TOWARDS AN INTERPRETATION OF HISTORICAL DROUGHTS IN NORTHERN NIGERIA

AONDOVER TARHULE and MING-KO WOO
Department of Geography, McMaster University, Hamilton, Ontario, L8S 4K1, Canada

Abstract. Both historical information on sub-Saharan droughts/famines and measured rainfall data from northern Nigeria were analysed. Their parallel existence since 1905 allows famine chronologies to be quantified from the rainfall series. It is found that the most disruptive historical famines occurred when the cumulative deficit of rainfall fell below 1.3 times the standard deviation of long-term mean annual rainfall for a particular place. Thus defined, rainfall droughts matched approximately 90% of the famine events chronicled for northern Nigeria. An attempt is made to utilise information obtained from this matching of events to interpret droughts which occurred before scientific measurements. Difficulties inherent in such interpretation are discussed.

1. Introduction

1.1. BACKGROUND

Interpretation and quantification of historical droughts which occurred in the Soudano–Sahel belt of Africa is useful in understanding the long-term climatic experience of the region. Here, the term ‘historical’ refers to the period predating the beginning of scientific measurements of climatic variables (Koslowski and Glaser, 1995). In the central and western Sahel, instrumental records for most climatic processes date back to only the beginning of this century. For large areas, synoptic weather stations were not established until the 1930s. Such series are not long enough, in the climatic sense, to provide information on long-term trends.

The usefulness of historical information and other proxy data in extending the length of available records has been demonstrated in many disciplines. In hydrology, paleo-flood records and other evidence of high water marks (physical, verbal, written archaeological and geomorphological) have been used to augment measured flow records (Guo, 1990; Sutcliffe, 1987). Despite inherent uncertainties, it is generally acknowledged that the information contained in such records, when used in conjunction with the systematic data, can increase the accuracy in estimating flood quantiles at a given site (Cohn and Stedinger, 1987; Hosking and Wallis, 1986; Salas et al., 1994; Stedinger and Baker, 1987). In climatology, Koslowski and Glaser (1995) used various sources of documentary historical data to reconstruct the ice winter severity in the western Baltic from about 1700. Rodrigo et al. (1994, 1995) reconstructed the total annual rainfall in Andalusia during the 16th and 17th centuries using annals and chronicles of cities, ecclesiastic archives and other documentary evidence. Similarly, Oliver (1991) compared monthly precipitation

Climatic Change **37:** 601–616, 1997.

distribution and wind direction during the period 100 BC–100 AD to present day conditions for many cities based on translations from al-Biruni's *The Chronology of Ancient Nations*.

The Sahel has a long history of droughts and information on many of these droughts exists in various forms from the days of the great empires and kingdoms. However, there has been no attempt to utilise historical information in articulating various attributes of drought such as their intensity or duration. This is somewhat surprising since drought analysis has often been constrained by shortness of record sample and can clearly benefit from extension of the effective record length (Woo and Tarhule, 1994). The situation is particularly acute in arid and semi-arid environments where for example, several years of record might yield only one sample drought event.

In northern Nigeria where rain-fed agriculture is practised, periods of severe famines often inflicted by droughts were given specific names by the people and preserved in songs, oral folklore and myth (Watts, 1983). Van Apeldoorn (1981) compiled such folklore events between 1835 to 1954. Eight drought periods were identified, six by their names. These events were subsequently collaborated by other historic evidence including reports of colonial administrators such as the Colonial Blue Books and Annual Report on Northern Nigeria. Unfortunately, apart from the names which hint at the approximate time when they occurred, not much else is known about such characteristics as their spatial extent, their severity or intensity, their durations or even what qualified them for such honours.

The parallel existence of record on historical or folklore droughts and measured scientific data since 1905 allows historical drought events to be defined from the rainfall series. The objective of this study is to decipher the information contained in historical or folklore droughts by comparing them with droughts defined by climatic data for a period when both sets of information are available. Unravelling the climatic causes of droughts is beyond the scope of this paper. Our goal is to interpret in quantitative terms those events already identified in the chronicles rather than to reconstruct the past climate. This will provide answers to the following problems: What is the rainfall threshold below which a historical/folklore drought is deemed to have occurred? What is the areal extent and spatial characteristics of such events? What are the durations and relative severity of historical droughts? Knowledge thus obtained may then be extended to the interpretation of historical droughts which predate scientific measurements.

1.2. DROUGHTS IN HISTORICAL RECORDS

The perception of drought is inextricably inter-woven in the social and political fabric of societies. Hence, considerations other than climate frequently influence whether an event is recorded or not. For example, a drought which coincides with an important socio-political event such as the death or coronation of a new king is more likely to be remembered and therefore recorded and preserved in some way. In addition, drought concepts vary between cultures and evolve in response to changing environmental and social conditions. This implies that similar evidence or records of historical droughts in different cultures could potentially refer to quite different phenomena.

For an economy based on rain-fed agriculture, the reconstruction of historical drought is facilitated by its close relationship with famine. However, there is no inevitable predetermined relationship between the two phenomena (Watts, 1983). Several factors other than rainfall deficit may cause famine including wars, incidence of pests and diseases, failure of the economy and other administrative measures. Excessive rainfall may also lead to famine by destroying field crops through flooding. Torry (1986, p. 8) distinguished between underlying (ultimate) and catalytic (proximate) causes of famine. The latter are "situational and originate shortly prior to or during an emergency"; the former are "predisposing conditions transforming proximate causes into famine distresses. . . . In fact proximate causes (e.g. drought) can land a household in the clutches of famine with or without the involvement of ultimate causes". Hence, "while a specific drought may be considered a proximate cause of famine droughts (in general) can be considered an underlying cause" (Glantz, 1987, p. 56). Similarly, Watts (1983, p. 104) observed that in Hausa land (northern Nigeria), "the great hungers of the past were the almost inevitable outcome of excessively poor rainfall (*fari*), either because seasonal totals were greatly inadequate, or the rains terminated abruptly prior to maturity (*Kumshi*) of the upland grain crops". While such considerations allow famine chronologies to be used as proxy for droughts, they nevertheless require that both the input information and the ensuing results be interpreted with caution.

2. Sources of Data

Two types of data were collected for this study: daily rainfall records, data on folklore or famine chronologies and historical droughts. Strictly speaking, all droughts extracted from historical records, gauged or otherwise, are historical. However, in this paper, the term is reserved for events predating scientific measurements. Folklore droughts refer to events appearing in oral folklore (*tsatsunyoyi* in Hausa), songs or stories many of which have names. Statistical droughts or simply droughts will be applied to events which have been calculated from the recorded data.

2.1. RAINFALL DATA (1905–1994)

Annual rainfall data for various locations in northern Nigeria were obtained from the archives of the Federal Department of Aviation and Meteorological Services Oshodi, Lagos. For this study, annual series for eight stations north of latitude 9° were utilised. The sample stations are well distributed over northern Nigeria and the length of their records varies from 54 years at Birnin Kebbi (1919–1973) to 90 years at Kano (1905–1994). Missing data were handled in one of two ways: where only one year of data was missing, it was replaced by the average value of the previous five years. Where two or more consecutive years of data were missing, they were estimated using Bradley's (1976) median of ratios method. From the series of rainfall data P_i^x and P_i^y, $i = 1, 2, \ldots, n$ at two adjacent gauging stations x and y, a series of ratios Z_i is formed so that

$$Z_1 = P_1^x / P_1^y, \qquad Z_2 = P_2^x / P_2^y, \ \ldots, \qquad Z_n = P_n^x / P_n^y . \tag{1a}$$

Because Z_i is often positively skewed, the median ratio is used to estimate the missing values (say, P_i^x) in either series:

$$P_i^x = P_i^y Z(\text{median}). \tag{1b}$$

The nearest stations with the highest inter-station correlation were used in calculating the ratios.

2.2. FAMINE/DROUGHT CHRONOLOGIES IN N. NIGERIA (1835–1954)

After the great droughts of 1968–1973, a survey was conducted in northern Nigeria to determine famines/drought events which could be remembered. Many of these events were discussed in folklore and subsequently verified by critical analysis of other supporting evidence (Van Apeldoorn, 1981). This study utilises the series of folklore droughts identified from these sources (Table I). The names given to these droughts often provide some insight about their location and time of occurrence or which agricultural activities were most adversely affected. For example, in northeastern Nigeria, the famine of 1913/14 was referred to as *Kankala Kori* (short stalks), an apt description for the stunted growth of field crops. Similarly, the famine of 1953/54 which affected areas from Bedde to Sokoto in northern Nigeria was known as *Dan Mubi*, possibly because the people were saved from starvation by grains brought from Mubi (northeastern Nigeria). It may be inferred further that northeastern Nigeria was unaffected by this drought.

2.3. FAMINE/DROUGHT CHRONOLOGIES IN THE CENTRAL SAHEL (1600–1920)

Nicholson (1976) and Watts (1983) compiled famine/drought chronologies from various sources for this period, covering many parts of Africa. For our study, the chronologies for three areas closest to northern Nigeria were selected including Niger Bend, Nigeria (Appendix 1), Chad and Borno (Figure 1). Periods described as 'normal', 'prosperous' or as having experienced a flood have been omitted. The chronologies for Chad and Chad and Borno were merged into one regional chronology. Concerning the reliability of the information, Nicholson (1976, p. 100) noted that "the chronicles from certain regions are surprisingly long and detailed. Those from Borno begin well before 1500; from at least 1500 the events during the reign of each king are described in great detail. A major problem involved

Table I
Famine chronologies in northern Nigeria 1900–1960, based on compilation by van Apeldoorn (1981) and Watts (1983)

Period	Name(s) of famine	Area affected	Comments
1905–1910	Ci abinki ta rimin gora (1905), Yunwar Kanawa (1908)	Most of northern Nigeria	Described as mild to severe Poorly documented
1912–1915	Malali or Kankala Kori (1913/14) Kakalaba (1915)	All of northern Nigeria	Considered one of the most severe and widespread droughts
1918–1921	–	Patchy	Generally described as mild
1926–1930	Mai Buhu or Shude Mu Gaisa	Western Kano Northern Sokoto	Poorly documented, worst drought N.W. of Sokoto
1941–1944	Yar Gusau Yar Balange	Sokoto, Katsina Kano	Inadequate rains aggravated by wartime economy
1950–1951	'Year of Cassava meal'	Republic of Niger, Kano	Described as mild and patchy Effects probably lessened by
1953–1954	Dan Mubi	Sokoto-Bedde	improved transportation

with this particular chronology was specifying the year in which events occurred. Famines can always be dated to a particular reign but there is little agreement among historians concerning reign dates". In western Africa where the Arab calendar was used by chroniclers, the dates are more reliable.

3. Definition of Droughts

A major assumption of this study is that famine chronologies are suitable proxy for rain deficits. This assumption allows quantification of historical or folklore droughts using gauged rainfall records for the period when both sets of information are available.

Agricultural and ecological systems in semi-arid environments are adapted to sporadic periods of rainfall deficit. Deficits refer to deviations below some expected norm or threshold and do not necessarily lead to stress; in fact, they may even go unnoticed. A drought occurs when rainfall deficit exceeds some critical level beyond which the prevailing adaptive mechanisms fail to cope. If deficit is defined as annual rainfall falling below a threshold value, P_c, the annual deficit for year t (d_t) will be

$$d_t = P_t - P_c, \qquad d_t < 0 \tag{2}$$

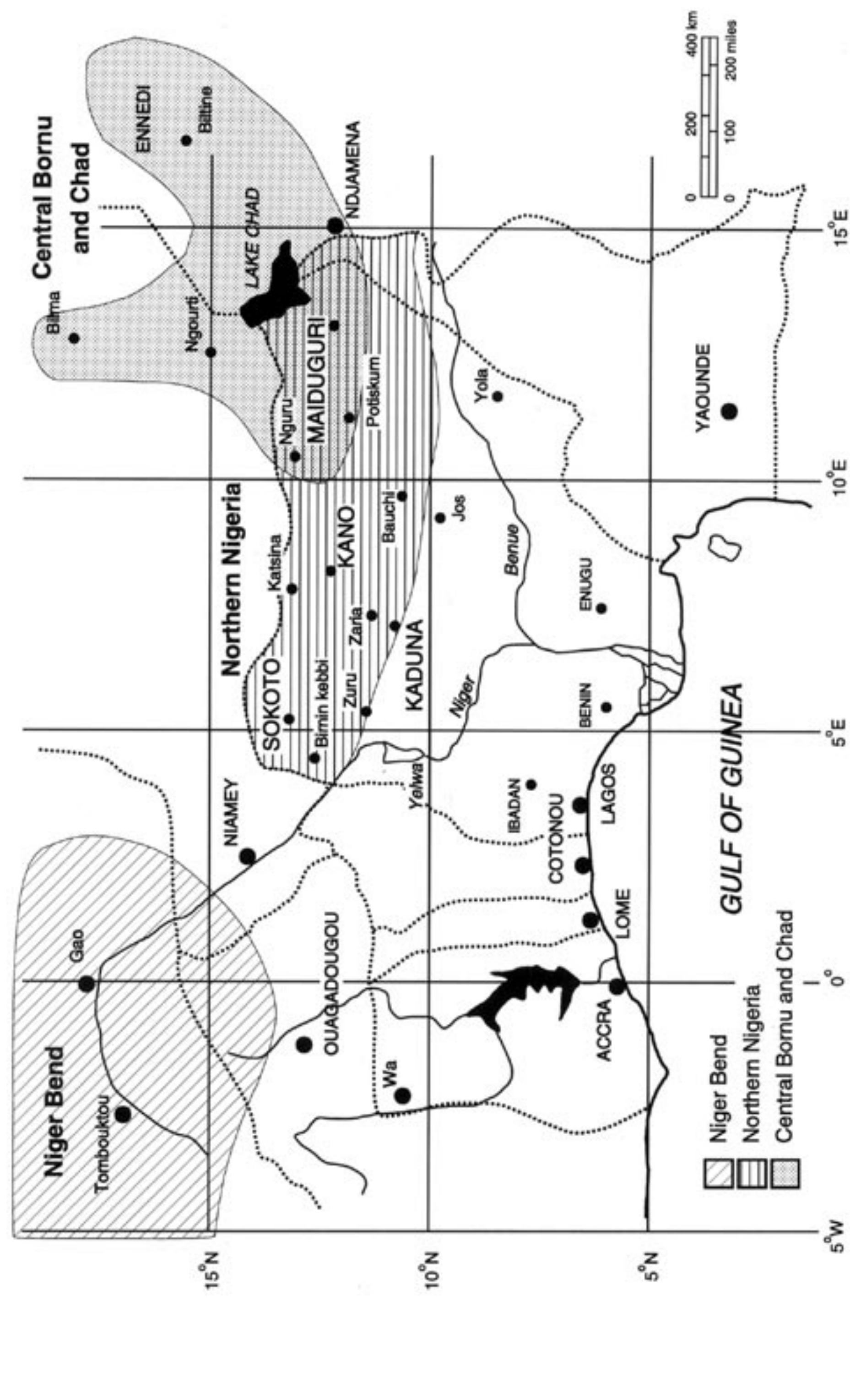

Figure 1. Rainfall gauging stations in northern Nigeria and areas from which famine chronologies were analysed.

where P_t is annual rainfall for year t. Water surplus, instead of deficit, is attained when $P_t > P_c$. When deficit reaches a critical level so that certain agricultural activities are curtailed, a drought occurs. It is argued that annual deficits are cumulative. In other words, a spell of dry years each with a rainfall deficit will lead to a worsening drought situation. On the other hand, a drought is broken when annual rainfall shows a surplus again. This follows from the definition of drought in terms of rain-fed agricultural activities. It is not necessary to satisfy previous annual deficits in order to begin a new planting season. Thus, the cumulative deficit reached on the ith year after the deficit began (D_i) is

$$D_i = \sum_{k=1}^{i} d_k \tag{3}$$

and drought occurs when $D_i < X_0$, with X_0 being the stage at which drought commences. Since droughts are a slowly worsening phenomenon, their arrival cannot be determined with precision. In this study, the duration of drought is considered to be the continuous period during which cumulative rainfall deficit exceeds the drought threshold.

Deficits can be obtained from the rainfall record once the expected threshold, P_c, is determined. Droughts can be defined when the critical threshold, X_0, is decided upon. These threshold values are probably related to some measure of the expected rainfall and a critical departure from this expected level for a particular site because the local agricultural practices are likely to have adapted to the long-term water supply conditions. To determine P_c and X_0 therefore, calibration of the recorded data against folklore drought events is required.

4. Calibration for the Thresholds

Kano provides the longest and most complete annual rainfall record (1905–1994). This city also has been of strategic importance in historical times and, as such, has a long chronicle of drought events. Hence rainfall data for Kano is used to illustrate the determination of P_c and X_0. It is argued that agricultural activities within a region are usually adapted to a norm which may be approximated by the long-term average rainfall. However, 'average' or 'normal' rainfall in the Sahel is sensitive to the period used in their calculation. Lamb (1982) suggested that the current downward trend in Sahelian rainfall began in the mid 1960s. As an experiment, the means calculated using sub-samples for various periods within the 1905–1965 record were found to be not significantly different. Consequently, 1905–1965 was decided upon as a suitable base period for the computation of the long-term mean. Using 1965 as a cut off point allowed most northern Nigerian stations to yield a significant length of record (>30 years) for spatial comparisons.

Through a crude optimization procedure, several values for P_c and X_0 were tried on the Kano (1905–1965) rainfall series using the mean, $\overline{P}$, and the standard deviation, S, as indicators. The criterion for optimizing these parameters is that they would reproduce the drought events indicated by the chronicles for Kano. An optimum solution was obtained at

$$P_c = \overline{P} \tag{4a}$$

and

$$D_i/S < -1.3 \tag{4b}$$

when all the recent folklore events in Kano (Table I) were successfully matched (Figure 2). Of significance, the famines of the late 1910s which were described as mild at Kano show up as deficits rather than droughts. Furthermore, prior to 1960, no deficits other than those indicated in the famine chronology crossed the 'drought' threshold.

5. Results

The above procedure was applied to eight locations well distributed across the major climatic belts in the Soudan and Sahel savanna regions of northern Nigeria. In Figure 3, the famine events cited in historical sources are indicated and those matched by the rainfall records are labelled. A total of 19 folklore 'station events' were cited at the four extreme northern locations with long rainfall records viz. Sokoto, Katsina, Kano, Maiduguri (Table I). Of these, seventeen (17) or approximately 89% are successfully matched by our drought analysis. Considering that the starting date of rainfall records varies from 1905 at Kano to 1922 at Katsina, the matching is considered to be satisfactory and suggests that despite the complexity of the relationship, famine chronologies can be used as a suitable proxy for drought occurrence.

Figure 3 shows that while droughts may end abruptly, their beginning is more likely to be preceded by a series of deficit years. For example, the drought of the early 1940s (Yar Balange) is preceded by three and two years of deficit respectively at Kano and Zaria. In the context of famines, it implies a gradual diminishing of stored food until the critical threshold is exceeded. Then the event is recorded as a folklore drought. Such analogy justifies the use of cumulative deficits to define droughts. Furthermore, the name of a drought may refer to a particular year but this does not mean that it is a one year event. Based on the rainfall analysis, Figure 3 shows that the duration of the Yar Balange (1942) drought ranged from two years at Bauchi to over seven years at Birnin Kebbi. The name may refer to the starting year, the year when the deficit reached the critical stage or a year with some significant non-climatic event such as war or pestilence. Watts (1983) stated that in Katsina, this drought was locally known as Yar Dikko in apparent reference to the role played by the Emir of Katsina (Dikko) who was reported to have confiscated

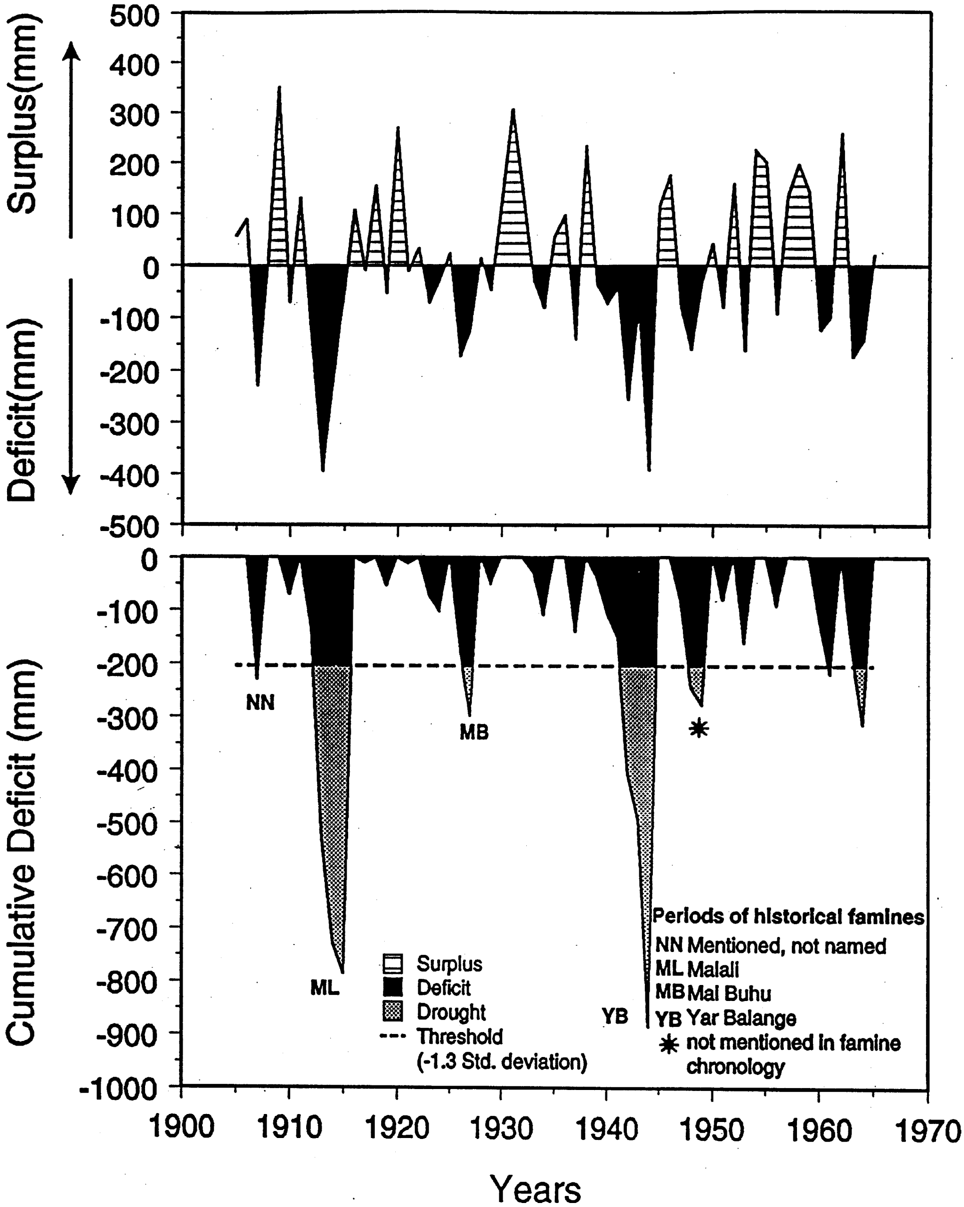

Figure 2. Definition of annual surplus, deficits and droughts using rainfall data for Kano. To obtain deficits (upper panel), the annual precipitation is first plotted and the threshold (the mean of 1905–1965) is superimposed. Values that fall below this threshold are considered as deficits. In lower panel, the deficits are accumulated, but the cumulative values are terminated once a subsequent year shows a surplus. The –1.3 times standard deviation (of 1905–1965) line is added and the period when the cumulative deficit falls below this line defines the drought duration.

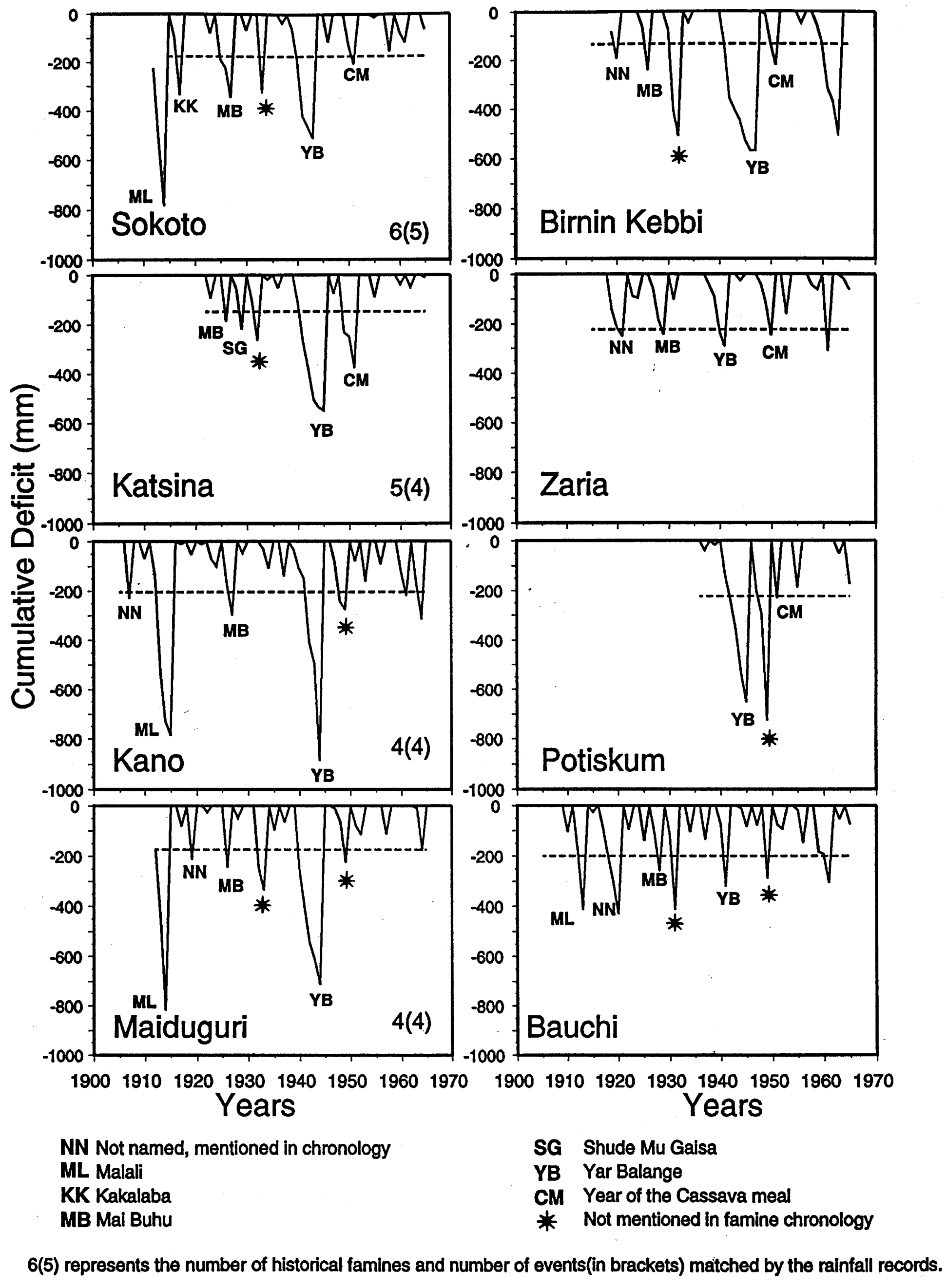

Figure 3. Matching rainfall droughts and historical famines in northern Nigeria. Dashed lines represent critical levels defined at 1.3 times the standard deviation below the mean.

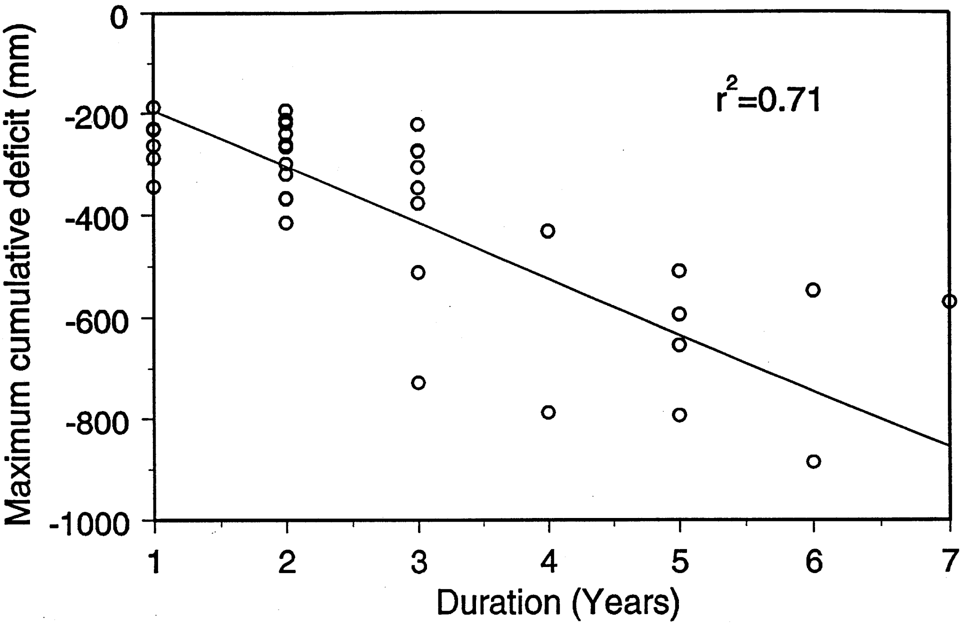

Figure 4. Relationship between drought duration and magnitude (maximum cumulative rainfall deficit) based on events from 13 stations in northern Nigeria.

foodstuff from around Katsina emirate to meet the target requisitions set by the colonial government.

Both the starting date and duration of drought are variable over space. The inter-station correlation of annual rainfall at Sokoto, Katsina, Kano and Maiduguri is very low, ranging from only 16 to 31%. Such high spatial variability implies that a drought could occur at one location but not at other northern Nigerian sites (see also Oladipo, 1995). This accounts for variations in chronicled events at the different locations. Further complication to the matching of rainfall and historical drought events is due to local variations in drought names, such that different folklore names at two locations may refer to the same event, though this is not always made clear in the chronicles. For example between 1926 and 1930, the famine which occurred west of Kano was known as Shudde Mu Gaisa to the north of Sokoto and Mai Buhu elsewhere. In this study, events at two locations whose durations overlap by less than 50% are considered as distinct events.

Since droughts are calculated on the basis of cumulative rainfall deficits, longer drought duration implies a worsening of the deficit. Defining drought magnitude as max(D), or the maximum cumulative deficit of an event, a relationship between drought duration and drought magnitude is presented in Figure 4. This result indicates that drought magnitude may be inferred from the duration of a famine despite the absence of historical information on magnitudes.

Further examination of the rainfall deficit records (Figure 3) allows two groups of droughts to be distinguished. Short events lasting less than three years tend to be patchy in occurrence. None of these droughts shown in Figure 3 occurred simultaneously at all eight locations and the range of their influence varied considerably. These events are caused by local scale, short-lived atmospheric forcing which disrupts the delivery of rainfall. Because they are localised, they are prone to go unrecorded in the chronicles and hence may be missed by our matching procedure. Several droughts detected from the rainfall record, notably those of the early 1930s and the late 1940s, fall under this category. Another possibility is that such short events were considered as part of other events (e.g. the drought of 1949 at Katsina and Zaria could have been merged with the 1950/51 drought).

A second type of drought event are those lasting longer than three years. They are more regionally extensive and reach larger magnitudes than the short ones. For example, the droughts of the early 1940s affected all of northern Nigeria. Although the paucity of rainfall record makes the determination of the spatial extent of the 1912–1914 drought difficult, it is known (Van Apeldoorn, 1981; Watts, 1983) that much of the western and central Soudan were affected. More than any other event, this drought has been compared to the drought of 1972–1973 both in terms of areal coverage and severity (Van Apeldoorn, 1981). A third category, droughts of extreme duration and large deficits, may be added for events which last longer than seven years. These three drought categories will be used in the interpretation of historical droughts which predate scientific measurements.

6. Interpretation of Historical Events (1600–1900)

Figure 5 summarizes the historical droughts from three regions in Sahelian Africa. Events known to have been caused by non-climatic reasons (i.e. wars, pests and epidemics) have been eliminated. Furthermore, since duration is the criterion for our drought classification, events of unknown duration have also been eliminated. Finally, when the precise date of occurrence of an event is unknown but there is general agreement on its duration, the event is included. Based on the definitions established above, we propose that the periods shown in Figure 5 suffered rainfall deficits in excess of 1.3 standard deviation of the long-term mean.

The duration of drought should be interpreted broadly as a ‘period of drought’ rather than as absolute duration. This interpretation allows for the possibility that the droughts may have been interrupted by brief interludes of surfeits but that on balance, the periods may be considered years of deficits. Even so, historians and chroniclers are not always agreed on the interpretation of certain information. For example, the frequent reference to ‘seven year’ drought at many locations may simply connote a long and severe drought which is metaphorically compared to the biblical drought rather than offering a specification of duration (Nicholson, 1976).

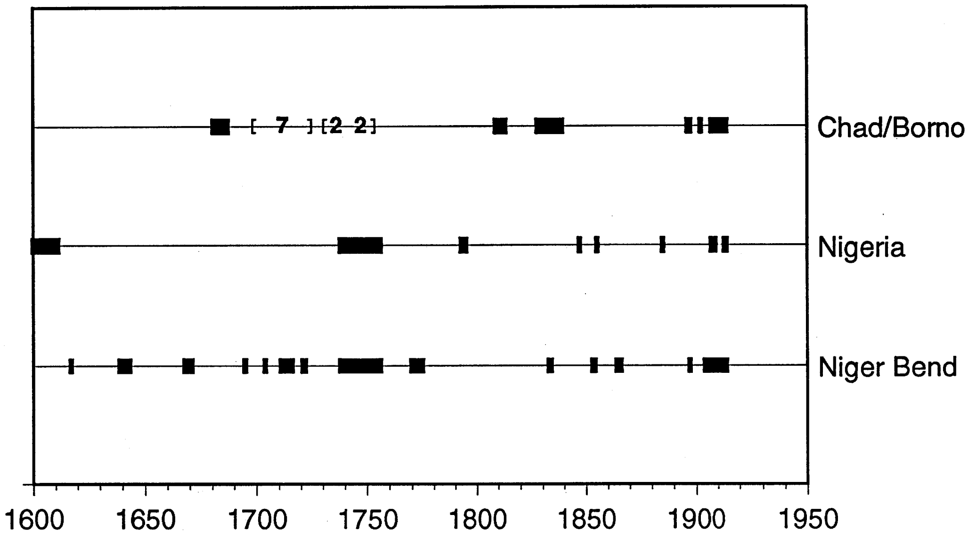

Figure 5. Records of historical drought in West Africa since 1600. The numbers for Chad/Borno indicate the durations of drought whose exact date of occurrence cannot be ascertained.

Most droughts recorded since 1600 were events of short duration which did not extend over all three regions from which the information was derived. The longest drought on record was approximately ten years and the longest period of contemporaneous droughts at all three locations was between 1740 and 1750. The beginning of this century also saw widespread, severe droughts. Information presented in the chronicles for northern Nigeria in the 18th century is very detailed. The scarcity of recorded droughts for this period may indicate that the region was relatively unaffected by large scale atmospheric anomalies. Apart from the droughts of 1831–1837 at Chad and Borno, events during the 19th century appeared to be generally short and spatially variable.

7. Conclusions

Parallel existence of historical information on famines and rainfall data in the sub-Saharan environment allows the matching of drought events and the interpretation of chronicled records. This study demonstrates such an application to northern Nigeria.

(1) In a rain-fed agricultural society, drought represents the cumulative effect of annual rainfall deficit as it reaches some critical level that cripples crop yield. In this regard, deficit arises when rainfall is below an expected norm represented by the long term mean and drought commences when cumulative deficit crosses a threshold represented by 1.3 times the standard deviation of annual rainfall. Thus defined, rainfall droughts matched approximately 90% of the famine events

chronicled for northern Nigeria, verifying the feasibility of interpreting proxy information using scientifically measured data.

(2) Drought duration is related to magnitude, considered here as the maximum cumulative rainfall deficit. This relationship confirms that longer droughts recorded in the chronicles are more severe than the shorter ones.

(3) Both chronicles and rainfall records show that droughts of short duration (<3 years) tend to be less severe, more frequent and spatially more variable than long droughts. Droughts lasting over three years are regional in extent and are separated by long intervals between occurrences.

(4) In the historical records for the Sahel dating back to 1600 AD, there were chronicled droughts lasting ten years or more. These are inferred to be of extreme severity. The paucity of droughts mentioned in the chronicles for the 18th century suggests that this was a relatively wet period while the droughts in the following century were mostly short and localised.

Acknowledgements

This study was made possible by an award from the Rockefeller Foundation (Sub-Saharan African Dissertation Internships Award) to the first author. Additional funding was provided by the Canadian International Development Agency.

References

Bradley, R. S.: 1976, 'Secular Changes of Precipitation in Rocky Mountain States', *Monthly Weather Review* **104**, 513–523.

Cohn, T. A. and Stedinger, J. R.: 1987, 'Use of Historical Information in a Maximum-Likelihood Framework', *J. Hydrol.* **96**, 215–223.

Glantz, M. H. (ed.): 1987, *Drought and Hunger in Africa: Denying Famine a Future*, Cambridge University Press, 457 pp.

Guo, S. L.: 1990, 'Unbiased Plotting Position Formulae for Historical Floods', *J. Hydrol.* **121**, 45–61.

Hosking, J. R. M. and Wallis, J. R.: 1986, 'The Value of Historical Data in Flood Frequency Analysis', *Water Resources Research* **22** (11), 1606–1612.

Koslowski, G. and Glaser, R.: 1995, 'Reconstruction of the Ice Winter Severity since 1701 in the Western Baltic', *Clim. Change* **31**, 79–98.

Lamb, P. J.: 1982, 'Persistence of Sub-Saharan Drought', *Nature* **299**, 46–48.

Nicholson, S. E.: 1976, *A Climatic Chronology for Africa: Synthesis of Geological, Historical, and Meteorological Information and Data*, Ph.D. Thesis, Univ. Wisconsin, Madison, 324 pp.

Oladipo, E. O.: 1995, 'Some Statistical Characteristics of Drought Area Variations in the Savanna Region of Nigeria', *Theor. Appl. Climatol.* **50**, 147–155.

Oliver, J. E.: 1991, 'al-Biruni's Chronology: A Source for Historical Climatology', *Clim. Change* **18**, 437–452.

Rodrigo, F. S., Estaben-Parra, M. J., and Castro-Diez, Y.: 1994, 'An Attempt to Reconstruct the Rainfall Regime of Andalusia (Southern Spain) from 1601 A.D. to 1650 A.D. Using Historical Documents', *Clim. Change* **27**, 397–418.

Rodrigo, F. S., Estaben-Parra, M. J., and Castro-Diez, Y.: 1995, 'Reconstruction of Total Annual Rainfall in Andalusia (Southern Spain) during the 16th and 17th Centuries from Documentary Sources', *Theor. Appl. Climatol.* **52**, 207–218.

Salas, J. D., Wohl, E. E., and Jarrett, R. D.: 1994, 'Determination of Flood Characteristics Using Systematic, Historical and Paleo-Flood Data', in: Rossi, G., Harmancioglu, N., and Yevjevich, V. (eds.), *Coping with Floods*, ch. 7, Kluwer Academic Publishers.
Stedinger, J. R. and Baker, V. R.: 1987, 'Surface Water Hydrology: Historical and Paleo-Flood Information', *Rev. Geophys.* **25**, 119–124.
Sutcliffe, J. V.: 1987, 'The Use of Historical Records in Flood Frequency Analysis', *J. Hydrol.* **96**, 159–171.
Torry, W. I.: 1986, 'Economic Development, Drought and Famines: Some Limitations of Dependency Explanations', *Geojournal* **12**, 5–8.
Van Apeldoorn, G. J.: 1981, *Perspectives on Drought and Famine in Nigeria*, George Allen and Unwin, 184 pp.
Watts, M.: 1983, *Silent Violence: Food, Famine and Peasantry in Northern Nigeria*, Univ. California Press, 687 pp.
Woo, M. K. and Tarhule, A.: 1994, 'Streamflow Droughts of Northern Nigerian Rivers', *Hydrological Sciences J.* **39**, 1, 1 9–34.

Appendix 1: Historical Droughts and Famines in Nigeria Compiled by Nicholson (1976), Watts (1983)

1600–1610	Eleven years of famine near Kano; may have been caused partly by war of the last century.
18th Century	Frequent famines in Borno during the second half of the eighteenth century.
1738–1756	Famine ravaged Tombouctoo and the Niger Bend during this period and probably affected all of the western Soudan, from Hausaland to Wolof (i.e. western Nigeria to Senegal). Similarly, Kano also suffered a severe drought of ten or more years' duration in the 1740s and early 1750s.
1793–1795	Rainfall drought in Northwestern Nigeria.
1790s	Kano hit by serious drought which depleted grain reserves and caused emigration.
1805–1810	Mild and patchy famines.
1847	Famine in Hausaland, known as *Darwara*.
1855	Very severe famine in Hausaland, known as *Banga-Banga*.
1863	Slight famine or inadequate rainfall.
1864	Slight famine in Hausaland.
1873	Slight famine in Hausaland.
1879	Famine, known as *Malali*.
1884	Slight famine in Hausaland.
1888–1890	Mild and localised famines in Katsina; *Yar mani* (1888), *Ci Kworiya* (1890).
1898	Localised famine, known as *El Commanda* in Daura.
1902–1910	Patchy, moderate to severe famines in northern Nigeria. In 1905, a localised famine occurred in Katsina referred to locally

	as *ci abinki ta rimin gora*. In 1908, famine (known as *Yunwar Kanawa*) afflicted Kano and its surrounding areas.
1912–1914	Severe famine, probably the most severe one in Hausaland since 1855, most of the African Soudan was affected.

For details concerning these events, the reader is referred to Nicholson (1976) and Watts (1983).

(Received 29 November 1995; in revised form 8 January 1997)