DROUGHT ANALYSIS IN BURUNDI

A THESIS SUBMITTED AND PRESENTED

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BY

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IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN HYDROLOGY AND WATER RESOURCES MANAGEMENT

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for the acceptance by the University of Arba Minch the dissertation entitled **“DROUGHT ANALYSIS IN BURUNDI”** in partial fulfillment of the requirements for the degree of Master of Science in Hydrology and Water Resources Management.

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DECLARATION AND COPYRIGHT

I, **CELEUS NGOWENUBUSA**, declare that this dissertation is my original work and that it has not been presented and will not be presented to any other University for similar or any other degree award.

Signature:

Date………………………

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- Last but not least, I wish to express my deep gratitude to all my family and my friends for their continuous moral support and encouragement in times of stress.

DEDICATION

As a memorial to

My Lovely Grand Mother Sofia Ntakabaronga

And

My Dear Father Michael Bayanda

Abstract

The objective of the study is to understand the rainfall variation in space and time in the study area and analyze drought characteristics: intensity, duration, frequency, and severity. In this study, the Standardized Precipitation Index (SPI) analyzed the differences in spatial patterns of drought over a range of time scales. Missing data were filled using Simple Average Method and Normal ratio Method. Consistency or homogeneity was tested using SPLIT RECORD TEST (F-test for stability of variance and t-test for stability of mean). Easy Fit software was used for fitting the best distribution.

In this study, during the period investigated, the results show that the rainfall decreased from 1989 but the decrease becomes stronger from 2000.In this period, the SPI for multiple scales under consideration namely 12 months (Jan-Dec), 8 months (Oct-May), 4 months (Oct-Jan), and 4 months (Feb-May) has been computed for all selected stations. The relationship between rainfall variability and drought event over the country was studied. The ratio is less than 25% and therefore, the variability is moderate in Burundi. Based on year 2005, it was found that the eastern part region of Burundi has the highest coefficient value (20%-32%) and the results show that there is a trend of SPI negative values from the year 2000 up to 2005 for all selected stations in general and the eastern part area in particular which implies that the eastern region of Burundi is vulnerable to drought. In fact, the maximum duration (64 months) was recorded at Giharo station, the maximum severity (8.43), maximum magnitude (0.19) and maximum intensity (-3.57) were found at Kinyinya station). It appears that period of drought have been quite frequent starting from 2000, with SPI ranging from about -1 to about -3.

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LIST OF ABBREVIATIONS

AMU	Arba Minch University
AWC	Available Water Content
C	Century
CMI	Crop Moisture Index
CSDI	Crop Specific Drought Index
CV	Coefficient of Variation
Dec	December
DR	Dependable Rain
ED	Extreme Drought
%ED	Percentage of Extreme Drought
Feb	February
Jan	January
IDWA	Inverse Distance Weight Average
IGEBU	Institut géographique du Burundi
m	Month
MD	Mild Drought
%MD	Percentage of mild Drought
MoD	Moderate Drought
%MoD	Percentage of Moderate Drought
NDI	National Rainfall Index
NDVI	Normalized differences of vegetation
P	Precipitation
PDSI	Palmer Drought Severity Index
PN	Percent of Normal
RAI	Rainfall Anomaly Index
RDI	Reclamation Drought index
S.d	Standard deviation

%SD	Percentage of Severe Drought
SMDI	Soil Moisture Drought Index
SPI	Standardized precipitation Index
SPI-4	Accumulation Precipitation of 4 months
SPI-8	Accumulation Precipitation of 8 months
SPI-12 (annual)	Accumulation Precipitation of Jan to Dec
SWSI	Surface Water Supply Index

CHAPTER ONE

1. Introduction and Background

1.1.Introduction

BURUNDI is a country prone to extreme climate events such as drought. Successive years of low precipitation have left large areas in drought that result in crop failure, water shortage and raising serious food security concerns. Drought is one of the environmental disasters in BURUNDI, generally characterized by a deficiency of precipitation over an extended period of time. Impacts are cumulative and the effects magnify when events continue from one season to the next. The economical impact occurs in agriculture and related sectors, which depend on the surface and groundwater supplies. In addition to obvious losses in yields in crop and livestock production, drought is associated with the increase in insect infestations, plant disease and wind erosion. The social impact is present in periods of extreme, persistent drought. The severity of drought depends upon the degree of precipitation deficiency, the duration and the size of the affected area. As there is no precise and universally accepted definition of drought, there exists uncertainty in the occurrence of drought and its severity. This uncertainty often affects decisions on whether to take the remedial measure at the right time and place. Drought impacts may vary from region to region based upon the differences in social, economical and environmental characteristics at all levels. Drought risk is based on a combination of the frequency, severity, and spatial extent of drought (the physical nature of drought) and the degree to which a population or activity is vulnerable to the effects of drought.

Although drought is a natural hazard, society can reduce its vulnerability .The impacts of drought, like those of other natural hazards; can be reduced through mitigation and preparedness (risk management). Planning for drought is essential (early warning, drought management, disaster prevention), but it may not come easily because one of the major impediments to drought planning is its cost and there are many constraints to planning:

- Decision makers, policy makers, and the general public may lack an understanding of drought.

- In areas where drought occurs frequently, governments and the public may ignore drought planning, or give it low priority. Governments and the public may have inadequate financial ressources.

- Most countries lack a unified philosophy for managing natural resources, including water

1.2.Background and location

In Burundi, some meteorological services are existing from 1962 and this paper used data available in meteorological services in order to carry out Drought Analysis. As the famine due to drought is nowadays a big concern, it is expected that such study should help through enhancing or improvement of actual conditions about degradation of environment, which may be one of the causes of drought. Burundi is a small country with a geographical area 27,834 km2 and its location is 3°3' under equator in Central Africa (Figure 1.1.)

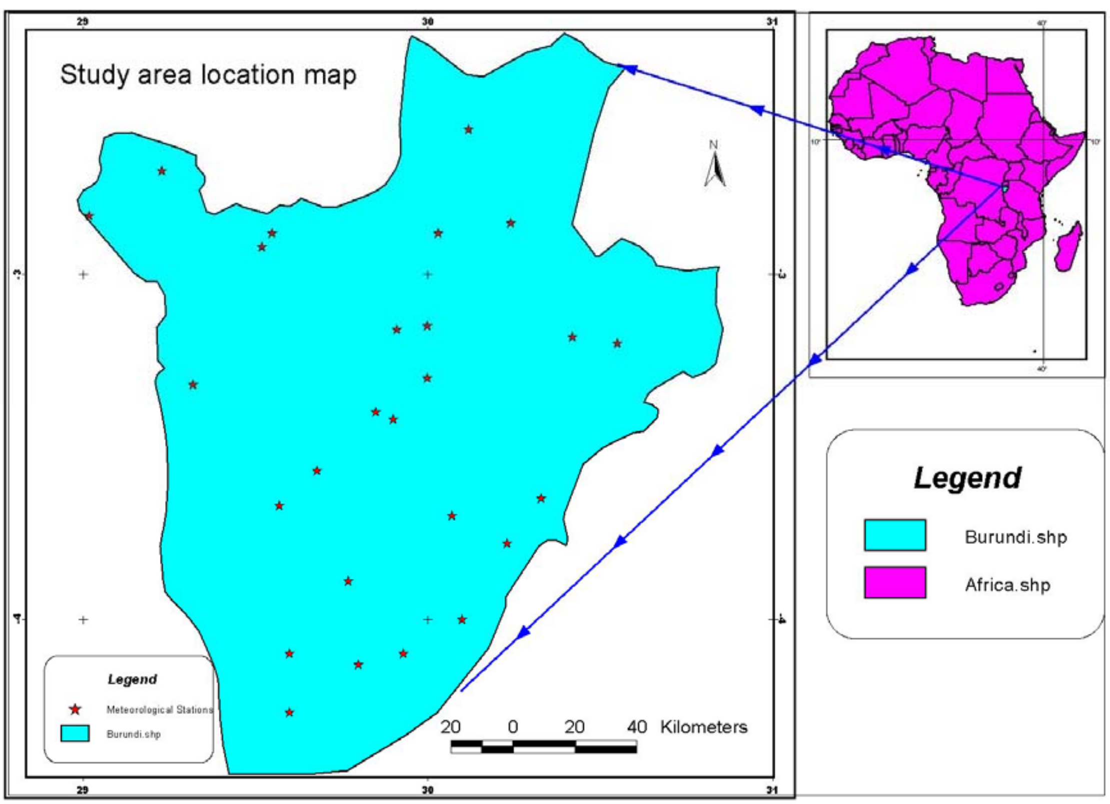


Figure.1.1.Study area

1.3. Climate and rainfall pattern

In Burundi, the general climate is defined as tropical highland, but differences in altitude from region to region cause temperature variations with an average of 23 degrees Celsius and annual precipitation of about 800mm. There are two main seasons: the dry season (June - September); the wet season (October- May). The water catchments of Burundi fall within 2 great African watersheds: the Nile basin and the Congo basin.

Rainfall variability could be expressed by the coefficient of variation (CV) which is defined as the ratio of standard deviation to mean in percent, where mean and standard deviation are estimated from rainfall data. In Burundi, the behavior of precipitations is bimodal as shown below with Cankuzo station (Fig1.2-Cankuzo station -1993). . This graphical representation of rainfall below is taken as an example but it is the same for all stations over all the country under study.

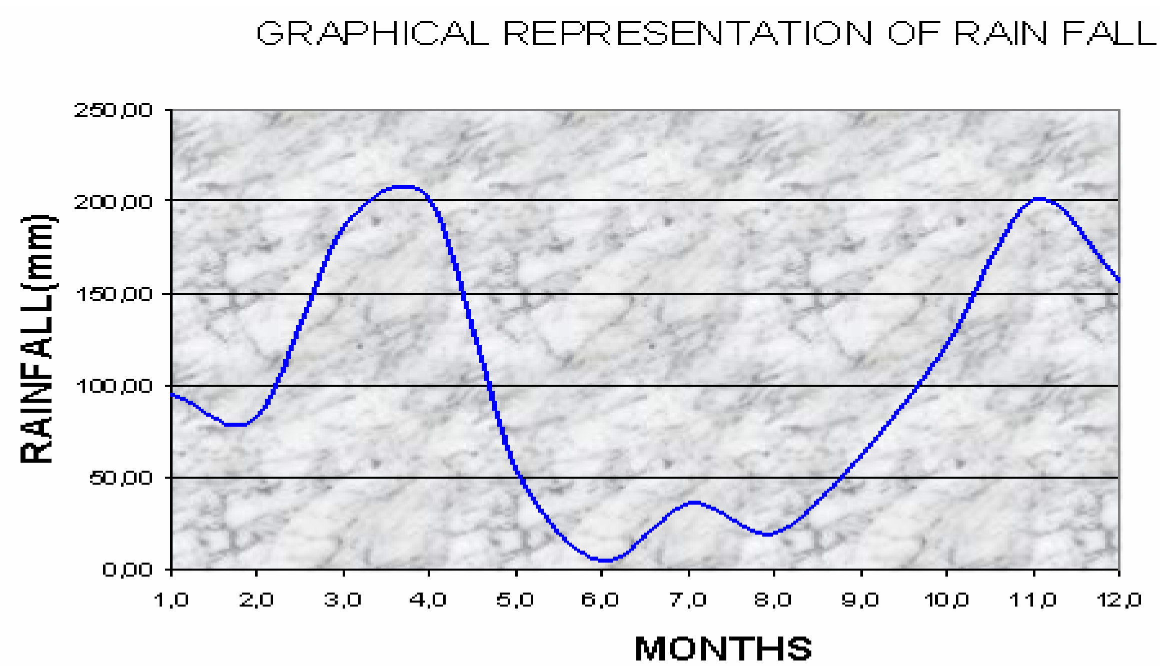


Figure 1.2.Graphical representation of Cankuzo station-1993

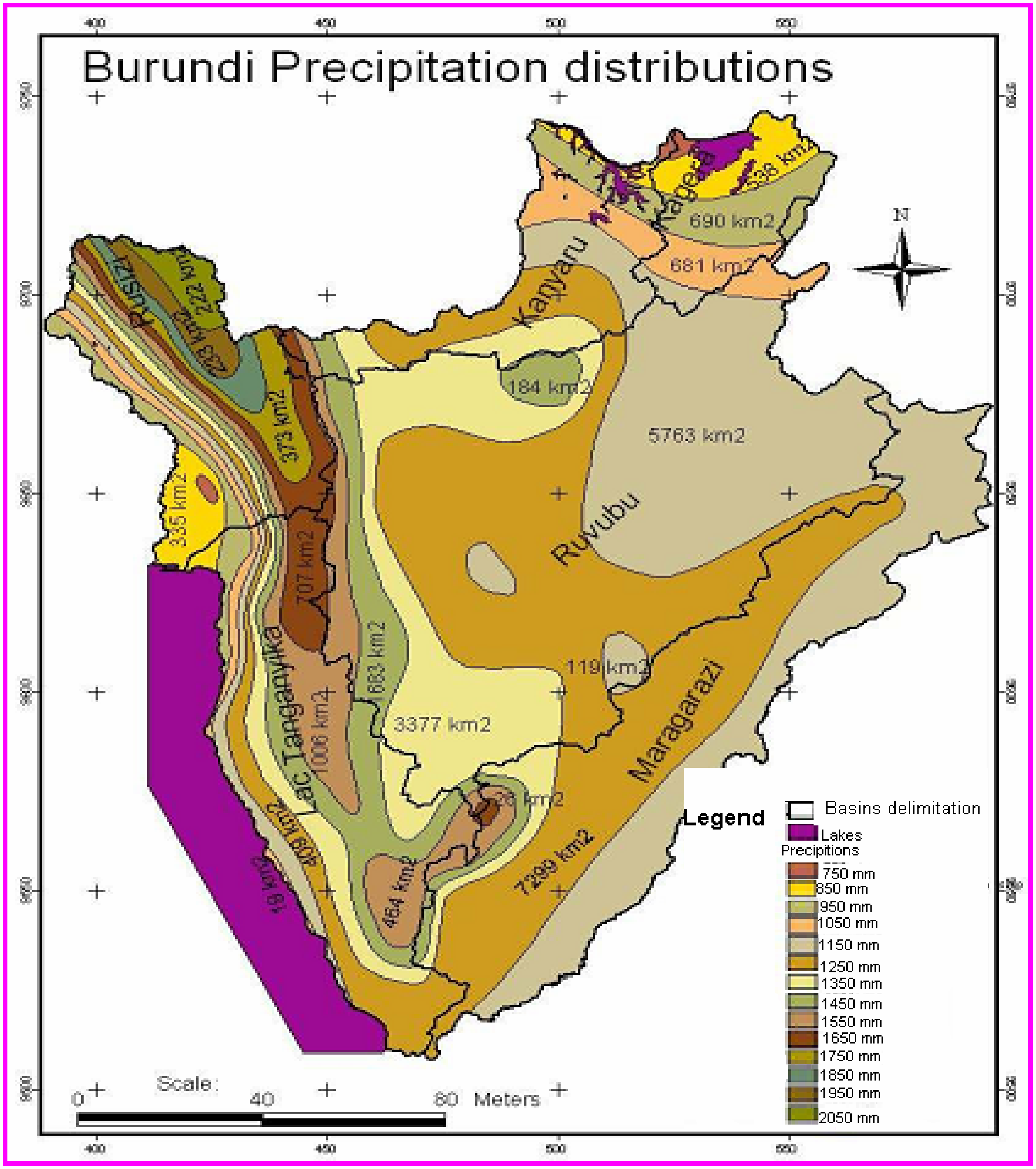


Figure 1.3 Burundi Annual Precipitation Distributions

I. 4. Statement of the problem and Objective of the study

Drought is natural disasters, which originates from the lack of precipitation and brings significant economic losses. It is not possible to avoid it but drought preparedness can be developed and droughts impacts can be managed. In Burundi, drought and desertification are taking place step by step, and there is a spatial variability between different locations because some receive insufficient rainfall in a year while in others locations it is more than 2000mm (Figure 1.3). Therefore, it is important to analyze the variations of precipitations in time and space.

The objective of the study is to understand the rainfall variation in space and time in the study area and analyze drought characteristics: intensity, duration, frequency, severity in order to solve the fundamental problem which is to protect people from repetitive drought impacts. This study may highlight recommendations about identifying appropriate mitigation action for future drought event and minimizing its impacts on water management and agriculture, economic sector, social sector, water resources and drinking water supply, health problems, environmental problems…etc.

CHAPTER TWO

2. LITERATURE REVIEW

2. 1. The concept of drought

A shortage of water is not the same as drought. Drought is an insidious hazard of nature. Although it has scores of definitions, it originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought should be considered relative to some long-term average condition of balance between precipitation and evapotranspiration (i.e., evaporation + transpiration) in a particular area, a condition often perceived as “normal”. It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains.

The term “drought “has different connotation in various part of the world: in Egypt, any year the Nile river doesn’t flood is drought, regardless of rainfall; in Libya when annual rain fall is less than 180 mm, so, drought can be neither accurately define in term of mm of rainfall or by number of days without rains. Drought occurs in almost all climatic regimes. It occurs in high as well as low rainfall areas. It is a temporary anomaly and as such it differs from aridity, which is a permanent feature of climate in low rainfall areas (Wilhite 2000).

Drought is considered by many to be the most complex but least understood of all natural hazards, making it hard to predict and monitor. Scientists are trying to develop mathematical models to help predicting drought a month or more in advance for most parts of the world.

Geraldine Wong of the University of Adelaide has used global climatic indices such as the Southern Oscillation Index (SOI) in conjunction with rainfall statistics to develop the copulas models that predict future droughts with a high degree of accuracy (The Economic Times,posted on Google –Alert drought by Willen Van Cotthem,june 2008).If you are a farmer, drought means that you do not have enough water in the soil for crops to grow normally or for pastures to produce enough grass for livestock. For farmers who rely on irrigation to produce their crops, drought may be a shortage of water in reservoirs, streams, or groundwater, and irrigation may be restricted. If you live in a city, drought may result in a shortage of water for watering grass, trees, and other plants. Often during drought, people in cities are asked to conserve water used inside the home and outside.

There are many definitions of drought because its characteristics and impacts differ from one location to another. Drought is more relative than absolute concept in water resources An operational definition for agriculture might compare daily precipitation values to evapotranspiration rates to determine the rate of soil moisture depletion, then express these relationships in terms of drought effects on plant behavior (i.e., growth and yield) at various stages of crop development. A definition such as this one could be used in an operational assessment of drought severity and impacts by tracking meteorological variables, soil moisture, and crop conditions during the growing season, continually reevaluating the potential impact of these conditions on final yield. Operational definitions can also be used to analyze drought frequency, severity, and duration for a given historical period. Such definitions, however, require weather data on hourly, daily, monthly, or other time scales and, possibly, impact data (e.g., crop yield), depending on the nature of the definition being applied. Developing climatology of drought for a region provides a greater understanding of its characteristics and the probability of recurrence at various levels of severity. Information of this type is extremely beneficial in the development of response and mitigation strategies and preparedness plans.

2. 2. Types of drought

According to World Meteorological Organizations, drought has been categorized as, Agricultural drought, Meteorological drought, Hydrological drought and Socio-economic drought (figure 2.1). The definitions of each drought term are given subsequently.

2. 2. A. Agricultural Drought

An agricultural drought refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop.

Agricultural drought occurs when the yield drops below the average crop production. This happens due to non-availability of desired level of natural soil moisture and the periods may not necessarily coincide with the period of meteorological and hydrological drought A good definition of agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. It occurs when yield drops much below the average crop production. Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, reduced ground water or reservoir levels, and so forth.

2. 2. B. Meteorological Drought

Period of meteorological drought is characterized by a situation when the rainfall is substantially below its climatologically expectations. In common language, large water shortage due to lack of precipitation implies meteorological drought. It is a measure of departure of precipitation from the normal and defined usually on the basis of the degree of dryness (in comparison to some “normal” or average amount) and the duration of the dry period. Its period may last a few days up to several weeks or even years.

2. 2. C. Hydrological Drought

Hydrological drought occurs when river flows or stored water in reservoir, lake and aquifers fall below some critical levels. It is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., stream flow, reservoir and lake levels, ground water).A fall of 20% or more in groundwater level with respect to normal mean positions is considered to be a drought year. The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency represents the temporal hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, stream flow, and ground water and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that is almost immediately discernible to agriculturalists, but the impact of this deficiency on reservoir levels may not affect hydroelectric power production or recreational uses for many months.

2. 2. D. Socioeconomic Drought

It refers to the situation that occurs when physical water shortage begins to affect people. It expresses features of the socio – economic effects of drought and can also incorporate features of meteorological, agricultural, and hydrological drought. They are usually associated with the supply and demand of some economic grounds.

Socioeconomic definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. It differs from the other types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts.

The supply of many economic goods, such as water, forage, food grains, fish, and hydroelectric power, depends on weather. Because of the natural variability of climate, water supply is ample in some years but unable to meet human and environmental needs in other years. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

2. 3. Impact of drought

When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage. Those who rely on surface water (i.e., reservoirs and lakes) and subsurface water (i.e., ground water), for example, are usually the last to be affected. When precipitation returns to normal and meteorological drought conditions have abated, the sequence is repeated for the recovery of surface and subsurface water supplies. Soil water reserves are replenished first, followed by stream flow, reservoirs and lakes, and ground water. Ground water users, often the last to be affected by drought during its onset, may be last to experience a return to normal water levels. The length of the recovery period is a function of the intensity of the drought and its duration.

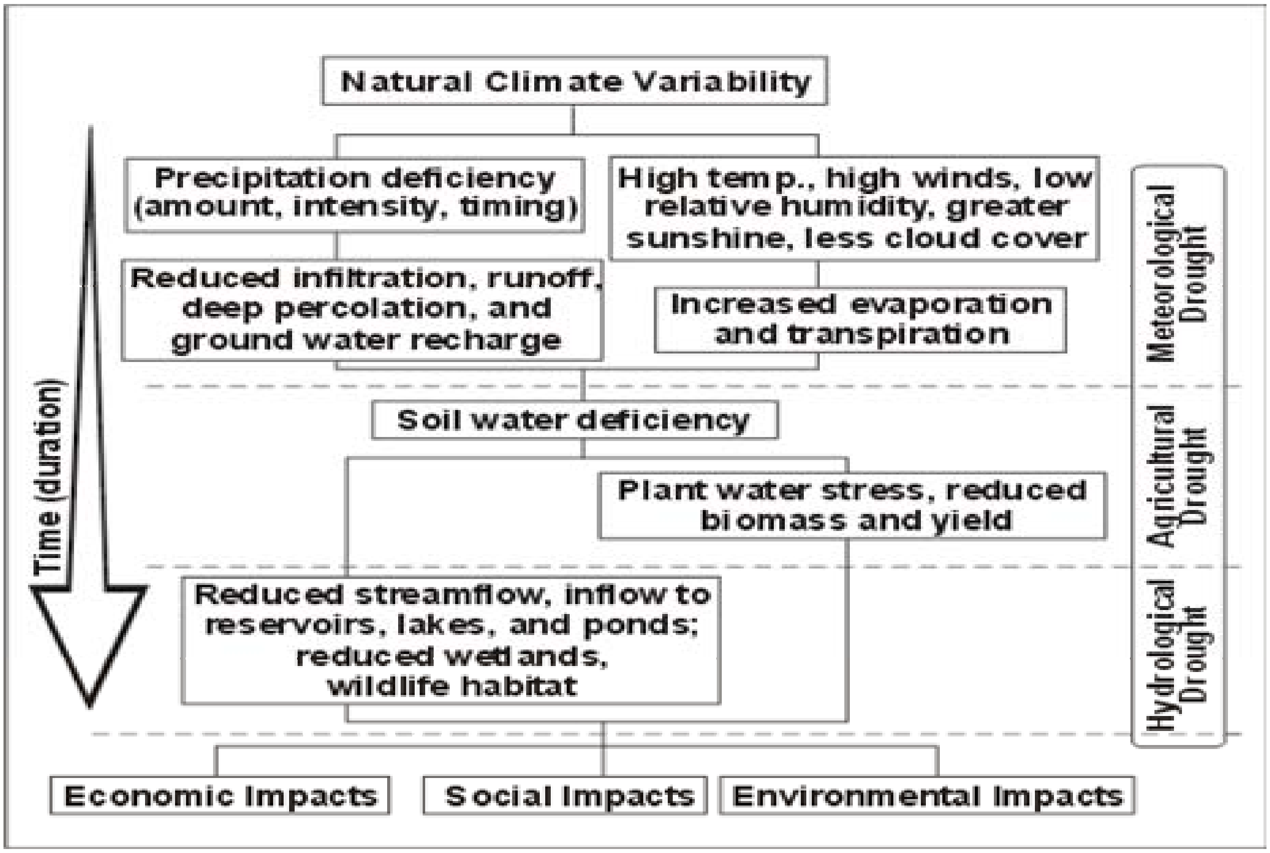


Figure 2.1.Types of drought (Wilhite and Glantz, 1985)

2. 4. Drought indices

A drought index value is typically a single number, far more useful than raw data for decision-making. There are several indices that measure how much precipitation for a given period of time has deviated from historically established norms.

2. 4.1. Standardized Precipitation index (SPI)

McKee *et al.* (1993) developed the Standardized Precipitation Index (SPI) for the purpose of defining and monitoring drought. The nature of the SPI allows an analyst to determine the rarity of a drought or an anomalously wet event at a particular time scale for any location in the world that has a precipitation record.

The SPI is an index based on the probability of precipitation for any time scale. Many drought planners appreciate the SPI versatility. The SPI can be computed for different time scales, can provide early warning of drought and help assess drought severity, and is less complex than the Palmer. The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee, 1997). Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation.

Because the SPI is normalized, wetter and drier climates can be represented in the same way, and wet periods can also be monitored using the SPI. McKee et al. (1993) also defined the criteria for a drought event for any of the time scales. A drought event occurs any time the SPI is continuously negative and reaches intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's magnitude.

Table 2.1: SPI Values

SPI values	
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-.99 to .99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and less	Extremely dry

2. 4.2. Palmer Drought Severity Index (The Palmer; PDSI)

Palmer has developed the PDSI in 1965. It is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer. Human impacts on the water balance, such as irrigation, are not considered. The Palmer is a soil moisture algorithm calibrated for relatively homogeneous regions.

Table 2.2: Palmer classifications

Palmer Classifications	
4.0 or more	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.5 to -0.99	Incipient dry spell
-1.0 to -1.99	Mild drought
-2.0 to -2.99	Moderate drought
-3.0 to -3.99	Severe drought
-4.0 or less	Extreme drought

There are considerable limitations when using the Palmer Index, and these are described in detail by Alley (1984) and Karl and Knight (1985). Drawbacks of the Palmer Index include:

- The Palmer Index is sensitive to the AWC of a soil type. Thus, applying the index for a climate division may be too general.
- The two soil layers within the water balance computations are simplified and may not be accurately representative of a location.
- Snowfall, snow cover, and frozen ground are not included in the index. All precipitation is treated as rain, so that the timing of PDSI or PHDI values may be inaccurate in the winter and spring months in regions where snow occurs.
- The natural lag between when precipitation falls and the resulting runoff is not considered. In addition, no runoff is allowed to take place in the model until the water capacity of the surface and subsurface soil layers is full, leading to an underestimation of runoff. Several other researchers have presented additional limitations of the Palmer Index.
- McKee et al. (1995) and suggested that the PDSI is designed for agriculture but does not accurately represent the hydrological impacts resulting from longer droughts.

2. 4.3. Percent of Normal

Percent of normal is easily misunderstood and gives different indications of conditions depending on the location and season. It is one of the simplest measurements of rainfall for a location. Analyses using the percent of normal are very effective when used for a single region or a single season. It is calculated by dividing actual precipitation by normal precipitation typically considered to be a 30-year mean and multiplying by 100%. This can be calculated for a variety of time scales. Usually these time scales range from a single month to a group of months representing a particular season, to an annual or water year. Normal precipitation for a specific location is considered to be 100%. One of the disadvantages of using the percent of normal precipitation is that the mean, or average, precipitation is often not the same as the median precipitation, which is the value exceeded by 50% of the precipitation occurrences in a long-term climate record. The reason for this is that precipitation on monthly or seasonal scales does not have a normal distribution.

2. 4.4. Surface Water Supply Index (SWSI; pronounced “swazee”)

Surface Water Supply Index (SWSI) was developed by Shafer and Dezman (1982) to complement the Palmer Index for moisture conditions. The procedure to determine the SWSI for a particular basin is as follows: monthly data are collected and summed for all the precipitation stations, reservoirs, and stream flow measuring stations over the basin. Each summed component is normalized using a frequency analysis gathered from a long-term data set. The probability of non-exceedence—the probability that subsequent sums of that component will not be greater than the current sum—is determined for each component based on the frequency analysis.

This allows comparisons of the probabilities to be made between the components. Each component has a weight assigned to it depending on its typical contribution to the surface water within that basin, and these weighted components are summed to determine a SWSI value representing the entire basin. Like the Palmer Index, the SWSI is centered on zero and has a range between -4.2 and +4.2.

Several characteristics of the SWSI limit its application. Because the SWSI calculation is unique to each basin or region, it is difficult to compare SWSI values between basins or regions. Within a particular basin or region, discontinuing any station means that new stations need to be added to the system and new frequency distributions need to be determined for that component.

Additional changes in the water management within a basin, such as flow diversions or new reservoirs, mean that the entire SWSI algorithm for that basin needs to be redeveloped to account for changes in the weight of each component. Thus, it is difficult to maintain a homogeneous time series of the index. Extreme events also cause a problem if he events are beyond the historical time series, and the index will need to be reevaluated to include these events within the frequency distribution of a basin component.

2. 4.5. Reclamation Drought Index

The Reclamation Drought Index (RDI) was recently developed as a tool for defining drought severity and duration, and for predicting the onset and end of periods of drought. The RDI differs from the SWSI in that it builds a temperature-based demand component and duration into the index. The RDI is adaptable to each particular region and its main strength is its ability to account for both climate and water supply factors. Like the SWSI, the RDI is calculated at a river basin level, and it incorporates the supply components of precipitation, snow pack, stream flow, and reservoir levels. The RDI values and severity designations are similar to the SPI, PDSI, and SWSI.

Table 2.3: RDI classifications

RDI Classifications	
4.0 or more	Extremely wet
1.5 to 4.0	Moderately wet
1 to 1.5	Normal to mild wetness
0 to -1.5	Normal to mild drought
-1.5 to -4.0	Moderate drought
-4.0 or less	Extreme drought

2. 4.6. Deciles

The deciles method was selected as the meteorological measurement of drought because it is relatively simple to calculate and requires less data and fewer assumptions than the Palmer Drought Severity Index. Arranging monthly precipitation data into deciles is another drought-monitoring technique.

It was developed by Gibbs and Maher (1967) to avoid some of the weaknesses within the "percent of normal" approach. The technique they developed divided the distribution of occurrences over a long-term precipitation record into tenths of the distribution. They called each of these categories a ***decile***. The first decile is the rainfall amount not exceeded by the lowest 10% of the precipitation occurrences. The second decile is the precipitation amount not exceeded by the lowest 20% of occurrences. These deciles continue until the rainfall amount identified by the tenth decile is the largest precipitation amount within the long-term record. By definition, the fifth decile is the median, and it is the precipitation amount not exceeded by 50% of the occurrences over the period of record. The deciles are grouped into five classifications

Table 2.4: **Decile classifications**

Decile Classifications	
deciles 1-2: lowest 20%	Much below normal
deciles 3-4: next lowest 20%	Below normal
deciles 5-6: middle 20%	Near normal
deciles 7-8: next highest 20%	Above normal
deciles 9-10: highest 20%	Much above normal

2.4.7. Crop Moisture Index (CMI)

. The CMI reflects moisture supply in the short term across major crop-producing regions and is not intended to assess long-term droughts. Because it is designed to monitor short-term moisture conditions affecting a developing crop, the CMI is not a good long-term drought-monitoring tool. Another characteristic of the CMI that limits its use as a long-term drought-monitoring tool is that the CMI typically begins and ends each growing season near zero.

This limitation prevents the CMI from being used to monitor moisture conditions outside the general growing season, especially in droughts that extend over several years.

The CMI also may not be applicable during seed germination at the beginning of a specific crop's growing season.

Palmer (1968) developed the Crop Moisture Index (CMI) from procedures within the calculation of the PDSI. Whereas the PDSI monitors long-term meteorological wet and dry spells, the CMI was designed to evaluate short-term moisture conditions across major crop-producing regions. It uses a meteorological approach to monitor week-to-week crop conditions based on the mean temperature and total precipitation for each week within a climate division.

2. 4.8. National Rainfall Index (NRI)

It is used to compare precipitation patterns and anomalies on a continental scale.NRI were developed by Gommes and Petrassi stated in Hayes (2003) to characterize recent precipitation patterns across Africa. It is calculated for each country by taking a national annual precipitation average weighted according to the long – term precipitation averages off all the individual stations. The NRI allows comparisons to be made between years and between countries.

2. 4.9. Dependable Rain (DR)

Dependable Rain is another rainfall monitoring tool which has been applied to the African continent by Le Houerou(1993) stated in Hayes (2003).It is defined as the amount of rainfall that occurs in four of every five years(statistically, not consecutively).In Africa, the relationship of the DR to the mean is not straight forward and reflects the characteristics of annual precipitation across the continent.

Table 2.5: Characteristics of drought indices

N°	Name	Factors used	Time scale	Main concept
1	PDSI	P, T, ET, SM, RO	m	Based on moisture ,inflow, outflow and storage
2	SWSI	PDSI, SN	m	Like the PDSI but consider SN
3	PN	P	m	Dividing actual P by the normal value
4	Deciles	P	m	Dividing distribution of occurrences over along term p record
				into sections each representing ten percent
5	SPI	P	3m	Difference of P from the mean for a particular time and
			6m	dividing it by the standard deviation
			12m	
			24m	
			48m	
6	RDI	P	m, y	Percent departure of P from the long-term mean
				in top 5 feet of soil profile
7	DR	P	y, c	Patterns and abnormalities of P on a continental scale
8	NRI	P	M ,y	P compared to arbitrary value of +3 and -3,which assigned
9	RDI	P	m, y	Percent departure of P from the long-term mean

2.5. Selection of drought index

Although none of the major indices is inherently superior to the rest in all circumstances, some indices are better suited than others for certain uses. Depending upon the data already available and collected, a suitable index can be chosen. The selection of method of analysis is governed by the availability of data and accuracy of the result required.

Among the drought indicators noted above, Standardized Precipitation Index (SPI) was selected because of the followings advantages:

- The SPI is a probability index that considers only precipitation, while Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff).
- The SPI can be computed for different time scales, can provide early warning of drought and help assess drought severity, and is less complex than the Palmer.

- It is simple, popular, recent, based only on rainfall.
- It can be used effectively in both summer and winter by avoiding dependence on soil moisture condition.
- It is not affected adversely by topography whereas the PDSI for example is used for large areas with uniform topography and designed for agriculture.
- The Standardized Precipitation Index (SPI) is a way of measuring drought that is different from the Palmer drought index (PDI).
- Like the PDI, this index is negative for drought, and positive for wet conditions.
- Accordingly, SPI has been chosen for this study and more over, the data namely the precipitations were available and collected from the Geographic Institute of Burundi (IGEBU, 2006).

CHAPITER THREE

3. METHODOLOGY

3. 1. General

The variation of rainfall and drought can be analyzed by Statistical analysis and using several indices (Table2.5). There are some Index: e.g. Percent of Normal (PN), Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI), Crop Moisture Index (CMI), Surface water supply Index (SWSI), Reclamation Drought Index (RDC), Deciles, etc. Dry or wet period is determined from the numerical value of the index**.** A drought index value is typically a single number and measures how much precipitation for a given period of time has deviated from historically established norms. To analyze the drought condition in Burundi, 26 meteorological stations among 169 stations scattered all over the country were selected based on a minimum of 25 years recording of data. The objective was achieved by using one of the most popular index: the Standardized Precipitation Index. It is a tool, which was developed primarily for defining and monitoring drought. It allows an analyst to determine the rarity of a drought at a given time scale of interest for any rainfall station with historic data. It can also be used to determine periods of anomalously wet events. The SPI is not a drought prediction tool. It is based on the cumulative probability of a given rainfall event occurring at a station. The historic data of the station is fitted to a gamma distribution, as gamma distribution has been found to fit the precipitation distribution quite well. This is done trough gamma distribution parameters, alpha and beta. A drought event occurs any time the SPI is continuously negative and reaches intensity of -1.0 or less. The event ends when the SPI becomes positive (Table2.1, SPI values).

Many researchers agree that, two characteristics are enough to identify the drought since they can derive the third and for each negative value.

- Duration is defined as the time difference between the onset and the end of the drought event (cumulative of mild, moderate, severe and extreme).
- Severity is defined as the cumulative water deficiency (degree of deficit), expressed based on SPI value (in table2.1)
- Drought intensity, as categorized(in table 2.1)
- Drought magnitude, defined as the ratio of severity to duration
- Drought duration is the number of successive months during which SPI value in table 2.1.is mild, moderate, severe or extreme.

3. 2. Data availability and source

Monthly data of rainfall has been acquired from the Geographic institute of Burundi (IGEBU). The appendix C shows the total of rainfall stations (169) over the country among which only 26 stations were selected for the study. The criteria for selection of these stations was subjective but an attempt was made to get stations scattered all over the country with a minimum recording data of 25 years in West, East, Centre, South and North of Burundi (table3.1).

Table 3. 1. Stations selected for study

Location	N°	Longitude	Latitude	Altitude	Starting Year	End Year	Total Years
West	1. Bugarama-Aéro	29.55	-3.3	2240	1971	2005	34
West	2. Bujumbura-Aéro	29.32	-3.3	783	1961	2005	44
East	3. Cankuzo	29.17	-2.7	1307	1973	2005	32
East	4. Giharo	30.23	-2.78	1250	1962	2005	43
Centre	5. Giheta	29.85	-3.4	1624	1971	2005	34
Centre	6. Gisozi	29.68	-3.6	2097	1961	2005	44
Centre	7. Gitega-Aéro	29.92	-3.4	1645	1971	2005	34
Centre	8. Karusi	30.17	-3.1	1600	1961	2005	44
South	9. Kayogoro (Maka)	29.93	-4.1	1550	1974	2005	31
East	10. Kinyinya	30.33	-3.65	1308	1967	2005	38
North	11. Kirundo	30.12	-2.58	1449	1971	2005	34
West	12. Mabayi	29.23	-2.7	1509	1958	2002	44
South	13. Makamba	29.82	-4.1	1450	1971	2005	34
West	14. Mparambo	29.08	-2.8	887	1961	1996	35
Centre	15. Mpota-Tora	29.57	-3.7	2160	1965	2005	40
Centre	16. Mugera - paroisse	29.97	-3.32	1757	1960	2005	45
East	17. Musasa	30.1	-4	1260	1961	2005	44
East	18. Musongati	30.07	-3.7	1770	1976	2005	29
Centre	19. Mutumba(Nyab)	29.35	-3.6	971	1971	2000	29
North	20. Muyaga	30.55	-3.2	1750	1931	2005	74
North	21. Muyinga	30.35	-2.85	1756	1961	2005	45
North	22. Nyamuswaga	30.03	-2.88	1720	1980	2005	25
South	23. Nyanza-Lac	29.6	-4.4	792	1980	2005	25
Centre	24. Ruvyironza	30.25	-3.5	1610	1961	2005	44
North	25. Rwegura	29.52	-2.9	2302	1961	2005	44
South	26. Rweza-vyanda	29.6	-4.1	1851	1980	2005	25

3. 3.Filling missing data and Screening Data

Different methods can be used when filling missing data like Arithmetic Mean Method, Normal Ratio Method, used when the normal annual precipitation of the index stations differ by more than 10% of the missing station, Regression Method, Inverse Distance Method, Weight Average using Loc Clim Software …etc. For this study, there were almost no missing data and when it was missing, Arithmetic Mean Method was used because stations in the study area were closed and the normal annual rainfall of the missing station say x was within 10% of the normal annual rainfall of the surrounding stations.

Screening data was also important to avoid erroneous recorded data and double mass curve technique was used to check the relative spatial consistency and homogeneity of the data. Using the tests for stability of variance (F-test)and mean (T-test), the data were suitable for further use according to the methodology in : Screening of Hydrological data (Tests for Stationary and Relative Consistency, by E.R. Dahmen & M.J.Hall, 1989).

3.4. SPI Computation

Mathematically, the SPI is based on the cumulative probability of a given rainfall event occurring at a station. The is computed by fitting a probability density function to the frequency distribution of precipitation summed over the time scale of interest. This is performed separately for each month and for each location in space. Each probability density function is then transformed into the standardized normal distribution. Thus, the SPI is said to be normalized in location and time scale.

Once standardized, the strength of values is classified as shown in table2.1.and the process of SPI calculation can be resumed as follows:

1. Calculation of accumulated precipitation for time scale interest.
2. Adjustment accumulated precipitation to the distribution functions, it may be Gamma, Lognormal, Logistic and so forth, but according to Edwards and McKee, Gamma distribution is fitting well precipitation data.
3. Select the distribution function that fit accumulated precipitation value
4. Transform the select distribution function obtained into SPI values.

Using Gamma distribution SPI is calculated as follows:

$$Z = SPI = -\left[t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right]$$ For 0<H(x) ≤0.5

$$Z = SPI = +\left[t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right]$$ For 0.5< H(x) <1

$$Where: t = \sqrt{In\left(\frac{1}{(H(x))^2} \right)}$$ For 0<H(x) ≤0.5

And

$$t = \sqrt{\ln\left(\frac{1}{(1 - H(x))^2} \right)}$$ For 0.5< H(x) <1

$C_0 = 2.515517$

$C_1 = 0.802853$

$C_2 = 0.0100328$

$d_1 = 1.432788$

$d_2 = 0.189269$

$d_3 = 0.001308$

$H(x) = Cumulative \Pr obabliity$
$= q + (1 - q)G(x)$

q=the probability of zero precipitation, gamma distribution is undefined for X=0 and q=p(x=0)>0

, G(x) = Cumulative probability

$$G(x) = \int_0^x q(x)dx = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} \int_0^x x^{\alpha} \frac{-x}{e^{B^n} dx}$$

$$G(x) = \frac{1}{r(\alpha)} \int_0^x t^{\alpha - 1} e^{-1} dt$$

Substituting t for x/β

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{\frac{-x}{\beta}}$$, for x>0

Where: α>0, α is a shape

β >0, β is a scale parameter

X>0, X is precipitation amount

$$\Gamma(\alpha) = \int_{0}^{\infty} y^{\alpha-1} e^{-y} dy$$, Γ (α) is the gamma function

Fitting the distribution to the request α and β to be estimated using the approximation of Thom for maximum likelihood as stated in Edwards (2000) as follows:

$$\alpha = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right)$$

For n observations

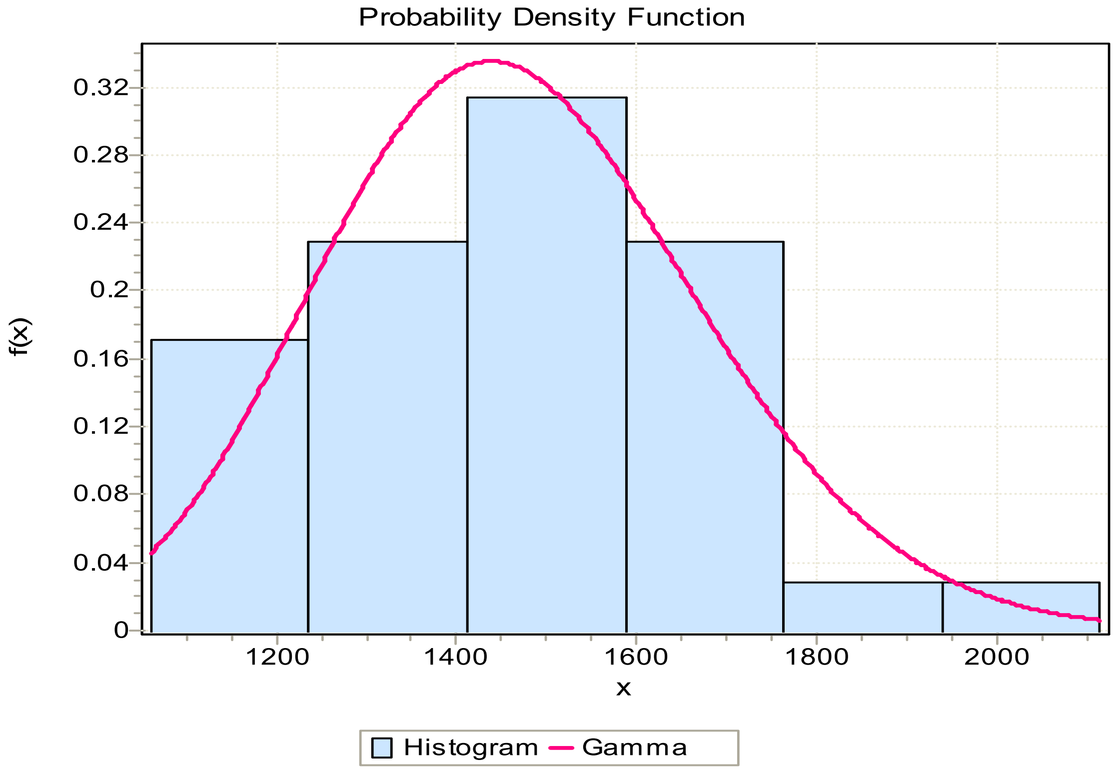
$$A = \ell n\left(\bar{x}\right) - \Sigma \frac{\ell n(x)}{n}$$

$$\beta = \frac{\bar{x}}{n}$$

3. 4. SPI INTERPRETATION

The process described allows the rainfall distribution at the station to be effectively represented by a mathematical cumulative probability function. Based on the historic rainfall data, an analyst can then see what is the probability being less than or equal to a certain amount. Therefore, if a particular rainfall event gives a low probability of the cumulative probability function, then this is indicates a drought event. Alternatively, a rainfall event, which gives a high probability on the cumulative probability function, is a wet event. Thus, medium SPI value is approximately zero (0), high SPI value closer to three (+3) is a heavy precipitation event while low SPI value closer to minus three (-3) is a drought event over time period specified. McKee *et al.* (1993) has also developed the SPI for the purpose of interpretation (table2.1) that shows clearly how the interpretation has to be for a wet or dry event. Therefore, the SPI can effectively represent the amount of rainfall over a given time scale, with the advantage that it provides not only information on the amount of rainfall, but that it also provides an indication of what this amount is in relation to the normal, thus leading to the definition of whether a station is experiencing drought or not and the longer the period used to calculate the distribution parameters, the more likely one gets better results (e.g. 50 years better than 20 years). Likely, for selected stations in this study, the minimum of recorded data up to 2005 is 25 years. Below is a show case of Bugarama station based on SPI-8 (Oct-May).

Figure 3.1 Probability density Function (Bugarama station)



Using Easy Fit software Gamma ranked first

#	Distribution	Anderson Darling Statistic	Anderson Darling Rank
1	Gamma	0.20672	1
5	Lognormal	0.21018	2
4	Logistic	0.21553	3
6	Lognormal (3P)	0.22504	4
2	Gamma (3P)	0.22669	5
3	Gen. Extreme Value	0.23116	6
7	Normal	0.23487	7
10	Weibull (3P)	0.24295	8
9	Weibull	0.60395	9
8	Student's t	493.54	10

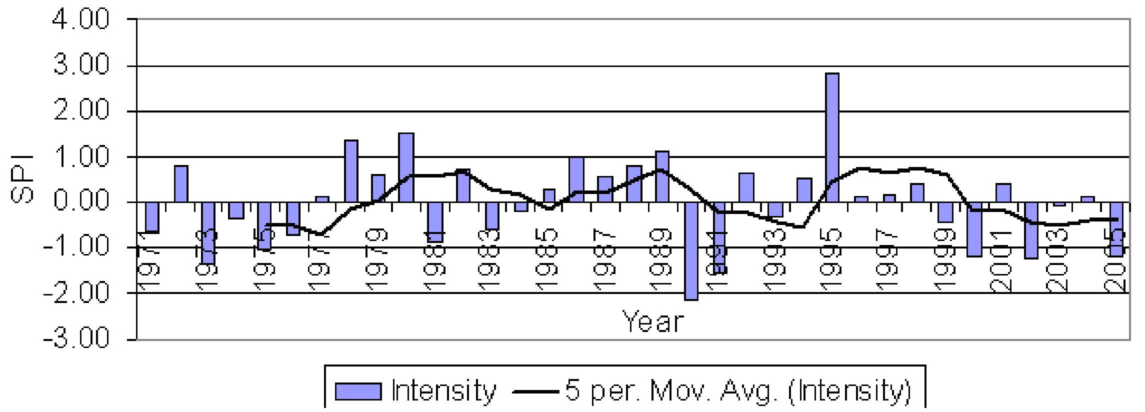
Table 3.2: Results of fit distribution using EasyFit software

Table 3.3: Results Based SPI-8 (Oct-May) case of Bugarama Station

Year	Rainfall(Oct-May)	LN(cum.rainfall)	G DISTRIB	t=transform	SPI
1971	1326.4	7.19	0.25	1.66	-0.67
1972	1630.6	7.4	0.79	1.77	0.81
1973	1195.1	7.09	0.08	2.23	-1.38
1974	1382.5	7.23	0.35	1.44	-0.38
1975	1257.4	7.14	0.15	1.95	-1.04
1976	1323	7.19	0.25	1.67	-0.69
1977	1478	7.3	0.54	1.24	0.09
1978	1751.1	7.47	0.91	2.2	1.35
1979	1588	7.37	0.73	1.62	0.62
1980	1794.8	7.49	0.94	2.36	1.54
1981	1293	7.16	0.2	1.8	-0.84
1982	1612.9	7.39	0.77	1.71	0.73
1983	1337.8	7.2	0.27	1.62	-0.61
1984	1418.8	7.26	0.42	1.31	-0.2
1985	1514.1	7.32	0.61	1.36	0.27
1986	1667.6	7.42	0.84	1.9	0.98
1987	1577.1	7.36	0.71	1.58	0.57
1988	1628.5	7.4	0.79	1.76	0.8
1989	1694.9	7.44	0.86	2	1.1
1990	1061.7	6.97	0.02	2.89	**-2.2**
1991	1164.7	7.06	0.06	2.37	-1.55
1992	1597	7.38	0.74	1.65	0.66
1993	1393.4	7.24	0.37	1.4	-0.32
1994	1565.4	7.36	0.7	1.54	0.51
1995	2112.5	7.66	1	3.48	**2.8**
1996	1482.2	7.3	0.55	1.26	0.11
1997	1486	7.3	0.55	1.27	0.13
1998	1537.3	7.34	0.65	1.44	0.38
1999	1369.7	7.22	0.33	1.49	-0.44
2000	1227.7	7.11	0.12	2.08	-1.2
2001	1541.3	7.34	0.65	1.46	0.4
2002	1218.1	7.11	0.11	2.12	-1.25
2003	1447.8	7.28	0.48	1.21	-0.05
2004	1482.7	7.3	0.55	1.26	0.12
2005	1224	7.11	0.11	2.09	-1.22

Table 3.3 above indicates the results of SPI calculated based on rainfall season from October to December for Bugarama station. From the table 2.1. It appears that the driest year is 1990 whereas the wet year is 1995. For more understanding, the figure 3.2 below indicates its graphical representation.

Figure 3.2: Graphical representation of the intensity of Bugarama station



3. 5. Time scale

The identification of drought characteristics requires the choice of the minimum discrete time interval to be used in the analysis of the time-series. Thus, drought will be identified as a negative departure from the truncation level assigned for the corresponding season. The different time scale (season) for which the SPI is computed address the various type of droughts: the shorter season for Meteorological and Agricultural drought (soil moisture deficit during 2-4months), the longer for Hydrological drought.

In BURUNDI, the wet season is from October to May and within this season there are 2 distinct periods: small precipitations from October to January and heavy precipitations from February to May. Therefore, in this study, 4 series of SPI time scales were considered:

1. SPI-4 (From October to January, for small precipitations)
2. SPI–4 (From February to May, for heavy precipitations)
3. SPI-8 (From October to May, for all the rainfall season)
4. SPI-12(From January to December, full year, wet and dry season)

CHAPTER FOUR

4. RESULTS AND DISCUSSION

The SPI values were computed for the time scale of 12 months (Jan-Dec), 8months (Oct-May) and 4months (Oct-Jan), and (Feb-May) for 26 stations (Appendix A). The statistical parameters namely coefficient of variation (CV), the standard deviation (SD) and the mean were also computed (Appendix B). The objective behind was to extract the maximum information and get somewhat a general overview of SPI values over the study area.

4.1.Rainfall Variability

Rainfall variability is expressed by the coefficient variation (CV) and is defined as the ratio of standard deviation to mean in percent, where mean and standard deviation are estimated from rainfall data. A high ratio indicates an erratic behavior. If the variability ratio is less than 15%, the precipitation is generally reliable. If it is between 20% and 25%, prolonged droughts may occur and when it is more than 40%, typical deserts are indicated (Rajit Kumar Ghosh, Forecasting Drought in Ethiopia, 30th May 2001). As a general rule, it is noted that variability is low where the average amounts are high, and vice-versa.

In this study, the monthly rainfall data for about 25 to 45 years (1961 up to 2005) were selected for 26 stations and the statistical parameters were computed. The CV has been computed separately for each of the 26 rain gauge stations (Table 4.1). It varies from 9.7 to 31.2 over the study area for the 26 stations selected. Table 4.1. Shows clearly that in Burundi, there is no high variability. In fact, for all time scale under study, more than 90% values in the table are less than 25% of CV. Based on year 2005 (from October to May), it has been interpolated into aerial data in Arc View GIS to demarcate its spatial variability (Figure 4.1).

Table 4.1: % of Coefficient of variation for different time scale

Station name		CV-SPI 8	CV-SPI 12	CV-SPI 4	CV-SPI 4
		(Oct-May)	(Jan-Dec)	(Oct-Jan)	(Feb-May)
1. Bugarama-Aéro		14.32	13.22	21.58	20.65
2. Bujumbura-Aéro		18.02658	16.90418	28.37561	22.68711
3. Cankuzo		17.78974	17.6266	21.54482	21.91866
4. Giharo		14.98	15.1	17.34	21.26
5. Giheta		18.68047	15.31107	24.79347	26.85119
6. Gisozi		14.69554	13.54124	20.897	17.68938
7. Gitega-Aéro		16.67106	15.86279	22.30511	24.39897
8. Karusi		22.9122	21.4354	26.29392	31.20431
9. Kayogoro (Makamba)		9.715283	8.553122	15.66593	11.83922
10. Kinyinya		25.68299	24.56811	31.81134	26.28712
11. Kirundo		13.50682	11.98293	20.87309	17.66627
12. Mabayi		16.45892	17.24511	20.57431	21.15042
13. Makamba		15.97177	15.50498	22.85751	19.39467
14. Mparambo		17.45579	15.43497	28.8287	22.6749
15. Mpota-Tora		11.99273	11.11694	16.67814	17.87824
16. Mugera - paroisse		17.37835	16.82925	26.17509	25.48906
17. Musasa		17.70392	17.33305	23.56575	21.02297
18. Musongati		13.54929	12.69768	17.49697	23.88344
19. Mutumba		19.32855	18.3621	15.73464	27.81911
20. Muyaga		18.00139	17.42797	26.01215	21.3892
21. Muyinga		17.09303	15.65317	25.73465	20.90156
22. Nyamuswaga		17.16499	16.05588	21.47181	23.15697
23. Nyanza-Lac		12.7275	12.33084	23.99412	22.46762
24. Ruvyironza		13.03857	12.57614	20.53482	16.17539
25. Rwegura		15.21221	14.5211	24.315	18.1811
26. Rweza-vyanda		17.74367	16.85485	22.17989	18.08673

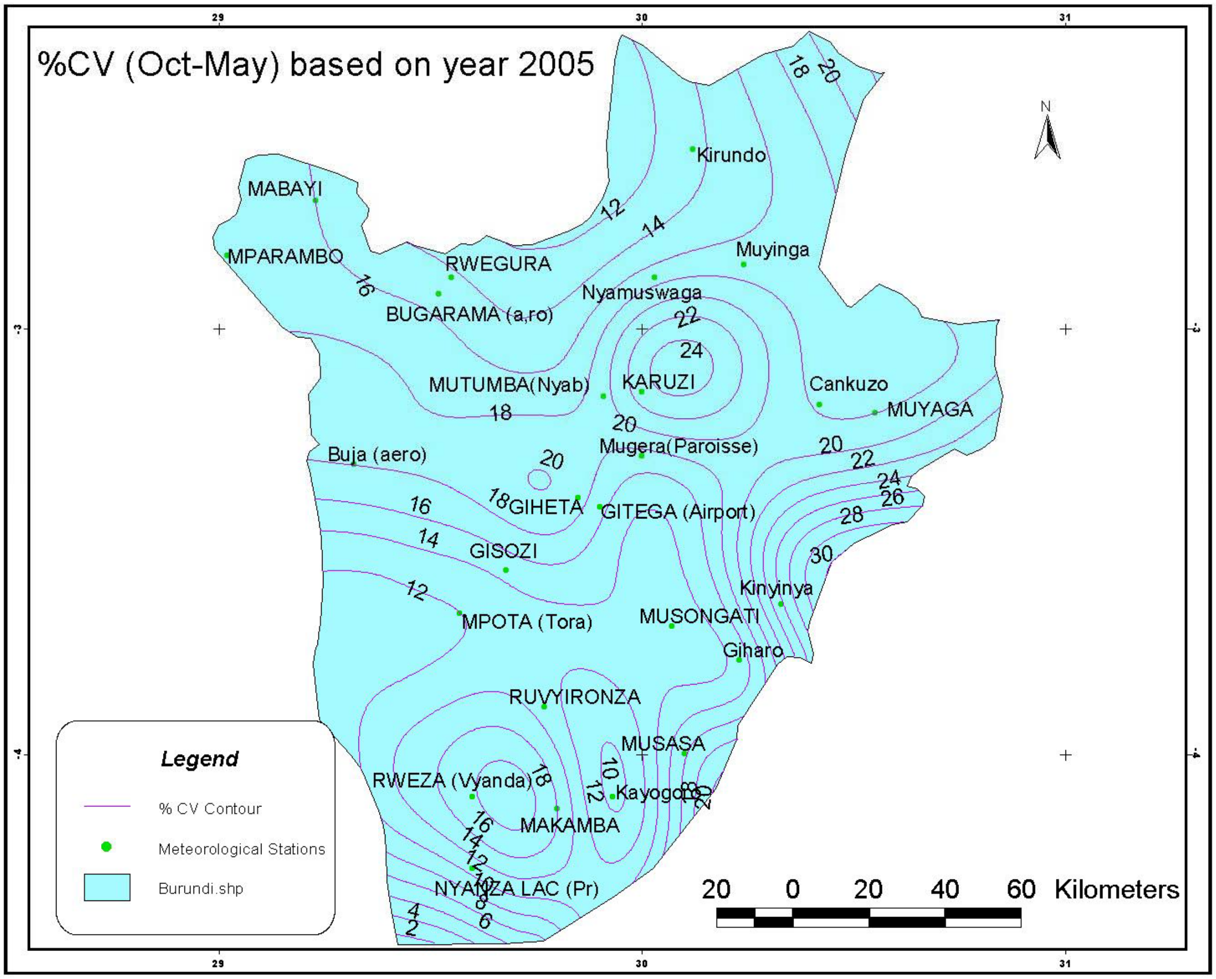


Figure 4.1 Coefficient of Variation (percentage) based on year 2005

Figure 4.1 above shows the coefficient of Variation expressed in percentage (for more understanding) over the study area. Based on year 2005, it was found that the eastern part region of Burundi has the highest coefficient value (20%-32%), which implies the vulnerability to drought. In fact, from table 4.1, Kinyinya station has the highest value, respectively the CV =25.7% (Oct-May), 24.6 % (Jan-Dec), 31.8 % (Oct-Jan), 26.3 % (Feb-May) but in general, the ratio is less than 25% and therefore, the variability is moderate in Burundi.

4.2 .Drought characteristics

In this study, based on SPI-8 (Oct-May), the table 4.2.below summarizes the results of the maximum and minimum values for drought characteristics namely: duration, severity, magnitude and intensity.

Table 4.2: Drought characteristics based on SPI-8 (Oct-May)

	Station Name	Duration		Severity		Magnitude		Intensity	
N°		Max	Min	Max	Min	Max	Min	Max	Min
1	Cankuzo	32	8	5.15	0.20	0.19	0.03	-2.21	-0.10
2	Kinyinya	48	8	8.43	0.07	0.19	0.01	-3.57	-0.06
3	Giharo	64	8	7.25	0.33	0.16	0.02	-1.53	-0.20
4	MUSONGATI	24	8	3.70	0.38	0.38	0.19	-2.12	-0.48
5	MUSASA	24	8	4.22	0.40	0.27	0.22	-2.44	-0.26
6	Muyinga	32	8	3.66	0.16	0.21	0.02	-1.78	-0.01
7	MUYAGA	56	8	4.55	0.01	0.20	0.00	-2.23	-0.05
8	Nyamuswaga	56	8	6.16	0.62	0.15	0.08	-1.97	-0.31
9	Kirundo	32	8	5.08	0.51	0.21	0.06	-2.06	-0.51
10	GITEGA (Airport)	56	8	4.94	0.29	0.26	0.04	-2.09	-0.05
11	RUVYIRONZA	40	8	3.26	0.36	0.16	0.02	-2.08	-0.04
12	Mugera(Paroisse)	56	8	5.51	0.50	0.19	0.04	-2.47	-0.06
13	GIHETA	32	8	3.70	0.22	0.19	0.03	-2.80	-0.16
14	Buja (aero)	48	8	8.29	0.18	0.35	0.02	-1.95	-0.16
15	GISOZI	40	8	5.24	0.09	0.19	0.03	-1.90	-0.06
16	MPOTA (Tora)	40	8	6.46	0.06	0.21	0.01	-2.03	-0.16
17	KARUZI	32	8	4.64	0.37	0.29	0.03	-2.55	-0.09
18	MUTUMBA(Nyab)	56	8	3.96	0.13	0.11	0.02	-1.50	-0.06
19	Kayogoro	32	8	3.48	0.60	0.11	0.05	-1.42	-0.21
20	MAKAMBA	48	8	4.67	0.23	0.15	0.03	-2.17	-0.05
21	NYANZA LAC	24	8	4.02	0.11	0.17	0.01	-1.86	-0.05
22	MABAYI	40	8	5.46	0.77	0.23	0.08	-1.62	-0.08
23	MPARAMBO	32	8	4.37	0.25	0.18	0.00	-2.18	-0.07
24	RWEZA (Vyanda)	40	8	2.80	0.21	0.35	0.03	-2.80	-0.21
25	RWEGURA	32	8	3.58	0.32	0.22	0.02	-2.65	-0.08
26	Bugarama-aéro	32	8	3.48	0.32	0.23	0.04	-2.16	-0.05

From Table. 4.2. above, since two characteristics are enough to identify the drought, based on SPI-8 (Oct-May), Table 4.3 below summarizes for each station under study the different worst years of drought, their duration and their severity.

Table 4.3: Worst years drought based on SPI-8, their duration & severity

SPI-8 (Oct-May)		Duration	Severity			Duration	Severity			Duration	Severity
1.Mparambo station				**2.Kirundo station**				**3.Ruvyironza station**			
Start	End			Start	End			Start	End		
1964	1967	24	2	1972	1976	32	3.1	1963	1966	24	0.4
1973	1976	24	4.4	1998	2001	24	5.1	1972	1976	32	5
1982	1986	32	2.8					1978	1981	24	1.8
1994	1996	32	2.3					1989	1994	40	3
								2002	2005	24	3.3
4.Nyanza Lac station				**5.Cankuzo station**				**6.Bujumbura station**			
Start	End			Start	End			Start	End		
1998	2001	24	4	1997	2000	24	2.5	1972	1978	48	3.8
2002	2005	24	1.7	2001	2005	32	5.2	1989	2001	24	8.3
7.Giharo Station				**8.Giheta STATION**				**9.Gisozi STATION**			
Start	End			Start	End			Start	End		
1989	1997	64	7.2	1972	1976	32	3.7	1972	1976	32	5.2
1998	2001	24	3.9	1986	1987	24	0.8	1991	1996	40	3.3
2002	2005	24	1.9	1989	1990	8	0.2	2000	2005	40	4.2
				1991	1995	32	1.1				
				1999	2001	24	1.1				
				2002	2005	24	2.1				
10.Gitega aero Station				**11.Karusi Station**				**12.Kayogoro Station**			
Start	End			Start	End			Start	End		
1989	1996	56	4.9	1963	1966	24	0.7	1973	1976	24	2.7
				1972	1976	32	3.1	1989	1993	32	3.5
				1987	1990	24	1.4				
13.Kinyinya station				**14.Mabayi Station**				**15.Makamba station**			
Start	End			Start	End			Start	End		
1973	1977	32	3	1957	1960	24	2.9	1970	1976	48	4.7
1999	2005	48	8.4	1965	1972	56	3.9	1982	1985	24	3.7
				1974	1979	40	3.8	2002	2005	24	3.4
				1995	2002	24	5.5				
16.Mpota-tora Station				**17.Mugera-paroisse Station**				**18.Musasa Station**			
Start	End			Start	End			Start	End		
1972	1977	40	4.7	1972	1976	32	4.5	1982	1985	24	2.1
2000	2005	40	6.5	1989	1996	56	5.5	1998	2001	24	1.8
19.Musongati Station				**20.Mutumba Station**				**21.Muyaga Station**			
Start	End			Start	End			1951	1958	56	7.3
1998	2001	24	3.7	1978	1985	56	4	1968	1971	24	1.6
				1992	1996	32	2.2	1997	2001	32	4.6
								2002	2005	24	3.1
22.Muyinga Station				**23.Nyamuswaga Station**				**24.Rwegura Station**			
Start	End			Start	End			Start	End		
1973	1976	24	2.3	1991	1994	24	3.6	1963	1966	24	3.2
1997	2000	24	3.7	1998	2005	56	6.2	1968	1971	24	1.4
								1977	1981	32	2.7
								1982	1985	24	2
25.Rweza Station				**26.Bugarama Station**							
Start	End			Start	End						
1997	2002	40	2.2	1972	1976	32	3.5				

Based on SPI-8 (from October up to May), Table 4.3.above shows that the worst droughts in Burundi have occurred in:

- Years 1972 up to 1976 for almost all stations existing at that time namely: Mparambo, Kirundo, Ruvyironza, Bujumbura, Gisozi, Giheta, Karuzi, Kayogoro, Kinyinya, Mabayi, Makamba, Mpota, Muyinga, Mugera and Bugarama.
- Years 2000 up to 2005 for almost all stations in use (because of the civilian war from 1993, some stations cut off) namely : Kirundo, Ruvyironza, Nyanza lac, Cankuzo, Bujumbura, Giharo, Giheta, Kinyinya, Mabayi, Makamba, Musongati, Muyaga, Muyinga, Nyamuswaga and Rweza.

Once again, as for the coefficient of variation, the results (from Tables 4.2 & 4.3) show that the eastern part area of Burundi is vulnerable to drought .In fact, the maximum duration (64 months) was recorded at Giharo station, the maximum severity(8.43) , maximum magnitude (0.19) and maximum intensity(-3.57) were found at Kinyinya station.

The analyses in which worst droughts have occurred indicates clearly that drought is becoming a real problem in Burundi be. In fact, it is known that the Burundian government has established an inter-ministerial committee to help boost aid to the people affected by food shortages.

Therefore, as the drought and the famine look like twins, and since historically the government of Burundi has decided to help the people affected by the famine in 2005 because of drought, that year was considered in this study as the worst year drought to be compared with the year 1978 which was the mild year drought according to its smallest negative values (Appendix A). Hence, below is the comparison of the years 2005 and 1978 through which the different contour maps were made based on SPI-12 (Jan-Dec), SPI-8 (Oct-May), SPI-4 (Oct-Jan) and SPI (Feb-May), using Arc View GIS.

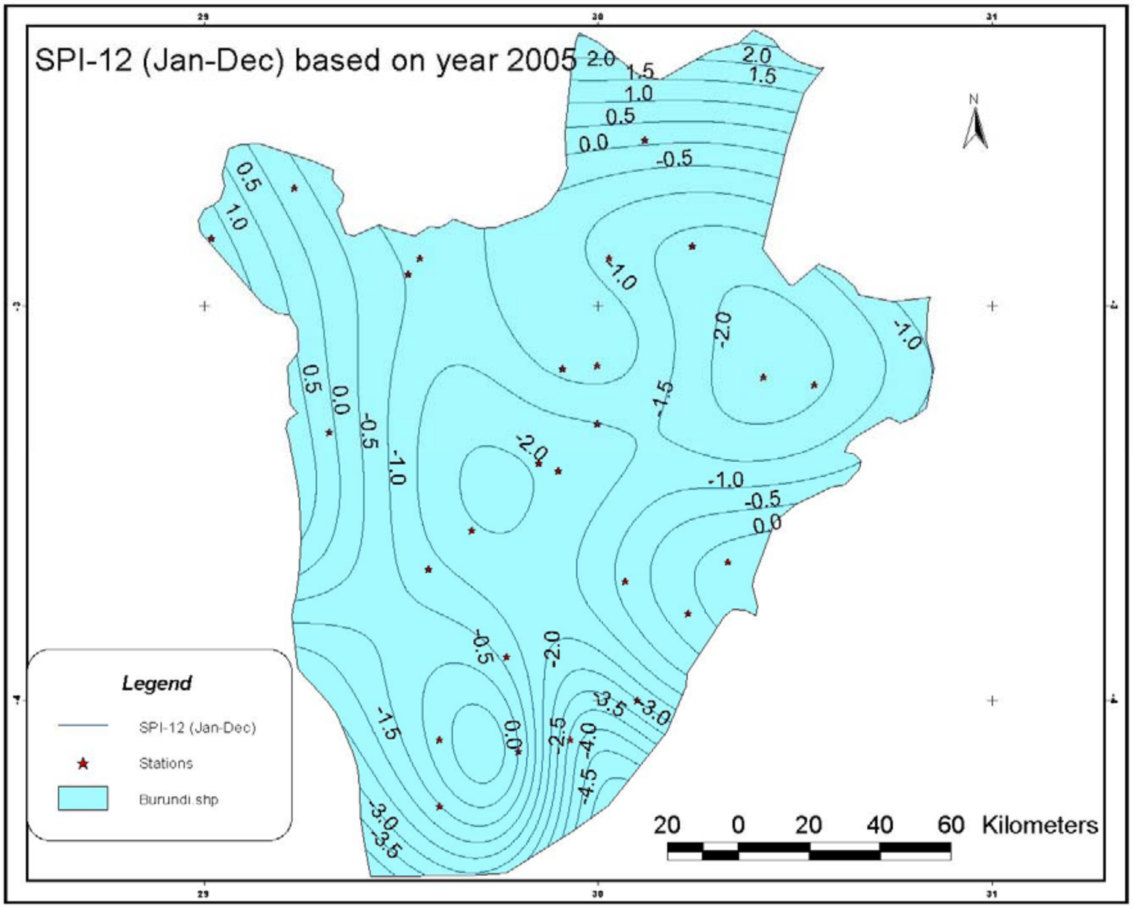


Figure 4.2 show case of SPI-12 rain season 2005

As categorized in Table 3.6 (SPI values), Figure 4.2 above shows that based on the year 2005 and SPI-12 (Jan-Dec), Burundi was affected by severe drought in general, and it was increasing from moderate to extreme drought in the north-west to the centre, south & eastern regions (SPI values from -0.5 up to -4.5).

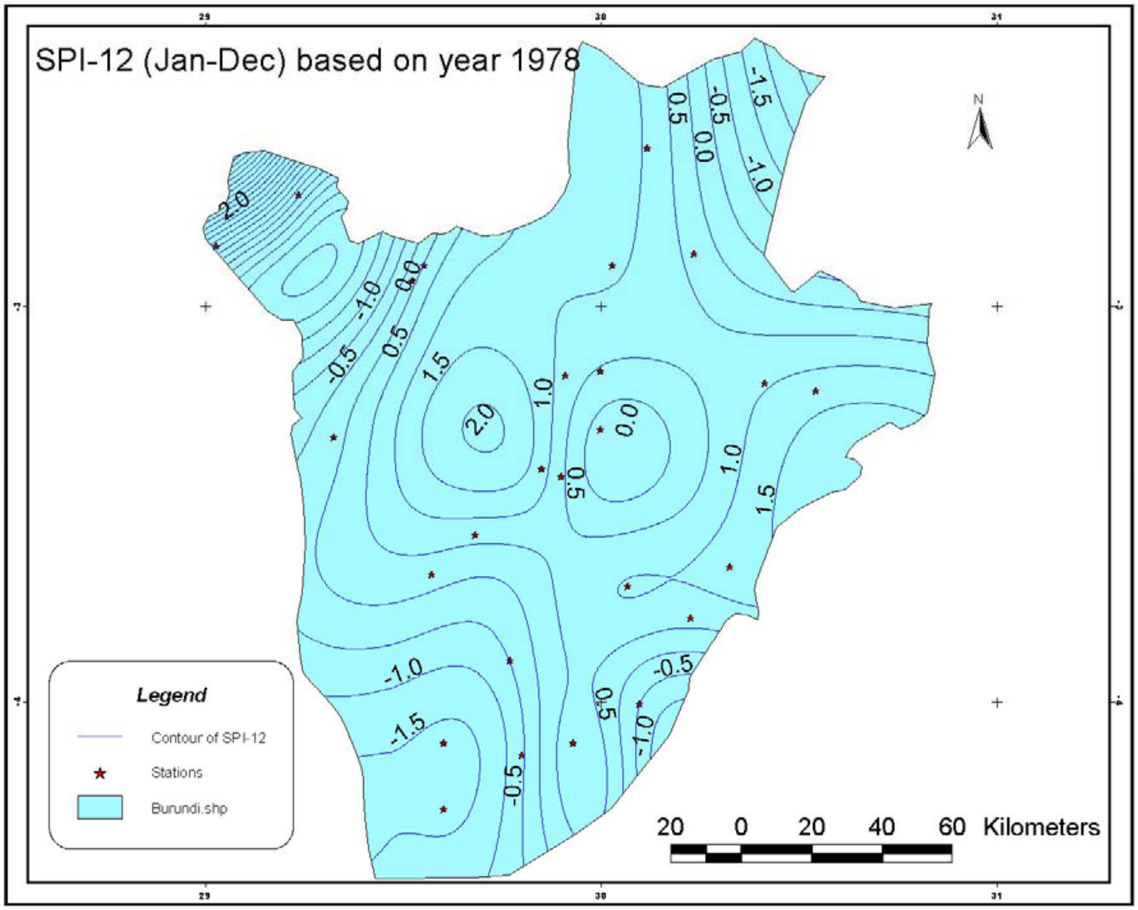


Figure 4.3 show case of SPI-12 rain season 1978

In contrast to Figure 4.2, Figure 4.3 above is different from figure 4.2 in that based on the year 1978 and SPI-12 (Jan-Dec), Burundi was affected only by moderate drought in the southern and northern regions.

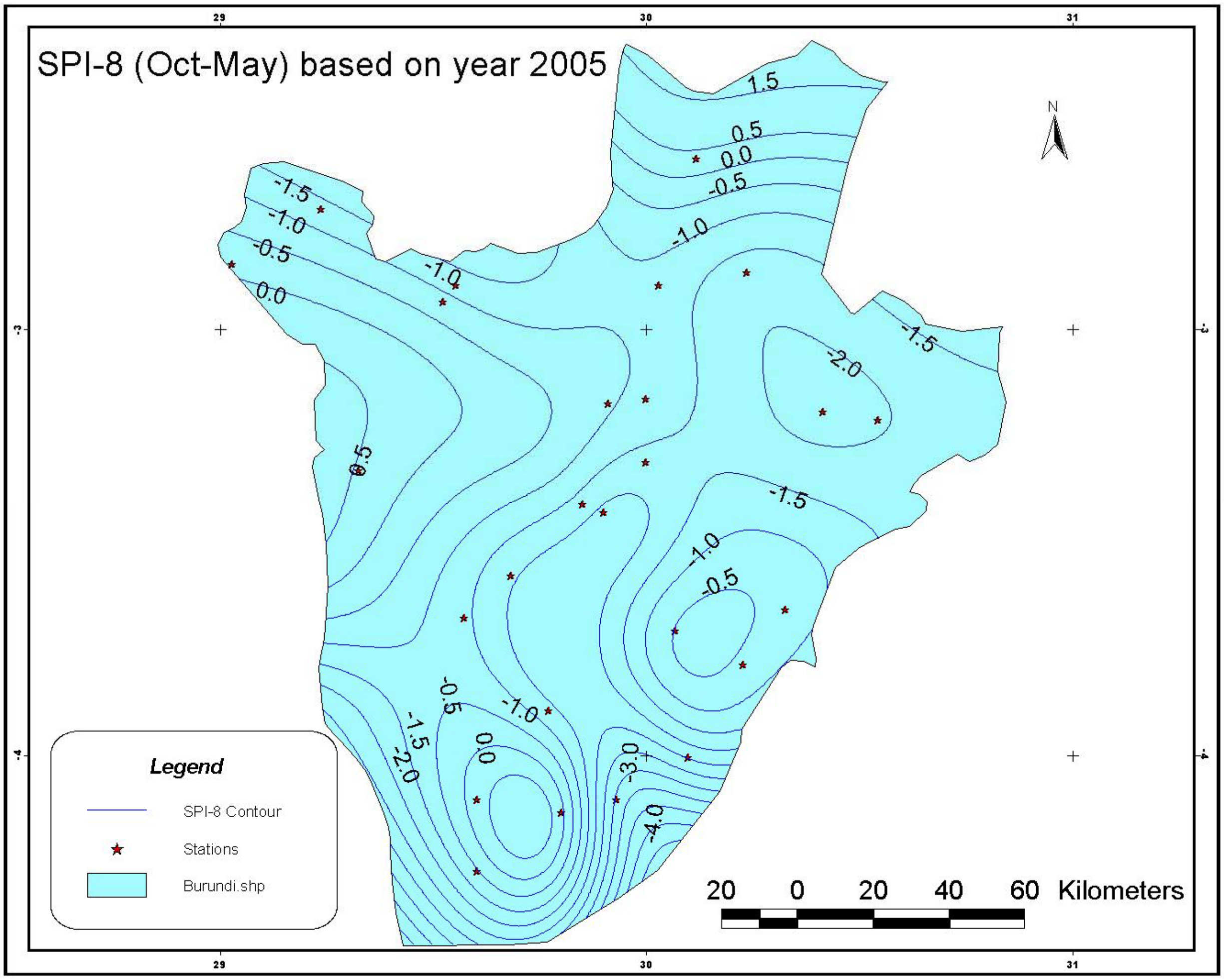


Figure 4.4 SPI-8 Rainy Season 2005

Figure 4.4 above shows from Table 3.6 (SPI values) that, based on the year 2005 and SPI-8 (Oct-May), Burundi was affected by severe drought in general, and by extreme drought in the southern east regions in particular.

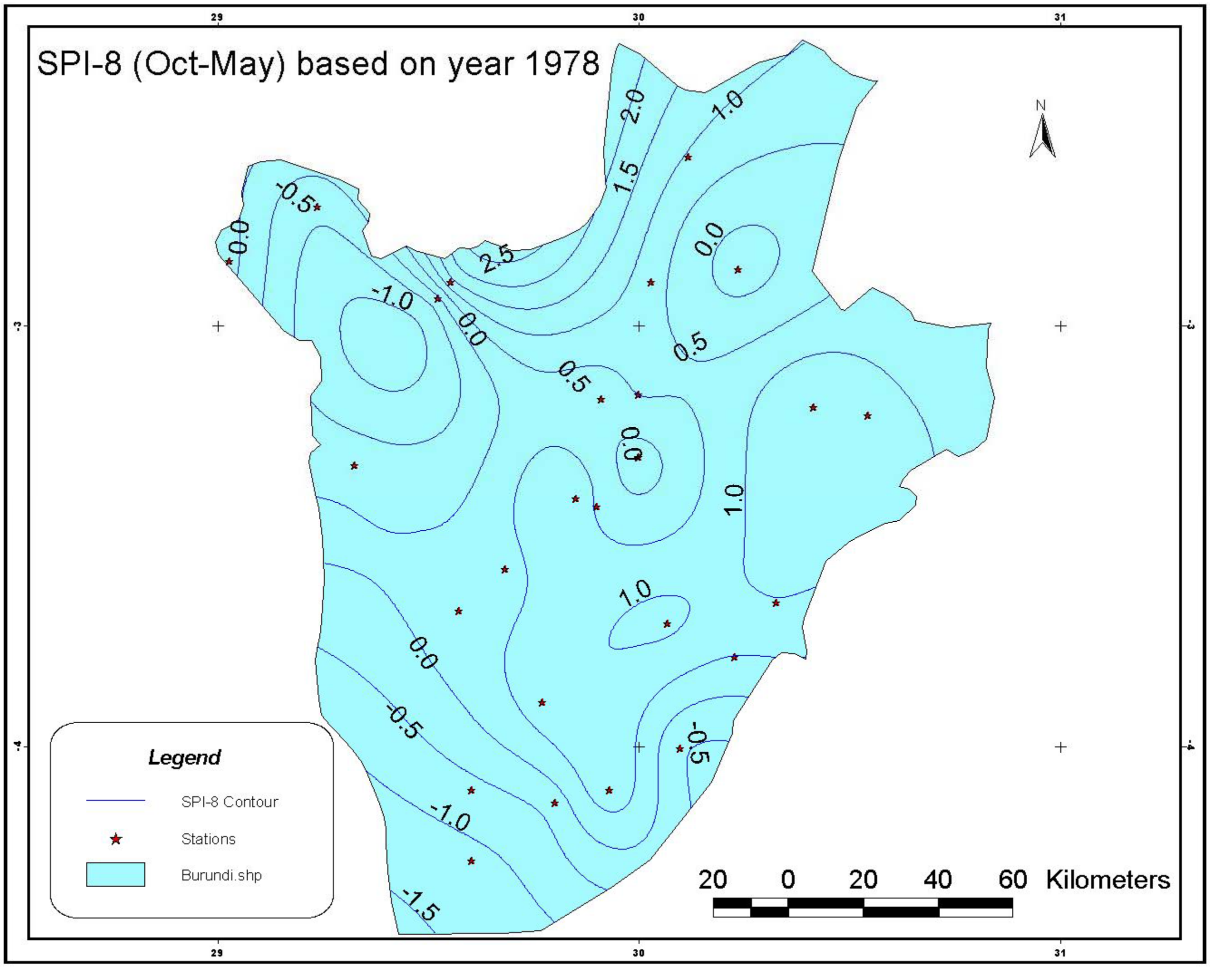


Figure 4.5 SPI-8 Rainy Season 1978

In the contrast to Figure 4.4, Figure 4.5 above shows from the table 3.6 (SPI values) that, based on the year 1978 and SPI-8 (Oct-May), Burundi was not affected by drought in general except the southern and the northern corner regions where moderate drought was recorded.

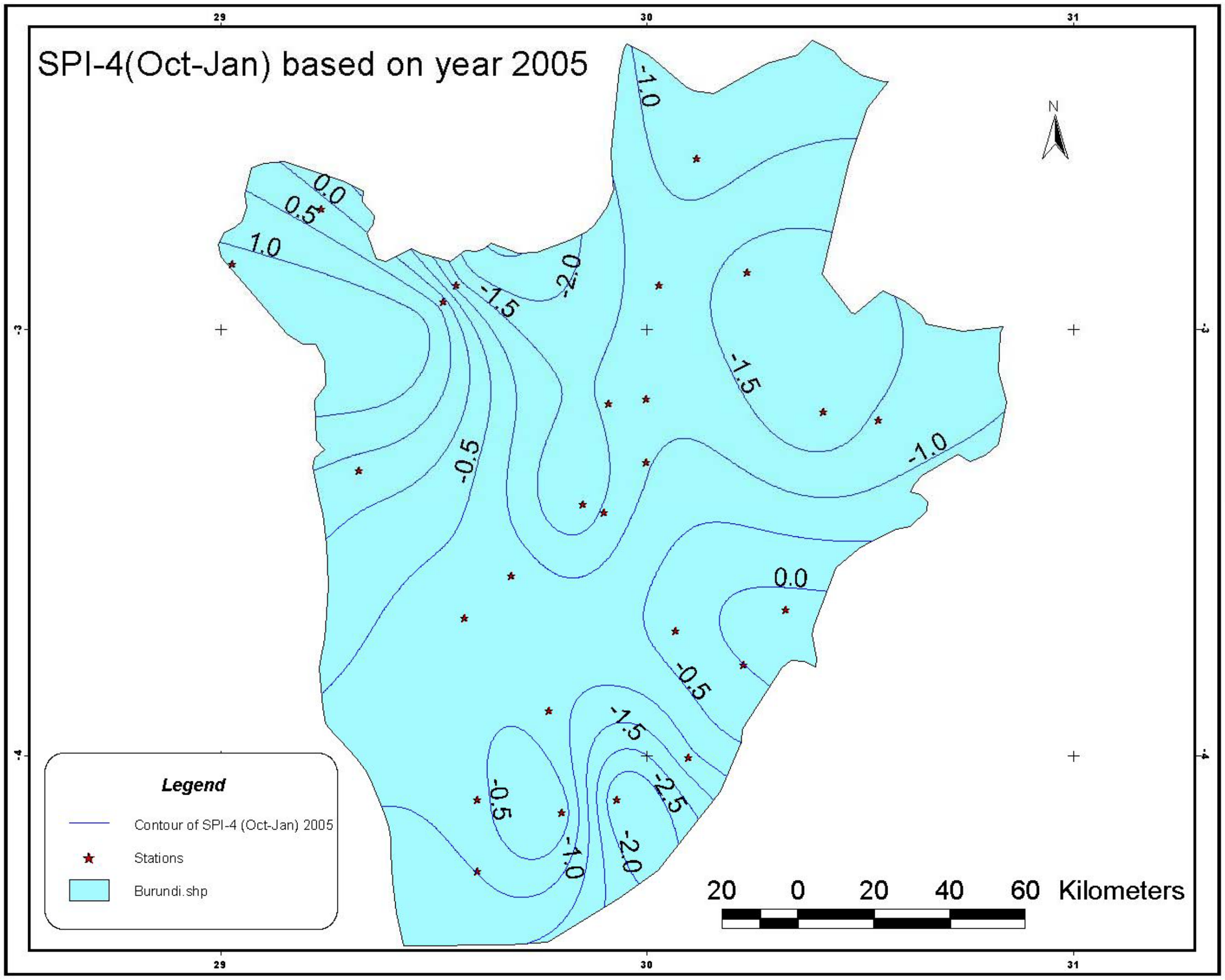


Figure 4.6 SPI-4 (Oct-Jan) rain season 2005

Figure 4.6 above shows from Table 3.6 (SPI values) that, based on the year 2005 and SPI-4 (Oct-Jan), Burundi was affected by drought in general and by extreme drought in the southern east regions in particular.

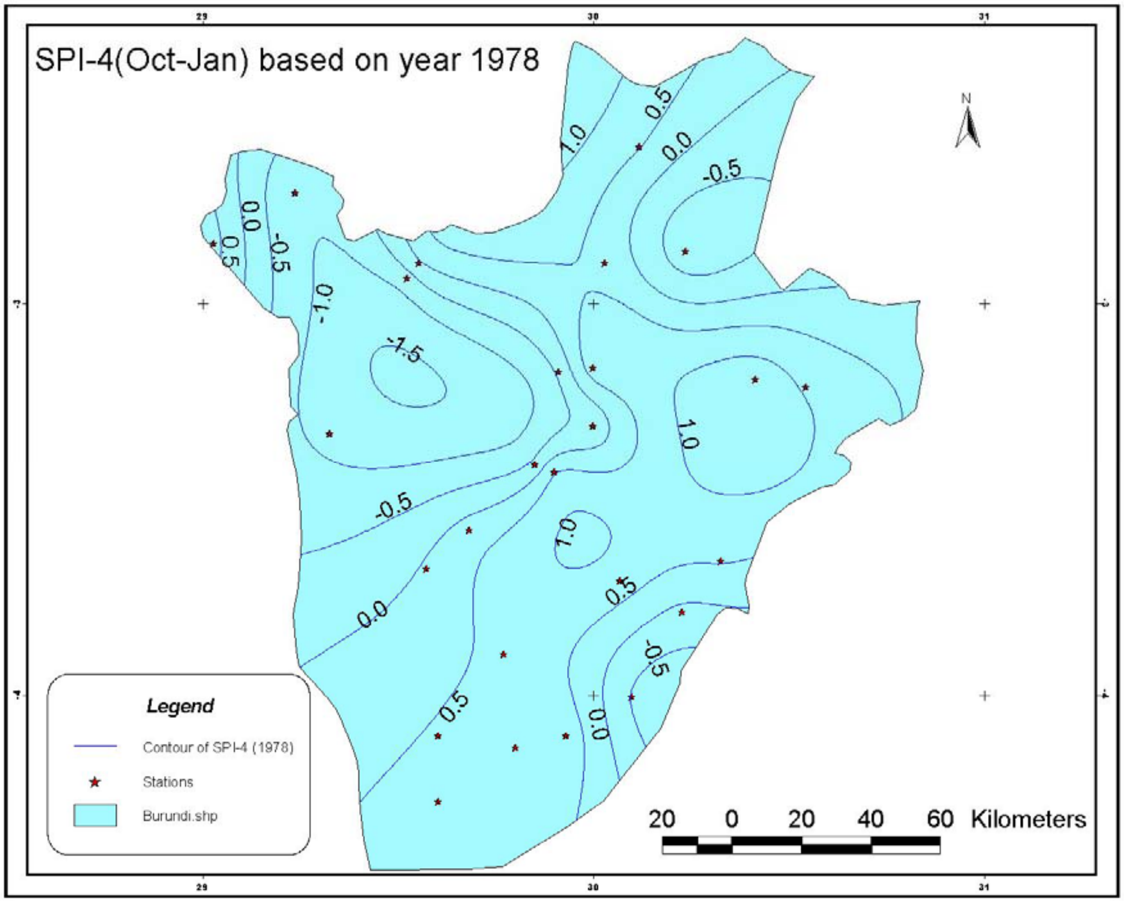


Figure 4.7 SPI-4 (oct-jan) rainy season 1978

In contrast to Figure 4.6, Figure 4.7 above shows from Table 3.6 (SPI values) that, based on the year 1978 and SPI-4 (Oct-Jan), Burundi was almost not affected by drought except in the northern west corner region where moderate drought is recorded.

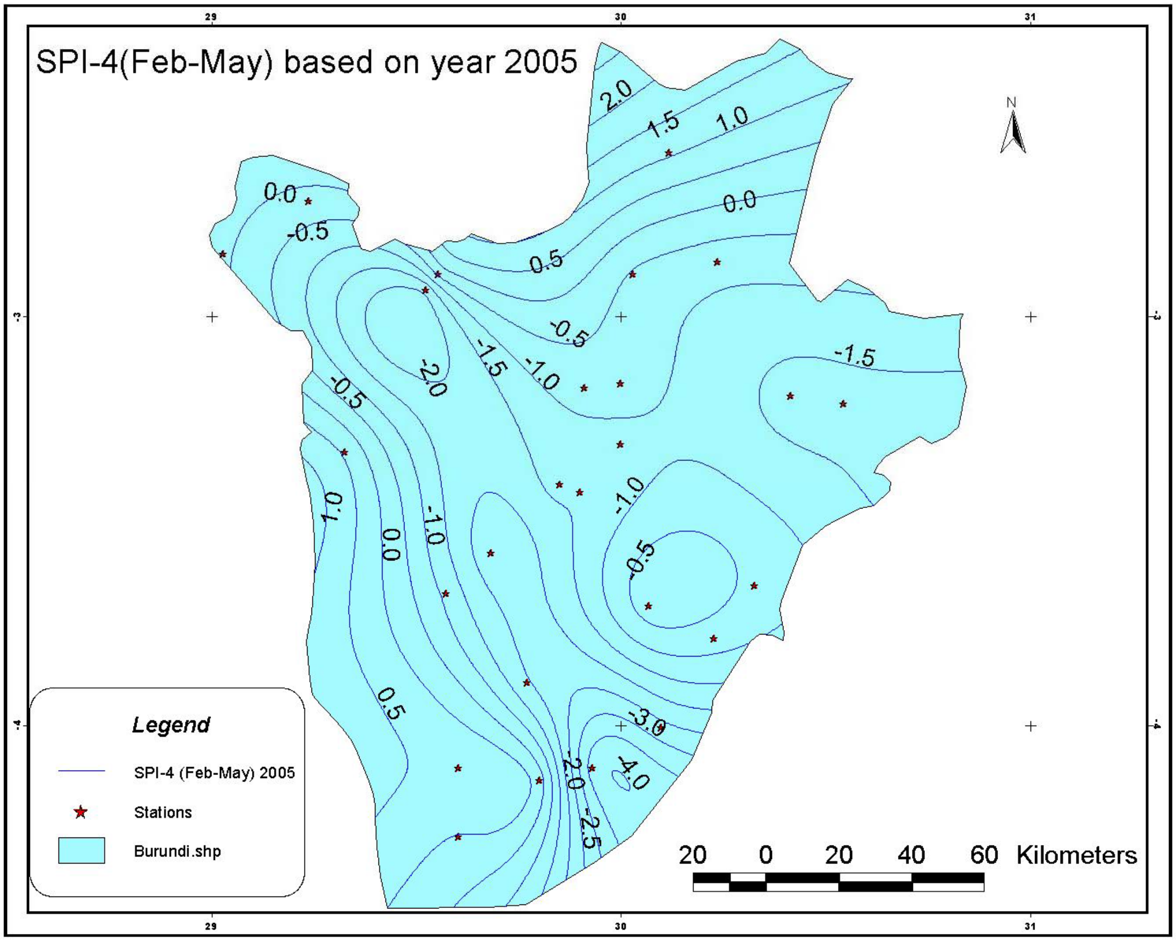


Figure 4.8 SPI-4 (Feb-May) Rainy season 2005

Figure 4.8 above shows from Table 3.6 (SPI values) that, based on the year 2005 and SPI-4 (Feb-May), Burundi was affected by drought in general and by extreme drought in the southern east regions in particular.

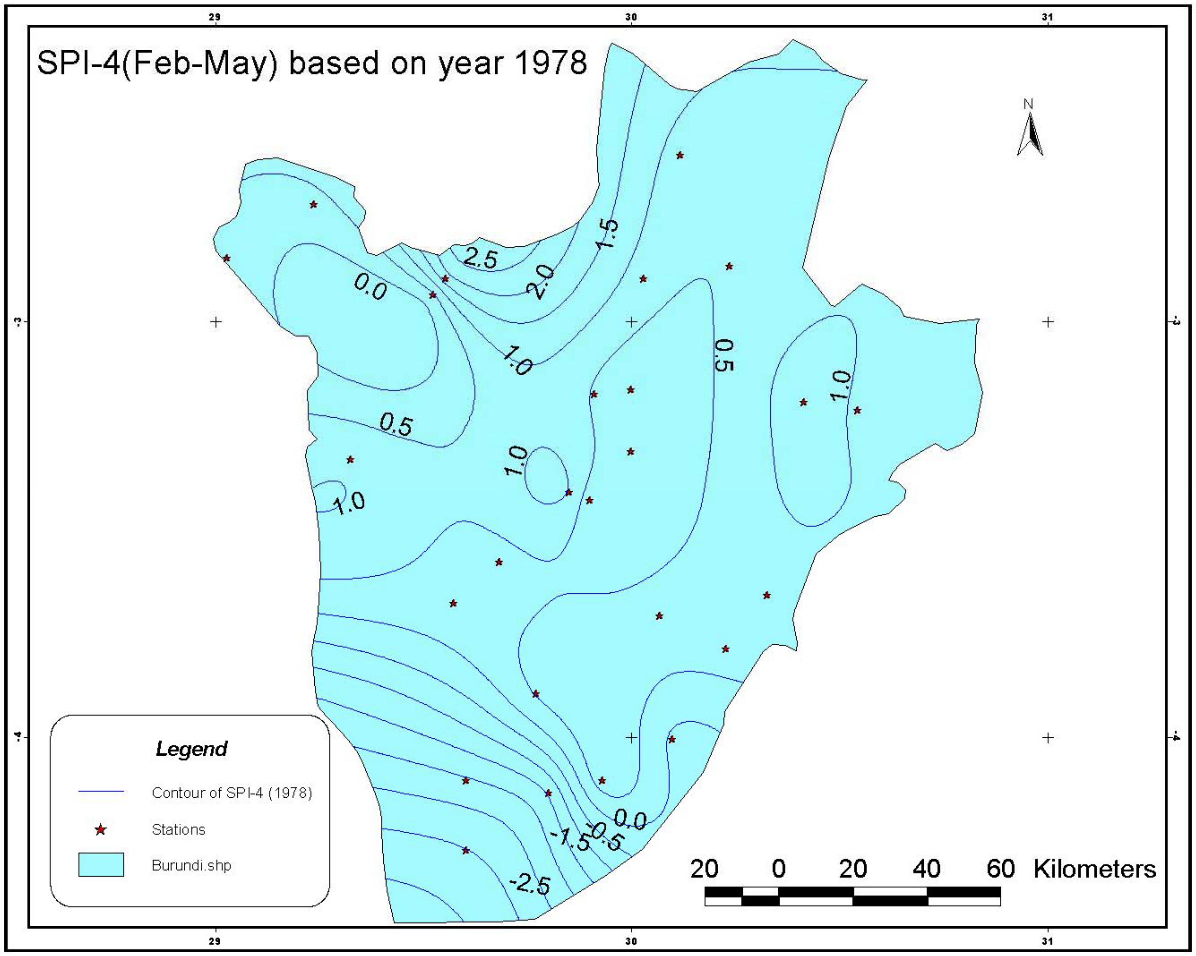


Figure4.9 SPI-4 (Feb-May) rainy season 1978

In contrast to Figure 4.8, Figure 4.9 above shows from the table 3.6 (SPI values) that based on the year 1978 and SPI-4 (Feb-May), Burundi was almost not affected by drought except in the southern region.

4.3. The trend of SPI over the study area

In this study, during the period investigated, the results show that the rainfall decreased from 1989 but the decrease becomes stronger from 2000 (Appendix D). In this period, the SPI for multiple scale under consideration namely 12 months (Jan-Dec), 8 months (Oct-May), 4 months (Oct-Jan), 4 months (Feb-May) has been computed for all selected stations. It appears that period of drought have been quite frequent starting from 2000, with SPI ranging from about -1 to about -3. Below is the trend case of Musasa station, located in the eastern region already mentioned as one region vulnerable to drought in Burundi.

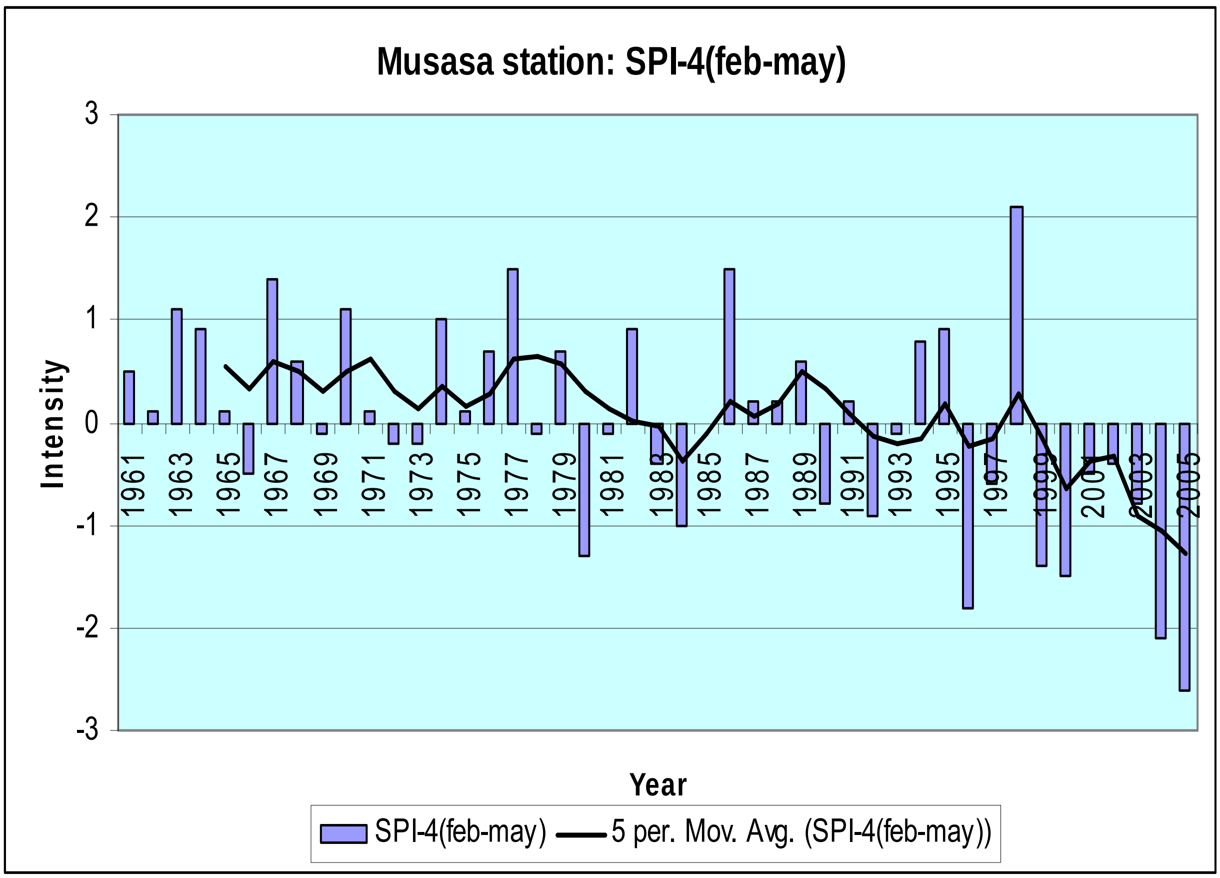


Figure 4.10. Drought Intensity and trend based on SPI-4 (show case of Musasa station

The figure4.11. Below is not considerably different from the figure 4.10 above because both show how precipitations decreased from 1999. The reason behind is to emphasize that the same trend were found for all selected stations (Appendix D). This implies also the evidence of climate change in Burundi.

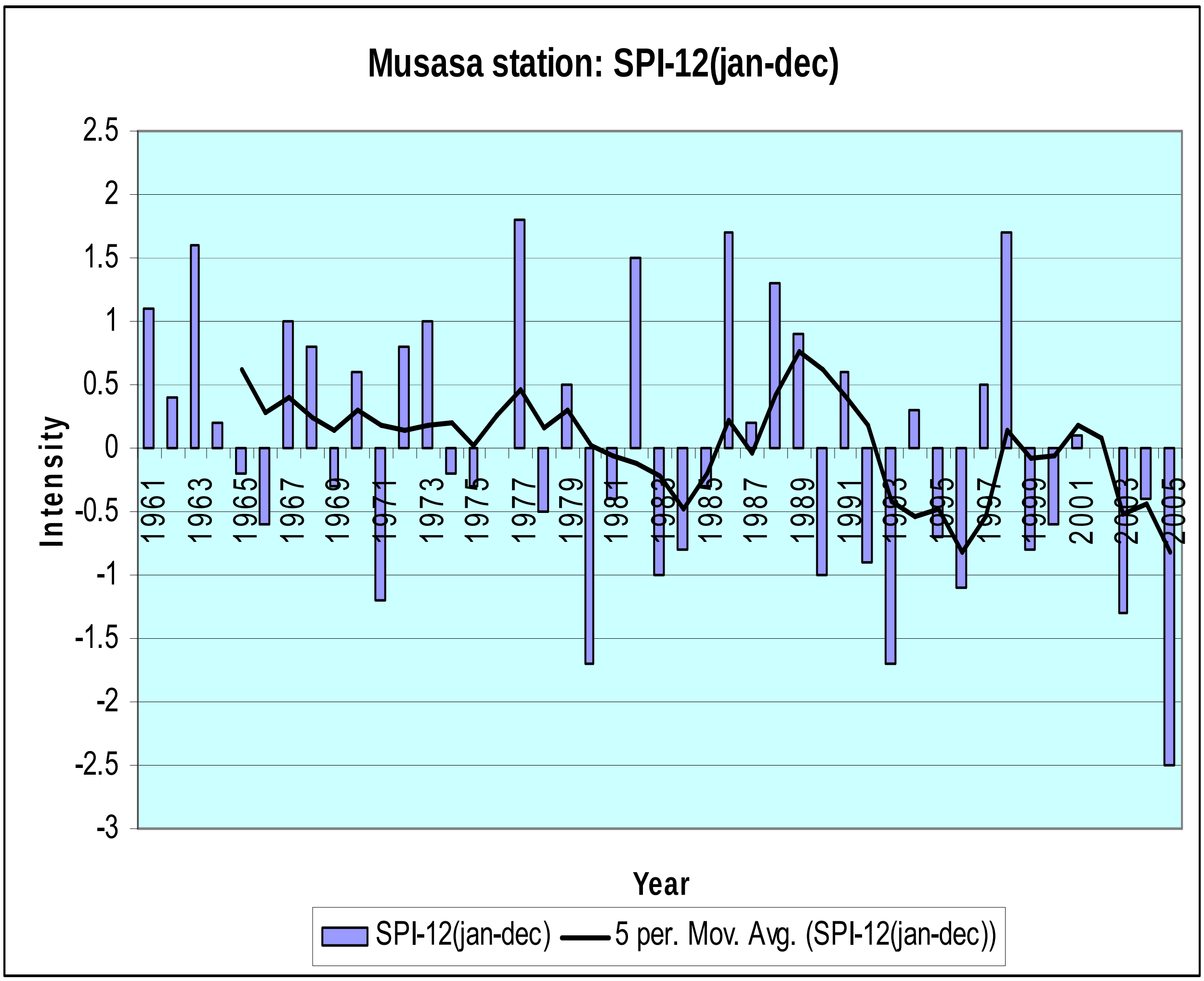


Figure 4.11. Drought Intensity and trend based on SPI-12 (case of Musasa station

CHAPTER 5

5.Conclusions and Recommendations

5. 1. CONCLUSIONS

In this study, during the period investigated, the results show that the rainfall decreased from 1989 but the decrease becomes stronger from 2000 (Appendix D). In this period, the SPI for multiple scale under consideration namely 12 months (Jan-Dec), 8 months (Oct-May), 4 months (Oct-Jan), 4 months (Feb-May) has been computed for all selected stations. It appears that period of drought have been quite frequent starting from 2000, with SPI ranging from about -1 to about -3. The North Eastern regions of Burundi is vulnerable to drought .In fact, the maximum duration (64 months) was recorded at Giharo station, the maximum severity (8.43), maximum magnitude (0.19) and maximum intensity (-3.57) were found at Kinyinya station and since historically the government of Burundi has decided to help the people affected by the famine in 2005 because of drought, that year was considered in this study as the worst year drought to be compared of the year 1978 which was the mild year drought according to its smallest negative values(Appendix A) using Arc View GIS . As categorized in the table 2.1 (SPI values), based on the years 2005 and 1978, for all time scale of SPI under study, Burundi was affected by severe drought in general in 2005, and it was increasing from moderate to extreme drought in the north-west to the centre, south & eastern regions (SPI values from -0.5 up to -4.5) whereas in contrast to the year 1978 for the same time scale, Burundi was in general not affected by drought except in very few northern east regions where moderate drought was recorded. Therefore, from the results of this study, drought is becoming a real problem in Burundi with the time. As drought and famine look like twins, even drought is a natural hazard, society can reduce its vulnerability like other natural hazards through mitigation, planning and preparedness (risk management) and recommendations are suggested.

5. 2. RECOMMENDATIONS

Drought is natural disasters, which originates from the lack of precipitation and brings significant economic losses. It is not possible to avoid it but drought preparedness can be developed and droughts impacts can be managed. Therefore, in Burundi, a national drought policy is strongly needed to coordinate or to take actions regarding above suggestions and recommendations:

5. 2.a. Information evaluation and needs

Analysis of all available information would lead to decision-making in the following areas: Food security and distribution, Water management and Agriculture, Water supply management, seeds, livestock survival and Health problems (Ruben Barakiza -2006).

In water management and Agriculture, priority should be given to the following actions: ensure water supply to the population and livestock affected, put in place local scale irrigation, campaign for technical water management supply necessary funds for repairing/install water pumps, strengthen continuous coordination among agricultural engineers, meteorologists, hydraulics engineers, agricultural monitors to inform and help farmers to adapt their farming practices to the drought situation

During drought it is important to conserve reserves of seeds and as

a measure of precaution, government should: set up conservation of seeds in seed bank, regional cooperation (external aid in seeds, fertilizers and pesticides from countries of similar soils and climate conditions), International aid organization such as FAO can mobilize seed assistance during emergency situation and research is needed with a view to develop varieties that are drought-resistant and early maturing varieties. •When drought is limited to only certain regions, livestock can migrate to others regions which are not experiencing drought

5.2. b. Early warning system

An efficient system of agricultural data in collaboration with Meteorological service should be able to supply to the government, at any time, information on: meteorological conditions and the characteristics of seasonal rainfall, the state of crops and variations outlook compared to previous seasons, infestations of insects and parasites, production outlook, situation of water supply for human, health problems and livestock consumption and those information should be supported by the Use of satellite data (Normalized differences of vegetation index-NDVI)

5.2. C. Drought management and prevention

When preventive measures are integrated in long-term economical planning they have a considerable effect in reducing drought related impacts.

The mitigate programs implemented by the country government during recent droughts can be characterized as emergency actions taken to alleviate the ongoing crisis and preparedness is the logical solution where a national drought policy and plan might be set up .A national drought commission should be set up and the commission should include meteorological service, agriculture, water resources management, planning, public water supply, natural resources, environmental protection, health, finance, rural development, emergency management, and tourism. The objectives that should be considered include the following:

- To provide timely and systematic data collection, analysis and dissemination of drought-related information;
- To establish proper criteria to identify and designate drought-affected areas and to trigger response activities by government and NGOs;
- To provide an organization a structure that assures information between and within levels of government and define the duties and responsibilities of all agencies with respect to drought;
- To develop a set of appropriate emergency programs;

- To provide a mechanism to ensure the timely and accurate assessment of drought impact on agriculture, industry, municipalities, wildlife, health, and other areas as appropriate;
- To provide accurate and timely information in order to keep the public informed;
- To establish and pursue a strategy to make equitable supply of water during shortage and encourage water conservation;
- To establish a set of procedures to evaluate and revise the plan

5. 2. d. Predicting Drought

Predicting drought is extremely important. It allows policy makers and others to take appropriate measures to combat drought's effects. It saves lives and reduces property damage. However, no perfect method exists to reliably predict the occurrence, persistence, cessation or recurrence of drought.
There are mathematical models to help predict drought. SYDNEY are Models developed to take the uncertainty out of predicting droughts and say exactly where and for how long they are expected to occur. The models, named copulas, can help assist farmers determine the viability of different crops and the drought mitigation steps they need to take under varying climatic conditions.

Actually, it is known that most of countries all over the world and especially in Africa, that prediction of drought is an alluring problem. It is not yet possible to foretell the exact onset and intensity of droughts with the current available knowledge. Therefore, since the objective of the present work is to analyze the past drought in Burundi and to develop some techniques for prevention and management, my expectations is that the government of Burundi will encourage for future studies in the sense of drought prediction.

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Appendix A: SPI Values for different time scale and for selected stations

	1. BUGARAMA-Aéro				2. BUJUMBURA-AEROPORT			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1961					3.2	3.2	3.5	0.4
1962					0.9	1.2	0.2	1.2
1963					1.2	1.0	0.9	0.9
1964					0.0	-0.1	-0.4	0.6
1965					0.1	0.2	0.0	0.3
1966					0.7	0.9	0.1	1.0
1967					0.1	0.1	0.4	-0.1
1968					1.2	1.0	0.4	1.4
1969					0.1	-0.2	0.4	-0.3
1970	Starting				1.1	1.0	0.6	1.0
1971	-0.7	-0.6	-1.3	0.3	0.9	0.9	1.0	0.2
1972	0.8	1.4	1.2	-0.1	0.7	1.0	0.5	0.6
1973	-1.4	-0.8	-0.8	-0.9	-0.6	-0.4	-1.0	0.2
1974	-0.4	-0.2	-1.7	0.9	-0.4	0.0	-0.5	0.1
1975	-1.0	-1.0	-0.1	-1.2	-1.4	-1.1	-0.7	-1.2
1976	-0.7	0.2	-1.5	0.5	-1.1	-0.8	-0.6	-0.8
1977	0.1	0.1	0.2	0.0	-0.2	0.1	-0.1	0.0
1978	1.3	1.5	-0.1	1.8	-0.2	-0.2	-1.1	0.9
1979	0.6	0.2	-0.4	1.2	1.4	1.1	0.1	2.0
1980	1.5	1.3	0.6	1.5	0.4	0.4	1.3	-1.1
1981	-0.8	-0.1	-0.5	-0.5	-1.2	-0.8	-0.7	-0.9
1982	0.7	0.6	0.5	0.5	0.1	-0.1	0.3	0.0
1983	-0.6	-0.9	0.6	-1.5	-0.6	-0.4	-1.0	0.2
1984	-0.2	-0.3	0.2	-0.4	0.5	0.2	1.1	-0.5
1985	0.3	0.1	-0.7	1.0	-0.2	-0.3	-0.8	0.7
1986	1.0	0.7	0.6	0.8	1.3	1.4	0.7	1.3
1987	0.6	1.2	0.4	0.5	-0.8	-0.3	-1.0	0.1
1988	0.8	0.9	1.3	-0.2	0.3	0.6	1.4	-1.4
1989	1.1	1.4	0.9	0.7	2.1	2.1	0.9	2.2
1990	-2.2	-1.9	-1.4	-1.4	-0.4	-0.5	-1.2	0.7
1991	-1.6	-1.4	-1.2	-0.9	-0.1	-0.3	-0.2	0.2
1992	0.7	0.5	0.5	0.4	-1.4	-1.7	-1.4	-0.4
1993	-0.3	-0.5	-0.9	0.4	-1.2	-1.7	-1.6	0.0
1994	0.5	0.3	1.0	-0.2	-0.9	-1.3	0.6	-2.2
1995	2.8	2.3	3.1	0.6	-1.9	-2.1	-1.9	-0.7
1996	0.1	-0.6	-1.2	1.2	-0.4	-0.3	-0.2	-0.2
1997	0.1	-0.5	1.0	-0.8	-0.1	-0.2	0.4	-0.6
1998	0.4	-0.2	-0.9	1.3	-0.3	-0.4	-2.0	1.4
1999	-0.4	0.0	0.5	-1.0	-0.6	-0.3	0.4	-1.4
2000	-1.2	-2.0	0.6	-2.4	-0.2	-0.6	1.2	-2.0
2001	0.4	0.9	0.1	0.5	-0.8	-0.3	-0.1	-1.1
2002	-1.3	-1.6	0.4	-2.2	0.1	-0.3	0.3	-0.1
2003	-0.1	-0.5	-0.5	0.5	-1.6	-1.6	-0.7	-1.6
2004	0.1	0.5	0.4	-0.2	-0.8	-0.7	0.0	-1.2
2005	-1.2	-1.1	-1.2	-0.4	0.5	0.1	0.3	0.4

	3. Cankuzo				4. GIHARO			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1962					-0.3	0.0	-1.9	0.9
1963					0.9	0.9	1.0	0.5
1964					-0.6	-0.8	-1.9	0.5
1965					1.6	1.7	0.6	1.6
1966					0.5	0.4	0.2	0.5
1967					0.7	1.0	0.5	0.5
1968					0.3	0.4	-0.5	0.7
1969					0.5	0.3	0.5	0.4
1970					1.7	1.6	0.9	1.6
1971					1.0	0.8	0.7	0.8
1972	Starting				1.5	1.5	1.2	1.1
1973	0.0	0.3	0.0	0.0	0.4	0.3	1.5	-0.7
1974	-1.5	-1.3	-1.6	-0.9	0.0	-0.1	0.0	0.1
1975	-0.1	0.3	-1.0	0.8	-1.2	-0.8	-0.9	-0.8
1976	0.0	0.2	0.5	-0.5	-0.8	-0.8	-0.7	-0.5
1977	1.9	1.8	1.1	2.0	1.0	1.2	1.2	0.4
1978	1.4	1.3	1.3	1.2	0.5	0.3	-0.1	0.7
1979	0.1	-0.1	-0.3	0.4	1.6	1.3	1.0	1.4
1980	-1.5	-1.4	-0.6	-2.0	-0.5	-0.5	-0.6	-0.1
1981	1.2	1.3	0.5	1.5	-1.1	-1.0	-0.4	-1.0
1982	0.2	0.1	0.1	0.3	1.4	1.4	1.9	0.4
1983	-0.5	-0.5	-0.7	-0.1	-0.4	-0.3	-0.4	-0.1
1984	0.0	0.0	0.7	-0.7	0.0	-0.2	0.6	-0.5
1985	0.0	0.2	-0.3	0.4	0.9	1.0	0.8	0.6
1986	0.8	0.5	1.0	0.3	-0.1	-0.3	0.0	-0.1
1987	-0.2	-0.2	0.3	-0.6	-0.2	0.3	-0.5	0.2
1988	1.2	1.2	1.1	1.0	0.8	1.3	0.7	0.6
1989	1.0	1.2	1.3	0.4	2.5	2.4	1.4	2.2
1990	0.2	0.1	-2.0	1.9	-1.3	-1.2	-2.8	0.3
1991	0.5	0.2	0.8	0.0	-1.1	-1.0	-0.4	-1.0
1992	0.8	0.6	0.7	0.7	-1.4	-1.4	-0.5	-1.3
1993	-0.5	-0.7	-0.6	-0.1	-1.5	-1.7	-1.5	-0.7
1994	0.8	0.6	1.2	0.0	-0.1	-0.3	-1.5	0.9
1995	0.2	0.2	-0.6	0.9	-0.7	-0.9	-1.4	0.1
1996	-0.5	0.0	-0.5	-0.2	-1.2	-1.1	0.1	-1.6
1997	1.6	1.6	2.2	0.3	-0.1	-0.3	-0.9	0.5
1998	-0.2	-0.4	-0.4	0.1	0.2	-0.1	0.3	0.0
1999	-1.5	-1.7	-0.6	-1.8	-1.5	-1.4	0.0	-2.1
2000	-0.8	0.0	-0.2	-1.0	-1.2	-1.5	1.0	-2.9
2001	0.6	0.4	0.6	0.5	-1.1	-0.8	-0.3	-1.2
2002	-0.1	-0.3	-0.1	0.0	0.2	0.2	1.2	-0.7
2003	-0.7	-0.7	0.0	-1.2	-1.1	-1.3	-0.4	-1.1
2004	-2.2	-2.4	-2.0	-1.6	-0.2	0.0	0.2	-0.3
2005	-2.1	-2.3	-1.8	-1.6	-0.6	-0.2	0.0	-0.8

	5.Giheta				6. Gisozi			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1961					2.6	2.4	3.1	0.7
1962					0.8	1.3	0.7	0.5
1963					1.2	0.9	1.2	0.7
1964					0.5	0.5	-0.2	1.1
1965					0.3	0.3	-0.9	1.3
1966					-0.1	-0.1	0.4	-0.6
1967					1.0	1.2	1.1	0.5
1968					0.6	0.7	0.8	0.1
1969					0.4	0.1	0.5	0.1
1970	Starting				0.5	0.2	-0.6	1.4
1971	0.4	0.3	0.9	-0.2	0.6	0.6	0.1	0.9
1972	1.0	1.6	1.3	0.8	0.5	1.2	0.2	0.7
1973	-0.2	-0.1	-0.6	-0.2	-0.6	-0.5	1.0	-2.5
1974	-1.1	-1.3	-2.0	-0.1	-1.5	-1.5	-1.7	-0.6
1975	-1.7	-1.7	-0.9	-0.5	-1.4	-1.7	-1.4	-0.8
1976	-0.7	-0.7	0.2	-0.5	-1.6	-1.5	-1.9	-0.5
1977	0.6	0.8	0.8	0.6	0.3	0.6	-0.2	0.7
1978	0.9	1.2	-0.4	1.0	0.3	0.5	0.2	0.3
1979	0.5	0.1	-0.2	0.9	0.7	0.4	-0.2	1.3
1980	-0.9	-1.1	0.4	-1.0	-0.8	-0.9	-0.4	-0.8
1981	-0.8	-0.5	-0.1	-0.7	-1.9	-1.4	-0.7	-2.2
1982	0.9	0.8	0.8	0.5	1.2	1.0	0.8	1.1
1983	-2.8	-0.6	-0.1	-3.5	-0.3	-0.5	-0.6	0.3
1984	-0.3	-0.1	0.0	-0.9	-0.4	-0.4	0.4	-1.2
1985	0.9	0.9	0.2	1.7	1.2	1.1	-0.2	2.0
1986	1.6	1.5	1.0	1.0	1.7	1.6	1.4	1.2
1987	-0.8	-0.9	-0.2	-0.5	-0.5	-0.2	0.2	-1.0
1988	1.2	1.4	1.0	0.6	0.2	0.4	-0.1	0.5
1989	1.2	1.3	-0.9	1.7	1.4	1.5	1.4	0.8
1990	-0.2	-0.5	-0.7	0.7	-0.9	-0.7	-1.6	0.1
1991	0.0	-0.3	0.2	0.6	0.8	0.8	0.6	0.6
1992	-0.4	-1.0	-0.5	-0.9	-0.9	-0.9	-0.8	-0.6
1993	-0.2	-0.6	0.1	0.1	-1.3	-1.9	-1.2	-0.7
1994	-0.1	-0.4	0.3	-0.1	-0.2	-0.4	0.3	-0.6
1995	-0.5	-0.8	-0.5	0.2	-0.8	-1.1	-0.7	-0.4
1996	0.6	0.8	0.5	1.0	-0.1	0.3	-0.9	0.8
1997	2.2	2.4	2.3	-0.1	1.5	1.3	1.9	0.4
1998	0.7	0.5	-2.8	1.2	-0.6	-0.8	-1.6	0.6
1999	0.5	0.7	-0.4	0.0	-0.4	-0.3	0.4	-1.1
2000	-0.7	-1.4	1.5	-1.5	0.2	-0.3	1.1	-0.9
2001	-0.4	-0.1	-0.4	-0.1	-0.7	-0.3	-0.3	-0.7
2002	0.6	0.3	0.9	0.3	-0.5	-0.7	0.0	-0.7
2003	-0.2	-0.4	0.9	-1.2	-0.4	-0.4	-0.7	0.1
2004	-0.2	-0.3	-0.8	0.3	-0.7	-0.6	-0.2	-0.8
2005	-1.7	-1.9	-1.8	-1.3	-1.9	-1.9	-0.7	-2.3

	7. Gitega-Aéro				8. Karuzi			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1961					0.7	0.5	1.1	0.1
1962					0.1	0.1	0.3	-0.1
1963					1.2	1.0	1.4	0.7
1964					-0.1	-0.2	0.0	-0.1
1965					-0.4	-0.3	-0.7	0.1
1966					-0.3	-0.1	-0.7	0.1
1967					0.2	0.3	0.3	0.2
1968					0.8	0.9	0.0	1.3
1969					-0.5	-0.8	-0.3	-0.5
1970	Starting				0.8	0.8	0.1	1.2
1971	-0.7	-0.6	-0.9	-0.1	-0.4	0.2	0.1	-0.6
1972	0.4	0.7	-0.2	0.7	0.4	0.4	0.5	0.2
1973	-0.3	-0.2	0.4	-0.7	-1.1	-1.3	-1.1	-0.7
1974	0.4	0.6	-0.4	0.9	-0.1	-0.2	0.1	-0.2
1975	-0.6	-0.2	-0.6	-0.2	-1.1	-0.9	-1.0	-0.8
1976	0.5	0.6	0.4	0.4	-0.8	-0.7	-0.8	-0.5
1977	0.6	0.7	0.5	0.4	0.9	0.8	0.2	1.3
1978	0.4	0.4	0.4	0.2	0.5	0.6	0.7	0.2
1979	1.6	1.2	0.3	1.8	1.9	1.8	-0.3	2.9
1980	-0.6	-0.6	0.4	-1.1	-1.1	-1.2	-0.9	-0.9
1981	-0.7	0.0	-0.7	-0.2	0.0	0.0	-0.2	0.3
1982	1.6	1.4	1.3	0.9	-0.3	-0.6	-0.4	-0.1
1983	-0.9	-1.1	-0.4	-0.8	-1.6	-1.5	-1.2	-1.5
1984	-0.1	0.0	1.5	-1.7	-1.7	-1.7	-1.8	-1.0
1985	0.5	0.6	-0.3	1.0	1.5	1.8	2.0	0.6
1986	1.9	1.6	1.1	1.6	0.8	0.6	0.8	0.6
1987	-0.5	-0.1	0.7	-1.3	0.1	0.0	0.4	-0.2
1988	1.5	1.7	1.4	0.8	-0.3	-0.2	-0.1	-0.4
1989	1.0	1.0	-0.3	1.6	-0.4	-0.2	0.2	-0.8
1990	-0.9	-0.7	-1.5	0.2	-0.7	-0.7	-0.6	-0.6
1991	-0.5	-0.7	-0.2	-0.4	0.0	-0.1	-1.2	0.9
1992	-0.1	-0.4	-0.2	0.1	0.2	0.0	0.0	0.3
1993	-1.9	-2.3	-2.7	-0.3	-0.7	-0.9	-1.0	-0.2
1994	-0.6	-0.6	-0.3	-0.4	0.6	0.5	1.5	-0.5
1995	-0.5	-0.8	-0.4	-0.3	-2.5	-2.7	-2.0	-2.3
1996	-0.5	-0.5	-0.9	0.2	-2.1	-1.8	-1.3	-2.2
1997	2.3	2.0	2.9	0.4	0.9	0.8	1.5	0.2
1998	0.5	0.2	-1.6	1.7	1.8	1.7	-0.2	2.7
1999	0.1	0.4	0.4	-0.1	0.2	0.5	0.6	-0.2
2000	-1.6	-1.9	0.4	-2.7	0.7	0.4	1.8	-0.6
2001	-0.2	0.3	0.3	-0.5	1.0	1.7	2.2	-0.5
2002	0.6	0.1	0.7	0.2	1.9	1.8	1.8	1.5
2003	-0.9	-1.0	0.2	-1.4	-0.4	-0.5	-0.5	-0.2
2004	0.3	0.4	-0.3	0.6	0.5	0.6	-0.1	0.9
2005	-2.1	-1.9	-1.4	-1.4	-1.2	-0.8	-1.2	-0.8

	9. Kayogoro				10. Kinyinya			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1967	0.4	0.6	-0.1	0.9				
1968	0.4	0.4	0.4	0.4				
1969	0.3	0.2	0.4	0.1				
1970	0.5	0.4	-0.2	1.1				
1971	0.2	0.2	0.3	0.0				
1972	0.7	0.8	1.2	-0.1				
1973	0.1	0.0	0.4	-0.2	Starting			
1974	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1	-1.4	1.2
1975	-1.1	-1.0	-1.2	-0.8	-1.4	-1.3	-1.6	-0.2
1976	-1.4	-1.2	-1.5	-0.9	-0.9	-0.7	-2.1	1.0
1977	-0.1	-0.1	-0.1	0.0	1.4	1.4	0.8	1.2
1978	0.8	0.8	0.7	0.7	1.0	1.2	0.5	0.9
1979	0.6	0.5	0.3	0.8	0.5	0.1	-0.1	0.9
1980	0.1	0.1	0.2	0.1	-0.5	-0.3	-0.4	-0.2
1981	-0.3	-0.3	-0.4	-0.1	-0.2	0.2	0.9	-1.6
1982	0.7	0.7	1.1	0.0	1.2	0.8	1.5	-0.1
1983	-0.3	-0.3	-0.1	-0.5	2.1	1.9	1.1	1.9
1984	-0.5	-0.5	-0.1	-0.7	-0.7	-0.6	0.3	-1.5
1985	0.9	0.8	0.1	1.6	-0.4	-0.6	0.2	-0.9
1986	0.8	0.8	1.0	0.6	1.7	1.4	1.5	0.7
1987	0.2	0.3	0.2	0.1	-0.6	0.2	-0.3	-0.6
1988	0.1	0.1	0.1	0.1	0.1	0.6	0.9	-1.1
1989	1.1	1.1	0.8	1.2	0.6	0.4	0.5	0.3
1990	0.3	0.2	-0.7	1.2	-1.0	-1.4	-1.1	-0.2
1991	0.4	0.3	0.2	0.6	-0.3	-0.1	-0.7	0.5
1992	-0.3	-0.3	-0.6	0.1	-1.2	-1.9	-0.4	-1.3
1993	-0.2	-0.4	-0.3	0.0	-1.0	-1.1	-0.4	-1.0
1994	-0.1	0.0	0.1	-0.2	End			
1995	1.9	1.9	1.8	1.7				
1996	0.1	0.2	-0.7	0.9				
1997	1.1	1.1	1.8	0.1				
1998	1.5	1.4	1.8	0.9				
1999	0.1	0.0	0.4	-0.3				
2000	-0.2	-0.3	0.5	-0.9				
2001	-0.2	0.1	0.2	-0.5				
2002	-0.1	-0.2	-0.4	0.2				
2003	-2.2	-2.1	-1.8	-2.2				
2004	-2.2	-2.4	-2.4	-1.7				
2005	-3.6	-3.6	-2.9	-3.7				

	13.Makamba				14.Mparambo			
ear	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1961					1.7	2.0	3.0	-1.9
1962					1.0	1.4	1.0	0.4
1963					2.8	2.5	0.8	3.2
1964					0.3	0.3	1.1	-1.0
1965					-0.9	-1.0	-0.7	-0.5
1966					-1.0	-0.7	-0.3	-1.1
1967					-0.3	-0.3	-0.3	0.0
1968					0.2	0.1	-0.3	0.7
1969					0.1	-0.4	0.5	-0.4
1970	Starting				0.8	0.7	0.5	0.6
1971	-0.6	-0.9	-1.2	0.3	-0.2	-0.3	-0.7	0.4
1972	-0.6	-0.4	0.3	-1.4	0.3	0.3	1.0	-0.8
1973	-1.4	-1.2	-0.9	-1.2	0.2	0.4	0.2	0.1
1974	-0.9	-1.1	-1.7	0.3	-0.9	-0.5	-0.7	-0.5
1975	-0.6	-0.7	-1.2	0.3	-1.7	-1.8	-1.4	-1.0
1976	-0.5	-0.7	-0.7	0.0	-2.6	-2.1	-2.6	-1.1
1977	0.8	0.6	0.5	0.9	0.3	0.7	-0.2	0.8
1978	-0.2	-0.3	0.8	-1.4	0.7	0.4	0.6	0.3
1979	0.5	0.5	0.4	0.4	-0.2	-0.6	-0.7	0.6
1980	-1.1	-1.3	-0.6	-1.1	0.9	0.7	1.1	0.1
1981	-0.7	-0.6	-0.5	-0.4	-0.2	0.0	-0.1	-0.1
1982	0.3	0.1	1.0	-0.7	0.2	0.0	0.9	-0.8
1983	-0.9	-0.7	-0.6	-0.7	-0.9	-0.6	-0.9	-0.2
1984	-2.2	-1.6	-1.8	-1.4	-1.2	-1.3	0.1	-1.9
1985	-0.6	-0.8	-0.3	-0.6	-0.7	-0.6	-1.7	0.7
1986	0.9	0.8	1.0	0.3	0.1	-0.3	0.5	-0.4
1987	-0.4	-0.2	-0.3	-0.2	1.0	1.0	0.4	1.0
1988	0.0	-0.1	0.0	0.0	0.0	0.6	0.3	-0.2
1989	1.8	1.9	1.1	1.7	1.2	0.9	0.3	1.5
1990	1.1	1.2	-0.2	2.0	0.7	0.7	1.1	-0.3
1991	1.1	1.5	0.2	1.7	0.4	0.2	-0.3	0.9
1992	0.5	0.4	0.5	0.4	-0.5	-1.0	-0.9	0.3
1993	-0.6	-0.8	-0.5	-0.4	0.0	-0.3	-1.1	1.1
1994	2.0	2.0	2.4	0.4	0.9	0.9	0.3	1.1
1995	0.9	0.8	1.1	0.2	-1.7	-2.2	-1.0	-1.4
1996	0.6	0.8	0.0	1.1	-0.4	-0.1	0.0	-0.5
1997	1.7	1.5	1.7	0.8	End			
1998	1.0	1.0	-0.8	2.3				
1999	-0.2	0.4	1.1	-1.9				
2000	1.2	0.9	1.5	0.2				
2001	0.3	0.7	0.3	0.1				
2002	0.4	0.1	0.5	0.1				
2003	-1.4	-1.7	-0.7	-1.4				
2004	-1.6	-1.4	-2.0	-0.4				
2005	-0.4	-0.6	-0.3	-0.3				

	15. Mpota-Tora				16. Mugera - paroisse			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1960					-0.5	-0.7	-0.3	-0.3
1961					1.7	1.5	2.4	-0.4
1962					0.4	0.3	0.5	0.2
1963					0.8	0.5	-0.1	1.2
1964	Starting				1.1	0.9	-0.3	1.8
1965	1.4	1.3	-0.1	1.9	0.5	0.6	0.4	0.3
1966	-0.8	-0.8	-1.2	0.0	-0.7	-0.4	-0.9	0.0
1967	0.0	0.3	0.8	-0.6	1.6	1.8	0.3	2.0
1968	0.9	1.1	-1.1	2.0	1.7	1.7	0.8	1.6
1969	-0.2	-0.4	0.2	-0.4	0.7	0.6	0.7	0.3
1970	0.6	0.4	0.4	0.4	0.8	0.9	0.3	0.9
1971	0.5	0.5	0.3	0.5	0.4	0.3	0.9	-0.3
1972	1.4	1.8	0.2	1.6	0.8	1.2	0.0	1.2
1973	-0.2	-0.1	1.1	-1.4	-0.7	-0.5	-0.4	-0.4
1974	-0.6	-0.5	-0.8	-0.1	-1.3	-1.4	-1.3	-0.4
1975	-1.8	-1.7	-1.7	-0.9	-1.6	-1.1	-0.8	-1.3
1976	-0.8	-0.6	-0.7	-0.3	-1.0	-0.8	-0.5	-0.7
1977	-1.2	-1.0	-1.1	-0.6	0.3	0.3	0.5	0.1
1978	0.2	0.1	0.1	0.3	-0.1	0.0	-0.3	0.2
1979	0.2	-0.2	-0.2	0.5	1.2	0.9	-0.5	2.1
1980	0.5	0.6	0.9	0.0	-0.9	-1.2	-0.1	-1.2
1981	0.1	0.5	0.8	-0.5	-0.6	-0.1	-1.0	0.2
1982	1.2	0.9	1.3	0.5	1.1	1.0	1.4	0.1
1983	1.0	1.2	0.3	1.1	-1.2	-1.3	-1.4	-0.2
1984	0.1	0.0	0.7	-0.4	-0.7	-0.5	0.4	-1.6
1985	-0.3	-0.4	-0.3	-0.1	0.3	0.2	0.1	0.5
1986	1.5	1.5	0.1	1.8	1.3	1.1	1.0	0.9
1987	-0.6	-0.2	0.0	-0.8	-1.5	-0.9	-1.2	-0.8
1988	0.6	0.6	1.0	0.0	1.3	1.5	1.6	0.1
1989	1.3	1.4	0.9	1.0	1.3	1.1	-0.1	1.9
1990	0.5	0.5	-0.8	1.3	-1.0	-1.2	-1.3	0.0
1991	0.5	0.9	-0.3	1.0	-0.1	-0.3	-0.6	0.5
1992	-0.2	-0.6	0.1	-0.4	-0.1	-0.5	0.0	-0.2
1993	-1.7	-2.1	-1.1	-1.2	-2.5	-2.9	-1.8	-1.5
1994	1.8	1.7	2.6	-0.1	-0.2	-0.3	0.4	-0.6
1995	0.3	0.0	1.0	-0.6	-1.6	-1.8	-2.4	0.1
1996	-0.1	-0.1	-0.5	0.4	-0.1	0.3	0.0	0.0
1997	1.2	0.9	1.8	0.0	0.9	1.1	2.1	-1.5
1998	0.4	0.3	-1.6	1.7	0.1	0.1	-1.7	1.5
1999	-1.7	-1.0	0.2	-2.7	-0.3	0.1	0.6	-1.2
2000	0.4	-0.2	1.1	-0.5	-0.2	-0.6	1.1	-1.8
2001	-1.7	-1.3	-0.7	-1.6	0.1	0.4	0.6	-0.5
2002	-0.2	-0.6	0.4	-0.5	-0.3	-0.6	0.8	-1.5
2003	-2.0	-2.3	-2.4	-0.6	-0.2	-0.3	-0.2	0.0

	17. Musasa				18. MUSONGATI			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1961	1.2	1.1	1.4	0.5				
1962	0.2	0.4	0.3	0.1				
1963	1.6	1.6	1.4	1.1				
1964	0.4	0.2	-0.3	0.9				
1965	-0.3	-0.2	-0.5	0.1				
1966	-0.5	-0.6	-0.2	-0.5				
1967	1.0	1.0	0.1	1.4				
1968	0.6	0.8	0.4	0.6				
1969	-0.1	-0.3	-0.1	-0.1				
1970	0.7	0.6	0.1	1.1				
1971	-1.1	-1.2	-2.0	0.1				
1972	0.4	0.8	0.9	-0.2				
1973	1.1	1.0	1.8	-0.2				
1974	-0.3	-0.2	-1.7	1.0	Starting			
1975	-0.4	-0.3	-0.6	0.1	Starting			
1976	0.1	0.0	-0.6	0.7	-1.6	-1.6	-1.4	-0.7
1977	1.9	1.8	1.4	1.5	0.3	0.8	1.3	-0.5
1978	-0.4	-0.5	-0.5	-0.1	1.1	1.0	0.8	0.7
1979	0.7	0.5	0.4	0.7	0.9	0.6	-0.1	1.1
1980	-1.6	-1.7	-1.1	-1.3	-0.5	-0.7	-0.7	-0.1
1981	-0.6	-0.4	-0.7	-0.1	1.6	1.5	2.0	0.5
1982	1.6	1.5	1.6	0.9	-0.2	-0.3	-0.4	0.1
1983	-1.1	-1.0	-1.3	-0.4	-0.7	-0.5	-0.4	-0.4
1984	-0.8	-0.8	-0.2	-1.0	1.0	1.0	0.9	0.6
1985	-0.2	-0.3	-0.4	0.0	2.0	1.7	-0.9	2.4
1986	1.9	1.7	1.5	1.5	0.7	0.5	1.6	-0.2
1987	0.0	0.2	-0.1	0.2	-0.4	-0.4	0.1	-0.4
1988	0.6	1.3	0.8	0.2	0.2	0.4	0.0	0.3
1989	0.8	0.9	0.8	0.6	0.9	1.1	0.6	0.7
1990	-1.1	-1.0	-0.9	-0.8	-0.7	-0.7	-1.0	-0.1
1991	0.6	0.6	0.8	0.2	0.4	0.5	-1.8	1.4
1992	-0.7	-0.9	-0.1	-0.9	0.1	0.1	-0.1	0.2
1993	-1.5	-1.7	-2.3	-0.1	-0.9	-0.7	-0.6	-0.5
1994	0.4	0.3	-0.3	0.8	-2.1	-2.0	-0.4	-2.1
1995	-0.5	-0.7	-1.9	0.9	0.5	0.2	-0.4	0.8
1996	-1.4	-1.1	-0.4	-1.8	-1.0	-0.8	-0.3	-0.8
1997	0.7	0.5	1.5	-0.6	0.9	0.8	2.7	-0.9
1998	1.9	1.7	0.9	2.1	0.6	0.2	-1.3	1.3
1999	-1.0	-0.8	-0.2	-1.4	-0.9	-0.9	-0.5	-0.6
2000	-0.3	-0.6	0.8	-1.5	-2.1	-2.5	0.4	-2.8
2001	-0.4	0.1	-0.1	-0.5	-0.7	0.0	0.4	-1.0
2002	0.2	0.0	0.7	-0.4	0.9	0.9	0.4	0.7
2003	-1.1	-1.3	-0.8	-0.8	-0.5	-0.6	-1.1	0.2
2004	-0.7	-0.4	0.7	-2.1	0.7	0.9	0.6	0.5
2005	-2.4	-2.5	-1.2	-2.6	-0.5	-0.8	-0.3	-0.3

	25. Rwegura				26. Rweza-vyanda			
Year	SPI-8	SPI-12	SPI-4	SPI-4	SPI-8	SPI-12	SPI-4	SPI-4
	Oct-May	Jan-Dec	Oct-Jan	Feb-May	Oct-May	Jan-Dec	Oct-Jan	Feb-May
1961	1.8	1.3	2.5	-0.4				
1962	1.1	1.7	0.8	1.4				
1963	1.7	1.5	0.2	1.5				
1964	-2.7	-2.3	-1.3	-2.1				
1965	-0.4	-0.4	-1.5	1.2				
1966	0.2	0.0	-0.4	1.1				
1967	0.8	0.8	1.0	0.3				
1968	1.3	1.0	0.9	1.7				
1969	0.1	-0.4	-0.5	1.1				
1970	0.4	0.2	-0.7	0.9				
1971	0.9	1.1	-0.2	1.8				
1972	-0.4	0.2	0.4	-1.0				
1973	-0.2	0.3	0.8	-1.4				
1974	0.5	0.8	0.1	0.5				
1975	-0.7	-1.1	-0.9	-0.5				
1976	-0.9	-0.4	-0.4	-0.2				
1977	-0.5	-0.7	0.6	-1.1				
1978	-0.1	-0.2	-0.7	0.5				
1979	0.3	-0.2	-0.6	0.9	Starting			
1980	-1.2	-1.2	-0.6	-1.1	-1.1	-0.9	-0.5	-1.5
1981	-1.2	-0.9	-0.8	-0.8	-0.6	-0.2	-0.3	-0.8
1982	0.8	0.9	0.6	0.2	2.2	2.2	2.4	1.3
1983	-0.8	-1.0	-0.1	-0.3	0.7	0.6	0.8	0.4
1984	-1.3	-1.3	-1.2	-1.5	-0.2	-0.3	0.3	-0.9
1985	0.0	-0.1	-0.8	0.5	0.0	-0.2	0.3	-0.4
1986	0.8	0.7	0.6	1.1	0.6	0.5	0.2	1.0
1987	-0.3	0.2	0.1	-0.4	0.4	0.3	0.2	0.6
1988	0.9	0.8	0.0	0.8	1.9	2.0	1.6	1.7
1989	3.1	3.3	2.9	0.3	-0.2	-0.1	-0.8	0.6
1990	-0.4	-0.2	0.3	0.3	0.8	0.7	0.3	1.4
1991	0.4	0.2	-0.3	1.3	0.7	0.7	0.3	1.0
1992	0.5	0.2	0.5	0.4	-0.9	-1.0	-0.7	-0.9
1993	-1.6	-2.0	-1.4	-0.2	-1.2	-1.4	-1.4	-0.5
1994	-0.1	-0.6	1.2	-0.4	0.7	0.6	0.9	0.3
1995	-0.3	-0.3	-0.1	-0.3	-2.8	-2.9	-2.3	-2.6
1996	-1.0	-0.8	-0.2	-0.3	0.2	0.1	-0.6	1.1
1997	1.1	0.7	1.5	0.5	1.5	1.3	1.9	0.4
1998	-0.1	-0.1	-2.7	1.1	-0.8	-0.6	-1.3	0.0
1999	-0.2	0.2	-0.9	-0.5	-0.5	-0.3	-0.7	-0.1
2000	0.0	-0.5	0.3	-1.4	-0.2	-0.4	0.5	-1.2
2001	0.1	1.1	0.8	-0.8	-0.3	-0.1	-0.3	-0.3
2002	-0.6	-1.0	-1.1	-1.0	-0.2	-0.3	-0.3	-0.1
2003	0.0	-0.1	0.6	-0.3	0.1	0.0	-0.2	0.4
2004	-0.8	-0.5	0.5	-1.4	-0.3	-0.1	0.4	-1.2
2005	-0.8	-0.9	0.2	-1.8	-0.2	-0.2	-0.6	0.4

Appendix B: STATISTICAL PARAMETERS (CV in %)

		SPI-8	SPI-12	SPI-4	SPI-4
		(Oct to May)	(Jan to Dec	(Oct. to Jan)	(Feb to May)
	CV(%)	14.3	13.2	21.6	20.7
	SD	210.2	214.5	156.0	153.8
1. Bugarama-Aéro	MEAN	1468.1	1622.6	723.0	745.1
	CV(%)	18.0	16.9	28.4	22.7
	SD	136.0	137.0	106.7	85.8
2. Bujumbura-aéro	MEAN	754.2	810.2	376.0	378.2
	CV(%)	17.8	17.6	21.5	21.9
	SD	198.1	208.4	125.3	116.6
3. Cankuzo	MEAN	1113.7	1182.2	581.8	531.9
	CV(%)	15.0	15.1	17.3	21.3
	SD	174.8	184.9	97.7	128.2
4. Giharo	MEAN	1166.9	1224.9	563.7	603.2
	CV(%)	18.7	15.3	24.8	26.9
	SD	202.0	178.5	136.1	142.9
5. Giheta	MEAN	1081.2	1165.9	548.9	532.4
	CV(%)	14.7	13.5	20.9	17.7
	SD	202.0	199.9	140.8	123.9
6. Gisozi	MEAN	1374.3	1476.0	673.9	700.4
	CV(%)	16.7	15.9	22.3	24.4
	SD	180.6	183.4	121.7	131.2
7. Gitega-Aéro	MEAN	1083.2	1156.3	545.4	537.8
	CV(%)	22.9	21.4	26.3	31.2
	SD	256.0	254.7	145.0	176.5
8. Karuzi	MEAN	1117.3	1188.1	551.5	565.8
	CV(%)	9.7	8.6	15.7	11.8
	SD	118.4	109.9	93.7	73.4
9. Kayogoro (Makamba)	MEAN	1218.3	1284.6	597.9	620.4
	CV(%)	25.7	24.6	31.8	26.3
	SD	292.8	292.6	176.8	153.6
10. Kinyinya	MEAN	1140.0	1190.8	555.8	584.2
	CV(%)	13.5	12.0	20.9	17.7
	SD	127.7	127.7	86.8	93.6
11. Kirundo	MEAN	945.7	1066.0	415.7	530.0
	CV(%)	16.5	17.2	20.6	21.2
	SD	273.4	320.5	165.8	180.8
12. Mabayi	MEAN	1660.9	1858.6	806.0	854.9

		SPI-8	SPI-12	SPI-4	SPI-4
		(Oct to May	(Jan to Dec	(Oct. to Jan)	(Feb to May)
	CV(%)	16.0	15.5	22.9	19.4
	SD	205.5	210.7	146.6	125.1
13. Makamba	MEAN	1286.3	1359.2	641.2	645.2
	CV(%)	17.5	15.4	28.8	22.7
	SD	150.4	147.3	117.4	103.1
14. Mparambo	MEAN	861.8	954.1	407.2	454.6
	CV(%)	12.0	11.1	16.7	17.9
	SD	171.2	169.6	115.4	131.5
15. Mpota-Tora	MEAN	1427.6	1525.6	691.9	735.7
	CV	17.4	16.8	26.2	25.5
	SD	199.5	207.0	151.8	144.8
16. Mugera - paroiss	MEAN	1147.9	1229.8	580.0	568.0
	CV(%)	17.7	17.3	23.6	21.0
	SD	197.9	202.1	126.5	122.1
17. Musasa	MEAN	1117.6	1165.7	536.9	580.7
	CV(%)	13.5	12.7	17.5	23.9
	SD	152.6	150.4	92.5	142.8
18. Musongati	MEAN	1126.2	1184.5	528.4	597.7
	CV	19.3	18.4	15.7	37.8
	SD	177.5	183.3	72.2	173.8
19. Mutumba	MEAN	918.4	998.3	458.9	459.6
	CV(%)	18.0	17.4	26.0	21.4
	SD	208.2	212.2	150.4	123.6
20. Muyaga	MEAN	1156.4	1217.6	578.3	578.1
	CV(%)	17.1	15.7	25.7	20.9
	SD	178.4	177.3	127.3	114.8
21. Muyinga	MEAN	1044.0	1133.0	494.6	549.3
	CV(%)	17.2	16.1	21.5	23.2
	SD	208.2	214.6	129.0	141.8
22. Nyamuswaga	MEAN	1213.2	1336.6	601.0	612.2
	CV(%)	12.7	12.3	24.0	22.5
	SD	148.2	148.6	148.8	122.3
23. Nyanza-Lac	MEAN	1164.4	1204.8	620.1	544.4
	CV(%)	13.0	12.6	20.5	16.2
	SD	162.4	165.9	131.6	97.8
24. Ruvyironza	MEAN	1245.6	1319.0	641.1	604.5
	CV(%)	15.2	14.5	24.3	18.2
	SD	233.0	247.3	187.0	138.6
25. Rwegura	MEAN	1531.4	1703.2	768.9	762.5
	CV(%)	17.7	16.9	22.2	18.1
	SD	244.2	243.2	167.0	112.8
26. Rweza-vyanda	MEAN	1376.5	1442.9	752.9	623.6

Legend – CV(%) = coefficient of variation

- SD = Standard deviation

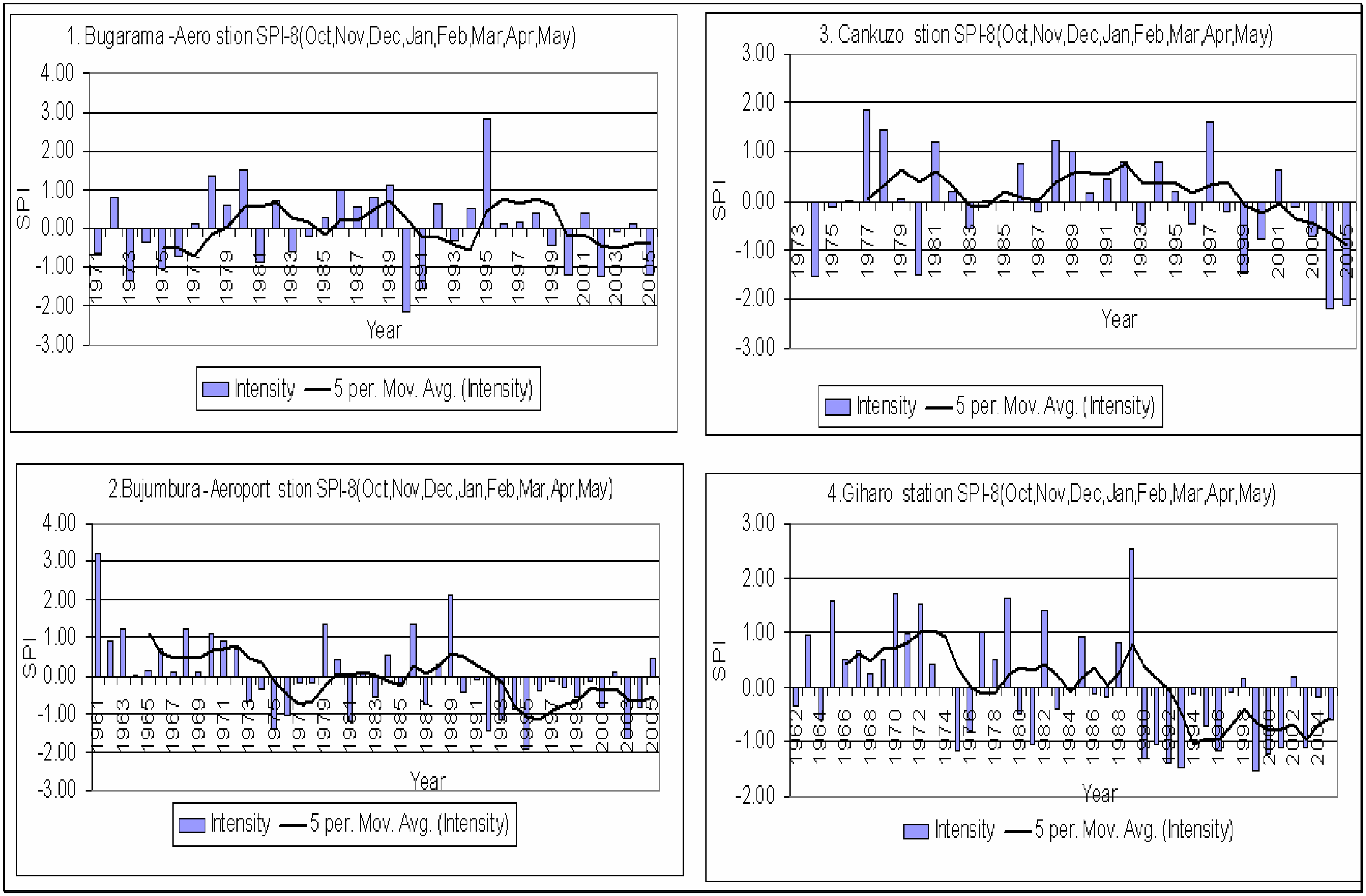
Appendix c: Table of total station in Burundi is 169

S.No	Station ID	Station Name	S.No	Station ID	Station Name	S. No	Station ID	Station Name	S.No	Station ID	Station Name
1	10001	BITEZI (Gasibe)	31	10031	CIBITOKE (Agri)						
2	10002	BUBANZA	32	10032	CIBITOKE (C.F.R)	62	10062	KAYERO	94	10094	MPANDA
3	10003	BUGARAMA (aero)	33	10033	FOTA	63	10063	KAYOGORO (Bukemba)	95	10095	Mparambo
4	10004	BUGARAMA (Commune)	34	10034	GASENYI (Buganda)	64	10064	KAYOGORO (Makamba)	96	10096	MPETE
5	10005	BUGENYUZI (Paroisse)	35	10035	GAKARA (Rutongo)	65	10065	KAYONGOZI	97	10097	MPINGA
6	10006	BUGIGA	36	10036	GATARA	66	10066	KAZIBA	98	10098	MPOTA (Tora)
7	10007	BUHIGA	37	10037	GIFURWE	67	10067	KIBIMBA	99	10099	MUBIMBI
8	10008	BUHONGA	38	10038	GIHANGA	68	10068	KIBUMBU	100	10100	MUGEGE
9	10009	BUHORO	39	10039	GIHARO	69	10069	KIGAMBA	101	10101	MUGERA (Cankuzo)
10	10010	BUHINYUZA	40	10040	GIHETA	70	10070	KIGANDA (E.F.I)	102	10102	MUGERA (Paroisse)
11	10011	BUJUMBURA (Aeroport)	41	10041	GIKWIYE	71	10071	KIGANDA (Paroisse)	103	10103	MUGERA (Lycee)
12	10012	BUJUMBURA (Ex college)	42	10042	GISANZE	72	10072	KIGARIKA (Mosso)	104	10104	MULEHE
13	10013	BUJUMBURA (Jabe)	43	10043	GISHUBI	73	10073	KINAZI	105	10105	MUKIKE
14	10014	BUJUMBURA (Kamenge)	44	10044	GISOZI	74	10074	KIGWENA (Mission)	106	10106	MUNANIRA
15	10015	BUJUMBURA (Port)	45	10045	GITANGA	75	10075	KINYINYA	107	10107	MUNGWA
16	10016	BUJUMBURA (Ville)	46	10046	GITEGA (Aerodrome)	76	10076	KIRAMBI	108	10108	MURAGO
17	10017	BUKEYE (E.F.I)	47	10047	GITEGA (Agri)	77	10077	KIREMBA	109	10109	MURAMBA
18	10018	BUKWAVU	48	10048	GITEGA (Ndebe)	78	10078	KIRUNDO (Agri)	110	10110	MURAMVYA

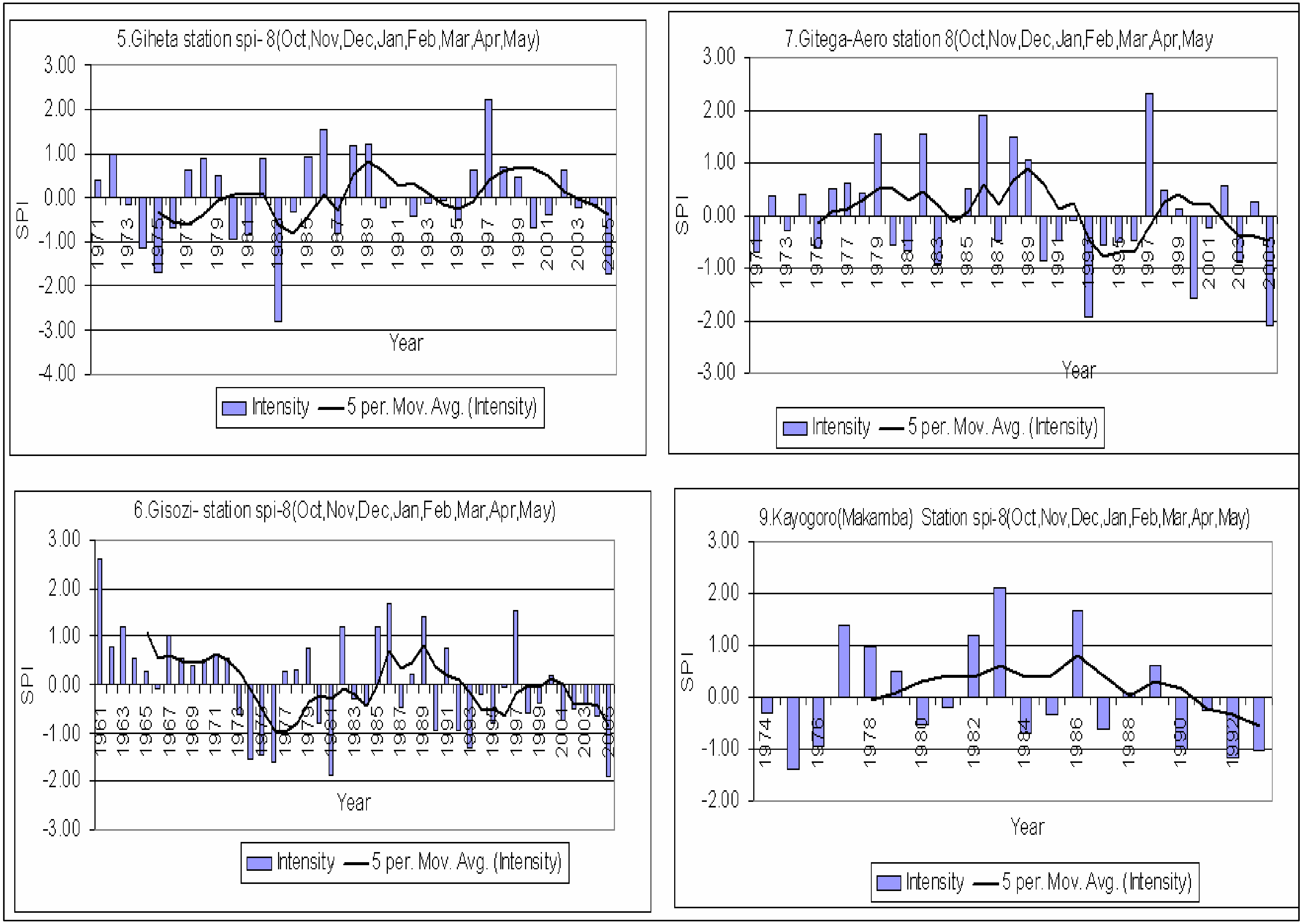
Table of total station in Burundi (Cont')

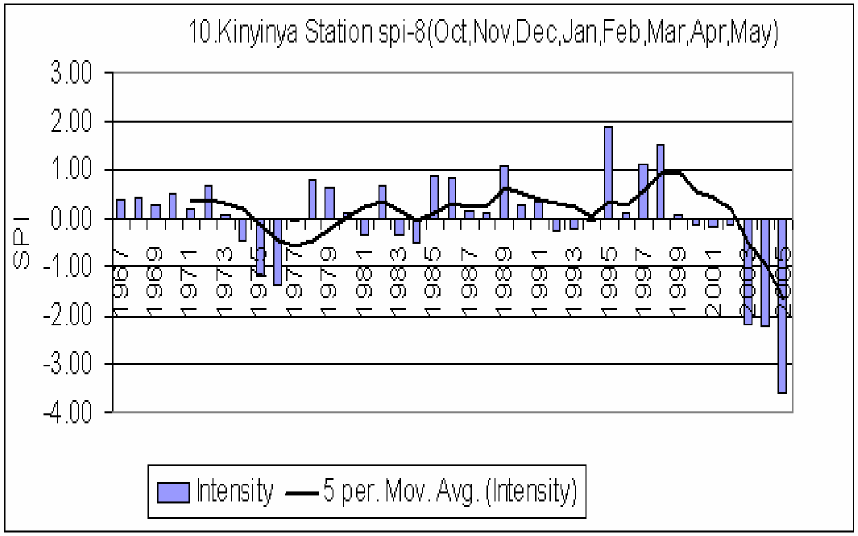
19	10019	BURASIRA (Seminaire)	49	10049	GITEGA (Zege)	79	10079	KIRUNDO (Projet)	111	10111	MUREHE (Mission)
20	10020	BURENZA	50	10050	GITONGO	80	10080	KIVOGA	112	10112	MURIZA
21	10021	BURURI	51	10051	GITWENGE	81	10081	MABANDA	113	10113	MURONG WE
22	10022	BUSIGA	52	10052	IMBO (Sems)	82	10082	MABAYI	114	10114	MURORE
23	10023	BUTA (Seminaire)	53	10053	IJENDA (Mission)	83	10083	MAKAMBA	115	10115	MURUKAR AMU
24	10024	BUTARA	54	10054	IJENDA (The villag)	84	10084	MAHANDE	116	10116	MUSASA
25	10025	BUTEZI	55	10055	KABEZI	85	10085	MAKEBUKO	117	10117	MUSEMA
26	10026	BUTORA	56	10056	KABUYENGE	86	10086	MARAGARAZI	118	10118	MUSENYI (Bubanza)
27	10027	BUYE	57	10057	KAJONDI	87	10087	MARAMVYA	119	10119	MUSENYI (E.F.I)
28	10028	BUZIRACAND	58	10058	KINANIRA (Imbo)	88	10088	MASHITSI	120	10120	MUSENYI (Paroisse)
29	10029	BWAGIRIZA	59	10059	KANYINYA (E.F.I)	89	10089	MATANA (Lycee)	121	10121	MUSIGATI
30	10030	CANKUZO (Projet)	60	10060	KANYINYA (Paroisse)	90	10090	MATONGO (Commune)	122	10122	MUSONGA TI
			61	10061	KARUZI	91	10091	MBIZI	123	10123	MUTUMBA
						92	10092	MINAGO	124	10124	MUTUMBA (Nyabikere)
126	10126	MUYANGE (Kayanza)	137	10137	NGOZI (Kagoma)	148	10148	RUGARI (E.F.I)	159	10159	RUTONGA NIK
127	10127	MUYINGA	138	10138	NGOZI (OCIBU)	149	10149	RUGARI (Paroisse)	160	10160	RUTOVU
128	10128	MUZINDA (Nyagatobe)	139	10139	NYABIGOZI	150	10150	RUGAZI	161	10161	RUVYIRON ZA
129	10129	MWARO	140	10140	NYAKAGUNDA	151	10151	RUKOKO	162	10162	RUVYIRON ZA
130	10130	MWEYA	141	10141	NYAKARARO	152	10152	RUMONGE	163	10163	RUYIGI (Mission)
131	10131	MWISALE	142	10142	NYAMUSWAGA	153	10153	RUSAKA	164	10164	RWEGURA
132	10132	NDAVA (Cogerco)	143	10143	NYANZA LAC (IRAT)	154	10154	RUSENGO (E.F.I)	165	10165	RWEZA (Nyangwa)
133	10133	NDORA	144	10144	NYANZA LAC (Mugerana)	155	10155	RUSHUBI (Bona)	166	10166	RWEZA (Vyanda)
134	10134	NGOMA	145	10145	NYANZA LAC (Projet)	156	10156	RUSHUBI (Village)	167	10167	TEZA (Nyabigond o)
135	10135	NGOZI (Caprin)	146	10146	RANDA	157	10157	RUTANA	168	10168	VUGIZO (Martyazo)
136	10136	NGOZI (College)	147	10147	REMERA	158	10158	RUTEGAMA	169	10169	SOSUMO (MOSO)

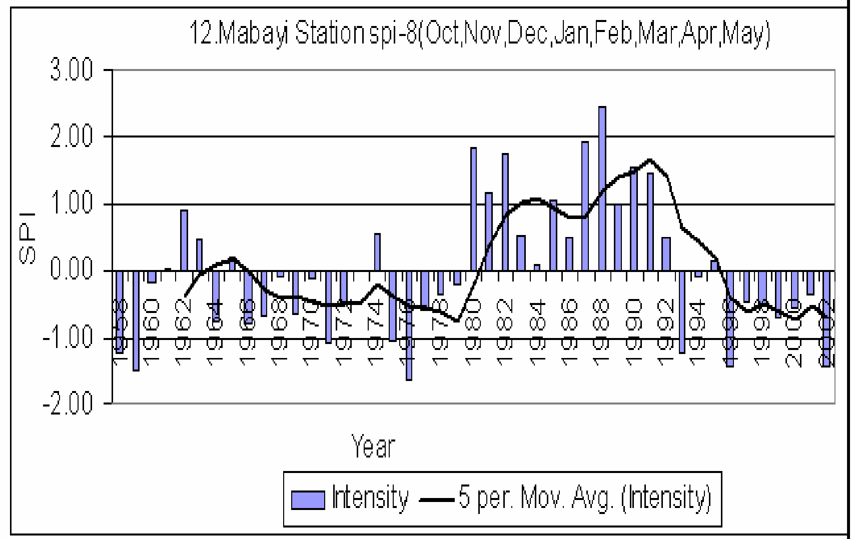
-Appendix D: Drought Intensity and Trend (SPI-8) for selected stations

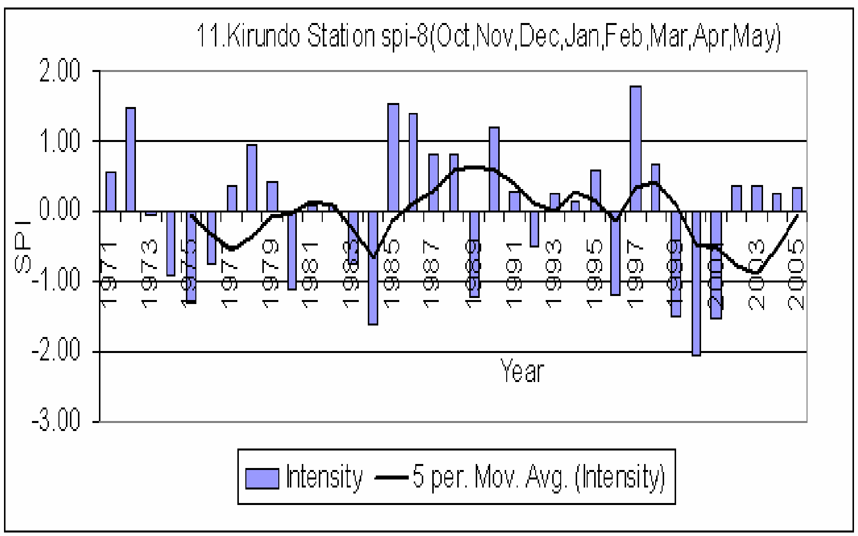


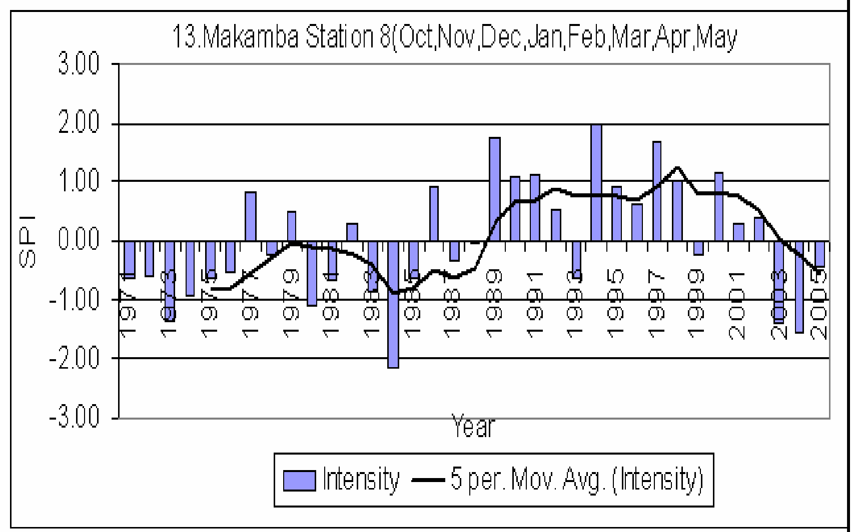
1. Bugarama -Aero stion SPI-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
3. Cankuzo stion SPI-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
2.Bujumbura-Aeroport stion SPI-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
4.Giharo station SPI-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

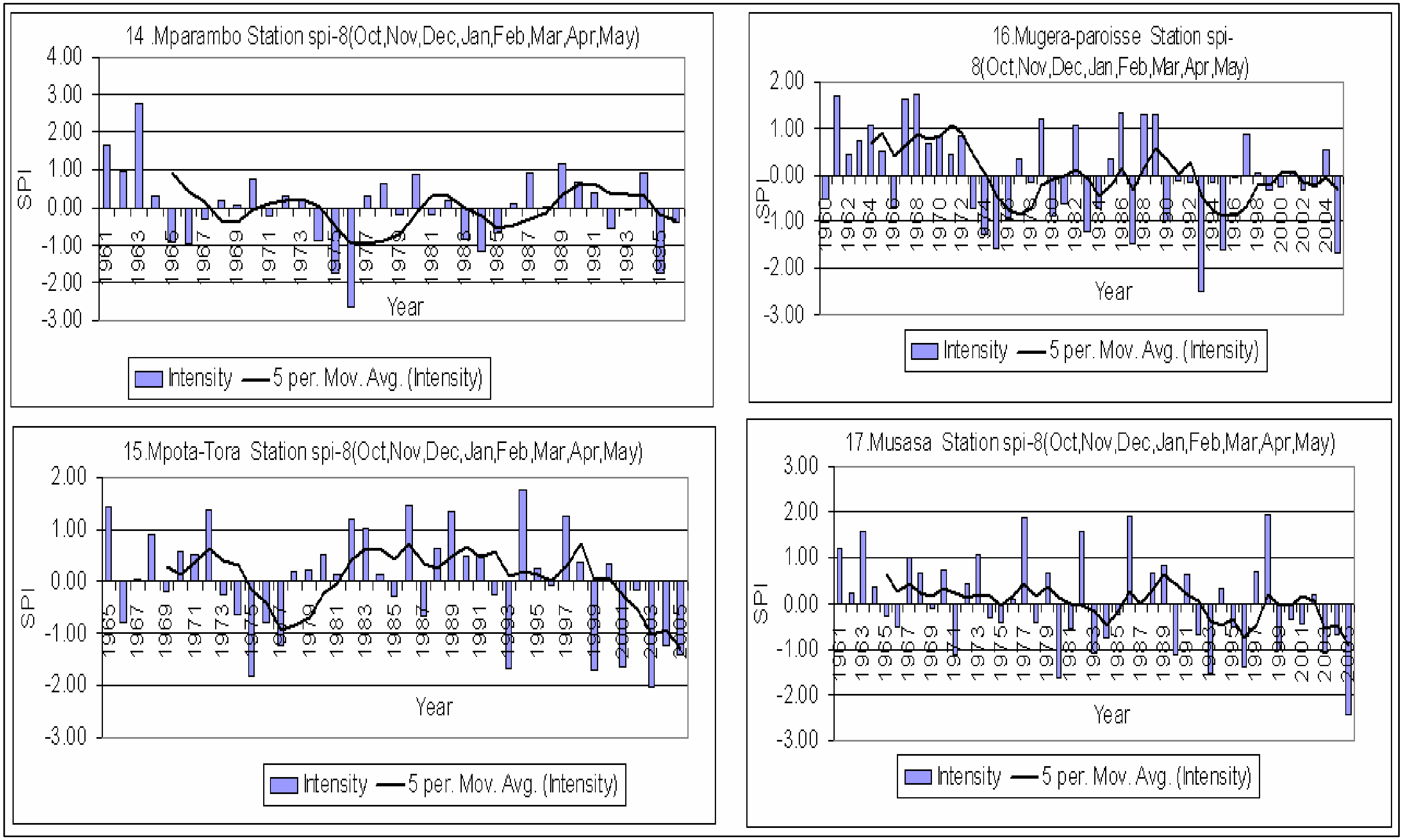

5.Giheta station spi- 8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
7.Gitega-Aero station 8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
6.Gisozi- station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
9.Kayogoro(Makamba) Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

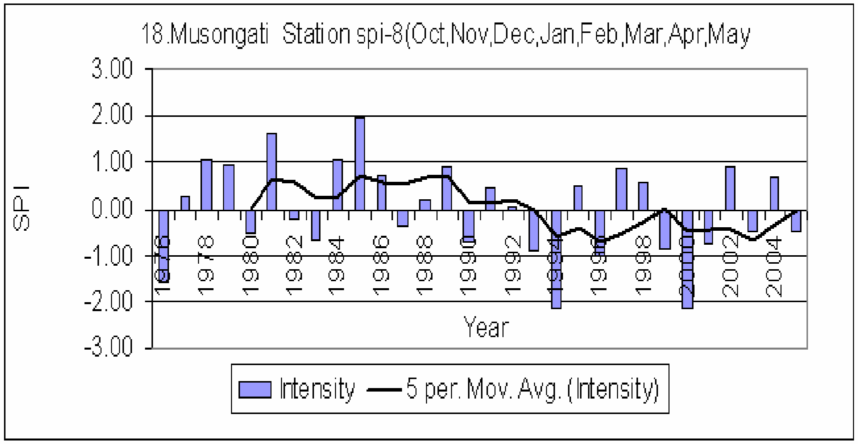

10.Kinyinya Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Intensity
5 per. Mov. Avg. (Intensity)

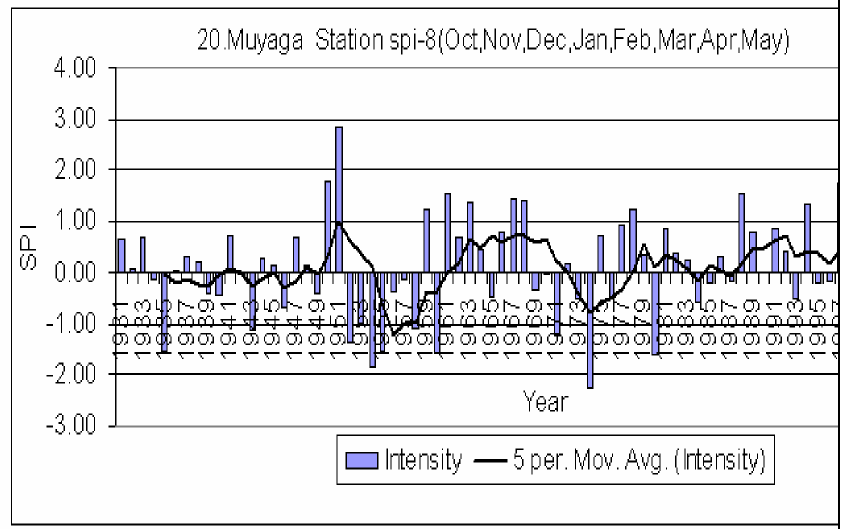

12.Mabayi Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

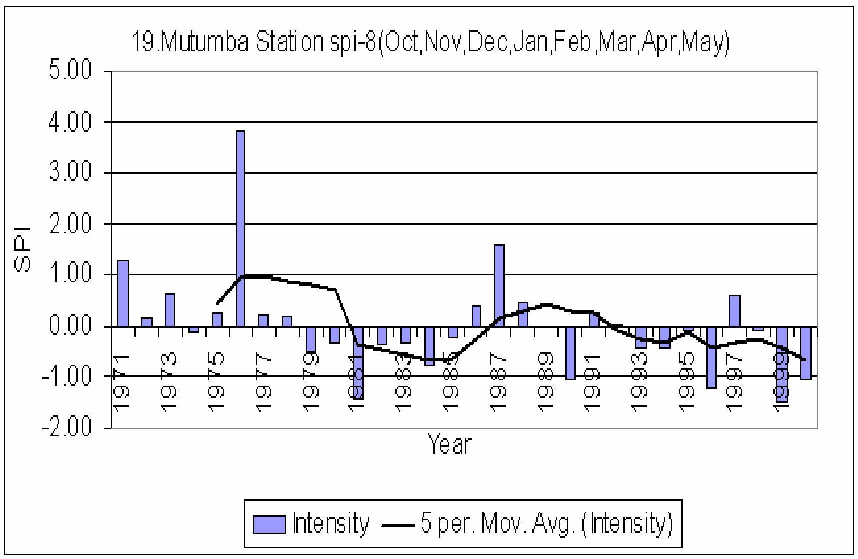

11.Kirundo Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

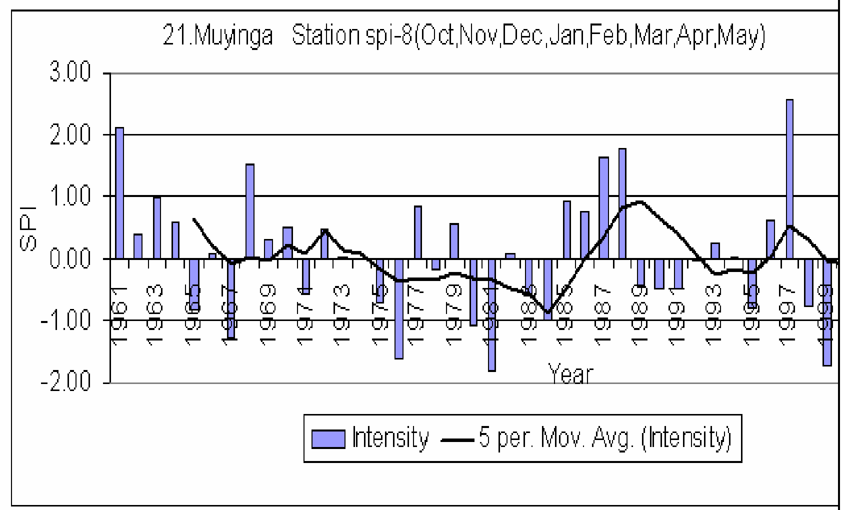

13.Makamba Station 8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

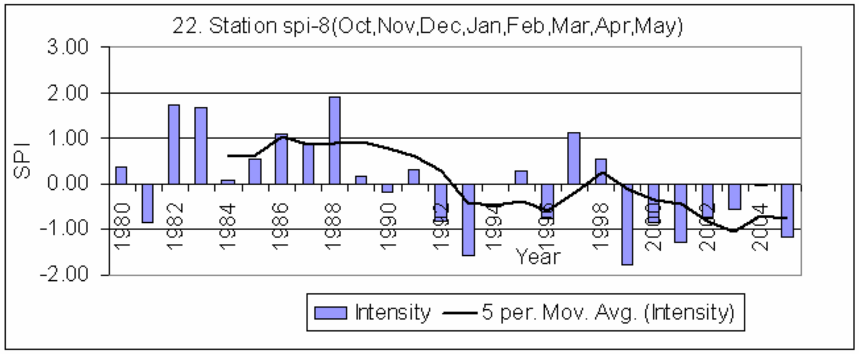

14 .Mparambo Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
16.Mugera-paroisse Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
15.Mpota-Tora Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)
17.Musasa Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

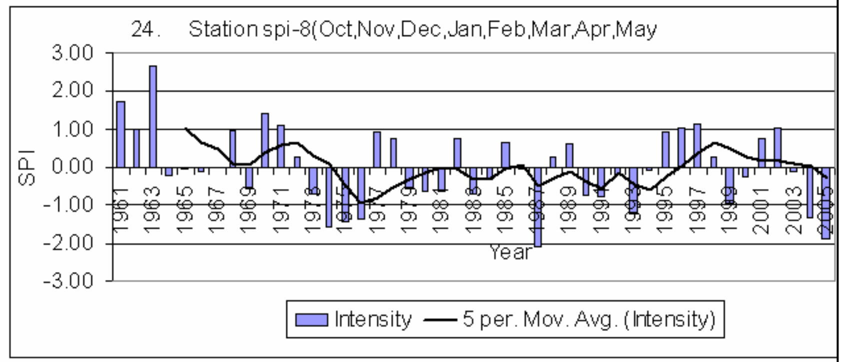

18.Musongati Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

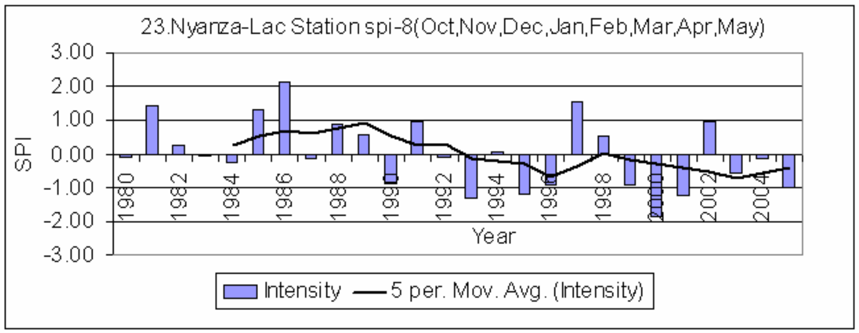

20.Muyaga Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

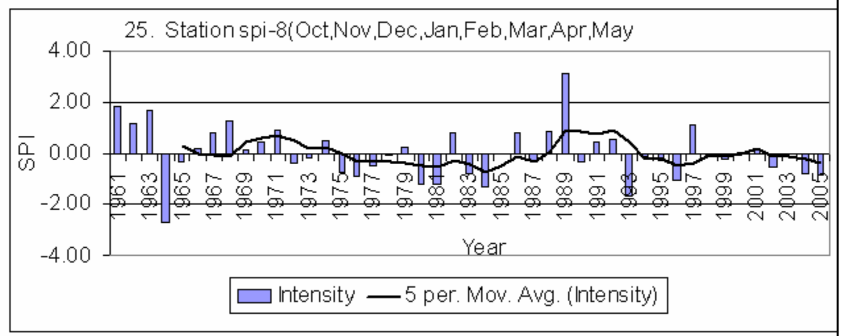

19.Mutumba Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

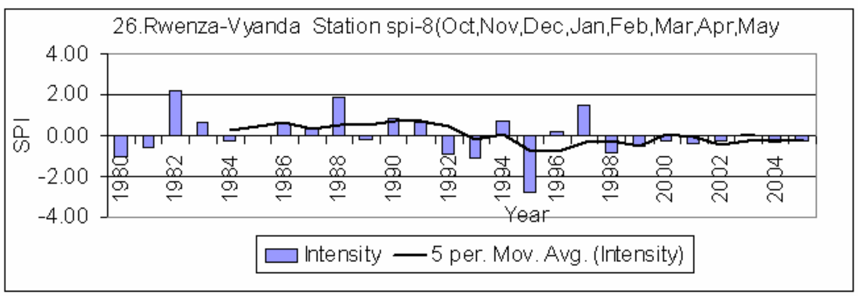

21.Muyinga Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)


22. Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)


24. Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)


23.Nyanza-Lac Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May)
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)


25. Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)


26.Rwenza-Vyanda Station spi-8(Oct,Nov,Dec,Jan,Feb,Mar,Apr,May
SPI
Year
Intensity
5 per. Mov. Avg. (Intensity)

Appendix E: Drought duration, severity, magnitude, frequency based on SPI-8

SPI-8	**Drought Parameters**	**Duration**	**Severity**	**Magnitude**	**Frequency**										
1.Mparambo station															
Start	End				MILD	MOD	SEV	EXT	Tot	%MD	%MoD	%SD	%ED	% All drought	
1964-Oct	1967-May	24	2.02	0.08	14	1	1	2	18	0.39	0.028	0	0.056	0.5	
1968-Oct	1969-May	8	0.98	0.12											
1970-Oct	1971-May	8	0.25	0.03											
1973-Oct	1976-May	24	4.37	0.18											
1978-Oct	1979-May	8	0.56	0.07											
1980-OCT	1981-May	8	0.03	0.00											
1982-Oct	1986-May	32	2.78	0.09											
1991-Oct	1993-May	16	1.25	0.08											
1994-Oct	1996_May	32	2.25	0.07											
SPI-8	**Drought Parameters**	**Duration**	**Severity**	**Magnitude**	**Frequency**										
2.Kirundo station															
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1972-May	1976-Oct	32	3.11	0.10	5	4	2	1	12	0.14	0.11	0.06	0.03	0.34	
1982-May	1984-May	16	2.38	0.15											
1988-Oct	1989-May	8	1.22	0.15											
1991-oct	1992-may	8	0.51	0.06											
1995-oct	1996-may	8	1.21	0.15											
1998-oct	2001-may	24	5.08	0.21											
SPI-8	**Drought Parameters**	**Duration**	**Severity**	**Magnitude**	**Frequency**										
3.Ruvyironza station															
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1963-Oct	1966-may	24	0.36	0.02	18	4	2	1	25	0.40	0.09	0.04	0.02	0.56	
1968-oct	1969-may	8	0.53	0.07											
1972-oct	1976-may	32	5.04	0.16											
1978-oct	1981-may	24	1.78	0.07											
1982-oct	1984-may	16	1.00	0.06											
1985-oct	1987-may	16	2.12	0.13											
1989-may	1994-may	40	2.98	0.07											
1998-oct	2000-may	16	1.18	0.07											
2002-oct	2005-may	24	3.26	0.14											

SPI-8	**Drought Parameters**	**Duration**	**Severity**	**Magnitude**	**Frequency**										
4.Nyanza Lac station															
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1979-oct	1980-may	8	0.11	0.01	10	4	1	0	15	0.38	0.15	0	0	0.58	
1982-oct	1984-may	16	0.32	0.02											
1986-oct	1987-may	8	0.16	0.02											
1989-oct	1990-may	8	0.88	0.11											
1991-oct	1993-may	16	1.38	0.09											
1994-oct	1996-may	16	2.08	0.13											
1998-oct	2001-may	24	4.02	0.17											
2002-oct	2005-may	24	1.70	0.07											
SPI-8	**Drought Parameters**														
5.Cankuzo station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1973-oct	1975-May	16	1.66	0.10	8	1	2	3	14	0.24	0.03	0.06	0.09	0.42	
1979-oct	1980-may	8	1.51	0.19											
1982-oct	1983-may	8	0.54	0.07											
1986-oct	1987-may	8	0.20	0.03											
1992-oct	1993-may	8	0.49	0.06											
1995-oct	1996-may	8	0.48	0.06											
1997-oct	2000-may	24	2.45	0.10											
2001-oct	2005-may	32	5.15	0.16											
SPI-8	**Drought Parameters**														
6.Bujumbura station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1972-oct	1978-may	48	3.79	0.08	16	3	2	1	22	0.36	0.07	0.04	0.02	0.49	
1980-oct	1981-may	8	1.19	0.15											
1982-oct	1983-may	8	0.58	0.07											
1984-oct	1985-may	8	0.18	0.02											
1986-oct	1987-may	8	0.76	0.09											
1989-oct	2001-may	24	8.29	0.35											
2002-oct	2004-may	16	2.46	0.15											

SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
7.Giharo Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODER	SEVERI	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought	
1961-oct	1962-may	8	0.33	0.04	13	10	1	0	24	0.3	0.227	0	0	0.5333	
1963-oct	1964-may	8	0.61	0.08											
1974-oct	1976-may	16	1.99	0.12											
1979-oct	1981-may	16	1.53	0.10											
1982-oct	1984-may	16	0.44	0.03											
1985-oct	1987-may	16	0.30	0.02											
1989-oct	1997-may	64	7.25	0.11											
1998-oct	2001-may	24	3.85	0.16											
2002-oct	2005-may	24	1.92	0.08											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
8.Giheta STATION		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODER	SEVERI	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought	
1972-oct	1976-may	32	3.70	0.12	15	1	2	1	19	0.43	0.03	0.1	0.03	0.54	
1979-oct	1981-may	16	1.75	0.11											
1982-oct	1984-may	16	3.11	0.19											
1986-oct	1987-may	24	0.79	0.03											
1989-oct	1990-may	8	0.22	0.03											
1991-oct	1995-may	32	1.14	0.04											
1999-oct	2001-may	24	1.06	0.04											
2002oct	2005-may	24	2.09	0.09											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
9.Gisozi STATION		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODER	SEVERI	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought	
1965-oct	1966-may	8	0.09	0.01	17	2	3	0	22	0.38	0.04	0.1	0	0.49	
1972-oct	1976-may	32	5.24	0.16											
1979-oct	1981-may	16	2.68	0.17											
1982-oct	1984-may	16	0.69	0.04											
1986-oct	1987-may	8	0.46	0.06											
1989-oct	1990-may	8	0.94	0.12											
1991-oct	1996-may	40	3.28	0.08											
1997-oct	1999-may	16	1.00	0.06											
2000-oct	2005-may	40	4.22	0.11											

SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
10.Gitega aero Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODER	SEVER	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought	
1970-oct	1971-may	8	0.70	0.09	16	0	2	1	19	0.5	0	0.1	0.03	0.54	
1972-oct	1973-may	8	0.29	0.04											
1974-oct	1975-may	8	0.61	0.08											
1979-oct	1981-may	16	1.25	0.08											
1982-oct	1984-may	16	0.97	0.06											
1986-oct	1987-may	8	0.49	0.06											
1989-oct	1996-may	56	4.94	0.09											
1999-oct	2001-may	16	1.81	0.11											
2002-oct	2003-may	8	0.90	0.11											
2004-oct	2005-may	8	2.09	0.26											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
11.Karusi Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODER	SEVER	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought	
1963	1966	24	0.75	0.03	13	3	2	2	20	0.3	0.07	0	0.04	0.44	
1968	1969	8	0.51	0.06											
1970	1971	8	0.37	0.05											
1972	1976	32	3.07	0.10											
1979	1980	16	1.10	0.07											
1981	1984	8	1.43	0.18											
1987	1990	24	1.43	0.06											
1992	1993	8	0.69	0.09											
1994	1996	16	4.64	0.29											
2002	2003	8	0.40	0.05											
2004	2005	8	1.17	0.15											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
12.Kayogoro Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODER	SEVER	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought	
1973	1976	24	2.66	0.11	8	4	0	0	12	0.4	0.2	0	0	0.6	
1979	1981	16	0.73	0.05											
1983	1985	16	1.07	0.07											
1986	1987	8	0.61	0.08											
1989	1993	32	3.48	0.11											

SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
13.Kinyinya station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1973	1977	32	2.98	0.09	11	1	0	3	15	0.28	0.03	0	0.08	0.38	
1980	1981	8	0.31	0.04											
1982	1984	16	0.79	0.05											
1991	1992	8	0.27	0.03											
1993	1994	8	0.07	0.01											
1999	2005	48	8.43	0.18											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
14.Mabayi Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1957	1960	24	2.93	0.12	16	5	2	0	23	0.36	0.11	0	0.00	0.51	
1963	1964	8	0.77	0.10											
1965	1972	56	3.85	0.07											
1974	1979	40	3.83	0.10											
1992	1994	16	1.32	0.08											
1995	2002	24	5.46	0.23											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
15.Makamba station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1970	1976	48	4.67	0.10	13	3	1	1	18	0.37	0.09	0	0.03	0.51	
1977	1978	8	0.24	0.03											
1979	1981	16	1.74	0.11											
1982	1985	24	3.69	0.15											
1986	1988	16	0.41	0.03											
1992	1993	8	0.63	0.08											
1998	1999	8	0.23	0.03											
2002	2005	24	3.37	0.14											

SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
16.Mpota-tora Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1965	1966	8	0.77	0.10	10	3	4	1	18	0.24	0.073	0.1	0.024	0.44	
1968	1969	8	0.18	0.02											
1972	1977	40	4.67	0.12											
1984	1985	8	0.27	0.03											
1986	1987	8	0.64	0.08											
1991	1993	16	1.91	0.12											
1995	1996	8	0.06	0.01											
1998	1999	8	1.71	0.21											
2000	2005	40	6.46	0.16											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
17.Mugera-paroisse Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1959	1960	8	0.50	0.06	17	3	3	1	24	0.37	0.065	0.1	0.022	0.52	
1965	1966	8	0.69	0.09											
1972	1976	32	4.50	0.14											
1979	1981	16	1.51	0.09											
1982	1984	16	1.89	0.12											
1986	1987	8	1.48	0.19											
1989	1996	56	5.51	0.10											
1998	2000	16	0.57	0.04											
2001	2003	16	0.56	0.04											
2004	2005	8	1.67	0.21											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
18.Musasa Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1964	1966	16	0.78	0.05	13	7	2	1	23	0.3	0.16	0	0.022	0.51	
1968	1969	8	0.13	0.02											
1970	1971	8	1.11	0.14											
1973	1975	16	0.71	0.04											
1977	1978	8	0.40	0.05											
1979	1981	8	2.17	0.27											
1982	1985	24	2.07	0.09											
1989	1990	8	1.10	0.14											
1991	1993	16	2.18	0.14											
1994	1996	16	1.92	0.12											
1998	2001	24	1.80	0.07											
2002	2005	24	4.22	0.18											

SPI-8	**Drought Parameters**	SPI-8(Oct to May)												
19.Musongati Station		**Duration**	**Severity**	**Magnitude**	**Frequency**									
Start	End				MILD	MODER	SEVERI	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought
1975	1976	8	1.56	0.19	9	1	1	2	13	0.3	0.03	0	0.07	0.43
1979	1980	8	0.52	0.07										
1981	1983	16	0.87	0.05										
1986	1987	8	0.38	0.05										
1989	1990	8	0.68	0.08										
1992	1994	16	3.01	0.19										
1995	1996	8	1.02	0.13										
1998	2001	24	3.70	0.15										
2002	2003	16	0.50	0.03										
2004	2005	8	0.48	0.06										
SPI-8	**Drought Parameters**	SPI-8(Oct to May)												
20.Mutumba Station		**Duration**	**Severity**	**Magnitude**	**Frequency**									
Start	End				MILD	MODER	SEVERI	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought
1973	1974	8	0.13	0.02	12	4	1	0	17	0.4	0.13	0	0	0.57
1978	1985	56	3.96	0.07										
1988	1990	16	1.08	0.07										
1992	1996	32	2.18	0.07										
1997	2000	24	2.63	0.11										
SPI-8	**Drought Parameters**	SPI-8(Oct to May)												
21.Muyaga Station		**Duration**	**Severity**	**Magnitude**	**Frequency**									
Start	End				MILD	MODER	SEVERI	EXTREM	Total	%MD	%MoD	%SD	%ED	% All Drought
1933	1935	16	1.65	0.10	25	6	4	1	36	0.33	0.08	0.1	0.013	0.48
1938	1940	16	0.84	0.05										
1941	1943	16	1.15	0.07										
1945	1946	8	0.70	0.09										
1948	1949	8	0.39	0.05										
1951	1958	56	7.27	0.13										
1959	1960	8	1.55	0.19										
1964	1965	8	0.48	0.06										
1968	1971	24	1.60	0.07										
1972	1974	16	2.74	0.17										
1975	1976	8	0.49	0.06										
1979	1980	8	1.58	0.20										
1983	1985	16	0.75	0.05										
1986	1987	8	0.16	0.02										
1989	1990	8	0.01	0.00										
1992	1993	8	0.52	0.06										
1994	1996	16	0.35	0.02										
1997	2001	32	4.55	0.14										
2002	2005	24	3.05	0.13										

SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
22.Muyinga Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1964	1965	8	0.82	0.10	13	4	4	0	21	0.29	0.089	0.1	0	0.4667	
1966	1967	8	1.25	0.16											
1970	1971	8	0.57	0.07											
1973	1976	24	2.32	0.10											
1977	1978	8	0.16	0.02											
1979	1981	16	2.86	0.18											
1982	1984	16	1.61	0.10											
1988	1992	32	1.46	0.05											
1994	1995	8	0.79	0.10											
1997	2000	24	3.66	0.15											
2002	2003	8	0.41	0.05											
2004	2005	8	1.71	0.21											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
23.Nyamuswaga Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1980	1981	8	0.62	0.08	6	5	1	0	12	0.23	0.192	0	0	0.4615	
1991	1994	24	3.60	0.15											
1995	1996	8	0.79	0.10											
1998	2005	56	6.16	0.11											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
24.Rwegura Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1963	1966	24	3.19	0.13	16	5	0	1	22	0.36	0.111	0	0.022	0.4889	
1968	1971	24	1.44	0.06											
1974	1976	16	1.34	0.08											
1977	1981	32	2.73	0.09											
1982	1985	24	2.04	0.08											
1990	1991	8	0.32	0.04											
1992	1993	8	1.41	0.18											
1994	1996	16	0.33	0.02											
1997	1999	16	3.58	0.22											
2001	2002	8	1.08	0.13											

SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
25.Rweza vyanda Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1979	1981	16	1.61	0.10	11	2	0	1	14	0.42	0.077	0	0.038	0.5385	
1983	1984	8	0.24	0.03											
1988	1989	8	0.21	0.03											
1991	1993	16	2.06	0.13											
1994	1995	8	2.80	0.35											
1997	2002	40	2.17	0.05											
2003	2005	16	0.53	0.03											
SPI-8	**Drought Parameters**	SPI-8(Oct to May)													
26.Bugarama Station		**Duration**	**Severity**	**Magnitude**	**Frequency**										
Start	End				MILD	MODEF	SEVERI	EXTREN	Total	%MD	%MoD	%SD	%ED	% All Drought	
1970	1971	8	0.67	0.08	9	5	1	1	16	0.26	0.143	0	0.029	0.4571	
1972	1976	32	3.48	0.11											
1980	1981	8	0.84	0.11											
1982	1984	16	0.81	0.05											
1989	1991	16	3.71	0.23											
1992	1993	8	0.32	0.04											
1998	2000	16	1.64	0.10											
2001	2003	16	1.30	0.08											
2004	2005	8	1.22	0.15											

Appendix F: Drought category based on SPI-8

Drought Category based on SPI-8														
1. MPARAMBO-Station		Drought	MD	MOD	SD	ED		2.Kirundo station		Drought	MD	MOD	SD	ED
		category						year	SPI-8(Oct to	category				
Year	SPI-8(OC to MAY)							1971	0.55					
1961	1.97							1972	1.46					
1962	1.42							1973	-0.07	Mild	1			
1963	2.54							1974	-0.93	Mild	1			
1964	0.27							1975	-1.34	Moderate		1		
1965	-0.98	Mild	1					1976	-0.78	Mild	1			
1966	-0.74	Mild	1					1977	0.36					
1967	-0.3	Mild	1					1978	0.95					
1968	0.14							1979	0.42					
1969	-0.39	Mild	1					1980						
1970	0.69							1981	0.09					
1971	-0.25	Mild	1					1982	0.09					
1972	0.31							1983	-0.76	Mild	1			
1973	0.41							1984	-1.62	Severe			1	
1974	-0.53	Mild	1					1985	1.53					
1975	-1.76	Severe						1986	1.39					
1976	-2.08	Extreme				1		1987	0.79					
1977	0.72							1988	0.79					
1978	0.42							1989	-1.22	Moderate		1		
1979	-0.56	Mild	1					1990	1.21					
1980	0.67							1991	0.28					
1981	-0.03	Mild	1					1992	-0.51	Mild	1			
1982	0.02							1993	0.24					
1983	-0.6	Mild	1					1994	0.15					
1984	-1.25	Moderate		1				1995	0.59					
1985	-0.65	Mild	1					1996	-1.21	Moderate		1		
1986	-0.28	Mild	1					1997	1.8					
1987	1.03							1998	0.68					
1988	0.62							1999	-1.49	Moderate		1		
1989	0.91							2000	-2.06	Extreme				1
1990	0.68							2001	-1.53	Severe			1	
1991	0.17							2002	0.37					
1992	-0.98	Mild	1					2003	0.34					
1993	-0.27	Mild	1					2004	0.23					
1994	0.94							2005	0.33					
1995	-2.18	Extreme				1								
1996	-0.07	Mild												

3.Ruvyironza station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1961	1.73					
1962	0.98					
1963	2.67					
1964	-0.22	Mild	1			
1965	-0.04	Mild	1			
1966	-0.1	Mild	1			
1967	0.01					
1968	0.96					
1969	-0.53	Mild	1			
1970	1.44					
1971	1.11					
1972	0.25					
1973	-0.71	Mild	1			
1974	-1.56	Severe			1	
1975	-1.44	Moderate		1		
1976	-1.34	Moderate		1		
1977	0.93					
1978	0.77					
1979	-0.55	Mild	1			
1980	-0.61	Mild	1			
1981	-0.62	Mild	1			
1982	0.78					
1983	-0.69	Mild	1			
1984	-0.31	Mild	1			
1985	0.65					
1986	-0.04	Mild	1			
1987	-2.08	Extreme				1
1988	0.25					
1989	0.63					
1990	-0.74	Mild	1			
1991	-0.77	Mild	1			
1992	-0.17	Mild	1			
1993	-1.22	Moderate		1		
1994	-0.08	Mild	1			
1995	0.91					
1996	1.01					
1997	1.15					
1998	0.24					
1999	-0.93	Mild	1			
2000	-0.25	Mild	1			
2001	0.76					
2002	1.01					
2003	-0.11	Mild	1			
2004	-1.3	Moderate		1	1	
2005	-1.85	Severe				

4.Nyanza Lac station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1980	-0.11	Mild	1			
1981	1.44					
1982	0.27					
1983	-0.05	Mild	1			
1984	-0.27	Mild	1			
1985	1.29					
1986	2.12					
1987	-0.16	Mild	1			
1988	0.88					
1989	0.56					
1990	-0.88	Mild	1			
1991	0.98					
1992	-0.08	Mild	1			
1993	-1.3	Moderate		1		
1994	0.07					
1995	-1.17	Moderate		1		
1996	-0.92	Mild	1			
1997	1.57					
1998	0.51					
1999	-0.94	Mild	1			
2000	-1.86	Severe			1	
2001	-1.22	Moderate		1		
2002	0.97					
2003	-0.54	Mild	1			
2004	-0.13	Mild	1			

5.Cankuzo station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME	
year	SPI-8(Oct to May)						
1973	0						
1974	-1.54	Severe			1		
1975	-0.12	Mild	1				
1976	0.01						
1977	1.87						
1978	1.44						
1979	0.06						
1980	-1.51	Severe			1		
1981	1.22						
1982	0.19						
1983	-0.54	Mild	1				
1984	0.03						
1985	0.03						
1986	0.76						
1987	-0.2	Mild	1				
1988	1.24						
1989	1.01						
1990	0.17						
1991	0.46						
1992	0.79						
1993	-0.49	Mild	1				
1994	0.79						
1995	0.19						
1996	-0.48	Mild	1				
1997	1.62						
1998	-0.22	Extreme					1
1999	-1.46	Moderate		1			
2000	-0.77	Mild	1				
2001	0.63						
2002	-0.1	Mild	1				
2003	-0.7	Mild	1				
2004	-2.21	Extreme					1
2005	-2.14	Extreme					1

6.BUJUMBURA-AEROPORT			Drought Ca	MILD	MODERATE	SEVERE	EXTREME
	year	SPI-8(Oct to May)					
1	1961	3.22					
2	1962	0.94					
3	1963	1.22					
4	1964	0.02					
5	1965	0.15					
6	1966	0.72					
7	1967	0.13					
8	1968	1.23					
9	1969	0.12					
10	1970	1.09					
11	1971	0.91					
12	1972	0.73					
13	1973	-0.63	Mild	1			
14	1974	-0.36	Mild	1			
15	1975	-1.36	Moderate		1		
16	1976	-1.05	Moderate		1		
17	1977	-0.18	Mild	1			
18	1978	-0.2	Mild	1			
19	1979	1.37					
20	1980	0.4					
21	1981	-1.19	Moderate		1		
22	1982	0.12					
23	1983	-0.58	Mild	1			
24	1984	0.55					
25	1985	-0.18	Mild	1			
26	1986	1.35					
27	1987	-0.76	Mild	1			
28	1988	0.28					
29	1989	2.13					
30	1990	-0.44	Mild	1			
31	1991	-0.08	Mild	1			
32	1992	-1.4	Moderate			1	
33	1993	-1.18	Moderate			1	
34	1994	-0.85	Mild				
35	1995	-1.95	Severe				
36	1996	-0.38	Mild	1			
37	1997	-0.13	Mild	1			
38	1998	-0.3	Mild	1			
39	1999	-0.57	Mild	1			
40	2000	-0.16	Mild	1			
41	2001	-0.84	Mild	1			
42	2002	0.11					
43	2003	-1.63	Severe			1	
44	2004	-0.83	Mild	1			
45	2005	0.46					

7.Giharo Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1962	-0.33	Mild	1			
1963	0.93					
1964	-0.61	Mild	1			
1965	1.57					
1966	0.51					
1967	0.67					
1968	0.26					
1969	0.5					
1970	1.71					
1971	0.98					
1972	1.52					
1973	0.41					
1974	0					
1975	-1.18	Moderate		1		
1976	-0.81	Mild	1			
1977	1					
1978	0.49					
1979	1.63					
1980	-0.48	Mild	1			
1981	-1.05	Moderate		1		
1982	1.43					
1983	-0.4	Mild	1			
1984	-0.04	Mild	1			
1985	0.9					
1986	-0.12	Mild	1			
1987	-0.18	Mild	1			
1988	0.83					
1989	2.53					
1990	-1.29	Moderate		1		
1991	-1.05	Moderate		1		
1992	-1.36	Moderate		1		
1993	-1.45	Moderate		1		
1994	-0.12	Mild	1			
1995	-0.71	Mild	1			
1996	-1.17	Moderate		1		
1997	-0.1	Mild	1			
1998	0.16					
1999	-1.53	Severe			1	
2000	-1.22	Moderate		1		
2001	-1.1	Moderate		1		
2002	0.2					
2003	-1.11	Moderate		1		
2004	-0.2	Mild	1			
2005	-0.61	Mild	1			

8.Giheta Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1971	0.41					
1972	1.01					
1973	-0.19	Mild	1			
1974	-1.13	Moderate		1		
1975	-1.69	Severe			1	
1976	-0.69	Mild	1			
1977	0.64					
1978	0.91					
1979	0.49					
1980	-0.93	Mild	1			
1981	-0.83	Mild	1			
1982	0.91					
1983	-2.8	extreme				1
1984	-0.31	Mild	1			
1985	0.94					
1986	1.55					
1987	-0.79	Mild	1			
1988	1.16					
1989	1.22					
1990	-0.22	Mild	1			
1991	0					
1992	-0.41	Mild	1			
1993	-0.15	Mild	1			
1994	-0.07	Mild	1			
1995	-0.51	Mild	1			
1996	0.62					
1997	2.23					
1998	0.7					
1999	0.46					
2000	-0.69	Mild	1			
2001	-0.37	Mild	1			
2002	0.62					
2003	-0.2	Mild	1			
2004	-0.16	Mild	1			
2005	-1.73	Severe			1	

9.Gisozi Station		Drought Ca	MILD	MODERATE	SEVERE	EXTRE
year	SPI-8(Oct to May)					
1961	2.62					
1962	0.8					
1963	1.21					
1964	0.55					
1965	0.27					
1966	-0.09	Mild	1			
1967	1.01					
1968	0.55					
1969	0.4					
1970	0.49					
1971	0.62					
1972	0.53					
1973	-0.64	Mild	1			
1974	-1.55	Severe			1	
1975	-1.44	Moderate		1		
1976	-1.62	Severe			1	
1977	0.28					
1978	0.31					
1979	0.75					
1980	-0.8	Mild	1			
1981	-1.88	Severe			1	
1982	1.21					
1983	-0.27	Mild	1			
1984	-0.42	Mild	1			
1985	1.2					
1986	1.67					
1987	-0.46	Mild	1			
1988	0.22					
1989	1.43					
1990	-0.94	Mild	1			
1991	0.76					
1992	-0.94	Mild	1			
1993	-1.3	Moderate		1		
1994	-0.19	Mild	1			
1995	-0.79	Mild	1			
1996	-0.06	Mild	1			
1997	1.54					
1998	-0.61	Mild	1			
1999	-0.38	Mild	1			
2000	0.18					
2001	-0.74	Mild	1			
2002	-0.49	Mild	1			
2003	-0.4	Mild	1			
2004	-0.68	Mild	1			
2005	-1.9	Severe			1	

10.Gitaga-aero Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1971	-0.7	Mild	1			
1972	0.35					
1973	-0.29	Mild	1			
1974	0.4					
1975	-0.61	Mild	1			
1976	0.51					
1977	0.61					
1978	0.42					
1979	1.55					
1980	-0.56	Mild	1			
1981	-0.69	Mild	1			
1982	1.55					
1983	-0.92	Mild	1			
1984	-0.05	Mild	1			
1985	0.51					
1986	1.88					
1987	-0.49	Mild	1			
1988	1.49					
1989	1.05					
1990	-0.87	Mild	1			
1991	-0.48	Mild	1			
1992	-0.11	Mild	1			
1993	-1.92	severe			1	
1994	-0.57	Mild	1			
1995	-0.52	Mild	1			
1996	-0.47	Mild	1			
1997	2.31					
1998	0.48					
1999	0.14					
2000	-1.57	severe			1	
2001	-0.24	Mild	1			
2002	0.55					
2003	-0.9	Mild	1			
2004	0.26					
2005	-2.09	extreme				1

.1.Karusi Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1961	0.69					
1962	0.08					
1963	1.18					
1964	-0.09	Mild	1			
1965	-0.36	Mild	1			
1966	-0.3	Mild	1			
1967	0.22					
1968	0.84					
1969	-0.51	Mild	1			
1970	0.83					
1971	-0.37	Mild	1			
1972	0.36					
1973	-1.06	moderate				
1974	-0.09	Mild	1			
1975	-1.13	moderate		1		
1976	-0.79	Mild	1			
1977	0.91					
1978	0.51					
1979	1.9					
1980	-1.1	moderate		1		
1981	0.05					
1982	-0.33	Mild	1			
1983	-1.62	severe			1	
1984	-1.66	severe			1	
1985	1.48					
1986	0.79					
1987	0.07					
1988	-0.34	Mild	1			
1989	-0.4	Mild	1			
1990	-0.69	Mild	1			
1991	0.01					
1992	0.2					
1993	-0.69	Mild	1			
1994	0.58					
1995	-2.55	extreme				1
1996	-2.1	extreme				1
1997	0.93					
1998	1.8					
1999	0.21					
2000	0.69					
2001	0.99					
2002	1.95					
2003	-0.4	Mild	1			
2004	0.51					
2005	-1.17	moderate		1		

12.Kayogoro Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1974	-0.31	Mild	1			
1975	-1.42	moderate		1		
1976	-0.93	Mild	1			
1977	1.39					
1978	0.98					
1979	0.49					
1980	-0.52	Mild	1			
1981	-0.21	Mild	1			
1982	1.19					
1983	2.11					
1984	-0.7	Mild	1			
1985	-0.37	Mild	1			
1986	1.67					
1987	-0.61	Mild	1			
1988	0.1					
1989	0.62					
1990	-1.01	moderate		1		
1991	-0.25	Mild	1			
1992	-1.17	moderate		1		
1993	-1.04	moderate		1		

13.Kinyinya Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1967	0.41					
1968	0.44					
1969	0.27					
1970	0.48					
1971	0.18					
1972	0.66					
1973	0.07					
1974	-0.44	Mild	1			
1975	-1.14	moderate		1		
1976	-1.35	moderate				
1977	-0.06	Mild	1			
1978	0.78					
1979	0.61					
1980	0.12					
1981	-0.31	Mild	1			
1982	0.68					
1983	-0.31	Mild	1			
1984	-0.47	Mild	1			
1985	0.9					
1986	0.84					
1987	0.16					
1988	0.1					
1989	1.07					
1990	0.29					
1991	0.39					
1992	-0.27	Mild	1			
1993	8.43	Mild	1			
1994	-0.07	Mild	1			
1995	1.92					
1996	0.12					
1997	1.13					
1998	1.52					
1999	0.06					
2000	-0.16	Mild	1			
2001	-0.19	Mild	1			
2002	-0.14	Mild	1			
2003	-2.17	extreme			1	
2004	-2.2	extreme			1	
2005	-3.57	extreme			1	

14.Mabayi Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1958	-1.23	moderate		1		
1959	-1.51	severe			1	
1960	-0.19	Mild	1			
1961	0.04					
1962	0.9					
1963	0.48					
1964	-0.77	Mild	1			
1965						
1966	-0.81	Mild	1			
1967	-0.67	Mild	1			
1968	-0.08	Mild	1			
1969	-0.63	Mild	1			
1970	-0.11	Mild	1			
1971	-1.08	moderate		1		
1972	-0.47	Mild				
1973	0.01					
1974	0.56					
1975	-1.05	moderate		1		
1976	-1.62	severe			1	
1977	-0.58	Mild	1			
1978	-0.36	Mild	1			
1979	-0.21	Mild	1			
1980	1.82					
1981	1.16					
1982	1.78					
1983	0.53					
1984	0.11					
1985	1.05					
1986	0.49					
1987	1.92					
1988	2.45					
1989	0.99					
1990	1.55					
1991	1.46					
1992	0.5					
1993	-1.24	moderate				
1994	-0.09	Mild	1			
1995	0.13					
1996	-1.44	moderate		1		
1997	-0.46	Mild	1			
1998	-0.52	Mild	1			
1999	-0.69	Mild	1			
2000	-0.56	Mild	1			
2001	-0.35	Mild	1			
2002	-1.43	moderate		1		

15.Makamba Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1971	-0.63	Mild	1			
1972	-0.58	Mild	1			
1973	-1.35	moderate		1		
1974	-0.95	Mild	1			
1975	-0.64	Mild	1			
1976	-0.52	Mild	1			
1977	0.84					
1978	-0.24	Mild	1			
1979	0.48					
1980	-1.08	moderate		1		
1981	-0.66	Mild	1			
1982	0.28					
1983	-0.87	Mild	1			
1984	-2.17	extreme				1
1985	-0.64	Mild				
1986	0.9					
1987	-0.36	Mild	1			
1988	-0.05	Mild	1			
1989	1.76					
1990	1.1					
1991	1.11					
1992	0.51					
1993	-0.63	Mild	1			
1994	1.98					
1995	0.9					
1996	0.65					
1997	1.68					
1998	0.99					
1999	-0.23	Mild	1			
2000	1.17					
2001	0.27					
2002	0.38					
2003	-1.38	moderate		1	1	
2004	-1.58	severe				
2005	-0.4	Mild	1			

16.Mpota-tora Station		Drought Category	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1965	1.42					
1966	-0.77	Mild	1			
1967	0.04					
1968	0.89					
1969	-0.18	Mild	1			
1970	0.57					
1971	0.53					
1972	1.36					
1973	-0.24	Mild	1			
1974	-0.63	Mild	1			
1975	-1.8	severe			1	
1976	-0.77	Mild	1			
1977	-1.23	moderate		1		
1978	0.2					
1979	0.2					
1980	0.55					
1981	0.11					
1982	1.2					
1983	1.03					
1984	0.13					
1985	-0.27	Mild	1			
1986	1.46					
1987	-0.64	Mild	1			
1988	0.61					
1989	1.34					
1990	0.51					
1991	0.53					
1992	-0.24	Mild	1			
1993	-1.68	severe			1	
1994	1.76					
1995	0.26					
1996	-0.06	Mild	1			
1997	1.24					
1998	0.38					
1999	-1.71	severe			1	
2000	0.35					
2001	-1.66	severe			1	
2002	-0.16	Mild	1			
2003	-2.03	extreme				1
2004	-1.21	moderate		1		
2005	-1.4	moderate		1		

17.Mugera (paroisse) Stat	Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)				
1960	-0.5	Mild	1			
1961	1.69					
1962	0.45					
1963	0.75					
1964	1.07					
1965	0.49					
1966	-0.69	Mild	1			
1967	1.63					
1968	1.72					
1969	0.69					
1970	0.81					
1971	0.43					
1972	0.82					
1973	-0.7	Mild	1			
1974	-1.25	moderate		1		
1975	-1.59	severe			1	
1976	-0.97	Mild	1			
1977	0.34					
1978	-0.14	Mild	1			
1979	1.21					
1980	-0.89	Mild	1			
1981	-0.62	Mild	1			
1982	1.08					
1983	-1.19	moderate		1		
1984	-0.71	Mild	1			
1985	0.35					
1986	1.35					
1987	-1.48	moderate		1		
1988	1.31					
1989	1.3					
1990	-0.97	Mild	1			
1991	-0.12	Mild	1			
1992	-0.14	Mild	1			
1993	-2.47	extreme				1
1994	-0.16	Mild	1			
1995	-1.6	severe			1	
1996	-0.06	Mild	1			
1997	0.87					
1998	0.06					
1999	-0.32	Mild	1			
2000	-0.25	Mild	1			
2001	0.1					
2002	-0.32	Mild	1			
2003	-0.24	Mild	1			
2004	0.53					

18.Musasa Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1961	1.2					
1962	0.23					
1963	1.58					
1964	0.38					
1965	-0.26	Mild	1			
1966	-0.52	Mild	1			
1967	1					
1968	0.64					
1969	-0.13	Mild	1			
1970	0.74					
1971	-1.11	moderate		1		
1972	0.44					
1973	1.07					
1974	-0.3	Mild	1			
1975	-0.41	Mild	1			
1976	0.09					
1977	1.86					
1978	-0.4	Mild	1			
1979	0.66					
1980	-1.61	severe			1	
1981	-0.56	Mild	1			
1982	1.59					
1983	-1.07	moderate		1		
1984	-0.75	Mild	1			
1985	-0.25	Mild	1			
1986	1.89					
1987	0.01					
1988	0.64					
1989	0.84					
1990	-1.1	moderate		1		
1991	0.61					
1992	-0.68	Mild	1			
1993	-1.49	moderate		1		
1994	0.35					
1995	-0.5	severe			1	
1996	-1.41	moderate		1		
1997	0.68					
1998	1.92					
1999	-1.02	moderate		1		
2000	-0.35	Mild	1			
2001	-0.43	Mild	1			
2002	0.19					
2003	-1.08	moderate		1		
2004	-0.7	Mild	1			
2005	-2.44	extreme				1

19.Musongati Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1976	-1.56	severe			1	
1977	0.26					
1978	1.07					
1979	0.94					
1980	-0.52	Mild	1			
1981	1.59					
1982	-0.21	Mild	1			
1983	-0.66	Mild	1			
1984	1.05					
1985	1.96					
1986	0.73					
1987	-0.38	Mild	1			
1988	0.2					
1989	0.9					
1990	-0.68	Mild	1			
1991	0.44					
1992	0.06					
1993	-0.89	Mild	1			
1994	-2.12	extreme				1
1995	0.48					
1996	-1.02	moderate		1		
1997	0.85					
1998	0.58					
1999	-0.86	Mild	1			1
2000	-2.11	extreme				
2001	-0.73	Mild				
2002	0.88					
2003	-0.5	Mild	1			
2004	0.71					
2005	-0.48	Mild	1			

20.Mutumba (nyab) Statio		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1971	1.31					
1972	0.15					
1973	0.66					
1974	-0.13	mild	1			
1975	0.24					
1976	3.83					
1977	0.22					
1978	0.19					
1979	-0.51	mild	1			
1980	-0.33	mild	1			
1981	-1.42	moderate		1		
1982	-0.38	mild	1			
1983	-0.32	mild	1			
1984	-0.76	mild	1			
1985	-0.22	mild	1			
1986	0.38					
1987	1.58					
1988	0.47					
1989	-0.01	mild	1			
1990	-1.07	moderate		1		
1991	0.26					
1992	0.05					
1993	-0.45	mild	1			
1994	-0.42	mild	1			
1995	-0.06	mild	1			
1996	-1.24	moderate		1		
1997	0.61					
1998	-0.08	mild	1		1	
1999	-1.5	severe				
2000	-1.05	moderate		1		

	21.Muyaga Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
	year	SPI-8(Oct to May)					
	1931	0.63					
	1932	0.08					
	1933	0.67					
	1934	-0.12	mild	1			
	1935	-1.53	severe			1	
	1936	0.04					
	1937	0.32					
	1938	0.21					
	1939	-0.4	mild	1			
	1940	-0.43	mild	1			
	1941	0.71					
	1942	-0.03	mild	1			
	1943	-1.12	moderate		1		
	1944	0.3					
	1945	0.14					
	1946	-0.7	mild	1			
	1947	0.7					
	1948	0.13					
	1949	-0.39	mild	1			
	1950	1.79					
	1951	2.83					
	1952	-1.36	moderate		1		
	1953	-0.98	mild	1			
	1954	-1.85	severe			1	
	1955	-1.51	severe				
	1956	-0.38	mild	1			
	1957	-0.12	mild	1			
	1958	-1.08	moderate		1		
	1959	1.21					
	1960	-1.55	severe			1	
	1961	1.54					
	1962	0.68					
	1963	1.38					
	1964	0.47					
	1965	-0.48	mild	1			
	1966	0.78					
	1967	1.43					
	1968	1.42					
	1969	-0.33	mild	1			
	1970	-0.05	mild	1			
	1971	-1.22	moderate		1		
	1972	0.18					
	1973	-0.5	mild	1			
	1974	-2.23	extreme				
	1975	0.72					
	1976	-0.49	mild	1			
	1977	0.95					
	1978	1.21					
	1979	0.36					
	1980	-1.58	severe			1	
	1981	0.85					
	1982	0.4					
	1983	0.24					
	1984	-0.57	mild	1			
	1985	-0.18	mild	1			
	1986	0.33					
	1987	-0.16	mild	1			
	1988	1.53					
	1989	0.77					
	1990	-0.01	mild	1			
	1991	0.87					
	1992	0.42					
	1993	-0.52	mild	1			
	1994	1.33					
	1995	-0.18	mild	1			
	1996	-0.16	mild	1			
	1997	1.77					
	1998	-1.43	moderate		1		
	1999	-0.91	mild	1			
	2000	-1.22	moderate		1		
	2001	-0.99	mild	1			
	2002	0.44					
	2003	-0.24	mild	1			
	2004	-0.77	mild	1			
	2005	-2.04	extreme				1

2.Muyinga Station		Drought Ca	MILD	MODERATE	SEVERE	EXTREME
year	SPI-8(Oct to May)					
1961	2.12					
1962	0.39					
1963	0.97					
1964	0.59					
1965	-0.82	mild	1			1
1966	0.08					
1967	-1.25	moderate		1		1
1968	1.5					
1969	0.32					
1970	0.49					
1971	-0.57	mild	1			1
1972	0.46					
1973	0.01					
1974	-0.01	mild	1			1
1975	-0.69	mild	1			1
1976	-1.62	severe			1	1
1977	0.86					
1978	-0.16	mild	1			1
1979	0.56					
1980	-1.08	moderate		1		1
1981	-1.78	severe			1	1
1982	0.1					
1983	-0.6	mild	1			1
1984	-1	moderate		1		1
1985	0.9					
1986	0.77					
1987	1.62					
1988	1.79					
1989	-0.45	mild	1			1
1990	-0.49	mild	1			1
1991	-0.48	mild	1			1
1992	-0.04	mild	1			1
1993	0.27					
1994	0.03					
1995	-0.79	mild	1			1
1996	0.62					
1997	2.56					
1998	-0.76	mild	1			1
1999	-1.73	severe			1	1
2000	-1.16	moderate		1		1
2001	0.11					
2002	0.08					
2003	-0.41	mild	1			1
2004	0.41					
2005	-1.71	severe			1	1

23.Nyamuswaga Station			Drought Ca	MILD	MODERATE	SEVERE	EXTREME	.Rwegura Station		Drought Category	MILD	MODERATE	SEVERE	EXTREME
	year	SPI-8(Oct to May)						year	SPI-8(Oct to May)					
	1980	0.36						1961	2.47					
	1981	-0.62	mild	1				1962	0.77					
	1982	1.48						1963	0.24					
	1983	1.36						1964	-1.26	moderate		1		
	1984	1.25						1965	-1.49	moderate		1		
	1985	0.69						1966	-0.44	mild	1			
	1986	0.7						1967	0.98					
	1987	1.26						1968	0.88					
	1988	1.85						1969	-0.51	mild	1			
	1989	0.6						1970	-0.74	mild	1			
	1990	0.13						1971	-0.19	mild	1			
	1991	0.13						1972	0.36					
	1992	-1.23	moderate		1			1973	0.83					
	1993	-1.97	severe			1		1974	0.14					
	1994	-0.4	mild	1				1975	-0.9	mild	1			
	1995	0.15						1976	-0.44	mild	1			
	1996	-0.79	mild	1				1977	0.58					
	1997	0.91						1978	-0.69	mild	1			
	1998	0.32						1979	-0.62	mild	1			
	1999	-1.16	moderate		1			1980	-0.62	mild	1			
	2000	-1.35	moderate		1			1981	-0.79	mild	1			
	2001	-0.36	mild	1				1982	0.63					
	2002	-1.03	moderate		1			1983	-0.08	mild	1			
	2003	-0.77	mild	1				1984	-1.16	moderate		1		
	2004	-0.31	mild	1				1985	-0.79	mild	1			
	2005	-1.17	moderate		1			1986	0.59					
				6	5	1		1987	0.12					
								1988	0.01					
								1989	2.85					
								1990	0.32					
								1991	-0.32	mild	1			
								1992	0.47					
								1993	-1.41	moderate		1		
								1994	1.24					
								1995	-0.12	mild	1			
								1996	-0.21	mild	1			
								1997	1.48					
								1998	-2.65	extreme				1
								1999	-0.93	mild	1			
								2000	0.32					
								2001	0.81					
								2002	-1.08	moderate		1		
								2003	0.64					
								2004	0.54					
								2005	0.16					

25.Rweza-vyanda Statio			Drought Ca	MILD	MODERATE	SEVERE	EXTREME	garama aero Statio		Drought Ca	MILD	MODERATE		EXTREME
	year	SPI-8(Oct to May)						year	SPI-8(Oct to May)					
	1980	-1.05	moderate		1			1971	-0.67	mild	1			
	1981	-0.56	mild	1				1972	0.81					
	1982	2.2						1973	-1.38	moderate		1		
	1983	0.68						1974	-0.38	mild	1			
	1984	-0.24	mild	1				1975	-1.04	moderate				
	1985	0						1976	-0.69	mild	1			
	1986	0.61						1977	0.09					
	1987	0.38						1978	1.35					
	1988	1.86						1979	0.62					
	1989	-0.21	mild	1				1980	1.54					
	1990	0.84						1981	-0.84	mild	1			
	1991	0.65						1982	0.73					
	1992	-0.91	mild	1				1983	-0.61	mild	1			
	1993	-1.15	moderate		1			1984	-0.2	mild	1			
	1994	0.72						1985	0.27					
	1995	-2.8	extreme				1	1986	0.98					
	1996	0.15						1987	0.57					
	1997	1.47						1988	0.8					
	1998	-0.84	mild	1				1989	1.1					
	1999	-0.54	mild	1				1990	-2.16	extreme				1
	2000	-0.22	mild	1				1991	-1.55	severe			1	
	2001	-0.34	mild	1				1992	0.66					
	2002	-0.23	mild	1				1993	-0.32	mild	1			
	2003	0.06						1994	0.51					
	2004	-0.3	mild	1				1995	2.82					
	2005	-0.24	mild	1				1996	0.11					
								1997	0.13					
								1998	0.38					
								1999	-0.44	mild	1			
								2000	-1.2	moderate		1		
								2001	0.4					
								2002	-1.25	moderate		1		
								2003	-0.05	mild	1			
								2004	0.12					
								2005	-1.22	moderate		1		