# A REVIEW OF FACTORS RESPONSIBLE FOR SORGHUM AND MAIZE CROP PATTERN CHANGES IN MOZAMBIQUE

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## ABSTRACT

## A REVIEW OF FACTORS RESPONSIBLE FOR SORGHUM AND MAIZE CROP PATTERN CHANGES IN MOZAMBIQUE

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Agriculture surveys and literature establish that sorghum was one of the most important food crops in Mozambique. A large number of farmers have been shifting production gradually from sorghum to maize production despite its susceptibility to drought.

The general objective of this study is to identify the factors responsible for decline of sorghum production in Mozambique.

Comparative analysis between sorghum and maize are done. Enterprise budgets and break-even analysis for both sorghum and maize are presented and discussed. Supply functions for sorghum and maize from 1950 to 1985 are estimated.

It is concluded that the major factors responsible for sorghum production decline are the lack of security in the country side, drought during the last ten years, lack of seed, poor varieties, innappropriate marketing policies. The estimated supply equation for maize suggests raising of official maize prices to increase the output of maize.

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# A REVIEW OF FACTORS RESPONSIBLE FOR SORGHUM AND MAIZE CROP PATTERN CHANGES IN MOZAMBIQUE

## CHAPTER I : INTRODUCTION

### 1.1 RESEARCH PROBLEM

Agriculture surveys and literature establish that in the recent past, sorghum was one of the most important food crops in Mozambique. However, the empirical evidence from 1950 to 1985 shows a relative increase of maize production and decrease of sorghum production.

In the current environmental conditions of Mozambique, researchers believe that sorghum has an economic and a agronomic comparative advantage over maize. Yet, a large number of farmers have been shifting production gradually from sorghum to maize production (which is more susceptible to drought).

The Southern Africa Development Conference Coordination (SADCC), a regional economic organization, as well as the Government of the People's Republic of Mozambique, have integrated programs (including Food Security Programs) whose objectives are to bring solutions to regional food shortage problems.

Policy makers are asking whether sorghum should continue to be replaced by maize or whether the current situation must be reversed, re-establishing sorghum as a major grain crop.

## 1.2 OBJECTIVES OF THE STUDY

The general objective of this study is to identify the factors responsible for the decline of sorghum production and crop pattern change in Mozambique. This general objective can be divided into the following specific objectives :

1- To review results of past research, as well as the scope of ongoing projects on sorghum in Mozambique, S.A.D.C.C., and other relevant regions of the World.

2- To compare enterprise budgets and farmers' management practices for both sorghum and maize production in Mozambique.

3- To review the evolution of grain market structure and policies in Mozambique, and to estimate the supply functions for sorghum and maize in Mozambique from 1950 to 1985.

4- To discuss the implications of supply trends, farm management practices, the marketing system, and policies for expansion of sorghum production in Mozambique.

## 1.3 METHODS

### a) DATA

Comprehensive data on land use, levels of production and marketing are difficult to obtain, principally because of the lack of information on the areas cultivated and grazed by the family sector or smallholder sector and exchange in kind that take place in rural areas of Mozambique. Tentative estimates of the total areas and levels of production are generated using the biannual surveys on agriculture since 1950 to 1972.

In general, the data used was extracted from surveys carried out from 1950 to 1970 by the " Missao de Inquerito Agricola de Mocambique", for the period between 1970 to 1975, the data was extracted from surveys done by M. de Carvalho, and from 1976 to 1985 the data came from the bulletin "Informacao Estatistica the Mocambique" generated by the National Agricultural Research Institute (INIA).

For analysis of water deficit in sorghum and Maize, data was used from a study published by J. Montalvao Marques in 1960 in " Esboco Para Uma Monografia Agricola Do Posto dos Muchopes e De Alguns Regulados do Chibuto. Data also came from studies carried out in Marracuene and Metangula Districtsy the author and published in the Faculty of Agronomy and Forestry of Eduardo Mondlane University . Other sources of data are the Ministry of Agriculture, the Department of Food Security of the Ministry of Commerce, Eduardo Mondlane University, FAO, World Bank, and the parastatal agency for marketing known as "AGRICOM". Reports of CIMMYT and SADCC also provided some useful information.

b) **ANALYSIS**

Comparative analyses between sorghum and maize enterprises are done. The enterprise budgets for both crops are presented and discussed to analyze the potential profitability of each crop. Supply functions for sorghum and maize from 1950 to 1985 are estimated using regression techniques. Break-even analyses are done to determine break-even prices and break-even yields for each crop. To complete the analysis, the grain market structure and policies in Mozambique are reviewed.

# CHAPTER II : RESEARCH ON SORGHUM

## 2.1 REVIEW OF LITERATURE

Research on sorghum is one of the priorities for several of the International Agricultural Research Centers (IARC). The past two decades of research on sorghum have produced some results to help the small farmers attain improved food security.

There are two complementary approaches to increase the productivity of farming families and improving their food situation: 1) Develop and disseminate relevant improved technologies, which enable the use of resources previously under-utilized, and 2) Develop relevant policies and support systems. The development of relevant policies can entail a combination of macro and micro level research.

In the World, sorghum research is carried out by several National Agricultural Research Stations (NARS) and IARCs. Sorghum is one of the five priority crops of the International Crops Research Institute for Semi-Arid Tropics (ICRISAT). Its mandate is to improve production stability and food quality of sorghum, pearl millet, pigeon pea, chick pea, and groundnut in the semi-arid tropics (Peacock, 1984). The ultimate aim of ICRISAT's sorghum improvement program is to produce higher and more stable yielding lines. The specific programs are sorghum physiology, pathology, entomology, and breeding programs. In collaboration with

NARS, ICRISAT has improved and created new varieties in India, Niger, Burkina Faso, Mali, Senegal, and Sudan.

ICRISAT has established regional program for Southern Africa Development Coordination Conference (SADCC) with headquarters in Bulawayo, Zimbabwe which is organized into four commissions of research on sorghum: 1) food technology research on Sorghum from traditional uses to industrial ,2) non-food industrial uses of sorghum, 3) sorghum in livestock feed, and 4) sorghum marketing and trade policy.

The International Sorghum and Millet Program (INTSORMIL) is a Collaborative Research Support Program (CRSP) created on July 1, 1979 in USAID. Its overall objective is to improve human nutrition through research and technology development. INTSORMIL is involved with NARS in a cooperative relationship. Mozambique has not yet established a cooperative relationship with this international network of research workers and organizations. Most of the specific objectives of INTSORMIL are similar to the objectives of the Sorghum Program of INIA in Mozambique. It would be advantageous for both INTSORMIL and INIA to develop a collaborative research.

In 1977, the ICRISAT-SUDAN Cooperative Program for Sorghum and Millet Improvement, supported by the United Nations Development Program (UNDP) was initiated with a mandate of strengthening sorghum and pearl millet improvement research in Sudan. With collaboration of

INTSORMIL, an array of useful germplasm was accumulated. Between 1979 and 1982 breeding programs resulted in a creation of a new variety Hageen Dura-1 which is a superior hybrid yielding over 150% of those improved local varieties under irrigated and rainfed conditions ( Ejeta, 1988). This variety is relatively drought tolerance, with good grain quality characteristics that helped its rapid spread and wide acceptance by farmers. The research themes being followed by ICRISAT in collaboration with SADCC include issues of technology adoption, crop substitution in production and consumption, household investment strategies, food security, and impact of institutional expansion. Research efforts are needed to summarize where sorghum is important and where productivity is lagging. SADCC/ICRISAT has recently reported the development of new sorghum variety which may increase smallholder yields from 500 MT per hectare to 3 to 5 tones per hectare(Mbanda and Rohrbach, 1988). Experts believe that a gain of even one-quarter this size could lead to higher yields on existing sorghum lands. Research should bring an explanation of why farmers are still not adopting the new improved sorghum technologies generated by ICRISAT and neighboring countries. Little is known about consumer preferences for alternative coarse grains. Sorghum has been considered inferior good. Preference for maize has been cited as a justification for relative growth of maize production in Zimbabwe. In

Mozambique is not yet clear if this is the case. The character of consumption preferences and range of factors influencing consumption levels needs investigation.

Sorghum is being promoted in dry and semi-arid zones of Mozambique as a drought tolerant crop. It is considered one of the security crops, however, farmer's perceptions of food security and their range of food security strategies are unknown. Analyses examining smallholder decisions regarding land allocation across different crops, input investment, input utilization and market sales are being conducted in Zimbabwe( Mushonga, 1987). These may provide some basis for identifying technological, institutional and policy priorities for promoting future growth in sorghum. Research in Mozambique should take advantage of these studies to accelerate the expansion of sorghum production.

## 2.2 RESEARCH ON SORGHUM IN MOZAMBIQUE

Few studies on sorghum have been conducted by the Mozambican Ministry of Agriculture. And until now, there has been not any agroeconomic study focusing on sorghum in Mozambique.

The traditional varieties adapted to different agro-ecological conditions are widely distributed within the country. SIREMA is a long cycle composite most widespread in the irrigated areas. Variety 50/59 is cropped under rainfed agricultural conditions. SIREMA is a brown seeded variety, high yielding and resistant to birds, but is not well accepted by consumers due to its bitterness associated with the brown seed characteristic. Variety 50/59 is a white seed colored, more palatable, but susceptible to grain molds.

The major constraints for sorghum production increase are (INIA, 1985) : 1) Lack of varieties adapted to the agro-ecological conditions of the main sorghum cropping regions, particularly the northern part of the country;

2) Lack of palatability of SIREMA, the high yield variety.

3) Poor cultural practices and management.

4) Large post harvest losses.

5) Low producer's price for sorghum.

6) Lack of improved technologies for the smallholder farmers.

The INIA Sorghum Program is working jointly with SADCC Sorghum Research Program to introduce and select new improved varieties adapted to the three major regions in the country.

However, issues on sorghum production are being discussed such as technology adoption by the smallholder farmers, crop substitution in production and consumption, household investment strategies, the existing institutions and their expansion.

The research up to now has focused on the supply side such as increasing sorghum production, improving of traditional varieties and undertaking actions programs to reduce post harvest losses. The research on the demand side such as quality of sorghum and nutritional traits is still to be created. Additional sorghum improvement studies specific to a local area and characteristics demanded by the consumers are needed. Research on quality, processing, and new food products could increase the acceptability of sorghum in Mozambique.

Progress in increased sorghum production has been made, however additional advances are needed and appear to be possible. In Mozambique, industrial demand for sorghum and other small grains has been relatively low. Continuing subsidies on maize appear to have discouraged substitution across the coarse grains. In Zimbabwe, in a survey of the six largest coarse grain purchases from the Grain Market

Board (GMB) indicated a lack of close substitutability between the alternative grains despite changes in price. In effect, small grains appear closer complements than substitutes with maize (Mbwanda and Rohrbach, 1988).

Concerns about sorghum consumers' preferences reflected a belief that most consumers prefer maize or maize-based products than sorghum. They place a higher value on maize than sorghum and they would be willing to forgo yield in return for taste or processing ease. The question of smallholder grain preferences in Mozambique is still open to debate. Concerns about lesser drought tolerance of maize should not overshadow the consideration of implications of maize preference. On the other hand, sorghum competes with yellow maize as livestock feed. This is relatively higher cost commodity to produce compared with sorghum, but achieves higher average yields. In the lowest rainfall regions, sorghum generally becomes relatively more profitable. Increasing sorghum yields could enlarge the region in which sorghum production for feed is profitable. The concerns in the consumers' side is about the tannin content of sorghum which decreases the efficiency of sorghum feeds. Research should be carried out to overcome this problem and evaluate possible opportunities for treating sorghum to offset tannin problem.

The issue of appropriate technology relates in part to the availability of acceptable technology for the smallholder farmers as well as the economic and operational efficiency of machinery available for processing sorghum. There is a need for promotion of sorghum utilization by industry in order to increase demand which in turn may stimulate the expansion of sorghum production. Mbwanda and Rohrbach (1988) indicate that in Zimbabwe the concerns are also related to consumer's acceptability and technological efficiency. Gomez (1987) reviews the potential for expanded use of sorghum as a replacement for maize and wheat and in the manufacture of new products. She identifies a potential demand for almost 500,000 MT of sorghum products in Zimbabwe such as sorghum meal porridge, biscuits, clear beer, pasta, starch, a rice substitute, and glucose. In Mozambique the potential demand for sorghum is not yet identified.

# CHAPTER III: NATIONAL PRODUCTION CHARACTERISTICS, ENTERPRISE BUDGETS, AND FARMER'S MANAGEMENT PRACTICES

## 3.1 THE STRUCTURE OF AGRICULTURE IN MOZAMBIQUE

Mozambique has an area of 789,800 square kilometers. The climate varies from subtropical to tropical, with two main seasons: a warm, wet season that lasts from November to April, and a cooler, dry season from April to early October. The population is estimated at 14 million. Agriculture contributes 40 percent to the GNP which currently is $210 (World Bank Development Report, 1988, p. 289). Roughly 84 percent of economically active population are engaged in agriculture, most of these in subsistence farming.

Agricultural production in Mozambique is carried out by several categories of producers: family producers and commercial producers including both state and private enterprises and cooperatives. Over 90 percent of the current cultivated area is in the family sector. The production system in the family sector is mainly manual labor, with hand tools and some animal traction where the tse tse fly is not a problem. Purchased inputs such as seeds, fertilizers, pesticides, and improved varieties are not available for the smallholder farmers. Traditionally, shifting cultivation is practiced with fallow intervals of four to six years. Sorghum and maize in the family sector follow this kind of agrotechnique.

In spite of the importance of the smallholder farmers to the national economy, little has been done to study the structure, organization, economic and production technology. Lately, few smallholder farmers in the irrigated areas receive some assistance. However, a large number of smallholder farmers are cropping in rainfed conditions.

All land is held by the state, which determines the conditions for its use and exploitation. The people have the right to work the land. Comprehensive data on land use is difficult to obtain, mainly because of the lack of information on the areas cultivated and grazed by the family farmers.

Estimates of the Ministry of Agriculture in Mozambique, establish that pasture and fallow land is 12 million hectares, representing 33 percent of the cultivable area and 2.5 to 3.0 million hectares are cultivated land representing 7 to 8 percent of cultivable area. Table 3.1 presents estimates of total number of family farms by categories.

The base year is 1980 with a total 2,218,650 farm families. Assuming a growth rate of 2.65% per year, the estimated total number of farm families in 1988 is 2,735,020.

The percentage of families by category was calculated based on survey done by M. de Carvalho from 1965 to 1969. It is assumed that the structural composition is still the same.

**TABLE 3.1: ESTIMATES FOR 1988 OF THE TOTAL NUMBER OF FAMILY FARMS IN MOZAMBIQUE**

| CATEGORY | SIZE (HA) | PERCENTAGE | NUMBER OF FAMILIES |
|---|---|---|---|
| I | LESS THAN 0.5 | 3% | 81, 777 |
| II | 0.51 - 0.99 | 19% | 515,825 |
| III | 1.00 - 1.50 | 28% | 775,652 |
| IV | 1.51 - 2.00 | 20% | 551,107 |
| VI | GREATER THAN 2.0 | 30% | 816,402 |

SOURCE : Mucavele, F.G. , 1988 based on 1980 census, Carvalho 1969, and Informacao Estatistica de Mocambique (various years) .

The total area cropped by the other three producer categories, state, cooperative and private, during the last two years has been less than 200,000 hectares. Table 3.2 presents areas cropped from 1983 to 1986. Mixed category refers to the joint venture between the private firm LONRHO and the Government. The area cropped by the state farms is decreasing. This is due to the new Government policy to reduce the number of large state farms and increase the number of cooperative and private farms. However, the area cropped by the cooperative farms also has been decreasing due to the inefficiencies in the sector. The private farms are increasing the areas cultivated.

This policy helps to solve in part the high cost to operate large and complex state farms which are not feasible due to management problems, incorrect timing of agricultural operations and low productivity of labor.

TABLE 3.2: CULTIVATED AREAS FROM 1983 TO 1986

| CATEGORY | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|
| | | '000 HECTARES) | | |
| FAMILY FARMS | NA | NA | NA | 12,000.0 |
| STATE FARMS | 118.6 | 122.8 | 90.7 | 66.9 |
| COOPERATIVE FARMS | 7.9 | 13.0 | 6.4 | 4.7 |
| PRIVATE FARMS | 41.2 | 53.7 | 45.3 | 54.9 |
| MIXED FARMS | 0 | 0 | 0 | 1.9 |
| TOTAL | 167.8 | 189.5 | 142.3 | 12,128.6 |

SOURCE : INIA, Ministry of Agriculture, 1987.

The so called "commercial farms" in Mozambique differ from family farmers in that they employ non-family paid labor. This sector cultivates 54,900 hectares according to the 1986 INIA report. Private farmers grow maize, fruit and vegetables. Sorghum is mainly cultivated by the family sector.

The state farms, compared to the family sector, use more imported inputs such as machinery (particularly tractors), improved seeds, fertilizers and pesticide. The cultivated area of sorghum in this sector is almost insignificant. The state farms are chiefly devoted to maize production.

The cooperative farms are currently being promoted. They have a cultivated area of 4,700 hectares, around two percent of the area is cultivated for sorghum.

The main food crops are maize, cassava, sorghum, rice, and millet. The major export crops are cashews, tea, sugar, sisal, and cotton.

## 3.2 SORGHUM AND MAIZE TRENDS

There are three major areas where sorghum is grown (see map in the appendices section); one is the northern area, bordered in the west by the maize highlands of Lichinga Province and in the East by the cassava belt. In the north is bounded by the Rovuma River and in the south by Zambeze province. The altitude of this region varies from 400 meters to 600 meters above the sea level. The evapotranspiration values vary from 1,300 to 1,700 mm, the rainfall is less than 1,000 mm per year. In the Central part of the country, sorghum is grown mainly in the provinces of Tete, Manica, and Sofala. The third region is south, where sorghum is concentrated in provinces of Gaza and Inhambane. This is the region with a very high risk of drought. The annual rainfall varies between 400 mm to 600 mm per year, which requires sorghum varieties with a growing period of less than 75 day.

According to INIA, sorghum represents 10 percent of the agricultural gross value. It is mostly cultivated by smallholder farmers. The average yields are about 540 Kg per hectare with production trend decreasing. It is estimated 50 to 60 percent of smallholder farm population grow sorghum. Figure 3.1 shows the estimated total area and sorghum production from 1950 to 1985.

The estimated total sorghum and maize production was done using a simple model for the period from 1950 to 1985.

This is because there are no statistics quantifying the total area and production of traditional crops such as sorghum. The data used for estimation was based on surveys done from 1950 to 1970 by the " Missao de Inquerito Agricola de Mocambique" published in portuguese in " anuario estatistico" prepared yearly by the "Imprensa National de Mocambique", in Lourenco Marques, from 1939 to 1972.Also used was the publication known as " A Agricultura Tradicional de Mocambique : Distribuicao Geografica das Culturas e a sua Relacao com o Meio", Mario de Carvalho, Missao de Inquerito Agricola de Mocambique, 1969. For recent trends, the general census carried out in 1980 was used. The model was an aggregation of production in family and commercial sectors of each province estimated as following:

$$OUTPUT = OPROV1 + OPROV2 + OPROVn$$

$$OPROVi = NUMFAMj \times ARCFAMj \times CRPYLDj$$

where: OUTPUT = Total estimated output of a crop in the country;

OPROVn = Total output of a crop in province n;

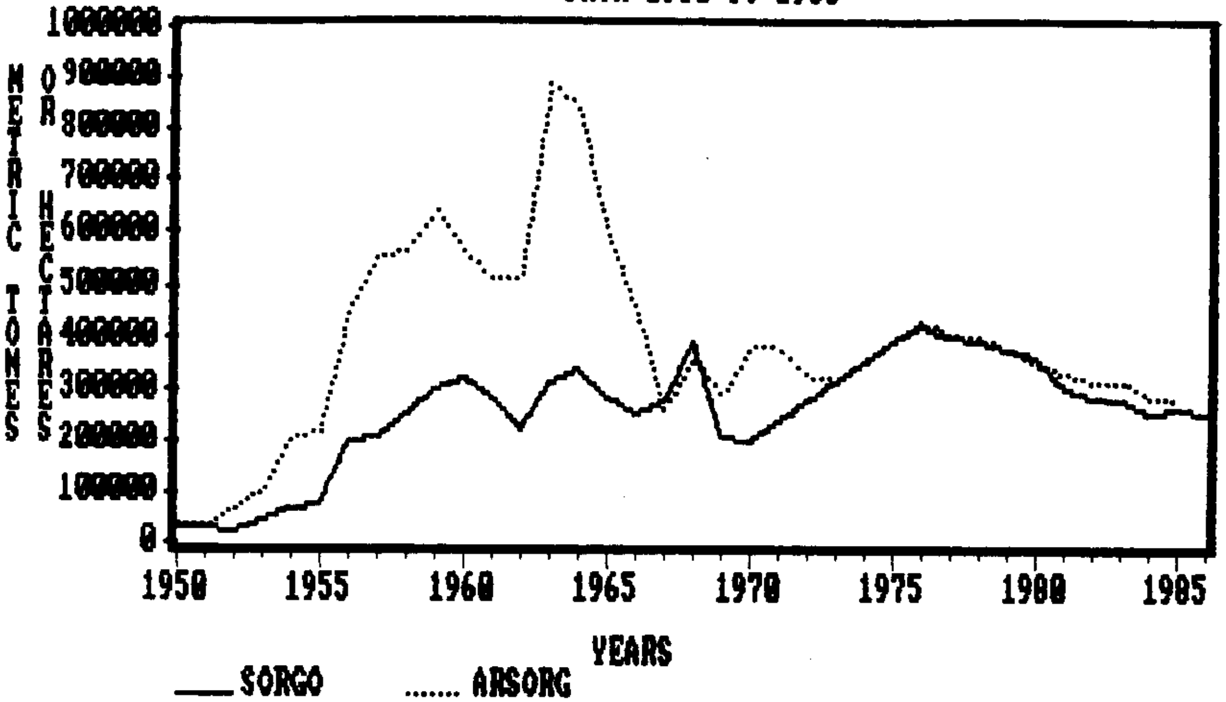
NUMFAMj = Number of farm families in province j producing the crop.

ARCFAMj = Average area cropped by the family in province j producing the crop.

CRPYLDj=Average yield of the crop in province j.

Complete output of the model is shown in the appendices section.

FIGURE 3.1: ESTIMATED TOTAL AREA AND TOTAL SORGHUM PRODUCTION FROM 1950 TO 1985




SOURCES: (1) Missao de Inquerito Agricola de Mocambique; Anuario Estatistico. Impressa Nacional de Mocambique, Lourenco Marques, Mocambique (1950 - 1972).

(2) Carvalho, Mario de; "A Agricultura Tradicional de Mocambique", 1969, Lisbon, Portugal.

(3) Informacao estatistica de Mocambique, Maputo, Mocambique.

TABLE 3.3: ESTIMATED TOTAL PRODUCTION OF SORGHUM, MAIZE, RICE, AND MILLET IN MOZAMBIQUE

| obs | SORGO | MAIZE | RICE | MILLET |
|---|---|---|---|---|
| 1950 | 32450.00 | 142000.0 | 72300.00 | 997.0000 |
| 1951 | 28900.00 | 157000.0 | 73500.00 | 3035.000 |
| 1952 | 25687.00 | 163000.0 | 84300.00 | 2030.000 |
| 1953 | 42890.00 | 174000.0 | 69200.00 | 1600.000 |
| 1954 | 69650.00 | 182000.0 | 100890.0 | 1500.000 |
| 1955 | 79845.00 | 187000.0 | 101509.0 | 1670.000 |
| 1956 | 197350.0 | 191600.0 | 99300.00 | 2300.000 |
| 1957 | 207890.0 | 235000.0 | 97300.00 | 2920.000 |
| 1958 | 250182.0 | 290420.0 | 95800.00 | 3358.000 |
| 1959 | 300056.0 | 300812.0 | 87100.00 | 3698.000 |
| 1960 | 322784.0 | 297510.0 | 99120.00 | 3579.000 |
| 1961 | 285000.0 | 296250.0 | 104100.0 | 6850.000 |
| 1962 | 220103.0 | 301867.0 | 112500.0 | 9871.200 |
| 1963 | 310132.0 | 312865.0 | 124500.0 | 15643.00 |
| 1964 | 335627.0 | 397029.0 | 132000.0 | 19876.00 |
| 1965 | 279104.0 | 544008.0 | 145200.0 | 29200.00 |
| 1966 | 250000.0 | 524910.0 | 158000.0 | 34539.00 |
| 1967 | 275980.0 | 579201.0 | 162900.0 | 37980.00 |
| 1968 | 389300.0 | 692000.0 | 172000.0 | 39473.00 |
| 1969 | 206166.9 | 798001.0 | 200100.0 | 48871.90 |
| 1970 | 194677.7 | 777012.0 | 198757.0 | 31992.70 |
| 1971 | 235980.0 | 800390.0 | 220200.0 | 35850.00 |
| 1972 | 278432.0 | 845820.0 | 235934.0 | 33290.00 |
| 1973 | 310037.0 | 881082.0 | 253498.0 | 33008.00 |
| 1974 | 348002.0 | 756923.0 | 287000.0 | 33719.00 |
| 1975 | 387320.0 | 745102.0 | 299000.0 | 33000.00 |
| 1976 | 423005.0 | 790600.0 | 256000.0 | 32281.00 |
| 1977 | 400213.0 | 756000.0 | 202800.0 | 31562.00 |
| 1978 | 389239.0 | 729800.0 | 167000.0 | 30843.00 |
| 1979 | 371880.0 | 710290.0 | 105000.0 | 30124.00 |
| 1980 | 358769.0 | 701004.0 | 107000.0 | 29405.00 |
| 1981 | 300729.0 | 715830.0 | 103000.0 | 28686.00 |
| 1982 | 286023.0 | 726122.0 | 91000.00 | 27967.00 |
| 1983 | 271439.0 | 707288.0 | 94000.00 | 27248.00 |
| 1984 | 250189.0 | 692100.0 | 95000.00 | 26529.00 |
| 1985 | 255980.0 | 650400.0 | 93000.00 | 25810.00 |
| 1986 | 255580.0 | NA | 99200.00 | 25890.00 |

SOURCES: (1) Missao de Inquerito Agricola de Mocambique; Anuario Estatistico. Impressa Nacional de Mocambique, Lourenco Marques, Mocambique (1950 - 1972).

(2) Carvalho, Mario de: "A Agricultura Tradicional de Mocambique", 1969, Lisbon, Portugal.

(3) Informacao estatistica de Mocambique, Maputo, Mocambique.

As can be seen in Table 3.3 the production of sorghum has been declining since middle 70's. The peak production was in 1976 with a total aggregate production of 423,005 metric tones.

About 66 percent of sorghum is intercropped with cowpea, cassava, and groundnut, where it constitutes the main crop.

Maize is grown in almost all of Mozambique covering more than 600,000 ha.In the north, maize is concentrated in the Lichinga highland. In this area,the evapotranspiration is below 1,300 mm per year. In the central part of the country, maize is grown intensively in two major areas: north of Tete Province and highland of Manica Province. The evapotranspiration in this region is below 1,200 mm per year. In the southern part of the country, maize is grown mainly in the alluvial valley of Maputo and Gaza Provinces from sea level to elevations up to 200 meters.

Table 3.4 presents the total estimated production of sorghum and maize per capita (using previous model). The peak of production was in 1973 with an estimated total production of 881,082 metric tones. Since then, the production has been decreasing. The total produce output of sorghum per capita increased from 1950 to 1968 and declined until 1985. Maize produced per capita also increased from 1950 to 1974 and declined until 1985. There are several factors that contributed for these declines: 1) lack of security in the country side due to the war since 1964 in conjunction with migration and dislocation of rural populations, 2) climatic disasters, 3) unstable international economy, 4) inappropriatepolicies, and 5) agricultural technology which did not improve fast enough to accommodate the population increase. To fulfil the growing food requirements, the Government has increased importations of rice and maize since 1977. From 1984, the Government launched appeals for international food aid to keep people from starving.

TABLE 3.4: ESTIMATED TOTAL PRODUCTION OF SORGHUM, MAIZE PER CAPITA IN MOZAMBIQUE

| obs | SORGPC | MAIZPC |
|---|---|---|
| 1950 | 5.018869 | 21.96239 |
| 1951 | 4.403756 | 23.92352 |
| 1952 | 3.856316 | 24.47073 |
| 1953 | 6.343792 | 25.73607 |
| 1954 | 10.14958 | 26.52153 |
| 1955 | 11.48238 | 26.89216 |
| 1956 | 27.87874 | 27.06647 |
| 1957 | 28.84841 | 32.61040 |
| 1958 | 34.10333 | 39.58833 |
| 1959 | 40.17863 | 40.27986 |
| 1960 | 42.49786 | 39.17028 |
| 1961 | 36.78744 | 38.23957 |
| 1962 | 27.85356 | 38.20062 |
| 1963 | 38.47701 | 38.81608 |
| 1964 | 40.82358 | 48.29214 |
| 1965 | 33.19979 | 64.71047 |
| 1966 | 29.06923 | 61.03491 |
| 1967 | 31.36864 | 65.83356 |
| 1968 | 43.25405 | 76.88621 |
| 1969 | 22.39163 | 86.67028 |
| 1970 | 20.69344 | 82.59319 |
| 1971 | 24.49579 | 83.08411 |
| 1972 | 28.22511 | 85.74217 |
| 1973 | 30.69236 | 87.22340 |
| 1974 | 33.64328 | 73.17593 |
| 1975 | 36.44576 | 70.11207 |
| 1976 | 38.79495 | 72.50810 |
| 1977 | 35.77451 | 67.57784 |
| 1978 | 33.91184 | 63.58267 |
| 1979 | 31.57841 | 60.31469 |
| 1980 | 29.57700 | 57.79093 |
| 1981 | 24.16391 | 57.51773 |
| 1982 | 22.39987 | 56.86618 |
| 1983 | 20.71903 | 53.98753 |
| 1984 | 18.61306 | 51.48948 |
| 1985 | 18.53625 | 47.09733 |

SOURCES: (1) Missao de Inquerito Agricola de Mocambique; Anuario Estatistico. Impressa Nacional de Mocambique, Lourenco Marques, Mocambique (1950 - 1972).

(2) Carvalho, Mario de; "A Agricultura Tradicional de Mocambique", 1969. Lisbon, Portugal.

### 3.3 SORGHUM ENTERPRISE BUDGETS

Representative enterprise budgets were estimated for Metangula, province of Niassa, and Marracuene, province of Maputo. The "Family Farm II" budget represents the common family farms in the southern part of the country, where draft power is used and manure is part of organic fertilization. Sorghum is mainly intercropped while most often maize is single cropped.

The sorghum enterprise budgets are estimated considering that inputs are used for intercropped conditions. Therefore, the figures presented in the sorghum enterprise budgets assume that 66 percent of the total inputs used in the sorghum mixture pertain to sorghum in particular. In case of family labor, it was observed that children and old people were used mainly for weeding and bird control while adult women and men were carrying other operations. The yield in each group of farm family is the average of ten farmers. It was estimated from surveys conducted by Eduardo Mondlane University students during the harvest time, measuring the total output and area, then adjusted to a one hectare basis.

The major variable costs for sorghum enterprises in rainfed and manual conditions are: land clearing and preparation, seeds, sowing, weeding, harvesting, transportation, and purchase of bags. There are often fixed costs. The only investment which can be considered as a fixed cost are hoes and draft animals. Table 3.5 presents sorghum enterprise budgets in rainfed conditions and manual cultivation. The amount of seed used is the average of ten observations. The measurement process was the same as used for yield measurements. The cost of seed is 100.00 MT. It was determined during the surveys.

The concept of opportunity cost was used to estimate the cost of family labor. Opportunity cost can be defined as the maximum net return that is sacrificed because the resource is not employed in its next most profitable alternative (Harsh, Connor, Schwab, 1981). This implies or recognizes the opportunities foregone by using labor in this enterprise.

To estimate opportunity cost, surveys were done from 1982 to 1985 in two regions: Metangula in the province of Niassa and Marracuene in the province of Maputo. The questionnaire was prepared by the Department of Crop Production and Plant Protection of the Faculty of Agronomy at Eduardo Mondlane University. It was directed to estimate how much the farmers would have to receive in order to be willing to leave their farming activities to work for other farmers. The ranking started with 10.00 Meticais up to 50.00 Meticais per day per hectare, during the time when exchange rate was 40.00 Meticais per dollar. The intervals used were 2.50 Meticais. It was found that 73 percent of the farmers interviewed in 1983 would be willing to work in another farm if paid 175.00 Meticais per day per hectare, in 1984 (converted to the current exchange rate of 400.00 Mt per dollar). Sixty four percent of the farmers were willing if paid 175.00 Meticais per day per hectare. And in 1985, 82 percent were willing to work if paid 250.00 Meticais per day per hectare. The complete table of results is shown in the appendices. There was no significant differences between Marracuene and Metangula districts with respect to opportunity cost. For this budget analysis, the last estimation of labor opportunity cost (250.00 MT/Day) is used. It is assumed that opportunity cost of labor has not changed since 1985; more recent data are not available.

For estimation of annual cost of hand tools, the "Straight-line Depreciation Method" was used. It was assumed that the salvage value at the end of usage period would be zero. the calculations are as follow:

$$D = \frac{C - S}{Y}$$

WHERE D = depreciation per year by straight-line method
C = purchase cost or basis
S = salvage value at the end of usage period
y = expected years of usage

$$D = \frac{5,040.00 - 0}{2} = 2,520.00 \text{ MT (Meticais)}$$

The coefficients of the factors and inputs used on Table 3.5

for this enterprise budget are the average of ten smallholder farmers of Metangula District, Province of Niassa in Mozambique. The observations were made during 1982 and 1983 by teams of Eduardo Mondlane University students. They are representative for the rainfed and manual conditions in the north. The area cultivated by these farmers varied from 0.5 ha to 2.0 ha, where 66 percent of the area was cultivated for sorghum. The labor force was mainly composed by the family members. The average number of the family members was Six.

An item called "Other revenues" was used in the budgets to incorporate secondary revenues from sorghum enterprise budgets, such as the use of plant residues after harvest to build small poultry houses and animal feeding. This kind of revenue is difficult to estimate accurately since there is no price attached to it. Again, the estimation was based on how much the farmers would be willing to pay to have their animals fed or for the small buildings for poultry.

Official prices are used because data for prices of inputs and outputs in the parallel market are not available. Yet, few farmers use official prices. This is a first attempt to build budgets in conditions of smallholder farmers in Mozambique, where most of the inputs are not purchased. More estimations will be necessary in the future to come with most accurate and significant figures.

## TABLE 3.5: SORGHUM BUDGETS PER HECTARE

FAMILY FARM I
REGION: NORTH
RAINFED,MANUAL
EXCHANGE RATE: 400.00 MT/US$

| VARIABLE COSTS | UNIT | Q | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | kg | 28 | 100 | 2,800 |
| Land clearing & preparation | m/d | 10 | 250 | 2,500 |
| Sowing | m/d | 4 | 250 | 1,000 |
| Weeding | m/d | 10 | 250 | 2,500 |
| Other labor requirements | m/d | 3 | 250 | 750 |
| Harvesting | m/d | 10 | 250 | 2,500 |
| Transportation | m/d | 4 | 250 | 1,000 |
| Bags | units | 5 | 200 | 1,000 |
| 1. TOTAL VARIABLE COSTS | | | | 14,050 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 2,520 | 2,520 |
| 2. TOTAL FIXED COSTS | | | | 2,520 |
| 3. TOTAL COSTS (1. + 2.) | | | | 16,570 |
| REVENUES | | | | |
| | | | yield (kg) | 500 |
| | | | price/kg (MT) | 60 |
| Gross income | | | | 30,000 |
| Other revenues | | | | 2,000 |
| 4.TOTAL REVENUES | | | | 32,000 |
| 5.NET REVENUES (4. - 3.) | | | | 15,430 |

SOURCE : Mucavele, F.G. , 1984 ; Metangula, Niassa, Mozambique.

**TABLE 3.6: SORGHUM BUDGETS PER HECTARE**

**FAMILY FARM II**
**REGION: SOUTH**
**RAINFED MANUAL/ANIMAL TRACTION**
**EXCHANGE RATE: 400.00 MT/US$**

| VARIABLE COSTS | UNIT | Q | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg | 30 | 100 | 3,000 |
| Land clearing & preparation | h/draf. | 8 | 400 | 3,200 |
| Manure | Kg | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 15 | 250 | 3,750 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/draf. | 1 | 400 | 400 |
| Other costs | | | | 1,000 |
| 1. TOTAL VARIABLE COSTS | | | | 19,600 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Animal/draft | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS (1. + 2.) | | | | 25,100 |
| REVENUES | | | | |
| | yield (Kg.) | | | 750 |
| | price/kg. (MT) | | | 60 |
| Gross income | | | | 46,000 |
| Other revenues | | | | 2,000 |
| 4. TOTAL REVENUES | | | | 48,000 |
| 5. NET REVENUES (4.-3.) | | | | 22,900 |

SOURCE: Mucavele, F.G., 1985; Marracuene, maputo, Mozambique.

### 3.4 MAIZE ENTERPRISE BUDGETS

The major costs for maize production are the same as those costs mentioned for sorghum. The calculations of costs and revenues followed the same procedures. One of the differences is that maize requires a very good land preparation and weeding. Therefore, maize enterprises entail higher operating costs than sorghum.

Table 3.7 is the maize budget per hectare in rainfed and manual agrotechnique.

TABLE 3.7: MAIZE BUDGETS PER HECTARE

| | | | | |
|---|---|---|---|---|
| FAMILY FARM I | | | | |
| REGION : NORTH | | | | |
| RAINFED,MANUAL | | | | |
| EXCHANGE RATE : 400 MT/US$ | | | | |
| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
| Seeds | kg | 30 | 130 | 3,900 |
| Land clearing & preparation | m/d | 15 | 250 | 3,750 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 35 | 250 | 8,750 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | m/d | 5 | 250 | 1,250 |
| Bags | u | 7 | 200 | 1,400 |
| 1. TOTAL VARIABLE COSTS | | | | 24,050 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 2,520 | 2,520 |
| 2. TOTAL FIXED COSTS | | | | 2,520 |
| 3. TOTAL COSTS (1. + 2.) | | | | 26,570 |
| REVENUES | | | | |
| | | | yield (kg) | |
| 600 | | | | |
| | | | Price/kg. (MT) | 65 |
| GROSS INCOME | | | | 39,000 |
| 4. TOTAL REVENUES | | | | 39,000 |
| 5. NET REVENUES (4. - 3.) | | | | 12,430 |

SOURCE : Mucavele, F.G. , 1984 ; Metangula, Niassa, Mozambique.

TABLE 3.8: MAIZE ENTERPRISE BUDGETS PER HECTARE

FAMILY FARM II
REGION: SOUTH
RAINFED MANUAL/ANIMAL TRACTION
EXCHANGE RATE: 400.00 MT/US$

| VARIABLE COSTS | UNIT | Q | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg | 32 | 130 | 4,160 |
| Land clearing & preparation | h/draf. | 8 | 400 | 3,200 |
| Manure | Kg | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 35 | 250 | 8,750 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/draf. | 1 | 400 | 400 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| 1. TOTAL VARIABLE COSTS | | | | 24,050 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Animal/draft | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS (1.+2.) | | | | 30,260 |
| REVENUES | | | | |
| | | | yield (Kg) | 850 |
| | | | price/Kg (MT) | 65 |
| Gross income | | | | 55,250 |
| Other revenues | | | | 1,000 |
| 4. TOTAL REVENUES | | | | 56,250 |
| 5. NET REVENUES (4.-3.) | | | | 25,990 |

SOURCE: Mucavele, F. G., 1985; Marracuene, Maputo, Mozambique.

## 3.5 MANAGEMENT PRACTICES

Sorghum and maize are mostly grown by the family sector. As noted earlier, family farmers use very simple techniques with low yields, utilizing little or no purchased inputs. Substantial reductions in yields relative to 1973 appear to be due to farmer's management and incorrect timing of the various agricultural operations. The seed quality is very poor and suffers from a high incidence of disease which further reduces yields. Manual labor and simple hand tools are mostly used for agricultural operations. Shortages of hand tools sometimes have exacerbated the labor shortages at critical times resulting in yield reduction. In the south, sorghum and maize cultivated on the sandy soils have very low yields.

Management of crop enterprises is a decision-making process. Numerous managerial decisions have to be made by the smallholder farmer in response to changing environmental, economic, technological, political, and social conditions. Changing of market prices for both inputs and outputs pressure the farmer to adjust to the new conditions. Under conditions of risk and uncertainty faced by farmers in Mozambique, the smallholder farmers are reluctant to take risk in adopting new technologies or improvements. The smallholder farmers adopt new technology, only when they are sure that the innovation will increase output, product price value, and total returns, or at least, with the expectation of producing the same level of output as before at lower cost or with less labor requirements.

The allocation of scarce resources among crops may depend on goals of the farmer and his/her attitude towards risk. In the south,where the rainfall is scarce and uncertainty is high, the farmers tend to grow sorghum almost all year long while maize is mostly grown during the rain season. This provides to the farmer, the security to have food all year long. Also, it is a conventional knowledge that sorghum is more tolerant to drought than maize, the probability of crop failure is minimized with sorghum. This is because sorghum has extensive and fibrous roots with many hairs, almost twice that of maize. It can reach moisture in soil which other plant crops can not. The goal of the farmer can be to minimize the risk or to maximize the net benefits from farming, to provide enough food for the family subsistence, leisure, and health. After these goals, farmer can have other goals like cash maximization for those involved in marketing, business survival, and social acceptance.

Several authors have attempted to analyze and classify the way farmers deal with risk and uncertainty in developing countries. For a farmer, a major objective may be to maximize the amount of food his/her family has to live on. He/she may also want his/her children to be educated, as a result, they may not be available to work full time in the farm. A farmer may want to avoid risk, and so may plan his cropping pattern to limit risk of crop failure to an acceptable level or to reduce the risk of his/her depending solely on the market for the food profits his/her family will assume. As a result, although he/she may be able to increase his/her income over time if he/she grows cotton instead of sorghum or maize, he/she would rather continue growing food grains to forestall the possibility that in an one year cotton crop might fail or that food gains might be available for purchase in the market only at very high price. All these considerations affect the farmer's cropping pattern choice (Gittinger, J. Price ; 1982).

Farmers must contend with their lack of perfect knowledge about future prices, yields, technology, institutions, and human relations. The situation is worse if we take in account that in Mozambique 87 percent of the population is illiterate, with lack of extension services, and inexistence of data on the past observations of production trends.

The ideal farmer would be the one who deals with the problems of risk and uncertainty, considering four general aspects such as : (1) Know his own ability and willingness to take risks; (2) evaluate all decisions in terms of alternative actions, possible events and payoff; (3) estimate the probabilities or odds associated with events affecting payoffs to decisions; and (4) develop managerial strategies to counteract uncertainty which are applicable to own individual environment (Harsh; Connor, and Schwab-1981). However, what happen is that farmers do not have time to go through this process or they do not have enough knowledge to make decision in this way. Most often, farmers follow the traditions in the family and the accumulated knowledge in the rural community to deal with risk and uncertainty.

When maize was being promoted in the early sixties in Mozambique, there was enthusiasm among farmers ( M. de Carvalho - 1969). However, in the early seventies this enthusiasm slowed down because of the high vulnerability of hybrid varieties introduced. These observations likely made farmers decide to continue with sorghum. However, sorghum production appear to be still declining, perhaps the market institutions are not favorable to stimulate farmers to produce more than what they need for their own consumption. Also, there are no estimates of the probabilities associated with any kind of crop risks in Mozambique. The management practices are based on a priori decision making, using family traditions, and communal knowledge of farmers in each region. Further studies on management practices are still in the research agenda.

## 3.5 COMPARATIVE ANALYSIS BETWEEN SORGHUM AND MAIZE

Sorghum and Maize are both grain crop enterprises with similar agricultural operations. However, they differ on types of market in which they are integrated, the quality of resource used in the production system, and tolerance toward rainfall conditions.

In terms of efficiency and productivity of these crops in rainfed conditions a lot can be said. Comparing the sorghum

enterprise budget shown in the Table 3.5 with the maize enterprise budget in the Table 3.7, it can be seen that maize requires 75 man days per hectare for all operations while sorghum only requires 41 man days per hectare. Maize requires more labor for weeding and land preparation. Even though, more accurate data is needed to come with more accurate figures, the numbers shown here are indicative on how labor is used in these enterprises.

The official price of maize is 65.00 Meticais per Kg and 60.00 Meticais for sorghum. This gives a competitive price advantage for maize over sorghum which likely farmers would get higher gross income in producing maize even with lower yields than sorghum. Estimating break-even points for price and yield ,assuming the yields shown in Table 3.5 and Table 3.7 are constant and without technological changes, considering opportunity cost of labor, sorghum has break-even price 33.14 MT while maize has break-even price of 44.28 MT. The calculations are as follow:

VALUE OF PRODUCTION = TOTAL COSTS

BREAK-EVEN PRICE FOR SORGHUM

$$500 * PRs = 16,570.00$$

$$PRs = 33.14 \text{ MT}$$

where PRs is the break-even price for sorghum

BREAK-EVEN PRICE FOR MAIZE

$$600 * PRm = 26,570.00$$

$$PRm = 44.28 \text{ MT}$$

where PRm is the break-even price for maize

If the previous assumption is taken out, admitting that sorghum varieties are improved, the break-even yield would be 650 Kg assuming actual prices constant.

Sorghum has less costs (16,570.00 MT ) than maize (26,570.00 MT) and higher net revenues.

Net returns to labor, management, and land also can be estimated. Assuming that the return to management is zero and returns to land is zero since the farmers do not pay for land, the net returns for labor can be estimated as :

SORGHUM : $NRLs = (VP - TC)/41$ m/days

where: NRLs is the net returns to labor in sorghum enterprise.

VP is the value of production for sorghum

TC is the total costs.

NRLs = (32,000.00 - 16,570.00)/41

NRLs = 376.34 MT m/day

MAIZE : NRLm = (VP - TC)/75

where: NRLm is the net returns to labor in maize enterprise.

NRLm = (39,000.00 - 26,570.00)/75

NRLm = 165.73 MT m/day

The farmers in this conditions would prefer sorghum enterprise since the returns to labor for sorghum enterprise is higher than labor returns for maize enterprises, assuming equal opportunity cost for labor in both enterprises, and considering all other factors ceteris paribus.

Without considering the opportunity cost from the survey, a new break-even opportunity cost of labor can be determined as follow:

VP = (TC -LC)+(OCL*m/days)

where: VP is the value of production for sorghum

TC is the total costs.

LC is labor cost (opportunity cost).

m/days is the total amount of labor

OCL is break-even opportunity cost of labor for the crop enterprise.

For Sorghum: 32,000.00=(16,570.00-10,250.00)+(OCL*41)

OCL=626.34

For maize: 39,000.00=(26,570.00-18,750.00)+(OCL*75)

OCL=415.73

The break-even opportunity cost of labor for sorghum is higher (626.34 MT) than the break-even opportunity cost of labor for maize (415.73 MT).

Considering a three years of consecutive farming, sorghum appears to have more advantages over maize. Table 3.9 presents a summary of enterprise budgets considering three consecutive years of farming in the same area by the same family. Two kind of agrotechniques were studied: rainfed-manual and rainfed animal- traction. The family farms I are located in the northern part of the country in the district of Metangula, province of Niassa, and the family farms II are located in the southern part of the country, district of Marracuene, province of Maputo.

Rainfed-manual agricultural technology is characterized by manual labor, without irrigation, where hoe is the main tool used. Fertilization of soils is not practiced and generally crops are mixed. Rainfed animal-traction is the kind of agricultural technology in which animal traction is used for land clearing and preparation and transportation. Animal or green manure is applied. More often, single cropping is practiced, mainly in maize.

The total fixed costs in case of family farm II is higher compared with to the fixed cost of family farm I because of draft animals and extra tools needed for animal traction.

The yield of sorghum in the second year for the family farm I is higher compared to the yield in the first year due to the second sowing which increases the plant density.

**TABLE 3.9:SUMMARY OF ENTERPRISE BUDGETS**

| ITEM | YEAR 1983 | 1984 | 1985 | TOTAL |
|---|---|---|---|---|
| **FAMILY FARM I : MAIZE** | | | | |
| TOTAL VARIABLE COSTS | 24,050 | 21,650 | 19,900 | 65,600 |
| TOTAL FIXED COSTS | 2,520 | 2.520 | 2,520 | 7,560 |
| TOTAL COSTS | 26,570 | 24,170 | 22,420 | 73,160 |
| GROSS INCOME | 39,000 | 34,450 | 32,500 | 105,950 |
| NET REVENUES | 12,430 | 10,280 | 10,080 | 32,790 |
| **FAMILY FARM II : MAIZE** | | | | |
| TOTAL VARIABLE COSTS | 24,760 | 25,210 | 26,210 | 76,180 |
| TOTAL FIXED COSTS | 5,500 | 5.500 | 5,500 | 16,500 |
| TOTAL COSTS | 30,260 | 30,710 | 31,710 | 92,680 |
| GROSS INCOME | 55,250 | 56,250 | 56,250 | 167,750 |
| OTHER REVENUES | 1,000 | 1,000 | 1,000 | 1,000 |
| NET REVENUES | 25,990 | 26,540 | 25,540 | 78,070 |
| **FAMILY FARM I : SORGHUM** | | | | |
| TOTAL VARIABLE COSTS | 18,800 | 11,200 | 18,800 | 48,800 |
| TOTAL FIXED COSTS | 2,520 | 2,520 | 2,520 | 2,520 |
| TOTAL COSTS | 21,320 | 13,720 | 21,320 | 56,360 |
| GROSS INCOME | 30,000 | 36,000 | 28,800 | 94,800 |
| OTHER REVENUES | 2,000 | 2,000 | 2,000 | 6,000 |
| NET REVENUES | 15,430 | 24,280 | 9,480 | 49,190 |
| **FAMILY FARM II : SORGHUM** | | | | |
| TOTAL VARIABLE COSTS | 19,600 | 12,700 | 19,400 | 51,700 |
| TOTAL FIXED COSTS | 5,500 | 5,500 | 5,500 | 16,500 |
| TOTAL COSTS | 25,100 | 18,200 | 24,900 | 68,200 |
| GROSS INCOME | 46,000 | 43,200 | 43,200 | 132,400 |
| OTHER REVENUES | 2,000 | 2,000 | 2,000 | 2,000 |
| NET REVENUES | 22,900 | 27,000 | 20,300 | 70,200 |

SOURCE : MUCAVELE, F. G. , 1984 - 1985 IN " AS COOPERATIVAS AGRICOLAS : ALGUNS FACTORES QUE AFFECTAM O SEU DESENVOLVIMENTO ECONOMICO"; MAPUTO, MOZAMBIQUE.

In terms of profits, sorghum under rainfed-manual agrotechnique in the northern part of the country has an accumulated net returns of 49,190.00 Meticais while maize has only 32,790 . In conditions of animal traction, maize performs better than sorghum. This is due to the density of plants per hectare which is higher in maize since the intercropping rate on maize more often is lower compared with sorghum.Also, it seems that maize responds well to manure fertilization (see in the appendices section).

Sorghum has an agronomic comparative advantage over maize. After harvesting sorghum in the first year, the plants can be cut 10 centimeters above the soil level and left on the field for the next season. The plants will grow and a second harvest can be done without expending as much inputs as the year before.

Empirical data from Manjacazi, a district of Gaza Province in the southern part of the country, shows that there is high correlation between the level of production on sorghum and maize and drought. However maize is more affected by water deficit than sorghum. Table 3.10 (page 41) presents the total production of sorghum in the district, the total production of maize in the district, total annual rainfall, real evapotranspiration (REVAPO), and water balance (WBALANCE) which is the difference between the total annual rainfall and real evapotranspiration (water availability or disposable).

TABLE 3.10: TOTAL PRODUCTION OF SORGHUM, MAIZE AND WATER BALANCE IN MANJACAZE, GAZA, MOZAMBIQUE

| YEAR | SORGHUM | MAIZE | RAINFALL | REVAPO | WBALANCE |
|---|---|---|---|---|---|
| | ( TONES | ) | ( | MILLIMETERS | ) |
| 1951 | 689.0 | 724.0 | 394.7 | 485.2 | -90.5 |
| 1952 | 733.0 | 854.0 | 828.5 | 702.1 | 126.4 |
| 1953 | 721.0 | 612.0 | 816.9 | 984.0 | -167.1 |
| 1954 | 552.0 | 355.3 | 330.1 | 672.5 | -342.4 |
| 1955 | 702.0 | 811.0 | 804.8 | 699.0 | 105.8 |

SOURCE: Marques, J.Montalvao, 1960. "Esboco para uma Monografia Agricola do Posto dos Muchopes e de Regulados do Chibuto"; Lisbon, 1960.

Some researchers are hypothesizing that the area usually used for sorghum production has been shifted for maize production. To test this hypothesis, time series analysis was done using regression techniques. The total planted area for maize was considered dependent variable while area planted for Sorghum and millet were considered independent variables. These crops are competing with maize for the land use.

The estimated regression equation was ( with standard error in parenthesis):

$$ARMAIZ = \underset{(64,268.750)}{134,577.070} - \underset{(0.125)}{0.176}*ARSORG + \underset{(1.413)}{17.548}*ARMILL$$

Where ARMAIZ = Total planted area for maize.

ARSORG = Total planted area for sorghum.

ARMILL = Total planted area for Millet.

The R-squared is 0.826 , adjusted R-squared is 0.815, the standard error of regression is 141,191.7, and Durbin-Watson statistic is 0.305. F-statistic is significant at 1 percent level. Except for ARMILL, all variables have the expected sign. Arsorg has negative sign, which means that a decrease in the area of sorghum planted results in an increase of maize area planted. This can be admitted as substitution of the sorghum land for use in maize cropping. However, t-statistic for sorghum land (ARSORG) is not significant at 5 percent level. Durbin-Watson statistic presents a probable serial correlation, since is close to zero (0.305). Even though, adjusted R-squared is high (0.815) indicating that the variation of the area planted for maize might be explained by proportion variation of the independent variables. Yet, further studies should be done to test this hypothesis.

Agronomically more aspects of sorghum can be compared. The following Table 3.11 compares the different characteristics between sorghum and maize.

**TABLE 3.11: AGRONOMIC COMPARISON BETWEEN SORGHUM AND MAIZE**

| CHARACTER | SORGHUM | MAIZE |
|---|---|---|
| ROOT SYSTEM | - Extensive and fibrous<br>- Deep and perennial<br>- Support development of ratoon | - Small root system<br>- 45 cm and annual<br>- No ratoon |
| PANICLE | - open panicle with spreading branches | - 2 inflorescence Each ear is protected by glumes or husks |
| ADAPTABILITY | - Many environments | - Mostly tropical with plentiful water |
| FERTILIZER RESPONSE | - Relatively low response | - High response |
| TEMPERATURE RELATIONS | - Produce grain even though temperature is high<br>-Floral development and seed are normal at temperature of 40 to 43 c | - Does not produce grain when temperature is above 38 c<br>- Above 32 c do not develop floral system |
| WATER RELATION | - Sorghum is usually grown under hot and dry conditions. Requires less water 332 Kg of water per Kg of accumulated dry matter. | - requires more water-368 Kg of water per of accumulated dry mater |
| WATER RELATION | - The root system is able extract moisture in deep levels of soil and more volume.<br>- Tend to "hang on" during dry season and resumes growth with return of rain<br>- Withstands wet extremes | - Root system is does not reach reach moisture under 45 cm<br>- "dies" during season<br>- Dies in wet extremes |

| CHARACTER | SORGHUM | MAIZE |
|---|---|---|
| SALT TOLERANCE | - Relative tolerance to salt and aluminum toxity | - Does not have tolerance to salt and aluminum toxity |
| STORAGE | - High losses | - relative low losses |
| DISEASES | - relative tolerance | - Less tolerant |
| BIRD DAMAGES | - High | - Low |
| STABILITY OF VARIETIES | - Low stability of hybrids | - High stability hybrids |

### 3.7 SUMMARY

In dry and rainfed conditions, sorghum enterprises analyzed in this chapter have less total costs and higher net revenues compared with maize enterprises. Considering the opportunity cost of labor given by the survey (250.00 MT per man/day), and assuming that the current agricultural technology does not change, sorghum has lower break-even price (33.14 MT) than maize which has a break-even price of 44.28 MT. Currently, the break-even opportunity cost of labor for sorghum is 626.34 MT while for maize it is 415.73 MT per hectare man/day. If technology improvements are made or new varieties are introduced without increasing the present costs of production, the break-even yield for sorghum would be 650 Kg per hectare. The net returns to labor for sorghum are also higher (376.34 MT) than net returns to labor for maize (165.73 MT).

A review of literature showed that sorghum in dry and rainfed conditions has agronomic comparative advantage over maize.

The trend analysis of total output has shown a relative decline of sorghum production in the last 15 years despite the above mentioned comparative advantages. The reasons are not yet clear, however is believed that migration from marginal and dry lands to more productive lands has caused a change in crop patterns. It also appears that the war has affected more the large sorghum producing regions of sorghum than it has to the large maize producing areas.

# CHAPTER IV : A REVIEW OF THE STRUCTURE AND POLICIES FOR GRAIN MARKET IN MOZAMBIQUE

## 4.1 THE STRUCTURE OF GRAIN MARKETS IN MOZAMBIQUE

Ninety percent of sorghum and maize are produced by smallholder farmers and the remaining 10 percent by the private sector and state farms. In the rural areas it is common to find product exchange, mainly sorghum for labor or poultry. The market for maize is more developed than it is for sorghum (MOA and FAO, 1987).

Before independence in 1975, the rural marketing system was operated by a system of "cantineiros", or types of local private traders. After independence, state trading firms were created "Empresas das Lojas do Povo" which replaced the system of cantineiros. They were responsible for input supply and crop purchase, storage, and marketing. Empresas das Lojas do Povo had many difficulties from 1976 to 1980. They were inoperative, and in 1980 they were abolished, with over 90 percent being sold to private traders and the rest to consumer cooperatives. In 1978 it was also decided to link the agricultural marketing and the supply of consumer goods to the smallholder sector under one Ministry. The National Directorate for Agricultural Marketing (DNCA) was created in the Ministry of Internal Trade. In 1981 improvements in the market structure were made by creating the State Enterprise for agricultural Marketing (AGRICOM) which replaced DNCA as a parastatal under the Ministry of Internal Trade. AGRICOM has a goal of working together with the network of private traders.

Currently, there are no legal barriers to participation in domestic marketing by the private sector in Mozambique. However, the current price setting system represents a potentially serious economic barrier. AGRICOM and private traders provide the main structure for marketing output and supplying consumer goods for the smallholder sector in rural areas. The basic policy is that private traders would buy grain production from smallholder farmers while AGRICOM would operate principally at the wholesale level, with responsibility for transport, storage, and distribution to urban areas and processing factories (FRELIMO, 1985). In summary, the assessment made by AGRICOM in 1985 with collaboration of the Mozambique Nordic Agricultural Programme (MONAP) reported the existence of 2452 private traders in the agricultural marketing network. Around 1,000 consumer cooperatives participated in the grain marketing and almost 100 other intermediaries including a number of Lojas do Povo which were still in operation, and purchasing outlets run by social and educational institutions ( AGRICOM, annual report, 1986). AGRICOM operates with two kinds of units : mobile brigades and fixed posts. Mobile brigades cover areas where neither private traders nor consumer cooperatives exist and the war is intensive. The fixed posts are mostly located in the villages. In 1985, there were 100 mobile brigades while the fixed posts were 150. In general, state farms and large private commercial farms take care of their own marketing, selling their production directly to the smallholder farmers as consumers and buying from them what they need.

AGRICOM have serious difficulties in transportation due to the damages and attacks on rural shops and vehicles by the anti-government groups. Many private transporters are also only prepared to operate in safe areas. The withdrawal of private traders from many areas forces AGRICOM to enter into the grain crop purchasing and distribution of inputs and consumer goods at the primary level, often at very high cost. The roads in the rural areas are very poor. Consequently, access is often very difficult which increases vehicle operating costs and times totally disrupts the marketing.

In Mozambique the supply of agricultural inputs is directly linked with marketing of agricultural production (MOA Report, 1985). Six state enterprises are involved in the import, distribution, and marketing of agricultural inputs. Imports are handled by INTERQUIMICA for fertilizer and pesticides; by MEDIMOC for veterinary products, by BOROR for seed, and by INTERMECANO for machinery. The distribution of pesticides, fertilizers, seed, and veterinary medicines and instruments is the responsibility of BOROR. AGRICOM Is responsible for distribution of inputs to the smallholder farmers. This implies that AGRICOM should be closely related with the import state enterprises to satisfy the demand on inputs of the smallholder farmers. More often, AGRICOM is not able to supply the inputs on time which in turn reduces the participation of the smallholder farmers in marketing.

## 4.2 MARKETING AND PRICING POLICY SYSTEM

In Mozambique, the state attempts to control the economy directly through production planning and investment, as well as indirectly by establishing the control over prices and salaries. This fact has implications for analysis and formulation of the grain price policy in Mozambique. There are two pragmatic points that can be identified when a development strategy for prices is to be established: First, prices should be maintained low to facilitate the resource transfer to the urban industrial sector and also rural consumers with small size farms. This may be put in parallel to the Arthur Lewis Model (1954) or theories of primitive accumulation based on peasant production. Second, prices are one critical factor in the production decision process of the farmers. In other words, production price relationship determines what the farmer would produce. This is a neoclassical position. In Mozambique, this two pragmatic situations are verified. It is believed that low grain prices for consumers will stimulate the demand side and in turn, the increase demand for grain will improve the supply for grain. However, it is believed that farmers respond better to higher price incentives which contradicts with the low price strategy. Then, the Government will have to subsidize the grain production or improve the agricultural technology to allow more sorghum production at existing prices if both demand and supply side objectives are to be satisfied.

The prices of sorghum, maize, rice, and wheat are controlled by the state through the National Commission for Salaries and Prices (CNSP). In addition, the CNSP also set marketing and processing margins and, where applicable, consumer prices. Although prices were, in principle, set on the basis of production costs on the state farms, these prices were adjusted infrequently and became increasingly out of line with domestic shortages and scarcities (World Bank Report, 1988). Through AGRICOM, the Ministry of Commerce coordinates purchases of most basic grains, including food imports, and purchases and distribution of consumer goods and agricultural inputs in the rural areas (Report of the Ministry of Commerce - MOC, 1987).

Shortages of main food grain, emerged in 1977 in official market and an active parallel market developed for almost all food grains. The system of fixing margins throughout the marketing chain has been very cumbersome and difficult to monitor, leading to distortions in the system of incentives for the smallholder farmers to store or even for the private sector to transport and process sorghum, maize, rice, and millet. An addition contributory factor for official grain supply decrease was the acute scarcity of consumer goods in the rural areas. Peasants have little incentive to produce surpluses for cash when there were no goods to buy with the money and real deposit rates usually are negative (MOA, 1987). Accumulations of money without sufficient consumer goods has led to a growing parallel market in consumer goods at prices that effectively diminished supply of grain crops in the official market, as farmers have either sold their produce in the parallel market or ceased to produce beyond subsistence needs. In the parallel market it seems that there was a relative supply or exchange of sorghum for labor or other rural goods. It is not clear if there is an effective demand in the rural areas (World Bank, 1988). More studies are needed to clarify this aspect. Also, there is a need to improve the market institutions to promote rural marketing .

Deflated official prices from 1975 to 1988 are presented in the Table 4.1 . The base year is 1975 using CPI as deflator to reflect producer purchasing power. The CPI is estimated by the National Directorate of Statistics (DNE) in the National Planning Commission (CNP).It is a weighted average of price changes in both official and parallel markets, based on rural and urban household expenditure surveys. The rate of inflation currently faced by different economic agents would vary depending on the principal locus of their purchases. Notice that the typical basket of consumer goods includes capulana, poplin, edible oil, sugar, soap, salt, batteries, gasoline, hoe, and scythe.

During the first years following independence, official producer prices were essentially unchanged. From about 1980. the Government became more aware of necessity to adjust producer prices, but, in practice, price official adjustments were made rather infrequently and generally in large discrete jumps ( World Bank, 1988).

**TABLE 4.1: DEFLATED OFFICIAL PRODUCER PRICES: 1976 - 1988**

| YEAR | CPI | SORGHUM | MAIZE (MT/KG) | RICE |
|---|---|---|---|---|
| 1975 | 100 | 2.30 | 2.50 | 5.50 |
| 1976 | 101 | 2.28 | 2.48 | 5.45 |
| 1977 | 103 | 2.91 | 3.11 | 6.02 |
| 1978 | 104 | 2.88 | 3.08 | 5.96 |
| 1979 | 106 | 2.83 | 3.02 | 5.85 |
| 1980 | 107 | 2.80 | 3.75 | 5.59 |
| 1981 | 109 | 3.67 | 3.67 | 5.69 |
| 1982 | 129 | 3.88 | 4.65 | 7.75 |
| 1983 | 165 | 3.03 | 3.64 | 6.06 |
| 1984 | 216 | 2.30 | 2.78 | 4.64 |
| 1985 | 178 | 6.74 | 7.30 | 8.99 |
| 1986 | 338 | 3.55 | 3.85 | 4.73 |
| 1987 | 845 | 4.14 | 4.73 | 5.68 |
| 1988 | 1,690 | 3.55 | 3.85 | 4.44 |

SOURCE: Mucavele, F.G. 1988. Calculations based on given CPI by the CNP and official prices practiced by AGRICOM.

The real official producer prices decreased from 1975 to 1980. During 1981 and 1982 the real producer prices of sorghum in the official market increased from 2.80 MT in 1980 to 3.88 MT in 1982. Assuming correct deflators, the real official producer price of sorghum in 1984 was the same as the real sorghum producer price in the official market (2.30 MT) in 1975. The highest real official producer price for sorghum was in 1985. Generally, in the official market the price of sorghum is relatively lower than prices of Maize and Rice (see Table 4.1). This brings a price conflict situation: sorghum has a comparative price advantage on the consumers' side relative to maize and rice, assuming that no other factors affects the consumers' choice. But on the other hand, lower prices give sorghum a comparative price disadvantage relative to maize and rice on the supply side.

In the parallel market, real (Table 4.2) prices have been increasing continuously following the increase of food shortages. Comparing the prices in both markets, it can be noticed that while in the first four years after independence official nominal prices were unchanged, in the parallel market nominal prices of sorghum were growing drastically, from 5.00 MT/kg of sorghum in 1976 to 11.00 MT/kg in 1980. This is almost four times the official price. Table 4.2. presents the deflated producer prices in the parallel market in Marracuene, Maputo Province (see methods used to obtain these prices in appendices section).

The real prices of sorghum in the parallel market increased continuously from 1975 to 1981 where the peak price of 11.93 MT was verified. Since then, the real prices of sorghum in the parallel market have been decreasing. This can be explained by the fact that changes in the official prices stimulated the producers to place their product in the official market instead of parallel market. Generally, marketing in the parallel market is high risk because of police and other legal barriers while in the official market producer do not face this problem. There is a level from which the producers are willing to leave the parallel market to official market. This can be the point where the expected price of sorghum in the parallel market does not compensate for the risk and cost of production.

**TABLE 4.2: DEFLATED PRODUCER PRICES IN THE PARALLEL MARKET: 1976-1986**

| YEAR | CPI | SORGHUM | MAIZE (MT/KG.) | RICE |
|---|---|---|---|---|
| 1975 | 100 | 5.00 | 3.00 | 6.00 |
| 1976 | 101 | 4.95 | 2.97 | 5.94 |
| 1977 | 103 | 7.28 | 7.77 | 9.71 |
| 1978 | 104 | 8.17 | 8.17 | 9.62 |
| 1979 | 106 | 9.43 | 9.43 | 14.15 |
| 1980 | 107 | 10.28 | 10.75 | 16.36 |
| 1981 | 109 | 11.93 | 12.39 | 18.35 |
| 1982 | 129 | 10.08 | 13.57 | 19.38 |
| 1983 | 165 | 7.27 | 12.12 | 18.18 |
| 1984 | 216 | 5.79 | 10.42 | 17.36 |
| 1985 | 178 | 7.87 | 14.04 | 25.28 |
| 1986 | 338 | 6.07 | 8.88 | 14.79 |

SOURCE : Mucavele, F.G., 1988. Calculations based on given CPI by the CNP and surveys carried out in Marracuene District, Maputo Province.

The official grain market decline can be attributed to a several factors.Partly it is due to exogenous factors such as drought, floods, shortage of essential inputs for production and marketing, and war. One important endogenous factor for decline in marketed grain production is the policy of price control (AGRICOM, 1984). The combination of nominal price controls and rapid inflation leads to declining real prices and profits. Then, farmers, processors, and merchants lose the incentive to produce and market the products through official channels. As the products begin to disappear from the official market, consumers bid more aggressively to fulfill their demand, putting upward pressure on parallel market prices. If the official prices are not revised upward, supply shortages and a parallel market will develop (Word Bank, 1988). Therefore, rigid short-term price controls tend ultimately to drive products from the controlled market to a parallel market, where prices are higher than in an official free market to compensate for the added risk of selling products illegally (MOC, 1987). Another important problem in the pricing system is that prices are set pan-territorial and do not vary throughout the regions and seasons.They are also the same regardless of quality of grain (MOA and FAO, 1987). This leads to inefficiencies. Maximum selling prices discourage product innovations to improve quality because the seller can get the same controlled price regardless of the quality of product ( Word Bank, 1988). In practice, what happen is that sellers tend to sell the worst quality produce at the official prices, especially to AGRICOM, and retaining the superior quality for parallel market and auto-consumption (Mucavele, 1985). High prices in the off season would provide signals to smallholder farmers to invest in improvements in agrotechniques in order to lengthen the growing season and correct seasonal imbalances of supply and demand. With a fixed nominal producer price all over the year, there are no such incentives; consequently, shortages emerge during the off season, leading either to some sort of rationing or to a parallel market with much higher prices (World Bank, 1988).

Official margins fixed for grain crops may have also affected marketing. They affect storage, transportation, and processing decisions. It reduces the incentives for private traders to buy grain at harvest for storage and sale later in the year since prices are not higher later in the season. Uniform price over a wide geographical area affects participation of the private sector in transportation (World Bank, 1988).

## 4.3 SUGGESTIONS AND POTENTIAL ALTERNATIVE POLICIES FOR FUTURE MARKETING PRICING POLICY SYSTEM IN MOZAMBIQUE

The Government has started an economic rehabilitation program where the main issues are the exchange rate and trade policies, budget and credit, pricing policies, and policy and institutions in agriculture. The grain market is one of the important agricultural marketing components to be considered.

The smallholder farmers produce more than 90 percent of the total food grain in Mozambique. Then, it can be recommended that Government concentrate its resources on increasing productivity in the smallholder farmers' sector rather than on promotion of the state farms. This does not mean that the state farm agriculture production sector is not important. What is suggested is that for the actual institutional and structural conditions in Mozambique, the smallholder farmers have much lower unit costs of producing than the large state farms and there are likely to be very high returns to low cost improvements in the smallholder farmer such as improved varieties, better quality seed, handtools and low doses of fertilizer utilization. On the other hand, it seems that resources when spread widely and thinly in the smallholder sector pose a lower security risk than in the large scale projects. The investment in the smallholder farmers can place less strain on scarce management resources than investments in large scale projects where deficits are more common.

Currently, the Government is reforming the pricing system. It would seem to be desirable that the fixed price system be limited to a few agriculture products where government can be able to effectively support and control. The analysis of real prices should be done to predict the behavior of producers and avoid decreases in the real prices. It would be desirable that real producer prices at least remain constant in the short term, with perspective to stabilize prices in the long run. For those products which the price would remain controlled, it would be better if the prices were adjusted regularly based on exchange rate changes, and international prices . To stimulate the smallholder farmers and traders to improve their grain marketing, the minimum price system should be introduced. This would avoid that certain smallholder farmers withdraw from grain production for official marketing. As well, the Government may be interested in favoring certain regions by establishing a relative high producer price as incentive to farmers who are affected by adverse conditions. This price reforms, perhaps can have an effect if in the rural areas the consumer goods are available so the smallholder farmers would devote their time to grow few crops and rely on the market for other commodities. However, this is not the only solution. There should be an integrated system of reforms, agriculture policies, and market institutions and technological improvements for the smallholder farmers. Research should bring new technologies suitable to the smallholder resource constraints as well as to bring increases on crop yields and land productivity. There should be food crop prices which are accessible to the consumers and acceptable to the producers.

The Government may consider the possibility of subsidizing small grains such as sorghum to create access for those who can not afford higher prices .

The Government should continue providing agricultural services such as research, extension, credit, education and training, and basic marketing infrastructure . The investments should be to provide services and facilities to support production and marketing rather than direct investment in large scale agriculture projects.

# CHAPTER V: SUPPLY FUNCTIONS FOR SORGHUM AND MAIZE PRODUCTION IN MOZAMBIQUE

## 5.1 SUPPLY MODEL FOR SORGHUM

### a) SPECIFICATIONS OF THE MODEL

Theoretically, the supply of sorghum produced is a function of producer's own food consumption requirements, the producer's price expectations for the product, the expected price of the major inputs, the expected prices of other commodities competing for the same resources or the same consumers, availability of land, area planted the previous year, institutional constraints such as government policy, time trend, change in agricultural technologies, and climatic conditions. Over the sample period to be examined, 1950 to 1985, there were two periods: the years from 1950 to 1976 characterized by an increase in total sorghum production and the second period, from 1977 to 1985 showing a decline in total sorghum production .

Some problems of sorghum production in Mozambique were discussed in the previous chapters - the lack of security in the country side due to the war, the decline in real prices over time, the climatic problems, poor varieties, and lack of incentives to producers. Due to the nature of smallholder's farming systems in Mozambique and the availability of data for the study, some of these factors will not be included in the analyses. This places constraints on the analysis especially, not have information to quantify the effects of war, yet the goal in this chapter is to try to do as much as possible with the data tha is available.

Conceptually, a supply model is specified as :

SORGO = f(PRSORG, PRMAIZ, MAIZE, MILLET, RICE)

where : SORGO = Total sorghum production in Mozambique

PRSORG = Official nominal producer price of sorghum

PRMAIZ = Official nominal producer price of maize

MAIZE = Total maize supplied in Mozambique

MILLET = Total millet supplied in Mozambique

RICE = Total rice supplied in Mozambique

Total sorghum production was used as the dependent because it was the best estimate of the supply among the data available for the study. Some authors suggest that the area planted in agricultural commodity is the best estimate of the supply produced because the farmer's decision about how much to produce is expressed by the amount of land planted to a crop. Once the crop is in the ground, the amount that will be produced is more or less determined. However, to analyze the data available for the present study, area estimated was not a good choice as the dependent variable because of reliability and discontinuity of data available .

The official nominal producer price of sorghum was used as one of the independent variables. This variable was lagged two years in the second regression because most of the sorghum produced in a given year reflects the price of the previous two years. Farmers do not appear to react to changes in price in the first year, but they do change in the second year. The sorghum producer price was used in monetary terms without deflating with CPI because there is limited knowledge among smallholder farmers about inflation, due to a poor marketing infrastructure. Official prices are used because the commodity prices of the parallel market are not available for all the variables included in the model.The maize producer price was included in the model to capture the effect of price changes on maize, since it is a substitute commodity for sorghum. Other substitutes considered in the model are millet and rice. Auto regression (AR) was used in to correct possible serial correlation between the error terms of different observations (years). This is the most elementary form of an auto regressive error process in which the effect of an error in any given time period is shown in the future time periods, but its magnitude diminishes over time.

There are two kind of residuals associated with one time auto-regression (AR(1)) estimation. One kind is the unconditional residual, computed just as in least squared estimation: the dependent variable minus each original independent variable multiplied by its regression coefficient. Making predictions without knowing the lagged residuals is a one-period-ahead forecast error.This error occurs when computing a forecast by applying the coefficients to the independent variables and then adding the prediction of the residual from its own past value (Hall and Lilien, 1986). Because of serial correlation, these residuals will tend to be smaller. The standard error and Durbin-Watson statistic are based on the one-period-ahead forecast errors. The improvements can be made using auto regression which reflects the extra predictive power of the lagged residual.

b) **RESULTS**

1) The original equation estimated was : (see Table 5.1, page 67)

SORGO=465,550.5 - 43,547.35*PRSORG(-2)

R-squared= 0.72 , Adjusted R-squared= 0.683, Standard Error of Regression =30,688.47 (SER), F-Statistic= 18.28

**STRENGTHS:** - Standard error of regression is only 10 percent of the mean of dependent variable .

- t-Statistic is significant at 5 percent level for the price variable.
- Adjusted R-squared is acceptable (0.683).
- F-statistic is significant at 1 percent.

**WEAKNESSES:**- The sign of the sorghum producer price was expected to be positive. However, it is negative.

TABLE 3.1: Sorghum Supply Equation

SMPL 1950 - 1986
9 Observations
LS // Dependent Variable is SORGO

| VARIABLE | COEFFICIENT | STD. ERROR | T-STAT. | 2-TAIL SIG. |
|---|---|---|---|---|
| C | 465550.51 | 39045.824 | 11.923183 | 0.000 |
| PRSORG(-2) | -43547.346 | 10184.327 | -4.2759178 | 0.004 |

| | | | |
|---|---|---|---|
| R-squared | 0.723139 | Mean of dependent var | 304425.3 |
| Adjusted R-squared | 0.683588 | S.D. of dependent var | 54556.77 |
| S.E. of regression | 30688.47 | Sum of squared resid | 6.59D+09 |
| F-statistic | 18.28347 | Log likelihood | -104.6243 |

Covariance Matrix

| | | | |
|---|---|---|---|
| C,C | 1.52D+09 | C,PRSORG(-2) | -3.84D+08 |
| PRSORG(-2),PRSORG(-2) | 1.04D+08 | | |

```
=====================================================================
          Residual Plot                   obs RESIDUAL  ACTUAL   FITTED
=====================================================================
:      :        :       * :      : 1978  23847.4  389239.  365392.
:      :        :         : *    : 1979  36971.5  371880.  334908.
:      :        :       * :      : 1980  23860.5  358769.  334908.
:     *:        :         :      : 1981 -34179.5  300729.  334908.
:  *   :        :         :      : 1982 -48885.5  286023.  334908.
:      :  *     :         :      : 1983 -19922.1  271439.  291361.
:      :        :*        :      : 1984  2375.22  250189.  247814.
:      :        :  *      :      : 1985  8166.22  255980.  247814.
:      :        : *       :      : 1986  7766.22  255580.  247814.
=====================================================================
```

SOURCE: Mucavele, Firmino G. (1988

The original equation was a first attempt to estimate the supply function, considering price as the only endogenous variable. It says that increases on nominal official producer price for sorghum will result in an decline of sorghum supply. This is opposite to the supply theory. The negative sign obtained was not expected. It is actually difficult to say if the sign is correct or not because of the limited variables considered in this regression. There must be other factors which are more relevant to explain the quantity of sorghum supplied. Price variable was lagged and the best estimate was found in the second period lag. Without lagged price, the Adjusted R-squared was 0.416, with SER equal to 49,443.28 which is 14.9 percent of the mean of dependent variable. F-Statistic was very low.

To improve the fit, more variables were brought into the model.

2) Second equation was: (see Table 5.2, page 69)

SORGO=-432,700.90 - 0.614*MAIZE + 0.096*RICE + 40.425*MILLET

- 18,753.041*PRSORG + 20,004.635*PRMAIZ

**STRENGTHS:**- High Adjusted R-Squared (0.994)

- F-statistic is significant

- Standard error of regression is only 1.4 percent of the mean of the dependent variable.

TABLE 5.1: Sorghum Supply Equation

SMPL 1950 - 1986
9 Observations
LS // Dependent Variable is SORGO

| VARIABLE | COEFFICIENT | STD. ERROR | T-STAT. | 2-TAIL SIG. |
|---|---|---|---|---|
| C | 465550.51 | 39045.824 | 11.923183 | 0.000 |
| PRSORG(-2) | -43547.346 | 10184.327 | -4.2759178 | 0.004 |

| | | | |
|---|---|---|---|
| R-squared | 0.723139 | Mean of dependent var | 304425.3 |
| Adjusted R-squared | 0.683588 | S.D. of dependent var | 54556.77 |
| S.E. of regression | 30688.47 | Sum of squared resid | 6.59D+09 |
| F-statistic | 18.28347 | Log likelihood | -104.6243 |

Covariance Matrix

| | | | |
|---|---|---|---|
| C,C | 1.52D+09 | C,PRSORG(-2) | -3.84D+08 |
| PRSORG(-2),PRSORG(-2) | 1.04D+08 | | |

| Residual Plot | obs | RESIDUAL | ACTUAL | FITTED |
|---|---|---|---|---|
| `! : ! * : !` | 1978 | 23847.4 | 389239. | 365392. |
| `! : ! : * !` | 1979 | 36971.5 | 371880. | 334908. |
| `! : ! * : !` | 1980 | 23860.5 | 358769. | 334908. |
| `! *: ! : !` | 1981 | -34179.5 | 300729. | 334908. |
| `! * : ! : !` | 1982 | -48885.5 | 286023. | 334908. |
| `! : * ! : !` | 1983 | -19922.1 | 271439. | 291361. |
| `! : !* : !` | 1984 | 2375.22 | 250189. | 247814. |
| `! : ! * : !` | 1985 | 8166.22 | 255980. | 247814. |
| `! : ! * : !` | 1986 | 7766.22 | 255580. | 247814. |

SOURCE: Mucavele, Firmino G. (1988)

- For ten-year time period ( due to the lack of data on prices for the period from 1950 to 1985), using five variables is acceptable.
- No serial correlation, the Durbin-Watson statistic is good (2.43).
- All independent variables, except PRSORG, have signs expected in model conceptualization.
- All coefficients are statistically significant at 5 percent level except RICE.
- The data used is of recent years which can reflect the current conditions and policies in the country.

**WEAKNESSES:**- Negative sign for PRSORG.

- Few number of observations (10 years).

This estimated sorghum supply equation says that as maize supply rises, the supply of sorghum will decrease. This may be correct. The supply theory supports this result and it is logical to think that increasing maize, which is a substitute for sorghum would reduce the consumption of sorghum which is considered inferior good relative to maize. The equation also says that increase in rice and especially millet supply would increase the sorghum supply. This may be true if rice and millet are complements for sorghum. Possibly, this complementarity may mean the mixture of millet and sorghum in processing flours and other traditional meals, beer, pasta and porridge. It is common to have ceremonies in which rice is the main ditch and beer prepared from sorghum is the complement. Mbwanda and Rohrbach (1988) refer to the kind of semi-complementarity verified in small grains in Zimbabwe, this may be the case in Mozambique. It is not yet clear if in fact they are semi-complements, further studies should be done to clarify this results. Another findings were that an increase in official price for sorghum would decrease the supply and an increase in official price for maize would increase the supply for sorghum. These may be true if the small farmers are net buyers for sorghum and maize. This equation is important because it indicates questions that policy makers should address before any policy is made.

The major improvements in this equation are shown by the Adjusted R-squared, which changed from 0.683 of the original equation to a very high Adjusted R-squared of 0.994. This means that the proportion variation in total sorghum production is better explained by the proportion of variation in the independent variables considered in the second equation. This high Adjusted R-squared is a "Good Fit" for the sorghum supply function. The number of independent variables increased to five. Three substitutes for sorghum (maize, rice, and millet) were brought into the model. All variables, excluding the producer price of sorghum, have the expected sign.

## 5.2 SUPPLY MODEL FOR MAIZE

### a) SPECIFICATIONS OF THE MODEL

In theory,supply for maize is a function of producer's consumption needs, the maize price, the price of substitutes and complements, the price of major inputs, availability of land, area planted the previous year, institutional constraints, time trend, change in agricultural technologies, and climatic conditions.

The sample period is from 1950 to 1985. The major problems of maize production in Mozambique were discussed in the previous chapters. Due to the lack of data, some of the factors affecting maize production will not be included in the analysis.

The initial model was specified as :

MAIZE = f(PRMAIZ, PRSORG, SORGO, MILLET, RICE)

where MAIZE = Total maize production in Mozambique.

PRMAIZ = Producer price of maize.

PRSORG = Producer price of sorghum.

Sorgo = Total sorghum supplied in Mozambique.

Millet = Total millet supplied in Mozambique.

Rice = Total rice supplied in Mozambique.

Like in sorghum supply model, total maize production was used as dependent variable because it was the best estimate of supply among data available for the study. The price for maize was used in monetary terms for the same already stated. Sorghum, millet, and rice variables were included as substitute commodities for maize.

**b) RESULTS**

1) The original equation estimated was: (see Table 5.3, page 74)

MAIZE = 766,564.18 - 9,514.8292*PRMAIZ

R-squared = 0.608, adjusted R-squared = 0.559, Standard error of regression (SER)= 24,866.45, Durbin-Watson statistic=0.836, F-statistics = 12.42

**STRENGTHS:** - The SER is only 3.5 percent of the mean of dependent variable.

- t- statistics for PRMAIZ is highly significant
- F-statistic is significant at 1 percent.

**WEAKNESSES** - The sign of PRMAIZ is negative.

- Low adjusted R-squared (0.559).
- Low Durbin-Watson statistic (0.836).

The equation says that increases in official maize price would decrease the supply for maize. This is wrong according the theory. It may suggest that the data used is not accurate or there are more variables that should be included.

The equation shows low adjusted R-squared (0.599) which means that the proportion variation of maize supply is not completely explained by the proportion variation of maize price. There should be more variables for which maize supply

TABLE 5.2: Maize Supply Equation

SMPL 1976 - 1985
10 Observations
LS // Dependent Variable is MAIZE

| VARIABLE | COEFFICIENT | STD. ERROR | T-STAT. | 2-TAIL SIG. |
|---|---|---|---|---|
| C | 766564.18 | 15878.504 | 48.276851 | 0.000 |
| PRMAIZ | -9514.8292 | 2699.5437 | -3.5246064 | 0.008 |

| | | | |
|---|---|---|---|
| R-squared | 0.608282 | Mean of dependent var | 717943.4 |
| Adjusted R-squared | 0.559317 | S.D. of dependent var | 37458.52 |
| S.E. of regression | 24866.45 | Sum of squared resid | 4.95D+09 |
| Durbin-Watson stat | 0.836043 | F-statistic | 12.42285 |
| Log likelihood | -114.2864 | | |

Covariance Matrix

| | | | |
|---|---|---|---|
| C,C | 2.52D+08 | C,PRMAIZ | -37239311 |
| PRMAIZ,PRMAIZ | 7287536. | | |

| Residual Plot | obs | RESIDUAL | ACTUAL | FITTED |
|---|---|---|---|---|
| `¦        :       ¦       :      * ¦` | 1976 | 47822.9 | 790600. | 742777. |
| `¦        :       ¦     * :        ¦` | 1977 | 19883.3 | 756000. | 736117. |
| `¦        :     * ¦       :        ¦` | 1978 | -6316.72 | 729800. | 736117. |
| `¦        *       ¦       :        ¦` | 1979 | -25826.7 | 710290. | 736117. |
| `¦       *:       ¦       :        ¦` | 1980 | -27500.9 | 701004. | 728505. |
| `¦        :  *    ¦       :        ¦` | 1981 | -12674.9 | 715830. | 728505. |
| `¦        :       ¦    *  :        ¦` | 1982 | 16646.8 | 726122. | 709475. |
| `¦        :      *¦       :        ¦` | 1983 | -2187.20 | 707288. | 709475. |
| `¦        : *     ¦       :        ¦` | 1984 | -17375.2 | 692100. | 709475. |
| `¦        :       ¦ *     :        ¦` | 1985 | 7528.60 | 650400. | 642871. |

SOURCE: Mucavele, Firmino G. (1988

depends on. The Durbin-Watson statistic is very low. It measures the association between adjacent residuals. This might be a serial correlation. If there was no problem of association between adjacent residuals, the statistic will be around 2. With positive correlation, Durbin-Watson statistic will fall below 2, in the worst case, it will be near zero. In the first regression, the Durbin-Watson statistic of 0.836 is probably a sure sign of trouble with positive serial correlation. It has three implications (Hall and Lilien, 1986): first, the reliability of the regression results is probably overstated. Regression theory rests on the assumption of zero serial correlation. Second, the regression is not the best prediction of the dependent variable if there is an association between adjacent residuals. Third, serial correlation is a sign of specification error in the regression.

The strengths of this supply function are the standard error of regression which is only 3.5 percent of the mean of dependent variable, the significant F-statistic at 1 percent and t-statistic also at 1 percent level.

To improve the first supply function more variables were brought into the model. The estimated equation is ( see Table 5.4, page 76).

MAIZE = -484,676.190 + 27,555.149*PRMAIZ + 0.206*RICE

-1.390*SORGO - 26,904.175*PRSORG + 55.651*MILLET

TABLE 5.4: Maize Supply Equation

SMPL 1950 - 1986
10 Observations
LS // Dependent Variable is MAIZE

| VARIABLE | COEFFICIENT | STD. ERROR | T-STAT. | 2-TAIL SIG. |
|---|---|---|---|---|
| C | -484676.19 | 287513.07 | -1.6857536 | 0.167 |
| SORGO | -1.3903196 | 0.2881090 | -4.8256725 | 0.008 |
| RICE | 0.2064192 | 0.1083981 | 1.9042705 | 0.130 |
| MILLET | 55.651058 | 12.893526 | 4.3162016 | 0.012 |
| PRMAIZ | 27555.149 | 10295.691 | 2.6763768 | 0.055 |
| PRSORG | -26904.175 | 9260.6640 | -2.9052101 | 0.044 |

| | | | |
|---|---|---|---|
| R-squared | 0.983546 | Mean of dependent var | 717943.4 |
| Adjusted R-squared | 0.962979 | S.D. of dependent var | 37458.52 |
| S.E. of regression | 7207.342 | Sum of squared resid | 2.08D+08 |
| F-statistic | 47.82096 | Log likelihood | -98.43649 |

Covariance Matrix

| | | | |
|---|---|---|---|
| C,C | 8.27D+10 | C,SORGO | 76554.88 |
| C,RICE | 23264.98 | C,MILLET | -3689587. |
| C,PRMAIZ | -2.13D+09 | C,PRSORG | 1.54D+09 |
| SORGO,SORGO | 0.083007 | SORGO,RICE | 0.017073 |
| SORGO,MILLET | -3.547934 | SORGO,PRMAIZ | -1750.088 |
| SORGO,PRSORG | 1267.633 | RICE,RICE | 0.011750 |
| RICE,MILLET | -1.011069 | RICE,PRMAIZ | -508.7494 |
| RICE,PRSORG | 333.6163 | MILLET,MILLET | 166.2430 |
| MILLET,PRMAIZ | 91317.22 | MILLET,PRSORG | -66082.55 |
| PRMAIZ,PRMAIZ | 1.06D+08 | PRMAIZ,PRSORG | -93211296 |
| PRSORG,PRSORG | 85759898 | | |

```
==========================================================================
            Residual Plot                   obs RESIDUAL   ACTUAL   FITTED
==========================================================================
:       :           |           *   | 1976  7064.92   790600.  783535.
:   *   :           |           :   | 1977 -8684.31   756000.  764684.
:       :     *     |           :   | 1978 -2738.76   729800.  732539.
:       :           |          *:   | 1979  6427.79   710290.  703862.
:       :    *      |           :   | 1980 -3530.54   701004.  704535.
:       :       *   |           :   | 1981 -1655.72   715830.  717486.
:       :           |    *      :   | 1982  2474.26   726122.  723648.
:       :           |     *     :   | 1983  2757.69   707288.  704530.
:       :      *    |           :   | 1984 -2167.91   692100.  694268.
:       :           *           :   | 1985  52.5657   650400.  650347.
==========================================================================
```

SOURCE: Mucavele, Firmino G.(1988

R-squared = 0.983, adjusted R-squared = 0.962,
SER = 7,207.342, Durbin-Watson statistic = 2.485,
F-statistic = 47.82 .

**STRENGTHS:**
- SORGO and PRSORG variables have correct signs.
- High adjusted R-squared (0.962).
- All variables except rice are significant at 5 percent level.
- The SER is only 1 percent of the mean of dependent variable.
- F-statistic is significant at 1 percent level.
- Durbin-Watson statistic is good (2.485), no serial correlation.
- For ten-year time period, using five variables is acceptable.
- The data used is for recent years.

**WEAKNESSES:**
- One independent variable (RICE) is not significant at 5 percent level.
- RICE and MILLET have opposite sign than it was expected.

This estimated equation says that increase of sorghum supply would decrease the supply of maize. This is logical considering the assumption that they are substitutes. It also says that increases in supply of rice and especially millet would increase the supply of maize. The results indicate that the increase of official maize price would increase the supply of maize. This is correct according our theory. The results also indicate that the increases in price of sorghum would decrease supply of maize. This seems not to be logic, unless sorghum is considered complement of maize as was stated before.

The inclusion of maize substitutes into the model improved the estimation of maize supply equation. Adjusted R-squared passed from 0.559 to 0.962. This means that the second estimate of maize supply is a "GOOD FIT". The variables introduced in the regression explain better the variations of maize supply. SORGO, PRMAIZ, and PRSORG have correct signs as it is stated by theory. For RICE and MILLET variables the exppectation was for a negative sign. The theory suggests that an increase in supply of substitute commodities, the supply of studied commodity might decrease. In the estimated supply function, increase of substitute commodity would be expressed by increase of maize supply. Analyzing this aspect and reviewing the literature, it is verified that rice is considered a "high social value" food crop. Income increase in households would contribute for the change in food consumption of maize. There is a "semi-complementarity" between maize and rice. Millet is considered a "low social value" food crop compared with maize. Like rice, millet is also a "semi-complement" of sorghum. One of the strengths of the estimated supply equation is the fact that all variables except RICE are significant at five percent level. It has a very low standard error of regression which is only one percent of the mean of the dependent variable. F-statistics is highly significant. The problem of association between adjacent residuals verified in the previous equation was minimized. The Durbin-Watson statistic improved from 0.836 to 2.485, getting closer to 2.

For the ten-year time period, using five variables can be considered acceptable. Less variables would be better, however, considering to the amount of factors that can influence such supply model in Mozambique, the estimation is considered the "BEST FIT". Moreover, the data used is for recent years.

One of the weaknesses of this estimated maize supply function is that RICE variable is not significant at five percent level.

The total output of sorghum per capita increased from 1950 to 1968 and declined until 1985. Maize produced per capita also increased from 1950 to 1974 and declined until 1985. There are several factors that contributed for these declines: 1) lack of security in the country side due to the war since 1964 in conjunction with migration and dislocation of rural populations, 2) climatic disasters, 3) unstable international economy, 4) inappropriate policies, and 5) agricultural technology which did not improve fast enough to accommodate the population increase. These factors are not possible to include into the model. Therefore, these model is useful to bring reflection for the policy makers and to suggest a kind of methodology in future studies. It is a first attempt to explain quantitatively the factors affecting supply of sorghum and maize in Mozambique.

## 5.3 SUMMARY

The two equations can be useful for future planning and decision-making process. The supply equation for sorghum appears to express better the relationship between the variables affecting sorghum production and the sorghum output in Mozambique than is the supply equation for maize. Both equations suggest raise of official maize prices, and lower sorghum price to increase the output of sorghum and maize. The logic can been seen as maize being superior grain over maize and most preferred by consumers. Also sorghum and maize appear to be complements, fact that should be studied in the future research.

Policy makers should be aware about problems of substitutability and complementarity among grains crops for future policy improvements which can bring increase of grain production to attain the current shortage in food in Mozambique.

# CHAPTER VI: CONCLUSIONS AND IMPLICATIONS OF THE ABOVE ANALYSES ON THE POTENTIAL FOR EXPANSION SORGHUM PRODUCTION IN MOZAMBIQUE

## 6.1 IMPLICATIONS ON THE SUPPLY OF SORGHUM

This paper has examined some of the economic factors affecting the sorghum supply in Mozambique. An econometric sorghum supply model was developed which showed the significant effect of other commodities such as maize and rice in the food system. Projections into the future should take in account the relative prices of sorghum and its substitutes if expansion of sorghum production is desired.

Cereal grains are the major food crops for both direct and indirect human consumption. Sorghum is one of the cereal grain crops which can help attain food grain security for the rural households. It offers proven versatility, hardiness, dependability over such a wide range of climates. Studies using data from Manjacazi District in Mozambique and a review of literature in the world show a comparative agronomic and economic sorghum production advantage over maize and other cereals under rainfed, and dry conditions like those in Mozambique. Policy makers need to be sensitive to these aspects and to the difficulties of creating a unique supply model for all the country. Regions should be considered individually and support services for smallholder's farming system should be done considering the following key aspects: (1) recognizing that programs to expand the production of sorghum have both costs and benefits for food security improvements; (2) recognizing that these costs and benefits must be calculated in the context of the farming and food systems; (3) recognizing that some forms of public support programs are more cost-effective than others, and that cost-effective measures should be compatible to those of the smallholder farmers.

Sorghum and millet supply 90 percent of the food energy requirements of the rural people in hot, dry Sahelian region of Africa (Hibbler and Stanley, 1981). In Mozambique, the full extent of sorghum's adaptation may not as yet be fully realized. In the fringe areas of production, because of the lack of experience with sorghum, associated with various uncertainties, and because of relatively well funded technology developments for maize (DEVRES/USDA report, 1985), there is less incentives to sorghum research and promotion. Continued improvements in sorghum may elevate its status as both a food and feed crop in Mozambique (FAO,1986). The modest level of past research on sorghum has been directed, understandably, to sorghum adaptation and general productivity. There is a need to characterize the socioeconomic conditions of the small farmers, the farming systems, the marketing and pricing systems to improve the sorghum production. Breeding and selection programs aimed at cultivar development for specific environments would help the spread of sorghum all over the country. Specific studies to each agroecological zone are needed, as sorghum appears to respond differently to variations in soils, rainfall, and intercropping systems.

Little research has been directed to nutrition and cooking quality in Mozambique. Compared to maize, the amount of research in sorghum is small. The increase in drought intensity in semiarid regions of the world is projected (Stoskoff, 1985). The adaptation of sorghum means that the crop might become increasingly important in Mozambique if research for sorghum is funded.

Around the world, authors have mentioned that unless crops suited to dry land conditions are available, crop production may have to be abandoned in arid regions of the world as irrigation water becomes increasingly scarce. Sorghum has considerable promise as a low moisture requirement crop (Garner et al., 1981). A sorghum composite grown under marginal environmental conditions revealed traits that may be desired in future sorghum cultivars (Kein et al., 1983). For the current conditions in Mozambique, it is possible to do more research and improvements to create composites of better adapted varieties and hybrids. However, stability of yield, ability of a genotype to avoid substantial fluctuations in yield over a range of environments, is a difficult breeding objective to achieve, especially under the funding constraints to which Mozambique is subject.

Finally, to expand sorghum production in Mozambique, research on many aspects of sorghum is needed. Research on quality processing, and new food products could increase the acceptability of this crop and raise its status.

## 6.2 IMPLICATIONS FOR SORGHUM MARKETING

In theory, price is the market regulator in free market. Mellor (1978) states that change in relative food prices is, in the short term, one of the most important determinants of change in the relative and absolute real income of low-income people. In the long term, food price policy may affect shifts in the supply function for goods and thereby influence the marketing. Because the inter-relationships among price the supply of goods, the pattern of production, and income distribution are so complex, only a general equilibrium analysis can determine the various effects of sorghum price policy on income distribution. The analysis on price policy has been dominated by partial analysis among crops. More studies are needed such as marketable sorghum surplus, risk uncertainty relationships, and shift of resources among enterprises. This paper shows that producer's price of sorghum is a significant variable to take in account for expansion of sorghum supply. However, it can not be considered alone. This should go along with a general pricing reform, adjustment of fixed prices, establishment of minimum price system for sorghum and adjustment of social costs.

Generally, the effects of changes in food grain producer's price differ from the effects on consumers in two important aspects (Mellor, 1978): first, the income effect, assuming production is constant, is in the same direction as the price change. Second, the largest effects, both relative and absolute, fall on the producers with largest marketing, and presumably with the higher income.

Increase in sorghum marketing requires technological change, higher prices to producers to counterbalance the added risk and uncertainty associated with farming in such dry conditions. If experience with new technologies itself reduces risk and uncertainty, higher prices may induce a shift to a new technology, which will not be reversed if prices later decline.

Availability of the consumer goods in the market is also a critical aspect of the terms of trade for the agricultural pricing reforms. If price increases on accompanied by an effort by the Government to channel consumer goods to the rural areas. Also, the market institutions and infrastructures should be improved. In addition, marketing activities will improve with improvement of transportation system, imports of vehicles, spare parts and fuel, together with investments in rural road rehabilitation and maintenance.

## 6.3 IMPLICATIONS FOR FOOD SYSTEMS

Sorghum is one of the food crops where increase would contribute greatly to reduce the chronic food insecurity in rural areas of Mozambique. It was stated before in this paper that sorghum offers versatility, hardiness, dependability over dry and arid farming conditions. A lots of people in rural areas would be assured staple food, feed for their animals, beer and other benefits. Its stalks provide fodder, fuel, shelter, sugar, and syrup. The plant stem and foliage are good green chop.

The sorghum plant makes good feed but a problem is the presence of hydrocyanic acid (HCN) in new growth following cuttings. This problem cam be managed by careful attention to selection of varieties low in HCN, and by prosper grazing. HCN is not a serious restriction to the use of sorghum as forage for feed in Mozambique.

The expansion of sorghum production in Mozambique, would help provide rural households with improved food grain security. Government can help the situation, by promoting policies that protect crops with stable yields and are widely tolerant to adverse climatic and soil conditions like is sorghum.

Sorghum, as input for beer processing, is also an indirect

income generator. Consequently, it helps creates food as well as other commodities and services access for the rural households.

## 6.4 CONCLUSIONS

The general objective of this study was to better identify the factors responsible for the decline of sorghum production and change in crop pattern in Mozambique. To accomplish this objective, a review of the literature was done, agronomic and economic comparative analysis were carried out, and supply equations for sorghum and maize were estimated. It is concluded in general that there are several factors that have contributed to the decline of sorghum production in Mozambique: 1) lack of security in the country side due to the war since 1964 in conjunction with migration and dislocation of rural populations, 2) climatic disasters, 3) unstable international economy, 4) inappropriate policies, and 5) agricultural technology which did not improve fast enough to accommodate the population increase.

The major conclusions of the study are:

1) Research and agricultural technologies for sorghum in Mozambique:

a) Research on sorghum in Mozambique is very recent. It is carried out by INIA which is actively working jointly with the SADCC sorghum research program to introduce and select new improved varieties. These programs are designed for crop adaptation and general improvement of productivity. Breeding programs, research on quality, processing, and new food products are not yet carried out.

b) Low yields are due to poor varieties, large post harvest losses and poor cultural practices and management.

c) There is poor extension services for the small farmers.

d) There is little improved crop technologies for small farmers.

e) Changes in cropping patterns are a combined result of agricultural policies, research output, and institutional changes.

2) The following factors seem to be responsible for the decline of total sorghum production:

a) Drought during the last ten years.

b) Lack of seed and poor varieties.

c) Lack of security in the country side.

d) Inappropriate economic policies.

e) Low price.

3) Enterprise budgets and crop management:

a) Sorghum has lower production costs compared with maize and higher annual net returns.

b) In consecutive farming, sorghum under rainfed manual agrotechnology in the northern part of the country has higher net returns than maize.

c) Maize has price and yield comparative advantage over sorghum.

d) Sorghum shows more significant tolerance to water deficit than maize.

f) Sorghum is cropped as a security crop, mainly in marginal lands, where other crops are not able to be grown.

4) Sorghum marketing

a) Sorghum is cropped as a subsistence crop. The market structure and institutions for sorghum are not yet developed. The market is more oriented to export crops and maize.

b) The nominal producer's price of sorghum is fixed by the state and is very low. This might improve access to sorghum for low income families with small farms such as 0.5 to 1.0 hectare to buy sorghum instead of producing it. Yet low producer's price does not give sufficient incentives to those producers who have some capacity to produce more than the subsistence level. Moreover, the real producer's price of sorghum is declining as inflation increases over years.

c) Inappropriate past marketing policies.

5) Sorghum supply model

A supply model for sorghum was estimated. The best fit equation is the following:

$$\underset{}{SORGO} = \underset{(124{,}966.249)}{-432{,}700.900} - \underset{(0.127)}{0.614}*MAIZE + \underset{(0.086)}{0.096}*RICE + \underset{(2.583)}{40.425}*MILLET$$

$$- \underset{(5{,}462.287)}{18{,}753.041}*PRSORG + \underset{(5{,}528.004)}{20004.635}*PRMAIZ$$

This estimated sorghum supply equation says that as maize supply rises, the supply for sorghum will decrease. This may be correct. Supply theory supports this result and it is logical to think that increasing maize which is a likely substitute for sorghum would reduce the consumption of sorghum which is considered an inferior good relative to maize. The equation also says that increase in rice and especially millet supply would increase the sorghum supply. This may be true if rice and millet are complements for sorghum. It is not yet clear if in fact they are complements: further studies should be done to clarify this results. Another findings is that an increase in official price for sorghum would decrease the supply and an increase in official price for maize would increase the supply for sorghum. These may be true if the small farmers are net buyers for sorghum and maize. This equations is important because it suggests questions that policy makers should deal with before any policy is made.

6) Maize supply model

The best fit equation for maize supply is:

$$\underset{(287{,}513.070)}{\mathrm{MAIZE} = -\,484{,}676.190} + \underset{(10{,}295.691)}{27{,}555.149*\mathrm{PRMAIZ}} + \underset{(0.108)}{0.206*\mathrm{RICE}} -$$

$$-\ \underset{(0.288)}{1.390*\mathrm{SORGO}} - \underset{(9{,}260.664)}{26{,}904.175*\mathrm{PRSORG}} + \underset{(12.893)}{55{,}651*\mathrm{MILLET}}$$

This estimated equation says that increase of sorghum supply would decrease the supply of maize. This is logical considering the assumption that they are substitutes. It also says that increases in supply of rice and especially millet would increase the supply of maize. This aspect was referred to before, in that there may be a kind of complementarity among these food crops. The increase of official maize price would increase the supply of maize. This is correct according the theory. Increases in price the of sorghum would decrease supply of maize. This seems not to be logical, unless sorghum is considered a complement of maize as was stated before.

## 6.5 SUGGESTIONS FOR FURTHER STUDIES

The present study was limited due to the absence of previous studies dealing with agroeconomic aspects specifically for sorghum and farming systems in general. More detailed survey and studies of sorghum would be desirable on the following issues:

1) Characterization of farming systems in which sorghum appears to have a comparative advantage.

2) Development of a research framework to examine the effect of changes in technology, institutions, and policy on food production and marketing, specially for sorghum.

3) Studies aimed to search for the most cost effective mix of domestic production, storage and trade in rural areas to solve problems of food shortages.

4) Research for new sorghum production technologies.

# APPENDIX A: CROP BUDGETS

## CROP BUDGETS PER HECTARE

MAIZE : YEAR I  
FAMILY FARM II  
REGION : SOUTH  
RAINFED MANUAL / ANIMAL TRACTION  
EXCHANGE RATE : 400 MT/US$

SOURCE :F.G. Mucavele, 1985  
Marracuene, Maputo, Mozambique

| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg | 32 | 130 | 4,160 |
| Land clearing & preparation | h/yoke | 8 | 400 | 3,200 |
| Manure | Kg | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 35 | 250 | 8,750 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/yoke | 1 | 400 | 400 |
| others | m/d | 5 | 250 | 1,250 |
| 1. TOTAL VARIABLE COSTS | | | | 24,760 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| yoke | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS ( 1. + 2. ) | | | | 30,260 |
| REVENUES | | | | |
| Yield ( Kg. ) | | | | 850 |
| Price/Kg. ( MT ) | | | | 65 |
| GROSS INCOME | | | | 55,250 |
| Others | | | | 1,000 |
| 4. TOTAL REVENUES | | | | 56,250 |
| 5. NET REVENUES ( 4. - 3. ) | | | | 25,990 |

## CROP BUDGETS PER HECTARE

SORGHUM : YEAR I
FAMILY FARM II
REGION : SOUTH
RAINFED MANUAL / ANIMAL TRACTION
EXCHANGE RATE : 400 MT/US$

Source: F.G. Mucavele, 1985
Marracuene, Maputo,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg | 30 | 100 | 3,000 |
| Land clearing & preparation | h/yoke | 8 | 400 | 3,200 |
| Manure | kg | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 15 | 250 | 3,750 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/yoke | 1 | 400 | 400 |
| Other costs | | | | 1,000 |
| 1. TOTAL VARIABLE COSTS | | | | 19,600 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Yoke | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS ( 1. + 2.) | | | | 25,100 |
| REVENUES | Yield ( Kg. ) | | | 750 |
| | Price/Kg. (MT) | | | 60 |
| GROSS INCOME | | | | 46,000 |
| Others | | | | 2,000 |
| 4. TOTAL REVENUES | | | | 48,000 |
| 5. NET REVENUES (4. - 3.) | | | | 22,900 |

## CROP BUDGETS PER HECTARE

MAIZE : YEAR II — SOURCE: F.G. Mucavele, 1984
FAMILY FARM I — Metangula, Niassa,
REGION : NORTH — Mozambique.
RAINFED, MANUAL
EXCHANGE RATE : 400 MT/US$

| VARIABLE COSTS | UNIT | QT | COST (MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | kg | 30 | 130 | 3,900 |
| Land clearing & preparation | m/d | 10 | 250 | 2,500 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 35 | 250 | 8,750 |
| Harvesting | m/d | 12 | 250 | 3,000 |
| Transportation | m/d | 5 | 250 | 1,250 |
| Bags | u | 5 | 200 | 1,000 |
| 1.TOTAL VARIABLE COSTS | | | | 21,650 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 2,520 | 2,520 |
| 2. TOTAL FIXED COSTS | | | | 2,520 |
| 3. TOTAL COSTS (1. + 2.) | | | | 24,170 |
| REVENUES | | | | |
| | | | Yield ( Kg. ) | 530 |
| | | | Price/Kg. ( MT ) | 65 |
| GROSS INCOME | | | | 34,450 |
| 4. TOTAL REVENUES | | | | 34,450 |
| 5. NET REVENUES (4. - 3. ) | | | | 10,280 |

## CROP BUDGETS PER CROP

MAIZE : YEAR III — SOURCE: F.G. Mucavele, 1984, Metangula, niassa, Mozambique.
FAMILY FARM I
REGION NORTH
RAINFED, MANUAL
EXCHANGE RATE : 400 MT/US$

| VARIABLE COSTS | UNIT | QT | COST (MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg. | 30 | 130 | 3,900 |
| Land clearing & preparation | m/d | 10 | 250 | 2,500 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 30 | 250 | 7,500 |
| Harvesting | m/d | 12 | 250 | 2,500 |
| Transportation | m/d | 5 | 250 | 1,250 |
| Bags | u | 5 | 200 | 1,000 |
| 1.TOTAL VARIABLE COSTS | | | | 19,900 |
| **FIXED COSTS** | | | | |
| Tools | set | 1 | 2,520 | 2,520 |
| 2. TOTAL FIXED COSTS | | | | 2,520 |
| 3. TOTAL COSTS (1. + 2.) | | | | 22,420 |
| **REVENUES** | | | | |
| | | Yield ( Kg. ) | | 500 |
| | | Price/Kg. ( MT ) | | 65 |
| GROSS INCOME | | | | 32,500 |
| 4. TOTAL REVENUES | | | | 32,500 |
| 5. NET REVENUES (4. - 3.) | | | | 10,080 |

# CROP BUDGETS PER HECTARE

MAIZE : YEAR II
FAMILY FARM II
REGION : SOUTH
RAINFED, MANUAL / ANIMAL TRACTION
EXCHANGE RATE : 400 MT/US$

SOURCE : F.G. Mucavele, 1985
Marracuene, Maputo,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST (MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg | 32 | 130 | 4,160 |
| Land clearing & preparation | h/yoke | 6 | 400 | 2,400 |
| Manure | Kg | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 35 | 250 | 8,750 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/yoke | 1 | 400 | 400 |
| Other operations | m/d | 6 | 250 | 1,500 |
| Repairs | | | | 1,000 |
| 1. TOTAL VARIABLE COSTS | | | | 25,210 |
| **FIXED COSTS** | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Yoke | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS (1. + 2.) | | | | 30,710 |
| **REVENUES** | | | | |
| | Yield ( Kg ) | | | 850 |
| | Price/Kg. ( MT ) | | | 65 |
| GROSS INCOME | | | | 55,250 |
| Other revenues | | | | 1,000 |
| 4. TOTAL REVENUES | | | | 56,250 |
| 5. NET REVENUES (4. - 3.) | | | | 25,540 |

## CROP BUDGETS PER HECTARE

MAIZE ; YEAR III
FAMILY FARM II
REGION : SOUTH
RAINFED MANUAL / ANIMAL TRACTION
EXCHANGE RATE 400 MT/US$

SOURCE : F.G. Mucavele, 1985
Marracuene, Maputo,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST (MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg. | 32 | 130 | 4,160 |
| Land Clearing & Preparation | h/yoke | 6 | 400 | 2,400 |
| Manure | Kg. | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 35 | 250 | 8,750 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/yoke | 1 | 400 | 400 |
| Other operations | m/d | 6 | 250 | 1,500 |
| Repairs | | | | 2,000 |
| 1. TOTAL VARIABLE COSTS | | | | 26,210 |
| **FIXED COSTS** | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Yoke | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS (1. + 2.) | | | | 31,710 |
| **REVENUES** | | | | |
| | Yield ( Kg. ) | | | 850 |
| | Price ( MT ) | | | 65 |
| GROSS INCOME | | | | 55,250 |
| Other revenues | | | | 1,000 |
| 4. TOTAL REVENUES | | | | 56,250 |
| 5. NET REVENUES (4. - 3. ) | | | | 24,540 |

## CROP BUDGETS PER HECTARE

SORGHUM : YEAR II
FAMILY FARM I
REGION : NORTH
RAINFED, MANUAL
EXCHANGE RATE : 400 MT/US$

SOURCE : F.G. Mucavele, 1984
Metangula, Niassa,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg. | 10 | 100 | 1,000 |
| Land clearing & preparation | m/d | 5 | 250 | 1,250 |
| Sowing | m/d | 1 | 250 | 250 |
| Weeding | m/d | 5 | 250 | 1,250 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | m/d | 5 | 250 | 1,250 |
| Bags | u | 6 | 200 | 1,200 |
| 1. TOTAL VARIABLE COSTS | | | | 11,200 |
| FIXED COSTS | | | | |
| Tools | set | 1 | 2,520 | 2,520 |
| 2. TOTAL FIXED COSTS | | | | 2,520 |
| 3. TOTAL COSTS (1. + 2.) | | | | 13,720 |
| REVENUES | | | | |
| | | | Yield ( Kg ) | 600 |
| | | | Price/Kg ( MT ) | 60 |
| GROSS INCOME | | | | 36,000 |
| Other revenues | | | | 2,000 |
| 4. TOTAL; REVENUES | | | | 38,000 |
| 5. NET REVENUES (4. - 3.) | | | | 24,280 |

## CROP BUDGETS PER HECTARE

SORGHUM : YEAR III
FAMILY FARM I
REGION : NORTH
RAINFED, MANUAL
EXCHANGE RATE : 400 MT/US$

SOURCE : F.G. Mucavele, 1984
Metangula, Niassa,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | kg | 28 | 100 | 2,800 |
| Land clearing & preparation | m/d | 15 | 250 | 3,750 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 15 | 250 | 3,750 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | m/d | 5 | 250 | 1,250 |
| Bags | u | 5 | 200 | 1,000 |
| 1. TOTAL VARIABLE COSTS | | | | 18,800 |
| **FIXED COSTS** | | | | |
| Tools | set | 1 | 2,520 | 2,520 |
| 2. TOTAL FIXED COSTS | | | | 2,520 |
| 3. TOTAL COSTS (1. +2.) | | | | 21,320 |
| **REVENUES** | | | | |
| | | | Yield ( Kg ) | 480 |
| | | | Price/Kg. ( MT ) | 60 |
| GROSS INCOME | | | | 28,800 |
| Other revenues | | | | 2,000 |
| 4. TOTAL REVENUES | | | | 30,800 |
| 5. NET REVENUES (4. - 3.) | | | | 9,480 |

## CROP BUDGETS PER HECTARE

SORGHUM : YEAR II
FAMILY FARM II
REGION : SOUTH
RAINFED MANUAL / ANIMAL TRACTION
EXCHANGE RATE : 400 MT/US$

SOURCE : F.G.Mucavele, 1985
Marracuene, Maputo,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg | 10 | 100 | 1,000 |
| Land clearing & Preparation | h/yoke | 2 | 400 | 800 |
| Manure | Kg | 200 | 10 | 2,000 |
| Sowing | m/d | 1 | 250 | 250 |
| Weeding | m/d | 5 | 250 | 1,250 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/yoke | 1 | 400 | 400 |
| Other costs | | | | 2,000 |
| 1. TOTAL VARIABLE COSTS | | | | 12,700 |
| **FIXED COSTS** | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Yoke | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS ( 1. + 2. ) | | | | 18,200 |
| **REVENUES** | | | | |
| | | Yield ( Kg. ) | | 720 |
| | | Price/Kg. ( MT ) | | 60 |
| GROSS INCOME | | | | 43,200 |
| Other revenues | | | | 2,000 |
| 4. TOTAL REVENUES | | | | 45,200 |
| 5. NET REVENUES ( 4. - 3. ) | | | | 27,000 |

## CROP BUDGETS PER HECTARE

SORGHUM : YEAR III
FAMILY FARM II
REGION : SOUTH
RAINFED MANUAL / ANIMAL TRACTION
EXCHANGE RATE : 400 MT/US$

SOURCE : F.G. Mucavele, 1985
Marracuene, Maputo,
Mozambique.

| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Seeds | Kg. | 30 | 100 | 3,000 |
| Land clearing & preparation | h/yoke | 5 | 400 | 2,000 |
| Manure | Kg. | 200 | 10 | 2,000 |
| Sowing | m/d | 5 | 250 | 1,250 |
| Weeding | m/d | 15 | 250 | 3,750 |
| Other labor requirements | m/d | 5 | 250 | 1,250 |
| Harvesting | m/d | 15 | 250 | 3,750 |
| Transportation | h/yoke | 1 | 400 | 400 |
| Other costs | | | | 2,000 |
| 1. TOTAL VARIABLE COSTS | | | | 19,400 |
| **FIXED COSTS** | | | | |
| Tools | set | 1 | 3,000 | 3,000 |
| Yoke | u | 1 | 2,500 | 2,500 |
| 2. TOTAL FIXED COSTS | | | | 5,500 |
| 3. TOTAL COSTS ( 1. + 2. ) | | | | 24,900 |
| **REVENUES** | | | | |
| | | Yield ( Kg. ) | | 720 |
| | | Price/Kg ( MT ) | | 60 |
| GROSS INCOME | | | | 43,200 |
| Other revenues | | | | 2,000 |
| 4. TOTAL REVENUES | | | | 45,200 |
| 5. NET REVENUES ( 4. - 3. ) | | | | 20,300 |

## CROP BUDGETS PER HECTARE

MAIZE
STATE FARM
RAINFED MECHANIZED
EXCHANGE RATE : 400 MT/US$

SOURCE : DIRECCAO NACIONAL DE ECONOMIA AGRARIA (DNEA), MINISTRY OF AGRICULTURE

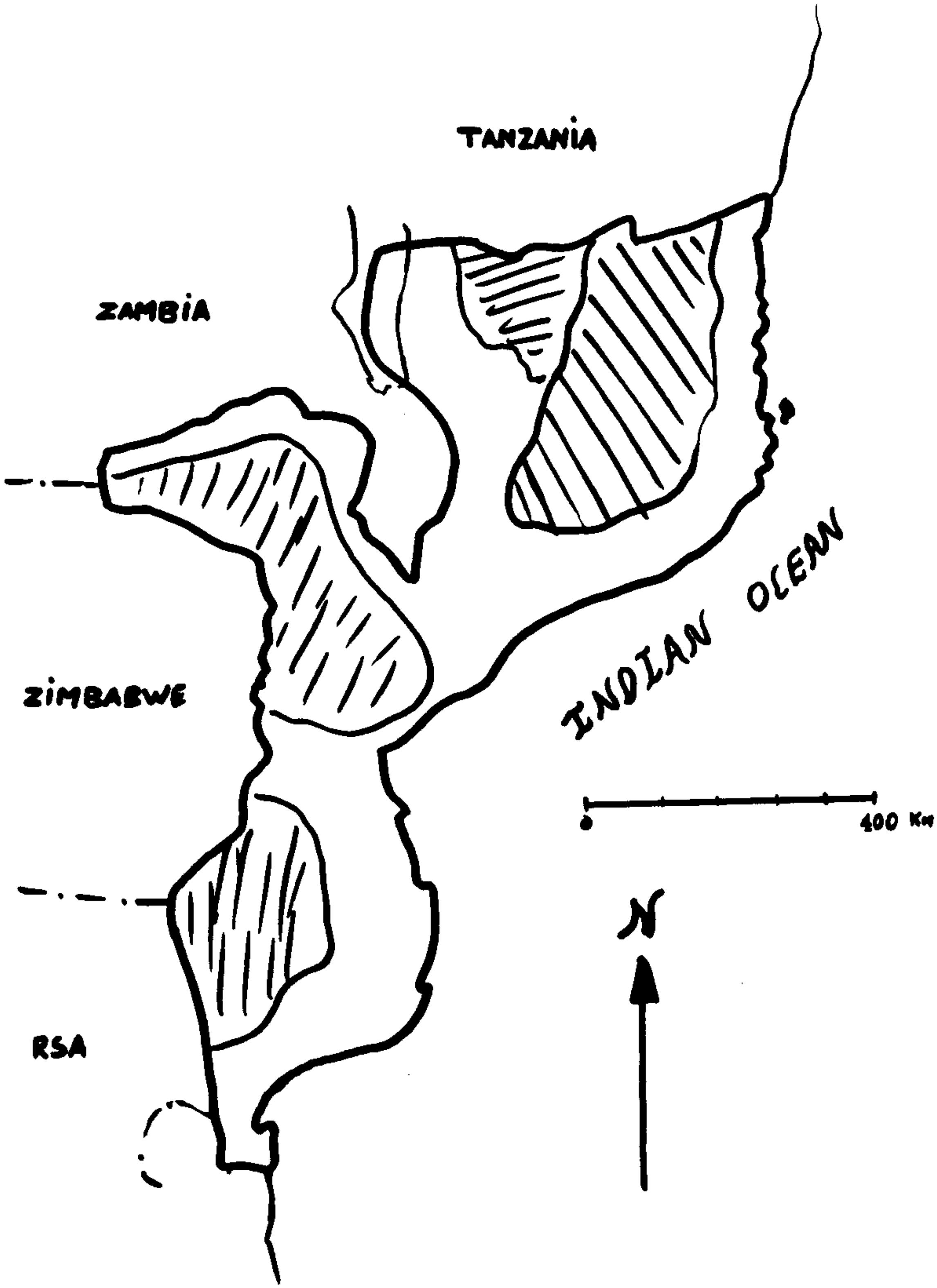
| VARIABLE COSTS | UNIT | QT | COST(MT)/UN | TOTAL |
|---|---|---|---|---|
| Ploughing | h.m | 3.6 | 3,096 | 11,145.6 |
| Grading | h.m | 2.7 | 3,706 | 10,006.2 |
| Forrowing | h.m | 2.0 | 3,706 | 7,412.0 |
| Fertilizer transportation | m/d | 0.8 | 141 | 112.8 |
| Fertilizer transportation | h.m | 1.2 | 3,652 | 4,382.4 |
| Fertilizer application | m.d | 2.0 | 141 | 282.0 |
| Sowing | m.d | 4.0 | 141 | 564.0 |
| Water transportation | h.m | 1.0 | 3,652 | 3,652.0 |
| Herbicide application | h.m | 1.0 | 6,068 | 6,068.0 |
| Fertilizer application | m.d | 2.0 | 141 | 282.0 |
| Weeding | m.d | 15.0 | 141 | 2,115.0 |
| Insecticide spraying | h.m | 1.2 | 6,068 | 7,281.6 |
| Transport of bags | h.m | 0.3 | 3,652 | 1,095.6 |
| Harvesting | h.m | 1.6 | 29,719 | 47,550.4 |
| Combine operators | m.d | 2.0 | 141 | 282.0 |
| Transport of production | h.m | 1.0 | 3,652 | 3,652.0 |
| Loading,weighting, and other | m.d | 5.8 | 141 | 817.8 |
| Fertilizer 15-30-15 | kg | 250.0 | 111 | 27,750.0 |
| CAN | kg | 200.00 | 82 | 16,400.0 |
| Seeds | kg | 25.0 | 163 | 4,075.0 |
| Herbicide Lazzo Atrazine | kg | 5.0 | 3,468 | 17,340.0 |
| Insecticide Thioodan | Lt | 1.8 | 692 | 1,245.6 |
| Bags | u | 35.0 | 197 | 6,895.0 |
| Tools | set | 0.3 | 2,520 | 756.0 |
| 1. TOTAL VARIABLE COSTS | | | | 91,248.0 |

| FIXED COSTS | |
|---|---|
| Overhead costs (20% of total costs) | 36,232.6 |
| Financial costs | 24,638.2 |
| 2. TOTAL FIXED COSTS | 60,870.8 |
| 3. TOTAL COSTS (1.+2.) | 242,033.7 |

| RETURNS | | |
|---|---|---|
| | yield (kg) | 2,500.0 |
| | price/kg (MT) | 65.0 |
| 4. GROSS INCOME | | 162,500.0 |
| 5.NET RETURNS (4. - 3.) | | -79,533.7 |

NOTE: 17% p.a interest rate, for 8 month, on total costs.

# APPENDIX B: GREAT ZONES OF SORGHUM IN MOZAMBIQUE


TANZANIA
ZAMBIA
ZIMBABWE
RSA
INDIAN OCEAN
400 KM
N

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