AN INVESTIGATION OF DROUGHT CHARACTERISTICS AND ASSESSMENT OF MITIGATION MEASURES IN THE GWEMBE VALLEY, ZAMBIA

BY

RABSON MWENDA

A dissertation submitted to the University of Zambia in partial fulfilment of the requirement of the degree of Master of Science in Geography

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figures Page

LIST OF APPENDICES

DECLARATION

This Dissertation represents my own work and has not previously been submitted for a degree at this or other university.

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APPROVAL

THIS DISSERTATION BY RABSON MWENDA **IS APPROVED AS FULFILLING THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF** SCIENCE IN GEOGRAPHY **BY UNIVERSITY OF ZAMBIA.**

NAME	SIGNATURE
.....	.....
External Examiner	
Dr. Henry M. Sichingabula	.....
Supervisor and Internal Examiner	
GEAR M. ICAJOBA	.....
Internal Examiner	
Prof. E.N. Chiclumayo	.....
Dissertation Chairperson	

DEDICATION

I dedicate this piece of work to my wife, Angela, who never tired to soldier on with the children during my absence from home. Yes, indeed, she single-handedly went through thick and thin just to afford me ample time to attend to this work.

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ACRONYMNS

ARPT	Adaptive Research Planning Team
CSO	Central Statistical Office
DACO	District Agricultural Coordinator
DIMS	Drought Impact Monitoring System
DMMU	Disaster Management and Mitigation Unit
ENSO	El-Nino Southern Oscillation
EFZ	Evangelical Fellowships of Zambia
FRA	Food Reserve Agency
GTDP	Gwembe-Tonga Development Project
IFAD	International Fund for Agriculture and Development
IUCN	International Union for the Conservation of Nature and Natural Resources
MP	Member of Parliament
MAFF	Ministry of Agriculture, Food and Fisheries
MOE	Ministry of Education
MOH	Ministry of Health
NEWS	National Early Warning System
NGO	Non-Governmental Organization
PAM	Programme Against Malnutrition
U.N	United Nations

USA	United States of America
UNZA	University of Zambia
VWI	World Vision International
WASHE	Water, Sanitation and Health Education in Zambia
WMO	World Meteorological Organization
ZRCS	Zambia Red Cross Society

ABSTRACT

There has been an increased frequency of drought occurrence in the Gwembe Valley in recent years. The situation, however, has not been addressed adequately due to lack of enough research on drought effects, especially the assessment of appropriateness and effectiveness of the mitigation measures that had been recommended and implemented to reduce the impacts. This study was carried out in the Gwembe Valley in the period September, 1999 to February 2000, covering the three districts of the valley namely Siavonga, Gwembe and Sinazongwe.

The objectives of the research were: (i) to determine the drought characteristics; (ii) to assess drought impacts on agriculture and water supply and (iii) to determine appropriate measures of reducing drought vulnerability of local communities.

Some of the analyzed data was collected from participants who included households of peasant farmers and village headmen. Other data came from civil servants working for the Ministry of Agriculture Food and Fisheries (MAFF), the Ministry of Education (MOE), Department of Meteorology in the Ministry of Transport and Communications and also from the Water Affairs Department of the Ministry of Energy and Water Development and from the Ministry of Health (MOH). Civic leaders included Member of Parliament (M.P.) for Gwembe (who was later appointed Deputy Minister for Southern Province) and District Council officials.

Both qualitative and quantitative types of data were collected. Interview, questionnaire and observation methods were used while analysis involved the 'run-methodology' and magnitude-frequency approaches. Results revealed that the droughts were not due to shortfall in expected total amount of rainfall per season alone but that the duration of dry-spells in the rain season and the actual number of rain days per month, contributed. The impacts of the droughts were manifested in crop failure and depleted food stocks. Water scarcity leads to many diseases and livestock deaths. Human reactions like failure to act quickly in the wake of drought signs, cultivation of inappropriate crop and in some instances, sheer laziness by people who depended on receiving free food-aid (especially) were among the accentuating factors to hardships local people faced. The study also suggested that drought occurrence was not random and had increased slightly since 1980, impacting agriculture and water supply more severely.

The recommendations to individuals emphasized the need to intensify the current mitigation measures being pursued while government was being urged not to procrastinate in implementing measures suggested to it as this derailed progress. It was observed that triumph in the fight against drought would need establishing a permanent body for drought mitigation and management. This body should be composed of professionals in matters on drought and who should be ready to address the issue whenever it showed signs of re-surfacing. The other contingency measures already adopted such as food aid and use of drought resistant crop varieties were to continue.

Unless both the affected parties and the interested parties worked together in the fight against drought in the area, the problem would remain insurmountable and the suffering would continue.

CHAPTER 1: INTRODUCTION

1.1 Introduction

Drought is generally defined as a temporary reduction in water or moisture availability significantly below the normal or expected amount for a specified period. There have been persistent stories about the existence of drought in the Gwembe Valley. However, due to limited documentary evidence of drought in the area, not much has been done to alleviate the hardships local people experience. The hardships from drought can not be over-emphasized. Drought affects life by casting a dark shadow on both social and economic development. It must be understood too that drought has varying characteristics. In the Gwembe Valley, agricultural drought, a situation when rainfall received is below the limit of the normal range of crops physical requirements, resulting into damage to agricultural produce, was singled out together with climatic drought, a situation when rainfall received was below the expected.

The purpose of this study was to investigate the drought characteristics in the Gwembe Valley and assess the mitigation measures that could reduce vulnerability. A clear understanding of the drought problem in the valley should help decision-makers to plan for future development of the area.

This report is divided into seven chapters. Chapter One gives the background to the research. Chapter Two reviews relevant literature to the study while the description of the study area is covered in Chapter Three. Chapters Four to Seven cover the methodology, findings of the

research, discussion and interpretation of results, and summary and conclusions, respectively.

1.2 Scope of the Study

The study covered three districts of the Gwembe Valley, namely, Siavonga, Gwembe and Sinazongwe involving more than 80 persons who were either interviewed orally or by completing a questionnaire. The research was limited to the following aspects: agricultural participation, difficulties faced due to drought occurrence in the area, mitigation measures taken in the face of drought, assistance received during drought times and the source, and finally, suggestions of the mitigation measures taken which were most appropriate and effective. The interviews with agricultural officers and the civic leaders covered, among other things, a brief history of drought in the area, the effects and impacts of drought on agriculture and water supply, responses to the effects and future plans to combat future droughts.

1.3 Research Problem

It is easy to ignore a rare event. This, however, cannot be said about the drought in the Gwembe Valley which has frequently occurred and has become a permanent feature in the news due to it's increased frequency (e.g. Simuchoba, 1985; McParland, 1985; Adaptive Research Planning Team, 1993). The drought frequency is more in some places than others within the area but no place can safely be said to be free from it.

Drought in the Gwembe Valley has brought a lot of hardships and uncertainties. For instance,

drought has led to poor harvests in the valley, inadequate pasture and lack of water for drinking, has led to loss of lots of livestock which has denied local people draught-power for agriculture. These problems have robbed the local people of meaningful economic development. Another fact is that most of the peoples' time in the valley is spent looking for food for their survival instead of venturing into other areas of economic development. Despite all these adverse effects of drought, little research has been conducted on drought and impacts and mitigation measures in the area for the purposes of reducing the vulnerability of the people to drought. Hence this study.

The agricultural season of 1991/92 is remembered in Zambia as one of the worst droughts in recorded history (Tiffen and Mulele, 1994). There was failure of rains over much of southern Zambia especially during the time of maize tasseling and silking in the months of January and February. A report on the Drought Impact Monitoring Systems in Zambia (DIMS) by the Central Statistical Office (CSO, 1998) states that the 1991/92 drought covered a total of 27 districts and affected about three million people in the Southern, Central, Lusaka, Western, Eastern and Copper-belt provinces. It reduced the percentage of crop production by 93.0, 85.0, 80.1, 79.3 and 57.0 in Southern, Lusaka, Western, Eastern and Central provinces, respectively, over the previous 1990/91 season (CSO, 1992). Late rains precipitated fungus diseases to maize crop and resulted in food shortages in the affected areas. The effects of the drought extended to livestock and reduced their numbers drastically. All this culminated in the loss of incomes of agricultural households who depended on selling crops and livestock.

Due to the outlined impacts of drought in the valley, the place has tended to lag behind in both

social and economic development.

1.4 Rationale

Droughts have caused serious adverse effects in the Gwembe Valley resulting into the Zambian government spending a lot of money through food relief programmes (Banda et al., 1997), and increased reports of crop failure (Tiffen and Mulele, 1994). Yet only limited amount of research has been done in Zambia. Among the few done include those by Sichingabula (1994a; 1998), which covered the whole country. Other studies concentrated on the southern part of the country (Muzumara, 1990; Tiffen and Mulele, 1994; Sichingabula and Sikazwe, 1999). In each of the studies mentioned above some mitigation measures were suggested, but no deliberate steps, except in the case of IUCN (1997), have been taken to find out whether or not those mitigation measures had been effective in reducing people's vulnerability to drought.

This study will contribute to knowledge on drought in Zambia by directly addressing the issue of drought in the Gwembe Valley. It has investigated characteristics and impacts of drought and assessed some effective measures (adjustments) of reducing vulnerability of the local people to drought. The knowledge obtained would be useful to planning, especially, in the agricultural and water supply sectors.

1.5 Objectives and hypotheses

The main objectives of the research were to:

(i) determine occurrence, duration, magnitude and severity of drought,

(ii) assess impacts of drought on agriculture and water supply; and

(iii) determine appropriate measures of reducing drought vulnerability.

To achieve these objectives the following hypotheses were tested:

(i) Drought occurrence and severity in the valley had increased since 1980;

(ii) The impact of drought on agriculture and water supply in the valley is more than it was before 1980; and

(iii) Mitigation measures so far recommended and implemented against drought in the valley were both appropriate and effective.

1.6 Choice of Study and Area

The main reason for taking up the study of drought was personal interest in the study of water and water-related aspects. The study was taken as a challenge to the hazardous developmental effect of drought to the country, especially in agriculture and water supply.

The study area (Gwembe Valley) was purposely selected primarily because it is one of the main areas in the country where drought was a recurring hazard. The area also has a long rainfall record going as far back as 1948. The area was also selected to assess changes made since the intervening period since Muzumara's (1990) study and as a follow-up on recommendations he had made. The area was quite unfamiliar to the researcher such that possible prejudices were non-existent.

The next chapter reviews relevant literature to the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Definition of drought

There is no universally accepted definition of drought (Landsberg, 1982; Ebert, 1988 and Gregory, 1986) because each definition of drought fits a particular situation, and interest of the investigator. Meteorologists define drought solely on the basis of the degree of dryness and the duration of the dry period. The agriculturist's idea links drought to impacts on farming focusing on the shortage of rainfall, the differences between actual and potential evaporation and factors such as the water periods deficit in the soil which is summarized as shortage of water harmful to man's agricultural activities. The hydrologist links drought to periods of shortfall of surface or sub-surface water supply such as stream-water flow, reservoir and lake-levels and groundwater (Smith, 1992; Heath-cote (1974) in White, 1974). The British Weather Bureau introduced aspects of absolute and partial drought. In Britain drought is defined as a period of at-least fifteen consecutive days without rain while in the United States of America (USA) it is defined as a period of twenty-one days when rainfall is 30 percent less of the average for the place and time (Campbell, 1968). Drought may be classified further on a national, regional or local level (Wisner and Mbithi (1974) in White, 1974).

In Zambia, Sichingabula (1994a) quoting Simango and Das (1977) defined drought as occurring when the annual rainfall at a station is below or equal to 50 percent of the normal rainfall but was quick to point out by saying that the physical basis of this definition was not

known. In general, Sichingabula states that in the Zambian context the term drought implies a period of days, weeks or months in the growing season during which little or no rain falls, grass for pasture and surface water diminish, crops fail and animals die. According to Kates (1972) depending on the rainfall range agricultural drought would be declared at different times by different farming systems. For instance, a farmer who planted early maturing maize, planted early and weeded early would not define a season which brought 180mm (seven inches) of rain as a drought season (Wisner and Mbithi (1974) in White, 1974). For operational purposes the meteorological office in Zambia has divided the country in rainfall belts in line with findings by Hutchinson (1975), which states that for the Gwembe Valley annual rainfall of less than 750mm constituted a meteorological drought. The study has adopted the definition for analysis of drought.

It must be noted, as many researchers including Muzumara (1990) and Tannehill (1947) have observed, that drought is a creeping hazard and it is one of the phenomena that occur naturally or in other words, one of the 'acts of God'. This attribute of drought makes it very difficult to pinpoint when exactly rains would start or end. To determine when the rains start, the Meteorological Department defines a minimum amount of 30mm of rainfall as 'planting-rains'. This study adopted this definition. However, others, determined onset and termination of drought based on a formula:

$$X = (MAD - MMMR) / 11,$$

Where X is a monthly increment, MAD is the mean annual deficit and MMMR is the maximum value of mean monthly rainfall. The test is based on a comparison of the sum of the negative differences from the point in time at which the test begins or ends (Herbst et al., 1966)

2.2 Research on Drought

Among the more common extreme geophysical events, drought was the most prevalent in the sub-Saharan region and had been rightly counted among natural hazards (White, 1974). A hazard, according to White was an extreme event in nature. Such an event was hazardous only if it affected people (Burton et al., 1978). Though natural-hazard research, is a recent field of geographic enquiry concerned with the human occupation of hazardous environments (Mitchell, 1974), a number of studies have been done on drought in different parts of the world. Several in Africa (Nicholson and Entekhabi, 1986; Bryson, 1973; Berry et al., 1971; Campbell, 1984; Dalby et al., 1973; Davy, 1974; Kates, 1981) and a handful in Zambia (e.g. Simango and Das, 1977; Government Report, 1984; Muchinda, 1988; Chipanshi, 1989; Muzumara, 1990; Sichingabula, 1994a, b). All these studies basically discuss a range of topics from definition to impacts while some include mitigation measures to drought.

Most researches done in Zambia, on drought are limited largely to those done at the University of Zambia (UNZA) for academic purposes. Others fall under the Zambia Meteorological Department (e.g. Simango and Das, 1977; Das, 1979; Muchinda, 1988; 1995). A few fall under the Ministry of Agriculture, Food and Fisheries and the Ministry of Energy and Water Development (e.g. Government Report, 1984); the Study Fund (e.g. Banda et al., 1997) and other organizations such as IUCN / IRISH AID (e.g. Tiffen and Mulele, 1994). Of the researches done at UNZA most have just been for academic purposes and as such the findings are locked away in the library archives without reaching the target communities. Had those studies been funded for community edification the situation could probably have changed tremendously by now.

2.3 Causes of Drought

To the question 'What causes drought?' Tannehill (1947) discrediting nearness to water as not being an assurance of rainfall and he cited examples of pieces of landmasses in the midst of vast stretches of oceans such as St. Helena, Ascension and Galapagos Islands whose shores have the climate of deserts. He however attributes this to the presence of cool ocean currents. He went further to explain that the presence of moisture from the oceans or seas though plenty does not bring rainfall as long as air is becoming warmer and drier instead of colder. This air, he explained simply passed over the land and may end up back at sea (Tannehill, 1947). Long ago, the cause of drought was popularly hypothesized to have been as a result of the displacement of the Inter-Tropical Convergence Zone (ITCZ) to the south. This, however, has since been refuted by a number of studies and is no longer accepted. The reason for rejection being, mainly, its failure to account for variation over the whole continent (Nicholson, 1987). Other scientists such as Bucha (1988), Bhalme and Jadhav (1984) in Starosolszky and Melder (1989) did not attempt to explain how droughts were caused. They simply concluded that droughts were triggered by "processes taking place inside and outside the earth manifested through geological, geophysical and oceanographic phenomena and extra-terrestrial influences with the leading role played by activity and transmission of solar energy " (Starosolszky and Melder, 1989: 10). For instance, scientists predict that global atmospheric changes could disrupt established weather patterns so that existing weather conditions such as droughts occur more frequently and that global warming may have caused or contributed to recent droughts though there is no conclusive scientific evidence yet to support this fact (IUCN, 1996). During the 1982/83 season, the severe drought in Southern Africa and the Sahel and the famine in

Africa, were linked to an El-Nino occurrence (Tiffen and Mulele, 1994). During the 1991/92 rainy-season in Southern Africa, the El Nino lasted until the end of February, 1992. The region responds to El-Nino-Southern Oscillation (ENSO). The ENSO is a global weather phenomenon during which the Equatorial waters across the Pacific Ocean get warmer. Normal airflow moves westward from the Pacific to the Indian Ocean, but during an El Nino this movement is weakened or altered. This results in high rainfall in some parts of Latin America but low rainfall and even drought in Southern Africa. The opposite extreme of the ENSO cycle occurs when a cold phase known as La-Nina or anti-El-Nino is experienced. The occurrence of the La-Nina results in unusually heavy rainfall in the Southern Africa (IUCN, 1996). It must be noted here that this, however, wasn't the case in 1999 when there was the strongest El Nino. More recent researches on drought focus on sea-surface temperatures and share the idea that variability in the equatorial zone and the southern sub-continent of Africa are linked to the Atlantic sea-surface temperature fluctuations with ENSO phenomenon. While the North-Atlantic dipole affects mainly West Africa, East and Southern Africa respond to Indian Ocean sea-surface temperatures (Nicholson, 1987 and Downing, 1993).

Environmentalists have argued that while the drought hazard came naturally, such acts were merely a trigger for natural disasters but were accentuated by some deliberate acts of man or his non-action (McParland, 1985). Confirming the same and adding a little more to this argument, White (1974) said that certain hazards were not just accentuated but were actually created by man through (1) alteration of land and water when making of dam, (2) an invasion of risky areas by indiscriminate cutting of trees in catchment areas causing the drying up of the water sources and (3) delayed action or non-action in the face of signs of danger.

2.4 Prediction of Drought

The fact that causes of drought are not well understood makes it very difficult to predict when a drought would occur. When scientists are asked to predict the occurrence of a drought they always employ a well-known prognostic rule which says 'Forecasting on a scientific basis is impossible without understanding the causes of the phenomena to be forecast' (Storosolszky and Melder, 1989: 10-11). Oguntoyinbo (1986) states that some ancient people managed to predict the occurrence of drought with some measure of accuracy but he could not explain the basis of such prediction. Attempts at predicting future climates will always be man's pre-occupation for as long as droughts occur. When, however, an attempt on drought forecast is made, scientists have not found it easy to categorically state how long in advance it is theoretically possible to do so. Starosolszky and Melder also mentioned the fact that the problem of predictability has been an on-going battle with many meteorologists using different models of the atmosphere. Even so, the limit of prediction has been found to range from five to twenty-two days.

It must be acknowledged, however, that the present methodology on drought prediction is full of limitations and uncertainties. Even when longer periodicity are noticed in certain data, the representativeness of such data is questionable. However, continued effort at modeling some characteristics of drought offer some hope for a breakthrough (Sharma, 1997). The past years has provided an understanding of the ENSO phenomena sufficient to allow prediction of major ENSO episodes at lead times of about one year (Graham, 1996). Another scientist says, 'predictability in southern Africa is relatively high because links between the global El Nino

and regional weather systems are robust and well unders tood' (Jury, 1996: 37). It must be noted, however, that Jury's predictions (on web-site) were off the mark in the 1998/1999 season.

2.5 Drought occurrence in Zambia

According to researches done in Zambia, Sichingabula (1994a, 1998) highlights that between 1921 and 1970 droughts lasting up to 10 years occurred in Zambia's recorded history. The drought of 1949 impacted 92 percent of the country's total area and was the most widespread. He hinted that, generally, the droughts that occurred between January and March were the most damaging in terms of crop yields. In his recent findings, Sichingabula (1999) gave the following highlights of hydrological droughts on the Kafue and Zambezi rivers. Droughts of different n-years were experienced on the Kafue and Zambezi rivers. On the Kafue in the period 1906 to1969 the 8-year drought (1910-1917) with -233 % departure from the mean was the most intense in terms of magnitude followed by the 5-year event of 1927-1931 (-214 %). On the Zambezi in the period 1908-1997 the worst n-year drought occurred in 1949 (-51%), followed by the 1990-1997 (8-year) with -43 % departure. Hydrological drought occurred on the Kafue and Zambezi rivers contemporaneously although those on the Zambezi tended to be of longer duration for the same period.

Sichingabula (1998) concludes that Zambia's drought is seen to be a chronic phenomenon taking its toll on human and animal lives. Worldwide press coverage and an increased number

of studies being undertaken have showed appreciation of drought-concern. Zambia has received colossal sums of money, food and other none-food aid valued at over US$70.00 million in 1992 (Sichingabula, 1994 b) and US$40 million in 1995 (Banda et al., 1997) towards drought relief. However, unless the recommendations offered in the studies being undertaken to alleviate drought vulnerability are addressed, there will be no end to the problems that come from droughts and a lot of resources will continue being directed in the area of drought relief at the expense of other developments.

2.6 The Cost of Drought

The cost of drought to Zambia, like any other nation is very real and can be divided into direct monetary costs in cushioning the impacts of droughts on the affected population, primarily through famine relief. Other costs arise from production losses such as value not added to the economy because activities in which farmers have invested time, money and labour fail: cattle lose weight, die, do not bear calves; plants wither or bear a fraction of their normal harvest (WMO, 1975). Social costs of drought are measured by increased nutritional problems and nutritionally related disease. Records at a rural clinic in Macha (Southern Province) show a growing trend in the percentage of children who were taken for 'Under-Five' Clinic that were under-weight for their age from 1990 to 1993 (Table 2.1).

Table 2.1: Percentage of Children who were taken for 'Under-Five' clinic who were Under-weight for their age at Macha Hospital Clinic in Choma District, Southern Province, Zambia.

	Year			
	1990 (%)	1991 (%)	1992 (%)	1993 (%)
January	14.77	23.62	15.83	33.25
February	13.66	25.82	14.84	33.33
March	26.50	25.19	21.13	33.61
April	21.39	24.65	27.19	34.51
May	19.74	20.86	24.80	36.08
June	17.77	19.59	24.17	-
July	12.90	16.86	21.78	-
August	34.37	24.41	50.56	-
September	18.64	23.51	49.59	-
October	13.41	21.10	24.37	-
November	22.81	13.25	25.15	-
December	22.98	18.50	68.14	-

Source: Tiffen and Mulele (1994

Drought also has an overall impact on the pace of technological change and rural development in the affected areas (Wisner and Mbithi (1974) in White, 1974). In the wake of the above outlined problems, White (1974) gave a prescription by stating that upon identification of a hazard such as drought, there was need for government concerned to target it so as to buffer social dislocation from the catastrophe and to improve productivity of available resources. He suggested that to cope with an environment, which was both physical and sociological, there was need to employ human adjustments that bore the two imbedded factors. Research had revealed that "modern societies could not expect to cope effectively with the hazards in the environment by relying solely upon technical solutions. A crucial aspect of any long-term adaptation to the human environment was the skilful, sensitive use of a wide range of coping strategies, including engineering devices, land management and social regulation." (White, 1974:13).

According to McParland (1985), most of the devastating natural disasters would not have the same effect if people were more careful with their environment. In most cases, McParland continued, the environment, especially in the Third World, is prone to disasters by people trying to change the environment through over-cultivation. He cited the case of Sudan in 1983 when despite the encroaching of the Sahara over Sudan at the rate of 5km per year, the then president Jaafar Mohammed al Nimeiri, at the FAO annual conference, was advocating for over-cultivation and over-grazing in the afflicted areas. This was done under the nation's motto "AGRICULTURE AND MORE AGRICULTURE" (McParland, 1985: 3).

The review of literature on the definitions of drought, the research done, especially in Zambia and the cost of drought on a nation, makes clear the position of the nation and the implications in the face of a drought. These revelations make it imperative that a study of the characteristics of drought and its mitigation measures in the Gwembe Valley is done in-order to help identify key drought mitigation measures. Planning will then be based and action focused on the mitigation measures in-order to reduce the vulnerability of the local people to drought.

The chapter that follows discusses the study area in terms of location, size, accessibility, physical, social and economic characteristics.

CHAPTER 3: DESCRIPTION OF THE STUDY AREA

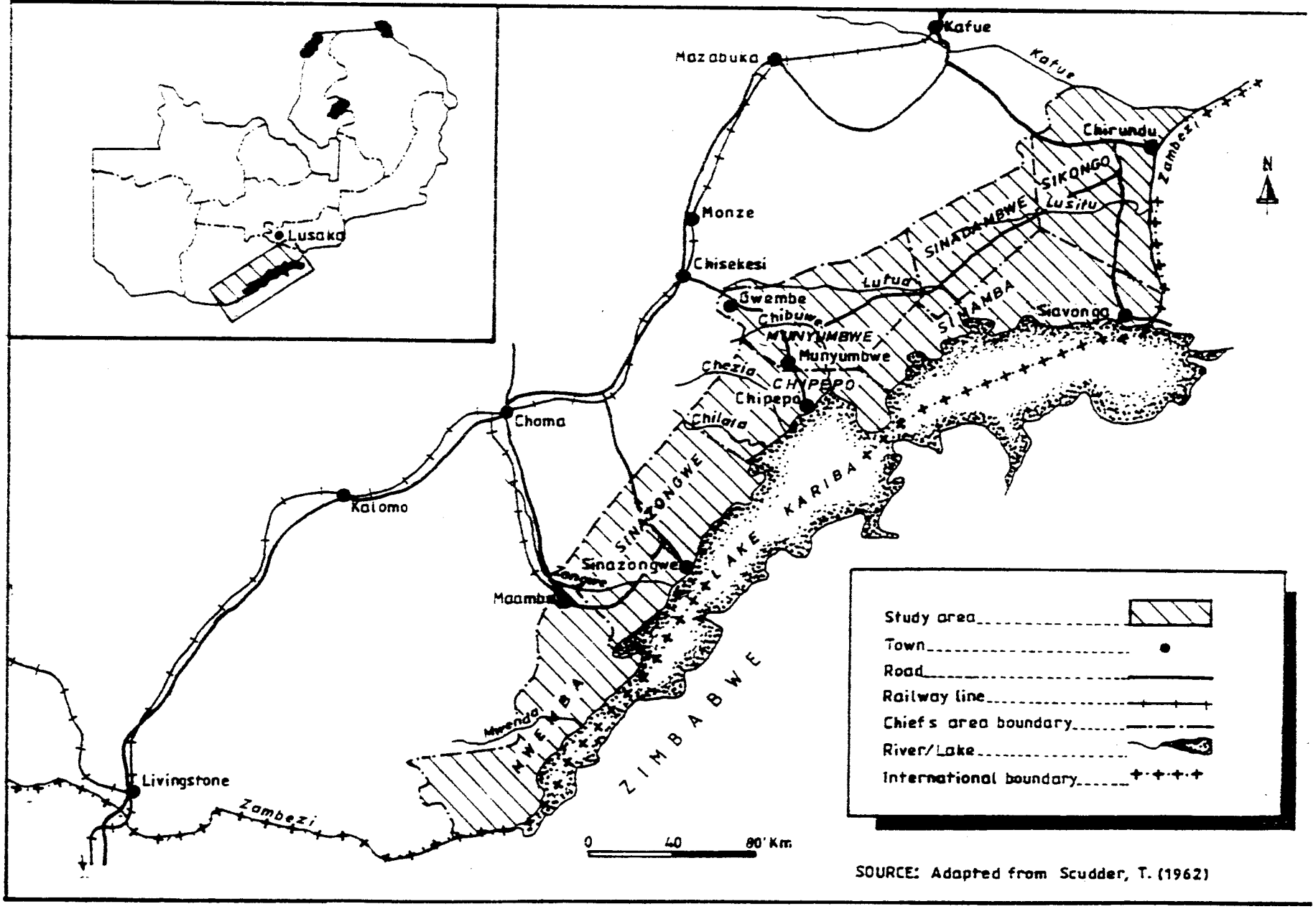
3.1 Location and size

The Gwembe Valley also known as the Middle Zambezi Valley lies between 27° and 29° East and stretches from 16° to 18° South. The area extends from the Batoka Gorge in the west to Kariba Gorge (or the Zambezi-Kafue confluence) in the east. It is about 265 km long and approximately 65 km in width at the widest point. The area is accessed from the road off the highway from Lusaka to Livingstone at Kafue, Chisekesi, Batoka Turn-off and Choma (Figure 1).

3.2 Physical Characteristics

3.2.1 Relief and Drainage

Gwembe Valley is essentially a hilly area. There is an escarpment near the plateau and a series of steeply sloping ridges often 300m to 400m high. Higher elevations range from 900m to 1200m while low-lying areas lie between 350m and 500m above sea-level. The low-lying areas were formerly part of the floodplain of the Mid-Zambezi River which are today occupied by Lake Kariba. Several rivers (formerly tributaries of the Zambezi River) flow into the lake. The Zongwe River is the only one of the tributaries, which is not seasonal (Money and Jackson, 1973; Muzumara, 1990).



SOURCE: Adapted from Scudder, T. (1962)

Before the alteration of the nature of the valley in 1958 by the construction of Lake Kariba, one of the largest man-made lakes in the world (5,250 km²) which was completed in 1962, Gair (1959) identified three physiographic zones in the valley, namely:

(1) an irregular belt of limited relief, approximately 5-13 km wide, at the foot of the scarp-zone and developed in the Karroo mudstone

(2) a more broken zone, 16-24 km wide separated from the first by a scarp feature, and comprised essentially of a series of cuesta features developed in Karroo sandstone,

(3) adjacent to the Zambezi, a zone of low-lying terrain with isolated hills, forms a narrow belt of about 25 km wide at its maximum.

3.2.2 Soils

Soils in the valley are varied and except for alluvia, soil types are closely related to underlying geological formations. Soils developed on Karroo rocks are the most extensive (Scudder, 1962).

There are three general categories of soil that Gair (1959) recognized. The first is the brown valley soils that are well drained and have their texture ranging from sandy-loam to sandy-clay-loam. Their physical character is underlined by a high content of magnesium, calcium and other minerals. Their clay is of the type which holds nutrients and potentially very fertile and can support a wide range of crops. The second type is the brown podzolic soils that are mainly sandy with a small amount of clay. These lack nutrients due to heavy leaching and are

generally poor for agriculture though they can support some crops such as bulrush-millet, sorghum and sweet potatoes. The third type of soil is the solonetzic soils ranging from dark-coloured clays, found in the Mopane woodlands, to grey sandy or loamy hardpan soils under grasslands. These soils are found in basin areas and pans and tend to be very compacted in nature perpetuating problems of root penetration and water-logging conditions. They also contain high sodium content. These soils are of little agricultural use.

3.2.3 Climate and Drought Situation

The climate of the Gwembe Valley is characterized by high uniform temperatures and varied rainfall. The mean temperature is about 21.7° C. The mean monthly maximum temperature during the summer months (October to December) ranges between 32° and 38°C, whereas June and July which are coolest is about 30° C. The most important single element of climate is rainfall. The distribution of rainfall in both space and time has a large influence on both animals and human lives and the prosperity of the area. Rainfall is generally low and unreliable. Rains are generally expected about mid-November and retreat by mid-March (Figure 2). The rainfall declines from north to south due to the fact that it lingers longer in the north by starting early and ending late. A season may be characterized by several dry spells of which some are localized while at other times the entire valley may be affected.

The reigning Meteorological Department's 30-year (1960-1990) mean annual rainfall for the valley is 750 mm as shown in Figure 3, the pattern being subjected and dictated by relief

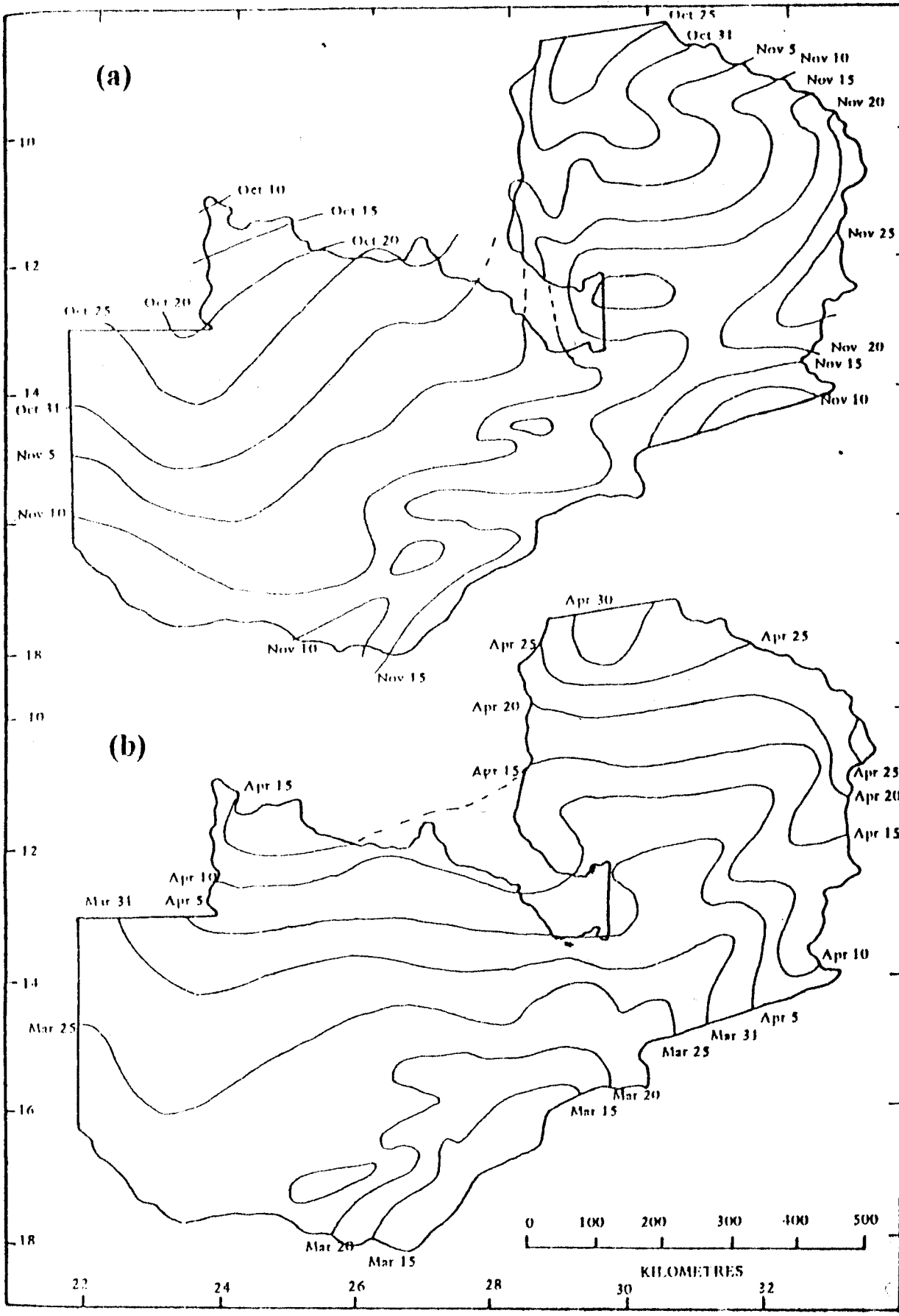


Figure 2: Maps showing (a) on-set of the wet season in Zambia and (b) retreat of the wet season Source Hutchinson (1974).

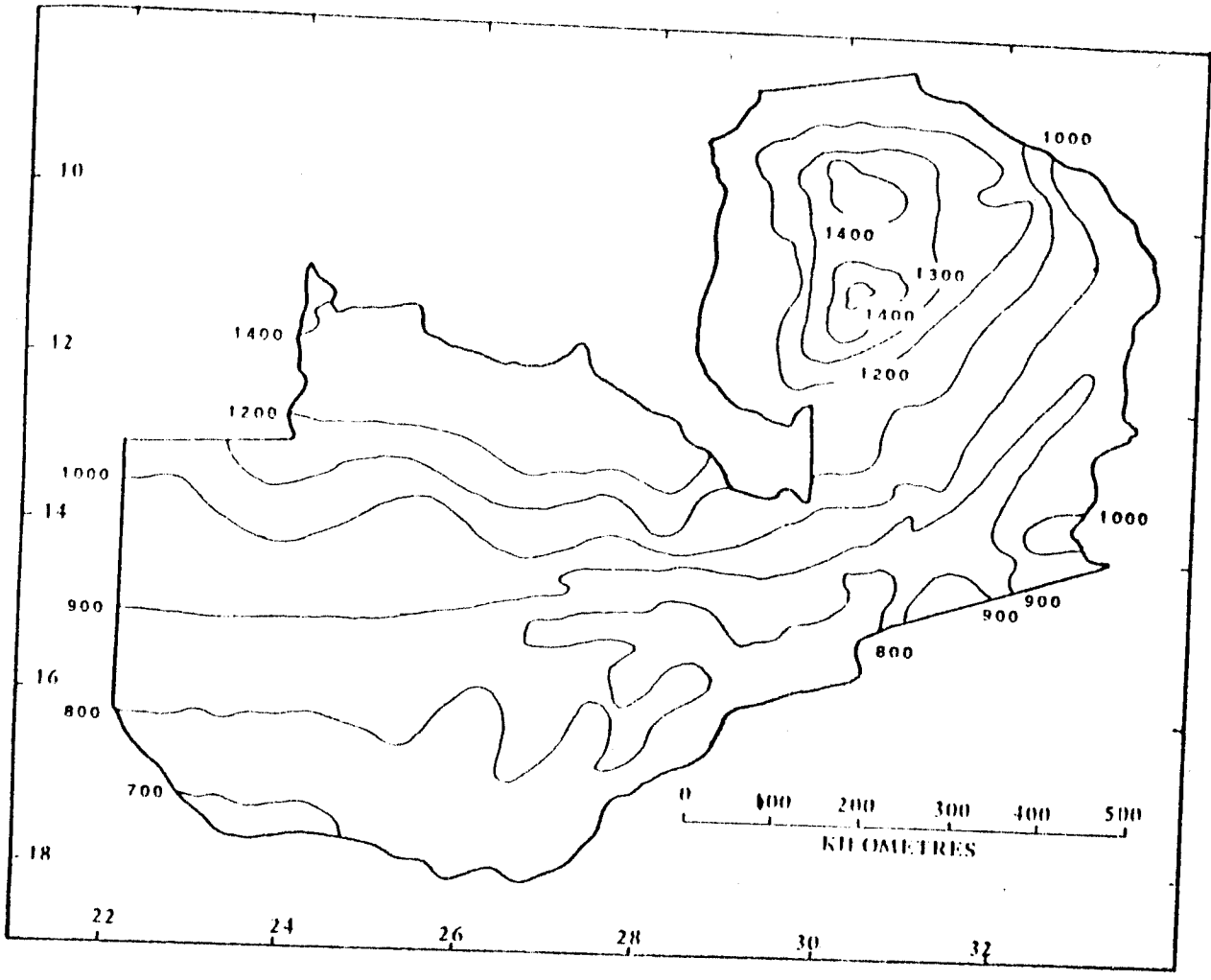


Figure 3: Mean Annual Rainfall (mm) in Zambia Source: Hutchinson (1974).

factors (Hutchinson, 1974). Hutchinson further stated that though the southern end of the valley suffers from the rain shadow effect, the formation of Lake Kariba has had some positive impacts on the rainfall in the surrounding areas, especially those very close to the lake, in inducing an increase in rainfall of not more than 10%. All in all, the valley is one of the droughts prone areas of the country and one of the driest, with a mean annual rainfall of less than 750 mm (Sichingabula, 1994a).

3.3 Social and Economic Characteristics

3.3.1 People of Gwembe Valley

According to Scudder (1962), the majority of the population found in the valley are Valley Tonga who are under the umbrella of seven chiefs: Mweemba and Sinazongwe to the south-west, Sikongo, Simamba and Sinadambwe to the north-east, while Munyumbwe and Chipepo are in the center. Currently, the area is divided into three districts namely Siavonga, Gwembe and Sinazongwe (Figure 4).

The origin of the Gwembe Valley Tonga people and the length of time they have lived in the valley are not known and there is no knowledge of any other homeland to them other than the Gwembe (Scudder,1962). Randles (1975), however, adds that the Batonga occupied the Zambezi Valley in the vicinity of the confluence of the Sanyati and Zambezi rivers, under the chieftain-ship of Netondo in the 16th Century. The Valley Tongas are essentially subsistence cultivators living in permanent or semi-permanent villages along the Zambezi River and its tributaries.

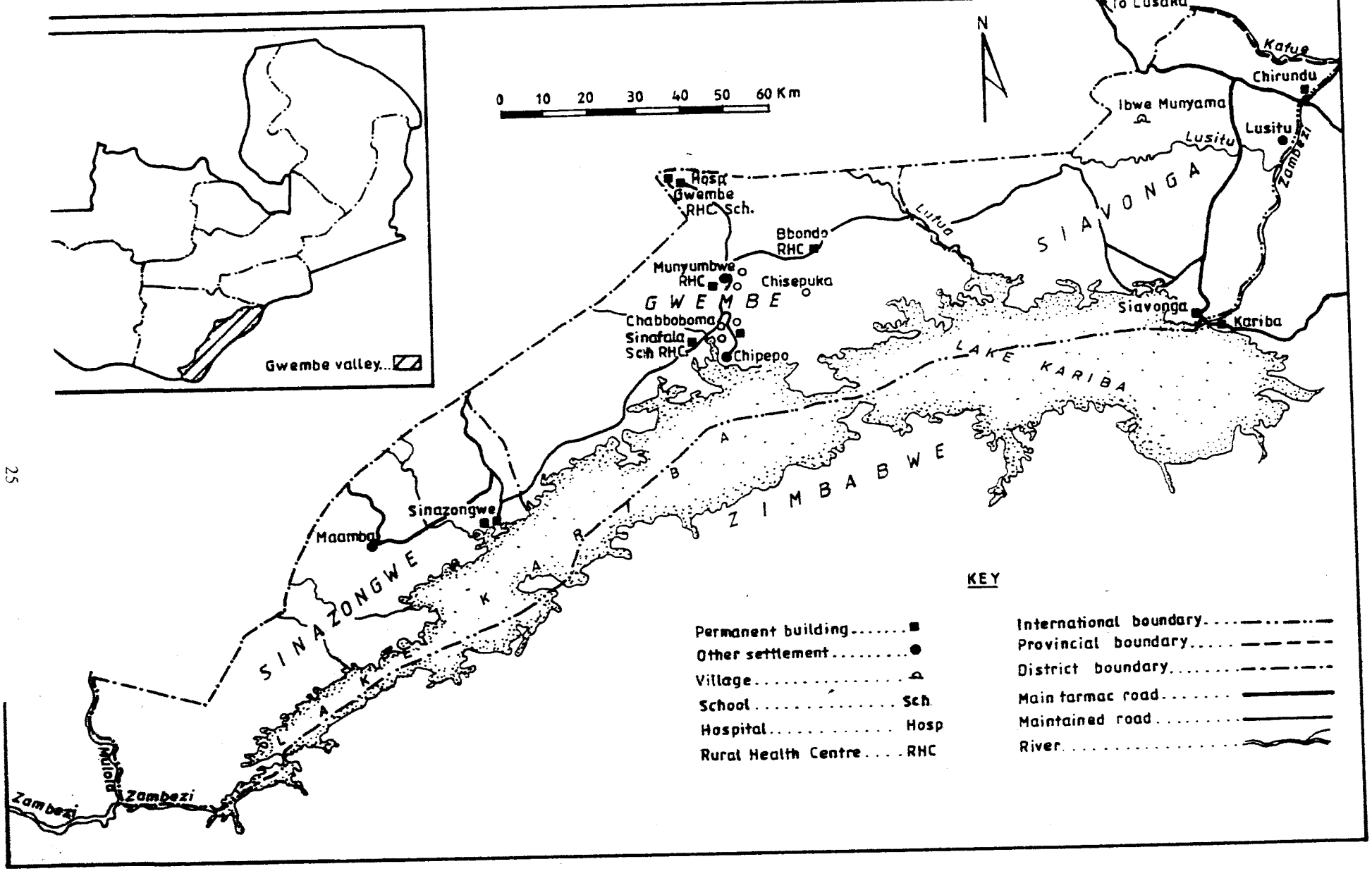


Figure 4 : The Gwembe Valley.

3.3.2 Agriculture

The Valley Tongas are primarily sedentary hoe-agriculturists whose subsistence economy is based on the cultivation of mainly three cereals: bulrush millet, sorghum and maize. A rainy-season crop, "inzembwe" (bulrush millet) was grown on well-drained sandy loams of either alluvial or Karroo origin. Planted just prior to the rains or immediately after their onset. It was harvested in February-March. "Maila" (sorghum) developed best in the heavy clay soils, sown several weeks after the rainy season started, the main variety being harvested in late April or in May, while "mapopwe" (maize), was planted both during the rainy season and during the dry season. This was done in the lower terrace alluvia that were annually inundated by the Zambezi and tributary floods.

Five types of gardens identified were: the "Jelele", a garden-land on the slopes; the "Kuti", a garden-land on flatland, the "Kalonga" (stream), a garden-land restricted to suitable locations in tributary beds, the "Unda", a rainy season garden and the "Temwa", a garden on an area of felled trees. Alas, the construction of the Kariba Dam in 1956-1959 brought in changes to this type of farming arrangement in the valley. About 57,000 people were displaced from the valley of the Zambezi River and were relocated in the upland areas to give way to the lake (GTDP, 1997). This movement away from areas along the Zambezi River which were annually inundated and allowed the people to cultivate crops three times per year, meant that the people could no longer do so as they now depended only on the rainy season.

Among livestock, sheep, goats, donkeys, pigs and cattle were kept and are still kept by the Gwembe Tonga but due to poor pasture and the presence of tsetse-flies, some areas in the valley have remained with no livestock, especially cattle.

3.3.3 Social Services

The local authorities, the district councils, make feeder roads. These roads are however in a state of disrepair and are impassable during rainy seasons. The main road from Gwembe to Chipepo via Munyumbwe is graded during the dry seasons but most parts get washed away during the rains due to water flowing down steep slopes.

By February, 2000, central Gwembe had several schools but only one hospital and five clinics. While Gwembe Hospital, Munyumbwe Health Center, Chabboboma Health Center, Sinafala Health Center, Chipepo Health Point and Chamwe Health Point were operational, Luumbo Bbondo and Lukonde were under construction (Figure 4).

The methodology of the study is explained in the next chapter.

CHAPTER 4: METHODOLOGY

4.1 Types and Sources of Data

Rainfall data used in drought determination was mainly from the Meteorological Department of Zambia for a number of stations that varied from time to time. For instance, according to Scudder (1962), chief boundaries before the lake were as follows: Chief Mweemba's area was covered by Kanchindu and Siameja; Chief Sinazongwe's area was covered by Sinazongwe; Chief Chipepo's area was covered by Sinafala, Chabboboma and Mazulu; Chief Munyumbwe's area was covered by Gwembe and Munyumbwe; Chief Sikongo's area was covered by Ibwe Mmunyama, Sikongo and Chirundu while Chief Simamba's area was covered by Kariba Station. At the time of writing this dissertation the picture had changed as most of the areas mentioned above were no longer collecting meteorological data.

The Meteorological Department did not compile data from stations that did not have most complete and reliable records. In some cases the Department obtained data from stations dispersed over the country. The Department believed that for general purposes one would not be far wrong in using the data of the nearest station, except for purposes demanding greater accuracy in which case one should consult the office.

The flow of data reaching the Meteorological Department from the valley was also erratic due to the fact that some stations were serviced by volunteers and interested persons who could not be strictly controlled in terms of data submission to the department. The rainfall data records at

the Meteorological Department in some cases went to as far back as 1948 (see Appendix I). The records up to 1970 were published while the data after 1970 has been compiled and put on the computer database in readiness for publication. This information is quite good and reliable to a great extent except in cases where there were too many gaps in the records.

Information on the history of drought was obtained from the Department of Agriculture, Water Affairs and the Meteorological Department and also from the local people. The official definition of drought that bases the thresh-hold at 750mm of rainfall per season was obtained from the Meteorological Department. The respondents (people who were involved in the study) were asked to give information on drought characteristics, the effects and impacts of drought and also on mitigation measures to drought.

Data collected through interviews and questionnaires though limited in nature, could be relied on especially that it came either from professionals or peasant farmers who were in most cases indigenous or had lived in the Gwembe Valley for a long period of time.

4.2 Methods and Procedure of Data Collection

Fieldwork formed the empirical data basis of the research. Field data collection was done from the month of September, 1999 to February 2000. The study used a combination of approaches to collect the required information. These were:

a) formal household survey approach which involved interviewing a stratified randomly

selected sample of sixty-six households. This was the main source of community based data on drought;

b) key-informant survey approach which involved interviewing headmen, members of the civic leadership and some specialists in particular aspects. This generated data of historical nature , mainly;

c) secondary-information survey approach which involved collecting and extracting data from offices concerned such as agriculture, education, health, etc. This supplied various types of data from historical to technical data ; and

d) field-observations that reinforced the various data collected from other approaches.

For the household-based information, a number of households were interviewed in selected villages. Any adult member of the selected household who was found at home at the time of the survey qualified as a respondent. The qualified respondent was free to consult other members of the household on different items in the questionnaire (see sample in Appendix II). Those who could read and write filled in the questionnaire on their own but those who could not read nor write were assisted by either one of the household members or the researcher.

In the key informant survey approach, particular departments or persons who were well versed with matters relating to drought or would give revealing information on drought were identified. Some of those who fell in this category were the Member of Parliament (M.P.) for Gwembe, District Council officials, Ward-Counselors, village headmen, teachers, health and agriculture personnel. A special set of questions (called interview guide) were asked in interview form and the responses noted down (see sample in Appendix III). These participants

were interviewed at their places of work. It is mainly from this group where data in booklets and pamphlets were also collected. The data collected is contained in Chapter 5.

Field observations revealed a lot concerning the state of the physical and social characteristics of the study area.

4.3 Sampling Methods

In order for the sample population to be more representative of the whole valley, it was drawn from the upland areas of Gwembe, the middle areas of Munyumbwe and the valley-floor in the Chipepo area, by the Lake Kariba. More than sixty-six persons involved in the study were drawn from eleven villages namely: Malambo, Chipepo, Siancheka (or Haancheka), Siabulowa, Simuyalali, Sinadambwe, Sialumya (or Haalumya), Siakalinda (or Haakalinda, a former part of Munyumbwe Village), Ulikonkezya, Cheelo and Haamuchiliba. The rest of the population sample, bringing the total to 80, composed of civil servants from government departments that were directly relevant to the study and the local authorities. The villages in an area were selected randomly with an inclination towards those near the road. This method of selection was due to transport constraint. Selection of households to participate in the survey was determined by the availability of the household owners.

While the area was demarcated in the three strata mentioned above this particular study did not go into looking at how different soils obtaining in each topographic area was affected by the drought situation but took a general overview.

4.4 Methods of Data analysis

To start with, the information obtained by both questionnaire and inter-view guide in Appendix II and III respectively were codified in a tabular-form according to the themes. In the case of information that needed quantification, the tally-marks process and a simple calculator was used to arrive at the statistics.

To show evidence of drought, climatological data obtained from the Meteorological Department was used. A quantitative approach of analysis was adopted. Data in Appendix I, for instance, was subjected to a run-test called a 'Wald-Wolfowiz'.

Since drought definition hinges on the deficit in the mean rainfall below the long-term mean, in this case the mean of 750mm, standardized departure from the mean were obtained by dividing the deviations by the series long-term mean as a ratio or percentage. The 'run-methodology' was used to find the duration, severity and magnitude of drought (Yevjevich, 1967). Duration of drought was given by the 'run-length' (time in years between successive failures (deficits) from 750mm rainfall) while severity was given by the 'run-total' (cumulative departure from 750mm rainfall). Drought magnitude for a given run-length was given by the 'run-intensity' (maximum departure from 750mm rainfall) (after Yevjevich, 1967). The assessment of drought impact on agriculture and water supply and indeed the aspect of appropriateness of mitigation measures were analyzed qualitatively. Agricultural drought was analyzed using aspects of long dry-spell in the rainy-season, 'shorter than usual' rainy-seasons.

The 'Magnitude-frequency' analysis of drought was conducted by plotting the lower extreme rainfall data on the Gumbel-Graph paper and by drawing the line of 'best-fit' from which recurrence interval and probabilities of occurrence of annual rainfall could be predicted (Dalrymple, 1960).

The next chapter discusses analysis and research findings.

CHAPTER 5: DATA ANALYSIS AND RESEARCH FINDINGS

5.1 Introduction

The chapter presents data analysis and research findings by discussing the basic characteristics of the population sample and drought characteristics. The findings are based on generic and not single episodes. Drought effects and drought mitigation measures adopted to reduce local peoples' vulnerability to drought are the major findings of the study.

5.2 Characteristics of Respondents

The sample population in this study composed of 80 persons. Of these, 60 were men while 20 were women giving the ratio of 3:1 in favour of men. This bias was as a result of local practices prevailing in the area. For instance, at households where men and women were found together, custom demanded that the man, as head of household, responded to any queries by strangers. At places of work the situation found was that the number of women was very low compared to their male counterparts.

The respondents in the study were mainly married persons except for a few who were living a single life after a divorce or being widowed. However, they were all responsible persons and were supporting families (Table 5.1).

Table 5.1: Marital Status of respondents

Marital Status	Upland	Middle	Valley-floor	%
Married	23	22	22	75
Single	0	1	1	2.5
Divorced	1	1	1	3.75
Widowed	2	3	3	10
Total	26	27	27	100

Source: Field data

The majority of the sample population has lived in the area since birth and the ages of the whole sample ranged from 21 to above 51 years (Tables 5.2 and 5.3).

Table 5.2: Period respondent has lived in the Gwembe Valley by 2000

Residence period in years	Upland	Middle	Valley-floor	%
1 to 10	5	4	4	16.25
11 to 20	3	2	4	11.25
21 to 30	0	6	1	8.75
31 to 41	1	0	0	1.25
Since birth	17	15	17	61.25
Total	26	27	26	100

Source: Field data

Table 5.3: Ages of respondents to the study of drought in the Gwembe Valley

Age	Upland	Middle	Valley-floor	%
21 to 30	5	6	5	20
31 to 40	10	10	11	38.8
41 to 50	6	7	7	25
51 and above	5	4	4	16.2
Total	26	27	27	100

Source: Field data

In terms of literacy levels, the sample population represented persons who had attained education above Grade 12 down to those who never went to school and are considered illiterate in terms of reading and writing (Table 5.4).

Table 5.4: Reported literacy levels of respondents to the study on drought in the Gwembe

Literacy level	Upland	Middle	Valley-floor	%
Could not read nor write	5	13	9	33.75
Formal schooling up to Grade 9 only	10	9	14	41.25
Formal schooling up to Grade 12	4	3	3	12.5
Formal schooling above Grade 12	7	2	1	12.5

Source: Field data

Most of the population sample comprised peasant farmers who in most cases combined two or

even three economic activities for meeting their daily food and other needs. Others were civil servants from government ministries (Table 5.5).

Table 5.5 Types of occupations respondents were engaged in

Occupation	Upper	Middle	Valley-floor
Farmer: Mixed farming and small business	2	1	1
Mixed farming and fishing	0	0	2
Mixed farming and black smith	0	1	0
Mixed farming only	5	10	13
Crop cultivation and small business	2	1	1
Crop cultivation only	3	6	4
Livestock keeping	0	1	0
Small business	2	0	0
Civil Servants: Agriculture personnel	0	6	0
Education personnel	0	4	0
Meteorology personnel	0	2	1
Water Affairs personnel	0	5	0
Health personnel	2	0	0
District council personnel	0	5	0
Total	16	42	22

Source: Field data

5.3 Settlement and Socio-economic Conditions

The Gwembe Valley comprises Siavonga, Gwembe and Sinazongwe districts. The populations (up to 1998) for the three districts were 55,210 (Siavonga), 62,563 (Gwembe) and 104,425 (Sinazongwe) giving a total of 222,198 (Appendix IV). The population is scattered across the valley with heavier concentration on limited flat land.

The next tables 5.6 and 5,7 show the problems and the type of agriculture people face and do.

Table 5.6 : Problems faced by people in the valley

Problem	Upland (%)	Middle (%)	Valley-floor (%)
Inadequate rains	20	14	10
Lack of resources	20	0	5
Poor land	10	0	0
Disease	5	0	5
Hunger	15	62	38
Transport	10	8	5
Other	20	16	37

Source: Field data

Table 5.7 : Agriculture of the people in the valley

(a) Major animals kept

Animal	Upland (%)	Middle (%)	Valley-floor (%)
Cattle	50	38	60
Goats	8	10	20
Pigs	2	0	5
Chickens	40	52	15

(b) Major crop planted

Crop	Upland (%)	Middle (%)	Valley-floor (%)
Maize	70	40	45
Sorghum	10	20	20
Groundnuts	10	8	10
Beans	5	2	5
Millet	5	30	20

Source: Field data

Inadequate rainfall, lack of resources and poor land came out strongly in the upland area of the valley while hunger was more highlighted by persons in the middle area of the valley (Table 5.6).

Cattle and chickens are kept throughout the valley while a larger population of goats and pigs were located in the valley floor (Table 5.7a).

The major crop planted in all the three strata of the valley is maize followed by millet, sorghum and groundnuts (Table 5.7b). People in all strata said they planted crops as soon as rains started.

For Gwembe District which is representative of the valley in this study, a number of observations were made. The district has a total of 1,261,000 ha. Of this, estimated land under cultivation was only 13,940, averaging 0.22 ha. per farmer as a large percentage of the land is hilly and suitable for cropping at small-scale level. The area with flat land was the one along the lake in Chief Chipepo's area.

Of the total population of Gwembe, about 55,000 (87.9%) was rural. The number of families was 6,419 classified according to different economic activities (Table 5.8)

Table 5.8: Type of farming establishment, number of farmers and area cultivated

Categories	Number	Cultivated Area (ha)
Small holders	6,409	9,316
Emergent farmers	10	4,315
Institutional Schools	22	11
Total	6,419	13,940

Source: DACO Hand-over Report (June, 1999)

The main crops grown are 'mapopwe' (maize), 'maila' (sorghum), 'inzembwe' (Bulrush- millet), 'mabele' (fingermillet), 'indongwe' (groundnuts), 'buluba' (cotton), 'chimbambwa' (beans), 'cimbwali' (sweet potatoes), sunflower and cassava. Plowing, sowing or planting of these crops was done in the months of November and December.

Livestock population and type (as at June 1999) for Gwembe was as shown in Table 5.9

Table 5.9: Number and type of livestock kept in the Gwembe District, June, 1999.

Livestock Type	Number
Cattle	51,831
Goats	22,381
Sheep	54
Fowls	18,032
Pigs	1,097
Donkeys	24

Source: DACO Hand-over Report (June,1999)

5.4 Drought Occurrence

Drought is said to occur if there is a deficit in the amount of rainfall expected.

Climatologically, and basing on the reigning official 30-year normal expected (1960-1990) rainfall in the valley per annum of 750mm, there was ample evidence of a shortfall in many years. Basing on the Gwembe Station with a more consistent record of rainfall since 1948, the drought frequency (number of years with rainfall less than the regional average of 750mm) was quite high. It was observed that there were 22 seasons with less than 750mm rainfall. Of these seasons, more than half occurred after 1980 (Appendix I and Figure 5.1). The annual rainfall departure from normal for season 1961/62 to 1998/99 indicated rainfall shortfalls of as much as - 400 mm (-53 %).

Results for the other stations could not be well compared for long periods as their records were not consistent and data had a lot of gaps. However, for short periods the situation for four stations for season 1972/73 to 1987/88 was as shown in Appendix V, representing Gwembe Boma, Lusitu, Sinazeze and Maamba. For this period the number of drought seasons are summarized in Table 5.10

Table 5.10: Number of drought seasons for Gwembe Boma, Lusitu, Maamba and Sinazeze in periods 1972 to 1980 and 1980 to 1988.

Period	Gwembe Boma	Lusitu	Maamba	Sinazeze
1972 to 1980	2	5	2	1
1980 to 1988	3	7	3	3

Source: Field data

The information in Table 5.10 indicates that the frequency of drought in Siavonga District

(represented by Lusitu) was much higher for both periods compared to the other two districts of Gwembe and Sinazongwe (represented by Gwembe Boma and Maamba, respectively).

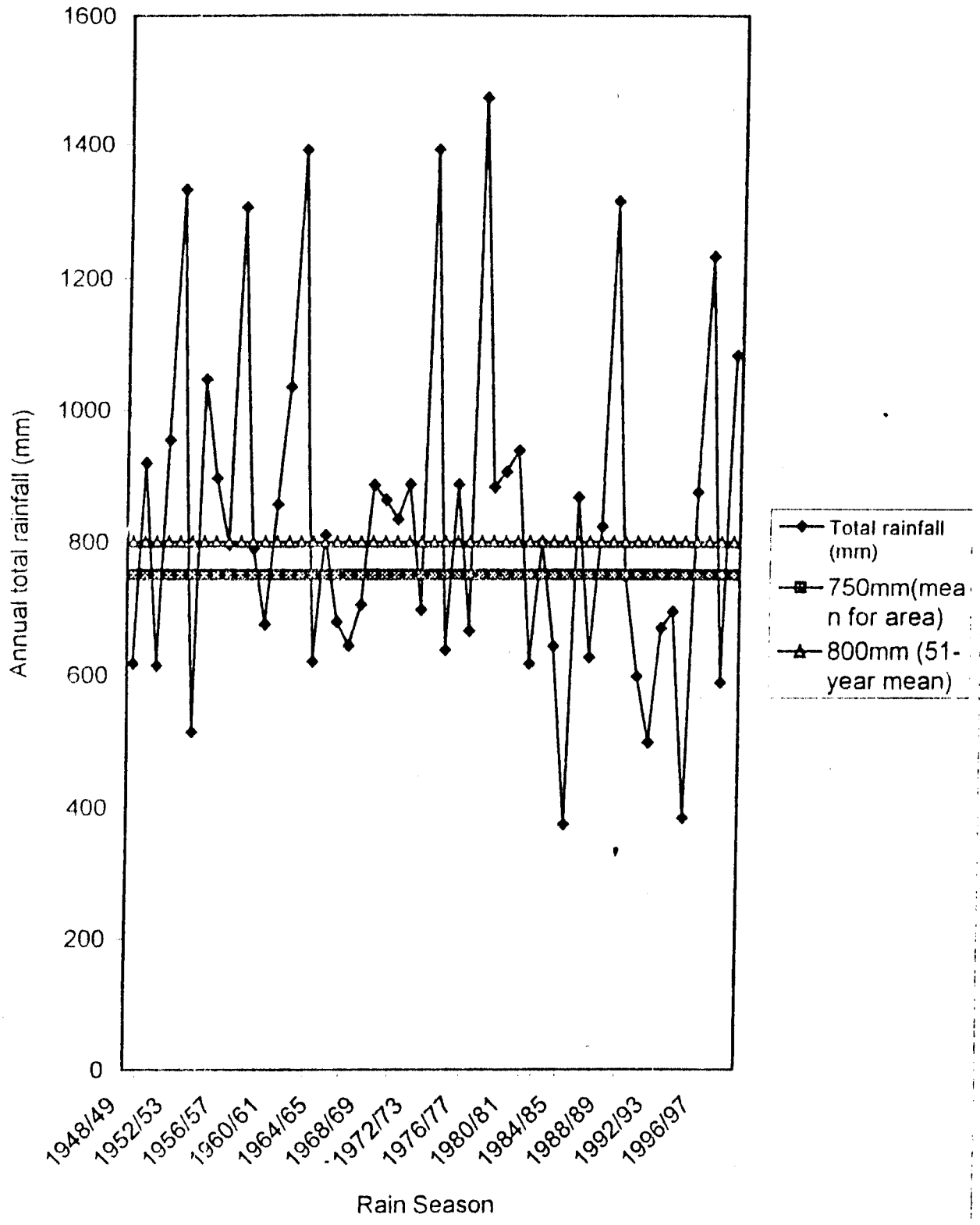


Figure 5.1: Gwembe station rainfall variation graph: 1948 to 1999

Climatologically, drought was also found to be more severe in the Siavonga District than in the other two, as shown by comparatively smaller precipitation figures recorded from Siavonga than from the other two districts during droughts (Appendix V).

Drought is also evidenced by long dry periods between rain days (Appendix VI). In Zambia 10-day periods called dekads are monitored by the Meteorological Department and any that receives less than 30mm rainfall in the period is taken to be undergoing a drought situation. The Appendix VII shows that such a situation was prevalent in the valley, especially when the dry dekads occur early in the growing season, in the months of November, December and sometimes January as this period is critical to farmers and any long dry spell led to crop failure.

Late start of enough rains ('planting-rains') is also an indication of drought occurrence. This may, however, not be so evident in some parts of the valley that rains started late as the records showed that rains started at the expected time (Appendix VIII). The Meteorological Department, however, has a way of detecting this by using aspects of 'enough planting rains' pegged at a 30mm rainfall-parameter. It was evident that from the time rains were expected in the valley (from about the10th of November), there were times when in the month of November, rains had started at all or when in that month 2 or 3 dry dekads could be observed. In some cases, the actual number of rain days (days receiving at-least 1mm rainfall) in the month could be as few as 3 only. This means that despite the fact that rains had started

not enough was received for farmers to sow their seed for the season. Otherwise there was an average of six dry dekads per season (Appendix VII).

Rainfall distribution is also another indicator of drought. For proper agriculture, most crops need steady rains for a relatively long period. The situation pertaining in the valley was such that in some cases only as few as 32 days received rainfall during a season (Appendix IX). There was no evidence of the rains being evenly distributed throughout a season. Many were the times when rains started later than expected and ended abruptly. During some months (even critical ones) only about 3 to 5 days received rainfall in a whole month.

5.4.1 Characteristics of Drought

According to the run-methodology drought duration is measured by the 'run-length'. A run-length is the time in years between successive failures from normal. For the Gwembe station, since the 1948/49 rain-season the longest climatological drought lasted 6 years from 1989 to 1995, a 3-year drought from 1965 to 1968 followed by another 2-year drought from 1983 to 1985. The records also showed that there were as many as ten 1-year droughts.

In the 'run-methodology', drought severity is measured by the 'run-total' (cumulative departure from normal rainfall for n-year droughts) while drought magnitude is measured by 'run-intensity' (maximum departure from the normal). Table 5.11 gives the summary results of the 'run-totals' and 'run-intensities' for Gwembe station for the most critical drought seasons during the period 1948 to 1999. The run-intensities were found by finding the cumulative rainfall departures from the normal expected for the particular n-year droughts while the run-totals

were found by getting the percentage cumulative departures from the expected normal for the n-year droughts concerned.

Table 5.11: Drought 'run-intensities' and 'run-totals' for Gwembe station for some n-year droughts in the period 1948 to 1999.

Seasons	Duration (years)	Run-intensities (mm)	'Run-Totals'
1965-1968	3	-223	-0.0991
1983-1985	2	-485	-0.3233
1989-1995	6	-913	-0.2029
1984-1985	1	-377	-0.5026
1994-1995	1	-367	-0.4893

Source: Field data

It was observed that during the period in question (1948-1999) single-year drought magnitudes were very big. In some cases, like the 1984/85 and 1994/95 seasons, the magnitudes were almost half the expected normal rainfall. Similarly, single-year run-totals indices were higher than those for cumulative years (e.g. –0.5026 for 1984-1985 season and –0.4893 for 1994-1995 season, compared to –0.3233 for 1983-1985 season, -0.2029 for 1989-1995 season and –0.0991 for 1989-1995 season.

By calculating the statistical (or probability) of a likelihood of precipitation occurring in any given rainy season of the year, using the formula:

Probability (%) = (Number of rainy-days) / (Number of days in the rainy-season),

the probability of dry days could be arrived at. The probability of dry days in the valley for the period 1993 to 1999 for Gwembe and Chipepo (see Appendix IX) was found to range from 33.6 to 73.44 % of the time of any year. Corresponding probabilities of dry days for Gwembe were 61.82, 66.8, 44.39, 33.6, 73.44, and 39.41 %, respectively. For Chipepo for the same period the probabilities of dry days were 67.63, 70.95, 51.86, 42.73, 57.67 and 45.22 %, respectively.

Using the information for Gwembe station rainfall, for the period 1948 to 1998, a magnitude-frequency approach was used for purposes of drought prediction (Figure 5.2). In this approach, the recurrence interval of a particular amount of rainfall on the y-axis of the graph could be obtained by reading the corresponding value of its recurrence on the x-axis of the graph. For the 50-year period considered, it was found that the least amount of rainfall of 373mm, signifying the severest climatological-drought, had a recurrence interval of 80 years. The probability of drought occurrence could then be found by the formula:

$$P\ (\%) = 1 / T,$$

where T is recurrence-interval. In this case, the probability of annual rainfall of 373mm was 0.0125 (1.25 %).

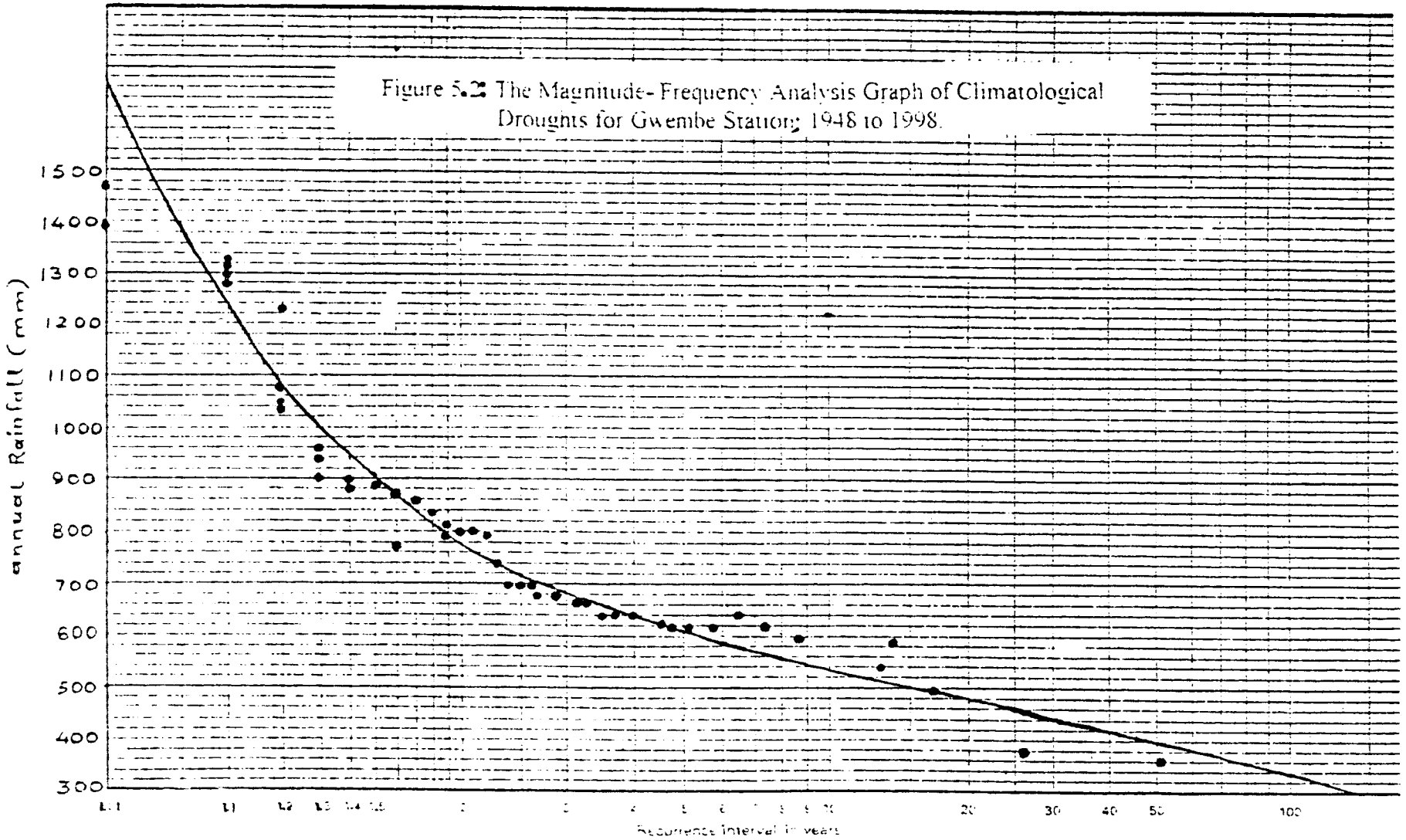


Figure 5.2: The Magnitude- Frequency Analysis Graph of Climatological Droughts for Gwembe Station; 1948 to 1998.

A 'Runs test, also called 'WALD-WOLFOWITZ test: one sample study', was done in-order to establish whether occurrence of droughts at Gwembe was random or had a particular pattern. A Null Hypothesis (Ho) stated that drought occurrence in the two time periods 1948 to 1980 and 1980 to 1999 was random while the Alternative Hypotheses (H1) stated that drought occurrence in the two periods had a specific pattern. Accordingly, the assumptions taken were that the elements of the sample were independently sampled and the scale of measurement was at-least nominal. The 'Decision-Rules' (for small size sample) was that the confidence interval is determined by both Appendices X: A (for the lower critical value) and B (for the higher critical value). The H0 would not be rejected only if the observed value lie between the critical values (for a small sample). The counted number of runs gives the observed value. In the computations that followed for Gwembe (see Appendix IV for data) with runs n 1 =18, n 2 =11, the observed value of 22 was found. Using the Tables of Critical Values of 'r' in the 'Runs Test' (see Appendix X), the following decision and conclusion were made: the lower limit was 9 and the upper limit was 20. Since observed value of 22 did not fall between the critical values (lower and upper limits), Ho was rejected and H1 was accepted. The conclusion was that there was a specific pattern of drought occurrence at Gwembe in the two periods considered. It was not in the scope of this study to establish the actual pattern of drought and hence this was left out for future studies.

5.4.2 The Nature and Causes of Recent Droughts

While a late start followed by an early retreat of rains would result in drought as outlined by Hutchinson (1974), the nature of recent droughts in the area have not been a result of late start of rains or it's early retreat. Except for the 1983/84 season, most started and ended at expected times, a period long enough to avoid agricultural and meteorological drought as evidenced in Appendix VIII. The droughts which are caused by uneven rainfall distribution seem to dominate.

The maximum number of rain days per month and per season for Chipepo and Gwembe stations for the seasons 1993/94 to 1998/99 are shown in Appendix IX. Chipepo in each case had fewer rain days compared to Gwembe Boma but in both cases for the majority of months, the rainy days were fewer than 15. The total number of rain days per season lay between 35 and 80. Appendix VII shows the monthly rainfall totals specifying the actual days in a month which have been considered for each particular month and showing dry dekads (<30mm) (Meteorological Department, 1999).

5.5 Impacts of Droughts Since 1980

5.5.1 General Effects

From the responses of the people in the valley, a number of general effects of drought identified included hunger and starvation as crops withered before maturing and livestock died due to lack of adequate water (Table 5.12).

Table 5:12 Number of Cattle losses in selected villages in Gwembe Valley, 1992

Village	Cattle Owned	Cattle Died	Cattle Sold	Cattle Stolen	Cattle Left
Munyumbwe	285	94	26	4	161
Nakanjele	598	185	71	0	342
Sinazeze	1554	119	954	13	468
Sinazongwe	581	364	34	0	183
Totals	3018	762	1085	17	1154

Source: Adapted from Tiffen and Mulele (1994)

The wealth of the people reduced through sale of personal property. Additionally, sources of water dried up completely or had yields decreased (Table 5.13) and caused lack of water for domestic use and livestock. Other types of vegetation also got affected causing a number of

both domestic and wild animals to reduce drastically due to lack of proper pasture and water. Sometimes when water levels in dams were very low, animals got stuck in the mud. People covered long distances to find water and queued for long hours to fill containers due to congestion. This increased the risk of water contamination. It was also found that prices of water went up due to high maintenance cost of pumps which kept breaking down due to long hours of operation. The Government response was to look for alternatives by digging deep wells in aquifers. The local authorities also pointed out that while all areas in the valley were affected by drought, in the case of Gwembe District, areas around Fumbo were hit hardest compared to Chamwe and Bbondo.

Table 5.13: Crop production in 1990/91 and 1991/92 Season in Southern Province (tons)

Crop	1990/1991	1991/1992	% Change
Maize	187,507	25,215	-86.55
Sorghum	5,357	136	-97.46
Irrigated Wheat	18,891	13,150	-9.12
Mixed Beans	15	11	-26.70
Groundnuts	4,008	2,906	-27.50
Seed Cotton	9,899	4,639	-54.15
Soya Beans	4,910	2,630	-46.44

Source: Adapted from Tiffen and Mulele (1994)

5.5.2 Drought Impact on Incomes and Food

The people in the area reported that increased livestock deaths led to income losses. This was not however supported by any data. It was also said that drought generally reduced incomes particularly for the poor and women since several of their sources depended on water such as sales of beer, vegetable and bricks. Incomes tended to fall because drought reduced overall demand as villagers increased their net expenditure on food and had less money for non-food items. The people also lamented the fact that drought reduced remittances from relatives and friends living in towns since they were also affected by the increased food prices.

Drought also affected other sources of food in that vegetation and wild fruits withered. Numbers of wild animals (game) and fish catches decreased. This too was not backed by data. Drought reduced the food poorer villagers obtained from working on the land of richer farmers whose harvests also failed and it cut the amount of food received as gifts.

5.5.3 Drought Effects on Health

In the study it was found that drought affected household water quality and the health of the people (Table 2.1). Due to water scarcity people were forced to obtain some water from contaminated sources such as muddy holes in the ground or dam which in most cases was

shared with livestock and game. This was feared would lead to water-related diseases such as diarrhea, dysentery, and cholera.

5.5.4 Drought Effects on Education

In times of drought, the then Gwembe District Inspector of Schools (Mr. W. Imasiku) pointed out that schools were turned into food distribution centres. This development brought in an atmosphere that was not conducive to learning. In the event where teachers were involved in relief food distribution, it disrupted the smooth running of the schools as the activity affected the concentration of both teachers and pupils. He further said, enrolment and class attendance became erratic due to increased need for family labour. Unfortunately he had no data pertaining to this aspect. He said some pupils, especially girls, spent most of their time helping their mothers fetching water from distant water-points and gathering wild fruits while the boys helped their fathers further afield looking for water and grazing livestock. Sometimes school going children were simply detained at home to help look after younger children when their parents were away looking for food. The erratic attendance of classes by pupils during drought times often led to poor performance. Additionally, teaching hours dropped as teachers spent more time looking for food.

Increase in expenditure on food during drought meant that families could not afford school fees and this was found to be a factor leading to an increase in school dropouts, a majority of whom are girls.

5.6 Drought Mitigation Measures

5.6.1 Individuals and Local Communities

In the next table is an outline of measures people take in the face of drought.

Table 5.14 : Measures Taken During Drought by Individuals

Measure	Upland (%)	Middle (%)	Valley-floor (%)
Buying food	5	0	0
Gardening	20	20	30
Planting early maturing seed variety	0	10	0
Fishing	0	8	15
Small business	25	32	45
Work for food	10	14	5
Do nothing	40	16	5

Source: Field data

Various responses were given by the sample population to the question 'What measures do you take to combat drought?'. Only people in the upland stratum said they buy food (possibly because they are near the line of rail). Gardening was practiced throughout the valley with more concentration in the valley-floor and so is fishing. The biggest number in all the strata said they involved themselves in running small businesses through buying and selling different goods and items. Among some things sold were fowls and small stock like goats, pigs and cattle. They sold these to urban areas as a way of raising money to buy maize. Those who could not source money to start businesses and had no animals to sale collected firewood and wild fruits for sale. A few depended on handcraft skills making such items as fishing-nets, hoes and

spears for sale. More people in the upland stratum said they 'did nothing' while the middle stratum led in the number of people who worked for food in addition to doing 'odd-jobs'.

Answering to a question on what measures would be appropriate for combating drought, planting early using the 'pot-holing' method was suggested. This method entails making a sizeable 'pot-hole' in the ground so that water collects in it for seed to have adequate moisture. The respondents also said there was need to plant a variety of drought resistant crops as well as using early maturing seed varieties. Sorghum and millet were specifically given by the middle-valley people as being ideal for drought situations. Another response emphasized the need to store up enough food in times of good rains. Raring pigs of local breed was to some another good idea as they said it would add to enriching the diet during drought when these pigs would be slaughtered for food and for sale. Others still advocated getting loans for irrigation and inputs such as fertilizers and seed.

Everyone, however, seemed to know that drought could not be stopped but could be mitigated by adopting the measures they were suggesting. It should be noted here that no new strategies of combating drought have emerged either by individuals or groups over the 50 years since re-location except for intensive research in drought resistant seed varieties.

5.6.2 Non-Governmental Organizations (NGOs)

The measures undertaken by different NGOs to combat drought are shown in Table 5.15.

Table 5.15: Drought mitigation measures taken by various NGOs

	Measures against drought adopted	NGO involved
1	Digging wells and bore-holes in villages and in Schools since 1998	The WVI ,The Gossinner Mission and the Catholic Church
2	Distributing food aid such as maize and sorghum to drought affected communities in the area	PAM, WVI, the Zambia Red Cross Society and the Evangelical Fellowships of Zambia
3	Maintaining Roads; building schools, clinics and toilets in villages	The WVI and the Zambia Red Cross Society
4	Training in community health of local people	The WVI

Source: Field data

The digging of wells and bore-holes provided water for drinking and saved the people from thirst and enabled them to continue with those economic activities which helped them economically, such as beer brewing. The food distributed cushioned the people from hunger and starvation. Maintained roads facilitated transport and sped up the delivery of food to needy people during droughts. Training in health helped people to be aware of what to do in times of drought, which is often accompanied by various nutritionally related diseases. All these measures help in the reduction of vulnerability of people to drought impacts.

5.6.3 Local Authorities

The local authorities through the District Secretary at Munyumbwe, in the Gwembe District pointed out that during droughts they were involved in identifying food deficit areas, soliciting for food through the central government and helping with relief food distribution. In conjunction with the Ministry of Agriculture personnel, the local people were taught the appropriate methods of farming and inputs required for drought situations and were encouraged to grow drought resistant crops and cash crops such as cotton. The local authorities were also involved in the re-sale of some maize at reduced prices.

The local authorities also were involved in making feeder roads for accessibility to many places in the valley.

5.6.4 Zambian Government

The Zambian government in a bid to combat drought in the area had embarked on digging wells and bore-holes for villagers. There were 101 water points in Gwembe and 98 in Siavonga by August 1997 and 187 in Sinazongwe by December 1996, giving the total of 386 water points (Table 5.16). Of these water-points, 298 (77.2 %) were dug by the government, 64 (16.6 %) by different NGOs and 24 (6.2 %) by the local communities.

Table 5.16: Water Points in the Gwembe Valley, August, 1997.

Type of water supply	Gwembe		Siavonga		Sinazongwe	
	In use	Not in use	In use	Not in use	In use	Not in use
Hand-dug well with bucket and windlas	17	15	9	36	47	51
Bore-hole with hand-pumps	60	8	28	25	48	33
Hand-dug well with hand-pump	1	0	-	-	2	1
Tube-well with bucket and windlass	-	-	-	-	0	1
Hand-dug well with wind-mill	-	-	-	-	2	2
Sub-total	78	23	37	61	99	88
Total	101		98		187	

Source: National WASHE (2000)

The government has created the National Early Warning Unit in Lusaka composed of the Central Statistical Office, the MAFF and the Meteorological Department. The purpose of the unit is to give advance warning, especially to farmers, of what is expected in terms of rainfall through monitoring of the weather, forecasting availability of food at the national level, including crop forecasts, storage levels, anticipated inputs and exports (GRZ, 1997). The unit also promotes the use of early maturing variety crops for farmers as a precaution for drought in the area

From the MAFF offices in the area, suggestions for combating droughts by government included training more veterinary officers to save animals from diseases, subsidizing agricultural in-puts, availing loans to farmers for seed, fertilizers and equipment giving both maize-seed and fertilizers as aid instead of giving food-aid alone. They also urged government to be sending farming in-puts in good time and providing farmers with early maturing seed varieties.

Another point emphasized by the MAFF personnel was that of investing in water conservation by increasing the number of water harvesting points such as dams, bore-holes and wells by rehabilitating old as well as dig new ones. As can be seen from Table 5.16, in most cases the government just initiated water points but did not rehabilitate those that broke down.

On the mode of food distribution, it was suggested that while government should continue with food aid, there was need to bring food distribution depots nearer to the people who are affected. They married the issue of food distribution to road maintenance to enable easy access to needy areas during drought times.

Lastly, it was suggested that a ready market for agricultural produce and livestock be established. This, however, could not be possible, as the prevailing policy was market liberalization.

5.7 Summary

As indicated in Tables 5.1 to 5.7 the research findings show that the sample in the study composed of both men and women from various walks of life. In Table 5.1 the marital status of a person was not seen as a hindrance to participate in the study. Tables 5.2 to 5.5 show the period of time these people lived in the area, their ages and a fact that most of them came from a humble education background but were actively engaged in subsistence farming and also in small businesses. Tables 5.6 and 5.7 are depicting the problems these people faced and the agriculture they have embarked on and this is shown in the various strata the area was divided in. All these were incorporated in-order to make the sample more representative. The Gwembe Valley which comprised Siavonga, Gwembe and Sinazongwe districts was represented by Gwembe which was central and had all the three main physiographic relief features of the valley namely the upland scarp-zone, the middle-zone comprising a series of cuesta features and the low-lying terrain.

The valley is a chronic drought area. The nature of drought is diverse and encompasses agricultural, climatological and hydrological droughts. Among the drought characteristics observed was the existence of a few long droughts with the longest lasting 6 years while the most common were single-season droughts. The severity (run-total) values were in some cases as high as -50.26 % with magnitude as big as half the expected normal rainfall. The frequency of drought was high with the probability of dry-days (per season) ranging from 33.6 to 73.44 %. Further more, the observed droughts suggested some sort of a none-random pattern of

occurrence. The impacts of the droughts included hunger and starvation as crops and livestock died while crops withered before maturing due to lack of adequate moisture. Increased livestock deaths led to income losses and reduction to area planted and smaller harvests. The droughts adversely affected health and education.

A number of mitigation measures to drought were suggested and addressed different categories of people. Some measures pertaining to individuals championed planting early-maturing crops and those that were drought resistant. The non-governmental organizations and the government were urged to increase digging wells and dams, among other things. One major problem identified against government was procrastination in implementation of mitigation measures to the extent that some good measures were over-taken by time.

The next chapter discusses findings of the study

CHAPTER 6: DISCUSSION

6.1 Introduction

In-order to highlight the different aspects of drought experienced in the Gwembe Valley, the chapter starts with a section on the characteristics of drought in the valley. The next section discusses the impact of drought on the people, with special focus on agriculture and water supply. Thereafter the mitigation measures that have been adopted to reduce the vulnerability of local people to drought are discussed. The chapter closes with an outline of implications on each aspect studied.

6.2 History and Characteristics of Drought

Analytical results revealed that in the valley, climatological droughts of different n-years occurred in Zambia's history. Using the 'normal' rainfall (750mm) given by the Meteorological Department for the period 1960 to 1990 for the three districts of the valley (Gwembe, Siavonga and Sinazongwe) there were 22 identified drought seasons. A comparison of two periods of equal length, e.g. 1961/62 to 1979/80 and 1980/81 to 1998/99 revealed that the period before 1980 had relatively fewer drought seasons than the period after 1980. Nicholson and Entekhabi (1986) confirm that during the 1980s wet years have been rare and drought has been the norm for most of the continent of Africa. They pinpoint that Zambia is one of the countries severely

affected by drought. For instance, for the Gwembe Station there were only seven droughts in the period before 1980 compared to eleven after. This agreed with the study hypothesis that states that there were more droughts experienced after 1980. Actual rainfall deficit from the normal during drought years ranged from 4 to 377mm, indicating a deficit of up to -50.26 %.

Another characteristic observed was that drought was quite frequent occurring at the rate of, at-least, a drought every two years on average. Some droughts were quite severe with run-total indices of the most severe droughts ranging from -9.91 to -50.26 %. In some cases, for example, as little as 373mm of rainfall was received from the expected 750mm. This often resulted in traumatic damage done in the field of agriculture where the harvests were adversely affected. There was a lot of misery caused in the water supply sector too. At times the drought occurred concurrently for several years like what happened between 1989 and 1995. However, one-year droughts were the most frequent. Frequency of drought in the valley was much higher in the Lusitu area of the Siavonga district compared to Gwembe and Sinazongwe districts, in the ratio 12: 5: 5, respectively (see Table 5.10).

The two main types of droughts in the valley were found to be agricultural and climatological. The severity of climatological droughts highlighted by cumulative departure from normal rainfall for n-year droughts listed in the order of severity, starting with the most severe:

1984/85 (-50.26%), 1994/95 (-48.93%), 1991/92 (-33.46%), 1983-1985 (-32.33%), 1953/54 (-31.33%), 1997/98 (-21.60%), and 1990/91 (-20.40%). From this, there is an indication that the most severe droughts occurred after 1980, and this too, agrees with the hypothesis of the study stating that the droughts were more severe after 1980. In some instances, like the 1991/92 season, the duration of the rainy-season or its magnitude was not so much an issue of drought severity. But, as Hulme (1993) noted, became so when a normal season suffered from insufficient 'planting rains' at the beginning of the season resulting into farmers sowing their seeds late. This then affected crops, as they did not have enough moisture at the time the rains ended, especially if the crops were not early maturing.

Presently, prediction of drought is not very reliable. If it were, it would serve as an important aspect of mitigation as it would instill in people a state of preparedness, to forestall the adverse effects of severe droughts. For now, "there is no fool-proof technique for prediction and so the search continues" (Oguntoyinbo, 1986: 88). Literature states that prediction of rainfall in Africa or elsewhere is only reliable for short periods of time (Nicholson, 1987). The 'run-test' revealed that drought in the Gwembe was set on some particular pattern, (though this is not the scope of this particular research), and the magnitude frequency analysis results obtained just gives us the probability of drought occurrence but not a clue as to when it may occur. This is because a prediction is not a forecast. The analysis, however, points to the fact that at-least the drought occurrence in the area is not random. It is therefore imperative that this pattern is established by the DMMU or any other interested parties as the knowledge would serve as an indicator of what is expected, though it may not be exact.

The above discussion on drought revealed that drought is a reality and is manifested in the area, especially through its impacts.

6.3 Impacts of Drought

6.3.1 Agriculture and Food Security

From the survey done in the valley it was evident that agriculture was adversely affected by the occurrence of drought. The valley was found to be one of the areas in the country which always produced less than the needed food for annual consumption and so had to be supplemented with food from outside the area by traders from within and outside the district. The out-going District Agricultural Coordinator (DACO) who attributed this grain shortfall to insufficient rainfall suggests this evidence in the hand-over report of Gwembe District (June 1999). The insufficient rains were the causes of crop failure in form of stunted growth of crops or crops wilting, altogether, before maturing time. This invariably ushered in the situation where there was no household food security for the majority of the people in the valley. The chain reaction of poor food harvest was that there was a shortage of food pushing the prices out of reach for many. For instance at the time of the survey (in October, 1999) a tin of 2.5 litres of maize was selling at K6,000 at Soweto market in Lusaka while the same was going at K8,500 in Munyumbwe and K9,000 in Chipepo. This triggered hunger and starvation to many resulting in the increase of nutritionally related diseases such as cholera and dysentery (Tiffen and Mulele, 1994).

The DACO (June 1999) also alluded to reduction in the area planted which in turn resulted in smaller harvests. This behaviour was taken as people did not have enough time to cultivate since most times they were busy looking for food and some did not have enough strength to work bigger pieces of land and others still for fear of wasting their effort due to inadequate rainfall.

Due to the fact that some farmers planted their maize immediately the first rains fell, some wasted their input (seeds and fertilizer) due to droughts that came thereafter. This discouraged them so much that only a few repeated the exercise due to either lack of more input or for fear of the uncertain rains.

The whole discussion above simply explains just how drought affected agriculture as per the requirement of the second objective, which requires an assessment of the impact of droughts on agriculture.

6.3.2 Water Supply

The major effect of drought on water supply was the crippling result of sources of water drying up completely or having yields decreasing causing lack of adequate water. The result of this on people in the valley was that there was no adequate water for domestic uses such as drinking, cooking and washing. There was also no adequate water for social and economic ventures such as beer brewing, making pots and bricks. All these made life very difficult for people and it gave them no option but to cover long distances to look for water and often times they found themselves queuing up for long hours at sources which still had some water. For people who received protected water from pumps there was a rise in water rates and cost due to maintenance of pumps which kept malfunctioning due to long hours of operation. As a result of these faults, 172 (44.6 %) of the water-points in the area were out of use (Figure 6). Due to the water problem in the area it is imperative that the government should source for more money to enable it to continue the exercise of providing more water points and to dig deeper wells in aquifers while the shallow wells should be made deeper.

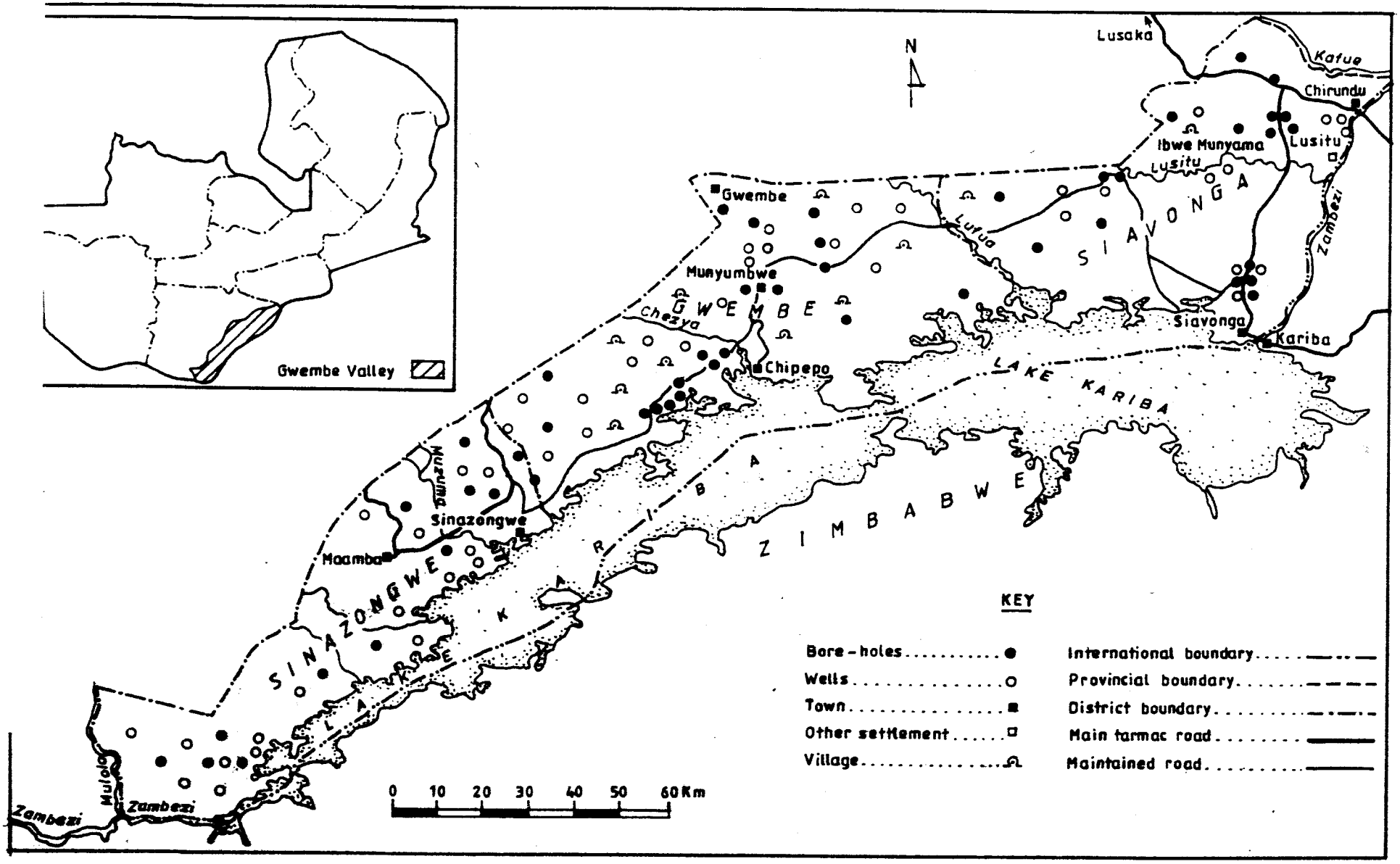


Figure 6 : Distribution of Wells and Bore-holes in Gwembe Valley, 1997.

6.3.3 Livestock

The drought effects of water supply did not only affect people but animals too. The number of domestic animals drastically reduced due to lack of proper pasture and water for drinking. For instance, cattle losses due to drought induced deaths in 1992, from four villages in the valley, accounted for 25.2% while the fear of losing more cattle in the wake of a persistent drought led to cattle-sales standing at 36% (Table 5.12). Even though the traditional attitude to keeping livestock is for social esteem, the modern world of market economy would benefit livestock owners as a source of cash to survive on.

When water levels in dams got really low some animals such as cattle and goats got stuck in mud in their search for water. This was another way in which drought impacted agriculture.
It is clear that the second hypothesis that suggests that the impact of drought was more after 1980 was true as it was supported by both supporting literature and analysis of data.

6.3.4 Some Implications on the Impact of Drought on Agriculture and Water-supply

Reduction in agricultural output would affect other productive sectors that are linked to it. For instance, frequent droughts would reduce the number of livestock due to lack of adequate pasture leading to livestock deaths (Table 5.12). Livestock deaths would then lead to a reduction in the area planted due to a reduction in the number of oxen used for plowing and this would consequently lead to even smaller harvest. Small harvests would entail reductions in agricultural export and substantial percentage decline in the Gross Domestic Product (GDP) of the nation (GRZ, 1999) and cause depressed demand leading to reduction in consumption and investment.

The increased use of fewer sources of water as depicted in Table 5.15 is another source of worry as it would cause easy contamination of water.

6.4 Mitigation Measures Pertaining to Government

6.4.1 Institutional Arrangements

The effects of drought in Zambia have affected the national economy adversely as already alluded to in Section 2.6, and also undermined the livelihoods of households in rural areas. To enhance the capabilities of farmers, agriculturists, agro-business and organizations to respond to this, it is desirable to have a national policy that deals with the effects of crop failure as well as to manage drought in a way which is both sustainable and consistent with long-term development policies. Zambia indeed requires short-term as well as on-going programs as methods of drought mitigation (Banda et al., 1997).

In Zambia, since the dawn of independence, earlier attempts at drought management concentrated on measures aimed at averting famine. It started with the establishment of the Contingency Planning Unit under the Office of the Prime Minister. This was responsible for coordinating emergency responses when disasters struck. This was phased out in 1992 and replaced with an ad-hoc committee comprising four key ministries of Health, Agriculture, Energy and Community Development. There was no proper coordination of emergency responses and this created unnecessary overlaps and wastage as well as bureaucratic delays due to lack of policy framework on relief and management of disasters. This was phased out and other ad-hoc committees followed but faced the same problems. It was then decided by the

government to create a permanent unit. Through this unit, the government would have the duty of making well-detailed drought monitoring and mitigation plans (O'Brien, 1988; Sichingabula, 1994). This is what prompted the creation of the Disaster Management and Mitigation Unit (DMMU) in the Office of the Vice President in 1994. From its inception, however, the DMMU has operated without a clear policy framework on mitigation. The proposed Bill on the Disaster Management and Mitigation Unit if passed by Parliament will go a long way in enhancing the operations of the unit as it will more clearly outline specific action to be taken in a particular situation. The Bill would also stipulate who should do what, when it should be done and the logistics involved. The Bill should have specific aims of achieving objectives of improving communication of climatic information to the public, media and decision-makers and set up short and long-term drought mitigation strategies.

The government having recognized the need for food security saw the need to have a strategic food reserve in the country for use in times of disasters and hence they enacted a law in Parliament called the Food Reserve Act in 1996 and established a Food Reserve Agency (FRA). The FRA is centralized in terms of procurement of necessary foodstuffs but has spread tentacles throughout the country for purposes of food distribution. So far it is doing fine except that there must be enough and consistent funding and as MAFF personnel (GRZ, 1999) observed, the agency should not concentrate on input acquisition and distribution as these could be left to the private sector.

6.4.2 Food-aid versus Loans

Providing food aid and not giving loans was a popular measure taken everywhere in the world in times of disasters and was quite appropriate especially in times of an acute drought as it effectively countered immediate effects of droughts such as hunger and starvation in those communities. The donor-community have been very supportive in this respect as can be seen in the 1995/96 drought when out of 80,181 metric-tons of total relief food required for Zambia, they contributed 81% while the host brought in the remaining 19%. (Banda et al., 1997; GRZ, 1997). To ensure the efficiency of this exercise, however, food distribution centers or depots should be closer to the people. The measure to give food aid without proper assessment of need could, however, cause some people to be lazy as was shown in the study when 40 % of the sample population indicated that they did not take any measures during the droughts but simply waited for aid from the government. This accords well with the observation made during the 1995/96 drought by Banda et al. (1997) when 43% of the respondents in the study had no drought coping strategies. What was observed during the survey was that instead of doing some thing in readiness for the 1999/2000 rain-season, most men in the villages were found just drinking beer leaving any semblance of concern to women alone.

In times of minor droughts, it is believed that, food aid was not appropriate. The most appropriate measure then, though supported by only 5.5 percent of the sample population would be government subsidy on agricultural inputs or giving loans to farmers for purchasing inputs and equipment. In line with this, in the 1995/96 drought, the none-food assistance to Zambia pledged by Norway, Sweden, FAO and the World Bank, together, amounting to

US$855,000 was for the purpose of seed-purchasing while Finland's pledge for US$305,000 was for seed distribution (Banda et al., 1997). This initiative, however, would only work well if it was done in good time for agricultural planning purposes. Farmers should be encouraged to buy drought resistant or/and early maturing seeds that should be easily obtained by them. It is here where the work of PAM in the Drought Rehabilitation Program 1995-2000 deserved a pat on the back for having given a good example to many others who may want to take that path. PAM embarked on facilitating and encouraging the development of sustainable agriculture production systems among small-scale farmers in disaster prone areas through the distribution of planting materials that were drought tolerant and early maturing. One of the ways in which they did this was through loans to farmers. This initiative by PAM of giving loans did not conflict with the current policy of market liberalization since farmers were being empowered to stand on their own but not forced to get seed which they did not want. The only hurdle that the lending institution might have faced could be loan recovery as other such institutions like Lima Bank and Agricultural Finance Company faced and in the end were forced to close down.

6.4.3 Water Provision

Lack of water prevents many household and community based activities for millions of people in the dry areas of the sub-Saharan Africa. Indeed among a variety of water uses are drinking, washing, food processing, beer brewing, brick making, and irrigation. Many of these water related activities have a high economic value and can play an important role in household income and livelihood strategies, and through diversification can avoid over-reliance on single production activities such as rain-fed cropping of marginal lands (Lovell et al., 1999).

Water resources vary widely, encompassing not only rainfall, stream and spring flow, dams and water brought from external sources such as reservoirs, but also groundwater accessed by means of bore-holes and wells (Whitmore, 1999). It was very appropriate for the Government of Zambia to have embarked on investing in water to be able to provide water in places of scarcity. The digging of wells and boreholes and the erecting of dams become very handy during droughts. However, it must be noted, with appreciation, that the logistical assistance of the water-supply projects, which include machinery and tools, comes from outside (Banda et al., 1997; GRZ, 1997).

Wells and boreholes were an appropriate investment as they could be established almost every where as long as there was enough groundwater. The appropriateness of digging wells and bore-holes is that they can be established in areas which could be inaccessible, like in aquifers. In addition, the advantage of this water was that it was pumped from underground making it to be more hygienic compared to surface water. A lot of attention has been shown by the government and the co-operating partners in this aspect and this is evidenced in the big numbers of wells and bore-holes, totaling 386 by the end of 1997, sank in the valley. Songolo (1997) observed that this particular drought measure had limited impact due to poor maintenance and bad management. To maintain the efficiency of these water points, however, it is inevitable to rehabilitate the old wells and boreholes which were becoming mal-functional as well as digging new ones. It must be underlined, too, that productive and more reliable water points are those that are community managed. The local people, therefore, should be empowered to own the resource by assuming responsibility for operation and maintenance.

This is a sure way of enhancing sustainability even after the project sponsor is long gone.

Dams are also appropriate as they are multipurpose in use: they cater for man's gardening purposes and provide drinking water for both domestic use and animals. Dams are indeed an essential part of the farming fraternity except that small dams dry up even in non-drought years.

Similar to the observation by Tiffen and Mulele (1994), both the MAFF and some people among the sample population were entertaining the idea of small-scale farmers undertaking irrigated farming so as to reduce dependency on rainfall. Investing in irrigation would be one of the very appropriate measures as this would entail gardening all year round and to maintain the crops that needed continued flow of water. It is only by irrigation that you can apply adequate water to crops according to their rooting depth and need during the growth cycle. One thing to do when embarking on irrigation is to make sure that the irrigation system and equipment settled on are economic in their use of water (Lovell et al., 1999). It must be noted, however, that the irrigation component of the MAFF lacks adequate equipment and facilities as well as experienced technical staff to be fully functional and operational. Besides, institutional weaknesses of this section have made it very difficult to handle the development plans for irrigation and related development programs. It should be noted too, that through MAFF some irrigation programs in Southern Province had been implemented through the Household Food Security Program with funds from IFAD (International Fund for Agriculture and Development) though the program was limited in coverage (Tiffen and Mulele, 1994). A precaution to take, however, is that large-scale irrigation was costly and so not usually justified for staple-type

food crops and compounded with the dams drying up even in non-drought years makes irrigation not so reliable especially in the Gwembe Valley.

6.4.4 Road Infrastructure

Many people lamented the lack of proper roads in the valley and this has caused the area to be marginalised when it came to development. Indeed without proper roads it becomes difficult to move logistics to places where they may be required. Many are the times when good intentions by the government have gone unappreciated because well intended things such as food in times of crises fail to reach the intended targets on time due to poor roads. The topography of the valley is dominated by hills and stones and during the rainy season, for instance, most roads become impassable as fast flowing streams wash away bridges and sections of roads leaving rocks on roads. The Gwembe-Tonga Development Project (GTDP, 1997), in a nutshell, has aims of rehabilitating the 'Bottom-Road' joining the three districts of the valley and the Nkandanzovu Roads, a move which is welcome as it will facilitate transport in case of an emergence operation in the valley. The GTDP has obtained funding from the World Bank and the Development Bank of Southern Africa (DBSA) to bring about community participation so as to enhance capacity building. The GTDP is also rehabilitating, upgrading and constructing clinics, as well as constructing dams, weirs and boreholes.

6.5 Drought Mitigation Measures Pertaining To Individuals

6.5.1 Keeping livestock

Keeping livestock is an appropriate measure to drought mitigation but the livestock herds should be kept to a minimum so that they match with the limited pasture brought about by short and unreliable rains. This is unlike the suggestion given by some 17.2 % of participants in Muzumara's (1990) study that advocated for an increased livestock herd. The livestock should, however, be sold off in good time before they wasted away so as to enable owners fetch a good amount on them which could then assist in the purchasing of necessary food during the droughts. Lovell et al. (1999) observed that by selling-off the livestock, a farmer would score financially by avoiding the mounting cost of intensive feeding of the livestock if he were to do so through the drought. The option of intensive feeding of livestock is unlikely in the Gwembe, as farmers are mostly the subsistence kind. Selling-off livestock, however, had its own problems since there was no ready established market where the animals could be sold and hence farmers ended up being cheated by some unscrupulous buyers. Due to the current policy of liberalized marketing it was up to individual farmers to decide what to do with their livestock. The only other alternative to selling-off, even alluded to by Muzumara's (1990) study was to move the livestock out of the area under-going drought to areas where pasture was in abundance. However, while this idea of "encouraging relocation or migration of people from drought-prone south to drought-free north, in concert with likely shifting of crop-growing zone" (Sichingabula, 1995) is good, the hindrance to this would be the transportation cost, especially if the distances involved would require the use of hired transport.

6.5.2 Diversification in farming

The farmers in the Gwembe needed to take up or engage in various farming methods and practices that directly counter the drought situation such as using the 'pot-holing method' of sowing seed, planting early using a variety of drought resistant crops such as sorghum, beans, cow-peas, cassava and groundnuts. After all, these are the traditional crops for the area. If one contemplated growing maize, only those varieties that were early maturing would be appropriate. The problem of promoting maize growing even in the agro-ecological zones, such as the valley, that could not support the production of maize even in the drought year was a matter of poor policy by the government. In the 1980s government policy promoted maize production. Its pricing policy along with availability of agricultural credit, extension services and research so much promoted crop specialization, centered on maize. Maize consumption was also subsidized through the regulation of milling and sales (GRZ, 1999). This development culminated in causing negligence of alternative crops that might have positive nutritional value. The fact that drought resistance in plants is rarely combined with high productivity (Kovda, 1980) may have contributed to discouraging some people abandoning high productive, though less drought resistant crops like maize. However, data from CSO (1994) crop-forecast survey indicates that there has been some crop diversification in the Southern Province where planting of more drought resistant crops such as sorghum and millet increased while that of maize decreased.

6.5.3 Investing for the future

Another appropriate measure to combat drought was to get ready for hard times by investing in the future by storing a lot of foodstuffs in granaries during the years of plenty. The problem that may arise with this alternative is the control of pests like weevils and grain-borers that attack stored grains, especially maize, beans and groundnuts. To go round this problem there are many agricultural fumigants and powders which keep these pests away like 'blue-cross' which should be put in place if one did not know traditional ways of preservation. In-fact, a modern facility of 'crop-insurance' can be adopted as a mitigation measure to loss through drought. Food security should be seen to be everybody's concern and not just the government. It should therefore be encouraged at national, provincial, district and household levels. Engaging small business ventures such as selling some economic items like fish and animals could be very helpful at lower levels. Encouraging entrepreneur-ship is what market-liberalization is all about and it comes gradually.

6.5.4 Social Services

Education and literacy levels in the valley are however a source of worry especially that a good number who claimed to have done at-least basic education could still not read, let alone write, and yet improved general education is a major drought mitigation factor. Education expands peoples' horizon; it opens up the understanding of events in a common way with the bigger society. Education enables and facilitates the understanding of other people elsewhere who may be in a similar situation and it empowers one to interact more intelligently with different people (Mwenda, 1999). However, the distribution of schools in the valley is poor and coordination of

these schools is also very poor due to lack of transport and distance from the central offices and the schools. Without a proper educational base analytical sense of problem solving lacks and hence the community suffers. The community, in Gwembe Valley, has a capacity to mitigate problems arising from droughts but this would be enhanced by improved general education.

The situation pertaining in the valley where the smooth running of schools are disrupted by the hunger situation both in pupils attendance and teachers availability is a situation of serious concern and demands quick action. Since the problem is drought, the only answer to the problem lies in the government and the local people to seriously address the problem, failure to which it will remain a nightmare forever, resulting in a big imbalance in the development of the area in future.

The health status in the valley is very low. There are too few health centers, for instance, only five operational centres in the whole of Gwembe District and as a result diseases make people fail to work hard and this is worsened during droughts. There is need for concerted effort by the government to increase the number of health centres so as to give the people of the area adequate medical attention. The issue of 'paid-medical' services has become a big impediment to the health of the poor. Something should be done quickly to alleviate the situation. While the situation now is that there should be cost sharing with a view of assisting government efforts, most people are living in abject poverty to be able to contribute and health is a government responsibility. Development can only come by a healthy people in that they would be able to face problems and grapple with them. The sickly would shun away and leave problems unattended, or poorly attended to.

The above suggested mitigation measures to drought are very appropriate and could be very effective if they were implemented. Some ten years since Muzumara's (1990) study giving drought-mitigating measures, some are being repeated in this study showing that they were not acted on by the concerned. To the third hypothesis that seeks to find out whether the implemented measures were appropriate and effective, the answer is that some of the mitigation measures like food aid to the afflicted and the provision of water points were appropriate. Food aid, however, made some people lazy. The water points would be effective if those that become mal-functional are repaired. The effectiveness of other measures could not be assessed because they were not fully implemented. For instance, the Bill for the DMMU on drought policy is still not yet ratified by Parliament and only a few farmers have obtained loans for agricultural implements. This development has made some farmers to be reluctant to diversify in agriculture, preferring traditional ways. The distribution of relief food and farming implements is still not done in good time.

6.5.5 Implications of Non-adoption of Drought Mitigation Measures

The continued delay in passing an Act of Parliament on the DMMU will continue to make the DMMU work without full support from other interested parties. Working without a clear policy framework on drought mitigation will see the current efforts being taken presently go to waste as earlier efforts did due to lack of coordination of effort and follow-up.

An achievement of food security in the valley would make it possible for people in the area to

get involved seriously with other developmental issues which are overshadowed when everyone becomes more serious in looking for food for survival during a drought. This would reverse the present status quo in which the area lags far behind in economic and social development compared to other areas in the country. If food security remains unachieved, the Gwembe Valley would continue to remain behind in development compared to other areas in the country, as people would continue addressing food issues while economic and social development remain unresolved.

In the absence of loans, agriculture would suffer as people will have no capacity to cultivate and buy agricultural implements in good time and to act quickly in case of a drought and this would cause them to continue loosing inputs that are applied late.

So long as roads remain in a state of disrepair, it will be a nightmare to get to some places in the valley in good time, to respond to any distress call on drought. This will mean leaving the problem unsolved and hence people will continue to suffer and even die.

Failure to adopt diversification in farming will remove the chance that is found in using a variety of methods and practices as some may work well.

Non-keeping of emergency food stocks will perpetuate starvation and death from drought impacts.

So long the provision of education is not stepped up in the valley, illiteracy would continue to

abound and such people would be finding it difficult to quickly grasp new ideas, no matter how useful the ideas may be in their situation.

In the absence of the health facilities the many diseases that become prevalent in a hunger-prone situation will not be stopped and hence the great risk of increased diseases and even death.

CHAPTER 7 : CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The Gwembe Valley is a drought prone area. While there wasn't much tangible evidence, except for misery, to show that the magnitude and the severity of drought had increased after 1980, climatologically it was found so. With the increase in drought frequency, drought impacts were exacerbated and equally required an increase in whatever mitigation measures were to be taken, failure to which misery would be felt more.

The Zambian Government wishes to promote agriculture as the primary source of growth in the economy. However, unless the implications of drought vulnerability on local people have been fully understood and addressed, this would not yield desired results, especially that Zambia relies mainly on rain-fed agriculture. The main preventive measures to drought-mitigation are to increase water points and enhance increased ability to maintain existing installations. This move would bring about the situation in which few people would be dependent on unreliable sources when shallower sources go dry. In other words, the situation necessitates water conservation and, in some cases, irrigation. However, irrigation should be recommended only where it could be done cheaply, easily and manageable by the concerned farmers. There's, need for concerted efforts by MAFF to encourage cost effective and sustainable irrigation measures that target small and medium scale farmers in the valley.

Drought was also found to have an effect on livestock. For instance loss of livestock, especially

cattle, has an impact on cultivated area, transport and indeed in the bargaining power on social affairs such as marriages, funerals and other festivals. Keeping more livestock in a place where pasture was limited, however, worked against a farmer. Farmers would be better advised to keep just enough for the available pasture to avoid losing all.

The road infrastructure was found to be in a state of disrepair. This was not good as without properly maintained roads communication becomes poor and this would make peoples' vulnerability to drought even more as aid would be failing to reach the intended target.

There were very few health centers operational in the valley. There was need to add to the numbers of health institutions and medical facilities if the health of the people was to be safeguarded.

The literacy levels in the valley were low but this was not a hindrance to the people in the valley as they seemed to understand the drought problem well and were willing, in principle, to deal with it by cooperating and adopting the suggested drought mitigation measures.

The aspect of food-security was not the responsibility for the government alone but for the whole valley community. Food stocks should be kept for future use from harvests of good seasons.

Finally, when one looks at the so many suggested appropriate measures to mitigate drought in the valley, one would wonder as to why drought still remains a problem. The thing that comes

out candidly in this case is that there is too much procrastination in the implementation of the measures. It should be remembered that a good solution today may fail to fit in well later as the situation may have acquired new dimensions. During droughts everyone from government to individual seems to be concerned with solving the problem of drought but immediately these droughts ebb away, the suggestions are forgotten until when droughts reappear later. At this time too, only ad-hoc approaches may be adopted. To end this type of drought management, which is in fact mismanagement, there must be a formation of a permanent drought monitoring team with the task of checking the occurrence so as to induce a timely action to remove the vulnerability the valley communities face. This will enhance a state of preparedness without which people will always be dependent on the government, a situation that is quite contrary to current qovernment policies.

7.2 : Recommendations

7.2.1 : To Government

(i) The existing program of drilling and repairing bore-holes and wells in the valley should continue instead of going for large-scale irrigation, which is costly and usually not justified for staple crops in the valley where population is dispersed.

(ii) Since drought leads to a decline in agricultural production there is need for the government, through MAFF, to continue encouraging local people to use drought resistant crop varieties so as to enable them maintain sizeable harvests.

(iii) Through MAFF there should be an intensification in research on crops that are drought resistant and early maturing so that people have a wide range of seed to choose from.

(iv) To have food-security in the valley, there should be adequate funding for both research and information dissemination on what crop varieties are suitable in the valley.

(v) The Food Reserve Agency (FRA) needs to be funded adequately for it to enhance keeping of a strategic food reserve but should not be burdened with the acquisition and distribution of inputs as this can be done by the private sector.

(vi) Parliament should quickly pass the Bill on the Disaster Management and Mitigation Unit to empower and enable the unit to deal effectively with matters on disaster preparedness and mitigation.

(vi) Introduce alternate and more drought resistant livestock such as donkeys and mules for transport and goats for meat and milk purposes.

(viii) The education and health authorities in the valley should be given adequate transport to enable them move freely and the roads be maintained all the time.

7.2.2 To Individuals and Community

(i) The farming communities in the valley should adopt the practice of planting crops early and crop diversification if the current situation of 'an area of food deficit' is to be reversed.

(ii) The valley community should adopt the practice of selling-off their livestock early when drought is suspected to avoid their animals dying or deteriorating in state.

(iii) Individual farmers should always anticipate a drought and so keep some food in granaries as an emergence measure.

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APPENDICES

APPENDIX I : Gwembe station annual total rainfall and departure From normal: 1948/1949 to 1998/1999 Seasons

Season	Rainfall (mm)	Departure from 750 mm	Season	Rainfall (mm)	Departure from 750 mm
1948/49	617	-135	1974/75	637	-113
1949/50	919	169	1975/76	888	138
1950/51	614	-136	1976/77	665	-85
1951/52	954	204	1977/78	1472	722
1952/53	1331	581	1978/79	884	134
1953/54	515	-235	1979/80	907	157
1954/55	1046	296	1980/81	939	189
1955/56	897	147	1981/82	616	-134
1956/57	795	45	1982/83	800	50
1957/58	1305	555	1983/84	642	-108
1958/59	789	39	1984/85	373	-377
1959/60	675	-75	1985/86	869	119
1960/61	858	108	1986/87	626	-124
1961/62	1035	285	1987/88	824	74
1962/63	1390	640	1988/89	1314	564
1963/64	620	-130	1989/90	746	-4
1964/65	811	61	1990/91	597	-153
1965/66	679	-71	1991/92	499	-251
1966/67	644	-106	1992/93	669	-89
1967/68	704	-46	1993/94	693	-57
1968/69	887	137	1994/95	383	-367
1969/70	865	115	1995/96	876	126
1970/71	835	85	1996/97	1233	483
1971/72	888	138	1997/98	588	-162
1972/73	696	-54	1998/99	1084	334
1973/74	1391	641	-	-	-

Source: Meteorological Department (Data from 1972-unpublished).

APPENDIX II : Questionnaire on Drought Characteristics in Gwembe Valley

Name of interviewer: _____

Name of respondent : _____

Village: _____

For Items 1 to 5 indicate by a tick

1.Sex of respondent: Male ( ) Female ( )

2. Marital status: Single ( ) Married ( ) Divorcee ( ) Widow / Widower ( )

3.Age of respondent: Less than 30 years ( ) 30 to 40 years ( ) 40 to 50 years ( )

Above 50 years ( )

4. Level of education: Cannot read nor write ( ) Formal schooling up to Grade 9 ( )

Formal schooling up to Grade 12 ( ) Formal schooling above Grade 12 ( ).

5. Major source of income (occupation): Crop cultivation ( ) Pastoral farming ( )

Other (specify) _____

6. How many years have you lived in this area?

7. What major problem(s) do you face by living in this area?

8. What major animals do you keep?

9. What major crops do you grow?

10. For each major crop grown, when do you plant it? (list out)

11. Do you normally plant crops at the right time?

12. Do rains come at the right time?

13. Do rains stay for a required period for crops?

14. How were you affected by recent drought?

15. How far away were you getting water for drinking?

16. How far away were you getting water for your animals?

17. What measures have been introduced by government to deal with drought in you area?

18. What other non-governmental organizations (NGOs) have come to assist you during drought and what have they done to help the situation?

19. Which is/are the most effective/useful measures to drought in your view?

20. What type of relief aid is sent in times of drought to your area?

21. Who sent this relief aid?

22. Who monitors and co-ordinates the distribution of this aid?

23. Can you suggest what could be done by either the government or voluntary agencies which could best help reduce drought vulnerability in the area other than what they are doing?

24. What measures do you take locally here as a community in times of drought?

25. Is there anything more that the community can do to reduce the drought problem?

26. What would you advise individual farmers to do in future when faced with drought?

Thank you very much for the information and for the time.

APPENDIX III : Interview-Guide

Name of Interviewer:_____
Name of respondent:_____

A. District Council Officials (Gwembe,Munyumbwe and Chipepo)

1. Can you give a brief history of drought/famine in the area?
2. What are the impact of recent droughts on agriculture and water supply in the district since 1980?
3. Which were the most badly affected areas by the recent droughts?
4. What are the efforts or measures being made to combat drought effects by the local authorities, the government and what is the response by people in the area?
5. What are the future plans of dealing with drought problems?

B Gwembe Member of Parliament (MP)

1. Can you give a brief history of drought/ famine in the area?
2. What are the causes of drought in the area?
3. What are the impacts of recent droughts (since 1980)?
4. What are the efforts or measures being made to combat drought by locals, District Council, voluntary organizations and the government?
5. What do you think are the appropriate measures of combating drought in the area?.
6. What are the future plans of dealing with drought?

C The Department of Agriculture (Gwembe)

1. Nature of soils and climate:
- what is the soil condition (with reference to crops)?
- what is the rainfall condition (with reference to crops)?
- what is the temperature condition (with reference to crops)?

2. Main Agricultural Activities in the area?
* what is the major source of income in the area for the majority?
* what are the types of farmers found in the area?
* what livestock is kept in the area?
* how is pasture management?
* what are the crops grown and when are they harvested?
3. What is the history of drought/famine in the district?
4. What is the nature and causes of recent droughts?
5. What are the drought effects on agriculture in terms of:crop, animal and other losses?
6. Would you specify measures taken to combat drought by: individuals, collective community action and the government?
7. What are the future plans of dealing with drought

D. The District Education office (Gwembe)

1. What is the number of schools in the area?
2. Where are they located?
3. What is the effect of drought on these schools?
4. Has education got any impact on drought in the area?
5. How easy is communication in the area?

E. The Ministry of health

1. What is the number of health institutions in the area?
2. Where are they located?
3. Has drought any effect on health?
4. Does health have any impact on drought?
5. How easy is it to coordinate health activities in the area?

F. The Ministry of Agriculture, Food and Fisheries (Lusaka)

1. What is the official definition of drought?
2. What is Government policy on drought?
3. What are the effects of recent droughts in Zambia (since 1980)?
4. What is the government doing to combat drought?
5. What is the response of people to government measures?
6. What are the future plans for dealing with the drought problem?

G. The Ministry of Energy and Water development (Lusaka)

(same questions as in F above).

H. The Department of Meteorology (Lusaka)

1. To ask for published rainfall data up to1970 and unpublished data after 1970 to-date.
2. To ask for the meteorological explanation of the nature and causes of recent droughts in Zambia.
3. To ask for the official government definition of drought and government policy.
4. To ask about drought forecasting and early warning system in Zambia,
5. To ask for government measures for dealing with drought problem.
6. To ask for government's future plans to combat drought.

APPENDIX IV: Population and food needs assessment in Gwembe Valley, 1998

District	Population	Food deficit (%)	Severely affected only (%)	Food requirement to severely affected only (kg)	Total requirement To all including the Moderately affected (tons)
Gwembe	62,563	62.95	25.49	837,389.72	985.02
Siavonga	55,210	65.70	20.56	596,055.58	826.86
Sinazongwe	104,42	60.20	23.48	1,287,137.33	1,584.17
Total	222,19	66.28	23.17	2,720,582.63	3,396.05

Source: Adapted from EWU/MAFF, Met. Dept., FEWS, CARE, PAM, WFP,NFNC.

APPENDIX V: Annual rainfall (mm) for Gwembe Boma, Lusitu, Sinazeze and Maamba: 1972/73 to 1987/88 Season

Season	Gwembe	Lusitu	Maamba	Sinazeze
1972/73	696.0	286.2	535.8	403.2
1973/74	1390.5	930.4	1625.9	1620.7
1974/75	637.3	580.1	1076.3	1121.6
1975/76	881.1	711.1	1522.4	1168.9
1976/77	664.9	489.2	569.5	549.4
1977/78	1471.7	1477.5	1731.1	1250.1
1978/79	884.4	663.5	875.8	807.3
1979/80	906.8	887.5	1034.0	1062.4
1980/81	939.0	943.0	1101.0	1073.0
1981/82	615.9	328.5	705.4	355.6
1982/83	800.1	380.8	608.0	361.7
1983/84	642.0	442.5	845.3	804.0
1984/85	373.1	686.7	861.6	927.5
1985/86	869.3	720.5	810.0	1069.0
1986/87	626.0	435.5	482.7	475.8
1987/88	823.9	618.1	929.6	790.0

Source: Meteorological Department.

APPENDIX VI: Dry-spells of more than 4-days duration at Gwembe Boma for particular months of the Seasons

Season	NOV		DEC		JAN		FEB		MAR	
	DAYS	DATES	DAYS	DATES	DAYS	DATES	DAYS	DATES	DAYS	DATES
1970/71	5	17-21	5 8 7	1-5 7-14 17-23	8 6	10-17 25-30	15	2-16	-	NO RAINS
1971/72	9 8	6-14 21-28	7	24-30	6	18-23	5 9 9	4-8 11-19 23-31	9 10	10-18 21-30
1972/73	21	10-31	6 18	2-7 13-30	5 14	1-5 11-24	8	2-9	5 11 5	1-5 7-17 26-30
1983/84	-	NO RAINS	-	NO RAINS	7	12-18	9 6	11-19 26-31	-	NO RAINS
1986/87	26	2-7	16	12-27	12 6	1-12 26-31	18	14-31	11 12 5	1-12 12-23 27-31
1988/89	7 18	12-18 10-27	7 6 5	9-15 20-25 27-31	-	-	-	-	9	7-15
1989/90	9	21-29	10 8	2-11 18-24	-	-	6	26-31	-	NO RAINS
1990/91	6	26-31	7	8-14	-	-	9	18-25	-	-

Source: Meteorological Department

APPENDIX VII: Monthly rainfall totals (mm) for Chipepo showing dry dekads

Season	J	A	S	O	N	D	J	F	M	A	M	J
1993/94	3	3	3	3	1	1	0	1	3	3	3	3
1994/95	3	3	3	2	3	2	2	2	3	3	3	3
1995/96	3	3	3	3	2	2	1	0	1	3	3	3
1996/97	3	3	3	3	1	1	0	1	0	2	3	3
1997/98	3	3	3	3	0	3	0	2	2	3	3	3
1998/99	3	3	3	3	3	1	-	-	-	-	-	-

Source: Meteopological Department

APPENDIX VIII: Monthly and annual rainfall (mm) from 1993/94 to 1998/99 seasons for Gwembe and Chipepo stations

	S	O	N	D	J	F	M	A	M	Total
Gwembe										
1993/94			117	194	304	61	11	6		693
1994/95		22	39	50	76	151	44.9			383
1995/96		9	127	167	210	176	173		14	876
1996/97	1	8	135	221	307	272	172	117		1233
1997/98	13	10	60	74	308	69	54			588
1998/99			185	241	209	276	170	2		1084
Chipepo										
1993/94	2		149	103	205	89	5			553
1994/95		81	9	80	59	77	28	5		339
1995/96		54	105	197	198	172	28	30		784
1996/97		79	114	114	331	246	179	43		991
1997/98	23		112	26	360	68	243	4		835
1998/99			19	267	367	312	217	13		1195

Source: Meteorological Department

APPENDIX IX: Rain-days per month from 1993/94 to 1998/99 for Gwembe and Chipepo stations

	S	O	N	D	J	F	M	A	M	Total
Gwembe										
1993/94			5	13	17	6	4	1		46
1994/95		4	3	7	9	10	7			40
1995/96		3	7	14	12	19	10		2	67
1996/97	1	1	8	17	22	16	11	4		80
1997/98	1	1	3	5	12	6	4			32
1998/99			6	19	22	13	12	1		73
Chipepo										
1993/94			9	10	13	6	1			39
1994/95		6	3	5	5	9	5	2		35
1995/96			5	10	12	13	11	2	5	58
1996/97			8	10	20	16	12	3		69
1997/98	2		8	5	19	8	8	1		51
1998/99			2	15	19	14	13	3		66

Source: Meteorological Department

APPENDIX X A: Table of Critical Values of r in the Runs Test

n_1 \ n_2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2											2	2	2	2	2	2	2	2	2
3					2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
4				2	2	2	3	3	3	3	3	3	3	3	4	4	4	4	4
5				2	3	3	3	3	3	4	4	4	4	4	4	4	5	5	5
6			2	3	3	3	3	4	4	4	4	5	5	5	5	5	5	6	6
7			2	3	3	3	4	4	5	5	5	5	5	6	6	6	6	6	6
8			2	3	3	4	4	5	5	5	6	6	6	6	6	7	7	7	7
9			2	3	3	4	4	5	5	6	6	6	7	7	7	7	8	8	8
10			2	3	3	4	5	5	5	6	6	7	7	7	8	8	8	8	9
11			2	3	4	4	5	5	6	6	7	7	8	8	8	9	9	9	9
12		2	2	3	4	4	5	6	6	7	7	8	8	8	9	9	9	10	10
13		2	2	3	4	5	5	6	6	7	7	8	8	9	9	9	10	10	10
14		2	2	3	4	5	5	6	7	7	8	8	9	9	9	10	10	10	10
15		2	3	3	4	5	6	6	7	7	8	8	9	9	10	10	11	11	11
16		2	3	4	4	5	6	6	7	8	8	9	9	10	10	11	11	11	12
17		2	3	4	4	5	6	7	7	8	9	9	10	10	11	11	11	12	12
18		2	3	4	5	5	6	7	8	8	9	9	10	10	11	11	12	12	13
19		2	3	4	5	6	6	7	8	8	9	10	10	11	11	12	12	13	13
20		2	3	4	5	6	6	7	8	9	9	10	10	11	12	12	13	13	13

Find in Table VI A and B the row and the column corresponding to n_1 and n_2. The critical value found at their intersection in Table VI A is the lower limit of the confidence interval and the one in Table VI B is the upper limit of that interval. **In a one-sample study,** if the observed value falls between these critical values, then H_o is not rejected. Otherwise, H_o is rejected. **In a two-sample study,** only Table VI A is used: if the observed value is smaller or equal to the critical value found in Table VI A, then H_o is rejected.

APPENDIX X B: Table of Critical Values of r in the Runs Test (Continued)

n_1 \ n_2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2																			
3																			
4				9	9														
5			9	10	10	11	11												
6			9	10	11	12	12	13	13	13	13								
7				11	12	13	13	14	14	14	14	15	15	15					
8				11	12	13	14	14	15	15	16	16	16	16	17	17	17	17	17
9					13	14	14	15	16	16	16	17	17	18	18	18	18	18	18
10					13	14	15	16	16	17	17	18	18	18	19	19	19	20	20
11					13	14	15	16	17	17	18	19	19	19	20	20	20	21	21
12					13	14	16	16	17	18	19	19	20	20	21	21	21	22	22
13						15	16	17	18	19	19	20	20	21	21	22	22	23	23
14						15	16	17	18	19	20	20	21	22	22	23	23	23	24
15						15	16	18	18	19	20	21	22	22	23	23	24	24	25
16							17	18	19	20	21	21	22	23	23	24	25	25	25
17							17	18	19	20	21	22	23	23	24	25	25	26	26
18							17	18	19	20	21	22	23	24	25	25	26	26	27
19							17	18	20	21	22	23	23	24	25	26	26	27	27
20							17	18	20	21	22	23	24	25	25	26	27	27	28