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How long and how strong must a climatic anomaly be in order to evoke a social transformation? Historical and contemporaneous case studies

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In recent years, scholarly interest in the nexus between climate change and human societies has risen dramatically, and many researchers from different disciplines have begun studying the possible effects of climate change and climate anomalies on past and present societies. In this article, we join this lively debate, seeking to extend it by raising, and providing possible answers to, two fundamental questions: what type of climatic anomalies can undermine social stability? What duration and intensity are necessary to instigate structural change? When attempting to answer these questions, researchers tend to view short-term climatic events, such as storms or mudslides, as "unusual" events that instigate an "unusual" reality for temporary, and measurable, time periods. We argue, instead, that gradual and more "usual" climatic events, such as prolonged droughts or extended periods of untimely rains, impact societies in a more profound and "extraordinary" manner, and it is here that our paper meets the theme of the extraordinary and the usual, the axes of the current collection of essays. Based on qualitative examination of collapse periods in western Asia and northern China during the eleventh and early twelfth centuries, and a high-resolution re-examination of the crisis in Mali at the beginning of 2010, we argue that extended climate anomalies that cause decreases in the amount of available food are the anomalies that most affect the fate of human civilizations. While people can cope with short-term climate anomalies that cause periodical food crises, lasting a year or two, extended climate anomalies that affect the availability of food, like droughts, cold spells or untimely rains, can have disastrous, long-term effects: they accelerate decisive processes, push people to migrate outside their regions of residence, increase violence and religious extremism, and, ultimately, lead to structural changes in the societies that are affected by the crises.

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Introduction

The growing preoccupation with the future implications of global warming has also increased the academic and public interest in the possibility that climate changes can affect the fate of human societies. Only few researchers dispute the destructive potential of continued global warming, and bleak forecasts regarding the impact of global warming on the biosphere, our physical environment and even the mere existence of our civilization, are continuously being published.

However, the wide scholarly and public consensus that the current warming is destined to change living conditions globally, in a fairly short time-period and a drastic manner, has in the past few decades also pervaded climate-centered historical studies. We can even state that most natural scientists who specialize in the many and varied branches of the immense field called climate sciences agree that climate anomalies changed the economic, physical, and cultural structures of past societies. Supposedly, all that is left to do is find the specific reasons and timeframes in which climate changes have affected human societies (England et al., 2008; Engler et al., 2013; McCormick et al., 2012; Kathleen et al., 2019; Xoplaki et al., 2016). While there is scholarly unanimity as to the effects of climate changes on future, past and present societies, it is our contention that this scholarly discourse is rather narrow and limited.

When it comes to the study of past climates and their potential impact on social transformations, the tendency is to accept proxy-based studies for their scientific appeal and statistical validity. Indeed, in recent years, leading historians and archeologists have joined forces with experimental scientists who study specific events, such as volcanic eruptions, as catalysts for massive climate changes, but also as events that influenced the fate of complex civilizations or the course of a society's political history (McConnell et al., 2020; Oppenheimer, 2011; Stommel and Stommel, 1983; Wood, 2014). Two prominent examples that come to mind are a study dealing with volcanism in western Alaska and its influences on the policies of the Roman Senate during the Late Republic (McConnell et al., 2020), and Indonesian volcanism and its various effects on past societies, including the political developments that led to the Battle of Waterloo (Oppenheimer, 2011; Stommel and Stommel, 1983; Wood, 2014).

While proxy-based studies of past climate events acknowledge the association between climate anomalies and social transformations, as do we, we argue that the geographic distribution and quality of dating of proxies is somewhat limited. Their margin of errors when reconstructing human-social processes is relatively wide (Ellenblum, 2012, 2021). Contemporary climatic studies, on the other hand, tend to give less weight to the climatic factor and instead emphasize institutional structures and human management capabilities as decisive factors in the process of social transformations (Hunter et al., 2013; Pearson and Newman, 2019; Seter, 2016). Our research, and this paper, therefore, seek to broaden the scholarly discussion of the role recent climate changes have played in inducing social and political transformations.

In order to do so, we begin by asking: What climate anomalies can hinder the stabilization of human societies? What is the level of change and duration necessary in order to affect human beings? In other words, what type of climatic anomalies can undermine social stability? What ought to be their duration and intensity in order to instigate structural change? While researchers tend to view short-term climatic events, such as earthquakes or mudslides, as "unusual" events that instigate an "unusual" reality for temporary, and measurable, time periods, we argue, instead, that gradual and more "usual" climatic events, such as prolonged droughts or prolonged periods of untimely rains, impact societies in a more profound and "extraordinary" manner. It is at this interesting crossroad of rethinking the prolonged and the "usual" that our paper meets the theme of the extraordinary and the usual, the axes of the current collection of essays.

To illustrate our claim, we will present our historical methodology for analysis of past climates and social transformations. We conclude by presenting the results of our recent study where we employ our historical methodology as a lens for viewing the potential association between climate anomalies and violent outbreaks in Mali between 2012 and 2013. All three cases are based on extensive research conducted in recent years (Ellenblum, 2012; Li et al., 2019). The case-studies discussed in this paper focus on different cultures located in different regions of the world and occurred in different historical periods. Nevertheless, they have in common that they are all cultures located in a geographical-agricultural area that we call the "Fragility Zone", referring to areas that receive an annual average precipitation of 400–600 ml (Ellenblum, 2021: pp. 156–158). In addition, all three cases are political-governmental entities that were considered efficient and administratively successful (Chipman et al., 2021; Ellenblum, 2012; Li et al., 2019; Ellenblum, 2021). Yet they experienced rapid deterioration and social collapse, which we suggest was driven by climatic anomalies that led to food shortages.

We argue that the anomalies that affect the fate of humans most severely through increases or decreases in the amount of available food. People can cope with the results of food crises that last a year or two, but extended climate anomalies that affect the availability of food, like droughts, cold spells, and untimely rains, can have disastrous long-term consequences. They accelerate decisive processes, pushing people to emigrate outside their normal areas of life, increasing violence and religious extremism, and they can lead, eventually, to structural changes in the societies affected by the crises.

What climate events can effect deep social changes?

Reconsidering the short-term/long-term dichotomy. In a ground-breaking article from 1973, researcher Buzz Holling defined resilience as an ecosystem's ability to absorb disturbances before a structural change occurs, or alternatively, the time it takes for the system to recover from the disturbance (van Bavel et al., 2020).

This definition assumes that the system exists within a world with a single equilibrium. Therefore, resilience is measured by how far the system has moved from that single equilibrium and how long it takes to return to its previous steady-state (Gunderson, 2000; Perrings, 2006). Another approach to resilience, which developed later and is called ecological resilience, emphasizes the system's multiple equilibria and flexibility. It argues that disturbance can move the system to a completely different equilibrium. In this case, resilience is measured by the magnitude of the disturbance that can be absorbed by the system before it redefines its structure and passes into a new equilibrium (Gunderson, 2000; Holling, 1973).[1] Since the early 2000s, research dealing with the concept of "resilience" has expanded into the social sciences, and terms such as adaptation, transformation, and transition have been added to the debate (van Bavel et al., 2020). Resilience in its social context refers to a society's ability to withstand external disturbances (or crises/shocks) that undermine the basis of its social structure (Adger et al., 2009; van Bavel et al., 2020).

In this article, we seek to focus on the disturbances themselves (what we call climate crises or climate events here), an aspect that is usually not addressed in the resilience discourse. We emphasize their duration and intensity and offer a model of disturbances

that can cause major structural change in societies. We argue that gradual, long-term, and cumulative climate events, which impact food availability, are particularly challenging for human nature and human institutional management.

Commonly, climatic events are divided to two main categories: short-term climatic events and gradual, long-term climatic one. The literature views **short-term climatic events** as events that deviate from the daily norm. Examples of such events are severe storms, such as hurricanes, cyclones, and tornadoes; mudslides; floods; other non-meteorological events such as earthquakes and volcanic eruptions are also included in this category. Such events are perceived as dramatic and extreme, and it is therefore relatively easy to determine their duration and the spread of their spatial impact. Since such events can have devastating impact on humans' well-being, even if only transitorily, they are also referred to as rapid onset hazards. Such events are viewed as potentially harmful for property, human life, and the social and economic order; they lie beyond our perceptual thresholds and instigate abnormal human behaviors. Migration is a prominent example of a typical response to short-term climatic events, mainly because immigration costs are lower than the costs involved in staying in a disaster area (Koubi et al., 2016). Notably, data concerning recent short-term climatic events allows us to accurately determine all aspects of the occurrence of climatic anomalies—timeframe, duration, and characteristics.

Short-term climatic events originate in natural processes, although human behavior and neglect of the environment can intensify or, alternatively, decrease the degree of damage (Renaud et al., 2011). One prominent example of short-term climatic events is Hurricane Katrina, which caused the eviction of one and a half million people from their homes (Groen, and Polivka, 2010), and Hurricane Mitch, that affected two million people, temporarily displacing them (Naik et al., 2007; Oliver-Smith, 2009). Such events undermine people's sense of security while increasing a sense of fragility. Short, sudden, and dramatic disastrous events receive wide media coverage and a rapid, comprehensive response (Renaud et al., 2011; University of Adelaide et al., 2009).

Gradual, long-term climatic events are commonly measured in years. Examples of such climatic events are rises and falls in sea levels; prolonged droughts that instigate desertification processes; land, soil, and water degradation; melting glaciers, etc. Most researchers agree that there is an association between gradual climate changes and mass migration (Renaud et al., 2011), and that gradual, long-term climatic events, such as droughts and heat waves, might become more prevalent in the coming years (Hunter et al., 2013; Wongtanachai et al., 2013). Yet there is still no scholarly consensus as to the duration and intensity levels that are necessary for climatic anomalies to effect social changes, the association between climatic events of this kind and global warming, or the magnitude of their potential social impact.

Gradual, long-term events are particularly hard to define because their particular location, onset, and ending dates cannot be accurately determined. Initially, long-term climatic events seem like routine and short-term fluctuations, making it difficult to conclude when they first started influencing specific areas and people's lives. Often, we learn of a gradual long-term event in retrospect, once damage has already been done, and causation seems less trivial.

The social impact of long-term climatic event can be abrupt, once a process reaches a threshold, or moderate. A rise in sea levels, for example, is the result of a prolonged process that can cause substantial gradual and sudden damages (Nicholls et al., 2007). Rising sea levels can cause a steady depletion of resources upon which a coastal community relies (Renaud et al., 2011), or it can cause immediate and abrupt damages as tidal waves reach further into the shore, enabling storm surges to damage important coastal infrastructures, such as roads, sewage treatment facilities, gas pipes, etc. (Nordhaus, 2010).

A study that viewed climate-induced migration processes in Pakistan over a period of 21 years found that while gradual, less conspicuous, and undramatic climatic events, such as heat waves, generally have greater impact, short-term climatic events in fact govern the public discourse on all matters concerning climatic crises, swaying policy and receiving more public resources. This is due to the higher visibility of short-term climatic events and the urgent need to allocate resources following short-term climatic crises. Results further show that while assistance resources were mostly allocated in instances of flood crises—events that also focused public attention—floods were found to have only marginal impact on migration over time. Heat waves, which are gradual and less distinct climatic events, were found to have significant impact on immigration over time (Bohra-Mishra et al., 2014); and researchers concluded that the down-turn in Pakistan's economic status and the declining incomes of both rural and non-farm population is an intertwining mechanism between heat waves and immigration processes (Mueller et al., 2014).

It is our contention that the common definitions of a climatic event as either gradual and long-term or short-term are relative and context dependent. It is impossible to determine whether a climatic anomaly that lasted only a few years is either "short" or "gradual". In order to grasp the meaning of duration—a by-product of, primarily, the extent of the impact and intensity of the climatic event—one has to better understand social processes and the way social structures and physical surroundings were impacted.

Ecologist Melinda Smith, in a 2011 article that reviewed climate extremes and their impact on ecological dynamics, proposes a definition for "extreme climatic events". In order to define an event that has "extremeness" to it, Smith argues, one has to consider both the physical aspect of the event (the "driver") and the change it caused (the "response") to the ecosystem or its functioning. Specific climatic parameters, such as temperature, precipitation, etc., are used to measure statistically the event's level of extremeness as "driver": an extreme climatic event will appear in the tails of the statistical distribution—assuming there is sufficient climate data. Observational tools, such as changes in species abundance in the afflicted area, loss of key species or invasion of new species, should be used to evaluate the extremeness levels of the event's impact, that is, its response. Smith further suggests that the response to an extreme climatic event is likely to entail a period of deep changes and a prolonged recovery of the ecological system (Smith, 2011).

Studies that propose appropriate policies for dealing with climate changes similarly distinguish the climatic event itself, and its characteristics, from the impact it has. A comprehensive scientific report by the US National Research Committee, for example, assesses the impact of climate change on social stress and security levels, focusing on the term "abrupt climate change". Significantly, in trying to define the nature of 'abrupt climate change', researchers note that "[e]ven a gradual forcing of a system with naturally occurring and chaotic variability can cause some part of the system to cross a threshold, triggering an abrupt change". Researchers further suggest that "it is likely that gradual or monotonic forcing increase the probability of an abrupt change occurring" (National Research Council, 2013: p. 26). It follows that abrupt and meaningful changes can be the result of gradual and even monotonic climate events.

Addressing the parameter of duration, the report states that an "[a]brupt climate change is generally defined as occurring when some part of the climate system passes a threshold or tipping

point resulting in a rapid change". Yet while the report emphasizes the rapid progression of climatic events, it is argued that the event "produces a new state lasting decades or longer", (National Research Council, 2013: p. 26), suggesting that, while the climatic event is brief, it generates a prolonged response. We agree with the observation that climatic events and social transformations are two inseparable parts of a single process, and that in order to determine whether a specific climatic event can instigate deep social changes, one has to consider both.

Historical perspective

What is the necessary timespan for a climate event to bring about structural changes? Many historians have engaged with this question since the 1950s. The idea of a "total history" was first developed by the Annales school, especially by Fernand Braudel, to link the lengths of time in which social, cultural, and economic processes occur, and the speed and type of changes that take place during them. Total history refers to a wide variety of patterns of change that extend over different timespans: short-lived *évènements*, whose duration and rate of change last between a few hours to a few months; cyclical and conjunctural phenomena (*conjonctures*) whose duration, effect, and changes last for decades; and long-term (*longue durée*) phenomena whose duration and rate of change lasts for centuries, sometimes even for millennia. The theory of total history criticizes the positivist conception of time and the preoccupation with dramatic and singular events as the main key to examining the historical past. Emphasizing such events, it is argued, turns the writing of history into an infinite list of important dates that disregards significant structural developments. Events of this kind left their mark on contemporaries due to their dramatic character, but their historical importance could derive only from their contribution to deep changes in social structures.

The conjunctural timespan refers to phenomena whose duration, like the societal changes that occur during them, lasts between a few decades to a century, such as demographic changes, price fluctuations, trends of economic growth and collapse, and the like. The Annales school, however, particularly emphasized the *longue durée*, in which structural phenomena that had existed almost unchanging for centuries, undergo transition. In this context Braudel refers also to nature and changes made to it (diversion of rivers, deforestation, etc.), to technologies of transportation and communication, forms of dress, architecture, religious ritual, collective mentalities, social stratification, and the like (Braudel, 1958).

The time spans presented in this paper are different from the broad brushstrokes used by the advocates of the longue durée theory, and they are based on the length of human life spans. History happens in real time and among real people, and a decade is a long period in the life span of individuals and societies. Longue durée-type discussions teach us that in the long run, most societies are able to overcome crises, and perhaps in the very long run every period of affluence comes to an end. However, such time spans are meaningless in the lives of an individual, a village, a society, and sometimes even an entire civilization. In this context, it is perhaps not superfluous to return to John Maynard Keynes' well-known dictum: "[The] long run is a misleading guide to current affairs. In the long run we are all dead" (Keynes, 1923: p. 80).

The effect of food crises or a pandemic on nutritional security; the awareness of fragility; the level of violence; the degree of influence of extreme religious groups; the willingness to carry out violent political coups; and the desire or need to emigrate from one's home: all should be examined in a time-span that is relevant to a human life span, ranging between less than a year to a decade or two. This is a very short duration in historical terms, one which is very difficult to follow in the experimental proxy data of past climatic events, whose margin of error for measurements is, in most cases, greater than one or two decades. Crises that last a decade or two may derive indirectly from global warming or cooling, but they are not the direct result of incremental warming (at the rate of fragments of a degree annually), nor are they the result of one-time disasters such as tropical storms, that can indeed cause significant loss of life and property but have limited influence on the way of life of societies or on the structural fabric of complex civilizations. The anomalies that most affect the fate of human societies do so thorough changes in food availability. Droughts, cold spells, untimely rains– all are extended climate anomalies that impact the availability of food and can have disastrous long-term consequences. We illustrate this argument with a review of two historical case studies: the first deals with the climate crisis that hit northern China in the late eleventh and twelfth centuries (Li et al., 2019). The second analyses the climate crisis and its effects on the complex societies of western Asia in the eleventh century (Ellenblum, 2012). During the climatic crises that hit western Asia and northern China in the aforesaid periods, these regions underwent significant political changes, such as the collapse of the Ikhshidids and the rise of the Fatimid dynasty, the collapse of the Liao dynasty in northern China or the fall of the Macedonian dynasty in Byzantium.

The Liao dynasty ruled over one of the most formidable empires of the medieval world, encompassing a large expanse of northern China and reaching its peak in the early eleventh century (see Fig. 1). The empire was founded by the Khitan (Chinese: Qidan) people, semi-nomadic pastoralists who inhabited areas of northwest China and eastern Mongolia from the fourth century CE. During the political vacuum that followed the demise of the Tang dynasty they established the Liao dynasty, that controlled a very large area of north China, Manchuria, and Mongolia. The Liao state was divided into five circuits. The upper-north circuit was the political and religious center, identified with the origins of the Khitan people. The eastern and middle ones were important economic centers of the dynasty and the home of non-Han tribes, including Bohai and Jurchen. The southern circuit was the home of the Han (Chinese) people and the main grain producer for the Liao. Finally, the western-capital circuit established in 1044 as a military and transportation junction (Hansen, 2018; Li et al., 2019).

During the first half of the eleventh century, the Liao experienced conflicts with its neighbors, the Chinese Song dynasty to the south and the Tangut Western Xia dynasty to their west, yet, following agreements, most of the conflicts were resolved. Thus, from the 1050s, the Liao ensured the dynasty's geopolitical position in the area. Against this background, the collapse of the Liao a few decades later (1125) seems to have been especially fast and dramatic.

The historical evidence depicts this collapse as the result of a rapidly escalating minor disagreement between the Liao and their Jurchen vassal tribes that started in the winter of 1112. Within 10 years of this dispute, the previously unorganized Jurchen tribes united, then annihilated the Liao, pushed the Song southwards and founded the Jin dynasty (1115–1234) (Li et al., 2019).

Most of the modern historical reasoning for the collapse of the Liao view their military decline purely within a political context—the weakness and incompetence of the Liao emperors. However, in our view, these explanations do not present the whole picture. We argue that the events occurred in the context of intense climatic instability in the region. The rapid unification of the Jurchen and their urge to move southward, we believe, was caused by frequent, extensive cold anomalies that were devastating for the nomadic Jurchen tribes.

Fig. 1 Map of East Asia during the eleventh century CE. The Liao Empire (in green) and its neigboring political entities – Westeren Xia (red) and Northern Song (yellow).

Our explanation is based on a thorough and systematic reading of the dynastic history of the Liao (the *Liao Shi*), supplemented with relevant data recorded in the dynastic history of the Jin (the *Jin Shi*). A previous study has encoded and charted indications of climatic-environmental stress (including apparent climatic disasters and abrupt increases in food prices, food riots, and large-scale migrations) (Li et al., 2019). This study revealed an unusual concentration of well-documented climatic anomalies, including extended droughts but especially strong cold spells (known as *dzud* in Mongolian), associated with the global climatic event known as the Medieval Climate Anomaly (MCA) (Li et al., 2019). These anomalies are at the core of our understanding of this turbulent period during the twelfth century, especially the two decades that preceded the collapse of the Liao.

As shown in Fig. 2, the first 80 years of the Liao dynasty enjoyed stable climatic conditions. The critical years in the history of the Liao can be divided into two periods: The first period of climatic anomalies and societal responses to them occurred between c. 980 and 1030, when the Liao dynasty was able to cope with natural challenges through political, diplomatic, and agricultural means.

As Fig. 2 shows, many of the climatic anomalies during this period were droughts and floods that affected agricultural productivity in the eastern and central capital circuits, but they were not strong enough to destabilize the Liao system. The Liao reaction to the shortage of food was a more intensive involvement of the government in relief and welfare activity. The Liao built granaries for emergency relief, decreased taxes, repaired public buildings, and improved transportation facilities. The second period, from 1066 to 1130, experienced stronger and longer climatic anomalies requiring more intensive governmental intervention. The later years from 1109 to 1116 and 1125 to 1127 show evidence of extremely lengthy cold anomalies (Fig. 3).

In fact, ten of the sixteen reports of extraordinary cold anomalies recorded between 901 and 1130 occurred between 1109 and 1127. Droughts were also recorded in 1109, 1113, 1119/20, and 1123. The combination of droughts, floods, and cold anomalies severely limited the agricultural production of the southern and eastern Liao state, leading to the dearth and famine reflected in the frequent reports of governmental relief efforts. The cold anomalies had especially dramatic effect on the Jurchen tribes who lived in very northern areas of present-day China's Heilongjiang province and southeastern Siberia. Repeating cold anomalies disturbed the ecological equilibrium of the Jurchens and compel them to unite and push southwards. The Liao, themselves struggling to cope with the magnitude of the many climate-induced stresses, were unable to overcome the invasion of the highly motivated Jurchens (Fig. 3).

The Nile River and the extensive agriculture in the Nile Valley made Egypt an important grain supplier of the Greek, Roman, and Byzantine worlds in antiquity and the Middle Ages. The rise of the Nile was the main factor responsible for the crops' success and it has been consistently measured and documented each year for millenia (Ellenblum, 2012: pp. 24–25). The level of the Nile's rise was officially announced at the beginning of the agricultural year, the Coptic New Year in September. The extent of the rise of the Nile largely determined the success of that year's crops and the expected food supply to Egypt and the entire eastern Mediterranean region (Ellenblum, 2012: pp. 23–31). The climatic system of the monsoons in East Africa and the precipitation of the Ethiopian plateau are primarily responsible for the degree of the rise of the Nile each year. This climatic system is separate and independent from the Mediterranean system. As a result, the Nile Valley served as a shock absorber, securing a minimal amount of grain supply when famines hit other regions of the eastern Mediterranean. A combination of droughts both in the eastern

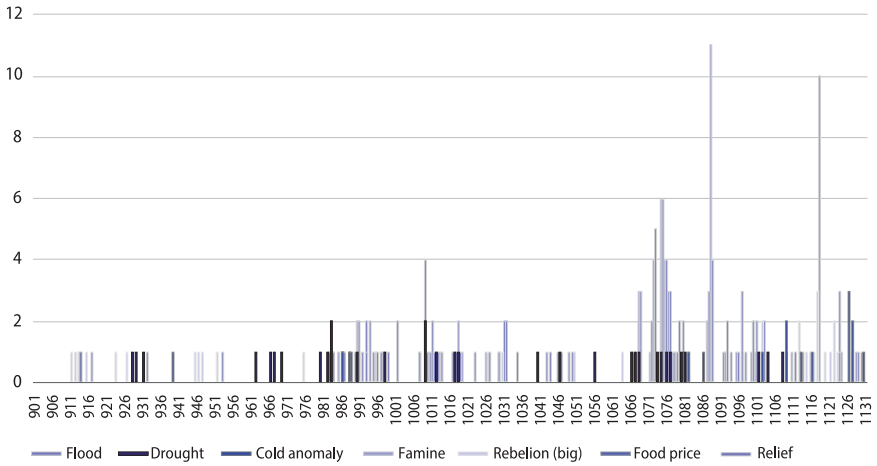

Fig. 2 Climate and societal anomalies during the Liao period. The numbers on the *y*-axis assigned to each event according to its magnitude. From: Li et al., 2019.

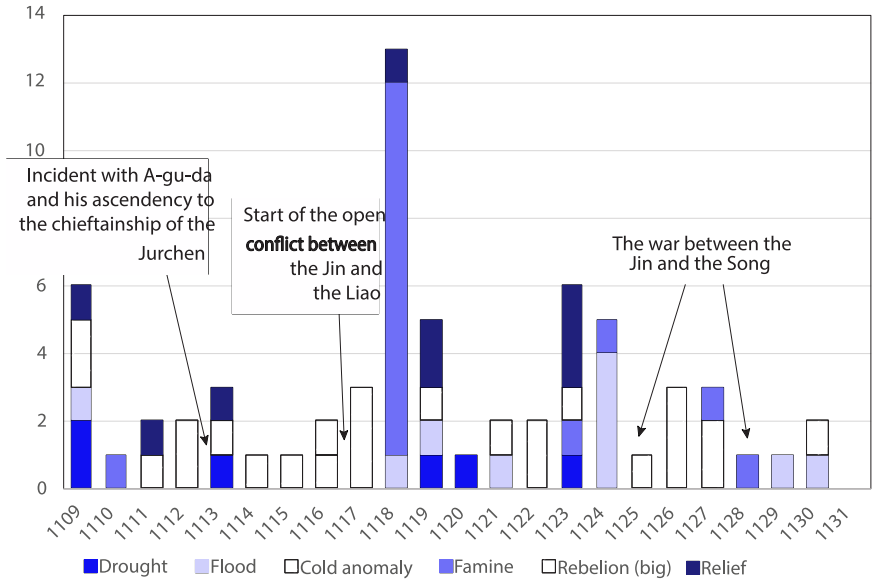

Fig. 3 Intense cold spells and the political events that led to the collapse of the Liao and Northern Song. From: Li et al., 2019.

Mediterranean and in East Africa is a relatively rare occurrence. Still, in the tenth and eleventh centuries, an accumulation of droughts occurred in both regions (Ellenblum, 2012).

The droughts that afflicted Egypt during the tenth and eleventh centuries—some lasting 6 or 7 years—can exemplify the significance and intensity of crises that, like the Liao case discussed above, are not "short" in the regular definition of climatic events but are also not very long-term. Our analysis is based on the precisely dated documents of the Genizah and the yearly records of the Nile's rise. Such data supports our argument that one decade is sufficient to instigate deep structural processes.

The Fatimid dynasty that ruled Egypt in the tenth and eleventh centuries was endowed with high management and planning abilities. The Fatimids came to power after the collapse of the Ikhshidid dynasty, which was also considered an efficient administration, but was severely damaged by six consecutive drought years between 963 and 969 (Ellenblum, 2012: pp. 41–49). The first two things the Fatimids did after their conquest of Egypt in 969 was to bring grain shipments from the western Mediterranean and to appoint a special government official to oversee the grain market (*muḥtasib*). His role was to prevent private and illegal storage of grain, to monitor grain prices, to punish millers and traders who harmed the market, and to plan special areas designated for grain markets (Ellenblum, 2021: pp. 41–49).

In the 1020s, after another series of consecutive drought years in the Nile, the Fatimid regime still attempted to prevent famine by efficient and close management of grain supply. Fatimid caliph al-Ẓāhir blamed his *muḥtasib* for the deterioration. He fired him and ordered the opening of 150 granaries and the sale of their content to millers and bakers at fixed and supervised prices. In addition, he ordered the confiscation of all ships that brought grain from Upper Egypt to Lower Egypt and took over the direct management of the grain reserves. All these actions were to no avail, and the drought and subsequent plague intensified and spread to nearby areas. The army was also affected by the shortage and raided the city of Fusṭāṭ and joined nomadic forces raiding the cities of Tinnīn, Ashmūnayn, and the pilgrim caravan to Mecca. After another year of drought, the crisis ended only when the Nile finally rose (Ellenblum, 2021: pp. 138–139.).

The sequence of 7 years of droughts in 1065–72 and the famine that followed was another peak in the dynasty's series of crises. The attempts by the authorities to alleviate the famine failed, probably due to the rate and sequence of years of drought that did

Table 1 Drought years in the Nile basin during the tenth and eleventh centuries compared to the number of pre-crisis drought years.

Between 383 and 950 CE, there were 11 years of drought in the Nile basin, on average one drought year every 60 years.		Between 950 and 1072 CE there were 27 years of drought in the Nile basin, on average one drought year every 4 years.	
346	One drought year	949	One drought year
385-383	Two drought years	954-955	Two drought years
463	One drought year	969-963	Six drought years
516-515	Two drought years	997	One drought year
645	One drought year	1005-1004	Two drought years
706	One drought year	1009-1008	Two drought years
715	Supposedly one drought year	1026-1023	Three drought years
745	One drought year	1056-1052	Four drought years
834	Supposedly one drought year	1072-1065	Seven drought years

From Ellenblum, 2012.

not allow a sufficient gap of time to accumulate food and prepare for the next crisis (Chipman et al., 2021).

The table below (Table 1) shows that, during the tenth and eleventh centuries, the average number of droughts along the Nile was more than fifteen time the number of droughts in the years that preceded the crisis. Several sequences of drought, lasting 4, 6, and even 7 years, occurred during the crisis—the severity of two of which was of Biblical proportions. The area experienced shorter drought events that lasted 2 or 3 years, and there were also extensive periods, for example between 1027 and 1052, when Egypt enjoyed prosperity and abundance as the Nile's levels rose sufficiently.

Are 7 consecutive years in which the Nile does not rise such a rare and harsh event? The answer, so it seems, is positive. The consecutive droughts during the tenth and eleventh centuries are the only historically documented cases whose records reference the destructive impact of prolonged drought. That said, there are semi-mythological narratives, such as the story of Joseph (Genesis 41, also mentioned in Surat Yusuf, Sura 12 of the Quran) and the inscription on the Famine Stele,[2] that mention seven consecutive years in which the Nile's water levels did not rise. This period is depicted as epically disastrous, and only a prolonged preparatory process on the part of the authorities served as an effective mechanism for dealing with the crisis.

Viewing these two historical case studies, it is evident that each was comprised of events that individually were of ordinary scale but whose accumulative affect, over several years, catalyzed socio-political change.

Each small-scale crisis caused food shortages that are well-documented in the written sources, and the destabilization of food security was accompanied by political volatility. When the untimely rainfalls and cold spells ceased, food prices returned to their previous levels and life returned to normal. The intensity of the crisis did not, therefore, stem from each of the small-scale crises separately, but was due to their cumulative affect in a relatively short time: the short time periods that elapsed between one crisis episode and another, interfered with food and water availability and often lead to famine. Brief intervals or very intense anomalies prevented the authorities from properly preparing for the next crisis, and even preventing it. Written sources indicate that food scarcity instigated social processes, which later compromised the resilience of these societies.

In recent years, many studies have examined the resilience of past and present societies in the face of climate crises through their food systems. These studies highlighted the differences between the ability of different societies to cope with crises as a result of their various agro-environmental systems, structural organization and culture (Adamson et al., 2018; Fraser, 2007; Hannaford, 2018; Holling and Gunderson, 2002: pp. 25–62; Nelson et al., 2016; van Bavel et al., 2020). Although we agree with the great importance of these parameters for analyzing the relationship between climate crises and human societies (see Ellenblum, 2012; Chipman et al., 2021; Li et al., 2019; Ellenblum, 2021), in this article we focus on the climate events themselves and the time frame in which they appear—their duration, extremeness levels, and type.

To conclude this historic chapter, we argue that an extreme climatic event is an event whose impact on a society—its food security, social stability, etc.—is comprehensive, prolonged, and significant. In order to further strengthen the validity and relevance of our methodological approach to understanding the association between gradual, long-term events and social processes, we use the same methodology to examine of the war that took place in Mali between 2011–2013 and the climatic crises affecting the area. The date available for this case study, which is not usually available for historical case studies, enabled us to analyze it in high resolution and with large quantities of real-time data.

The War in Mali (2012–2013)

In the 1990s, following the transition to a democratic regime, Mali enjoyed relative stability (Harmon, 2014; Lebovich, 2013; Radelet, 2010). Thus, the conflict that erupted in 2012 as a national uprising of the Tuareg group and escalated into the war was unpredicted (for a map of Mali and the area where the conflict took place, see Fig. 4).

While many studies conducted within the framework of classical disciplines (political science, IHB, security studies, etc.) have dealt with the violent processes in Mali, most explore the social, economic, and political relationships within Malian territory or the geopolitics of Africa's northern and western regions (Harmon, 2014; Thurston and Lebovich, 2013). We argue that an important component missing form those studies is the climatic context and how climatic conditions affected the social and political upheaval.

To address our research questions, we compiled an extensive database from a period of one decade (2005–2019), including quantitative-observational data (temperatures, drought indices, precipitation, etc.) and qualitative data—reports and surveys that unfold the extent, nature, and characteristics of the climatic impact on various social groups in Mali and political upheavals in Mali for the period of 2008–2014. Our analysis of the data is presented in Fig. 5.

Main results. As the chart clearly indicates, 2012 is the year in which the violent conflict reached its apogee. It is when most central events occurred and therefore it is the year in which the conflict evolved from a limited, secular Malian revolt by the Tuareg tribal group to a widespread religious war that involved international players and with broad implications, such as the waves of immigration to Europe that followed. Our analysis suggests that, along with other factors within Mali's regional and national arenas that matured at the beginning of 2012, the **climate factor**, referring to the droughts that hit Northern Mali in 2009–2010, the exceptionally high temperatures measured during the spring months of 2011, and the **availability of food** had a central role in triggering, cultivating and escalating Mali's violent conflict. Our analysis suggests that during the period in question, the prevailing climate conditions affected two main arenas, the

Fig. 4 Map of modern Mali. The northern part (in orange) is the main area where the conflict took place.

civilian and the military, therefore shaping the dynamic of the violent conflict in the following manner:

In the **civilian arena**, the decrease in the amount of food, especially amongst the northern nomadic and pastoralist population, had made these groups particularly vulnerable. Most of the food reserves of Mali's nomadic and pastoralist households depend on the condition and size of their herds and grain reserves for the dry season, and, naturally, those depend on the climate conditions of the previous year or two. Owing to the droughts of 2009 and 2010, and the high temperatures that characterized the spring months of 2011, many met the spring months of 2012 in a particularly unprotected state and with diminished food reserves. The escalation of the food crisis into violent conflict and then into a war was hastened during the spring and summer months of 2012 due to the heavy rains and the government's inability to repair the damages caused by them. Road infrastructures were damaged, thus disrupting the local food supply system and preventing assistance from southern Mali. The rainy summer of 2012 and the floods that hit northern crops added to the sense of food insecurity, price rises and citizens' general state of vulnerability. The northern population initially migrated internally to Mali's southern cities, and, later, to neighboring countries and to Europe.

In the **military arena**, the rising levels of food insecurity and the drought-induced precarious economic state intensified the northerners' social unrest against the central government, increasing the formers' motivation to instigate a revolt. (For studies on a similar mechanism and the relationship between climatic events and conflicts, see Cederman et al., 2013; Chassang and Miquel, 2009; Jia, 2014; Koubi et al., 2018; Prediger et al., 2014). Our analysis also suggests that the second, more violent, stage of the conflict was influenced by the expedited collapse of the central government in North Mali and the chaos this created during the spring and summer of 2012. The demonstrations of February 2012 were followed by the coup of March 21–22 and by the violent suppression of a rebellion on June 12 in the city of Kidal, which was already governed by the Islamists. In our view, these extreme political events may be considered to be the outcome of the climatic anomalies and the decreased food security, which this caused in northern Mali, prior to the outbreak of the conflict.

In contrast to research dealing with a climate-society relationship in historical cases, research dealing with contemporary examples is saturated with available and accurate data. Taking advantage of this, much of the research in the last few years implements statistical methods, emphasizing large-N statistical analysis (Ide, 2017). Although in recent years statistical research in the field has progressed greatly (von Uexkull and Buhaug, 2021), it is still limited in its ability to fully explain the causal connections between climate and conflicts (Buhaug, 2015; Degroot et al., 2021; Ide, 2017). The analysis of the case of Mali presented here may not prove beyond any doubt a causal link between climatic conditions and socio-political unrest. However, it presents a diachronic analysis that cross-references various resources, thus contextualizing societal processes within a broader climatic perspective. This perspective draws on the historical fragility theory—the theoretical framework underlying this article (Ellenblum, 2021).

Studies that explore the violent conflict in Mali during the 1990s and address the droughts that occurred in Mali during the 1970s and 1980s, view the effect of climate crises over a period of 5 to 15 years. Our study shows that the influence of the droughts

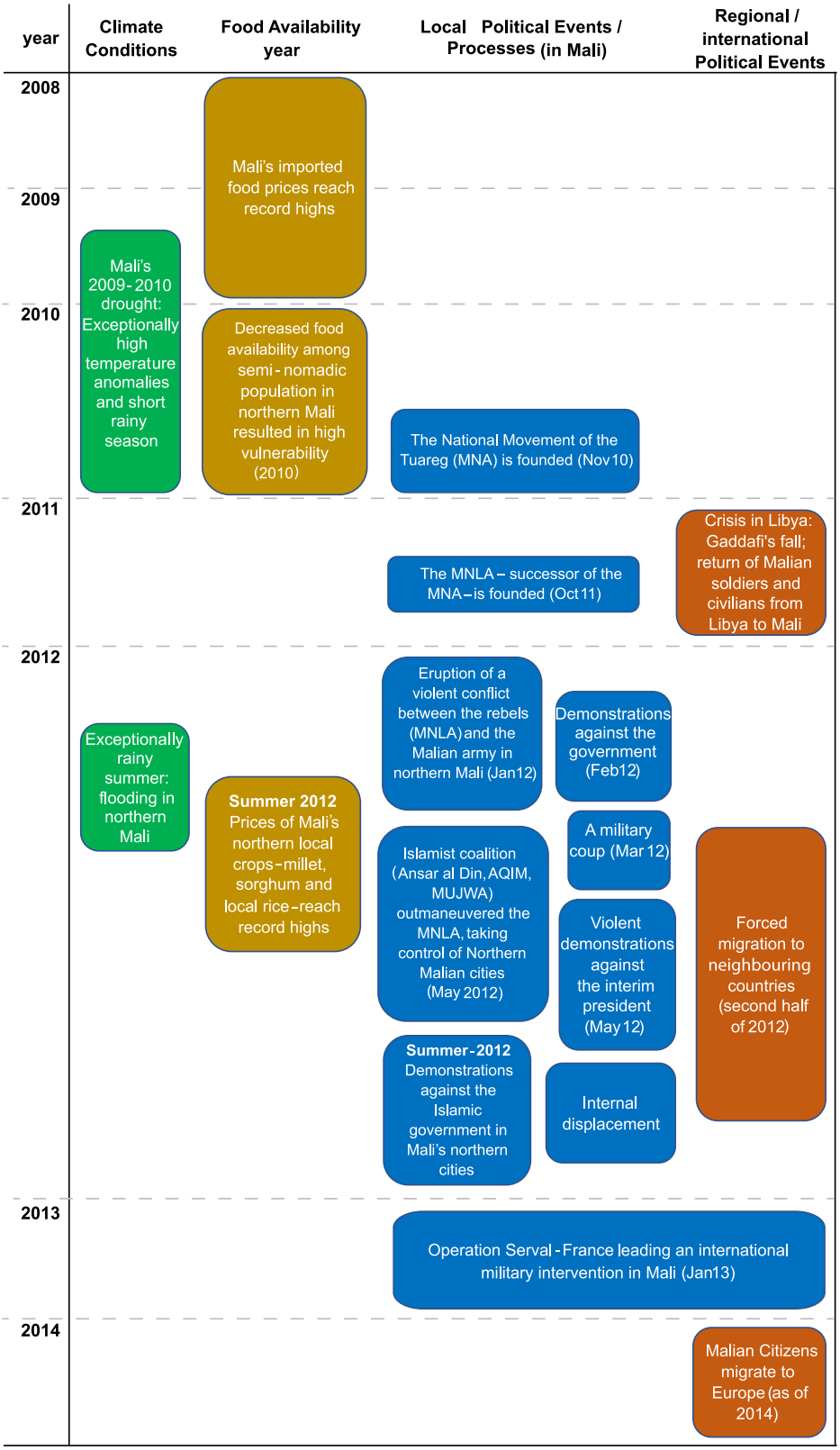

Fig. 5 Sequence of major events that took place in Mali circa the 2012–2013 conflict. The left vertical bar represents a timeline for the period 2008–2014 and lists the conditions and main events that occurred within this timeframe. The other columns are divided into subjects: climate conditions (green), food prices (brown), local events and processes that took place in Mali (blue) and abroad (red).

on Mali's 2011–2013 conflict spread over a shorter period of 1 to 2 years. We, therefore, propose that a timeframe for addressing our research question ranges from several years to a decade.

Discussion

This essay proposes a methodological approach updating those of Smith (2011) and the National Research Committee (2013), who suggested that the level of extremeness of a climatic event afflicting human societies does not derive solely from its rarity and intensity, but also, and to no lesser extent, from the extent of the damage it inflicts and its long-term effect on human societies. In this context, we reference the theme of the extraordinary and the usual, the axes of the current collection of essays, and argue that events that are perceived as normal and recurring, like droughts (which in themselves are not uncommon in the areas in which our research focused) can, when they accumulate critical mass, be a catalyst for extraordinary and dramatic events (civil war, large-scale migration, etc.). Moreover, it is conceivable that even the long-term impact of what at first glance seems to be an unusual event (such as a hurricane) is less unusual, compared to the effects of events that superficially seem normal.

We argue that one of the main criteria for evaluating the impact of a climatic event is the level of its impact on food availability. We performed a qualitative examination, based on historical documentation, of collapse periods in western Asia and northern China during the eleventh and early twelfth centuries, and a high-resolution re-examination of the crisis in Mali at the beginning of the 2010s. We conclude that extreme and short-term climatic events, such as tropical storms, as well as dramatic natural disasters, such as tsunamis and earthquakes, hinder food availability, and yet, because they are single events, they do not change the economic structure, nor do they have long-term impacts on food security, and the damages they inflict can be immediately quantified and, to some extent, repaired. Prolonged droughts, however, having no foreseeable ending, can cause cumulative damage that has severe impact on food security. Similarly, cold waves or prolonged periods of untimely rains can cause extensive damage, as crops are left to rot in the fields.

Our analysis of the three case studies suggests that continuous damage—that is, a climatic anomaly that lasts 2 consecutive years or more—turns droughts, unseasonal rains, or exceptionally harsh winters, into extreme climatic events that impact food security levels and can push societies beyond their resilience threshold. A food crisis starting from an extended climate anomaly can intensify societal fragility, instigating social unrest that can cause deep and dramatic social changes with long-term implications: individuals, communities and even entire countries can experience a declining sense of security. People then tend to look for scapegoats in the form of central governments, minorities, other religious groups, etc. Massive immigration waves, internal struggles and wars are also direct results of food insecurity, although more gradual than immediate.

It is our contention that due to the immense primal and elementary impact climate has on food availability—in terms of both quality and quantities—food becomes a significant, perhaps even the most significant, variable influencing human behaviors in marginal areas. In this sense also, the ordinary (food) is transformed into extraordinary (socio-political upheaval). The scholarly reluctance to thoroughly consider the food variable, and the academic demand that all available variables be addressed at all times, mean that we often ignore an entire stratum of possible associations between climate and society, therefore finding it difficult to understand meaningful social changes and transformations.

Conclusion

The three cases we presented can explain how irregular climatic events, lasting one decade or two, and, on occasion, even less than a decade, can develop into social crises that leave their mark on society even once the intensity of the catalyst, the climatic event, lessens. Each crisis originated from a climatic event, and each climatic event was carefully depicted in various sources. By tracing such detailed depictions, we can reconstruct the climatic events that generated social crises. More importantly, however, we can also trace the social processes that followed, and which pushed societies to, and even over, the threshold of their resilience, resulting in social decline and even collapse of past societies. Of the crises we reviewed, food availability is the variable that pushed societies to their threshold of resilience. Food scarcity is the variable linking climatic anomalies and political, economic, and social processes that lead to structural changes. Prolonged droughts, excess rainfall or untimely rains, extensive floods, and cold spells—all disastrous climatic events—caused a sudden decrease in food availability and a steep rise in food prices.

Our review of the three crises suggests that a decrease in food availability for a period of a few consecutive years had great, and unusual, long-term effects on the entire society. Such gradual declines in fact had a more substantial and extraordinary societal impact than did powerful, short-term, one-time climatic events, whose impact on food reserves and food security was limited. The association between climate changes and depletion of food reserves might therefore prove beneficial in addressing the question "what is an extreme climatic event?"

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the reasons described in the postscript but are available from the corresponding author on reasonable request.

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Notes

1 For additional models and approaches that emphasize the different types of "resilience," see (Holling and Gunderson 2002: pp. 27–31); the cup and ball model (Carpenter et al., 1999; Carpenter and Cottingham 1997; Scheffer et al., 1993); and "adaptive capacity" (Gunderson, 2000).

2 The Famine Stele was discovered in 1887 by British Egyptologist Flinders Petrie, on an island south of the city of Aswan in Upper Egypt. The Famine Stele was inscribed by the end of the third century or beginning of the second century BCE, yet it refers to a distant event that took place, according to the inscription, 2500 years before the inscription was made: seven consecutive years of drought and famine that supposedly occurred during the reign of King Djoser, in the first half of the twenty-seventh century BCE. The inscription depicts the king's concerns and the rage and agony of his people facing the upcoming disaster.

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Competing interests

The authors declare no competing interests.

Additional information

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