AIACC Project AF38
Dealing with Extreme Climatic Events

DROUGHT CASE STUDY FOR MALAWI

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SUMMARY

A spatial rainfall analysis has been made for 10-Day, monthly and seasonal rainfall data for the period 1948 to 2003 for 17 locations in Malawi using percentiles statistical method in order to characterize droughts in Malawi. It has been established that during the 55 years under study, 1948/49 and 1991/92 seasons have been categorized as severe drought seasons. The seasons which have been identified as serious droughts are 1967/68, 1972/73, 1982/83 and 1994/95.

Temporal rainfall analysis has also been made for selected stations based on region. The analysis is based on Standardized Precipitation Index (SPI) which is an index that measure how much precipitation for a given period of time has deviated from historical established norms. The results show that extreme drought years vary from one locality to another. However, most stations depict 1948/49, 1991/92 and 1994/95 as outstanding drought years.

An additional temporal analysis for 10-day rainfall was prepared. Each of the drought years was compared with normal rainfall during the season spanning from November to April. A general trend for all the three drought years shows that the actual rainfall fell much below normal rainfall. There were short periods where rainfall was above normal rainfall either at the beginning of the season, mid-season or towards the end of season. There are frequent periods of dry spells throughout the season.

The last part of the study was based on oral interviews covering various aspects on drought. These interviews were conducted in three districts basically being guided by a questionnaire that sought to know people's knowledge about previous droughts, the impact of those droughts and how they responded to them. The results show that drought has multi-dimensional impact on various sectors including agriculture, water, health and education. The results also show that people have various copping mechanisms and that in recent drought there has been a tendency to rely on relief assistance as well.

1.0 INTRODUCTION

Extreme climate events such as droughts are very common in Malawi and yet their impacts are generally not well factored into the long term National Development Plan. Good examples of the potential hazards of the extreme Climate events have been demonstrated by the impacts of the 1948/49 and 1991/92 droughts.

The two eminent droughts had harsh negative impacts on agriculture, livestock, wildlife, tourism, water resources and hydroelectric generation. The low water levels in the dams led to intense power rationing which resulted to large losses in the economy. The impacts of these *El Nino* related droughts were therefore very severe and could not be accommodated within the limited national resources. The government had to seek support from international communities to address their impacts.

It should be noted that the impact of extreme climate events affects the welfare of the majority of the rural communities and tend to enhance poverty, especially in Malawi where rain-fed agriculture and hydroelectric power forms a major source of food and energy respectively.

Records from the National Profile of Disasters indicate that the 1991/92 drought impinged heavily on the whole country and 6.1 million people were affected. Conversely, the 1948/49 drought was country-wide as well and unspecified number of people died. Some of the response actions included intensification of supplementary feeding programmes to vulnerable groups and provision of drugs for waterborne diseases.

The severe impacts associated with extreme events can be reduced among others, through good understanding of the climate patterns.

This pilot project will therefore make an assessment of previous droughts that affected the country.

The overall objective of this study is therefore to assess historical droughts that had detrimental effects on the economy. Specifically the project will be aiming to develop thematic mapping areas affected by droughts so as to identify vulnerable zones and to identify profile of notable droughts in terms of areas affected, their impact and responsive measures.

1.1 Country's Geographical Profile

Malawi occupies the southern part of the East African Rift Valley and lies between latitude 9 and 17 degrees South and longitude 32 - 36 degrees East. It is bordered by Mozambique to the south and east, Zambia to the west and Tanzania to the east and north-east. With a total territorial area of 119,140 sq km, the country varies in altitude from near sea level to well over 2,000 metres above mean sea level. Of this area, one fifth is water bodies largely dominated by Lake Malawi which is Africa's third largest lake.

The country's rainfall regime is greatly influenced by the great variation in altitude and the proximity to the huge lake that covers two thirds of the country's length. Annual rainfall varies from around 500mm in low lying areas to well over 2,000mm over highlands and the lakeshore areas. The country experiences one distinct rainy season that spans from November to April. The major synoptic systems that dominate over the country are the Inter Tropical Convergence Zone (ITCZ), Congo Air Boundary, Semi-permanent anti-cyclones (the Mascarene and South East Atlantic High Pressure Areas), tropical cyclones and easterly waves. The teleconnection link amongst upper air flow, low pressure cell over Botswana, southeast trades, northeast monsoons and mid-latitude pressure system influences rainfall distribution in space and time.

The economy of Malawi is heavily dependent on the agricultural sector, with nearly 90 percent of the rural population deriving their livelihood from agriculture (UNDP, 1993). In addition, agriculture contributes about 33 percent of the country's export earnings (primarily from tobacco, tea and sugar), and about 75 percent of the country's employment.

1.2 Definitions of Drought

Drought is a familiar climatic phenomenon but difficult to define. It is, however, universally identified with a period of insufficient water resources initiated by reduced precipitation (AMS, 1990). Gibbs (1984) defines drought as the lack of water to meet essential needs. To avoid a universal definition, drought is more often defined in terms of specific water use activity. Thus people often talk about agricultural drought, hydrological drought and meteorological drought. Meteorological drought is defined as a period of abnormal dry weather sufficiently prolonged for the lack of water to cause serious hydrological imbalance in the affected area (Huschke, 1959). Essentially, it is a measure of departure of precipitation from normal. Agricultural drought is a climatic excursion involving a shortage of precipitation sufficient to adversely affect crop production and range production (Rosenberg, 1979). Basically, it refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop. Hydrological drought is defined as a period of below average water content in streams, reservoirs, ground-water aquifers, lakes and soils (Yevjevich et. al 1977). This occurs when surface and subsurface water supplies are below normal. There is also what is referred to as socioeconomic drought. This situation occurs when physical water shortage begins to affect people.

1.3 Characteristics of Drought

The characteristics of drought in this study are expressed in terms of drought index. A drought index assimilates thousands of data on rainfall and other water-supply indicators into a comprehensive picture. A drought index is typically a single number, far more useful than raw data for decision making.

There are as many drought indices as there are drought definitions. There are those that use rainfall alone such as the rainfall percentiles/deciles extensively used in Australia (Gibbs, 1987). There are those that use a combination of parameters (rainfall, temperature, wind, evapotranspiration, etc) such as the Palmer Drought Index and the Food and Agricultural Organization (FAO) Water Satisfaction Index (Du Pisani, 1989).

A comprehensive summary of droughts in Australia was examined and a remarkable correspondence was found between the droughts and the occurrence of annual rainfall in the first decile range (below 10^{th} percentile), irrespective of location in arid, semi-arid or other areas (Gibbs, 1987). These results imply that the user of water learns to adapt to the amount of water available and the variability in its supply except when it occurs within the first decile range. Gibbs (1967, 1984, 1987) defines drought as occurring within the first decile. Serious drought is defined as occurring between the 5^{th} and 10^{th} percentile and severe drought at below the 5^{th} percentile.

1.4 Previous Studies

In analyzing Malawi's annual rainfall time-series for a few selected locations, running from 1897 to 1983, Munthali and Ogallo (1986) singled out 17 major negative rainfall anomalies. Kamdonyo (1993) made an attempt to characterize two droughts in Malawi based on percentiles. From the study, a time-series of normalized annual rainfall departures for the period 1922-1992 (70 years) for seven locations also shows several negative departures but two of them, 1948/49 and 1991/92 stand out. With more than 30% departure from the normal, these two droughts have been the most severe in Malawi during the last century.

2.0 METHODOLOGY

2.1 Data

Ten-day, monthly and seasonal rainfall totals for the period 1948/49 – 2002/2003 (55 years), for 14 locations in Malawi have been used in this study. Seasonal totals are for the period of November of one year to April of the following year which generally covers the growing period for most crops in most areas in Malawi. Hence data for the 1948/49 season covers the period November 1948 to April 1949 and likewise for 2002/2003 covers the period November 2002 to April 2003.

2.2 Methods

Percentile drought indices have been used for spatial analysis of rainfall data while Standard Precipitation Indices have been used for temporal analysis.

2.2.1 Percentile Index

The percentile drought indices have been used in this study. The percentile, which is based on cumulative frequencies, is given as:

P = ((n - 0.5)/m) x 100 where
P is the percentile value,
n is the rank, and
m is the number of years.

The lower the percentile value the more severe the rainfall deficiency or drought. The percentile indices have an advantage over the use of the mean in that they express the rank of rainfall over a given period within frequency distributions for that period without specifying the amount of rainfall (Gibbs, 1987). The use of the arithmetic mean is misleading when dealing with skewed data such as rainfall data from arid and semi-arid areas. Often the totals are not normally distributed and hence the mean differs significantly from the median.

For this study, drought severity has defined by adopting Gibbs approach as follows:

Percentile Range	**Drought Condition**
Below 5^{th} percentile	Severe
05 - 10	Serious
10 - 30	Mild
30 - 70	Normal season

above 70	Above normal

2.2.2 Standardized Precipitation Index (SPI)

There are several indices that measure how much precipitation for a given period of time has deviated from historically established norms.

In this study the Standardized Precipitation Index is used.

The index measures how the precipitation has deviated form normal as measured by standard deviation. The index is produced by dividing the result of subtracting the mean value from the actual value by a standard deviation.

The index is negative for drought and positive for non-drought conditions, with zero as mean. For example, SPI of 2 indicates 2 standard deviations above normal while SPI of -2 indicates 2 standard deviations below normal.

A drought event is when index is less than or equal to -1.0. The following is classification system linking SPI with drought intensities:

SPI values	**Drought condition**
1.0 to1.49	Moderately dry
1.5 to 1.99	Severely dry
2.0 and less	Extremely dry

2.2.3 SURVEY

A third approach to the study was the use of a drought impact assessment survey.

Questionnaires pertaining to drought study were distributed to three sample areas to determine people's knowledge about drought, the impact of drought and how they responded to it. Oral interviews were conducted in Karonga (North), Balaka (South) and Mangochi (South). A copy of the questionnaire is appended as Annex 1.

2.2.4 Tools

Using Microsoft Excel computer software graphs showing time series of departure from normal seasonal rainfall for selected stations were created. Using the same software, graphs depicting actual versus normal ten-day rainfall for chosen drought years for selected stations were produced. For mapping, Surfer for Windows Software, was used. Microsoft Word was used for writing the report.

3.0 RESULTS

3.1 Spatial Rainfall Analysis

From the percentile analysis on the rainfall situation during the 55 seasons under study, the following observations were made:

- During the 55 years there have been two occurrences of severe droughts; 1948/49 and 1991/92 rainfall seasons.

- There have been four occurrences of serious drought. These were 1967/68, 1972/73, 1982/83 and 1994/95.

- Localised mild droughts have been more frequent in some areas than others such as Karonga and Salima. Drought has occurred at Karonga during 1948/49, 1952/53, 1953/54, 1964/65, 1981/82, 1982/83, 1991/92, 1999/2000 and 2002/2003. Salima has experienced localized droughts during 1953/54, 1980/81, 1981/82, 1991/92 and 1994/95.

- The 1948/49 drought covered more areas and hence affected a bigger part of the population.

- The 1991/92 drought covered fewer areas but was more severe in the sense that it lasted longer and hence affected water supplies as well.

- The analysis shows that both 1948/49 and 1991/92 droughts intensified during the peak rainfall months of January and February and droughts progressed from south to north.

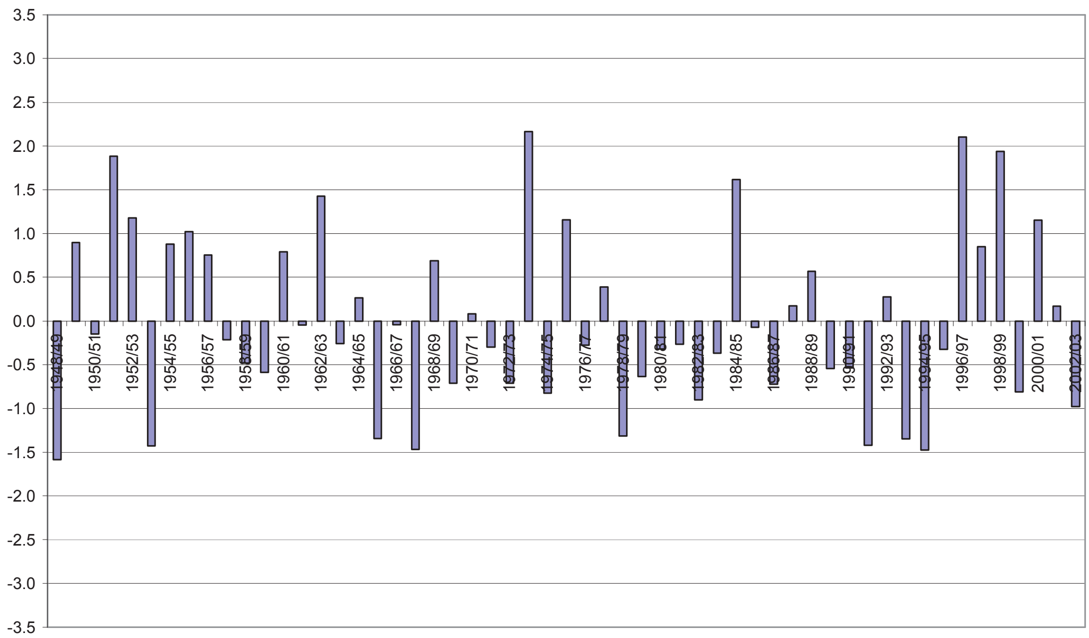
- Of the drought seasons, 1948/49 was not affected by El Nino, while 1953/54, 1972/73, 1982/83, 1991/92, 1994/95 were affected by El Nino phenomenon.

Maps depicting percentile analysis of monthly rainfall of drought years are found in Annex 2.

3.2 Temporal rainfall Analysis

The SPI was extensively used to depict the temporal characteristics of seasonal rainfall.

FIG. 1: STANDARDIZED SEASONAL RAINFALL TIME SERIES
BVUMBWE: 1948/49 TO 2002/03

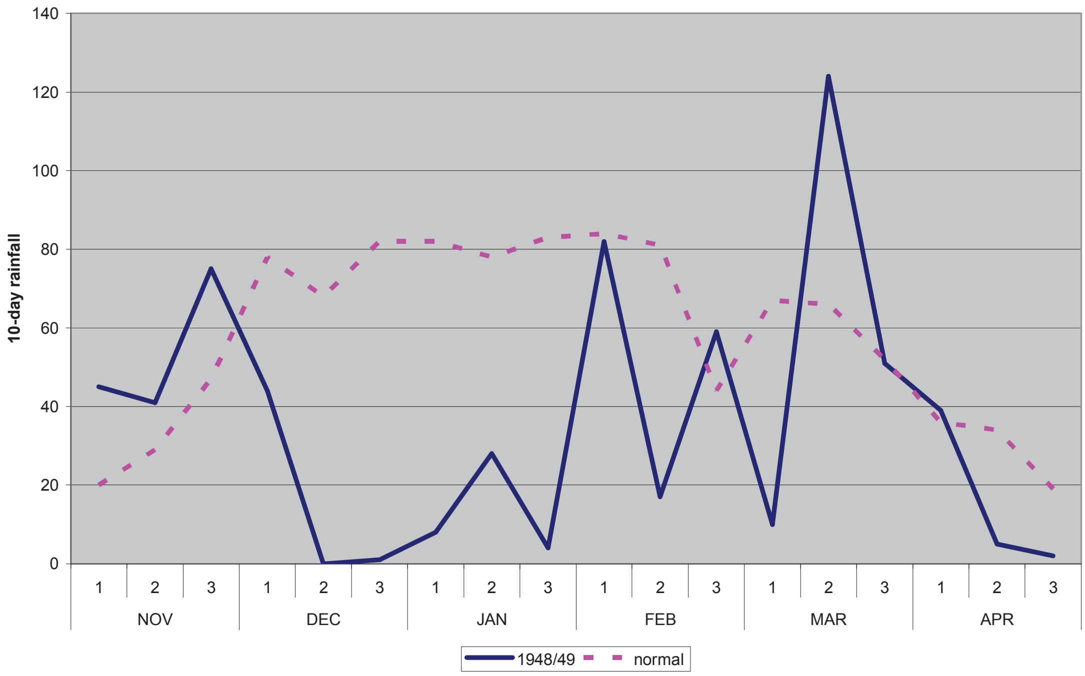


A look at the long term time series of normalized seasonal rainfall for Bvumbwe (Fig. 1), 1948/49 SPI value is -1.5 indicating that the season deviated by 1.5 standard deviation below normal. Using the

SPI drought classification, the SPI values are showing that 1948/49 was affected by severe drought while 1953/54, 1965/66, 1967/68, 1978/79, 1991/92, 1993/94 and 1994/95 seasons were affected by moderate drought. These results do not expose distribution of rainfall; rather they are based on seasonal rainfall totals. The results also show that extreme drought years vary from one locality to another. However, the outstanding drought years for all the selected stations were 1948/49, 1991/92 and 1994/95. Details for the other selected stations are in Annex 3.

The ten-day rainfall graphs for the outstanding drought years for the selected stations are showing the actual rainfall distribution in time against normal rainfall, from November to April. For instance Bvumbwe (Fig. 2) shows that during 1948/49 season dry spell set in from mid December to end of January, the period when the cereal crop is at flowering stage and requires adequate moisture. It is most likely that in Bvumbwe area cereal crop production went down.

Fig. 2: 1948/49 Vs Normal for Bvumbwe



In 1991/92 the situation was the same, but during 1994/95 onset of rains was suppressed until mid December. The rains ended abruptly at the end of February. Overall the Bvumbwe area experienced relatively short period of dry spells implying that the crops were not adversely affected during the critical period.

Looking at the ten-day graphs for the other selected stations in Annex 4 shows the following:

A general trend during the 1948/49 season is that the actual rainfall fell much below normal rainfall. There were short periods where rainfall was above normal rainfall either at the beginning of the season, mid-season or towards the end of season. There were intermittent incidences of dry spells throughout the season.

Again, a general trend for 1991/92 season is that the actual rainfall was much below normal rainfall. Just like 1948/49 season, there were occasional peaks of rain falling above normal either at the beginning of the season, during mid-season or towards the end. That is, there were intermittent incidences of dry spells throughout the season.

3.3 Survey

People interviewed in Balaka, Mangochi and Karonga indicated different years when drought was severe in those areas. Respondents in Karonga indicated that the most severe drought was 1997/98 while those in Balaka and Mangochi indicated 2001/02. The droughts that occurred in these areas affected major sectors of the economy such as agriculture, health, education and water sector.

3.3.1 Agriculture

It was reported that agricultural production was adversely affected during drought years. Maize yield was particularly affected when dry spell conditions set in during peak rainfall months of January and February and in some cases when onset of rains was erratic. In the case of livestock, it was reported that some animals lost weight and died due to lack of food and water, while others were attacked by various diseases such as African swine fever and black coat.

As coping mechanisms for both the drought and the ensuing femine, officials from the Ministry of Agriculture, Irrigation and Food Security advised people to grow sweet potatoes, cassava, and early maturing maize varieties. The survey indicated that people actually switched to cassava, sweet potatoes, millet and early maturing maize varieties. In some cases farmers sold their cattle and other animals and engaged in income generating activities so as to satisfy their needs. Some farmers had to take their animals to localities where there was adequate animal feed and water.

Drought relief assistance was provided by CADCOM and GTZ. The relief assistance was in form of maize, maize flour, beans, seeds (beans, soya and ground nuts seeds) and fertilizer, especially during 2001/2002 drought season.

3.3.2 Health

The droughts were associated with disease outbreaks such as cholera, malaria, diarrhea, kwashiorkor and maramus. It was also reported that a few people both young and old died due to hunger-related diseases and cholera. The actual figures were difficult to establish.

As a response to health problems some NGOs such as Save the Children Fund assisted the affected people particularly the children with nutritional food such as locally made *Likuni phala* and salt. UNICEF also provided similar assistance.

3.3.3 Education

The droughts and ensuing famine also led to school drop-outs and increased absenteeism among pupils; they had no food to carry to school and were busy looking for food. It was unclear whether teachers were also affected by the droughts.

In response to the effects of drought on the education sector, some NGOs have established school feeding programmes in some primary schools.

3.3.4 Water

In the water sector, droughts led to the shortage of water. Low levels of water in the rivers and wells were observed and in some cases rivers and wells dried up. This resulted in reduction of water for both human and animal consumption.

As way of coping with the drought situation, some farmers had to take their animals to localities where there was adequate animal feed and water.

3.3.5 Mitigation Measures

There was a mixed reaction in terms of whether people were warned in advance about any impending drought. However, some people got information on the impending droughts through the radio and the message was passed on to others through informal interactions. On the other hand some people never got the information at all.

As a long term solution to the problems that occur due to droughts, most people suggested that the government should promote irrigations systems in the country particularly in the drought prone areas. In addition, people interviewed also indicated that there is need for the government to make available information on impending drought on time for them to prepare for the drought.

4.0 CONCLUSION

This research study has brought some interesting facts about the prevalence of drought in Malawi. It is evident that drought is recurrent in Malawi and occurs at various intervals and severity. The frequency is higher in some areas while other areas experience drought less often.

The survey has shown that drought impacts are felt most by the rural poor and that these people look up to government and donors for coping mechanisms.

Some droughts like 1948/49 show remarkable recovery towards the end of the season in March and April. In such cases a tangible coping mechanism would be growing winter crops by utilizing residual moisture and supplementing with irrigation.

It has been established that not all the droughts in Malawi were El Nino induced. On the other hand not all El Nino phenomena resulted in droughts in Malawi. Other droughts occurred when sea surface temperatures in the eastern central equatorial Pacific Ocean were neutral, e.g 1958/59, 1959/60 and 1967/68, while other seasons experienced normal rainfall in Malawi while there was El Nino e.g. 1997/98 season. These facts render the prediction of drought in Malawi very difficult. More research needs to be done to ascertain the causes of each drought using other methodologies.

5.0 LESSONS LEARNT

- In 2 years out of 55 years it is possible to have drought that can affect all the three regions of the country. Otherwise, drought conditions can be expected somewhere in the country in a good number of years, but it is rare for all the regions to be drought stricken at the same time.

- A more rigorous definition of drought was needed in order to distinguish between low rainfall, true drought, and drought effects induced by poor management.

- The severity of drought cannot be judged only from the reduction in total annual rainfall; the distribution of rainfall within the season is important, especially for crops.

- An effective early warning system is invaluable for timely implementation of drought mitigating and relief measures, but must be accompanied by an infrastructure for implementation.

- NGOs can play an extremely useful role in the administration of drought relief measures in the rural communities.

- There is a need to come up with a National Drought Policy and Strategy document for Malawi.

7.0 WAY FORWARD

This study has been based on 55 years of temporal and spatial rainfall analysis. There is need to increase the number of years so as to establish whether drought is a phenomena of recent years or not. In addition, drought has a multi-dimensional impact on the economy of the country. The next updated study should therefore make a more comprehensive socio-economic analysis.

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ANNEX 1: QUESTIONAIRE ON DROUGHT

1. When do rains start in your area?
....
2. Which months do you usually experience dry spells?
....
3. When do rains end? ....
   ....
4. Which year did you experience drought? ....
5. Of those drought years which one was the worst?.............................
6. Why do you think it was a worst drought year?..................................
....
7. What were the major effects on:..
   - Water in rivers, wells?...
     ....
     ....
   - Animals (death, migration)?...
     ....
   - People?...
     ....
   - Crops?..
     ....
8. What remedial activities did you do?..
....
9. Did you receive any relief assistance?...
10. Who provided relief assistance?...
11. What did you receive as assistance?.................... ....
    ....
12. What advice did you receive from officials from agriculture
    ....
    ....
    ....
13. Was there any disease outbreak during the drought years?
    ....
....
14. Mention the names of the diseases..
....
....
15. Was there any outbreak of animal diseases? ....
If yes which diseases?..
16. What action did the animal health officials take? ....
....
....

17. How many people died:
    - Young people? …………………………………………………………………….
    - Old people?..
18. Did the drought situation affect the school attendance of
    - School going youth?............ If yes explain how ....
    - Teachers? ………….. If yes explain how ……………………………………………………………………………………… ………………………………………………………………………………..
19. Were you ever warned of the impending droughts? …… If yes, who? ………………………………………………………………………………………
20. What should the government do in future to protect you from serious impacts of drought? ……………………………………………..

………
………
……………………………………………………………………………………………………….