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Climatic information of Western Sahel (1535–1793 AD) in original documentary sources

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Abstract

The Sahel is the semi-arid transition zone between arid Sahara and humid tropical Africa, extending approximately 10–20° N from Mauritania in the West to Sudan in the East. The African continent, one of the most vulnerable regions to climate change, is subject to frequent droughts and famine. One climate challenge research is to isolate those aspects of climate variability that are natural from those that are related to human influences. Therefore, the study of climatic conditions before mid-19th century, when anthropogenic influence was of minor importance, is very interesting. In this work the frequency of extreme events, such as droughts and floods, in Western Sahel from the 16th to 18th centuries is investigated using documentary data. Original manuscripts with historical chronicles from Walata and Nema (Mauritania), Timbuktu and Arawan (Mali), and Agadez (Niger) have been analyzed. Information on droughts, intense rainfall, storms and floods, as well as socioeconomic aspects (famines, pests, scarcity, prosperity) has been codified in an ordinal scale ranging from −2 (drought and famines) to +2 (floods) to obtain a numerical index of the annual rainfall in the region. Results show wet conditions in the 17th century, as well as dry conditions in the 18th century (interrupted by a short wet period in the 1730s decade).

1 Introduction

The Sahel (10° N–18° N, 15° W–30° E) is the semi-arid transition zone between arid Sahara and humid tropical Africa, extending from Mauritania in the West to Sudan in the East. The Sahel region is characterized by a strong N–S rainfall gradient and high interannual variability, with annual rainfall ranging from 500–600 mm in the South to 100–200 mm in the North. Most of the precipitation falls in connection with the northward penetration of the West African Monsoon in the boreal summer, especially from July to September (Nicholson and Grist, 2001; Linderholm et al., 2009). The Sahel region is geographically unique because it is adjacent to the largest desert in the face of the Earth, and it represents the largest land surface contiguous without extensive mountain terrains (Shukla, 1995). One of the most dramatic recent cases of climate variability occurred in the West African Sahel, in the late 1960s. Rainfall has been below the century-long average almost every year since 1968. Over this area, the 30 year average, that provides the standard "climatological normal", has declined by 30–40 % (Nicholson and Webster, 2007). In the meteorological data recorded in the past 100 years, there is no other region on the globe of this size for which spatially and seasonally averaged climatic anomalies have shown such persistence (Shukla, 1995).

Climatic fluctuations in this area represent a large part of the tropics and subtropics climates as well as the climatic interaction of the two hemispheres. Thus, knowledge of this area is crucial in understanding global climatic history (Nicholson, 1981). The short instrumental record in Africa (mainly from the late 1880s to present) does not provide an adequately long time-series to fully capture and understand the range of natural climate variability and interactions of long-term (decadal, inter-decadal or centennial scale) of the climate system (Olago and Odada, 2004). In tropical Africa, relevant data to determine this variability are scarce because of the limited potential of standard high-resolution proxy records such as tree rings and ice cores (Verschuren et al., 2000; Verschuren, 2004). Paleoenvironmental data are relatively scarce to the late Holocene, including much of the historical period (Brooks, 2004), so interpretation of climatic variability during the historical period is based on archaeological data (Mayor et al., 2005), written records (reports of settlers and travelers, local histories) and lakes and river geologic studies (Nicholson, 2001a, b; Nicholson and Yin, 2001).

The use of historical information extending the length of available records has demonstrated useful in many regions (Brázdil et al., 2010). For the Sahel, climatic information exists in several chronicles from the days of the great empires and kingdoms (for instance, Tarhule and Woo, 1997, analyzed historical droughts in Northern Nigeria since 1600 AD, using data compiled by Nicholson, 1976, and Watts, 1983). The main goal of this paper is the reconstruction of rainfall regime in Western Sahel from the 16th to 18th centuries. Original manuscripts with historical chronicles from Walata and

Nema (Mauritania), Timbuktu and Arawan (Mali), and Agadez (Níger) have been used to reconstruct climatic conditions during this period. Except Agadez, all the localities belong to the homogeneous region 14 defined by Nicholson (2001a) and centered at 16.2° N, 2.1° W.

2 Documentary sources

The most important documentary sources on the Western Sahel are in the great collections of manuscripts located in the city of Timbuktu (Johansen et al., 1995–1998), and due to the colonial process, in French funds as well as the National Library of France and other private collections (Hunwick, 2003). The first attempt to synthetise information from this area was published by Cissoko (1968), using French translations of the original texts. In the work that we present here the number of documentary sources used has been enlarged. These manuscripts deal with a wide variety of subjects including Islamic jurisprudence, legal texts, theology, medicine, mathematics, astronomy, grammar, poetic verse, along with comments and marginalia (Farouk-Alli and Shaid Mathee, 2008). The authors belonged to the more Islamized social class of the area. Climatic information appears mainly in historical chronicles, urban annals, obituaries and biographies of the main figures. Because of its importance to the people of the area these are the sources that have survived. Other documents related to routine administrative processes (such as diplomatic correspondence, books of accounts of harvests, or tax records) are insignificant or nonexistent.

Most of these manuscripts are written in Arabic but there are a large number of manuscripts written in native languages using the Arabic script, especially in Songhay, Fulfulde and Tamasheq. Particularly, in regard to our study, it was necessary to work with Songhay language concepts because many of the relative terms to disasters often appear in that language in the Arabic manuscripts (Millán, 2010). The extreme meteorological phenomena described in the chronicles are assumed as misfortunes sent by Allâh to punish the bad human actions. The authors of the major chronicles don't

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have the Arabic language as their first language. They have learned this language mainly from the Quran and pre-Islamic poetry as it was common in their days. That is why almost all of the standard terms used to describe the meteorological phenomena ("hail", "lightning", "thunder", "sandstorm") and their consequences are originally Quranic. Other times they can difference a general wind from a whirlwind that accompanies a storm, or regular rainfall from large storms capable of create floods and overflows.

Regarding to the Niger bend the major historical chronicles begin to be written only after the Saadi conquest of Timbuktu, Jenne and Gao in 1591. They were centred upon the task of making historical sense of the political and social upheavals brought about by the Moroccan invasion of 1591, and constitute a valuable source of information about periods chronologically closer to the chroniclers (Moraes Farias, 2008). The chronicles used here are the following: *Ta'rîj al-fattâšfîajbâr* (in abbreviation T. F.), known as the "chronicle of the researcher"; *Ta'rîj al-sûdân* (T. S.) or "chronicle of the land of the black man"; the chronicle *Taḏkirat al-nisyânfîajbârmulûk al-sûdân* (T. N.) is an biographical dictionary of kings of Timbuktu; and the chronicle *Ḏikr al-wafâyâtwamâḥadaza* (D. W.) is written in the manner of urban annals. There are other documentary sources corresponding to small cities (Fig. 1): *Ta'rîj al-brâbîš* (T. B.) known as "chronicle of Arawan"; *Ta'rîj al-Na'ma* (T. Ne.) or the chronicle of Nema; *Ta'rîj al-Walâta* (T. W.) or chronicle of Walata, and the so-called *Chronicles of Agadez,* which contains an anonymous history of the tuaregs (A. K.), and the autobiography of AbûBakrb. ṬâhirTâšî (1657–d. after 1699), source known as *Ta'rîjAhîr* (T. A.). The main interest of these chronicles is that most of the authors were eyewitness of the events narrated. Although there are translations into French, English, or Spanish, original texts were used in this study. Bibliographic details of the different sources are given in the Appendix A. The time embraced by this set of chronicles covers the period between 1535 and 1876. In some periods, (1535–1599, 1637–1656, 1680–1793), there are descriptions of events in more than two different chronicles. So, in various cases (basically droughts) it was possible the cross-comparison between the information from

different chronicles, and to confirm the spatial coverage of the phenomena recorded. The information available for the 19th century in these chronicles is very fragmentary, therefore our study is limited to the period between 16th and 18th centuries.

3 Climatic information

Analyzing Arabic sources, the influence of the use of a lunar calendar must be considered carefully (Domínguez-Castro et al., 2012). All the dates were converted to Gregorian calendar and correspondence of Hijrî and Gregorian dates was calculated using the "Minaret" software by Kamal Abdali (available on http://patriot.net/~abdali/ftp/) with an error of one day. The majority of data correspond to rain-related phenomena, basically extreme events, such as intense rainfalls, floods and droughts, but a few records are related to thermal regime, thunderstorms and clouds. Similar to Nicholson et al. (2012), a basic assumption is that information pertaining to any location within the region can be used to produce a precipitation time series representing the region.

Most of the droughts recorded correspond to periods of two or three years. This kind of droughts is more regionally extensive and reaches larger magnitudes than the short ones (Tarhule and Woo, 1997). For an economy based on rain-fed agriculture, the reconstruction of historical drought is facilitated by its closed relationship with socioeconomic features, such as rise of grain prices, scarcity, and particularly famines (Tarhule and Woo, 1997; Brooks, 2004). This is the case of the great drought and famines recorded from 1617 to 1619, from 1639 to 1641 and from 1742 to 1744, when cannibalism events occurred. An example of the description of a drought and its impacts can be seen in the source T. S. (pp. 129–130 of the Arabian edition) on the 1617–1619 drought:

"*In that year was no rain and people go out for the rogations that lasted about 14 days, but the sky continued clear, only after some rain was poured. The rise in food was excessive in the region of Timbuktu and starved countless people who even atedead animals and men. The exchange fell to 500 cowries. This was followed by a pest that* *killed many people not counting those who were dead by hunger. The increased cost of food continued for two years, it ruined people who had to sell their furniture and utensils. The old agreed that they never saw anything like this or heard anything like this to their elders.*"

In general terms, it can be established a certain graduation of drought severity, considering the impacts recorded in the sources, from hard dry conditions responsible of famines and cannibalism episodes (severe droughts), to slightest events, for instance when rogations praying for rain were "satisfied" with rainfalls a few days after (July 1669, September 1670, August 1736).

Floods represent net rainfall over a basin rather than at a point, they smooth the effect of random variations from point to point and provide a valuable indication of climatic fluctuations (Sutcliffe, 1987). An example of this type of information can be seen in the source T. S., (p. 171 of the Arabian edition), on the flood on 3 February 1652:

"*On Friday 22th of safar of the year 1062 the water from the river reached the ma'dugu, that happened on the 22nd day, but the river level did not rise to it usual point, it stopped in Marmara Yinde. A strange thing that never saw or listened to happened: the strangest thing in it time.*"

The extreme variability in Sahel rainfall explains that floods can occur anywhere and at any time, even during periods of severe drought (Tarhule, 2005; Tschakert et al., 2010). This is the case, for instance, of the floods in Timbuktu in December 1617 and January 1619, included in a drought period from 1617 to 1619. This apparent contradiction only appears again in 1704, when drought conditions are associated with the information of a flood probably during June, and 1736, when dry conditions were interrupted by torrential rains. The sensitivity of runoff to variations in rainfall explains the marked annual variations of river flow in response to annual variations in rainfall (Sutcliffe, 1987; Itiveh and Bigg, 2008). Most of the floods recorded correspond to Timbuktu. This city is located in the north of the Inner Niger Delta. The flooding of the delta depends on the water supply of the rivers Niger and Bani, with a temporal delay of about 3–4 months with respect to the rainy season (Seiler et al., 2009; Zwarts, 2010). This

temporal delay between the rainy season and the flooding season explains the dates of the main floods recorded in Timbuktu, between November and February. Therefore, these events indicate the wet character of the previous rainy season in the headwaters of the rivers (Guinea highlands). The problem here is if this information can be used as a proxy of precipitation in the study region. Three stations located in the Upper Niger River (Siguiri, Kankan, and Dabola, in Guinea) were studied. A regional series of annual anomalies of precipitation for the instrumental period 1922–1995 was obtained averaging the local series of standardized anomalies (Dai et al., 2004) and compared with the series corresponding to the study region (Timbuktu, Gao, and Nema) during the same period. Monthly rainfall data were extracted from the updated Global Historical Climatology Network version-2 (available in http://www.ncdc.noaa.gov, Petterson and Vose, 1997). The correlation coefficient between Upper Niger and the study region series was 0.60 (significant at the 95 % confidence level), and the sign of the anomalies was similar in the 67 % of the cases. Therefore, interannual behavior of rainfall during the instrumental period is very similar in Upper Niger and Inner Niger Delta, and it is plausible using floods information as proxy of rainfall in the study region.

Other climatic events recorded in the chronicles are also related to precipitation regime. The variability in the number of high intensity rain events is the single most important factor responsible for differences between wet and dry years in the Sahel because heavy rain events account for a significant proportion of total annual rainfall despite their small number (Le Barbé et al., 2002; Tarhule, 2005). It is noteworthy the snowfall (a very rare event in the studied area) recorded at Timbuktu on August 1736, as well as the appearance of thunderstorms and rains during the dry season (January 1672, December 1737). Some years were especially wet, so the thunderstorm of 5 January 1672 was preceded by a flood in Timbuktu on 4 January, and the rainfalls of December 1737 were preceded by the flood on 4 December. This event is described in the source T.N. (pp. 14–15 of the Arabian edition) in the following way:

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"*On Wednesday 11th of shabân the bright, seventh day of the rain station, the water from the river came to HariBundu, and on Monday 23rd of the same month fell a light rain, and in the night on Thursday 26th it rained torrentially . . .*"

There was a strong link between cultural development and climate variability in the studied area during the pre-colonial period (Verschuren et al., 2000). Chronicles identify periods of "prosperity" (characterized by political stability and agricultural success), which in general terms coincide with the absence of relevant climatic events. These periods in Timbuktu are 1549–1583 (T. F., p. 94), 1622–1627 (T. S., p. 131), and 1679–1680 (T. N., p. 159). As an example, the period 1622–1627 is described in the source T. S. (p. 131 of the Arabian edition) in the following way:

"*On Friday 16th of rabi I of the year 1031, the governor Yusuf ibn 'Umar al-Qasri was invested . . . He was blessed governor and his days were bright, a period of prosperity, abundance and fertility.*"

4 Rainfall index

Between 1535 and 1793 we can characterize from a climatic point of view a total of 96 years, that is, around 37 % of the total number of years, with an average value of around 4 years per decade. Although this information is insufficient to provide continuous chronologies it can be used when it relates to markedly anomalous periods in the past and is useful for climatologists (Nicholson, 1981). The usual reconstruction methodology consists in deriving ordinal intensity indices from documentary data (Brázdil et al., 2005, 2010). Table 1 shows the indices used in this study, based on the impacts of the climatic events, and the years climatologically characterized. Only the events with an explicit mention to their climatic causes were taken into account. In this work the category "normal" (index value 0) is assigned to years with information on economic prosperity and absence of extreme events, or when the information appears contradictory (i.e. references to both dry and wet conditions). In these cases, we follow the criteria by Nicholson (2001a), and consider these years as relatively normal. The

lack of reference to wet or dry conditions is interpreted as a normal year. However, in historical climatology it is always possible to find new documentary data that compel to revise the analyses. Therefore, we must be cautious in interpreting the results. There is a certain skew of the indices towards very extreme conditions (indices +2 and −2), because documentary sources normally recorded events of major impact.

Figure 2 shows the time series of the ordinal index. This series must be understood as a first approach to the time evolution of rainfall in the study area from 16th to 18th centuries. A first view can be obtained from these results: wet and dry phases alternated during the past centuries, with wet peaks mainly during the 17th century and the 1730s decade, and predominance of dry conditions in the 18th century.

The best check of the reliability of these results is to see if other evidence exists that shows similar characteristics. In the Sahel, other sources of data come from archaeological studies (McIntosh and McIntosh, 1982; McIntosh, 2000; Mayor et al., 2005) and geologic studies of lakes and rivers (Verschuren et al., 2000; Nicholson and Yin, 2001; Overpeck et al., 2002; Verschuren, 2004). All these works indicate the predominance of wet conditions interrupted by episodes of aridity and drought, especially during the 17th century (Webb, 1995; Nicholson, 2001b). In particular, McIntosh and McIntosh (1982) indicate high flooding in the Middle Niger, with high levels of Chad Lake, in 1592, 1616, and 1618–1639, coinciding with the floods in Timbuktu. These authors also record severe droughts in the periods 1640–1644 and 1738–1756, coinciding in time with droughts in 1639–1641 and 1742–1744 detected here. The water levels in Lake Chad (13°0′ N, 14°0′ E) reconstructed by Maley (1993) from geologic and paleolimnological data, also show similitudes: dry conditions in the 16th century, wet peaks during the 17th century and dry episodes in the 18th century.

There are two remarkable historical events occurred during the 18th century related to climate shocks that transformed the area completely: the great migrations of the nomads of central Sahara to the Sahel, looking for pastures along the banks of the Niger, which culminated in the 18th century with the occupation of many cities of the Niger bend (Lhote, 1984; Brunk and Gronenborg, 2004; Vansina, 2010), and the decline of

Timbuktu in the 18th century, around 1770 (Abitbol, 1982). The only stable political structure of the area, created in Timbuktu in 1591, could not overcome the climatic disasters. The major political crises are related to the great droughts in the 18thcentury.

The Little Ice Age (LIA) is conventionally defined as a cold period of the Northern Hemisphere extending from the 13th to 19th centuries (Crowley, 2000). The appearance of this cold period has been found in many studies on the tropical climate change (e.g. Holmes et al., 1997; Thompson et al., 2006). A faunal record of sea-surface temperature (SST) variations off West Africa also documents the LIA cooling at subtropical Atlantic (deMenocal et al., 2000). The rainfall regime over Western Sahel has a strong link to SST in the tropical Atlantic, particularly in the Gulf of Guinea (Ward, 1998; Giannini et al., 2003; Hoerling et al., 2006). High SSTs in the equatorial Atlantic promote convection in the equatorial latitudes to the South of the Sahel. In contrast, the low temperatures of SST push the rain belt further north, and this may be a contributing factor to the stronger convection in the sahelian latitudes (Nicholson and Webster, 2007). Solar variability may have been responsible for these fluctuations, with dry (wet) periods in the Sahel coinciding with phases of high (low) solar radiation (Gasse, 2001).

The SST variability is instrumental in determining the sign of rainfall anomalies in the Sahel, whereas land–atmosphere interaction acts to amplify them (Giannini et al., 2003). If the natural variability of the global climate system were to produce an initial drought, the strong atmosphere–land interaction over the Sahel region could contribute toward the persistence of that drought (Shukla, 1995). This feedback mechanism has been studied among other works by Charney (1975), Zeng et al. (1999), and Nicholson (2000). In a first view, historical data presented here seems show minor persistence than that of the 20th century. The reconstruction of a continuous and homogeneous time series from 16th to 20th centuries (now in preparation) will allow to analyze if there have been changes in the persistence of the events in the study region.

5 Conclusions

In an annual time scale, the main results of this study indicate wet conditions during the 17th century, and progressive drier conditions during the 18th century. These results are in good agreement with previous works, based on qualitative analysis of documentary data and paleoenvironmental studies on lake levels and salinity. The rainfall regime over Sahelian West Africa has a strong link to the sea surface temperature (SST) in the tropical Atlantic, particularly in the Gulf of Guinea. In this sense, results shown in this work may provide an indirect estimation of SST in the tropical Atlantic during historical periods. However, they are not conclusive. It is necessary to enlarge the data base, with the incorporation of new documentary sources, amplifying the spatiotemporal coverage of the data. The incorporation of new data of the 19th century will allow construct an uninterrupted series of the climatic evolution from 16th to 20th centuries. This is a project in progress, and it will be the main goal of a future work.

Appendix A: Data sources

A1 European sources

The first description of the Western Sahel and southern Sahara during the early modern period was published in 1550 (*Della descrittione dell'Africa et delle cose notabli che ivi sono)*. The author Leo Africanus (Ḥasan b. Muḥammadal-Wazzân al-Fâsî) (c.1494–c.1550) visited the most important cities in the Niger bend (Timbuktu and Gao) in around 1510. Leo's text presents a general description of the climate in North Africa and the Sahel in which he is aware of the importance of climate on human behavior and economic development.

Leo Africanus (Ḥasan b. Muḥammadal-Wazzân al-Fâsî) (c. 1494–c. 1550)

BNR no. 953, Biblioteca Nazionale Centrale di Roma. Discovered in 1931 the original Italian text is written from Arabic notes.

"Navigationi e Viaggi", G. B. Ramusiocompilation,Venezia, 1550.

A2 African sources

(1) The chronicle *Ta'rîj al-fattâšfîajbâr* (in abbreviation T. F.), known as the chronicle of the researcher, written by Maḥmûd Ka'ti b. al-ḥâyy al-mutawakkilKa'ti al-Kurminîal-Tinbukti al-Wa'koray (?–1593), describes events occurred in the Niger bend (Jenne, Timbuktu, Gao) until 1599. Information after the death of the author was included by one of his sons. It provides information about the town of Timbuktu during the Songhay Empire (1468–1591) and the establishment of the Moslem kingdom of Timbuktu after this date. The main interest of this text is that the author was eyewitness of the events occurred during the second half of the 16th century. There is an Arabic edition and translation into French by Houdas and Delafosse (1913).

-Ta'rîj al-fattâšfîajbâr al-buldânwa al-yuyûšwaakâbir al-nâswaḏikr waqâ'i' al-Takrûrwa'aẓâim al-umûrwatafrîqansâb al-'abîd min al-ajrâr by Maḥmûd Ka'ti b. al-ḥâyy al-mutawakkilKa'ti al-Kurminî al-Tinbukti al-Wa'koray (?–1593)

1. Timbuktu (Institut des Hautes Etudes et de Recherches Islamiques Ahmed Baba (IHERI-AB)), MSS: 1, 64, 2221 (II) (partial), 2934, 3927 (Huodas A), 8378.
2. Paris (Bibliothèque Nationale de France), MS: 6651.

(2) The chronicle *Ta'rîj al-sûdân* (T. S.) or "chronicle of the land of the black man", written by 'Abd al-Raḥmân b. 'AbdAllâh b. 'Imrân b. 'Âmir al-Sa'dî (1596–c. 1655/56), shows events occurred in the same area until 1655. The chronicle describes the whole western sahelian area, because the author was official and he travelled through the region including the inner delta of the Niger river. The author was eyewitness of the events occurred in the first half of the 17th century. There is an Arabic edition and translation into French by Houdas (1898–1900), Spanish translation by Cano and Millán (2011) and partial English translation by Hunwick (1999).

-Ta'rîj al-sûdân by'Abd al-Raḥmân b. 'AbdAllâh b. 'Imrân b. 'Âmir al-Sa'dî (1596–c. 1655-6)

1. Alger (Bibliothèque Nationale d'Algérie, Fonds Ben Hamouda), MSS: Ḥ4, Ḥ5 (partial).
2. Dakar (Institut Fondamental d'AfriqueNoire, Fonds Brevié), MS: 19 (partial).
3. Paris (Bibliothèque Nationale de France), MSS: 5147, 5256, 6096.
4. Paris (Institut de France), MS: 2414 (200).
5. Timbuktu (Institut des Hautes Etudes et de Recherches Islamiques Ahmed Baba (IHERI-AB)), MSS: 61 (partial), 660, 681, 3487.

(3) The *Taḏkirat al-nisyânfîajbârmulûk al-sûdân* (T. N.) was an anonymous biographical dictionary of kings of Timbuktu written around 1750. It contains information mainly of Timbuktu, from 1591 to 1746. It is the document with more climatic information, in particular from the first half of the 18th century, when the author was eyewitness. There is an Arabic edition and translation into French by Houdas (1899–1901).

-Taḏkirat al-nisyânfîajbârmulûk al-sûdân (Anonymous).

a. *Dîwân al-mulûkfîsalâṭîn al-sûdân* (base text)

   1. Paris (Bibliothèque Nationale de France), MS: 5259.
   2. Timbuktu (Institut des Hautes Etudes et de Recherches Islamiques Ahmed Baba (IHERI-AB)), MSS: 2221, 5343 (partial).

b. *Taḏkirat al-nisyânfîajbârmulûk al-sûdân* (final compilation)

   1. Dakar (Institut Fondamental d'Afrique Noire, Fonds Brevié), MS: 20.
   2. Kaduna (Nigerian National Archives), MS: O/AR10/1,3.

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3. Paris (Bibliothèque Nationale de France), MS: 6097.

(4) The short chronicle *Dikr al-wafâyâtwamâhadaza* (D. W.) written by MûlâyQâsim b. MûlâySulaymân (?–c. 1801) gives details of Timbuktu in the period 1747–1801. It is written in the manner of urban annals. Probably, the author was eyewitness of the events that occurred in the last years of the 18th century. There is an Arabic edition and translation into French by Abitbol (1982).

-*Dikr al-wafâyâtwamâhadaza min al-umûr al-'izâmwa al-fitan* by MûlâyQâsim b. MûlâySulaymân (?–c. 1801)

Paris (Bibliothèque Nationale de France), MS: 5259, ff. 24–34

(5) There are other documentary sources corresponding to small cities. These chronicles are small lists of years in which are collected the more important events of each year, a sample of the written expression of oral records of nomadic groups. These small documents are copies made by the French colonial officials in the early twentieth century. The *Ta'rîj al-brâbîš* (T. B.) known as "chronicle of Arawan" (200 km to the north of Timbuktu) is divided into two parts: the first includes data from 1635 to 1744, and the second data from 1794 to 1876. There is a translation into French by Monteil (1938). The cities of Nema and Walata, to the southeast of Mauritania, have their respective lists of years: the *Ta'rîj al-Na'ma* (T. Ne.) or the chronicle of Nema, gives details of the city and its surroundings from 1739 to 1879 and provides interesting information of the 1790s; the *Ta'rîj al-Walâta* (T. W.) or chronicle of Walata with data from 1549 to 1818, but most of the details of events occurred in the late 18th century. The two texts were translated partially into French and published by Marty (1927).

-*Ta'rîj al-brâbîš* (Anonymous) (Monteil, 1938)

-*Ta'rîj al-Na'ma* (Anonymous)

Rabat (Faculté des Lettres et Sciences Humaines, Université Mohammed V), MS: 272/2Klm.

-*Ta'rîj al-Walâta* (Anonymous)

1. Rabat (Faculté des Lettres et Sciences Humaines, Université Mohammed V), MS: 273 Klm.
2. Dakar (Institut Fondamental d'Afrique Noire, Fonds Brevié), MS: 6.

(6) The so-called *Chronicles of Agadez* (a set of Arabic sources compiled in 1907 by Ibrâhîm al-Dasuqîthat) describes the events of the city of Agadez and the region of Ayr, covering the period from 16th to 20th centuries. These chronicles has been used to obtain information on the spatial extension of some events (basically droughts). They were translated to French and published by Urvoy (1934) and translated partially into English and published by Norris (1975). Among the different documents we can find an anonymous history of the tuaregs Kel Ewey, *AslKalAwiwanubda min Ta'rîjma'rakatTa'wâjiwaasl al-Sandal* (A. K.) from 1683 to 1829, and the autobiography of AbûBakrb. TâhirTâšî (1657–d. after 1699), source known as *Ta'rîjAhîr* (T. A.), eyewitness of the events narrated, which ends in 1699.

-*AslKalAwiwanubda min Ta'rîjma'rakatTa'wâjiwaasl al-Sandal* by AbûBakr b. TâhirTâšî (1657–d. after 1699)

Niamey (Institut de Recherche en Sciences Humaines, Université Abdou Moumouni), MS: 9.

-*Ta'rîjAhîr* (Anonymous)

Zaria (Department of History, Ahmadu Bello University), MS: 189/7

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Table 1. Years climatically characterized according to the index values during the period 1535–1793.

−2 (severe droughts)	−1 (droughts)	0 (normal)	+1 (great rainfall, storms)	+2 (floods)
1537	1586	1549, 1550	1667	1592
1538	1647	1551, 1552	1672	1602
1539	1688	1553, 1554	1698	1603
1587	1689	1555, 1556	1717	1605
1588	1710	1557, 1558	1730	1616
1619	1711	1559, 1560	1770	1646
1639	1712	1561, 1562		1651
1640	1713	1563, 1564		1653
1641	1714	1565, 1566		1671
1695	1715	1567, 1568		1733
1696	1716	1569, 1570		1737
1742	1720	1571, 1572		
1743	1721	1573, 1574		
1744	1738	1575, 1576		
1745		1577, 1578		
1746		1579, 1580		
		1581, 1582		
		1583, 1617*		
		1618*, 1622		
		1623, 1624		
		1625, 1626		
		1627, 1669*		
		1670*, 1679		
		1680, 1704*		
		1736*		

* References to both dry and wet conditions. The rest of the years classified as "normal" (index value = 0) correspond to "prosperity periods", with agricultural success, political stability, and explicit mention to absence of extreme events.

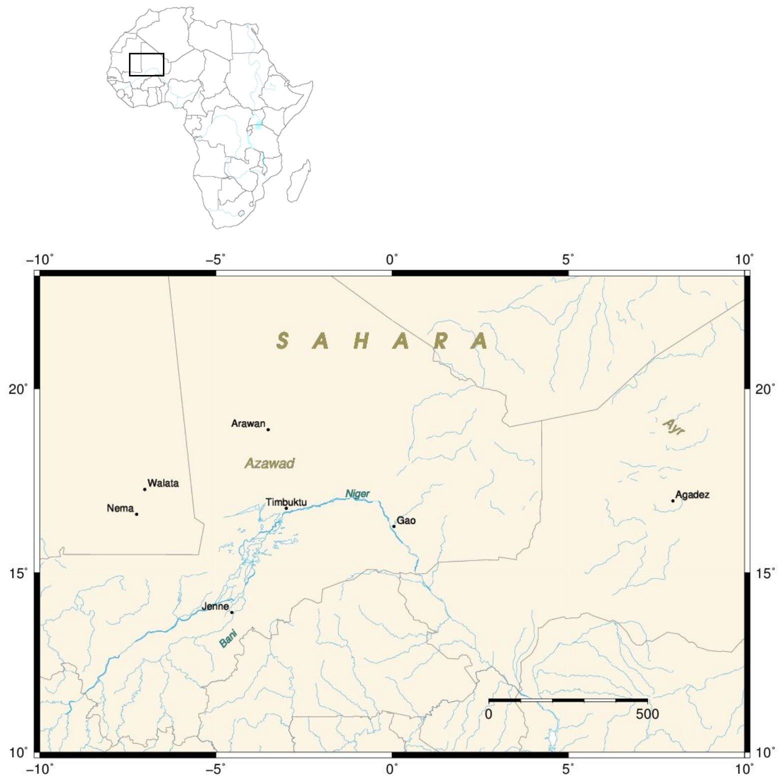

Figure 1. Map of the studied area. The cities with historical chronicles are indicated.

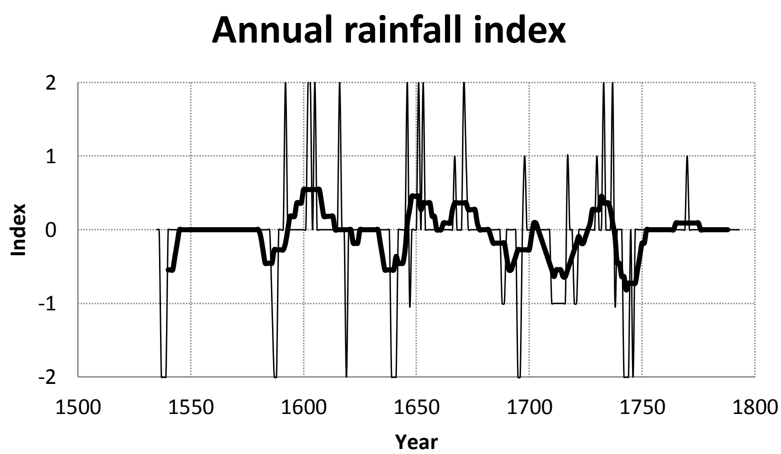

Figure 2. Time series of the annual rainfall index inferred from documentary sources (−2 = severe droughts; −1 = droughts; 0 = normal; +1 = great rainfall, storms; +2 = floods). Thick line: 11 year moving average.

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