Climate change and ancient civilizations

The history of the rise and fall of great past civilizations has often been closely linked to changing climatic conditions. This link is justified by the crucial importance at these times of regular agricultural production, which is very sensitive to climatic conditions and in particular to water availability. While archaeologists allow us, through their work, to better understand the history of these civilizations, paleoclimatology allows us to reconstruct some climatic variations in the past, and, among other things, to link changes in the water balance with environmental changes that may promote or degrade people's lives in the past. Several examples illustrate this link between the history of human settlements and the climatic events that have marked the past millennia and raise questions. How could repeated episodes of drought have pushed Sumerian and Mayan civilizations to decline? What was the impact of the Little Ice Age on some populations in Europe and Asia?

1. The emergence of the first ancient cities favoured by the climate

The great ancient cities were often at the heart of the first civilizations. Placed on a world map, most of them are located in intertropical areas (Figure 1). This geographical distribution, which does not seem to be the result of chance, reveals a hypothesis: the location of these cities is due to the need for significant agricultural production to meet the needs of their inhabitants.

Endemic agriculture has been the basis of each of these civilizations:

maize for pre-Columbian civilizations;

rice for Asian peoples;

wheat and barley for the first western and eastern cities.

Not only do these agricultures require a significant supply of water, but also a drier period. Tropical to subtropical climates offer the best hydrological conditions for such crops, with maximum rainfall in summer and a dry season in winter.

This maximum precipitation corresponds to the passage of the **Intertropical Convergence Zone** (ITCZ; Figure 1), a narrow climatic band that extends from east to west and migrates in latitude during the year (Read Jet-streams). This migration occurs between the tropics, i.e. between 20° N and 20° S, following approximately the maximum exposure. Winter is a dry season that limits the total water supply over the year and avoids flooding of crops. This alternation of highly contrasting hydrological conditions is less pronounced for temperature, although the latter could also play a decisive role on crops.

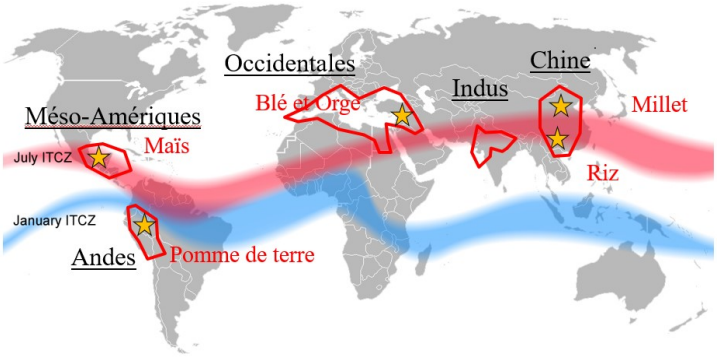

Figure 1. Distribution map of civilizations' outbreaks and meteorological zones of heavy rainfall according to seasons (ITCZ). The extension areas of the first centers of ancient civilizations are surrounded by a red line. The stars represent the privileged areas of endemic agriculture (after V. Boqueho, ref.[1]). Background map: current location of the intertropical convergence zone (ITCZ) in January (blue-coloured zone) and July (pink-coloured zone) [Source : Mats Halldin, 2006, via Wikimedia commons [Public domain]].

Vincent Boqueho in his book *Les civilisations à l'épreuve du climat* [1] underlines the importance of a **seasonal variation in temperatures**, with a period of the year below a certain threshold. According to him, low temperatures limit the development of several diseases of microbial origin, carried by parasites and promoted by high temperatures. The combination of these requirements - high water supply, alternating wet and dry conditions, colder periods - considerably reduces the geographical areas favourable to optimal crop yield. On a more regional scale, the altitude favours cooler temperatures. Figure 1, resulting from Boqueho's work, presents on the one hand the endemic agricultures that benefited from ideal climatic conditions, as well as the regions of emergence of the first great civilizations: the superposition of their distribution is striking.

Only Mediterranean civilizations have developed in a much wider area, beyond the "fertile crescent". Eastern peoples probably migrated from the Middle East following the upheavals of the first Mesopotamian civilizations; it was only after a first settlement in the north of the Arabian Peninsula that these peoples moved to an area particularly favourable to economic exchanges through navigation: the Mediterranean basin.

The location of the major centers of civilization, whether eastern, western, Asian or Amerindian, was, at least in part, determined by the favourable climatic conditions of these **tropical latitudes**. These conditions are also more locally found in Mediterranean and mountain climates, in particular. However, these climatic conditions have fluctuated on a regional scale, in particular in relation to the seasonal dynamics of the ITCZ. Paleoclimatic reconstructions allow us to specify these variations in different regions of the globe. Can we relate these variations to those of human populations? We will try here to show how a natural evolution of the climate has contributed to the establishment, growth, decline, or migration of human populations, with examples from different periods and continents.

2. Migration of climate zones over the last few millennia

The establishment and development of the civilizations in question took place several millennia ago; around 5,000 to 4,000 BC for the first Asian (first intensive rice cultivation) and Eastern (Mesopotamia) outbreaks, and 3,000 to 2,000 BC for the first Mesoamerican civilizations. These settlements therefore took place between 7,000 and 4,000 years ago BP, i.e. compared to today[2].

Technically, the **dates** indicated in this text refer to the Gregorian calendar, which uses as a reference the year 'zero', and the notations 'before Christ' (B.C.) and 'Anno Domini' (A.D.) for the years before and after the year zero respectively. These years can also be expressed **in age**, defined in relation to a current reference: the B.P. ('Before Present') rating uses the year 1950 AD

as a reference, and the B2K ('Before Year 2000') rating the year 2000 AD. Thus, the year 4000 BC corresponds to ages of 5,950 years BP.

How can we reconstruct climatic variations over such past periods, and what do these reconstructions teach us? The scientists who reconstruct past climates from natural archives are **paleoclimatologists**. In tropical areas, these **experts** have highlighted migrations from the famous Intertropical Convergence Zone (ITCZ) over the last few millennia at different time scales. Thus, a general southward migration of the ITCZ has first been suggested over the past 6,000 years, ref. [2].

More recently, shorter-scale migrations (up to decades) have been specified, particularly during the so-called **Early Ice Age** period [3]. These climate changes are attributed to several factors, such as variations in sunstroke, and some large volcanic eruptions, amplified by feedback mechanisms between oceanic and atmospheric circulations [4]. This turning point, since 6,000 years B.P., corresponds more or less to the **emergence of the first major centers of civilization** in the regions exposed in the introduction, where men have found ideal climatic conditions for their development. In natural archives (such as lake or marine sediments, or cave stalagmites), records of the water balance indicate significant changes that must have affected the agricultural resources that ensure human survival. What evidence shows that these civilizations have been affected by these **climate variations**?

3. The Sumerian civilization

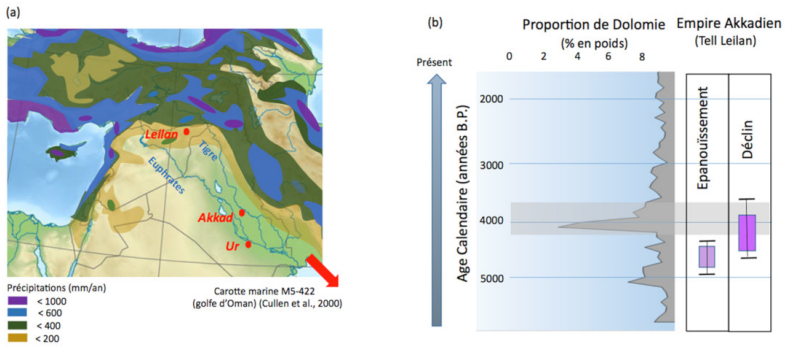

Figure 2. (a) Map of current rainfall distribution in the Near East, and location of some ancient cities. (b) Left: variations in the dolomite content of sediments in the M5-422 marine core from the Gulf of Oman. The presence of this mineral attests to a dry period (grey band) on the continent. Right: chronology of the Akkadian Empire deduced from the excavation results of the city of Tell Leilan (Syria). [Source: Left, adapted from Geyer and Sauvage, background map Викмор В [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)]; Right, adapted from Cullen et al., 2000, ref. 5]

A first example is provided by the Sumerian civilization, which flourished in Mesopotamia, between the banks of the region's two rivers, the Tigris and the Euphrates (Figure 2a). People occupied this region as early as the 7th millennium BC, long before the Sumerians flourished around 3500 BC. This civilization brings significant progress, such as the invention of the wheel, the cuneiform writing, and develops monumental cities like Uruk (Figure 2a).

In order to feed the inhabitants of its cities, the State must ensure significant agricultural production: it relies on writing, which allows better management of resources such as crops, places, plants and animals' accounting), but also on river exploitation, which guarantees the necessary water supply. These large rivers are fed by the Transcaucasian mountain range in the northern part of the Fertile Crescent, east of Anatolia (Figure 2a). Currently, these mountains receive between 0.6 and 1m of precipitation per year, which is sufficient to create large rivers (Figure 2a) [5]. Such climatic conditions, if they were identical more than 5,500 years ago, must have contributed to **the proper development of agriculture**, and therefore to the development of Sumerian civilization.

This civilization was at a turning point around 2,334 BC, with the influence of a new ruler, King Sargon, who brought together the various cities under the hegemony of a new capital, Akkad, to found the Akkadian empire. However, it seems that a major setback struck this empire a century after its emergence, that is, about 4,100 years ago. The term collapse of the Akkadian empire is often used to describe the loss of political influence of these large cities throughout the region, also corresponding to major armed conflicts and the exile of a significant part of the urban population. As often, it is not a real collapse since traces of occupation are still found in the region 300 years later.

What do the climate archives tell us about this period? Geological records show significant dust deposits, on the one hand in the area of the city of Tell Leilan in present-day Syria [6], and on the other hand in marine sediments in the Gulf of Oman, ref[5]. Marine deposits are dated at approximately 4,025 years B.P. with an uncertainty of 125 years (Figure 2b). These deposits

indicate a **rapid shift to much drier climatic conditions**. Some writings report much more difficult agricultural conditions at that time, suggesting that significant climate change has had a drastic impact on agriculture, and consequently on the cohesion of the Akkadian empire. From a climatic point of view, the aridification of Mesopotamia would be **linked to the cooling of surface waters** in the North Atlantic, as such an atmospheric link has been demonstrated for the current climate. Paleoclimatic records show a drop in temperatures in the North Atlantic Ocean of about 1 to 2°C 4,100 years ago B.P. [7].

The climate cause is certainly not the only one to explain the fall of the Akkadian empire. Nevertheless, these significant climate changes have inevitably had impacts on agriculture and caused difficulties in meeting the needs of the population. These difficulties have undoubtedly contributed to conflicts between cities and a destabilization of political power.

This climatic event seems to have affected the entire tropical zone, probably in two phases, one around 4,200 years old and the other around 3,900 years B.P. [8], causing drought events in some geographical areas and heavy rainfall events in other regions. The magnitude of this climatic event is such that it is now used as a stratigraphic reference point for the definition of the most recent Holocene period sub-story, under the name of **Meghalayan** [9]