Logistics for Food Security in Zimbabwe
An Economic Analysis for Maize Availability

By

Lovemore M. Rugube

A Dissertation
Submitted to the Faculty of Graduate Studies
in Partial Fulfilment of the Requirements
for the Degree of

Doctor of Philosophy

Department of Agricultural Economics and Farm Management
University of Manitoba
Winnipeg, Manitoba

0-612-23657-9

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

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Abstract

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This study presents an economic analysis of the logistics for food security in Zimbabwe. The study emphasizes an economic analysis of maize availability, as maize is the major staple food crop in Zimbabwe. The country has to maintain stable maize supplies to meet part of the food security objectives. The study presents a methodology which outlines alternative strategic options designed to solve transitory food security problems related to maize availability. The methodology is used to demonstrate how the logistics involved in assuring maize supply stability for a staple food can be evaluated. It should be noted that this method of analysis can be extended to evaluating other alternative crops.

For the strategies outlined, cost analysis is used to evaluate two strategic options which would maintain stable maize supplies. The first strategic option is: the country will maintain strategic reserve stores equivalent to 12 months consumption requirements. The second strategic option is: the country will maintain strategic reserve stores equivalent to 5 months consumption requirements and use hard currency to import deficit consumption requirements of maize until the next harvest.

Results show that the second strategic option, of maintaining 5 months strategic stores and using hard currency to import the deficit consumption requirements until the next harvest is a preferred option. Sensitivity analysis performed on the cost variables show that the overall cost is most sensitive to the opportunity cost for maize in storage and maize import costs. The methodology presented can be used by policy markers to analyze the least cost strategic option suitable for maintaining stable maize supplies for the nation, therefore achieving an essential element of the food security objective.

Acknowledgements

I wish to make a variety of specific acknowledgements to many people who have played very important roles in the course of my graduate studies and during the writing of this dissertation.

I thank my advisory committee for their guidance and support. I thank my major advisor Dr. Henry Rempel for being there for me at a time when I needed support to complete my dissertation. His creativity, knowledge and experience helped me to see beyond my limited data set. My gratitude is extended to other members of my committee, Dr. Barry Prentince and Dr. Barry Coyle who continued to provide sound theoretical and empirical guidance. I also thank my external examiner, Dr.E.W. Tyrchniewicz for his invaluable feedback and comments. I would like to thank Dr. R.A. Loyns for initially providing insight in the topic of this dissertation. I extend my thanks to Dr. Kraft for his added support in making sure that my dissertation work is completed.

I am grateful for the financial support I received from the International Development Research Center (IDRC) Canada. Without their support this academic work wouldn't be possible. Special thanks to Rita Bowry for her added support and encouragement during the course of my study period.

I extended my thanks and appreciation to the support staff of my Department, special thanks to Debra Henry, Elaine Negrych and Bonnie Warkentine for their invaluable administrative support as well as creating a pleasant working environment. I owe gratitude to my fellow graduate students for their moral support and encouragement.

I express my special thanks to my family for their patience, encouragement and emotional support throughout my study period. My deepest gratitude is extend to my Father, Mr. Kenneth Rugube and my mother Mrs. Daisy Rugube, for the gift of life. Thanks.

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CHAPTER 1

INTRODUCTION

1.1 Background

In recent years Zimbabwe, like many other SADC (Southern African Development Community) countries, has been faced with the problem of severe food shortages as a result of large declines in grain harvest due to successive seasons of drought. Zimbabwe's weather patterns have been so erratic, resulting in reduced harvests, livestock losses, malnutrition, starvation and general economic hardships in both rural and urban communities. Zimbabwe's droughts of 1946/47, 1967/68, 1972/73, 1982/83,84, the worst drought in 1991/92 and the recent 1994/95 drought bear testimony to these effects.

In the month of July, 1995 Zimbabwe declared a state of disaster in the communal, resettlement and small-scale farming areas, noting that the drought affecting the country threatened the life and well being of people in these areas of the country. Zimbabwe needed to feed and protect more than five million people affected by drought in a programme that was estimated to cost Z$2 Billion (The Herald, July, 1995).

Drought jeopardizes every aspect of peoples lives, crops and livestock, jobs, possessions and savings, the social cohesion, economic and political stability of communities and their health. Zimbabwe experienced the most severe drought in 1991/92. While the historical mean rainfall is 663mm per year, rainfall during the agricultural season of 1991/92 was only 335 mm which was 51 percent of normal. The failure of the 1991/92 rainy season resulted in severe crop losses. The volume of agricultural production fell by one third, contributing only 8 percent to the GDP compared to 16 percent in normal years

(SADC,1992). In April 1992, national maize production was estimated to be 362,000 metric tonnes which was less 20 percent of the average for the seasons of 1988-90. With the government estimated average monthly consumption of about 200,000 metric tonnes during the drought period, there was need to import 2,400,000 metric tonnes of maize to make up for the shortfall. The threat that drought conditions similar to the ones outlined above can reoccur, bringing instability in crop production, increases the risk and uncertainty in the agricultural sector and concern for food security in Zimbabwe. Development policies should incorporate strategies that mitigate against the impact of and reduce vulnerability of future droughts.

The primary form of nutrition for Zimbabweans is cereals, especially course grains. The primary cereals consumed are maize, wheat, millet. rice and sorghum. The quantities of cereal grains produced in Zimbabwe for the period 1961 to 1994 are shown in Figure 1. Maize is shown to be the dominate cereal grain produced, and is the dominate staple food crop. The quantities of cereal grains consumed per capita for the period 1961 to 1995 are shown in Table 1. Data on cereal grain consumption shows that maize is the dominant source of nutrition in the Zimbabwean diet. The minimum average annual maize consumption is estimated at 116 killograms per capita, followed by wheat 24 killograms per capita, millet 21 killograms per capita and sorghum 9 killograms per capita respectively. It should be noted that millet consumption was above wheat consumption until 1977, since 1978 wheat consumption has exceeded millet consumption.

The shortage of maize brought about by drought conditions can have adverse effects on both humans and livestock in Zimbabwe. This brings concern for food insecurity for the

Figure 1:Cereal Production in Zimbabwe
For the Period (1961-94)

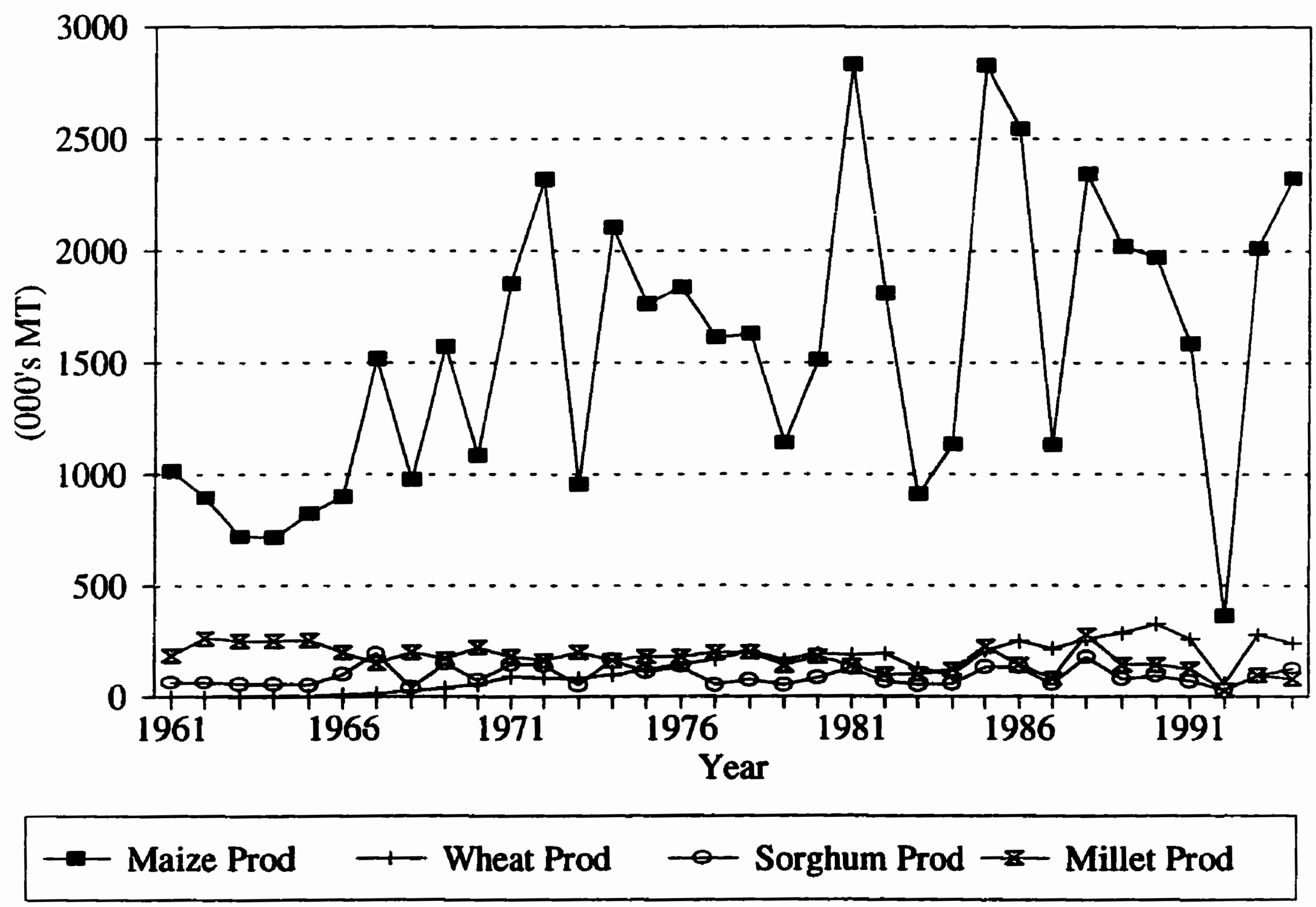


Table 1 : Summary of Cereal Consumption in Zimbabwe (1961-95).

Year	Total Cereal Consumption Kg/Year Per Capita	Maize Consumption Kg/Year Per Capita	Wheat Consumption Kg/Year Per Capita	Millet Consumption Kg/Year Per Capita	Sorghum Consumption Kg/Year Per Capita
1961	177	109	21	36	11
1962	181	106	15	50	10
1963	179	105	19	46	9
1964	180	109	17	45	8
1965	181	110	17	46	7
1966	177	108	20	33	15
1967	168	107	21	24	15
1968	180	110	21	31	16
1969	163	107	18	25	12
1970	186	116	20	32	16
1971	183	116	23	25	18
1972	175	112	24	22	16
1973	173	117	22	27	6
1974	176	114	24	20	18
1975	159	99	24	22	13
1976	167	107	22	22	15
1977	175	122	23	23	5
1978	182	126	25	23	7
1979	174	130	24	15	4
1980	187	135	25	19	7
1981	180	130	24	14	11
1982	170	132	23	10	5
1983	162	121	24	10	4
1984	162	121	23	11	5
1985	167	119	31	11	5
1986	169	121	30	10	6
1987	163	113	30	11	6
1988	165	114	31	14	6
1989	170	116	31	14	7
1990	167	114	30	13	7
1991	160	112	29	13	4
1992	161	118	30	6	5
1993	169	126	30	7	5
1994	165	122	29	5	7
1995	160	120	30	6	7
Averages		116	24	21	9

Source: F.A. O. Publications, 1995.

Zimbabwean population. The social groups most prone to food insecurity are the families working seasonally on commercial farms, families in the resettlement areas, households in the semi - arid communal areas and low - income urban dwellers (C.S.O., 1995). By far the largest number of the most food insecure populations are in the low - rainfall communal lands subject to recurrent drought.

Food security will pertain to maize availability at times of food crisis (e.g.) the 1991/92 drought and the logistics involved in achieving the desired results. It can also be defined in terms of stabilization of the quantity of maize grain that can be made available for use in the extreme shortfall event. In case of severe maize shortages, the objective is to close the gap between maize production and maize consumption, which relates to maize availability. Food security is concerned with both food availability and ability of people to purchase sufficient amounts of food. Food security can either be short-term, which is transitory (e.g.) famine resulting from a crop failure or chronic which is long term undernutrition. This study will focus on one part of food security as it relates to maize availability decline, defined as short term, which is transitory food security.

1.1.1 Zimbabwe's Maize Production Regions

Zimbabwe has a total land area of 39.07 million hectares and a population of about 11 million, with an annual population growth rate of about 3 percent. The total land surface area in Zimbabwe is distributed as follows:

Commercial Farming Land	15.70 million hectares
Communal Farming Land	16.35 million hectares
National Parks Estate	4.24 million hectares
Resettlement Land	2.64 million hectares
State Forest Land	0.92 million hectares
Urban and State Land	0.22 million hectares

Figure 2: Map of Zimbabwe showing Natural Regions

Zimbabwe: Natural Regions

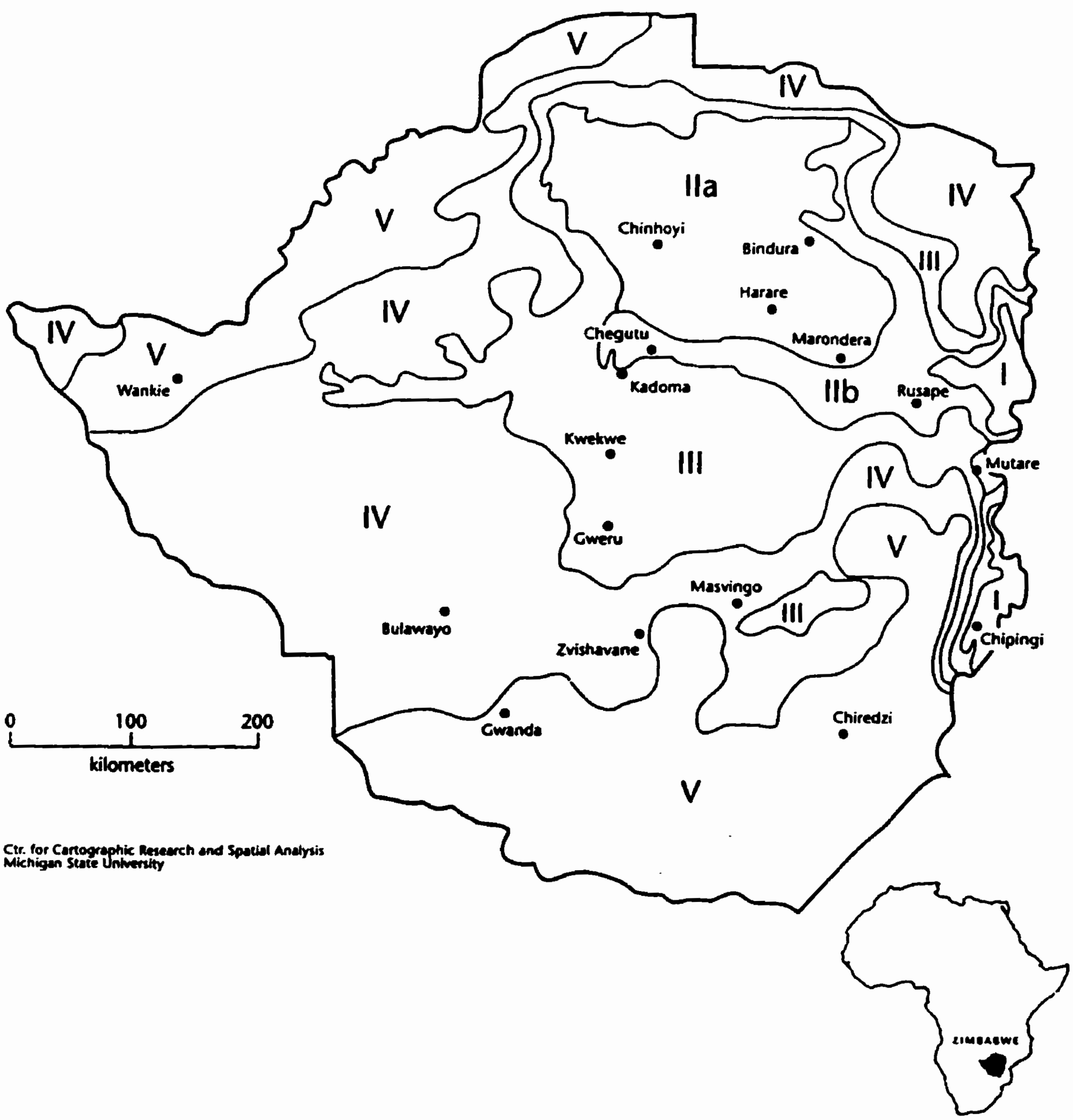


Table 2: Zimbabwe's Agroecological Regions

Region	Land Area (million Ha)	Percent of Total Area	Characteristics
I	0.62	1.6	Specialized and diversified farming. Very high rainfall often in excess of **1000mm**. Suitable for dairy, forestry, tea, coffee, fruits, and corn production.
II	7.31	18.8	Intensive Farming region. Annual Rainfall is between **750-1000mm**. Suitable for rainfed agriculture for crops like corn, tobacco, cotton and beef production.
III	6.85	17.6	Semi-intensive farming region with annual rainfall of **650-800mm**. Suffers from severe mid season drought and is marginal for corn and tobacco production, ideal for livestock.
IV	12.84	33	Semi-intensive farming region with annual rainfall of **450-650mm** and is subject to periodic drought.The region is marginal for rainfed corn production but ideal for drought resistant crops like sorghum.
V	11.28	29	Extensive farming region located in hot low lying areas suitable for extensive animal production and crops under irrigation. Annual rainfall (**under 450mm**) is too low for rainfed agriculture.

Source: Grain Marketing Board Reports, Belvedere Weather Station.

Zimbabwe is subdivided into five natural regions; Natural Regions I, II, III, IV, and V Figure 2. Details on these natural regions are described in Table 2. Over 60 percent of Zimbabwe's farmland lies in drought-prone regions receiving an average of less than 650 mm annual rainfall. Zimbabwe has an irregular weather pattern, not only is rainfall unreliable, but it is poorly distributed geographically, as can be observed in Table 2.

The Zimbabwean agricultural sector comprises about 16 percent of GDP and is the second largest contributor to the value of Zimbabwe's output of goods and services. The country has a number of distinct farming systems dominated by two sectors: the Large-Scale Commercial Sector and the Communal (Small Scale) Sector. The importance of these two farming sectors is addressed is chapter 2. The Large Scale Commercial farms cover about 15.7 million hectares. Over 40 percent of these farms are in Natural Regions I and II , which are the best agricultural regions in Zimbabwe (Transitional National Development Plan, 1994). The Large Scale Farmers mainly practice commercial production, of which most of the maize produced is marketed. The Small Scale (Communal Farms) covers about 16.3 million hectares, and only 8.5 percent of this land, where 56 percent of the Zimbabweans live, is in Regions I and II . Forty-two percent of the total area is in communal lands located primarily in Regions IV and V which are poorly suited for crop production and for meeting the needs of the rural population. A large section of the population therefore, subsists on land which is both inadequate in holding, size and incapable of producing sufficient maize for their families . Nearly a quarter of the rural families run out of maize before the next harvest, even in good years . Most Small Scale Farmers produce for subsistence and the market.

Among the principal crops produced maize dominates the cropping areas for both Large-Scale and Small Scale production. Maize is Zimbabwe's dominant staple food crop: about 64 percent of the maize produced is used for human consumption and about 22 percent of the maize produced is used for livestock feed.The importance of maize in the agricultural economy of Zimbabwe is apparent from the following; about 90 percent of the maize is produced by both sectors and maize accounts for 88 percent of total coarse grain production in the country, 80 percent of coarse grain production among smallholder and 61 percent of coarse grain production in Natural Regions IV and V . Maize does not grow favourably in regions IV and V where most of the communal population live, yet maize is grown. This has resulted in harvests which provide neither sufficient cash nor enough food for the families in these marginal rainfall areas. About 80 to 90 percent of marketed maize surplus is produced in natural region II (Government of Zimbabwe, 1992). Maize meal accounts for 70 percent of the total caloric intake in the Zimbabwean diet. Maize is predominately a dryland crop, although in recent years supplementary irrigation has reduced yield variability in areas where irrigation can be used. Given the current reoccurances of droughts in Zimbabwe bad weather can mean poor harvests, which translates to shortfalls in maize production and low consumption levels and a threat to the country's food security.

1.1.2 Maize Availability: Food Security Issues

As the term food security has evolved in the literature it is defined as the ability of all households in a nation to acquire a calorie adequate diet throughout the year. In recent years food security has come to be defined as: the ability of a country or region to assure on a long term basis, that its food system provides the total population access to a timely, reliable and nutritionally adequate supply of food (Eicher and Staatz, 1986). Food security has two interrelated components: overall food availability at the national level through production, storage or trade, and access to food through own or self production, purchases in the market from income earned, or transfers. On the supply side the major factors that affect food supply are: a) variability in local production, including regional variability caused by weather or agricultural policies; b) global supply, including regional supply (SADC), and maize world prices. Food insecurity results from the food system's inability to provide an adequate supply of food both in terms of volume and at an affordable cost. On the demand side, food security arises from the inability of the country to either provide income generating opportunities to enable households to purchase in the market or acquire food through transfer (Pinckney, 1988).

Food security is influenced by both micro and macro factors; weather, technology, and support institutions available to farmers and merchants, monetary, fiscal and exchange rate policy. At the macro level, food security requires a nation to meet its citizen's food requirements through the acquisition of sufficient food supplies from production, national stocks, and imports, both commercial and non-commercial. This in turn implies, among other things, devising effective policies that will stimulate production, strategic reserves, and an adequate supply of foreign currency to import food in times of shortfalls in domestic production.

Food availability or supply however is dependent on a number of factors such as the incentive structure, investment policy, import capacity and flexible institutional structure. The incentive structure comprises producer prices, adequate supply of incentive goods and the overall terms of trade, especially relative prices. Incentives are however, effective only when they are combined with a sufficient supportive infrastructural investments, such as transportation, extension services, marketing infrastructure, agricultural research, etc. These would help raise agricultural supplies and improve producers' welfare. Since most of Zimbabwe's agriculture is rainfed, this means that in times of drought, the country has to rely on food reserves, imports and food aid. Reliance on food imports implies a strong import capacity. The performance of the export sector and proper management of foreign currency reserves is a crucial consideration given the competing demands on the country's limited resources.

At the micro level food security implies that all citizens get entitlement to adequate food (Sen, 1982). Much of the food security literature seems to assume explicitly that food security should be based on domestic food production. However, as Tollens (1985) points out, food self-sufficiency is not a necessary condition for food security. It is possible for a country to import food and still guarantee food security for its citizens, as long as sufficient foreign exchange reserves are available. Food security at the national level, therefore, is largely affected by variability in local production and global supplies.

The policy instruments available to achieve maize availability at times of drought crisis are: trade (imports), food aid, stock maintenance policies, storage capacity and transportation which includes logistics of grain movement. Once aggregate maize supply (domestic production plus imports) has been determined for a given year, there remain other problems. For example, maize supplies must be allocated throughout the year and distributed amongst target groups in the population.

A food security policy relating to maize availability therefore raises issues relating to:

- trend levels of maize production and imports;
- stabilization of the market for maize between seasons;
- ensuring that aggregate national maize supplies are distributed adequately to all regions and social groups;
- coping with unpredictable fluctuations in maize supply; and
- allocation of maize between feed for animals and for human consumption.

1. 2 Problem Statement

The f equency of drought forms a threat to Zimbabwe's food security, relating to maize availability. The country's droughts of 1946/47, 1967/68, 1972/73, 1982/83, 84, and the worst drought in 1991/92 and the recent 1994/95 drought bears testimony to this. Precipitation fluctuates widely from season to season and its shortfall is a common occurrence. The wide variation in precipitation eventually translates into wide variation in maize yields, production, consumption and producer prices. The problem of rainfall scarcity in Zimbabwe is illustrated in Table 3. Since 1946 the country has faced seven drought seasons, this explains some of the cycles in maize production Table 3.

The observed high frequency of drought in Zimbabwe establishes the difficulty the nation is facing in terms of safeguarding the nation's maize availability. Historical data presented in Table 3, shows that low rainfall was received in each year relative to either the preceding or succeeding year. In each of the drought years production fell below the expected maize production levels. With the drop in maize production, supply of maize to the Grain Marketing Board (G.M.B.) is low, commercial purchases or sales of maize from the

Table 3: The Relationships Among Maize Production , Seasonal Rainfall and the November to January Rainfall shown as Critical Rainfall in Zimbabwe (1961 to 1995).

Year	National Maize Production (000'sMT)	Seasonal Rainfall (mm)	Critical Rainfall (mm)	Year	National Maize Production (000'sMT)	Seasonal Rainfall (mm)	Critical Rainfall (mm)
1961	1014	783.6.	603.6	1981	2717	989.5	883.5
1962	894	677.8	570.8	1982	1716	547.5	538.7
1963	720	875.3	788.5	**1983**	**861**	**584.2**	**430.7**
1964	716	510.7	486.1	**1984**	**1487**	**540.3**	**429.8**
1965	822	630.5	596.0	1985	2638	884.9	732.7
1966	900	638.0	557.7	1986	2486	799.0	620.6
1967	1518	690.4	580.3	1987	1098	518.9	459.6
1968	**975**	**432.5**	**372.3**	1988	2193	838.1	637.4
1969	1572	821.5	570.6	1989	1931	605.3	258.1
1970	1055	640.3	564.6	1990	1994	625.1	382.5
1971	1783	667.2	606.2	1991	1586	501.6	264.3
1972	2233	867.3	706.2	**1992**	**361**	**335.2**	**218.0**
1973	**929**	**422.5**	**370.1**	1993	2012	629.6	364.3
1974	2038	1072.2	948.8	1994	2326	519.3	413.6
1975	1695	895.8	800.4	**1995**	**840**	**418.8**	**231.0**
1976	1755	744.0	508.8				
1977	1540	799.9	616.3				
1978	1552	1056.2	823.9				
1979	1161	595.8	518.3				
1980	1488	681.8	589.4				

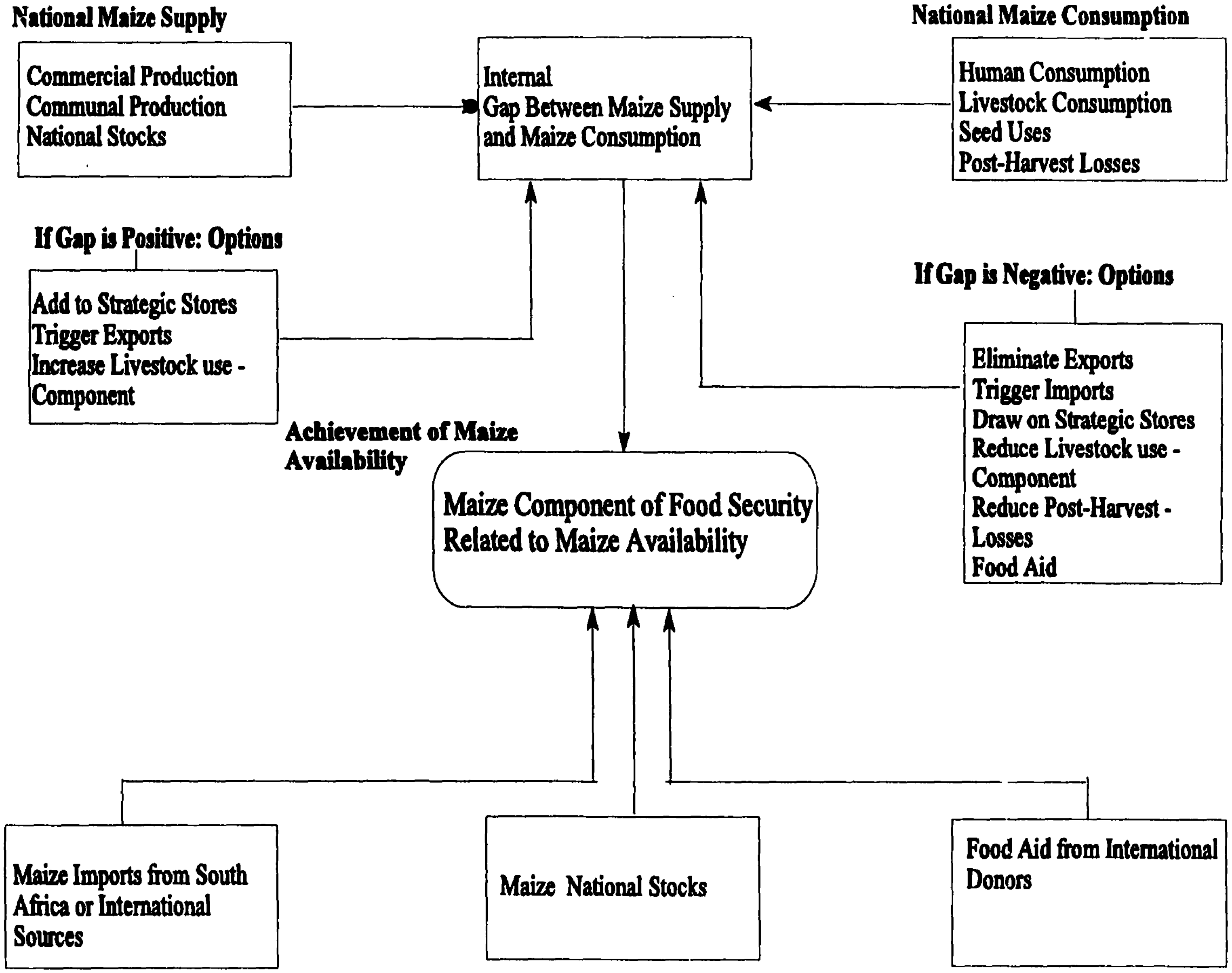
Source: G.M.B. Reports and Belverdere Weather Station

NB: Bold numbers indicate major drought years.

G.M.B. are typically high. There is an inverse relationship between rainfall and GMB sales and purchases. During low rainfall years maize sales are high and during high rainfall years maize sales are low. Maize sales by the G.M.B. during years of drought is high because the rural households are not able to produce maize to meet their subsistence requirements, whereas in normal times the rural population (75 percent of the population) produce adequate maize supplies for their own consumption, therefore sales are low. Rainfall inadequacy or adequacy precedes changes in other variables such as maize production, supply and sales, through time. Thus, the weather heralds a good or bad production year.

The maize situation in Zimbabwe during the worst drought of 1991/92 highlighted the inability of maize supplies to meet food security requirements The national rainfall of 335 millimeters received in the 1991/1992 season was the lowest since 1901 (Belvedere Meteorology Station, 1992). Total domestic supply of maize for the 1992 season was estimated at 530,000 metric tonnes, thus 67 percent below the annual national average production of 1.5 million metric tonnes. Zimbabwe's import requirements of maize in 1992 were estimated to about 2.4 million metric tonnes, at an estimated cost of Z$2,430 million.Expenditure on imports worsens the foreign currency shortages and increases the depreciation of the Zimbabwean dollar. Thus, maize shortages poses the question whether a reduced variability in maize supply can be designed for Zimbabwe. The question to be addressed is, what are the best economic alternative options for achieving stable maize supplies as a means to achieve food security as it relates to maize availability, under crisis conditions such as the 1991/92 drought. The economic logistical dimensions of this problem is of major importance to achieve maize availability Figure 3.

Figure 3: Logistics for Maize Component of Food Security, Related to Maize Availability



The broad concept of food security potentially involves strategic considerations as well as the overall economic resource use implications. The main variables of interest in this problem are: domestic maize production, human and livestock maize consumption, storage relating to national stocks, seed use, post harvest losses, imports, and food aid. The gap between production and consumption can either be positive or negative. To meet the food security objective relating to maize availability, defined as a product of population size and an average of maize consumption per capita. If the gap becames negative the alternative strategies are; drawing on strategic stores, trigger imports, reduce livestock use, eliminate exports, reduce post harvest losses or rely on food aid. If the gap becames possitive the alternative strategies are; to add to strategic stores, trigger exports to generate foreign exchange for future imports, increase livestock use component Figure 3. The central problem to be addressed in economic terms is one of minimizing the cost in national terms of assuring a basic level of consumption under crisis conditions and evaluating alternative logistic strategic options, so as to achieve food security, thus closing the gap between production and consumption. The problem of maize availabilty in the face of drought can be evaluated as closing the gap between production and consumption. Since the GMB has control over domestic stocks, setting producer prices, imports and exports, its efficiency and effectiveness is needed to consider strategic alternatives which will assure a stable supply of the primary staple food.

At the national level there is need to evaluate production, consumption, storage and import requirements to meet the maize availabilty objective. Other variables of interest include; G.M.B. intake, consumption requirements, maize producer prices, domestic stocks, storage capacities, storage and handling costs, transport costs, opportunity costs for maize in storage, opportunity cost for hard currency, costs on maize waste, transport capabilities, port facilities, seasonal and critical rainfall and G.M.B. sales. On the macro level the policy variables considered are: trade (thus imports and exports), foreign currency, import prices, bufferstocks and food aid. Domestic stocks can act as a buffer to fluctuations in maize supply, and an assessment on storage and handling cost can provide information on how much to store at minimum cost. Production and consumption requirements will be needed to evaluate the nature and magnitude of the production consumption gap, transport capabilities and costs would be necessary to solve the logistics problem. Weather information is necessary to assess the probabilities of droughts and the price information is necessary for price policies which stimulates production. Alternative measures such as the use of price policy, alternative crops, irrigation insurance, storage, an efficient transportation and handling system, foreign currency, imports, and food aid can play an important role in closing the production- consumption gap.

The problem arises of how to find the most efficient cost minimizing way of handling national stocks internally, thus procuring stocks, storage and distribution to the regions of consumption at a minimum cost. To assure that this objective is met, logistic activities will provide the bridge between production and consumption at market locations that are separated by time and distance. In this study logistics of food security is defined as: the process of planning, implementing, and controlling the efficient, cost-effective means of achieving maize availability, subject to drought crisis. It is a plan designed to improve maize availability so as to solve the transitory part of the food security problem in

Zimbabwe. Solving this part of the maize availabilty problem is a necessary but not sufficient condition. The economic variables to be addressed in the maize availability problem are as follows: quantities of maize produced, maize available for human consumption, domestic stocks, variations in rainfall, storage, storage location, imports and exports. Other variables considered include on-farm storage, transportation as it affects the distribution of maize from supplus regions to deficit regions. The amount of maize available for consumption will depend on what is left after the other uses of maize have been deducted, (eg) waste, feed and seed. Given the economic changes and the ever increasing frequencies of drought, a food security plan which involves alternative strategies of couping with maize production shortfalls is needed.

1.3 Objectives

The objective of this study is to illustrate a methodology to enable decision-making based on a cost effective logistic approach to assure food security that relates to maize availability. This will include setting out a plan and analyzing alternatives for achieving maize availabilty under crisis conditions such as the 1991/92 drought. The major objective of this study is to use national maize data on production, domestic stocks or supplies, imports and consumption requirements to analyze two alternatives for achieving maize supply stability under crisis conditions, for the purpose of assuring adequate maize availability at minimum cost, subject to meeting the overall objective of the food security strategy. A national food security plan will be formulated for the primary staple grain maize. This crop is chosen because of its importance as the major food crop for the lower income classes.

The specific objectives in demonstrating a methodology are:

a) outline the nature, frequency and magnitude of the food security problem through analysis of production trends;

b) determine the magnitude of the production - consumption gap for maize and analyzing the probability of such shortfalls and surpluses in maize;

c) determine role of weather as a major variable affecting maize production variability;

d) analyze the costs of alternative food security strategies (e.g.) using imports or domestic stocks as a food security strategy;

e) provide a logistical analysis on alternatives which would minimize the cost of eliminating the gap between production and consumption under crisis conditions; and

f) explore different logistic based policy options, (both macro and micro) that will ensure maize supply stability both under normal and crisis conditions such as the 1991/92 drought situation

This study will help expand the knowledge and the literature as it relates to identifying the preferred logistic strategy for greater food security. It presents a unique approach to a methodology which presents two alternative strategies designed to solve transitory food security problems relating tomaize availabilty in Zimbabwe. The methodology can be used to illustrate data requirements and demonstrate how the cost of a logistic approach to assuring supply stability for a staple food can be reduced. The methodology presented in this study should be of considerable interest to agricultural policy makers in Zimbabwe and other SADC countries where maize is being utilized as a staple food crop, as a guide to planning and reorganization of maize availability so as to meet the food security objective.

1.4 Scope and Organization of Study

This study contains six chapters. The first chapter presents the background to the study, the problem statement, objectives, scope and organization of the study. The second chapter presents an overview of the maize production and consumption, reviews policies on agricultural production and, isssues of food security and indicates the severity of the food security problem. A review on the operations and logistics of the Zimbabwean Grain Marketing Board and Zimbabwe's weather patterns is presented. The third chapter presents a domonstration of the extent of the food security problem thus assigning probabilities to maize availability, production, consumption, and the weather variables. The fourth chapter presents, a list and description of alternative strategies necessary to assure stability in the maize supply requirements for Zimbabwe's food security . The fifth chapter presents a methodology regarding the estimation of costs for each of the alternative strategies. Zimbabwe is used as a case study to demonstrate the data requirements and how the methodology would work. Finally, the sixth chapter presents the conclusion, policy recommendations and recommendations for future research.

CHAPTER 2

AN OVERVIEW OF MAIZE PRODUCTION AND CONSUMPTION

2.1 Introduction

This chapter presents an overview of maize production and consumption in Zimbabwe. A discussion on the operations and organization of the Grain Marketing Industry, and an evaluation of the logistics for the maize marketing are addressed. Also a brief summary on Zimbabwe's agricultural policies and their influence on maize production and marketing is presented.

2.2 Maize Production Trends and Statistics in Zimbabwe

The production and availability of maize in different regions and for different socio-economic groups directly affects incomes and household food security. National food security is substantially dependent on the adequacy of maize supplies, with maize meal accounting for 70 percent of the caloric intake in the Zimbabwean diet.

Zimbabwe has a number of farming systems, the Large Scale Commercial Sector, Small Scale Commercial Sector, Resettlement Areas and the Small Scale Communal Sector. These farming systems are dominated by two distinct farming systems the Large Scale Commercial Sector and the Small Scale Communal Sector. Among the principal crops produced, maize dominates the cropping areas of both sectors; maize accounts for 88 percent of the total coarse grain production in the country, 80 percent of coarse grain production amoung small scale farmers and 61 percent of coarse grain production in Natural Regions IV and V (Government of Zimbabwe, 1992). Zimbabwe is composed of five Natural

Table 4: Distribution of Agricultural Land by Natural Region, Zimbabwe, (1995).

Natural Region	Average Annual Rainfall (mm)	Large- Scale Commercial (%)	Small-Scale Commercial (%)	Communal Farmers (%)	Resettlement Farmers (%)
I	>1000	3	0	1	2
II	750-1000	30	18	8	20
III	650-750	16	38	17	37
IV	450-650	23	37	45	38
V	<450	28	7	29	3
		100	100	100	100

Source: Agricultural Ministry of Lands and Resettlement, Harare (1995).

Regions Figure 1 in Chapter 1 and Table 4. The most suitable and productive regions for maize production are regions II and III, with about 80 to 90 percent of the maize markted surplus originating from Natural Region II. Good rainfall in these regions provide less variability in yields which garantees marketed surplus in non drought years. Of the total agricultural land, 30 percent of the commercial lands are in Natural Region II and 16 percent are in Natural Region III and 51 percent of the commercial lands, many of them ranches, are in the low rainfall Natural Regions IV and V. Of the total agricultural land, 8 percent of the Small Scale Communal lands are in Natural Region II and 17 percent in Natural Region III. 74 percent of the communal lands are in Natural Regions IV and V where maize production is marginal, mostly deficit areas even in normal years. While there is significant diversity within subsectors, production systems on the Large Scale Commercial farms are substantially more capital intensive and technologically advanced than on the majority of farms in the other subsectors. Supplementary irrigation is also widely employed for maize production in the Large Scale Commercial sector, a factor which in conjunction with high inputs and the location of most Large Scale Commercial maize production in Natural Region II, provides a valuable stability to yields, production and marketed supplies of maize from the subsector. The stability of maize yields, combined with the commercial orientation of the Large Scale Commercial farmers to provide relatively stable supply of maize to the market, a valuable element of national food security management.

Between 1961 to 1995, maize production in Zimbabwe has gone from a high of 2,717,000 metric tonnes in 1981 to a low of 361,000 metric tonnes in 1992 as depicted by the historical national maize production data in both Table 5 and (Appendix Figure 4 at end of Chapter 2). Statistical analysis on national maize production data in Table 6 shows that the mean national maize production for the period 1961 to 1995 is 1,503,000 metric tonnes, a standard deviation of 607,300 metric tonnes, a maximum of 2,717,000 metric tonnes and minimum of 361,000 metric tonnes. Commercial maize production statistics show that the mean production for the same period is 850,000 metric tonnes, a standard deviation of 372,800 metric tonnes, a maximum of 1,717,000 metric tonnes and a minimum of 246,000 metric tonnes. Communal maize production statistics show that the mean production for the same period is 653,000 metric tonnes, a standard deviation of 409,000 metric tonnes, a maximum of 1,609,000 metric tonnes and a minimum of 115,000 metric tonnes.

A measure of the moving average has been used to depict the upward and downward trends in maize production overtime. For the 1961 to 1995 period, measured by a five year moving average commercial maize production reached a high of 1,717 million metric tonnes in 1981, thereafter production has been on a downward trend to a low of 500,000 metric

Table 5: Maize Production , GMB Intake and Consumption in Zimbabwe (1961 to 1995).

Year	National Maize Production (000'sMT)	Commercial Maize Production (000'sMT)	Communal Maize Production (000'sMT)	Total G.M.B Intake (000'sMT)	Commercial G.M.B Intake (000'sMT)	Communal G.M.B Intake (000'sMT)	National Consumption Requirements (000'sMT)
1961	1014	540	474	201	201	na	430
1962	894	503	391	389	389	na	430
1963	720	400	320	287	287	na	440
1964	716	396	320	208	208	na	470
1965	822	472	350	229	229	na	490
1966	900	602	298	289	289	na	496
1967	1518	937	581	441	441	na	510
1968	975	562	413	767	767	na	544
1969	1572	686	886	400	400	na	543
1970	1055	809	246	869	869	na	611
1971	1783	1328	455	616	616	na	630
1972	2233	1682	551	1061	1061	na	629
1973	929	784	145	1340	1340	na	678
1974	2038	1567	471	540	540	na	676
1975	1695	1260	435	1290	1290	na	605
1976	1755	1205	550	1007	958	49	677
1977	1540	1140	400	959	875	84	794
1978	1552	1102	450	941	857	84	843
1979	1161	706	455	876	813	63	895
1980	1488	888	600	512	474	38	959
1981	2717	1717	1000	815	729	86	958
1982	1716	1121	595	2013	1650	363	1000
1983	861	576	285	1391	1022	369	950
1984	1487	817	670	616	464	152	979
1985	2638	1080	1558	942	552	390	996
1986	2486	1138	1348	1828	1009	819	1051

Table 5 continued

Year	National Maize Production (000'sMT)	Commercial Maize Production (000'sMT)	Communal Maize Production (000'sMT)	Total Maize Intake (000'sMT)	Commercial Maize Intake (000'sMT)	Communal maize Intake (000'sMT)	National Consumption Requirements (000'sMT)
1987	1098	470	628	1594	912	682	1016
1988	2193	584	1609	402	247	155	1056
1989	1931	743	1188	1197	441	756	1114
1990	1994	732	1262	1166	511	655	1131
1991	1586	567	1019	781	357	424	1139
1992	361	246	115	605	234	371	1234
1993	2012	878	1134	13	12	1	1352
1994	2326	1012	1314	1338	620	718	1344
1995	840	500	340	1148	547	601	1362

Source: Grain Marketing Board, Zimbabwe (1994).

Table 6: Descriptive Statistics on Maize Production and GMB Intake in Zimbabwe. (1961-95)

	National Maize Production (000's MTs)	Commercial Maize Production (000's MTs)	Communal Maize Production (000's MTs)	Commercial Maize Intake (000's MTs)	Communal Maize Intake (000's MTs)
Mean	1,503	850	653	664	343
Standard Error	103	63	69	82	62
Standard Deviation	607	373	409	365	279
Variance	368,830	138,969	167,410	133,214	77,594
Minimum	361	246	115	12	0.72
Maximum	2,717	1,717	1,609	1,650	819
Sum	52,607	29,750	22,857	13,284	6860
Coefficient of Variation (STD DEV / Mean) (Percent)	40	44	63	55	81

tonnes in 1995. This is about 71 percent below peak production in 1981 (Appendix, Figure 5). On the other hand communal maize production during the same period has experienced a high of 1,609,00 metric tonnes in 1988, since then production is shown to be on a downward trend to a low of 339,600 metric tonnes in 1995. This is about 79 percent below peak production in 1988 (Appendix, Figure 4). The difference in production trends between commercial and communal maize production could be due to an increase in area planted in the communal sector and a decrease in area planted in the Commercial Sector. At the national level, since 1980 total area planted to maize has reached a high of 1,416,000 hectares in 1982. Area planted to maize by communal farmers has gone from a low of 477,000 hectares in 1973 to a high of 1,169,000 hectares in 1994, thus a 59 percent increase in area planted. For the same period area planted to maize by commercial farmers has gone from a high of 388,000 hectares in 1972 to a low of 153,000 hectares in 1992, thus a 61 percent decrease in area planted (Appendix, Figure 6), Commercial farmers diversified into cash crop production. Total area planted to maize is shown to be on a downward trend to a low of 881,000 hectares in 1992, thus about 38 percent decline in area planted. Since 1980, National maize production has gone from a high of 2,717,000 metric tonnes in 1981 to a low of 361,000 metric tonnes in 1992 and 840,000 metric tonnes in 1995, thus a decline in national maize production from the peak, of about 87 percent and 69 percent respectively (Appendix, Figure 4). National maize production, measured by a five year moving average is shown to have a steady increase up until 1989, since then maize production is shown to be on a downward trend (Appendix, Figure 7). This could have been caused mostly by the weather variable because since 1983 Zimbabwe has experienced four major drought periods (see Table 3 in Chapter 1). The coefficient of variation is used to determine the variations in maize production for both the Large Scale and Small Scale maize producers. The Coefficient of variation shows that Small Scale maize producers experience more maize production variation than the Large Scale maize producers (see Table 6). Per Capita National maize production is shown to be on the downward trend from 1975 to 1995 (Appendix, Figures 8).

Using production as a dependent variable and time as an independent variable, simple OLS regressions were run to produce estimates on production trends, both for nominal national maize production and per capita national production for the periods 1961 to 1995, 1961 to 1979 and 1980 to 1995. (Appendix, Figures 9, 10, 11, 12 and 13 at end of chapter 2). The series of per capita maize production data is broken into two series, 1961 to 1979 and 1980 to 1995 because of the trends depicted in the five year moving average. A five year moving average shows that per capita maize production took a downward trend from 1980 to 1995. For the period 1961 to 1995 national maize production is shown to have an upward trend (Appendix, Figure 7). During the period 1961 to 1979 norminal national maize production is shown to have an upward trend (Appendix, Figure 9). During the period 1980 to 1995 nominal national maize production is shown to have a downward trend (Appendix, Figure 10). Measured by the estimated trend line national maize production has decline, form a high of 1,869,000 metric tonnes to 1,446,000 metric tonnes, thus a 22 percent decline in norminal national maize production for the period 1980 to 1995 (Appendix, Figure 10). Per capita national maize production in Zimbabwe, is shown to have a downward trend for the production period 1961 to 1995, thus per capita production measured by the estimated trend line has declined, from a high of 334,000 metric tonnes to a low of 249,000 metric tonnes, thus a 25 percent decline in per capita production (Appendix, Figure 11). During the 1961 to 1979 period per capita maize production is shown to have an upward trend (Appendix, Figure 12), while for the 1980 to 1995 period per capita maize production measured by the estimated trend line, has declined from 359,000 metric tonnes to 213,000 metric tonnes, thus about 40 percent decline in per capita production (Appendix, Figure 13). Given the production statistic presented above, Zimbabwe's maize production problems have been concentrated in the 1980 to 1995 production period. Since maize production problems were experienced in this time period, this study will use this time period as the basis for analysis.

Table 7 : Summary of maize usage in Zimbabwe, (1961-94).

Year	Maize Feed 1000 MT	Maize Seed 1000 MT	Maize Food 1000 MT	Maize Waste 1000 MT
1961	50	24	430	148
1962	70	23	430	85
1963	55	23	440	85
1964	175	23	470	87
1965	210	24	490	93
1966	150	26	496	103
1967	180	22	510	220
1968	200	27	544	224
1969	210	27	543	214
1970	250	29	611	144
1971	300	30	630	335
1972	350	24	629	368
1973	255	31	678	239
1974	350	30	676	164
1975	300	31	605	121
1976	300	26	677	297
1977	240	29	794	252
1978	160	24	843	241
1979	355	34	895	244
1980	321	41	959	166
1981	350	42	958	239
1982	250	40	1000	267
1983	300	41	950	124
1984	310	39	979	73
1985	566	39	996	234
1986	480	37	1051	202
1987	250	39	1016	132
1988	350	35	1056	164
1989	270	34	1114	143
1990	250	33	1131	117
1991	280	26	1139	112
1992	360	37	1234	97
1993	200	42	1352	196
1994	200	42	1344	185
1995 na	na	na	na	
Averages	261.67647	31.588235	813.823529	179.852941

Source: F.A.O., (1995).

2.3 Maize Consumption in Zimbabwe

Table 7 shows historical data on maize usage in Zimbabwe for the period 1961 to 1994. Most of the maize produced in Zimbabwe is used for human consumption and the remainder is used as maize feed, maize seed or is wasted . For this 34 year time period, a yearly average of about 814,000 metric tonnes of maize was used for human consumption, 262,000 metric tonnes as livestock feed, 31,000 metric tonnes as seed and 180,000 metric tonnes is wasted. In a normal year government estimates that, Zimbabwe requires an average of 750, 000 to 900,000 metric tonnes of maize for human consumption. Per Capita maize consumption is shown to have a steady upward trend, with an average yearly consumption of 118 killograms Figure 1 in Chapter 1 . Table 8 shows maize consumption requirements by province or region for the 1995 period. The total national maize consumption requirements for the 1994/95 period was 1,227,410 metric tonnes. Since the highest yielding production surplus region II is situated in the Nothern part of the country a considerable amount of maize has to be transported to the deficit regions IV, V , and III, 516,568 metric tonnes a year, or 42 percent of total national maize consumption requirements. Total maize requirements for both regions IV and V amounted to 362,907 metric tonnes a year, thus 30 percent of total national maize consumption requirements .

Figure 14 shows the major flows of marketed maize, its origins and destinations. The dominant movements are evident and indicate the surplus to deficit area pattern. What is also apparent is the generally northern to southern flow of maize. The Grain Marketing Board transports about 200,000 tonnes of maize annually to Bulawayo, the main Southern urban center in Natural Region V and a further 100,000 to 200,000 tonnes to Zishavana, Gweru and Masvingo, which are in Natural Regions III and IV, generally from depots in region II. This puts a heavy load on the critical scarcity of transport capacity and becames a logistical problem.

In years when national production is below national consumption, the production consumption gap has to be filled through imports. Measured by the import dependancy ratio thus (imports divided by domestic stocks) Table 9, Zimbabwe is shown to be self sufficient in maize production except in drought periods. Table 9 shows that the highest import dependancy ratio was in 1993, during the worst drought that Zimbabwe had ever experienced. Since 1980 to 1995 the country has imported maize 7 times out of the 16 year period, thus 44 percent of the time.

Figure 14: Flows of Major Maize Origins and Distributions in Zimbabwe

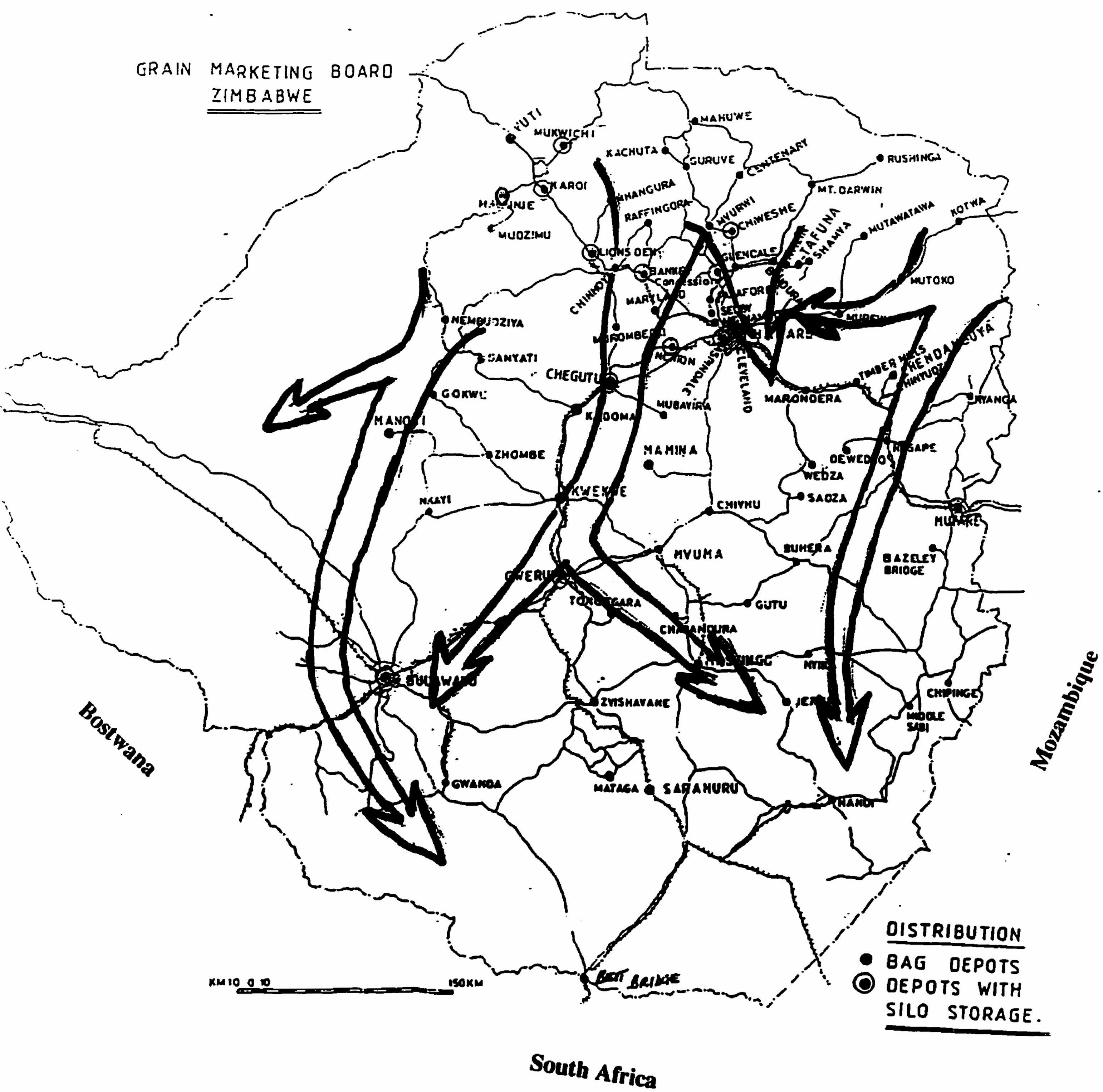


Table 8: Maize Consumption Requirements by Province (1995).

Province	Region	Population	Kgs/Person	Yearly Consumption Requirements (1000) MT
Manicaland	I	1537676	118	181446
Mashonaland Central	II	857318	118	101164
Mashonaland East	II	1033336	118	121934
Mashonaland West	II	1116928	118	131798
Midland	III	1302214	118	153661
Masvingo	IV	1221845	118	144178
Matebeleland North	V	640957	118	75633
Matebeleland South	V	591747	118	69826
Harare	II	1478810	118	174500
Bulawayo	V	620936	118	73270
Total		10401767		1227410

Source: Central Statistical Office, Government of Zimbabwe, Harare (1995).

Table 9: Import Dependency Ratio for Maize in Zimbabwe (1980-95)

Year	Import Dependancy Ratio
1980	0.29
1981	0.10
1986	0.15
1992	0.14
1993	145.09
1994	0.15
1995	0.36

Source: Grain Marketing Board, Harare (1980-95)

Table 10. Summary on National Maize Production, Availability, Change in Stocks, Exports and Imports For the Period, (1970-95).

Year	National Production 1000 MT	Maize Availability 1000 MT	Change in Stocks 1000 MT	Maize Exports 1000 MT	Maize Imports 1000 MT
1970	1085	1035	-220	271	0
1971	1855	1296	350	210	0
1972	2317	1371	500	446	0
1973 *	955	1203	-610	362	0
1974	2104	1221	520	363	0
1975	1763	1057	-150	856	1
1976	1838	1300	170	368	0
1977	1613	1316	-100	397	0
1978	1628	1269	-160	520	0
1979	1142	1528	-610	229	5
1980	1511	1487	100	69	145
1981	2833	1590	1000	244	0
1982	1808	1557	-100	352	0
1983*	910	1415	-1000	495	0
1984*	1133	1401	0	3	272
1985	2828	1836	800	192	0
1986	2546	1771	320	455	0
1987	1131	1438	-750	443	0
1988	2341	1606	340	396	0
1989	2019	1562	250	206	0
1990	1932	1532	-310	750	0
1991	1586	1559	-500	528	1
1992*	362	1729	-100	26	1293
1993	2021	1791	500	217	496
1994	2326	1772	400	156	1
1995*	840	1770		100	200

Source: F.A.O., (1995)

* Major Drought Years.

Imports play a critical role in bridging the gap between production and consumption. Table 10 shows historical data on national maize production, maize supply, change in domestic stocks, exports and imports for the period 1970 to 1995. Data shows that domestic opening stocks have been above the yearly consumption requirements of about 800,000 metric tonnes, thus 6 times out of the 16 year period, about 38 percent of the time. This occured in 1983, 1984, 1987, 1988, 1990, and 1991. With the highest amount of stocks being held in 1988 and the highest imports being realized in 1992. In times of surplus maize production, exports play an important role in terms of generating foreign currency from maize sales outside the country. Managing maize domestic stocks, maize imports and maize exports is a necessary condition for maize availability and food security in general. The maize production - consumption gap is explained fully in Chapter 3, were the extent of the production - consumption problem is addressed.

2.4 A Review of the Operations and Logistics for the Zimbabwean Grain Marketing System.

The involvement of the government in farm programs dates back to the 1930's. Monopoly marketing boards were created and empowered to control and regulate the production and marketing of farm products. The main reason was to create conditions in which the agricultural sector in an environmentally suitable way play the following roles in the development of the country:

a) produce a supply of food necessary to feed the entire population;

b) maintain an appropriate strategic food reserve that allows for viable exportable surpluses;

c) create or generate economic growth in the economy;

d) sustain employment in the agricultural sector;

e) improve the standards of living and the quality of life of farm families, in particular those in the rural areas;

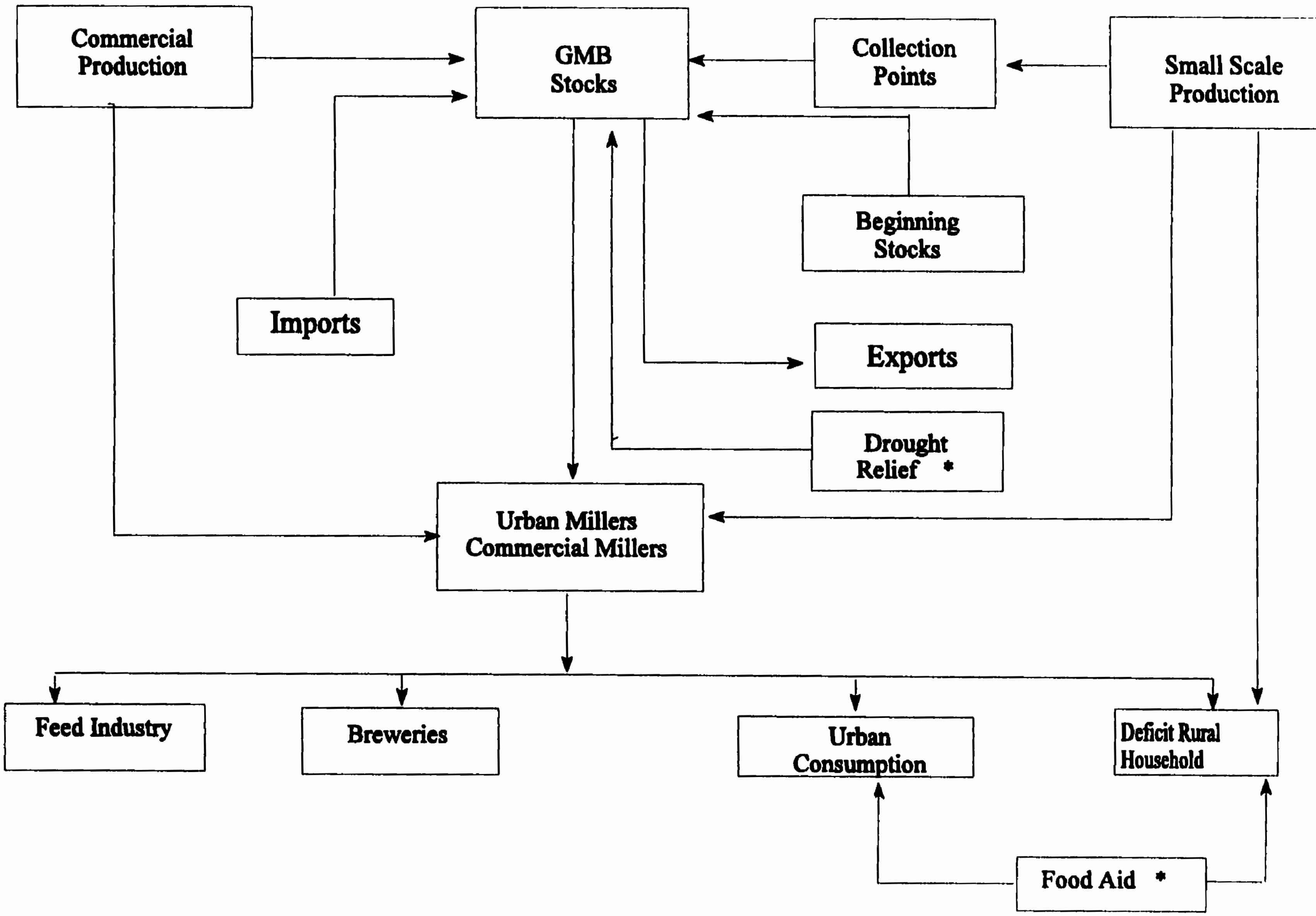
f) contribute to the improvement of balance of payments both through increasing export earnings and generating import savings; and

g) produce and supply raw materials for the manufacturing industry.

Maize is the most important product of Zimbabwe's agricultural system. Because of its primary importance as a national foodcrop maize became controlled by the government as early as the great depression of the 1930's. The grain board, a parastatal, handles six controlled crops and five regulated crops. The controlled crops were; maize, soyabeans, groundnuts, white sorghum, sunflower seed and coffee, while the regulated ones are red sorghum, finger millet, pearl millet, edible beans and rice. As of to date the Grain Marketing System has been deregulated allowing producers free trade in all areas. The only crop which remains regulated is maize, this is because of its importance as the country's staple food. The G.M.B establishes the floor price for maize and is obligated to purchase all surpluses offered to it by producers (acting as a residual buyer).

During the March/April period , the government establishes producer prices for all controlled crops that will be produced during the next farming season. For maize the established prices are important to producer's planting decisions in October/November since it reflects the price to be paid by the Grain marketing Board for maize harvested in the following March/April period. Producer prices are established approximately one year to

Figure 15: Flow Chart Showing the Grain Marketing System in Zimbabwe



actual production. The established prices are based on the current stocks of maize held by the G.M.B., anticipated maize purchases by the G.M.B. during the May to October period, farmer's cost of production, export opportunities and the Board's trading position. During the May to October months farmers have the options of either selling maize to the G.M.B., to other potential buyers or retain maize for on farm use (e.g.), feeding of livestock or human consumption. The G.M.B. stores the grain and eventually sells to end users such as millers, breweries, stock-feeders or to export markets. The end users (domestic) sell their products to wholesalers and retailers who in-turn sell to the individual consumer. About 80 percent of the G.M.B. sales are to millers and stock-feeders, with one miller accounting for over 50 percent of G.M.B sales. A flow chart on the Zimbabwean grain marketing system is illustrated in Figure 15. Until as recent as 1992/93, the Grain Marketing Board, (G.M.B) a parastatal marketing agency, has been the sole buyer and seller of all major grains in Zimbabwe. The G.M.B was instructed to buy all controlled grains that were offered by producers at a price set by the government, and to sell all the grains demanded at prices set by the government. Economic development in Zimbabwe has moved towards liberalizing the grain market structure. Such changes would affect established organizational and operational patterns and functions of the G.M.B. The G.M.B still maintains the function of setting a floor price for maize, and functions as a residual buyer of maize. The board is required to buy all the maize brought to its depots. The G.M.B also maintains its functions of storing, handling imports and exports of national stocks. The Grain Marketing System has been characterized as predominately a one way flow of grain from commercial and small-scale producers to urban areas, where centralized milling and storage facilities are located.

After production, grain is sold to the Grain Marketing Board depots in urban centers, Grain Marketing Board collection points in rural areas, licensed private traders that operate on behalf of the Grain Marketing Board, to breweries, to millers in urban centers. In the case of communal farmers, some grain is returned for consumption. Commercial farmers also retain some grain for use as livestock feed. On the supply side, grain comes from imports, G.M.B intake from both commercial and communal producers, and end stocks. At times of severe maize shortages grain can be obtained as food aid. G.M.B intake is a function of producer price, end stocks, weather and quantity produced in a given year. G.M.B disposal depends on exports, stock accumulation and G.M.B sales.

An inverse relationship between G.M.B intake and sales develops during bumper years and drought years. In times of bumper crops, which were experienced in 1980/81 and 1984/85, grain intake increased, and grain outflow from the G.M.B to end user is reduced, thus sales were low. On the other hand, in drought years, which were experienced in 1981/82, 1982/83, 1986/87, 1991/92 and 1995 the supply of grain to the G.M.B was small. Consequently intake was reduced and G.M.B outflows increased, thus sales were high. Maize stocks held by the grain marketing authorities like the G.M.B perform two broad functions;

a) provide a working stock for normal operational requirements; and

b) provides a reserve for periods of deficit.

The primary function of holding stocks is to provide a working stock for day to day requirements. Therefore, the need to hold stocks for distribution between harvests is an option. As the G.M.B has the function of transporting grain from surplus areas to deficit areas. During surplus periods, a transport problem is created adding costs to the Board. The second generally accepted function is to provide a reserve, usually referred to as a strategic reserve or buffer stock, for use in times of production short falls and drought or similar disasters. A strategic reserve attempts to provide stability across seasons. At present there is no explicit reserve stocking policy in Zimbabwe. The G.M.B. follows the principle of holding one full years' supply as a reserve (750,000 to 800,000) tonnes. In 1995 reserve stocks were kept at 936,000 tonnes at a cost of Z$949,686. By any standards this is a large reserve and costly to maintain. There is need to clarify the actual intended reserve stocks to be held by the G.M.B. Some farmers have argued that a reserve stock as low as 400,000 tonnes should be set. The argument being large carry over stocks tend to depress producer prices. Issues of logistics in the marketing system are of central concern in this study. The question is, what are the appropriate logistical approaches to a marketing system under crisis conditions.

2.4.1 The Grain Marketing Board Import Logistical Problems

In periods of severe food shortages such as the 1991/92 drought, land locked Zimbabwe faces an import logistical problem. The G.M.B. faced serious logistical problems in importing maize in the face of the severest drought in 1991/92. Domestic stocks of maize had fallen to almost zero. Drought was affecting the whole of the Southern African region, placing even greater pressure on transport and handling infrastructure. Forecasts for intake for the season were 67, 000 tonnes, compared with 1.2 million in an average year. The G.M.B. planned to import 2.5 million tonnes of grain by May 1993. Since the November 1991 the G.M.B. had only managed to import 100,000 tonnes of maize, or less than 1,000 tonnes a day. This represented one fifth of the daily consumption requirements of 5,000 tonnes. During March 1992 the Government authorized the importation of a further 540,000 tonnes of maize to supplement the 100,000 tonnes authorized in November 1991. Orders were placed, but the G.M.B. was faced with an extreme logistical problem of physically getting the maize into the country. Logistics at strategic grain handling facilities will have to be improved to facilitate efficient movement of grain to meet food security goals, in times of severe food shortages.

2.5 Agricultural Policies affecting Maize Production, Marketing and Consumption

The dominant agricultural policies in Zimbabwe in the 1980's were that of achieving and maintaining food security, improving income levels for small farm households and increasing foreign exchange earnings/savings. In the early 1990's, government adopted strategies intended to;

- stabilize national food supplies in the face of recurrent droughts;
- stimulate food and cash crop production among large and small-scale farmers to facilitate the generation of foreign exchange for imports;
- stimulate the increased marketing of food and cash crops; and
- improve household food security throughout the country.

This study focuses more on the first strategy, the other strategies are discussed lightly. The strategy that the government pursues in managing production, storage and distribution of maize is of great importance for producers, consumers, government budget and the government's political support. The operations of production, procurement, storage and distribution of maize has major welfare effects to the nation as a whole. Efficient organization of the grain industry will be of great importance in terms of both reducing government budget costs and achieving food security. Food security can be achieved through the availability of grain at the time when it is needed at low cost at official established food markets. A permanent program, or policy is needed to make sure that food is available to households in the low rainfall communal lands.

2.5.1 Price Policy

In many respects the pricing system in Zimbabwe represents a tradition of intervention which has been in place for many years. The principal mechanisms for intervention have been through crop marketing boards possessing monopoly powers within their respective domestic markets, and the administrative determination of both producer and to some extent consumer prices. Producer and selling prices of controlled agricultural products are fixed by government on a formula that weights viabilty, implications on parastatal trading accounts and consumer welfare and equity more than market forces of supply and demand. Producer prices are therefore set relative to farm costs of production on a cost plus basis. They are pan-territorial and pan-seasonal. Consumer prices are set relative to changes in purchasing power of industrial wages, with any difference between these and GMB's procurement and marketing costs being met by state subventions. The objectives of the pricing policy are;

a) to attain food self sufficiency;

b) promote inexpensive food supplies for low income groups;

c) enhance foreign exchange earnings; and

d) increase supply of inputs to the industry.

A number of policy questions can be addressed: a) can the government implement an incentive policy to farmers with irrigated land as insurance against drought crisis, thus drawing from surpluses as needed? b) can the government set aside hard currency as insurance for foreign currency in time of imports needs? c) what would be the trade-of between livestock and humans in terms of maize requirements? d) what are the optimal policies for storage, handling and transportation during crisis conditions? e) can price and subsidy policy be variables of concern? The other question to be addressed is, given the drought crisis such as the 1991/92 crisis, can the current marketing system maintain the required maize grain supplies in both the periods of severe drought and almost normal harvests, as to improve food security at least cost? A country faced with fluctuations in the production of a staple food grain is often left with three choice decisions; change consumption, change foreign trade, or change domestic stocks. This study will concentrate on issues related to coping with situations of severe drought such as 1991/92. The issue is the optimal means for Zimbabwe to prepare for a situation such as the 1991/92 drought in terms of having the maize grain available and / or the means to access external maize as required.

APPENDIX

FIGURES 4 to 13

Figure 4: Zimbabwe Maize Production
For the Period (1961-95)

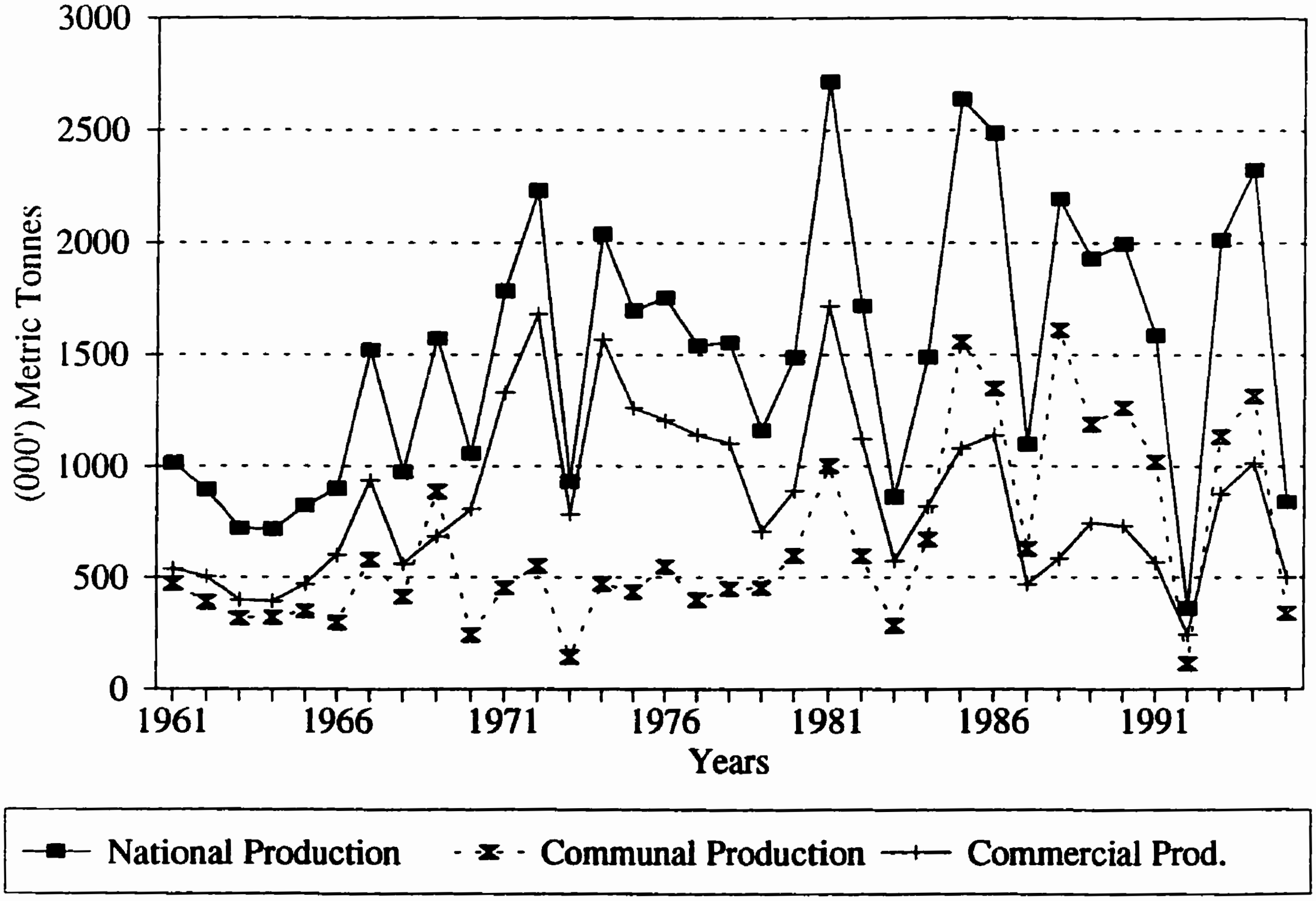


Figure 5:Commercial Maize Production
(1937-1995)

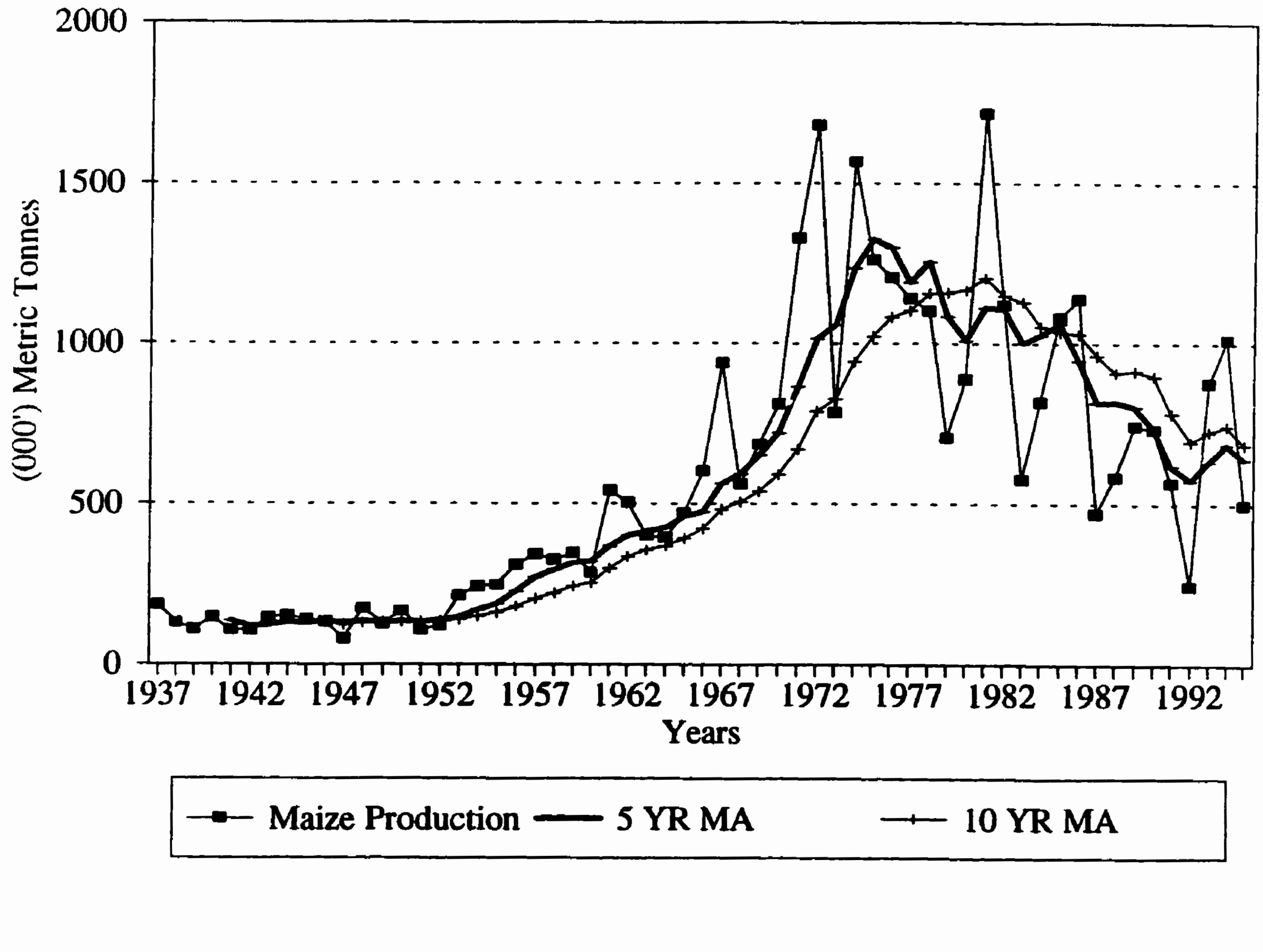


Figure 6: Area Planted to Maize
(1970-94)

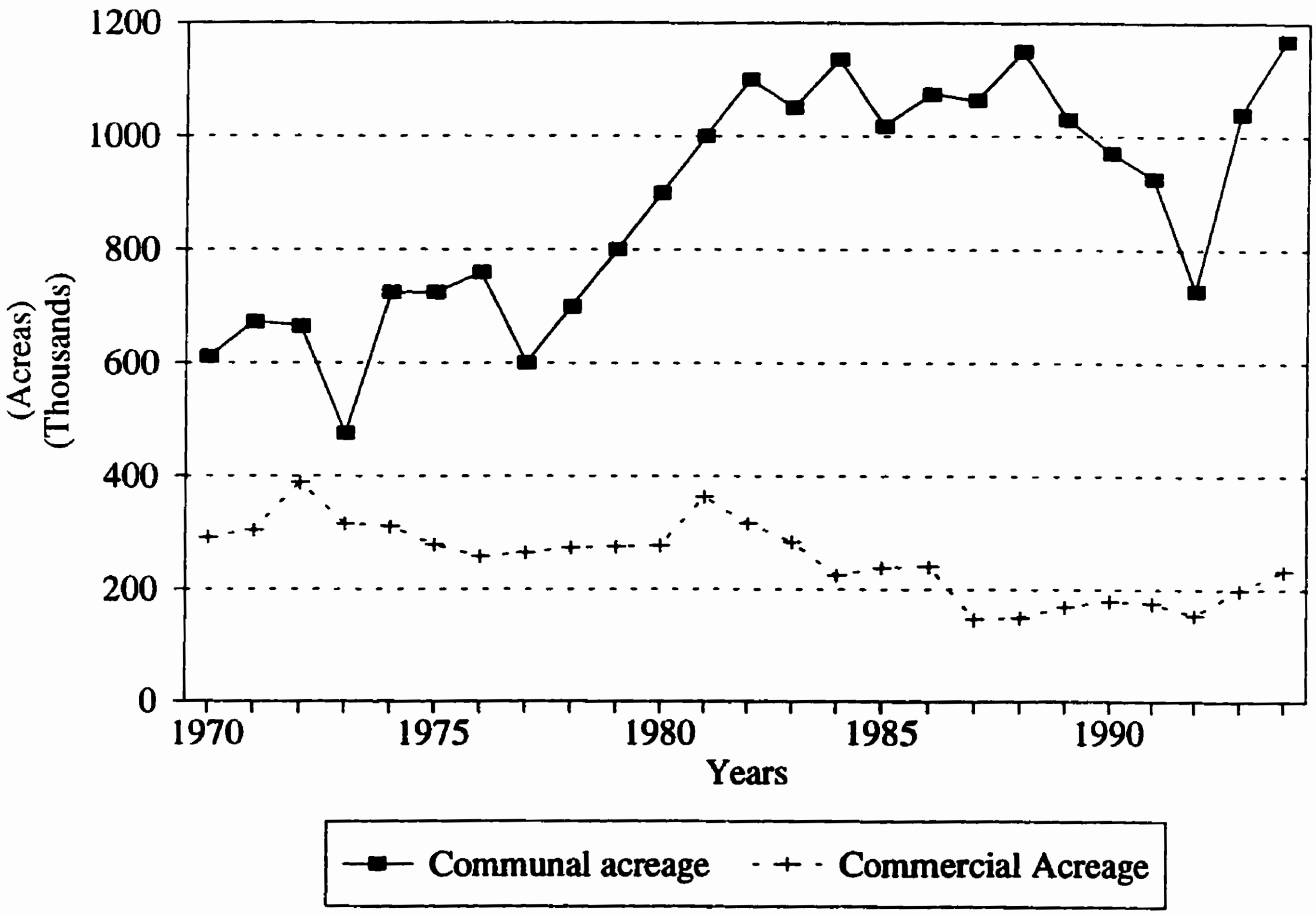


Figure 7: Zimbabwe Maize Production
5 Year Moving Avg. (1961-95)

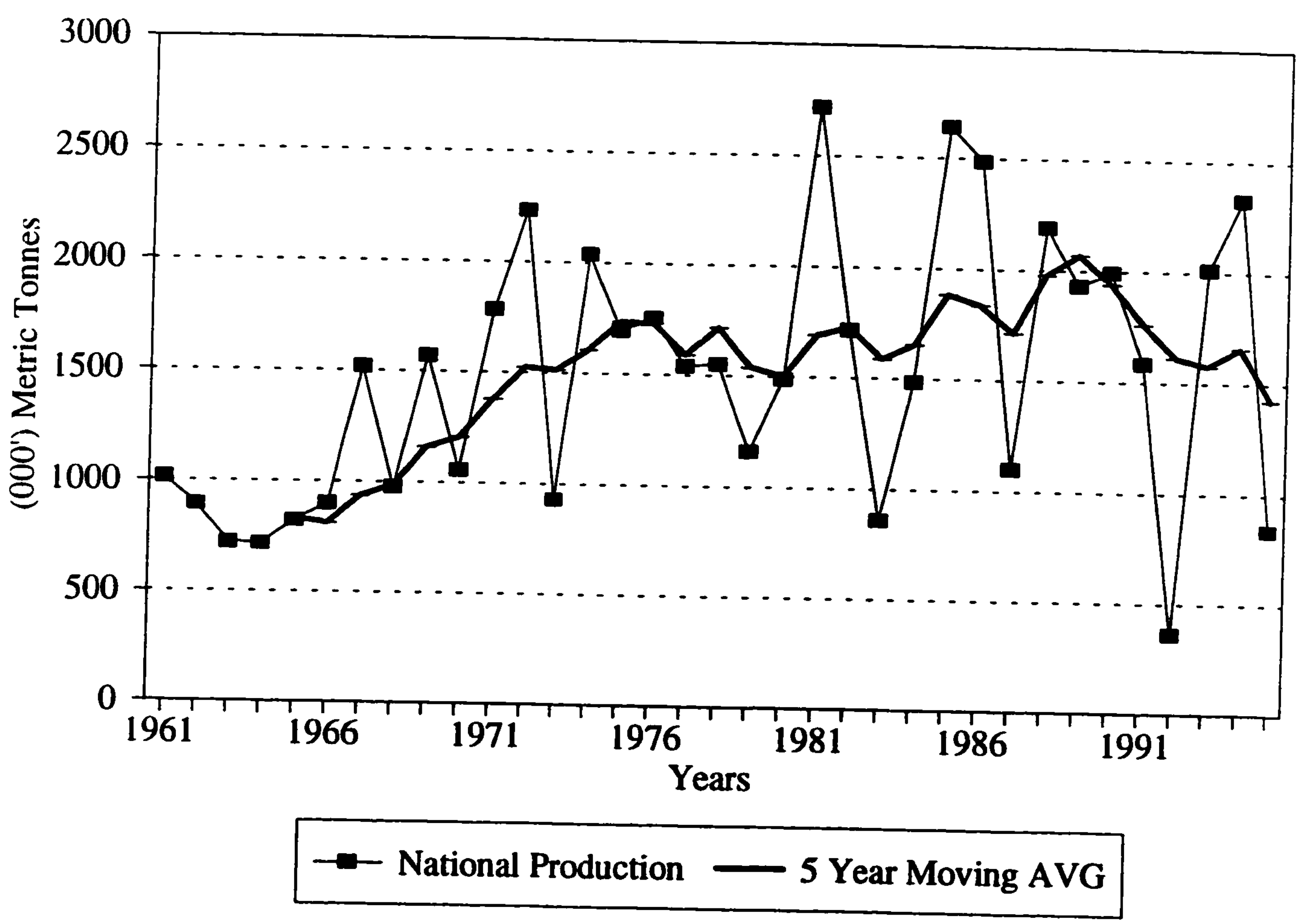


Figure 8: Zimbabwe Maize Production
Per Capita Maize Production (1961-95)

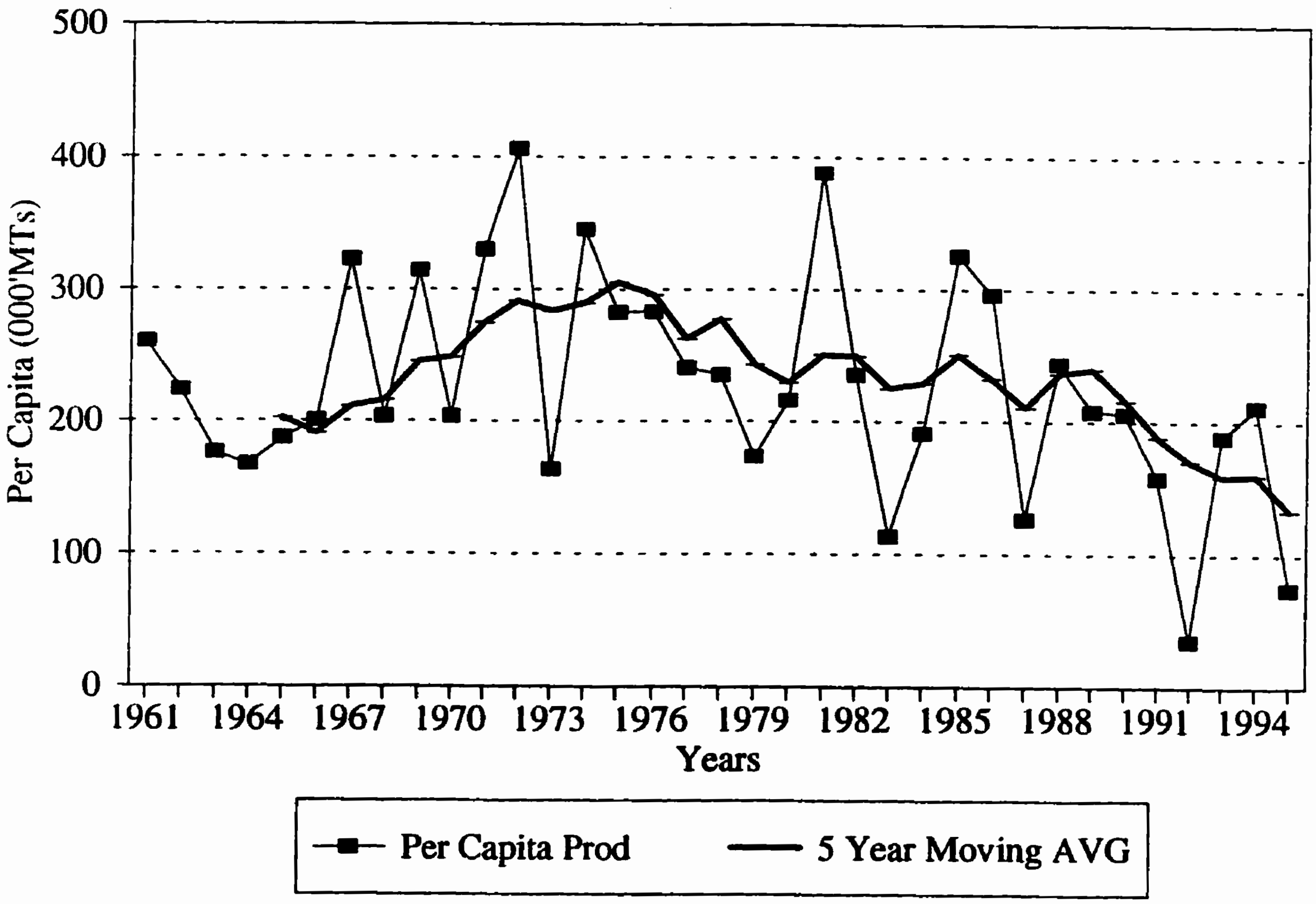


Figure 9: Maize Production Trend
(1961-79)

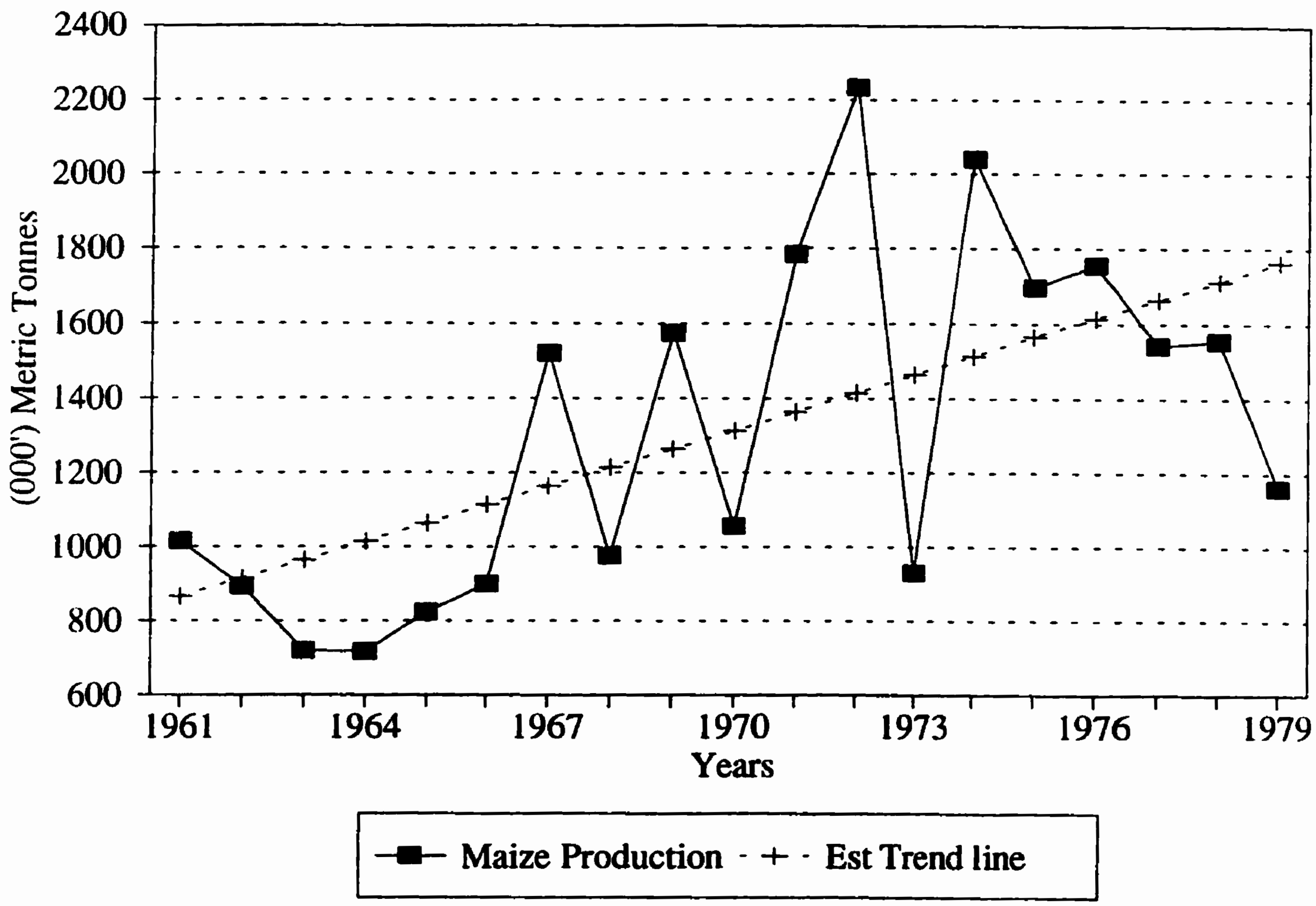


Figure 10: Maize Production Trend
(1980-95)

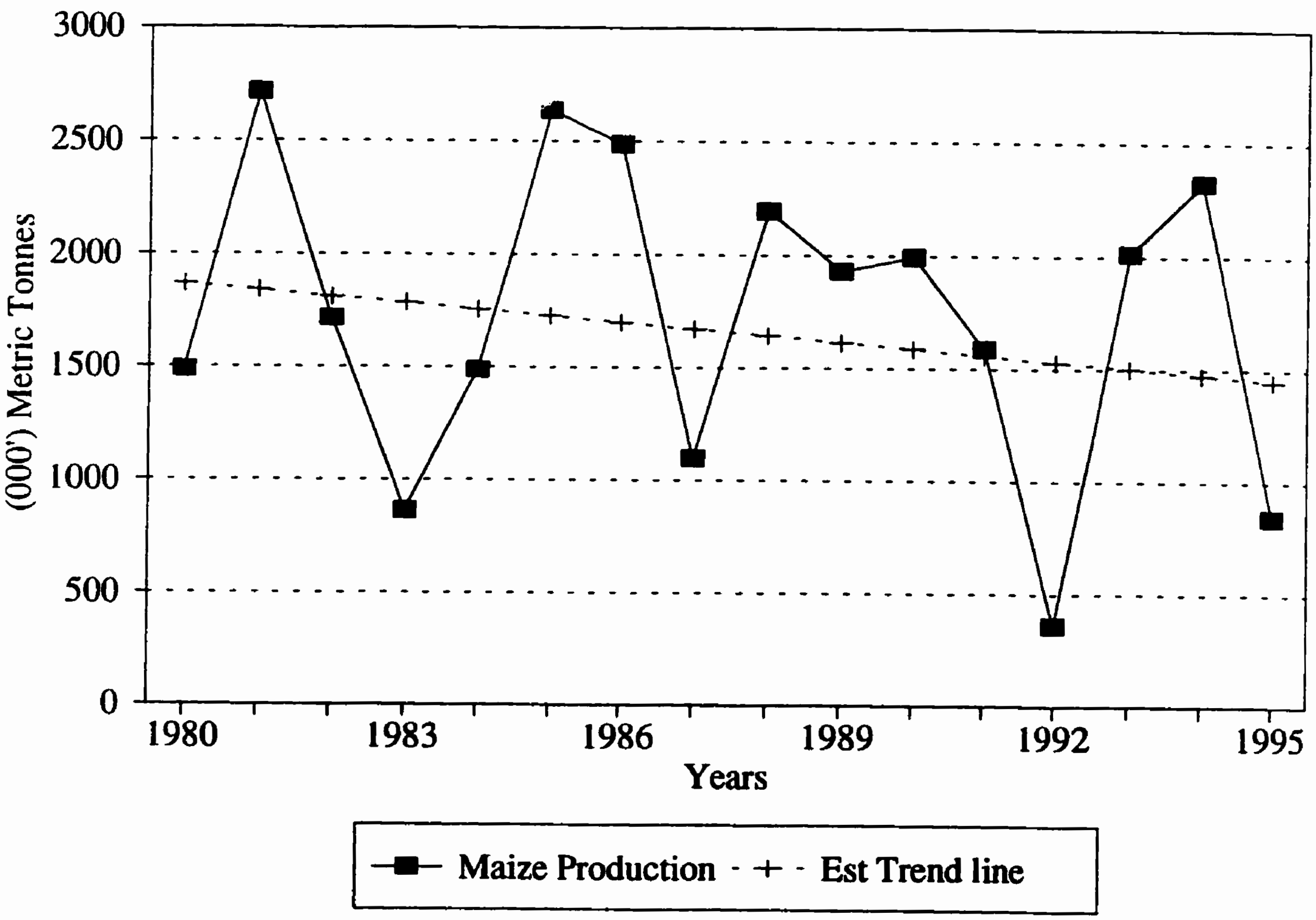


Figure 11: Per Capita Maize Production
Estimates for the Period (1961-95)

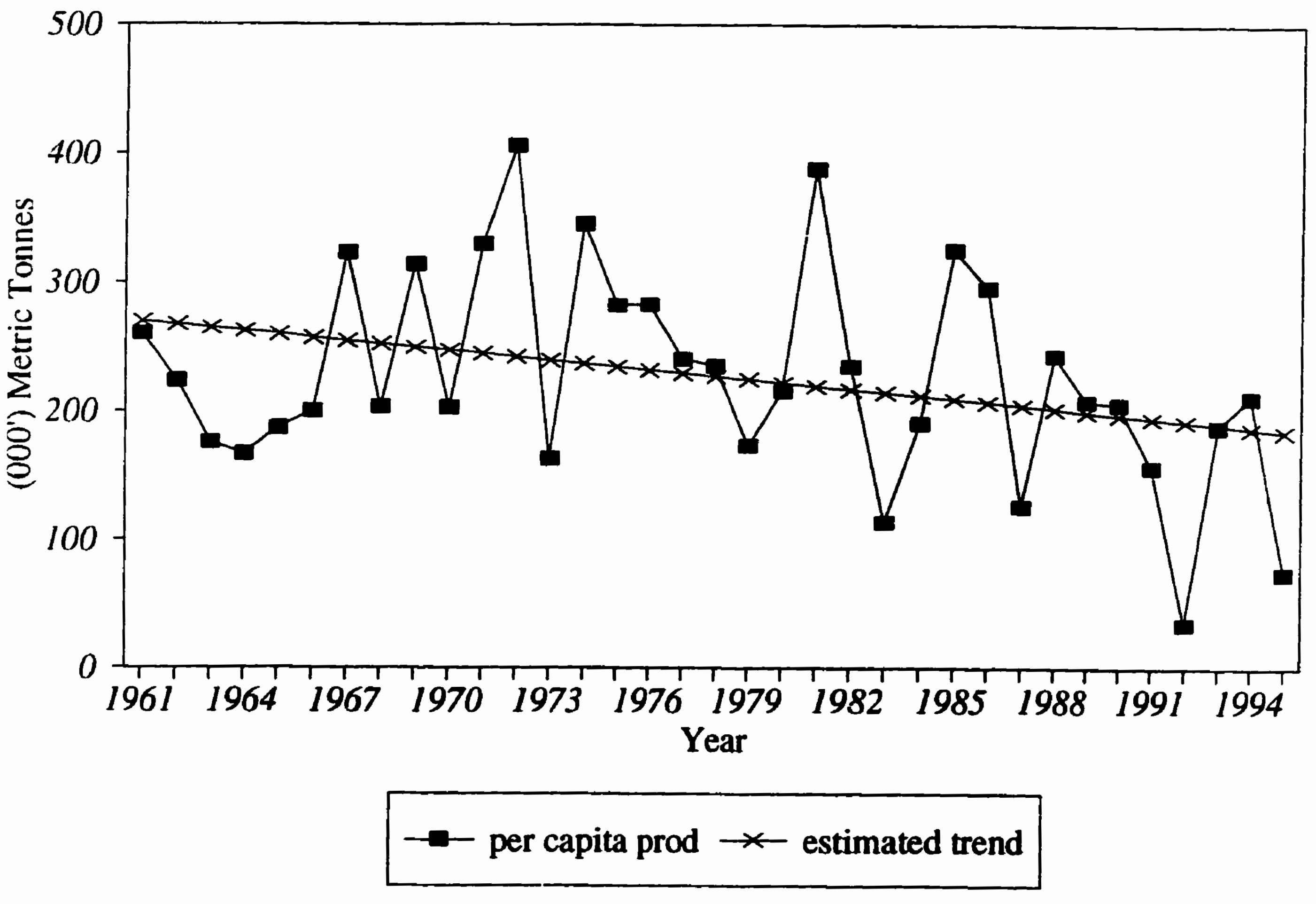


Figure 12: Per Capita Maize Production
Estimates for the Period (1961-79)

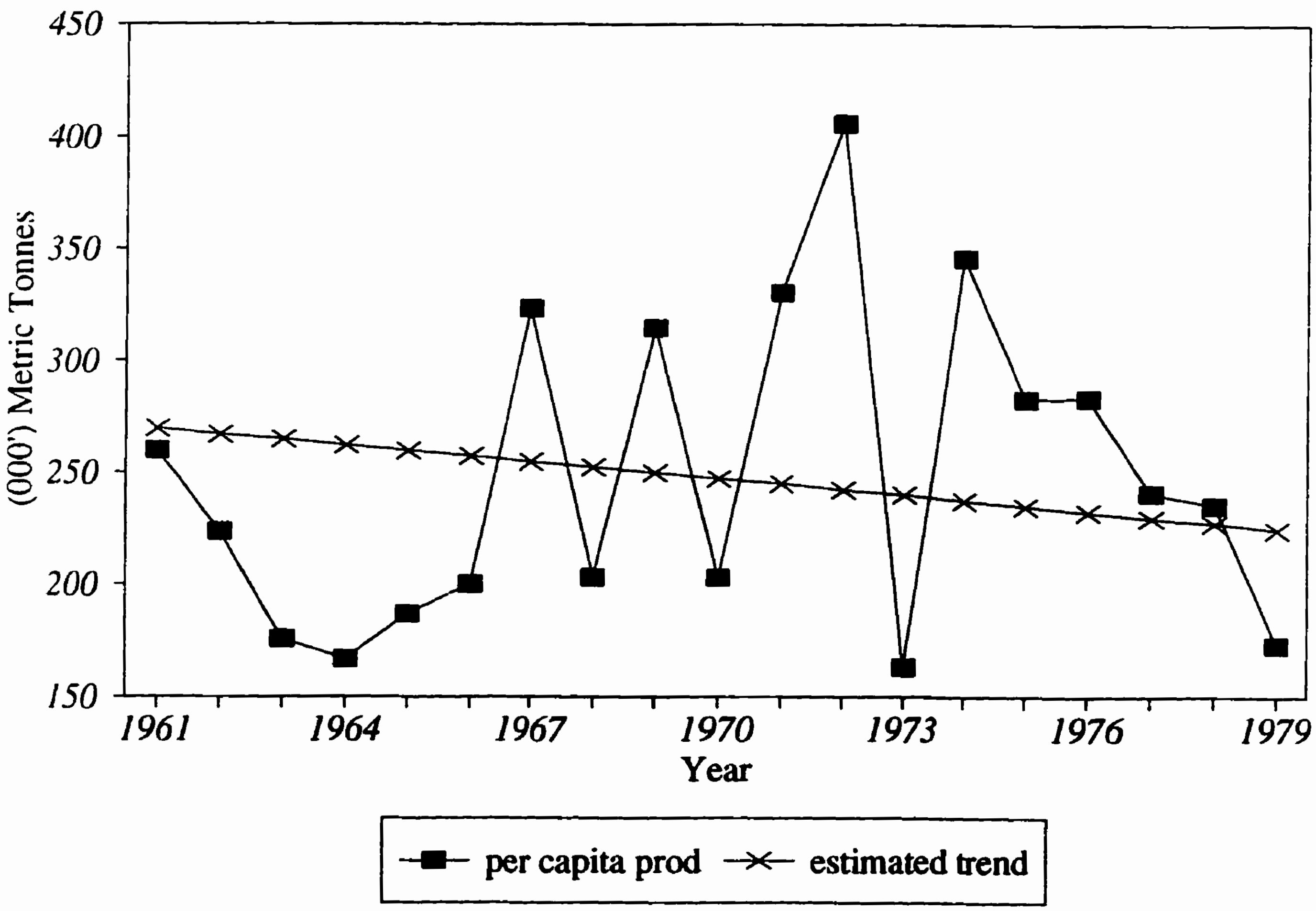
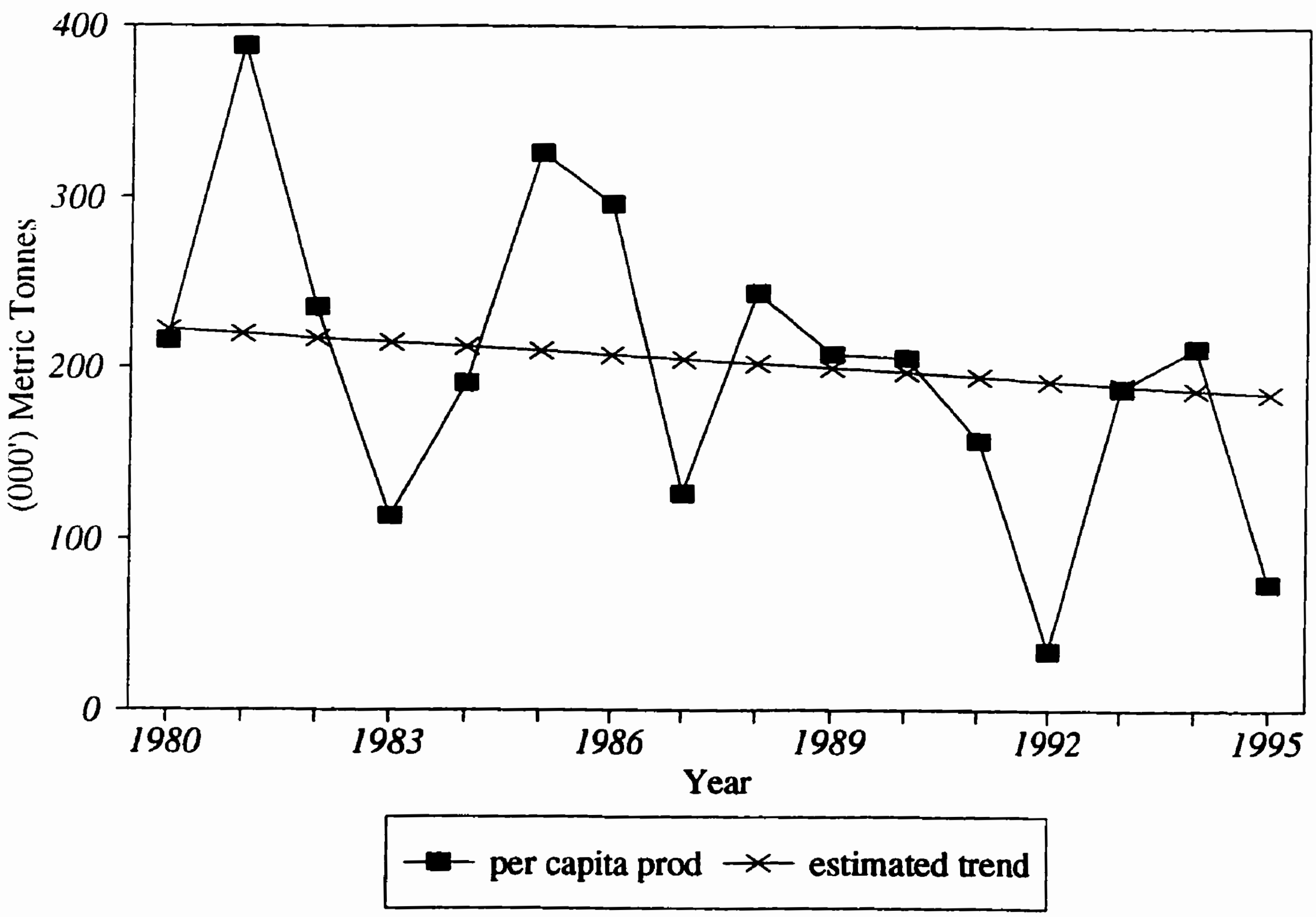


Figure 13: Per Capita Maize Production
Estimates for the Period (1980-95)



CHAPTER 3

EXTENT OF THE MAIZE AVAILABILITY PROBLEM

3.1 Introduction

This chapter presents a discussion on the extent of the maize availability problem. An introduction on drought and its effects on maize availability and Zimbabwe's weather patterns and their effects on maize availability are presented. The discussion includes: variation in rainfall and maize availability; production trends, maize availability problems and production variability; trends in maize availabilty, maize domestic stocks, maize imports and maize exports; and the extent and magnitude of the difference between maize availability and consumption needs. An evaluation of maize shortfalls, assigning probabilities and percentages to maize availability and consumption needs, is presented.

3.2 Drought and its Effects on Maize availability.

During the 1991/92 drought in Southern Africa, a total of 86 million people, 72 percent of the region's population, and 2.6 million square miles of the land were reported to have been affected to varying degrees by a drought of enormous severity and extent (World Disasters Report, 1994). Drought placed 20 million people in the SADC countries at serious risk. This prompted the importation of maize into the region. Maize had to be transported into land locked countries such as Zimbabwe - through long over land routes and a net work of export oriented ports, roads and railways, a logistics effort of daunting proportion.

In July 1995, Zimbabwe declared a state of disaster in the communal, resettle ment and small-scale farming areas. Noting that the drought affecting the country threatened the life and well being of people in these areas. The country needed to feed and protect more than five million people affected by drought in a programme that was estimated to cost Z$2 Billion (The Herald, July, 1995). Drought jeopardizes every aspect of peoples lives, crop and livestock, jobs, possessions and savings, the social cohesion, economic and political stability of the communities and their health. Drought in Zimbabwe is a recurrent short and long-term phenomenon. Development policies should incorporate strategies that mitigate the impact of and reduce vulnerability of future droughts.

Zimbabwe experienced the worst drought in 1991/92. While the historical mean rainfall is 663 mm per year, rainfall during the agricultural season 1991/92 was 335 mm which was 51 percent of normal rainfall. The failure of the 1991/92 rainy season resulted in an almost complete crop loss. The volume of agricultural production fell by one third, contributing only 8 percent to the GDP compared to 16 percent in normal years (SADC, 1992). In April 1992, national maize production was estimated to be 362,000 metric tonnes which was less 20 percent of the average for the seasons of 1988-90. With an estimated average monthly consumption of about 100,000 metric tonnes during the drought period, there was need to import 1, 200,000 metric tonnes of maize to make up for the shortfall.

The drought coincided with the global economic recession declining export earnings and the effect on oil prices of the 1990 Gulf crisis. The Structural Adjustment Programme was underway in Zimbabwe, leading to rising food prices and declining public sector spending and employment. To comply with international demands for rigorous economic reform programme, Zimbabwe sold most of its 1,200,000 metric tonnes of national maize reserves to contain apparently unaffordable storage costs. A year later the country had to import maize at three times the price per tonne it received for the stockpile.

The maize availability situation was aggravated because reserve stocks were allowed to decline. Despite the warning signals of potential maize shortages, early as July 1991, the government did not take the necessary measures to ensure that adequate stocks were maintained. Commercial imports of cereals were only initiated in November 1991. As a result of the delayed action, maize stocks fell from 643,000 metric tonnes to 42,000 metric tonnes by April 1992. This revelation of events has led to the scope of this study that presents an analysis of improving maize availability during crisis conditions.

In view of a drought crisis of 1991/92 that led to maize shortages, the Zimbawean government responded with different policy measures. Given that the National Early Warning Unit had produced monthly bulletins on the predicted maize production, demand, stock level and implications for imports, actual steps to import maize were not made in time, leading to maize shortages in both the urban areas and the drought affected rural areas. The delay in the decision to import maize reveals poor logistics policy measures. Once maize shortages started, the Grain Marketing Board originally intended to leave existing scarce supplies of maize in rural depots for purchase by rural consumers and for use in rural drought relief operations. However it was later decided to reallocate most of the maize stocks to urban industrial millers for urban consumption, also most import supplies were confined to industrial millers. Most private traders and small millers were restricted from buying more than one 90kg bag per month from the Grain Marketing Board under the assumption that these agents were hoarding or would feed the maize to livestock. These policies were intended to maximize scarce maize supplies for human consumption. Finally, the government put a large subsidy on industrial roller-meal to keep food costs low.

These policies had unforseen effects. First, the subsidy on the maize meal became prohibitively expensive because of the difference in the import parity price which was higher than the subsidized selling price to industrial millers. Second, the maize subsidy was not being transferred fully to consumers as intended, because of import constraints. The demand for maize meal outstripped supplies causing excess demand. The actual street price of maize meal doubled the controlled price. Also the subsidy created substantial differences in Zimbabwean maize meal prices, ex-mill and prices in neighboring countries, causing illegal outflows of maize to Mozambique and Bostwana. Third, the decision to reallocate the remaining supplies of maize from rural areas to industrial millers worsened rural maize shortages and inflated rural maize prices far beyond those in urban areas. Failure to make grain available in rural areas forced many rural households to sell livestock and buy food. Yet draught livestock are a critical input in land preparation for crop production and marketing. Zimbabwe's experience of the 1991/92 drought crisis which lead to maize shortages reflects the need for timely identification, dissemination of emerging trends, and a mechanism to translate this information into timely action.

3.3 A Review of Zimbabwe's Weather Patterns

Among other economic variables, weather has been shown to be an important variable in determining the variability of maize production in Zimbabwe. The country's droughts of 1946/47, 1967/68, 1972/73, 1982/83, 84, the worst drought in 1991/92 and the recent 1994/95 drought bears testimony. Of these the 1991/92 rainfall season was the worst followed by the drought of 1946/47. Droughts of this nature bring instability in maize production, therefore increasing the risk and uncertainity in the agricultural sector and concern for food security in Zimbabwe. Droughts according to one of the many definitions, is the unfulfillment of the expected rainfall. In semi-arid Zimbabwe over 70 percent of the population depends entirely upon summer rain fed agriculture for survival. Drought results in reduced harvests, livestock losses, malnutrition, starvation and general economic hardship in both rural and urban communities.

As shown in Table 11, Zimbabwe's weather patterns are variable, since 1970 the country has experienced five major droughts, with four of these droughts occuring from 1983 to 1995. This shows that the occurance of drought has been more frequent in recent years, thus addding to the food security problem. Using historical data for the years 1937 to 1995 a five year moving average

on both seasonal and critical rainfall shows a decline in rainfall from 1980 to 1995 (Appendix, Figures 22 and 23 in Chapter 3). Seasonal rainfall is defined as annual rainfall and critical rainfall is defined as rainfall received during the critical months of the growing season, thus, from November to January. The historical data show a cyclical pattern of the below average rainfall or lowest rainfall being experienced almost every 10 years in a 30 year period of (1967-1972-1982). During a 36 year period from 1961 to 1996 the country had rainfall above normal in 1973, 1977, 1980, and 1996. Thus 4 times out of a 35 year period translating to about 11 percent of the given time. If 700 millimeters is the minimum

Table 11: Summary of Commercial and Communal Maize Production, Combined with Seasonal and Critical Rainfall, (1970-95).

Year	Commercial Production	Communal Production	National Production	Seasonal Rain	Critical Rain
1970	809	246	1055	640.30	564.63
1971	1328	455	1783	667.22	606.20
1972	1681	551	2232	**867.29**	**706.17**
1973 *	784	145	929	422.51	370.07
1974	1567	471	2038	**1072.21**	**948.84**
1975	1260	435	1695	**895.81**	**800.43**
1976	1205	550	1755	**744.01**	508.77
1977	1140	400	1540	**799.86**	616.33
1978	1102	450	1552	**1056.23**	**823.90**
1979	706	455	1161	595.83	518.27
1980	888	600	1488	681.80	589.43
1981	1717	1000	2717	**989.46**	**883.47**
1982	1121	595	1716	547.53	538.70
1983*	576	285	861	584.2	430.67
1984*	817	670	1487	540.34	429.77
1985	1080	1558	2638	**884.92**	**732.72**
1986	1138	1348	2486	**798.99**	620.56
1987	470	628	1098	518.87	459.62
1988	584	1609	2193	**838.14**	637.39
1989	743	1188	1931	605.30	258.10
1990	732	1262	1994	625.10	382.50
1991	567	1019	1586	501.60	264.30
1992*	246	115	361	335.20	218.00
1993	878	1134	2012	629.60	364.30
1994	1012	1314	2326	519.30	413.60
1995*	500	340	840	418.80	231.00

Source: Grain Marketing Board and Central Statistical Office, Government of Zimbabwe, Harare (1995).
*** Major Drought Years. Bold Numbers= Good Rainfall**

droughts in Zimbabwe. Preliminary results have indicated that prediction of droughts is possible However at present the prediction is merely a probability of occurrence rather than a definitive statement.

One of the phenomenor currently under investigation is the El Nino. This is a term which describes abnormal warm water that occassionally appears off the coasts of Ecuador and Peru in South America in December. Intense world-wide data gathering by scientists in the sixties has now confirmed that the El Nino is a significant part of the large-scale atmospheric circulation. On- going research has indicated that there is an association between droughts in Zimbabwe and the El Nino. Researchers found that between 1973 and 1990 Zimbabwe's rainfall and maize yields fluctuated in lock step with the oscillating surface temperatures in the tropic Pacific, dropping in years when the temperatures were above normal (an El Nino event) and rising in years when the temperatures dropped below normal (an occurance known as La Nina). Current consensus suggest that major El Nino events have a return interval of four to five years. In addition, when it occurs, it often lasts from 12 to 18 months. If the trend continues then the next major drought is expected around 1997. However droughts in Zimbabwe occur simultaneously with major El Nino events only in 32 percent of the cases (Makarau, 1993).

Seasonal rainfall patterns in Zimbabwe are also linked with sea surface temperatures in the Indian Ocean, especially in the equatorial region between India and Madagascar. The relationship accounting for about one third of the variation in rainfall over Zimbabwe, anticipates the El Nino by more than three months (Makarau, 1993). Thus, scientists claim that, the Indian Ocean sea surface temperatures offer a much better objective tool to use in

Table 12: Contingency Table showing Occurrence of Extreme Rainfall in Zimbabwe, El Nino (High ENSO) and La Nina (Low ENSO) Events from (1901-92).

	Excess Rainfall	Drought Season	Normal Season
El Nino Year High (ENSO)	1914, 1922 1952, 1977	1911, 1923, 1946 1972, 1981, 1982 1986, 1991	1912, 1918, 1919 1925, 1926, 1930 1932, 1940, 1941 1951, 1957, 1965 1969
Total	(4)	(8)	(13)
La Nina Year Low (ENSO)	1917, 1924 1928, 1938 1954, 1973	1915, 1963	1904, 1909, 1950 1956, 1964, 1970 1971, 1975, 1988
Total	(6)	(2)	(9)
Neither	1901, 1980	1913, 1921, 1959 1967, 1983	Remaining Years
Total	(2)	(5)	(43)

Source: Belvedere Weather Station

attempting to predict seasonal rainfall well in advance. These new findings suggest that scientists can use predictions of this nature to forecast crop conditions in Zimbabwe as much as a year in advance, enabling planners to anticipate and cope with droughts. Thus, providing a powerful new tool for agricultural planners. Table 12, shows a contingency table indicating the association between extreme ENSO years and extreme rainfall years in Zimbabwe (Ropelewski and Jones, 1993).

3.4 Variation in Rainfall and Maize Availability Decline

The underlying assumption in this study is that most of the annual variation in maize availability is a product of forces beyond those controlled by the government (e.g) maize prices, input prices or prices for alternative crops. Rainfall is hypothesized to be a significant variable contributing to the variation in maize availabilty. The theoretical assumption is that there are no shifts in demand for maize, shifts will only occur annually as population increases. Maize supply shifts to the left as supply decreases because of rainfall variations caused by droughts.

To test the above underlined hypothesis, Ordinary Least Squares regressions where performed for both the Commercial and Small Scale farming sectors. OLS regression equations where run with maize yields being dependent on seasonal rainfall, time trend, and critical rainfall defined as rainfall received during the critical growing months of November to January. Table 13 presents regression results showing Commercial maize yields being dependent on seasonal rainfall and time trend for the time period 1961 to 1995. The R^2 of 0.66 shows that the independent variables used in the maize yield equation explains 66 percent of the variation in maize yields. T statistics of 6.44 for seasonal rain show that this variable is significant at the 0.5 percent level of significance. The time trend variable has a T statistic of 1.14 showing little significance. All variables carry the correct theoretical signs. There is a positive relationship between maize yields and seasonal rainfall, as seasonal rainfall increases, maize yields increase. The Durbin - Watson statistic of approximately 2 indicates that there is negative serial correlation.

Table 14 presents regression results showing Small Scale maize yields as being dependent on seasonal rainfall and time trend for the time period 1961 to 1995. The R^2 of 0.50 shows that the independent variables explain 50 percent of the variation in maize yields in the Small Scale farming sector. All variables carry the right signs, and both seasonal rainfall and time trend have a T statistics of 4.21 and 3.39 respectively, showing significance at the 0.5 percent significance level. A D.W statistic of 1.74 shows negative serial correlation.

Tables 15 and 16 presents regression results on maize yields for both Commercial and Small Scale farming sectors maize as being dependent on critical rainfall and time trend. Table 15 presents regression results showing Commercial maize yields being dependent on critical rainfall and time trend for the time period 1961 to 1995. The R^2 of 0.40 shows that the independent variables used in the maize yield equation explains 40 percent of the variation in maize yileds. T statistics of 3.80 for critical rainfall show that this variable is significant at the 0.5 percent level of significance. The time trend variable has a T statistic of 1.08 showing little significance. All variables show that they carry the correct theoretical signs. There is a positive relationship between maize yields and critical rainfall, as critical rainfall increases, maize yields increase. The Durbin - Watson (D.W) statistic of 1.86 shows no signs of serial correlation.

Table 16 presents regression results showing Small Scale maize yields as being dependent on critical rainfall and time trend for the time period 1961 to 1995. The R^2 of 0.31 shows that the independent variables explain 30 percent of the variation in maize yields in the Small Scale farming sector. All variables carry the right signs, and both critical rainfall and time trend have T statistics of 2.81 and 2.65 respectively, showing significance at the 0.5 percent significance level. A D.W statistic of 1.73 shows negative serial correlation. Given the variables specified in the above OLS regression equations, results support the hypothesis that rainfall is a significant determinant of maize yield variation in both the Commercial and Small Scale farming sectors. The time trend variable is only significant in

Table 13: Contribution of Time Trend and Seasonal Rainfall to Commercial Maize Yields in Zimbabwe, Dependent Variable (Maize Yields) (1961-1995)

Independent/ Variable	Coefficient	Standard Error	T. Ratio
Constant	-41672	0.3742E+05	-1.11
Time Trend	21.469	18.77	1.14
Seasonal Rain	4.343	0.68	6.44*

Note: * Significant at 0.5 percent level
R.Squared = 0.66
D.W. Statistic = 1.9

Table 14: Contribution of Time Trend and Seasonal Rainfall to Small Scale Maize Yields in Zimbabwe, Dependent Variable (Maize Yields) (1961-1995)

Independent/ Variable	Coefficient	Standard Error	T. Ratio
Constant	-60289	0.1784E+05	-3.38
Time Trend	30.36	8.955	3.39
Seasonal Rain	1.28	0.304	4.21*

Note: * Significant at 0.5 percent level
R.Squared = 0.50
D.W. Statistic = 1.74

Table 15: Contribution of Time Trend and Critical Rainfall to Commercial Maize Yields in Zimbabwe, Dependent Variable (Maize Yields) (1961-1995)

Independent/ Variable	Coefficient	Standard Error	T. Ratio
Constant	-61226	0.5860E+05	-1.05
Time Trend	31.768	29.41	1.08
Critical Rain	3.834	1.010	3.80*

Note: * Significant at 0.5 percent level
R.Squared = 0.40
D.W. Statistic = 1.86

Table 16: Contribution of Time Trend and Critical Rainfall to Small Scale Maize Yields in Zimbabwe, Dependent Variable (Maize Yields) (1961-1995)

Independent/ Variable	Coefficient	Standard Error	T. Ratio
Constant	-64089	0.2433E+05	-2.63
Time Trend	32.408	12.22	2.65
Critical Rain	1.117	0.398	2.81*

Note: * Significant at 0.5 percent level
R.Squared = 0.31
D.W. Statistic = 1.73

the Small Scale farming sector. This suggests that there has been more technical and institutional changes in the Small Scale farming sector.

3. 5 Production Trends and Maize Availability Problems

To understand the maize availability problem, it is necessary to develop analytical methods to characterize the history of maize production, simulate future maize production with respect to the multiple objectives. Curve fitting and statistical analysis to characterize three aspects of past production data are used.

a) How the expected volume of production has changed over time

b) The variability of production around the expected volume

c) Any effects of surplus or shortages in one year upon production in another year.

This method assumes that there exists a pattern in an historical maize production series. It further presupposes that physical (climate, land, fertilizer, etc) and institutional (prices, government policies, technology etc) factors which may determine the production volumes are implicit in the historical data series.

There is need to determine the nature, frequency and magnitude of maize actually available in Zimbabwe for human consumption. Measures that will reduce production shortfalls given crisis conditions are required to maintain maize availablity. Availability is defined as: production - exports +imports - (waste + feed use + seed use) + change in domestic stocks. Availability [C] is an aggregate concept of food consumption, sometimes called "apparent consumption" or "disappearance" as opposed to a measure taken directly from the observation of consumption itself. Food security can be analyzed by assuming that the relative residual u of availability follows normal distribution $N(0,\delta_u)$ one can compute the probability that availability will fall below a minimum level C_m thus;

$$\text{Prob}\ (C < C_m).$$

When there is a definite trend in the series, the probability that availabilty falls below a certain percentage α to the trend value is calculated as:

$$Prob\ (\ C < \alpha\ \hat{C}\ )$$

More specifically, these indicators are calculated as follows:

$$Prob(C < C_m) = Prob\left(\frac{C - \bar{C}}{\sigma(C)} < -\frac{\bar{C} - C_m}{\sigma(C)}\right) = 1 - F_{(\bar{C} - C_m)/\sigma(C)}$$

$$Prob(C<\alpha\hat{C}) = Prob\left(\hat{u}=\frac{C-\hat{C}}{\hat{C}} < -(1-\alpha)\right) = Prob\left(\frac{\hat{u}}{I(C)} < -\frac{1-\alpha}{I(C)}\right) = 1-F_{(1-\alpha)/I(C)}$$

Where $\alpha(C)$ is the standard deviation of C, $I(C) = \sigma_u$ the index of variability of C, and F the cumulative normal distribution.

3.5.1 Trends and Fluctuations in Maize Production

The production perfomance is analyzed in terms of trend and fluctuations using maize production [Y] data for the peroid 1961 to 1995. The trend of a series Y is measured by the estimated average growth rate during the period which is given by the slope of the regression of Y on time t.

$$Y = a + mt.$$

The fluctuation of a series is measured by the coefficient of variation around the trend. This is the standard deviation of the relative deviations around the trend. To complete the analysis on production, the probability of production falling below or above the trend line can be computed, as in item (c).

3.5.2 Variance in Maize Production

Analysis of the variation in maize production is necessary for the purposes of determining the magnitude of the maize availability problem. Variation in maize production will affect both producer and consumer prices, thus resulting in high maize prices and food shortages. These in turn affect the year to year availabilty of maize to consumers and instability in producer prices and their incomes. High variance in maize production has adverse implications on food security.

The variation of maize production can be evaluated by various methods. The method used in this study is the coefficient of variation. The coefficient of variation is used in this study because it is easy to compute and understand. It is defined as the standard deviation divided by the mean multiplied by 100. In equation form it is written as:

$$CV = \frac{S}{\bar{X}}$$

Where: CV = Coefficient of Variation

S = Standard Deviation

$\bar{X}$ = Mean

3.6 Production Variability

Estimates on maize production probabilities using historical production data from 1961 to 1995, were performed using the probability methodology above. Table 17 shows the results of the probability at which production has fallen below 95 percent of the trend line, over the past 16 year period examined. Production has fallen below 95 percent of the trend value six times. The probability of production falling below 95 percent of the trend value is 38 percent, this implies that one should expect production to fall below 95 percent of the trend in about six years out of sixteen.

High maize production variability often translates into problems of food insecurity, thus creating instability in producers incomes and consumer prices. The variation in maize production is measured by the coefficient of variation as indicated in the methodology section. Results showing variation in maize production around the trend line are presented in Tables 18. The greatest maize production variability has occured during the 1980 to 95 period followed by the 1961 to 1995 period, the lowest production variability around the mean occured during the 1961 to 1979 period. An analysis of maize production variability for both Zimbabwe and South Africa was performed. The two countries have similar patterns in production variability, with South Africa showing a slight decrease in variability for the 1985 to 1995 period (see Table 19). Measured by the coefficient of variation, results show that there has been a remarkable increase in the variability of maize production in the past ten years. A comparison of Zimbabwe and South Africa's maize production variability was made because South Africa is a major supplier of white maize in the SADC region.

3.7 Trends in Maize Availability, Consumption, Domestic Stocks, Imports and Exports

Appendix Figures 16 and 17 at the end of this Chapter show both nominal and per capita trends in maize availability in Zimbabwe for the time period 1980 to 1995. Maize availability is shown to have a slight downward trend. Measuring the probability that availability falls below 95 percent of the trend line, results show that maize availability has fallen below 95 percent of trend 38 percent, during the examined period. This has occured 6 times out of the 16 year period. The highest percentages occurring in 1983, 1.5 percent and 1992, 1.2 percent.

3.7.1 Production - Consumption Gap

Measured in per capita terms, the production - consumption gap is shown to have widened during the 1989 to 1995 period, thus consumption requirements are above actual production in this period. Measured by the difference between estimated maize availability trend line and consumption needs trend line, results show that the gap has widened during the 1990 to 1995 period (see Figure 18). In all results indicate an emerging widening of the production - consumption gap, with consumption trends rising above maize availability trends. Per capita maize production is shown to be on the decline. Appendix Figure 11 and 13 in Chapter 2. While per capita maize consumption is shown not to vary a great deal from year to year (see Figure 1, Chapter 1). There is though, a marked upward trend in maize consumption for the period 1961 to 1995. Since the 1961 to 1995 period per capita maize consumption has gone from a low of 99 killograms per capita in 1975 to a peak of 135 killograms per capita in 1980, thus a 27 percent increase in consumption. Since 1980 maize consumption has declined to a low of 112 killograms per capita in 1991, thus a 17 percent

Table 17 : Estimates on Production Trends and 95 Percent Production Below Predicted Trend, for the Period (1980-1995).

Year	Estimated Production Trend 1000 MT	Production 5% Below Estimated Trend 1000 MT	Actual Production 1000 MT	Actual Production Fall Below 95 Percent Trend Line 1000 MT	Per Capita Consumption Kg/Year
1980	1545.00	1472.27	1488.00	15.73	135
1981	1573.00	1494.45	2717.00	1222.55	130
1982	1596.00	1516.63	1716.00	199.37	132
1983*	1619.80	1538.81	861.00	-677.8*	121
1984*	1643.14	1560.99	1487.00	-73.99*	121
1985	1666.49	1583.17	2638.00	1054.83	119
1986	1689.84	1605.35	2486.00	880.65	121
1987*	1713.19	1627.53	1098.00	-529.53*	113
1988	1736.53	1649.71	2193.00	543.29	114
1989	1759.88	1671.89	1931.00	259.11	116
1990	1783.23	1694.07	1994.00	299.93	114
1991*	1806.58	1716.25	1586.00	-130.25*	112
1992*	1829.92	1738.43	361.00	-1377.43*	118
1993	1853.27	1760.61	2012.00	251.39	126
1994	1876.62	1782.79	2326.00	543.21	122
1995*	1899.96	1804.97	839.60	-965.37*	121

NB: * Probability that actual production falls below 95 percent of the trend line

Table 18: Coefficient of Variation Around the Trend Line, Maize Production Variability in Zimbabwe.

Year Period	Coefficient of Variation Around Trend (Percent)
1961 - 1995	34.8
1961 - 1979	26.5
1980 - 1995	38.2

Table 19: Coefficient of Variation around Mean, Maize Production in Zimbabwe and South Africa.

Year Period	Coefficient of Variance	
	Zimbabwe	South Africa
1961 - 1970	29.4	26.2
1971 - 1980	24.5	22.3
1981 - 1995	41.0	40.2

decline in consumption. During the 1961 to 1995 period on-farm consumption measured by the difference between production and supplies to the GMB has been on the negative side 38 percent, thus this has happened about 6 times out of the 35 year period . These results raise concern to the maize availability problem.

3.7.2 Trends in Maize Domestic Stocks

Since 1980 maize stocks held by the Grain Marketing Board reached a high of 1.8 million metric tonnes in 1988 and a low of 65,000 tonnes in 1993 (see Figure 19). The overall average level of maize stocks held by the G.M.B was 70 percent higher during the late 1980s than in the early 1980s. Two major reasons can be cited for this; first, the carry-over stock rule followed bt the G.M.B. management which aims to carry over one years supply for the domestic market; and second, the difficulty experienced in disposing of stocks held in excess of this carry over. The G.M.B. follows a rule of holding one full years supply of 750,000 to 800,000 metric tonnes of maize as resserve stocks and does not have a reserve stock policy in place. The current practice of G.M.B. management is precautionary rather than statutory. By any standards this constitutes a large reserve for maize availability, greater than that required in respect of import lead. There is need to clarify the actual intended reserve stock to be held by the G.M.B as a policy mandate and to relate this to the incremental cost of reserve stocksholding.

3.7.3 Trends in Maize Imports

Zimbabwe is mostly self-sufficient in maize production and meets its internal maize demand most of the time. The only time Zimbabwe has imported maize, are years when Zimbabwe experienced drought. Since 1970 Zimbabwe has made maize imports only 8 times in the 26 year period, thus about 31 percent of the time (Appendix, Figure 19). The highest import levels were realized in 1992 where 1.2 million metric tonnes of maize were imported in the country, this was during the worst drought ever in Zimbabwe. Given that Zimbabwe is landlocked there exist import logistic problems in terms of transportation and imports timing.

3.7.4 Trends in Maize Exports

In the past, Zimbabwe's ability to export white maize has been an important means of stabilizing the maize market, enabling government to elicit high levels of supplies from domestic producers while having an outlet for the excess of deliveries over local sales. Since 1960 Zimbabwe has exported maize in all the years except in 1984 and only 26,000 metric tonnes in 1992 when 1.2 million metric tonnes were imported. Zimbabwe's export market in recent years has been dominated by international aid donors which now purchase 97 to 98 percent of Zimbabwe's total exports, principally for the Southern African region. In 1988/89 donors bought 269,000 metric tonnes of Zimbabwe Maize (FAO, 1995). The average price realized by the Board from these exports has been lower than the domestic price realized every year during the 1980s except for 1988/89 period when the export price rose sharply, from $181.37 to $329.72. With prevailing levels of world prices, internal producer prices and the present level of marketing costs, it is not possible for Zimbabwe to export to the world market except at a loss.

3.8 Extent and Magnitude of Maize Availability and Consumption Needs Problem

The extent and magnitude of the maize availability problem in Zimbabwe can be measured in terms of maize production, maize availability and consumption needs. The difference between minimum consumption needs and actual maize availability, form the basis of analyzing the extent of the problem.The probability of the problem is analyzed in terms of how often does actual maize availability and minimum consumption needs deviate from the estimated trend lines.

Using the historical maize production data for the period 1961 to 1995, results in Table 20 show that actual maize availability fell short of the required consumption needs 10 times, thus about 29 percent of the time in the 35 year period. The wost shortfalls were experienced in 1983, 1992, 1973 and 1979 (Table 20). To evaluate the extent of the maize availability problem trend estimates on both maize availability and consumption needs were performed (Appendix, Figures 20 and 21). Results show that consumption needs trend line and the maize availability trend line are getting much closer to each other from 1990 to the present (Appendix, Figure 20).

The extent of the maize availability problem has been getting worse since 1980, maize consumption needs are increasing more than the maize available for human consumption. To assess the probability of how often the quantities of maize available for human consumption and consumption needs fall below the estimated trend lines, calculations on probabilities of falling below the availability trend line and the consumption needs trend line were performed (Table 20). In the 35 year period , results show that maize availability fell 14 times below the trend line, thus about 40 percent of the time. The worst declines from the trend line happened in 1983, 1992, 1987, and 1979, with amounts of 1,812,000, 1,608,000, 1,355,000 and 1,216,000 metric tonnes respectively.

Calculations on the percentages, for how far actual maize availabilty was below the maize availabilty trend line were performed (Table 21). The most serious shortfalls from the availability trend line were a 150 percent decline in maize availabilty in 1983, followed by a 120 percent decline in 1992 (Table 20). An average of five yearly percentages was estimated to evaluate the magnitude of maize availabilty being below the trend line and above the 5 months consumption needs trend line for the 35 year period. In the last ten years, results show that maize availabilty has gone from a low of 10 percent to a high of 30 percent below the trend line and above the 5 months consumption needs trend line. An average of five yearly percentages on how far maize availability has fallen below the five months consumption needs trend line were performed (Table 20). The most serious shortfalls from the five months consumption trend line were a 50 percent decline in maize availabilty in 1981, followed by a 30 percent decline in 1991 (Table 20). The rational for estimating the percentages of maize availabilty below the availabilty trend line and above the 5 months consumption needs trend line is to estimate the probability of activating stocks or moving stocks from storage to fullfill maize consumption needs. If maize availabilty is below the 5 months consumption needs trend line the option is to activate imports from the rest of the world.

Given that it takes five months to import maize from the rest of the world, a five months maize reserve buffer stock is suggested as one of the logistics strategies. This study will use five months maize reserves as a buffer to allow for maize importation. An estimation of five months maize consumption needs was performed (Appendix, Figure 21). With the five months maize consumption reserves rule, results show that maize availability would have been below the five months requirements 6 times out of the 35 year period, thus about 17 percent of the time (Appendix, Figure 21). The wost case scenarios would have been in 1983 and 1992 a shortfall of 977,700 metric tonnes and 744, 300 metric tonnes respectively. Consumption needs would have fallen below the five months consumption reserves only four times out of the 35 year period (Appendix, Figure 21), thus about 12 percent of the time.

The above information gives the bases for formulating strategies or options to closing the gap between maize production and or maize available for human consumption and consumption needs. Given the extent and magnitude of maize availabilty and maize consumption needs, alternative strategies to closing the gap between maize availability and consumption needs will be evaluated to achieve the Food Security objective. A cost analysis methodology will be applied to different strategies outline in chapter 4.

Table 20: Summary on Maize Availability and Consumption Needs Shortfall Probabilities

Year	Opening Stocks (1000 MT)	Difference Between Maize Availability and Consumption Needs (1000 MT)	Percent of Maize Availability Below Availability Trend Line and above the 5 months consumption Needs	A Ten Year Average Percentage of Maize Availabilty Below Availability Trend Line and 5 months Consumption Needs Trend Line	Percent of Maize Availability Below the 5 Months Consumption Needs Trend Line	A Ten Year Average Percentage of Maize Availabilty Below the 5 Months Consumption Needs Trend Line
1961	na	331	0.0		0.0	
1962	na	243	0.2		0.0	
1963	na	72	0.3		0.0	
1964	na	77	0.5		0.0	
1965	na	25	0.4	0.3	0.0	0.1
1966	na	89	0.3		0.0	
1967	na	540	0.0		0.0	
1968	na	43	0.7		0.0	
1969	na	530	0.0		0.0	
1970	na	18	0.6		0.0	
1971	na	480	0.0		0.0	
1972	na	841	0.0		0.0	
1973	na	238	0.7		1.6	
1974	na	797	0.0		0.0	
1975	na	534	0.0	0.3	0.0	0.2
1976	na	400	0.0		0.0	
1977	na	263	0.2		0.0	
1978	na	348	0.1		0.0	
1979	na	264	0.7		1.3	
1980	307	144	0.1		0.0	
1981	65	1,259	0.0		0.0	
1982	158	297	0.1		0.0	

						Table 20 Continued
1983	1,201	**502**	0.7		2.6	
1984	1,035	144	0.1		0.0	
1985	123	**842**	0.0	0.3	0.0	0.3
1986	462	775	0.0		0.0	
1987	1,426	**351**	0.7		1.2	
1988	1,806	581	0.0		0.0	
1989	755	386	0.0		0.0	
1990	940	**448**	0.0		0.0	
1991	1,154	**25**	0.5		0.0	
1992	643	**1,361**	0.6		1.5	
1993	65	310	0.0		0.0	
1994	267	600	0.0		0.0	
1995	886	**915**	0.6	0.3	0.1	0.2

* Bold Numbers in Column 3, Indicate a Shortfall in Maize Available for Human Consumption

APPENDIX

FIGURES 16 to 23

Figure 16: Net Maize Availability
Availability Trend (1980-95)

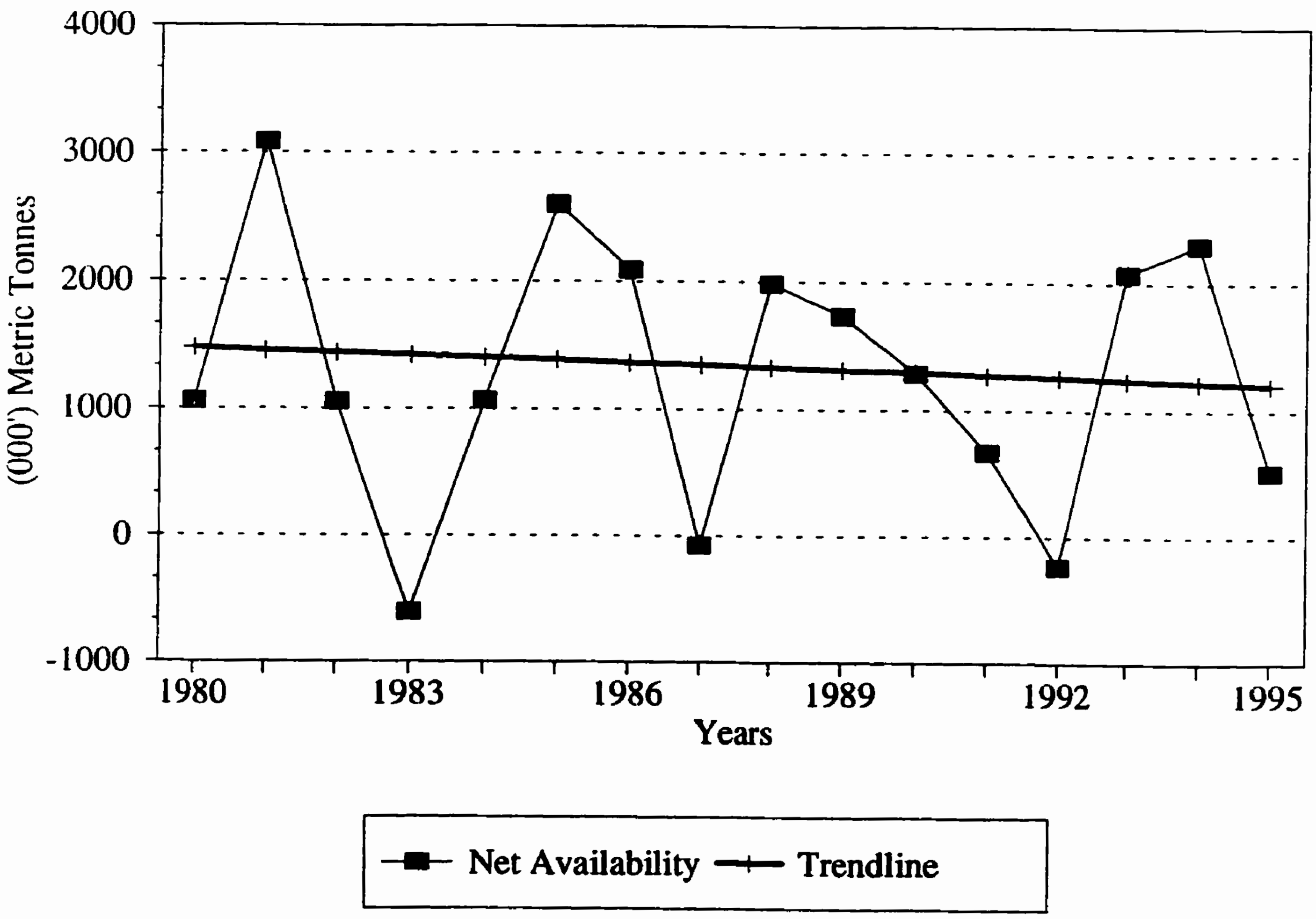


Figure 17: Per Caipta Availability
Maize (1961-95)

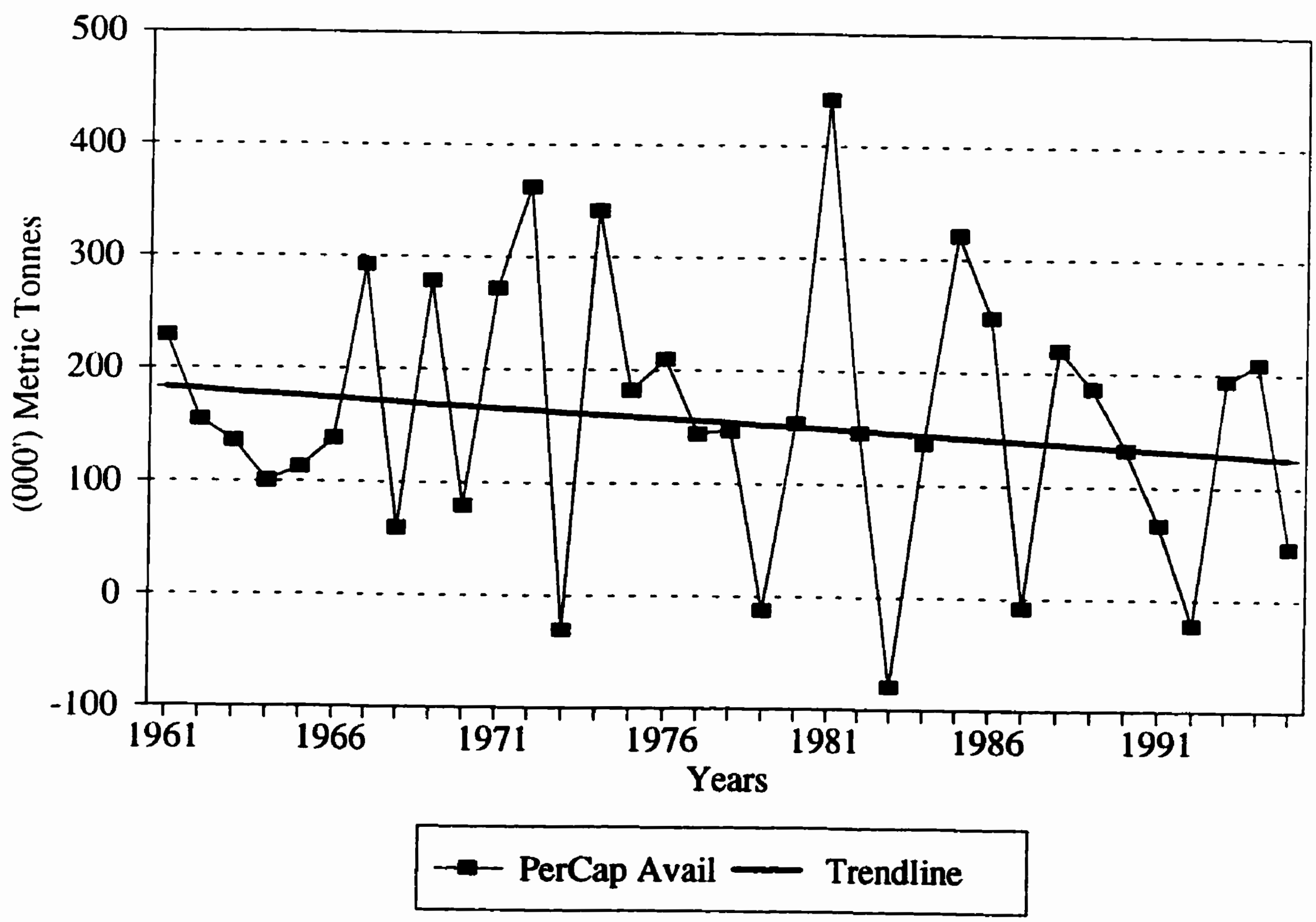


Figure 18: Consumption Needs vs
Maize Availability (1980-95)

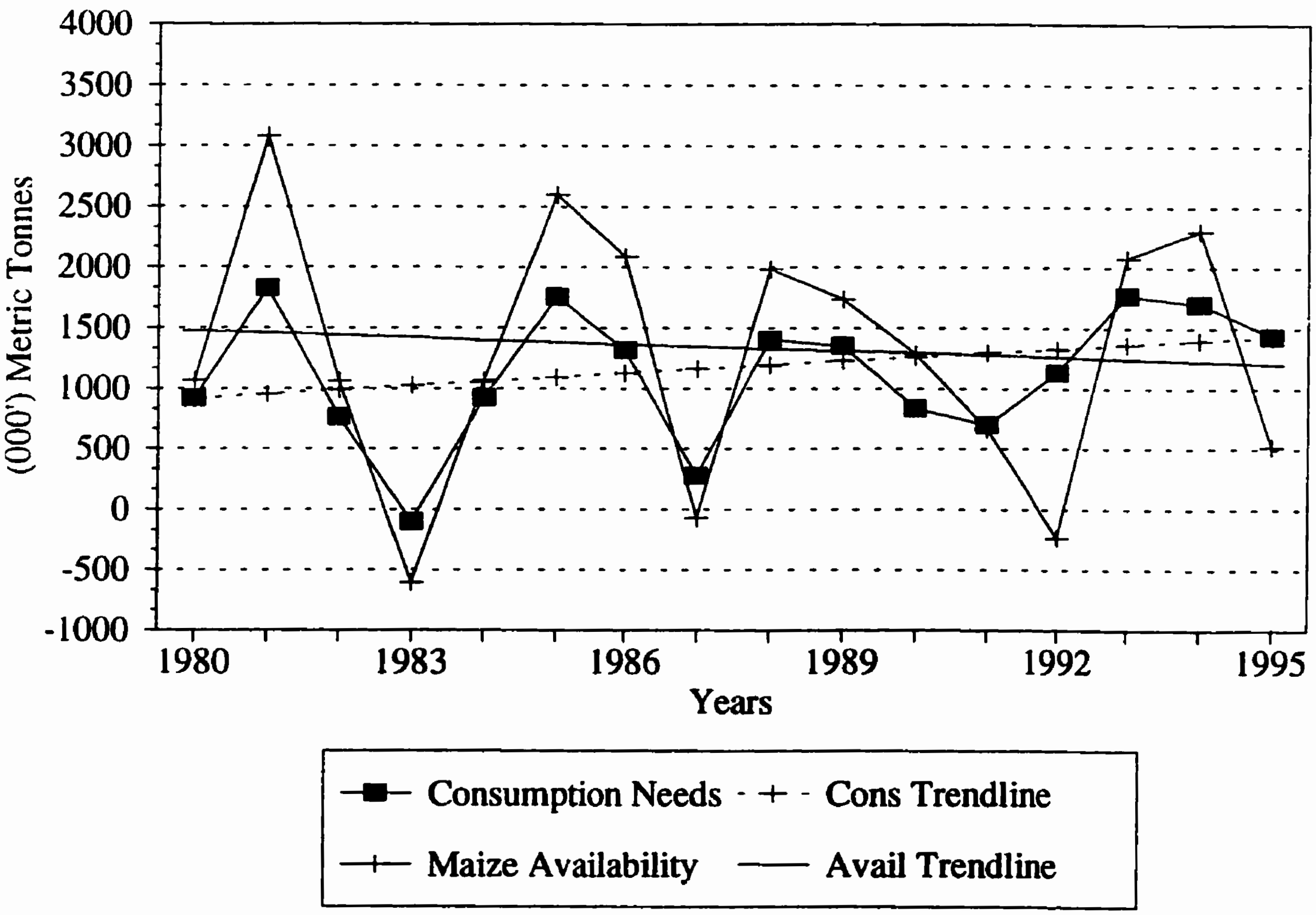


Figure 19:Imports vs Domestic supply
For the Period (1980-95)

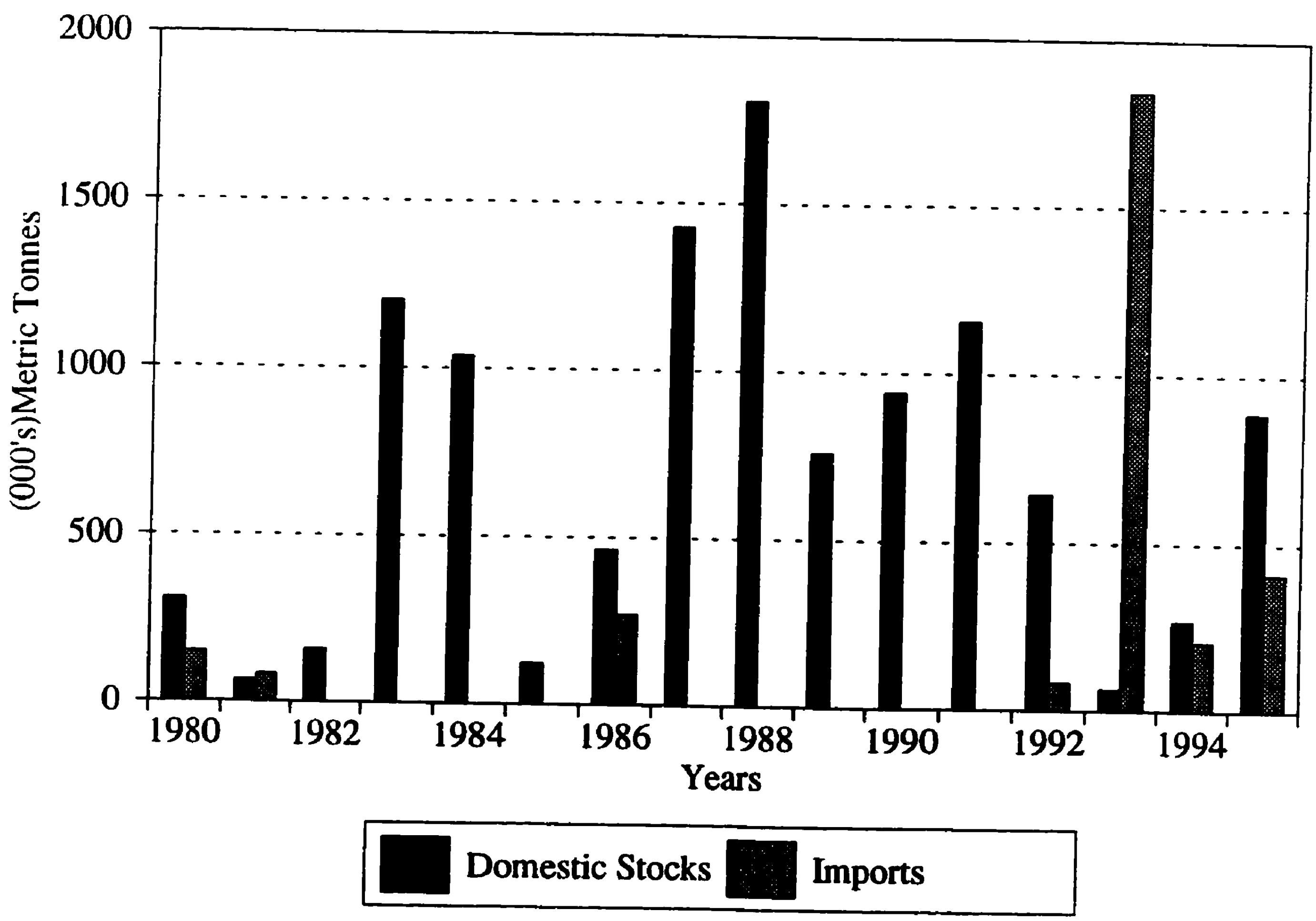


Figure 20: Net Maize Availability vs Consumption Needs (1961-95)

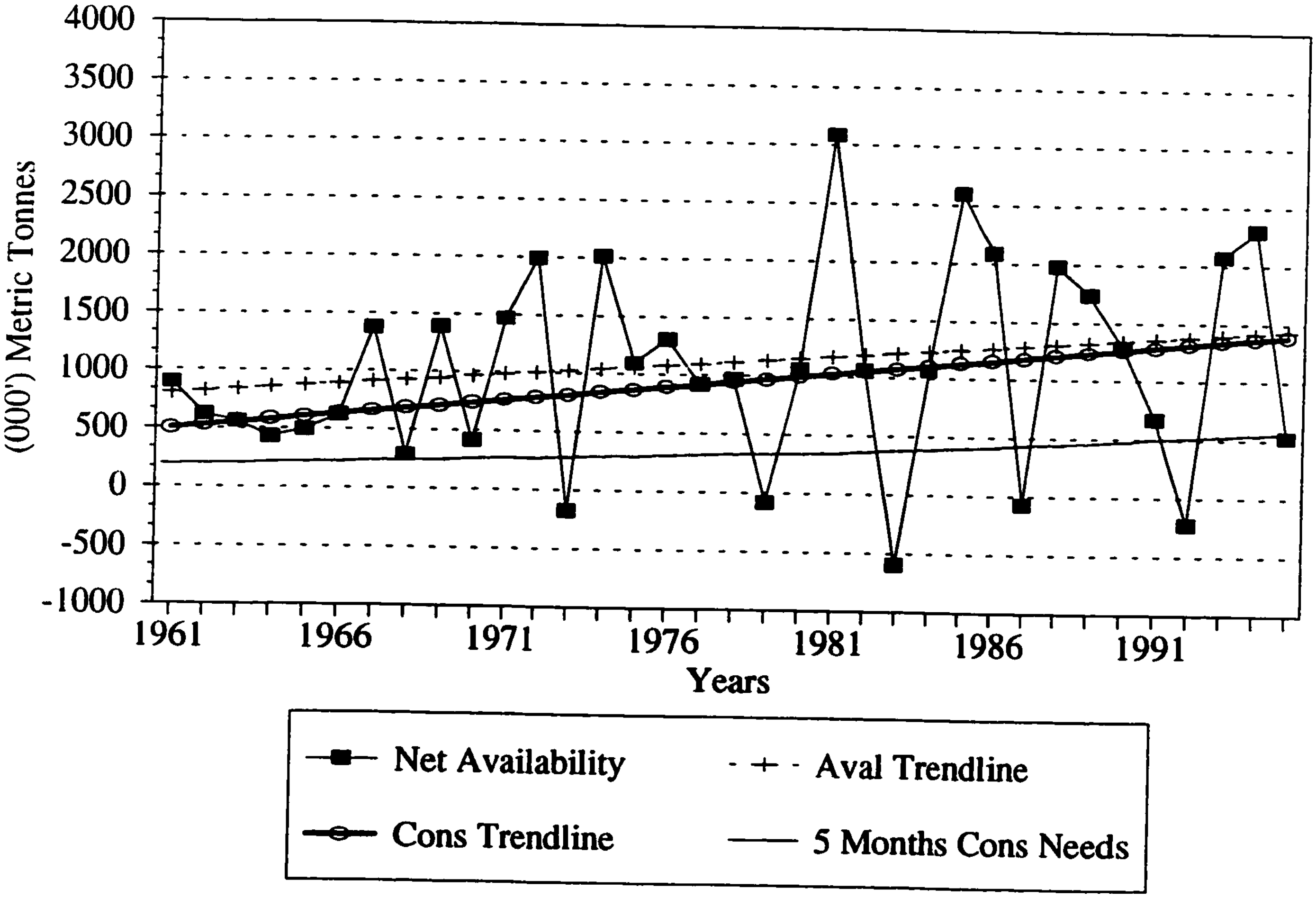


Figure 21: Net Maize Availability, vs
5 Months Consumption Needs (1961-95)

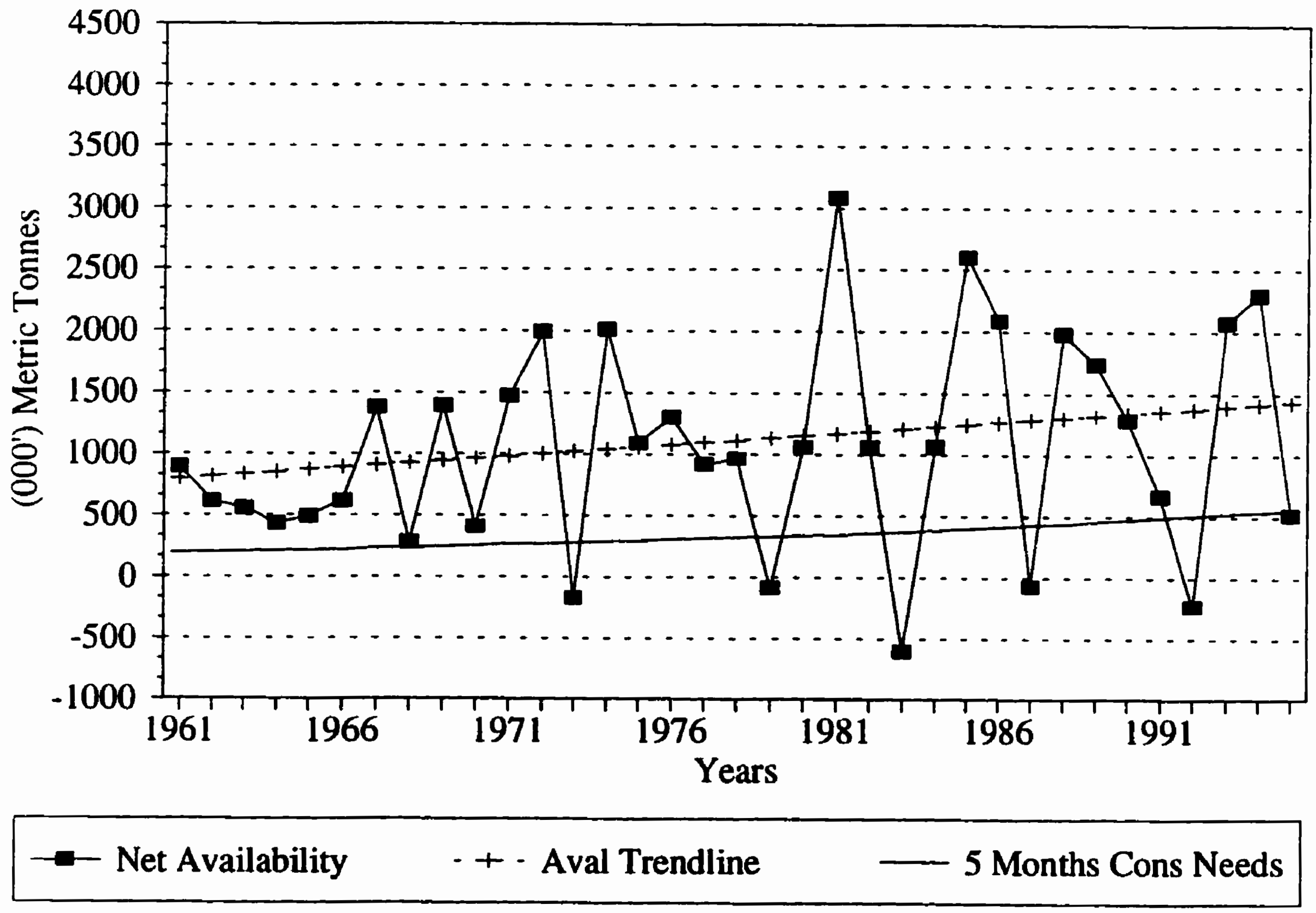


Figure 22: Zimbabwe Critical Rainfall
(1937-1995)

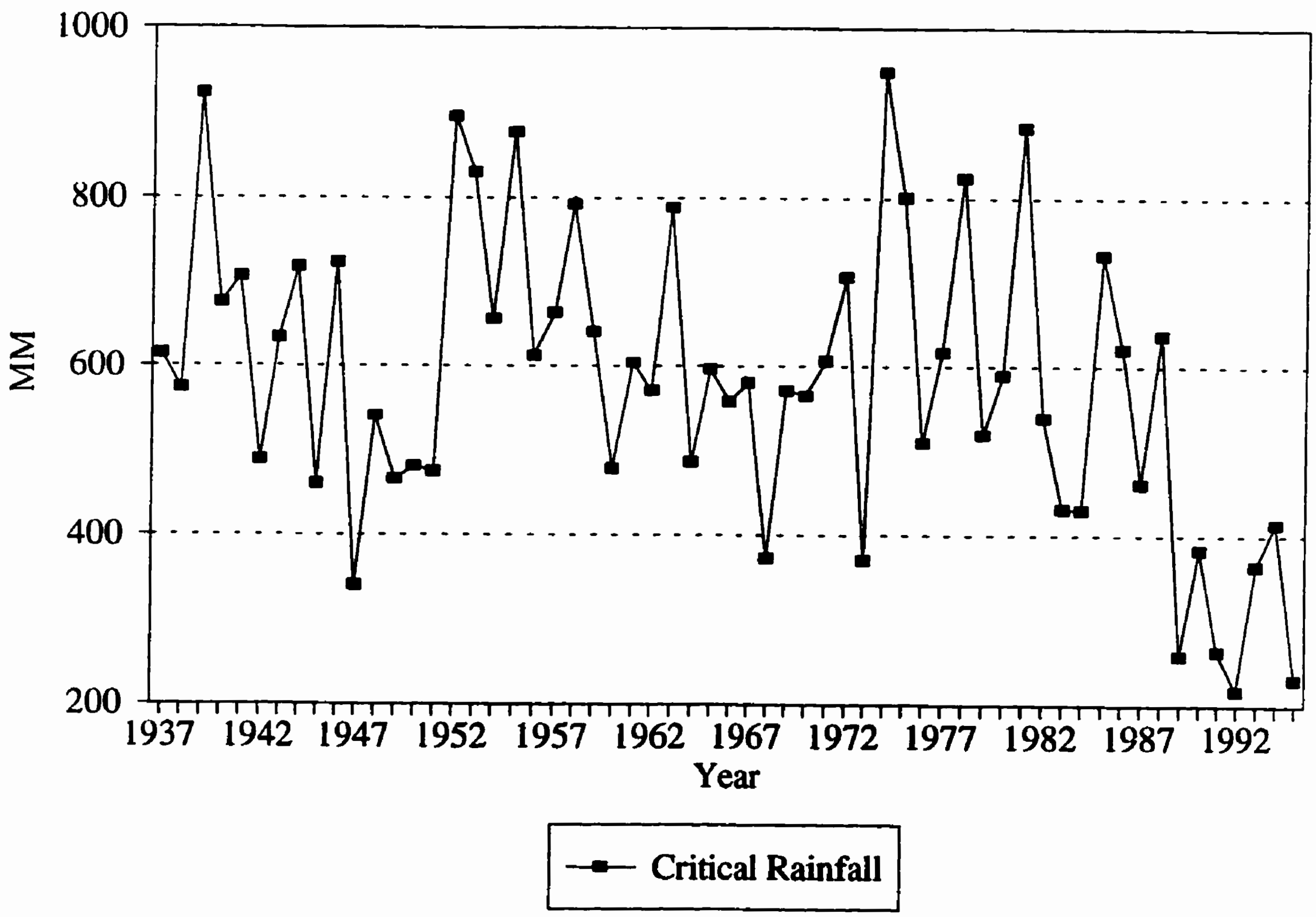
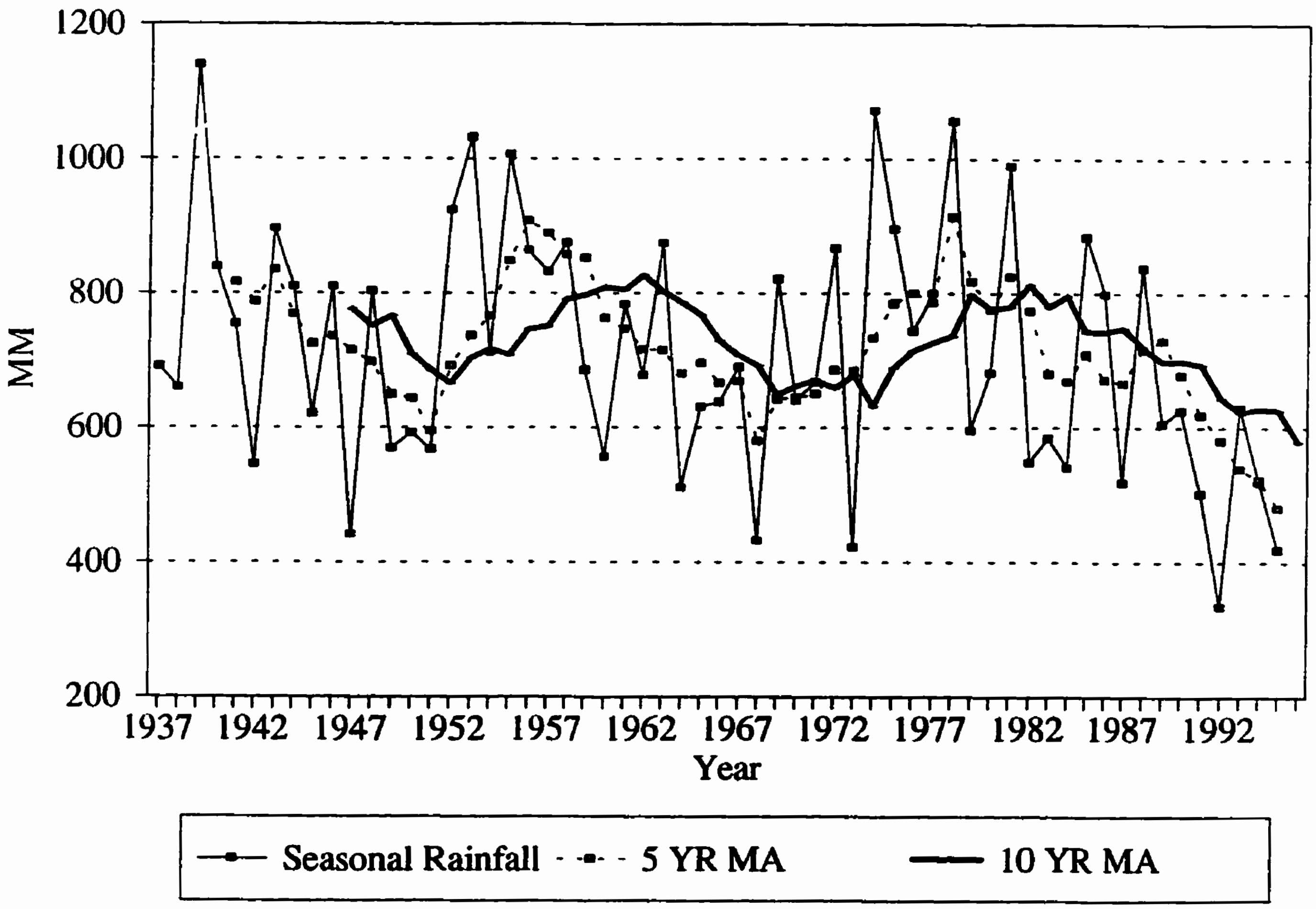


Figure 23: Zimbabwe Seasonal Rainfall
5 and 10 Year Avgs, (1937-95)



CHAPTER 4

ALTERNATIVE STRATEGIES FOR ASSURING STABLE MAIZE SUPPLY

4.1 Introduction

This Chapter outlines the two alternative strategies for assuring stable maize supply for Zimbabwe, thus closing the annual gap between maize availability and consumption needs. A brief discussion of alternative maize availability strategies for Zimbabwe is presented. Finally, a discussion on data requirements, assumptions and approach of the study are presented.

4.2 Theory on Variables Necessary for Evaluating Alternative Strategies

With the drop in per capita maize production, a slight increase in maize consumption and the reoccurences of drought in recent years, there is need to assure the Zimbabwean population adequate supplies of maize at all times. At the country or regional level, food security can be monitored in terms of indicators such as: production, availability, trade (thus imports and exports), and food aid. An interaction of these five economic variables is necessary in terms of formulating options for maize availability to successfully manage the maize availability crisis. Variables necessary for alternative strategies to stablize maize availability are: domestic production, domestic stocks, trade (thus imports and exports), domestic food availability and food aid. The term production is used to characterize domestic production which is a function of own price, prices of competing crops, weather, input prices and technical change. The concept of stocks is used to characterize domestic stocks which are a function of: storage costs, storage capacity, past inventory, waste or losses, domestic and export sales. Maize availability is used to characterize food security. Availability is an aggregate concept of final consumption or disappearance, as opposed to a measure taken directly from observation of consumption itself. Maize availability is defined as follows: Net Maize Availablity = Production - Exports + imports - (Feed use + Waste + Seed Use) + Change in Stocks. Trade is used to characterize imports and exports. Imports are a function of: exchange rates. world grain prices, availability of foreign currency, import costs and source of supply. The term food aid is used to characterize maize donated by other countries to supplement domestic maize shortages.

a) Production

Production is a major economic element of the problem. In theory production is defined as: Quantity Produced = f (Own Price, Price of Competing Crops, Input Prices, Weather, and Technology). To stimulate production there are a number of policy options necessary to implement. In theory, the first policy option is to use price policy as an instrument for increasing production. Second is a policy that increases area under irrigation to supplement shortfalls in production. Use of reliable crop forecasting methods which include the weather variable will be necessary. Other economic policy variables necessary to increase production are the use of subsidized inputs, and use of alternative crops as substitutes to the staple food. This study does not address the economic effects of these variables on domestic production. Actual levels of production are used to evaluate maize availability in the country.

b) Domestic Maize Stocks

Domestic maize stocks can be used to manage the maize availability crisis. Domestic stocks can be used as a buffer to supplement maize shortages in times of production shortfalls. A storage policy that requires strategic reserves is necessary to assure stable maize supplies. A storage policy led by imports is an option to safeguard maize shortage, thus fullfilling food security objectives. Inventory management is necessary to solve the domestic stocks problem. Other components to stock management are reducing storage waste and the critical location of storage facilities, to allow efficient distribution of maize in times of crisis conditions.

c) Maize Imports

Imports can play a major part in managing maize availability crisis as imports can be used to supplement short falls between production and consumption. In theory imports are a function of exchange rates, import costs, world grain prices and availabilty of foreign currency. A trade policy that requires foreign currency availability is necessary to assure imports in times of maize shortages, (e.g. building foreign currency reserves, as insurance for foreign currency to import maize in times of need, use of exports to generate foreign currency reserves for imports). The logistics for acquiring imports is a necessary condition for minimizing the costs of importing the required amounts of maize when they are needed.

d) Maize Availability and Consumption Needs

Maize availability and consumption needs are the central economic variables necessary to manage food security crisis. Policy instruments required to assure maize availability to meet the required consumption needs are imports versus storing domestic stocks. Benefits and costs analysis is used for evaluating the importance of food consumption between humans and livestock. Policies designed to increase maize production can serve to assure maize availability. Perfect maize availability is achieved when maize used in every year is less than or equal to the expected volume of maize production .

4.3 Proposed Alternative Strategies for Achieving Maize Availability

This study examines the following alternative strategies to assure the stability in maize availability requirements for Zimbabwe's food security. The first strategy is to maintain strategic maize stores equivalent to 12 months consumption requirements, which is the current practice. The second strategy is to maintain strategic maize stores equivalent to 5 months consumption requirements plus hard currency equivalent to importing 7 months consumption requirements. The country is assumed to import required maize from South Africa provided shortfall is made of the 5 months consumption limit.

The first strategy assumes that the country has enough storage capacity to maintain strategic reserves equivalent to 12 months consumption, thus 1,227,410 metric tonnes. The logistics of where to locate and store these reserves are evaluated as follows:

- evaluation of location for current storage depots (Surplus and Deficit Regions);
- evaluation of maize storage depots close to port of entry for imports;
- evaluation of consumption requirements for each Region;
- evaluation of storage capacity constraints in each Region;
- evaluation of quantities of maize shipped from surplus Regions to deficit Regions; and
- evaluation of maize stored in each Natural Region (Surplus and Deficit).

To evaluate the cost of maintaining 12 months strategic reserves, the following cost are included in the analysis:

- storage, handling plus capital and interest costs;
- internal transportation costs;
- import costs from South Africa or the rest of the World;
- opportunity cost of maize sales foregone; and
- waste in storage costs.

The second strategy estimates that it takes 5 months to import maize into the country from the rest of the world (G.M.B Annual Report, 1995). Therefore, the country must maintain strategic reserves equivalent to 5 months consumption requirements plus hard currency equivalent to import 7 months consumption requirements from the rest of the world. This strategy assumes that the country holds adequate hard currency available for imports. The estimated 5 months consumption requirements is about 500,000 to 600,000 metric tonnes. The logistic of where the 5 months maize strategic reserves should be located and importation of maize to critical consumption points is evaluated as follows:

- evaluation of surplus and deficit consumption Regions;
- evaluation of storage capacity constraints in each Region;
- distribution of maize to stores should be based on critical deficit Regions and available storage capacity in each Region; and
- evaluation of quantities of maize to be shipped to stores closer to import routes.

To evaluate the cost of maintaining 5 months strategic reserves plus hard curreny equivalent to 7 months import requirements, the following costs are included in the analysis;

- storage, handling and capital loan interest costs;
- internal transportation costs - producer to storage and storage to consumption points;

- storage losses - estimates from waste;
- value of maize stored - thus opportunity cost of maize sales foregone;
- import costs of maize from the rest of the world; and
- opportunity cost for 5 months consumption requirements plus hard currency for 7 months consumption requirements.

After evaluating the costs related to each of the strategies, the least cost option assuring stable maize availabilty in Zimbabwe is recommended for policy purposes.

In times of severe maize shortages (e.g., drought years), when maize availabilty is below the 5 months consumption level, an alternative strategy is to use the maize availabilty equation defined as: Net Maize Availabilty = Production - (Feed Use + Waste + Seed Use) + Change in Stocks. Given that mean production, feed use and waste are known, net maize availability can be increased by reducing feed use or waste. Sensitivity analysis using this equation can result in different options for increasing maize availabilty.

4.4 Justifying Rationale for Selection of the Stated Alternative Strategies

This study examines two alternative strategic options necessary for achieving maize availability of the food security problem. The main alternative strategic options are defined as follows:

a) Strategic option A, in a given year the country maintains strategic reserves equivalent to 12 months consumption requirements;

b) Strategic option B, in a given the country maintains strategic reserves equivalent to 5 months consumption requirements plus hard currency equivalent to importing the necessary consumption reuirements until the next harvest.

Within the main strategic options A and B, there are three alternative scenarios attached to each of these options. The alternative scenario options to be examined are defined as follows:

a) Scenario A1, the country maintains strategic reserves equivalent to 12 months consumption requirements, given the condition that the country has maize production shortfalls (e.g. the worst drought in the 1991/92 season)

b) Scenario A2, the country maintains strategic reserves equivalent to 12 months consumption requirements, given that the country has maize availabilty below the trend line but above the 5 months consumption requirements.

c) Scenario A3, the country maintains strategic reserves equivalent to 12 months consumption requirements, given that the country is self-sufficient in maize production.

d) Scenario B1, the country maintains strategic reserves equivalent to 5 months consumption requirements plus hard currency to import the necessary consumption requirements until the next harvest, given the condition that the country has maize production shortfalls (e.g. the worst drought in the 1991/92 season)

e) Scenario B2, the country maintains strategic reserves equivalent to 5 months consumption requirements plus hard currency to import the necessary consumption requirements until the next harvest, given the condition that the country has maize availabilty below the trend line but above the 5 months consumption requirements.

f) Scenario B3, the country maintains strategic reserves equivalent to 5 months consumption requirements given the condition that the country is self-sufficient in maize production.

The rationale for selecting strategic option A is based on the current domestic stock reserve policy, were the country is required to maintain maize stocks equivalent to a years consumption requirements. In Zimbabwe maize is only produced once a year, from November to March, therefore the need to maintain maize stocks equivalent to a years consumption requirements. The rationale for selecting option B is based on the assumption that, maintaining 5 months consumption requirements is less costly than maintaining 12 months consumption requirements in storage. The World Bank study on buffer reserve implications study (Walker, 1989) have indicated that the 12 months reserve policy is a costly practice. The study used a simulation model on tradeoffs between reserve size and the estimated reliability for targeting food security. The study included a multi objective linear program to optimally size the grain reserve. A second World Bank study reviewed in the (The Herald, 1994) arrived at a similar conclusion. As a result, we define an alternative option B, which does not rely on 12 months consumption of maize in storage as the means to assured net availability of maize. Grain Marketing Board Logistics Report published in 1993, after the 1992 drought, reported that it took at least five months to mobilize adequate maize imports into the country. Given that it takes 5 months to mobilize imports in the worst case scenario, this study suggests the country should maintain strategic reserves equivalent to 5 months consumption requirements plus hard currency for importing the necessary maize consumption requirements until the next harvest.

Due to data limitations, this study has selected these two alternative strategic options for the purpose of demonstrating a methodology to analyze alternative approaches to achieving food security. There are other strategic options which could be considered as alternatives to achieving maize availability, therefore achieving the objective of food security. These alternative strategic options are as follows: a) the country could look at increasing maize production, through manipulation of production explanatory variables, such as producer prices, input prices, etc; b) maize production could be supplemented with a set of alternative crops suitable for the high risk food deficit populations; c) the need to optimize storage location, size and type is necessary to reduce logistic costs on waste, storage and handling; d) the trade-off between human and livestock maize consumption; e) use of irrigation and more drought resistant crops ; and f) additional variations of the 12 months and 5 months strategic reserve options. The data available at this time does not enable extending the demonstration of a methodology to one or more of these alternative options.

4.5 Proposed Domestic Stock Management Rules and Plans for Achieving Maize Availabilty .

The methodology for achieving maize availability is presented as the quantity rule. A buffer stock management rule based upon quantity is implemented for both strategies. It is the variability in total quantity of maize produced from year to year that generates the need for stocks. In the context of a Zimbabwean buffer stock where the country maintains strategic reserves equivalent to 12 months consumption. The rule is specified as: a) store 12 months consumption requirements according to regional consumption requirements and regional storage capacities; b) in a given year when maize availablity falls below the predicted availabilty trend line based on the past 35 year actual maize availabilty, the country withdraws maize grain from the 12 months stores to make up for the shortfalls in the annual consumption requirements; c) the country imports maize equivalent to the amount of maize grain drawn from storage to maintain the 12 months strategic reserve requirement; and d) the country exports or adds to storage if actual availability in excess of 25 to 30 percent above the predicted maize availability trend line is realized. If harvest is greater than maize availability required, with 12 months stores in place, exports are allowed. The lower quantity bound is established with the assumption that the country has a limited market to purchase white maize and it takes 5 months to import maize into the country. The area of concern is the lower bound below the 5 months consumption trend line.

Under the second option, the country maintains strategic reserves equivalent to 5 months consumption requirements plus hard currency equivalent to importing 7 months consumption requirements: a) store strategic reserves of maize equivalent to 5 months consumption according to silo storage capacity in the country and consumption requirements in deficit Regions: b) if maize availability falls below the 5 months consumption trend line the country withdraws maize grain from stores; and c) the country uses hard currency available to import an amount equivalent to the consumption requirements until the next harvest plus the equivalent of 5 months consumption in storage from the rest of the world. Origins of maize imports for Zimbabwe are United States of America, Argentina, South Africa, Canada, Mexico, and China respectively.

An evaluation of the above alternative strategies to achieve maize availability are analyzed using a quantitatve analysis of measuring costs of each strategy and the cost analysis is presented in Chapter 5. An economic analysis of the variable options provided are analyzed given the available data and economic theory. The analysis is done on a spreadsheet. The analysis will be comparing each of the three scenarios given above plus the addition of the maize availability probabilities calculated in Chapter 3. An evaluation of feasible options to improving maize availability is addressed for policy recommendations.

4.6 Data Requirements and Presentation

The primary source of data utilized in this study is the agriculture data series 1961 to 1995, compiled by the Central Statistical Office and the Meteorological Station in Harare and the Food and Agriculture Organization, FAOSTAT-PC Data Set (Rome, 1995). Other data were compiled by the researcher from different Agricultural Institutes in Zimbabwe.

Historical data on production are evaluated in terms of production trends, established deviations from normal production and variation in production. Data on consumption are used to evaluate consumption needs and establishing the magnitude of the production-consumption gap. Data on domestic production, GMB intake, imports - exports and domestic stocks are utilized to analyze maize availability. Data on population, population growth rate and caloric intake are used to evaluate per capita maize production and consumption, national and regional maize consumption requirements. Data on domestic stocks and storage costs are utilized to analyze reserve stock requirements, benefits and costs of storage and stock management in case of both production shortfalls and surpluses, thus fullfilling the maize availability objective. Data on imports and import costs are used to analyze the benefits and costs of imports virsus domestic stocks. This data can also be used to evaluate import needs in times of production shortfalls. Data on the oportunity cost of maize in storage is derived from the quantities on maize in storage and the maize selling price in the country. Data on both seasonal and critical rainfall are used to determine the frequency and probability of drought in Zimbabwe.

4.7 Assumptions of the Study

The following assumptions are made in this study to simplify the analysis of alternative strategies for achieving maize availability;

a) all theoretical variables known to influence production are implicit in the production estimates;

b) the frequency of drought is assumed to be measurable and predictable over the years;

c) quantities and storage capacities required at consumption points are known;

d) at the national level required maize stocks are known;

e) production and consumption patterns are predictable with manageable error;

f) maize can be traded freely on the international markets;

g) transportation is readily available to move grain from ports or storage to consumption points; and

h) maize waste is assumed to be related to storage waste.

4.8 Summary of Approach

In the preceding chapters we have established that irregular occurance of drought conditions in Zimbabwe creates maize availability declines of sufficient magnitude to cause food insecurity.

As the primary intent of the thesis is demonstrating a methodology, the testing of hypotheses is not central. In the previous chapter it was established that weather is a significant determinant of the variation in maize availabilty from the longer-term production trend line. The benefit-cost analysis will provide the means for comparison whether minimum storage, combined with foreign exchange reserves to cover required maize imports, is an economically efficient strategy to assure adequate food supplies in times of production shortfalls. Option B is hypothesized to be preferred to option A.

CHAPTER 5

EVALUATION OF ALTERNATIVE LOGISTICS STRATEGIES

5.1 Introduction

This chapter presents evaluations on alternative strategies for assuring stable maize supplies in Zimbabwe. A discussion on strategy options and the evaluation methodology is presented. Results from the strategy scenarios analysis are presented. Two alternative strategies are applied to three scenario situations; a) major drought causing large maize availability decline e.g., 1991/92; minor drought where maize availability decline is just above the five months consumption requirements; and c) a normal year where Zimbabwe is a net exporter of maize.

5.2 Strategy Options

The maize availability plan is designed to meet the objective of assuring stable maize supplies, closing the maize availability - consumption gap. The major strategy options designed to meet this objective are outlined as;

a) The country maintains strategic maize reserves equivalent to 12 months consumption requirements.

b) The country maintains strategic reserves equivalent to 5 months maize consumption requirements plus enough hard currency to import 7 months maize consumption requirements.

Option A

In a given year, the country stores maize equivalent to 12 months consumption. In a year in which quantities of maize fall below consumption requirements, shortfall is drawn from 12 months of storage. As maize is withdrawn from strategic stores, the country has to import maize equivalent to the amount of maize withdrawn from stores. The assumption is that, imports originate from South Africa. Where to store the 12 months consumption requirements is determined by the available regional storage capacities and regional consumption requirements. Distribution from yearly maize available from production into regional stores and consumption areas is determined by regional consumption requirements and storage capacities in each region. Imports are distributed to regional 12 months stores or deficit regions.

Costs for evaluating option A are presented as follows:

- storage and handling costs for 12 months consumption;
- transportation costs for internal distribution;
- costs on maize waste;
- opportunity cost for the value of maize in storage and
- import costs for replacing the 12 months consumption requirements in deficit or drought years.

Option B

In a given year, the country stores maize equivalent to 5 months consumption plus hard currency equivalent to importing 7 months consumption requirements. In a year when quantities of maize fall below consumption requirements, shortfall is drawn from 5 months of storage. As maize is withdrawn from strategic stores, the country imports maize equivalent to the amount of maize withdrawn from stores plus the 7 months consumption requirements. The assumption is that, imports originate from the rest of the world. Where to store the 5 months consumption requirements are determined by the location of regional silo storage capacities and regional consumption requirements. Distribution from yearly maize available from production into regional stores and consumption areas is determined by regional consumption requirements and storage capacities in each region. Imports are distributed to regional 5 months stores or deficit regions.

Costs for evaluating option B are presented as follows:

- storage and handling costs for 5 months consumption;
- transportation costs for internal distribution;
- costs on maize waste;
- opportunity cost for the value of hard currency held for 7 months consumption requirements;
- opportunity cost for the value of maize in storage and
- import costs for replacing the 5 months consumption requirements and the importation of the 7 months consumption requirements.

5.3 Basic Data Used for Evaluation of Alternative Scenarios

Data on production, maize availability, consumption requirements, storage capacities, storage, handling costs and interest on capital, internal transportation costs, import costs, opportunity costs and costs on maize waste for the 1991/92 season were used to evaluate alternative scenarios A1, A2, A3, B1, B2 and B3 . Data on regional consumption

Figure 24: Location and Distribution of Silo and Bag Depots in Zimbabwe

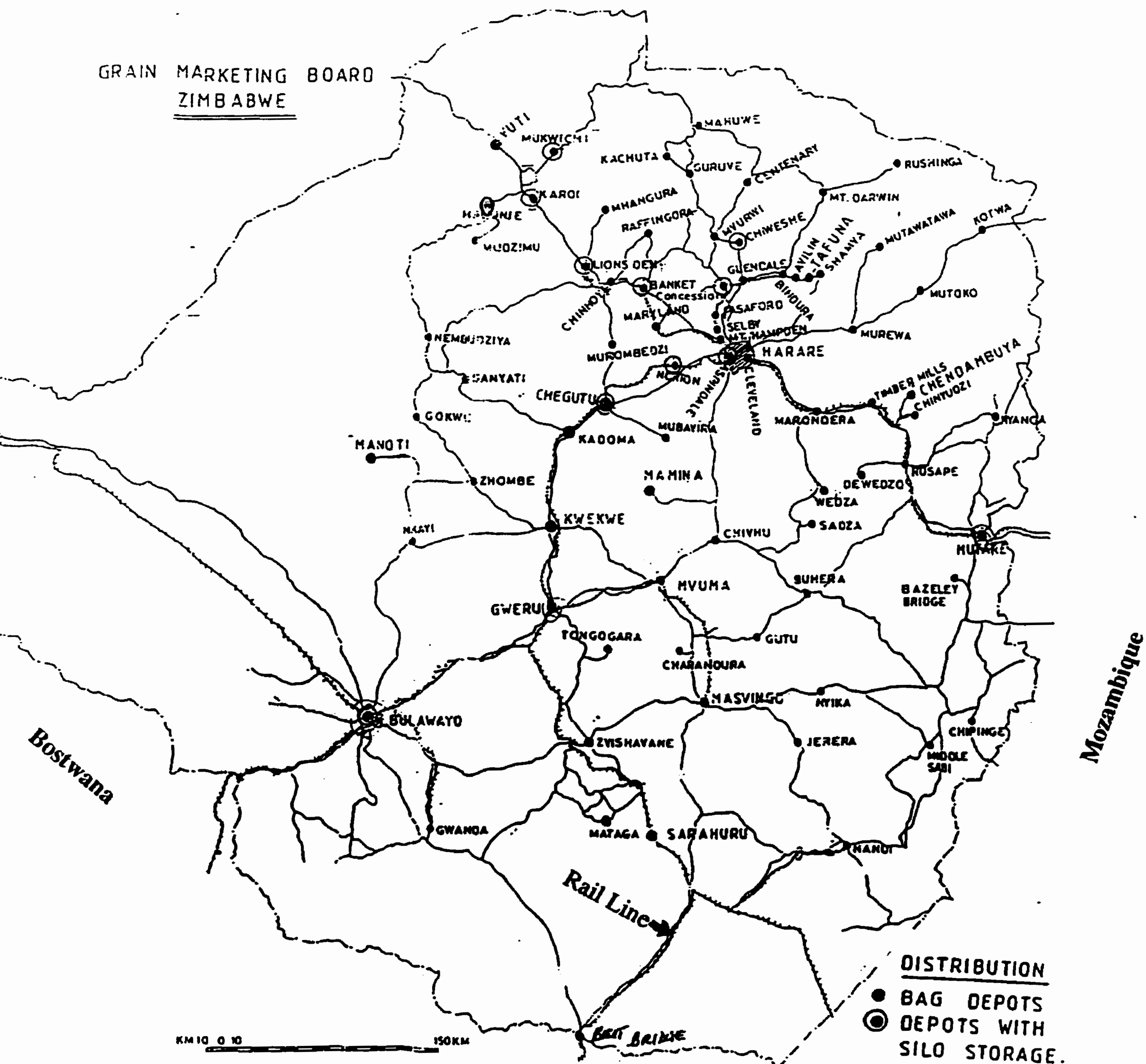


Table 21: Regional Consumption Requirements and National Storage Capacities.

Province	Region	Annual Consumption Requirements (Metric Tonnes)	National Silo Capacity (Metric Tonnes)	National Silo plus Bag Storage Capacity (Metric Tonnes)
Manicaland	I	181,446	None	171,210
Mashonaland	II	529,396	670,100	2,089,250
Midlands	III	153,661	None	76,500
Masvingo	IV	144,178	None	84,600
Matebeleland	V	218,729	75,000	115,050
Totals		**1,227,410**	**745,100**	**2,536,610**

Source: Grain Marketing Board, Planning Unit, 1995.

Table 22: Selected Internal Storage Depot to Depot Distance in Zimbabwe,(1995).

Origin Depot	Destination Depot	Distance (Kms)	Natural Region
(1)	(2)	(3)	(4)
Mutare	Aspindale-Harare	279	I to II
Aspindale-Harare	Chegutu	93	II to II
Aspindale-Harare	Gweru	260	II to III
Aspindale-Harare	Bulawayo	428	II to V
Aspindale-Harare	Masvingo	301	II to IV
Mutare	Masvingo	298	I to IV
Chegutu	Gweru	168	II to III
Bulawayo	Masvingo	283	V to IV
Lions Den	Aspindale-Harare	152	II to II

Source: Zimbabwean Grain Marketing Board, Planning Unit, (1995).

requirements and national storage capacities is presented in Table 21. Total national annual consumption requirements are 1,227,410 metric tonnes, total national storage capacity is 2,536,610 metric tonnes of wchich 745,100 is silo storage capacity. Eleven of the twelve national silo storage facilities and located in natural region II, with a capacity of 670,100 metric tonnes and one of the twelve national silo storage facilities is located in natural region V. The rest of the national storage facilities are bag depots. Silos offer the economics of bulk storage but such economies are neutralized by the need to unbag and then bag the maize at the silo. Figure 24 shows the location of silo and bag depots in Zimbabwe. It is evident that storage facilities are concentrated more on the nothern part of the country than the southern part. The nothern part of the country being the supplus region and the southern part of the country being the deficit region. Data on selected internal storage depot to depot distance is presented in Table 22. Selection of depots was made on the basis of their importance as major origins or destinations of maize grain. Data on internal rail and truck transportation rates for maize is presented in Table 23, transport rates are a result of tenders determined by the Grain Marketing Board. Internal transport costs are quoted in Zimbabwean dollars, on per ton/ kilometre basis and import costs are quoted in U.S. dollars, on per ton basis. Data on distance and transportation rates from port of entry to selected destinations in Zimbabwe is presented in Table 24. Figure 24 shows the major rail and road routes connecting storage facilities.

The Grain Marketing Board's transportation services are critical to delivering maize throughout the country in surplus or drought times. With tight storage some maize is often moved into other depots simply to make room for GMB purchases of other crops.

Table 23: Internal Rail and Truck Transportation Rates for Maize in Zimbabwe (Z$ Ton/KM,1992).

KM (1)	Rail (2)	Truck (3)
50	28	18
100	38	36
150	49	54
200	59	72
250	69	90
300	79	108
350	90	126
400	101	144
450	107	162
500	114	180
550	120	198
600	127	216

Source: Cassavant, Transportation Analysis in Zimbabwe, (1992).

Table 24: Distance and Transportation Costs From Port of Entry to Selected Zimbabwe Destinations,(1995).

Port (1)	Destin (2)	Route (3)	Mode (4)	Trans Costs US/D P/Ton (5)	Distance (Kms) (6)
Beira	Harare	Beira Corr	Rail	12.98	602
		Beira Corr	Road	55.56	615
Maputo	Harare	Limpopo Res	Rail	21.23	1,269
		Garcia	Rail	41.74	1,481
Durban	Harare	Beitbridge	Rail	57.58	2,068
		Warmbath	Rail/Road	109.2	1,967
East London	Harare	Beitbridge	Rail	66.26	2,370
Port Elizabeth	Harare	Beitbridge	Rail	69.15	2,456
Cape Town	Harare	Beitbridge	Rail	82.18	2,892
Beira	Bulawayo	Beira Corr	Rail	21.07	1,088
		Beira Corr	Road	87.30	1,056
Maputo	Bulawayo	Limpopo Res	Rail	18.89	1,083
		Garcia	Rail	39.53	1,295
Durban	Bulawayo	Beitbridge	Rail	55.37	1,882
		Warmbath	Rail/Road	77.45	1,467
East London	Bulawayo	Beitbridge	Rail	64.06	2,184
Port Elizabeth	Bulawayo	Beitbridge	Rail	66.94	2,270
Cape Town	Bulawayo	Beitbridge	Rail	79.98	2,706

Source: SADC, Food Security Technical Unit, Bulletin (1994)

Transportation is the dynamic link between the production areas of Zimbabwe and the consumption areas that are separated by time and space. Rail and truck transportation modes are both used in Zimbabwe, although rail movements are not high in the perspective of more local farmers. Rail transportation is managed by the National Railways of Zimbabwe (NRZ). Maize is carried on 7,000 high side railcars and 2,000 low sided railcars, in payloads of 40 - 48 tons, usually near the 40 ton volume.Rail movements are lower cost and capable of handling (and storing) large bulk or bagged quantities of maize. Rail is presently being used to move grain over the longer distances in the country. Athough trucks are used to transport maize over long distances most of the time trucks are used to move maize from the farm to the GMB storage facilities or milling facilities. The disadvantage of truck transportation is that most trucks can only handle bagged maize rather than bulk. For the majority of Small Scale farmers, bagged maize has to be moved by truck from the farm to either bagged GMB depots or GMB silo depots. Then the GMB has to move maize from storage to millers and deficit consumption regions. Maize imports are mostly moved as bulk or bagged by rail into GMB silos in the country. Maize from South Africa can be moved by truck as bagged maize into bag depots in the country.

5.4 Evaluation of Scenario Option A1

An analysis of regional maize availability, regional storage, regional consumption requirements, regional shipments of maize to deficit regions and regional import requirements is presented in Table 25. In scenario option A1 Table 25, the country will maintain strategic reserves equivalent to 12 months consumption, (1,227,410 Metric Tonnes). The amount of maize available from production for option A is 200,000 metric tonnes, this relates to the worst case scenario e.g. the 1991/92 drought. In scenario A1 maize is stored according to regional storage capacities and regional consumption requirements (Table 21). The strategy is to store the 12 months consumption requirements in the deficit Natural Regions V, IV, III and 1. When all storage available in deficit regions is used up, the remaining 12 months consumption requirements are stored in the surplus Natural Region II which always have excess storage capacity. Maize is distributed from Natural Region II to all the other regions according to shortfalls in consumption requirements in those areas. Imports to replace the 12 months consumption requirements are first shipped to deficit regions according to storage capacity available and consumption requirements, then to surplus Region II which always has excess capacity.

The 12 months strategic reserves are stored in Natural Regions V, IV, III, I and II respectively. Natural Region II absorbed most of the strategic stores due to its excess storage capacity. The regional and total quantities of maize grain available and stored for the 1991/92 season are presented in Table 25 Columns 2 and 4. Given the amount of maize stored in each region, Natural Region II had an excess of 410,654 metric tonnes of maize available for distribution into other deficit regions. The amount of maize shipped to deficit Regions from Region II is presented in Table 25 Column 6. Most of the shipments are to Natural Regions V, IV and III respectively. For the 1991/92 season, the country would have had a surplus of 200,000 metric tonnes of maize, but would have imported 1,027,410 metric tonnes of maize to maintain the 12 months strategic reserve consumption requirements. Imports for scenario option A1 are assumed to originate from the rest of the world since maize availability was viewed as the worst case scenario. South Africa is assumed to have

Table 25: Regional Storage, Consumption Requirements and Distribution of maize in Zimbabwe for the 1991/92 season. **Scenario Option A1: Store 12 Months Consumption Requirements, with Maize Availability at (200,000 metric Tonnes).**

Natural Region (1)	Supply Maize Availabilty (2)	12 Months Stores (3)	Annual Consumption Requirements (4)	Net Maize Stored by Region (5)	Shipments From Region II to Other Regions (6)	Imports to Replace 12 Months Stores (7)
I	8,000	171,210	181,446	179,210	2,236	171,210
II	160,000	780,050	529,396	940,050	410,654*	580,050
III	20,000	76,500	153,661	96,500	57,161	76,500
IV	7,000	84,600	144,178	91,600	52,578	84,600
V	5,000	115,050	218,729	120,050	98,679	115,050
Totals	**200,000**	**1,227410**	**1227410**	**1,427,410**	**210,654**	**1027410**

* Surplus from Natural Region II, to be distributed to other deficit Regions

maize shortfalls as well.

In scenario option B1, Table 26 the country maintains strategic reserves equivalent to 5 months consumption requirements and uses hard currency to import an amount equivalent to the consumption requirements until the next harvest plus the equivalent of 5 mounths consumption in storage. The amount of maize available from production for scenario Option B1 is 200,000 metric tonnes, this relates to the worst case scenario e.g. the 1991/92 drought. The decision where to store the 5 months consumption requirements is based on the location and available silo storage capacities in the country. The country has 12 silo storage facilities of which 11 of these silos are located in Natural Region II and 1 of the silos is located in Natural Region V, with storage capacities of 670,100 and 75,000 metric tonnes of maize respectively. The total storage capacities of these silos have enough storage for 5 months strategic reserve requirements. Storage in silos is preferred because maize grain can be efficiently stored and moved in bulk. Therefore the 5 months strategic reserves are stored in Natural regions V and II Table 26 column 3.

For the 1991/92 season the country would have 75,000 metric tonnes stored in the deficit Natural Region V and 525,000 metric tonnes stored in Natural Region II. The total amount of maize available for the 1991/92 season (Table 26 column 5) is stored in Natural Regions V, IV, III, I and II respectively . All of the other Natural Regions had deficit consumption requirements in storage, except Natural Region II which had a surplus of 155,604 metric tonnes of maize in storage Table 26 Column 6. The amount of maize grain shipped from Natural Region II to deficit Regions is presented in Table 26 Column 6, with most of the maize grain shipped to Natural Regions IV, I, V and III, respectively. The country would have had a shortfall of 427,410 metric tonnes to meet the annual storage requirements. For the 1991/92 season e country would import maize equivalent to 1,027,410 metric tonnes, thus according to Regional consumption requirements in deficit Regions. This amount includes the replacement of the 5 months consumption required for strategic stores Column 7, Most of the imports are shipped to the deficit Natural Regions II, V, III, I and IV respectively. Imports are assumed to originate from the rest of the world.

Table 26: Regional Storage, Consumption Requirements and Distribution of maize in Zimbabwe for the 1991/92 season. **Scenario Option B1: Store 5 Months Consumption Requirements, with Maize Availabilty at (200,000 Metric Tonnes).**

Natural Region (1)	Supply Maize Availabilty (2)	5 Months Stores (3)	Annual Consumption Requirements (4)	Net Maize Stored by Region (5)	Shipments From Region II to Other Regions (6)	Imports to Replace 5 Months Stores Plus Deficit (7)
I	8,000	-	181,446	8,000	42,954	130,492
II	160,000	525,000	529,396	685,000	155604*	525,000
III	20,000	-	153,661	20,000	-	133,661
IV	7,000	-	144,178	7,000	77,600	59,578
V	5,000	75,000	218,729	80,000	35,050	178,679
Totals	**200,000**	**600,000**	**1,227,410**	**800,000**	**155604**	**1027410**

* Surplus from Natural Region II, to be distributed to other deficit Regions

For the second scenario, options A2 and B2. In scenario option A2 Table 27, the country maintains strategic reserves equivalent to 12 months consumption, (1,227,410 Metric Tonnes). The amount of maize available from production for option A2 is 600,000 metric tonnes, this relates to the case when maize availability is above the minimum 5 months consumption requirements but below the normal maize availability trend level. In scenario option A2 maize is stored according to regional storage capacities and regional consumption requirements (Table 21). The strategy is to store the 12 months consumption requirements in the deficit Natural Regions V, IV, III and 1. When all storage available in deficit regions is used up, the remaining 12 months consumption requirements are stored in the surplus Natural Region II which always has excess storage capacity. Maize is distributed from Natural Region II to all the other regions according to shortfalls in consumption requirements in those areas. Imports to replace the 12 months consumption requirements are first shipped to deficit regions according to storage capacity available and consumption requirements, then to surplus Region II which always has excess capacity.

The 12 months strategic reserves are stored in Natural Regions V, IV, III, I and II respectively. Natural Region II absorbed most of the strategic stores due to its ability for excess storage capacity. The regional and total quantities of maize grain available and stored for the 1991/92 season are presented in Table 27 Columns 2 and 4. Given the amount of maize stored in each region, Natural Region II had an excess of 850,654 metric tonnes of maize available for distribution into other deficit regions. The amount of maize shipped to deficit Regions from Region II is presented in Table 27 Column 6. Most of the shipments are to Natural Regions V, III, IV and I respectively. For the 1991/92 season the country

Table 27: Regional Storage, Consumption Requirements and Distribution of maize in Zimbabwe for the 1991/92 season. **Scenario Option A2: Store 12 Months Consumption Requirements, with Maize Availability at (600,000 Metric Tonnes).**

Natural Region (1)	Supply Maize Availabilty (2)	12 Months Stores (3)	Annual Consumption Requirements (4)	Net Maize Stored by Region (5)	Shipments From Region II to Other Regions (6)	Imports to Replace 12 Months Stores (7)
I	50,000	171,210	181,446	171,210	10,236	171,210
II	390,000	780,050	529,396	1,380,050	850,654*	180,050
III	100,000	7650,660	153,661	76,500	77,161	76,500
IV	40,000	84,600	144,178	84,600	59,578	84,600
V	20,000	115,050	218,729	115,050	103,679	115,050
Totals	**600,000**	**1,227410**	**1,227,410**	**1,827,410**	**250,654**	**627,410**

* Surplus from Natural Region II, to be distributed to other deficit Regions

Table 28: Regional Storage, Consumption Requirements and Distribution of maize in Zimbabwe for the 1991/92 season. **Scenario Option B2: Store 5 Months Consumption Requirements, with Maize Availability at (600,000 Metric Tonnes).**

Natural Region (1)	Supply Maize Availabilty (2)	5 Months Stores (3)	Annual Consumption Requirements (4)	Net Maize Stored by Region (5)	Shipments From Region II to Other Regions (6)	Imports to Replace 5 Months Stores Plus Deficit (7)
I	50,000	-	181,446	50,000	131446	171210
II	390,000	525,000	529,396	915,000	385,604*	180,050
III	100,000	-	153,661	100,000	53,661	76500
IV	40,000	-	144,178	40,000	104,178	84600
V	20,000	75,000	218,729	20.000	96,319	115050
Totals	**600,000**	**600000**	**1,227,410**	**1,200,000**	**385,604**	**627,410**

* Surplus from Natural Region II, to be distributed to other deficit Regions

would have had a surplus of 600,000 metric tonnes of maize, but the country would have imported 627,410 metric tonnes of maize to maintain the 12 months strategic reserve consumption requirements. Imports are assumed to originate from South Africa for options A2 and B2.

In scenario option B2, Table 28 the country maintains strategic reserves equivalent to 5 months consumption requirements and uses hard currency to import an amount equivalent to the consumption requirements until the next harvest plus the equivalent of 5 mounths consumption in storage. The amount of maize available from production for scenario option B2 is 600,000 metric tonnes, this relates to the case were maize availability is above the minimum 5 months consumption requirements and below the normal maize availability trend level. The decision where to store the 5 months consumption requirements is based on the location and available silo storage capacities in the country. The country has 12 silo storage facilities of which 11 of these silos are located in Natural Region II and 1 of the silos is located in Natural Region V, with storage capacities of 670,100 and 75,000 metric tonnes of maize respectively. The total storage capacities of these silos have enough storage for 5 months strategic reserve requirements. Storage in silos enables maize to be stored and moved in bulk.

The 5 months strategic reserves are stored in Natural regions V and II Table 28 column 3. For the 1991/92 season the country would have 75,000 metric tonnes stored in the deficit Natural Region V and 525,000 metric tonnes stored in Natural Region II. The total amount of maize available for the 1991/92 season (Table 28 column 5) is stored in Natural Regions III, I, IV and V respectively. All of the other Natural Regions had deficit consumption requirements in storage, except Natural Region II which had an excess of 385,604 metric tonnes of maize in storage Table 28 Column 6. The amount of maize grain shipped from Natural Region II to deficit Regions is presented in Table 28 Column 6, with most of the maize grain shipped to Natural Regions I, V, IV, and III respectively. For the 1991/92 season the country would import maize equivalent to 627,410 metric tonnes, thus according to Regional consumption requirements in deficit Regions. This amount includes the replacement of the 5 months consumption required for strategic stores Column 7, Most of the imports are shipped to the deficit Natural Regions II, I, V, IV and III respectively. Imports are assumed to originate from South Africa.

For the third scenario options A3 and B3 the country is self sufficient, with the possibility of the country being a net exporter. Options A3 and B3 will be evaluated in the same way as in options A2 and B2 the only difference is that the country has no imports. The country would maintain 12 months strategic stores in option A3 and 5 months strategic stores in option B3. The annual consumption requirements are met through internal maize availability.

5.5 Evaluating the Costs for maintaining Strategic Scenario Options A1,A2,A3, B1,B2 and B3

To evaluate the cost of maintaining strategic scenario option A1, A2,A3, B1,B2 and B3 costs were assigned to major variables that would measure the cost of maintaining these option. The major cost variables are:

- storage and handling costs;
- transportation costs (internal distribution);
- import costs;

- transportation costs from port of entry to country destinations;
- storage waste costs;
- opportunity cost for the value of maize grain in storage; and
- opportunity cost for borrowing hard currency equivalent to 7 months consumption requirements;

Estimates for storage and handling costs plus interest and capital were obtained from the Grain Marketing Board Annual Report, 1992. Annual storage and handling costs were estimated at Z$32.00 per ton. Estimates for distance and internal transportation were obtained from an Agricultural Market Information Systems: Transportation Analysis in Zimbabwe by Dr Ken Casavant, 1995. Transportation rates were measured on dollars per ton kilometre basis Table 23. Import costs were based on the 1992 import costs of Z$1200.00 per ton and distance and transportation costs from port of entry to selected Zimbabwe destinations were obtained from the Food Security Technical Unit, 1994 Table 24. Storage waste costs were based on the average annual maize waste published by the F.A.O, 1995. The opportunity cost for the value of maize kept in storage was measured by multiplying the quantities of maize in storage by the internal maize selling price of Z$1070.00. The opportunity cost for the value of borrowing hard currency equivalent to import 7 months consumption requirements is based on the world borrowing interest, estimated at 10 percent.

Table 29 presents results on the evaluation of costs for maintaining strategic scenario options A1 and B1. To maintain strategic option A1, the country imports maize to maintain the equivalent of 12 months consumption requirements, given that maize availability from production is 200,000 metric tonnes. To obtain storage costs, net maize stored by region in column 5 Table 25 is multiplied by the annual storage costs. Costs on storage waste were obtained by using the annual average quantities of maize lost in storage estimated by F.A.O., (1995). The cost of maize waste only applies to maize waste in storage, estimates for maize waste during importation and transportation were not available, therefore it should be noted that costs on maize waste could be under estimated. Costs on transporting maize from region to region, especially from surplus regions to deficit regions were estimated by multiplying the quantities of maize grain moved and distributed from surplus regions to deficit region in column 6 Table 25 by the rail or truck costs presented in Table 23 columns 2 and 3. Opportunity cost of maize in storage was estimated by multiplying the amount of maize grain in regional stores column 5 Table 25 by the local maize selling price. Estimates for import costs were obtained by multiplying the quantities of maize imported into the country column 7 Table 25 by the world maize price if imports are from the rest of the world.

If imports are from South Africa, import costs are obtained by multiplying quantities of maize imported by the maize selling price in South Africa. Additional import cost from transporting maize grain from port of entry to destinations in Zimbabwe is obtained by multipying quantities of maize imported column 7 Table 25 by transportation rates quoted in U.S. dollars in column 5 Table 24. Opportunity costs for hard currency by the use of the 10 percent interest rate for borrowing hard currency equivalent to importing the amount of maize needed to fullfill the shortfalls in annual consumption requirements plus 5 months consumption stores. Costs for evaluating strategic scenario options B1, A2, B2, A3 and B3 were calculated as above, the only difference is with refence to option Table numbers.

Tables 29 presents results on the costs of maintaining strategic options A1, and B1. Results show that it would cost the country Z$2,831,720,674 to maintain scenario option A1 and Z$2,129,179,774 to maintain scenario option B1. Results show that for the 1991/92 drought season scenario option B1 is superior to scenario option A1. It should be noted that option A1 has higher internal transportation costs.

Table 30 presents results on the cost of maintaining strategic scenario options A2 and B2 . Results show that it would cost the country Z$2,361,905,794 to maintain scenario option A2 and Z$1,667,665,974 to maintain Scenario option B2. Option B2 is superior to option A2. It should be noted that option B2 has higher internal transportation costs than options A2, A1 and B1. Cost variables most sensitive to all options are; opportunity cost for storage, import costs, storage costs, internal transportation costs and waste in storage respectively. Import costs and internal transportation costs are most sensitive for scenario option B2. Finally results show that a strategic option of maintaning maize strategic reserves equivalent to 5 months consumption requirements plus maize availability at 600,000 metric tonnes above 5 months consumption reguirements trend level is the best and lowest cost strategy.

Table 31 presents results on the cost of maintaining strategic scenario options A3 and B3. The country will maintain 12 months strategic reserves in option A3 and 5 months strategic reserves in option B3, of maize availability from production at the self sufficiency level, with zero imports. After evaluating this strategy, as in the other options, the difference is in internal distribution costs and zero import costs. An estimated internal distribution cost of Z$25,153,434 would be realized as the regional 12 months strategic reserve distribution costs and an estimated regional distribution cost of Z$37,048,734 would have been realized as the 5 months strategic reserve distribution cost. The total cost for maintaining this options A3 and B3 were estimated at Z$1,563,938,554 for option A3 and 982,048,734 for option B3. The third scenario options A3 and B3 have lower costs than all the other options. Internal transportation costs for option B3 are much higher than other options. Because of data limitations costs on waste only apply to waste in storage, it should be noted that scenario options B1, B2 and B3 could be slightly biased in their favour.

5.6 Assigning Probabilties to Strategic Scenario Options A1, A2,A3,B1, B2 and B3

To evaluate which option is the best for policy purposes, each of the options is assigned a probability measure which was calculated using an average probabilty of ten years on maize availability being either below the 5 months consumption requirements trend line or above the 5 months consumption requirements trend line and below the normal maize availability trend line. The average ten year probabilities were calculated on the assumption that periodic droughts in Zimbabwe ocour in every ten years. A ten year moving average on the weather data supports this assumption plus other weather related studies done in Zimbabwe.These probabilities have been calculated in chapter 3. The total costs for maintaining scenario options A1, A2 and the self sufficiency option A3 are multiplied by the estimated probabilities for each option, The result is the total cost under strategy (A) in which the country will maintain strategic reserves equivalent to 12 months consumption requirements. Results under this strategy are presented in Table 32. Similar calculations are done for strategy (B) in which the country will maintain strategic reserves equivalent to 5 months consumption requirements and importing quantities of maize equivalent to consumption requirements until the next harvest plus the equivalent of 5 months consumption in storage. Results under this strategy are presented in Table 33. Final results from the probability estimates are presented in both Table 32 and 33 show that, for logistics purposes maintaining strategic option (B) is better than maintaining strategic option (A). Some of the data utilized in these calculations may not be accurate. It should be noted that the objective of this study is to show the methodology of analyzing costs related to different logistic strategic option for assuring maize availability in Zimbabwe so as to meet the food security objective.

Table 29 : Results on the Costs of Maintaining Strategic Scenario Options A1 and B1 (1991/92)

Option A1		Option B1	
Costs	Zimbabwean Dollars	Costs	Zimbabwean Dollars
Storage and Handling	44,800,000	Storage and Handling	25,600,000
Transportation Internal Distribution	25,153,434	Transportation Internal Distribution	15,747,516
Import Costs	1,232,892,000	Import Costs	1,232,892,000
Transportation Internal Distribution After Importation	52,275,240	Transportation Internal Distribution After Importation	60,690,258
Opportunity Cost of Maize in Storage	1,284,000,000	Opportunity Cost of Maize in Storage	642,000,000
		Opportunity Cost of Borrowing Hard Currency	72,000,000
Maize Waste	192,600,000	Maize Waste	80,250,000
Total Costs for Option A1	**2,831,720,674**	**Total Costs for Option B2**	**2,129,179,774**

Table 30 : Results on the Costs of Maintaining Strategic Scenario Options A2 and B2 (1991/92)

Option A2		Option B2	
Costs	Zimbabwean Dollars	Costs	Zimbabwean Dollars
Storage and Handling	58,477,120	Storage and Handling	38,400,000
Transportation Internal Distribution	28,861,434	Transportation Internal Distribution	37,048,734
Import Costs	752,892,000	Import Costs	752,892,000
Transportation Internal Distribution After Importation	45,075,240	Transportation Internal Distribution After Importation	45,075,240
Opportunity Cost of Maize in Storage	1,284,000,000	Opportunity Cost of Maize in Storage	642,000,000
		Opportunity Cost of Borrowing Hard Currency	72,000,000
Maize Waste	192,600,000	Maize Waste	80,250,000
Total Costs for Option A2	**2,361,905,794**	**Total Costs for Option B2**	**1,667,665,974**

Table 31: Results on the Costs of Maintaining Strategic Scenario Options A3 and B3 (1991/92)

Option A3		Option B3	
Costs	Zimbabwean Dollars	Costs	Zimbabwean Dollars
Storage and Handling	44,800,000	Storage and Handling	25,600,000
Transportation Internal Distribution	25,153,434	Transportation Internal Distribution	37,048,734
Import Costs	-	Import Costs	-
Transportation Internal Distribution After Importation	-	Transportation Internal Distribution After Importation	-
Opportunity Cost of Maize in Storage	1,284,000,000	Opportunity Cost of Maize in Storage	642,000,000
		Opportunity Cost of Borrowing Hard Currency	72,000,000
Maize Waste	192,600,000	Maize Waste	80,250,000
Total Costs for Option A3	**1,563,938,554**	**Total Costs for Option B3**	**982,048,734**

Table 32: Cost of Maintaining Strategic Option (A), Maintaining 12 Months Stores. (1991/92).

Strategy Option (A) Maintaining Strategic Reserves Equivalent to 12 Months Consumption Requirements			
Strategic Options	Strategic Costs (Zm.Dollars)	Probabilities Ten Year Averages	Probabilties Multiplied by Strategic Costs (Zm. Dollars)
Option A1 Worst Case Scenario	2,831,720,674	.2	566,344,135
Option A2 Maize Availability Above the 5 Months Consumption Requirements trend line and below the Normal maize Availability trend line	2,361,905,794	.3	708,571,738
Self Sufficiency Option A3	1,563,938,554	.5	781,969,277
Total			**2,056,885,150**

Table 33: Cost of Maintaining Strategic Option (B), Maintaining 5 Months Stores plus Hard Currency for Imports. (1991/92).

Strategy Option (B)
Maintaining Strategic Reserves Equivalent to 5 Months Consumption Requirements plus Importing an Amount Equivalent to Consumption Requirements Until the Next Harvest, plus the Equivalent of 5 Months Consumption in Storage.

Strategic Options	Strategic Costs (Zm.Dollars)	Probabilities Ten Year Averages	Probabilties Multiplied by Strategic Costs (Zm. Dollars)
Option B1 Worst Case Scenario	2,129,179,774	.2	425,835,955
Option B2 Maize Availability Above the 5 Months Consumption Requirements trend line and below the Normal maize Availability trend line	1,667,665,974	.3	500,299,792
Self Sufficiency Option B3	982,048,734	.5	491,024,367
Total			**1,417,160,114**

5.7 Sensitivity Analysis on Alternative Strategic Scenario Options

To evaluate the sensitivity of the following cost variables; (storage and handling, transportation internal distribution,imports, transportation internal distribution after imports, opportunity cost for maize in storage, opportunity cost for hard currency and maize waste); to their total cost for each of the two strategic options (A) and (B) , a sensitivity analysis was perfomed by increasing the cost on each of the cost variables by 10 percent. Results on the sensitivity analysis measured by the percentage change in variable cost to the intial total cost of each scenario option are shown in Tables 34 and 35. For scenario strategic option (A) where the country has to maintain 12 months strategic reserves, the cost variables which have the greatest effect on total cost are: opportunity cost for maize in storage with scenario option A3 being most sensitive cost; followed by import costs with scenario option A1; being most sensitive to cost; followed by maize waste and transportation costs respectively. For strategy option (B) where the country has to maintain 5 months strategic reserves, the cost variables which have the greatest effect on total cost are: import costs with scenario option B1 being most sensitive to cost; followed by opportunity cost for maize in storage with scenario option B3 being most sensitive to cost; followed by maize waste, opportunity cost for hard currency and transport costs respectively. The noticable difference in sensitivity between the two strategic options is that import costs come first in option (B).

An analysis which included the 10 percent increase in costs and the average ten year probabilities was performed on both strategic options (A) and (B). The average ten year probabilities on maize availability used in this analysis were obtain from earlier probability estimations peformed in Chapter 3. The total scenario option costs were multiplied by the average ten year maize availabiltiy probabilities to give a number which would enable the comparison in cost for the two strategic options A and B. Results in both Tables 36 and 37 show that strategic option (B) is still a preferred choice to strategic option (A). It is interesting to note that, although option (B) is preferred to option (A), the two options are not very different from each other in terms of the estimated total costs. Given the limitation on maize waste data to include maize waste during importation, strategic option B might be slightly under estimated.

Table 34: Results on the Sensitivity Analysis for Strategic Option (A), with a 10 Percent Increase in Variable Costs to Total Scenario Option Costs, (A1,A2 and A3).

Cost Variables	Options	Initial Total Costs for Each Option	A 10 Percent Increase in Cost of Variable	Total Cost After Increase in Cost of Variable	Percent Change in Total Cost
Storage and Handling	A1	2,831,720,674	4,480,000	2,836,200,674	0.16
	A2	2,361,905,794	5,847,712	2,367,753,506	0.25
	A3	1,563,938,554	4,480,000	1,568,418,554	0.29
Transportation Internal Distribution	A1	2,831,720,674	2,515,343	2,834,236,017	0.09
	A2	2,361,905,794	2,886,143	2,364,791,937	0.12
	A3	1,563,938,554	2,515,343	1,566,453,897	0.16
Import Costs	A1	2,831,720,674	123,289,200	2,955,009,874	4.35
	A2	2,361,905,794	752,89,200	2,437,194,994	3.19
	A3	1,563,938,554	0	1,563,938,554	0
Transportation Internal Distribution After Importation	A1	2,831,720,674	5,227,524	2,836,948,198	0.18
	A2	2,361,905,794	4,507,524	2,366,413,318	0.19
	A3	1,563,938,554	0	1,563,938,554	0
Opportunity Cost for Maize in Storage	A1	2,831,720,674	128,400,000	2,960,120,674	4.53
	A2	2,361,905,794	128,400,000	2,490,305,794	5.44
	A3	1,563,938,554	128,400,000	1,692,338,554	8.21
Maize Waste	A1	2,831,720,674	19,260,000	2,850,980,674	0.68
	A2	2,361,905,794	19,260,000	2,381,165,794	0.82
	A3	1,563,938,554	19,260,000	1,583,198,554	1.23

Table 35: Results on the Sensitivity Analysis for Strategic Option (B), with a 10 percent increase in Variable Costs to Total Scenario Option Costs, (B1,B2 and B3).

Cost Variables	Options	Initial Total Costs for Each Option	A 10 Percent Increase in Cost of Variable	Total Cost After Increase in Cost of Variable	Percent Change in Total Cost
Storage and Handling	B1	2,129,179,774	2,560,000	2,131,739,774	0.12
	B2	1,667,665,974	3,840,000	1,671,505,774	0.23
	B3	982,048,734	2,560,000	984,608,734	0.26
Transportation Internal Distribution	B1	2,129,179,774	1,574,752	2,130,754,526	0.74
	B2	1,667,665,974	3,704,873	1,671,370,847	0.22
	B3	982,048,734	3,704,873	985,753,607	0.38
Import Costs	B1	2,129,179,774	123,289,200	2,252,468,974	5.79
	B2	1,667,665,974	75,289,200	1,742,955,774	4.52
	B3	982,048,734	0	982,048,734	0
Transportation Internal Distribution After Importation	B1	2,129,179,774	6,069,026	2,135,248,800	0.29
	B2	1,667,665,974	4,507,524	1,672,173,498	0.27
	B3	982,048,734	0	982,048,734	0
Opportunity Cost for Maize in Storage	B1	2,129,179,774	6,420,000	2,193,379,774	3.02
	B2	1,667,665,974	6,420,000	1,731,865,974	3.85
	B3	982,048,734	6,420,000	1,046,248,734	6.54
Maize Waste	B1	2,129,179,774	8,025,000	2,137,204,774	0.38
	B2	1,667,665,974	8,025,000	1,675,690,974	0.48
	B3	982,048,734	8,025,000	990,073,734	0.82
Opportunity Cost for Hard Currency	B1	2129179,774	7,200,000	2,136,379,774	0.34
	B2	1,667,665,974	7,200,000	1,674,865,974	0.43
	B3	982,048,734	7,200,000	989,248,734	0.73

Table 36: Results on the Sensitivity Analysis for Strategic Option (A), with Average Maize Availability Probabilities.

Cost Variables	Options	Total Costs for Options After 10 Percent Increase in Cost	Probabilities Ten Year Averages	Probabilities Multiplied by Total Costs (Zm. Dollars)
Storage and Handling	A1	2,836,200,674	.2	567,240,135
	A2	2,367,753,506	.3	710,326,052
	A3	1,568,418,554	.5	783,454,623
Transportation Internal Distribution	A1	2,834,236,017	.2	566,847,203
	A2	2,364,791,937	.3	709,437,581
	A3	1,566,453,897	.5	783,226,949
Import Costs	A1	2,955,009,874	.2	591,001,975
	A2	2,437,194,994	,3	731,158,498
	A3	1,563,938,554	.5	781,969,277
Transportation Internal Distribution After Importation	A1	2,836,948,198	.2	567,389,640
	A2	2,366,413,318	.3	709,923,995
	A3	1,563,98,554	.5	781,969,277
Opportunity Cost for Maize in Storage	A1	2,960,120,674	.2	592,024,135
	A2	2,490,305,794	.3	747,091,738
	A3	1,692,338,554	.5	846,169,277
Maize Waste	A1	2,850,980,674	.2	570,196,135
	A2	2,381,165,794	.3	714,349,738
	A3	1,583,198,554	.5	791,599,277
Total Costs for Strategic Option (A)	**A1 A2 A3**			**3,454,699,223**

Table 37 : Results on the Sensitivity Analysis for Strategic Option (B), with Average Maize Availability Probabilities.

Cost Variables	Options	Total Costs for Options After 10 Percent Increase in Cost	Probabilities Ten Year Averages	Probabilities Multiplied by Total Costs (Zm. Dollars)
Storage and Handling	B1	2,131,739,774	.2	426,347,955
	B2	1,671,505,774	.3	501,451,732
	B3	984,608,734	.5	492,304,367
Transportation Internal Distribution	B1	2,130,754,526	.2	426,150,905
	B2	1,671,370,847	.3	501,411,254
	B3	985,753,607	.5	492,876,804
Import Costs	B1	2,252,468,974	.2	450,493,795
	B2	1,742,955,774	.3	522,886,732
	B3	982,048,734	.5	491,024,367
Transportation Internal Distribution After Importation	B1	2,135,248,800	.2	567,389,640
	B2	1,671,370,847	.3	501,411,254
	B3	982,048,734	.5	491,024,367
Opportunity Cost for Maize in Storage	B1	2,193,379,774	.2	438,675,955
	B2	1,731,865,974	.3	519,559,792
	B3	1,046,248,734	.5	523,124,367
Maize Waste	B1	2,137,204,774	.2	427,440,955
	B2	1,675,690,974	.3	502,707,292
	B3	990,073,734	.5	495,036,867
Opportunity Cost for Hard Currency	B1	2,136,379,774	.2	427,275,955
	B2	1,674,865,974	.3	502,459,792
	B3	989,248,734	.5	494,624,367

		Table 37 Continued	
Total Costs for Strategic Option (B)	**B1**		**3,163,775,160**
	B2		
	B3		

Chapter 6

CONCLUSION, POLICY RECOMMENDATIONS AND FUTURE RESEARCH

In this chapter, the summary of major findings of this study are presented. Limitations of the study are identified and suggestions for future research are provided.

6.1 Conclusions

The worst drought experienced in Zimbabwe in the 1991/92 growing season has highlighted important lessons regarding food security issues related to maize availability in the country. The drought situation was exacerbated because the likelihood of a drought occurring had not been taken into consideration when planning and budgetary provisions were made in 1991/92 and the absence of a strategic grain reserve policy had added negative effects to shortfalls of maize availability.

The major objective of this study was to address issues of food security as it relates to providing adequate maize supplies for the country in times of severe maize shortages caused by drought. The study is limited to demonstrate a methodology that analyses alternative strategic options for maintaining adequate supplies of maize, therefore achieving the objective of food security. Two strategic options have been evaluated given the availability of data and the need to evaluate the logistics of maintaining adequate maize supplies during times of production shortfalls. Other strategic options necessary to maintain adequate maize supplies have been discussed in Chapter 4, but they were not evaluated in this study due to limitation in data requirements. It should be noted that the methodology presented could be extended to other alternative crops that could supplement maize availability (e.g. sorghum and millet).

Evaluation of historical data on maize production, maize consumption and weather in Zimbabwe has shown that, there is a decline in per capita maize production and an increase in per capita maize consumption. Since most of the maize produced in Zimbabwe is rainfed, a failure of rain would transfer into severe maize shortages. Weather data has shown that there has been a remarkable decline in rainfall received in Zimbabwe in the last decade. This finding raises concern for increased need to improve alternative strategies for maintaining adequate supplies of maize, given the hypothesis that weather is a significant determinant of the variation in maize availability in Zimbabwe. Using the coefficient of variation as a measure of maize production variation in the 35 year period, results show that there has been an increase in maize production variability. Results from the maize-yield regression equation show that weather is an important variable in explaining the variation in maize yields. These finding show that the maize production - consumption gap is getting narrower, raising concern for maintaining adequate maize supplies for the Zimbabwean population, therefore concern for food security in Zimbabwe.

The logistics of alternative strategic options for assuring adequate maize supplies were examined and two option were evaluated on the basis of cost. The government's present strategic reserve policy was found to be adequate but high cost. For the three strategic options presented, results show that the least cost strategic option suitable for assuring stable maize supplies in times of drought situations is Strategic Option B: to maintain a strategic maize reserve equivalent to five months annual consumption requirements and importing quantities of maize equivalent to consumption requirements until the next harvest plus the equivalent of five months consumption in storage. When the ten year average maize availabilty probabilities for maize availability for the time period 1985 - 1995, being below or above the five months consumption trend line were incorporated in the cost analysis, results show that maintaining five months strategic reserves is still superior to maintaining twelve months strategic reserves. It should be noted that in this case the cost difference is not very large. Sensitivity analysis performed on the scenario option cost variables show that the most sensitive variable to cost in Strategic option A is the opportunity cost for maize in storage,followed by import costs, maize waste, storage and transport costs respectively. The most sensitive cost variable in strategic option B were, import cost, opportunity cost for maize in storage, maize waste and transport costs respectively.

6.2 Policy Recommendations

The primary findings of this study is the usefulness of the logistic approach in evaluating alternative approaches to assuring adequate supplies of maize to provide the means to food security. In addition, findings from this study show that the overall cost of maintaining maize buffer stocks is sensitive to the opportunity cost for maize in storage and import cost. These two items absorb a large share of the government's budget on maize grain management. There is need to improve the strategic reserve storage policy and finding efficient ways of reducing import costs. Other findings show that storage location is important in terms of the logistics of distributing maize grain in the country. Storage capacities in deficit regions are a constraint to meeting the annual consumption requirements in these regions. There is a lot of grain movement from the north to the southern part of the country, adding to distribution transport costs. On farm storage and opening up to private importers of maize would ease the budern on government finances towards maize imports and storage.

This study recommends that a study on storage location, size, and numbers would be beneficial to the government in terms of finding the least cost method for storing, and moving maize grain from surplus regions to deficit regions. Findings from this study show that maize imports from South Africa come in through Beit Bridge as bulk yet there are no bulk storage facilities in most deficit regions. This study suggests that bulk storage facilities should be built somewhere near Gweru in the Midlands to facilitate bulk maize shipments from South Africa to the deficit regions in the Midlands, Masvingo and Matebeleland. These bulk handling facilities would therefore save transport costs, speed up internal distribution of maize and help to relieve the pressure on Harare/Gweru section of rail.

From the major findings of this study, a recommendation on reducing maize waste and animal feed in drought years would increase maize availability. The policy recommendations on which logistic strategic reserve option to maintain are that, the country should maintain a maize strategic reserve equivalent to five months consumption requirements and importing quantities of maize equivalent to consumption requirements until the next harvest plus the equivalent of five months consumption in storage. The country will save hard currency equivalent to importing consumption requirements until the next harvest plus replacing five months consumption withdrawn from storage. Weather is seen to be a major threat to maintaining stable maize supplies, crop forecasts which include the weather data would be useful for planning purposes.

6.3 Limitations and Suggestions for Further Research

This study has made some contributions to solving the problems of food security as it relates to maize availability in Zimbabwe. The limitations of this study are that it does not address the full picture as defined by the word food security. This study has addressed the first part of food security which deals with maintaining enough maize supplies to close the gap between production and the desired levels of consumption. There is need to address the second part of food security which deals with access at the household level, to existing maize stocks available in the nation.

A second limitation is the availability and quality of the data used in this study. Historic data, reflecting various government policies in place, were used. No attempt was made to estimate the relevant shadow prices of maize in storage, maize import costs, transport costs, etc. The basic methodology has been demonstrated and such refinements as accurate estimates of opportunity cost will be of value only with access to relevant data.

Third, the strategic alternative of policy interventions designed to increase maize production was not attempted. Given that annual increases in maize production at least equal to the growth in population might well affect options A and B differently, a complete study of the logistics of alternative approaches to strategic stores should include increased maize production as one of the options.

Fourth, to illustrate the methodology only one time period was used. An ideal approach would study the present value of the logistics of alternative approaches to strategic stores over time. With time as a variable, more attention would need to be given to the shadow price for maize in storage, maize imported and foreign exchange held for food security purposes. These prices would vary over time, possibly seasonally as well as annually, and may well be different for the two approaches to holding strategic stores of maize.

Fifth, the study ignored the role of maize stored in places other than the Grain Marketing Board, e.g., on farm. Changes in agricultural policies that affect on-farm storage of maize would be relevant to a study of the maize supplies required for food security.

Finally, other sources of food other than maize would form part of a food security strategy. The methodology can be extended easily to such crops as sorghum and millet. Also, there is a need to introduce better forecasting methods which include the weather variable. Since maize storage is a major part of the logistics in maintaining adequate maize supplies, there is need for further research on determining the location, capacities and numbers of storage facilities in the country. With the inclusion of the other strategic options presented and outlined in Chapter 4, so as to address comprehesive alternative strategies to maintaining adequate supplies of maize, will serve to advance achieving the objective of food security in Zimbabwe.

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