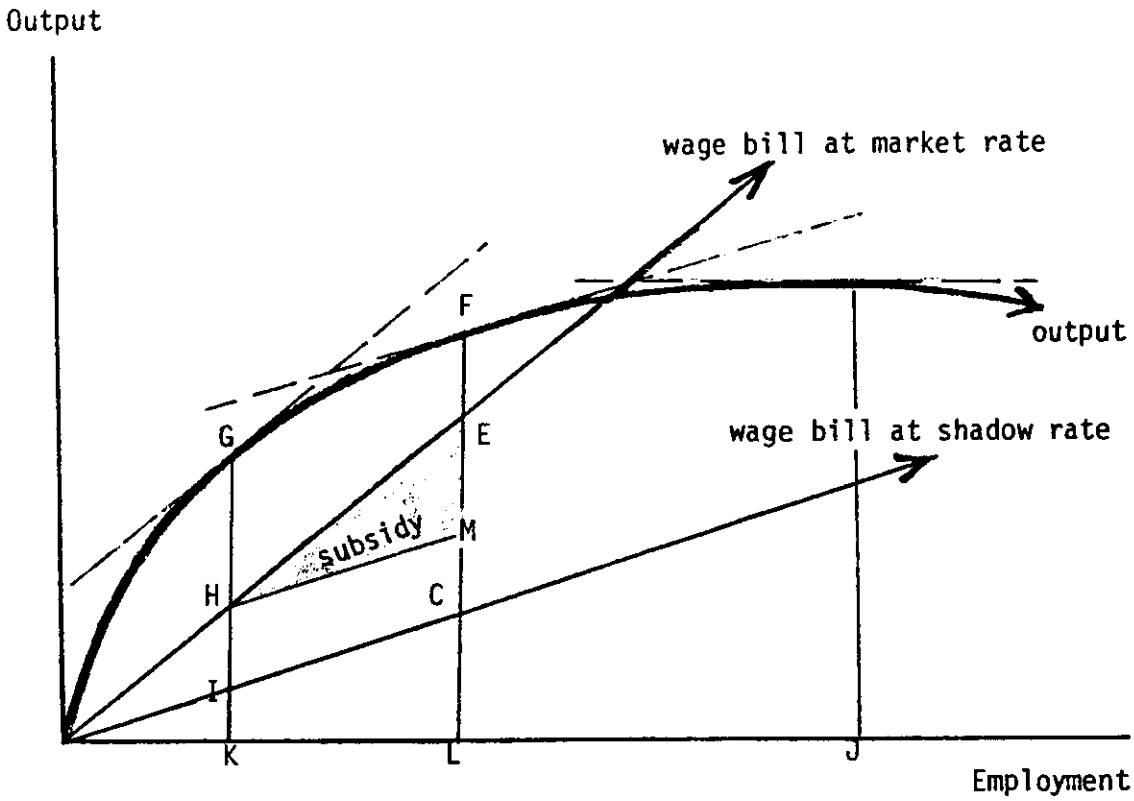
Average production cost/kg : traditional farming(Dar El Barka)= 7.5 UM

modern farming(Mlaiga) = 8 UM

Source : RAMS, 1980.

APPENDIX B-I

Shadow Wage Rate and Market Wage Rate



J : maximizes employment with zero wage rate

K : maximizes profits (savings or growth) at market rate

L : to obtain optimum employment at L,employers must get payroll subsidy (tax rebate per employee) of EM (FM=GH).

Note : Subsidy amounts to EM that is less than the difference between the shadow wage bill (LC) and the market wage bill (LE).

APPENDIX B-II
Other Best Estimated Equations Results

(standard deviations in parenthesis)

YIELD EQUATION

	Dependent variable YIELD	Intercept C	Lagged yield YIELD-1	Market price CPRT	Technology TECHNO	R^2	D.W.
(1)	OLS	.58		.078	1.9	.89	2.3
				(.05)	(.73)		
(2)	OLS	.83	.16		2.37	.84	2.4
			(.18)		(.65)		

HECTARAGE EQUATION

	Dependent variable HECTARAGE	Intercept C	Producer price PPRT	Sorghum price SPT	DV1 DV1		
(1)	OLS	.54	.16	.005	-.42	.82	2.0
			(.04)	(.01)	(.21)		

IMPORT EQUATION

	Dependent variable IMPORT	Intercept C	Foreign exch. FOREX	Sorghum price SPT	World price WPRICE		
(1)	OLS	23.5	.355		-1.016	.57	1.3
			(.13)		(1.07)		

DEMAND EQUATION

	Dependent variable CONSUMPTION	Intercept C	Income INC1	Market price CPRT	DV2 DV2	Deflated income	Deflated price	1/Income	R^2	D.W.
(1)	OLS	3.14	.86-04	1.81	-25.1				.87	1.5
			(.001)	(.89)	(6.1)					
(2)	CORC	117.32	-.26-02	.95	-17.6				.91	1.3
			(.0008)	(.59)	(2.5)					
(3)	OLS	114.05			-16.4	-.77	215.76		.79	.9
					(9.2)	(.24)	(76.6)			
(4)			log INC1							
	OLS	-304.5	34.77		-23.5				.81	1.4
			(6.8)		(6.8)					
(5)	LOG CONSUMPTION									
	OLS	4.6			-1.3			-19429	.84	1.3
					(.27)			(3790)		

Appendix B-III

Domestic production elasticity derivation

Given:

(1) DQPR = Hectarage * Yield (by definition); DQPR = domestic quantity produced of rice
(2) Hectarage = f_1 (PPRT, ---); PPRT = producer price of rice
(3) Yield = f_2 (CPRT, ---); CPRT = consumer price of rice
(4) CPRT = f_3 (PPRT, Marketing spread, ---)

Elasticity derivation:

Taking the derivative of equation (1) with respect to market price CPRT):

$$(5) \quad \frac{\partial DQPR}{\partial CPRT} = Hectarage * \frac{\partial Yield}{\partial CPRT} + Yield * \frac{\partial Hectarage}{\partial CPRT}$$

Hectarage is not related directly to CPRT, hence the following transformation is useful in the second element of the right-hand-side (RHS):

$$(6) \quad Yield * \frac{\partial Hectarage}{\partial CPRT} = Yield * \frac{\partial Hectarage}{\partial PPRT} * \frac{\partial PPRT}{\partial CPRT}$$

Substituting equation (6) into equation (5):

$$(7) \quad \frac{\partial DQPR}{\partial CPRT} = Hectarage * \frac{\partial Yield}{\partial CPRT} + Yield * \frac{\partial Hectarage}{\partial PPRT} * \frac{\partial PPRT}{\partial CPRT}$$

Multiplying through equation (7) by $\frac{CPRT}{DQPR}$ (measured at the means):

$$(8) \quad \frac{\partial DQPR}{\partial CPRT} * \frac{CPRT}{DQPR} = \left(Hectarage * \frac{\partial Yield}{\partial CPRT} + Yield * \frac{\partial Hectarage}{\partial PPRT} * \frac{\partial PPRT}{\partial CPRT}\right) \frac{CPRT}{DQPR}$$

Replacing DQPR by its identity in (1) and simplifying gives:

$$(9) \quad \frac{\partial DQPR}{\partial CPRT} * \frac{CPRT}{DQPR} = \frac{\partial Yield}{\partial CPRT} * \frac{CPRT}{Yield} + \frac{\partial Hectarage}{\partial PPRT} * \frac{\partial PPRT}{\partial CPRT} * \frac{CPRT}{Hectarage}$$

Assuming that the marketing spread is relatively constant, as it has been in the last seven years, then ∂ PPRT/∂ CPRT = 1.0 and:

(10) domestic production elasticity = yield elasticity + Hectarage elasticity
= .98 + .70
= 1.68

Elasticity discussion:

What this figure indicates is that the supply response function for rice is elastic. Specifically, the supply elasticity estimate of 1.68 means that a 1% change in both consumer price and producer price would generate a 1.68% increase in domestic production. This response is fairly large, as compared to figures obtained for Ivory Coast and Sierra Leone. Coulibaly (1979) found the domestic supply elasticity to be .25 in Ivory Coast, and Kargbo (1979) calculated a .178 domestic supply elasticity for Sierra Leone. This finding indicates that larger quantities will be produced by farmers if prices are increased.

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