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# Climate and famines: a historical reassessment

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This study, dealing with the question of the impact of climate and extreme weather events on famines, has two objectives. The first objective is to review recent literature on the topic, distinguishing between economic and political science papers aimed at addressing contemporary famine events in the Third World countries, and historical research dealing with famines of the past. The former category of literature is characterized by a tendency to take the connection between the two variables for granted. The latter category, however, tends to exercise more analytical caution, but it still exhibits a degree of environmental determinism. The second objective of the article is to reassess the role and impact of climate and short-term weather anomalies on famines in pre-Industrial societies, in both European and non-European history. At first, it appears that famines went invariably hand-in-hand with climatic changes and anomalies. A closer analysis, however, reveals that those climatic events created environmental shocks (harvest failures and blights), which implied shortages, rather than famines. Whether those shortages were bound to transform into full-fledged famines was determined by nonenvironmental factors: primarily, human institutions and demographic trends. Climate alone, it is argued, is incapable of creating famines. The often unquestioned connection between the two variables appears to be an imaginary cultural and political construct of our era, when the fear of global warming and the awareness of climate change dominate the public and scholarly discourse. 

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## FAMINES AND FOOD SHORTAGES: SOME CATEGORICAL CLARIFICATIONS

Despite fast growing corpus of scholarly literature, famine remains arguably one of the most contested topics among historians, development economists, political scientists, sociologists, anthropologists, and biologists. One controversial, and still much underappreciated and badly misunderstood question is 'What creates famine?' Roughly speaking, there are three main schools of thought. The first approach, pioneered by Nobel Laureate Amartya Sen in his classic monograph *Poverty and Famines*, blames humans, human decisions, and institutions in creating famines, by misallocating the scarce food resources and denying the poor masses of their basic entitlements for food.[1] Despite some criticism, the 'institutionalist' approach remains highly influential.[2–4] The other major school of thought sees demographic trends as a primary force regulating the levels of food supply. This view goes back to Malthus's *Essay on the Principle of Population* (1798) and regards famines, alongside with wars and diseases, as a 'providential' or 'positive' check preventing the population from exceeding the available

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landed resources.[5] This approach is especially valid in the case of pre-Industrial societies, in which the population levels and the sheer volume of available food are usually negatively correlated. Finally, there is the 'environmentalist' approach, which revolves around the idea that Nature is the primary trigger of famine conditions, through climatic anomalies and biological shocks.[6]

Although all three approaches deserve analytical treatment, I shall confine the discussion primarily to the connection between climate and food supply. To avoid some potential confusion, some categorical and terminological clarification is required. Firstly, it is essential to distinguish between 'famine' and 'food shortage,' each representing a different degree of severity of subsistence crisis.[7] Although the definition of 'famine' can be fluid and varying across schools of thought and disciplines, it would not be too inaccurate to define it as *a condition of collective starvation occurring in years/periods of extreme and omnipresent deficiency of food resources, in relation to the sheer levels of population*. 'Food shortage,' however, is understood here as *localized and partial deficiency of food resources*. Secondly, it is important to distinguish between *real* and *artificial* deficiency of food. *Real* deficiency is objective unavailability/nonexistence of food supply, while *artificial* deficiency is created by intentional displacement of food resources from place A/group A to/by place B/group B. As a result, place A/group A loses its entitlement to food resources and thus, 'artificial' deficiency is created.[1] To a large degree, the distinction between *real* and *artificial* deficiency overlap with Sen's contrast between the 'Food Availability Decline' (FAD) and 'Food Entitlement Decline' (FED). Obviously, one cannot talk about 'food shortage' as a uniform phenomenon: the degree and intensity of food shortage can vary pronouncedly across space and time, and some theorists and historians define an 'instrumental' scale of food shortage magnitude.[8]

One important distinction between famine and food shortage is that famine conditions eventually lead to *excessive* mortality on a *collective* (i.e., regional or national) level, usually resulting from starvation-related diseases. Conversely, food shortages may increase the levels of poverty and depress living standards, but apart from possible instances of individual deaths, overall death excess is unlikely. The longevity of a disaster is another definitional factor. Unlike famine, which may last no more than a few years, the condition of continual food shortage may last for decades, without creating widespread starvation and excessive mortality because of starvation and hunger-related diseases among general populace. Such situation was prevailing in preindustrial societies, especially those suffering from overpopulation and armed conflicts. One good example is northwestern Europe in the first half of the 14th century, and especially England, northern France, and the Low Countries. Thus, in England, where our data on crop yields and commodity prices is by far the most complete, about 20% of annual crop yields stood at 20% below average in 1270 and 1450 and about 4% of harvests stood at 40% below average. Moreover, in the course of that period there were three episodes of several back-to-back harvest failures (1315–1317, 1349–1351, and 1437–1438).[9] In other words, harvest shortfalls were quite common in that period and they were almost invariably related to bad weather and climatic shifts. This implies that the phenomenon of food shortage was common, and this was especially true in the period before the Black Death (1348–1351), when the degree of overpopulation, rural congestion, poverty, and low real wages reached its peak.[10] Yet, in the course of that period, there was only *one* subsistence crisis, which is to be classified as a famine: the Great European Famine of 1315–1317. Similar situation exists today in some countries of the so-called Third World. Of course, there have been some recent instances of proper famines (thus, the 2005–2006 famine of the African Horn, the 2010–2013 crisis in Haiti and the 2011–2012 famine in East Africa), but overall, the prevailing condition is that of food shortage, rather than famine.

## CLIMATE AND SUBSISTENCE CRISES: STUDYING THE PRESENT AND FORECASTING THE FUTURE

Is there a clear connection between climate and subsistence crisis? Or put differently, do short-term anomalies or long-term climatic shifts create subsistence crises? In the context of the Green Revolution, the increasing awareness of the global challenges of Global Warming, and the emergence of various branches of environmental sciences from the late 1960s, there is a growing body of literature looking at this issue from a scholarly perspective. Although born out of the same political, social, and cultural context, there are, roughly speaking, at least two distinctive kinds of scholarship dealing with this question. One approach considers the issue from our *contemporary perspective, within the context of the widespread political and cultural concern about global warming*. There is an abundant literature on

  

the impact of global warming on food security and food shortage of the developing countries of the so-called 'Third World.'[11–13] These authors, natural scientists, political scientists, and economists alike, blame climatic anomalies, such as excessive droughts in sub-Saharan Africa or tropical storms in southeast Asia, for compromising the food security of local populations and creating widespread dearth and famine. In other words, they tend to have an inherent bias toward exogenous causation of natural events. One characteristic of this scholarship is an attempt to use the existing data from the present, to forecast the future. For instance, in 1994 a special issue of *Global Environmental Change* was dedicated to the topic of climate change and global food security. Those studies constructed various economic models predicting the impact of global warming on food crisis in the 21st century, and especially in the low-latitude regions.[14–18] Two years later, there was a publication of an edited volume dealing with the impact of global warming on agriculture and food security in the semi-arid tropics of Africa, Asia, and America.[19] Some predictions are indeed gloomy: according to one forecast, by 2060, sub-Saharan Africa will lose one-third of her agricultural output potential,[20] while another prophecy predicts that by 2100 some African countries might be bereft of their agricultural production altogether.[21,22] To combat the ongoing crisis in the present and prevent the famine in the future, scholars suggest to implement various strategies. Some advocate better institutional policy, based on a fairer and a better-monitored food distribution.[17] Other scholars believe that technological advances in climate control are a key factor in coping with famines.[23]

Similarly, some scholars have drawn our attention to the likely impact of global warming on the spread of infectious diseases of humans. According to this model, crop failures and food shortage compromises the immune system of humans and make them more vulnerable to various pathogens.[24] In other words, those scholars undoubtedly acknowledge that climate change is directly responsible for famine. Humans, however, are not the only victims of climate-induced diseases. As some studies have shown, climate change and extreme weather events can bring about plant diseases, resulting, in turn, in reduced crop production.[25] In 2011, a special issue of *Plant Pathology* was dedicated to the subject of climate change and plant disease, with several studies dealing with the impact of plant diseases, primarily fusarium head blight and mycotoxin, which drastically reduce cereal production in the developing world.[26]

## CLIMATE AND SUBSISTENCE CRISES: STUDYING THE PAST

The second approach is more dynamic, which attempts to study the impact of climate on famines from *a historical perspective*. Here, both historians and social scientists differ in their methodological approach from economists forecasting the state of food security in the future. Instead of economic and econometric models, they rely on historical sources (narrative and statistical) and proxy data, which, combined together, serve the basis for their studies of the past. Interestingly, despite the emergence and expansion of environmental history as a full-fledged historical field from the late 1960s on, historians and *some* social scientists tended to favor endogenous, rather than exogenous interpretations of historical famines and food shortages, for another three decades or so. This is in a sharp contrast with natural scientists and forecasters, who, as we have seen, are biased toward exogenous causation or social consequences of natural events. Thus, in discussing famines, Noble Laureate Robert Fogel went as far as rejecting any other factors (climate included), except entitlement failures.[27] Likewise, Abel[28] and Persson,[29] both economic historians, denied any impact of climate on economic shocks. In fact, the two prevailing explanations until c. 2000 were the Senian theory of entitlements[1,30,31] and demographic pressure.[32] This, in turn, can be explained by the fact that it was not until the late 1990s, and especially the first decade of the 21st century, that the collective awareness of global warming became widespread in both scholarship and media.[33] Naturally, there are several notable exceptions. One environmental historian, who has been exceptionally attentive to the impact of climatic variations on agrarian economy and food shortages in particular, is Christian Pfister, who brought up this topic time and again in several articles in the 1970s and 1980s.[34–37] Pfister was undoubtedly influenced by Emmanuel Le Roy Ladurie, who had pioneered the study of historical climate in his *Times of Feast, Times of Famine*.[38] Hubert Lamb, one of the most prolific and influential historical climatologists of his days, too, stressed the impact of climate and weather anomalies on food supplies in Europe and beyond, in a number of studies in the 1970s, 1980s, and 1990s, sometimes in collaboration with other scholars.[39,126,127]

The real shift, however, came in the early 2000s, when more and more historians and social scientists began paying more consideration to natural factors, climate forces first and foremost, in explaining historical famines. In a sharp contrast with the

  

balanced and nondeterministic views of Pfister and other predecessors, those studies appear to have adopted, more or less, the deterministic views. The first few years were dominated by the studies of non-European famines. Although there is a large body of growing literature, a few examples would suffice. In his quasi-popular (and, to say the least, controversially called) *Late Victorian Holocausts: El Niño Famines and the Making of the New World,* Davis takes a deterministic approach to the roots of European Imperialism and the creation of the so-called 'Third World.' For him, the intensity of El Niño events in the late 19th century created famines across the Pacific and aided Europeans to gain control of their Asian and African colonies.[40] Holmgren and Öberg surveyed historical famines in East Africa in the context of climatic fluctuations, in a long run.[41] Likewise, Damodaran saw drought as the main cause of the Bengalese famines of 1770 and 1897.[42] Finally, Saito made a strong case for the strong correlation between climatic oscillations and famines in Japan, in a very long run (from the 8th to the 19th centuries).[43]

The history of climate and famines in Europe, however, was lagging behind in the 2000s. Two factors, theoretical and practical, may account for that. Firstly, despite some clear oversimplification and generalization, it would not be too far from truth to say that the traditional 'western' (or Eurocentric) perception of European history is that of the rise of a great civilization, made of a cultural symbiosis of Greco-Roman Antiquity, and Christianity, which, despite various challenges, rose to the international dominance in the 15th or 16th centuries and came to dominate other parts of the world in the course of the 19th century. The economic prosperity, resulting from the technological advances and the success of capitalist economy, makes famine inconceivable in today's Western World, to the point that even climate change cannot make it happen. In other words, the Eurocentric narrative is that of might and wealth, rather than vulnerability and poverty. The history of the so-called 'Third World,' on the other hand, is perceived from the viewpoint of stagnation and largely backwardness, where food shortages and famines are still an everyday reality, and local communities are vulnerable to various vagaries of Nature. Famines, therefore, are commonly associated with the 'developing world,' rather than with the so-called 'First World' countries. It is only in recent years that historians of long-term economic development become more and more aware that the economic performance and living standards of many regions in Europe until the early modern period were on par with some developing countries of today.[44] This awareness of long-term economic developments on the one hand and the discovery of the 'once-poor and vulnerable' Europe, on the other, might have invigorated the appreciation of long-term climatic cycles and their impact on food security and food crises. The second reason is purely practical: scholars are more encouraged to work on contemporary famines of the developing world and they are much more likely to receive funding to study the causes of the Haitian famine of 2010–2013 than, say, the Great European Famine of 1315–1317.

Despite this significant historiographic gap, the Eurocentric scholarship was slowly catching up in the 2000s. In his now-classic (yet suffering from factual and conceptual errors) *The Little Ice Age: How Climate Made History, 1300–1850*, Fagan considered all preindustrial famines and major subsistence crises in Europe to be caused by short-term climatic anomalies and long-term climatic changes, within the wider context of the Little Ice Age (LIA).[45] Stothers looked at the biological and economic repercussions of the 1258 volcanic eruption on famine and diseases in Europe and the Middle East.[46] The real paradigm shift, however, came with the publications of Campbell. In his 2010 article, Campbell pointed out the impact of natural forces on food shortages and mortality crises; for him, Nature is a primary historical mover, or 'historical protagonist.'[47] Campbell developed and sharpened his ideas in several subsequent publications, leading to the forthcoming publication of his *Great Transition*.[48] For Campbell, local weather anomalies, which brought about low harvests and consequently famines, were not isolated events, but parts of larger climatic shifts on a global scale. Therefore, to understand regional climatic changes, one needs to appreciate a wider, global context. Besides being major historical contributions, Campbell's works also have a great theoretical merit, because they set up a new analytical framework for economic and environmental historians.

In the same vein, the last two decades saw the emergence of series of studies, stressing the impact of climate or extreme weather events on famine and food crises in Europe and the Middle East. A few examples would suffice. Hoyle studied the 1622–1624 famine in North England, underlying its environmental causes.[49] Newfield drew our attention to the occurrence of early medieval European famines in the context of weather anomalies.[7] White stressed the connection between climatic oscillations of the LIA and food shortages and famines in early modern Ottoman Empire.[50,51] Likewise, Alfani demonstrated the role of the LIA in contributing to famines in early

  

modern Italy.[52,53] Slavin considered the role of the cold and damp weather in creating shortage in fodder resources for domestic animals in the early 14th century.[54] Oram pointed out the decisive role of climatic change in a socioeconomic shift in late-medieval Scotland, which included a series of subsistence crises and marginalization of agricultural production.[55]

As indicated above, those studies focus on historical famines to understand the past, rather than draw conclusions for the future. An altogether different approach is assumed by some scholars, who see historical climate-induced famines as tools to understand the impact of climate on subsistence crises of the present and to prevent famines in the future. For instance, in his 2005 study, Fraser used Ireland's Great Famine (aka, the Potato Blight) of 1845–1852, the El-Niño famines of the late 19th-century in the Pacific and the Ethiopian famines of 1972–1973 and 1983–1985, to identify several common denominators, which can be used to design strategies to cope with food vulnerability in the present and the future.[56]

## DOES CLIMATE *REALLY* CREATE FAMINES?

With global climate change being an omnipresent feature of both the academic and media discourse and with global warming moving to the very center of public environmental awareness, the link between climate and food availability becomes unquestioned and unchallenged. When talking about famine, pointing the finger at climate appears as a new fashion, shared by scholars, journalists, public intellectuals, and policy makers. The result is quite obvious: the public takes the connection for granted and adhere to the dogma of environmental determinism. But is this connection that straightforward, or is it, in fact, an oversimplification of more complex phenomena? As Devereux and Edwards have shown in their 2004 study of African famines, other institutional and technological factors are to be taken into account, in order to reach a more proper understanding of famine.[57] The remaining section of the article adheres to this dictum, challenging the widespread deterministic approach and offering an alternative model for understanding famines in preindustrial Europe and contemporary 'Third World' countries.

Let us begin by surveying some contours of Europe's changing climate from c. 250 CE to c. 1850 CE. Paleoclimatology is still rather scant for the first millennium. There are certainly far more studies of natural climate proxies pertaining to the second millennium. Consequently, regional trends and the temporal parameters of climate evolutions are less clear in the first millennium than they are in the second. Very roughly speaking, pronounced climate variability characterized the period spanning c. 250–575 CE, with dryer conditions defining much of the third and fourth centuries. This 'drought' was inconsistent, as are all overarching climate patterns. A period of above average precipitation set in c. 380 and lasted until c. 450, when dry conditions returned once again, to dominate the continent until c. 575. This climatic instability went hand-in-hand with the political turmoil marking the decline and 'fall' of the Roman Empire. A cool period of c.535–650, corresponding to the cementing of 'Barbarian' kingdoms in Europe, was replaced by a period of relative warmth c.650–750.[58] After a brief cooling c.750–830, there was another period of heighten climate instability, characterized by cold winters (c.830–950).[59] This instability corresponds to the era of political, military, and socioeconomic crises that accompanied the decline of Carolingian rule. Roughly speaking, the period of c.950–1250 (aka, the 'Medieval Climate Anomaly,' or the *MCA*) was marked by warm and, at least initially, dry conditions. But again, there were breaks in the overarching climate regime, for instance the cooling of the 'Oort Minimum c.1010–1050.[60,61] During the *MCA*, one witnesses a pronounced demographic growth, the expansion of economy and trade, as well as the flourishing of the 'High Medieval Christian civilization.' From c.1250 until c.1420, Europe entered into a period of climatic instability, marking a transitional period between the *MCA* and the *LIA*. During that period, there was a gradual reduction in solar irradiance levels. In particular, solar irradiance was abysmally depressed between c.1280 and 1340, a period referred to by some scholars as the 'Wolf Minimum.' The period c.1420 until c.1850, now known as the *LIA* (and the exact chronology is highly debated among historians and paleoclimatologists) was dominated by a long-term cooling trend and short-term cooling events, mostly related to volcanism. In the course of that era, there were two particularly cold phases, when average temperatures and sunspots reached their lowest *minima* in the last two millennia: the 'Maunder Minimum' of c.1645–1715 and the 'Dalton Minimum' of c.1790–1820.[62]

Each of these climatic phases had short-term extreme weather events, around which severe famines have been reported. Thus, the harsh famines of 368–369 and 375–376 in the Eastern Roman Empire have occurred in the context of the extreme drought

  

of the 360–370s.[63] The famines of 791–794, 805–807, and 820–824, reported in the Carolingian Empire and the British Isles, happened in a wider climatic milieu of climatic instability and short-term cold weather events.[7] As Figures 1 and 2 indicate, in many instances, subsistence crises occurred in the context of solar activity minima or volcanic activity (in many instances, short-term solar minima was caused by volcanic eruptions). Thus, the famine of 1030–1033 is to be seen in the context of the 'Oort Minimum.'[64] The global famine of 1258–1259 occurred after the eruption of Rinjani (Samalas, Indonesia) in 1257.[46] The Great European Famine of 1315–1317 occurred during the Wolf Minimum (c.1280–1340), itself a part of a larger climatic shift from the *MWA* to the *LIA*.[65] The pan-Eurasian Famine of 1590s and the early 1600s, stretching all the way from the Iraq in the east to Scandinavia in the west, ravaged at the height of another short-term climatic anomaly, manifesting in a great drought in Asia and torrential rainfall and cold winters in Europe.[66] In particular, the 1601–1603 famine in northeastern Europe appears to have been closely correlated to the eruption of Huaynaputina (Peru) in 1600.[67] The famine of the 1690s, which devastated much of Northern Europe, was at the very height of the 'Maunder Minimum,' with an unknown volcano erupting in 1695.[68] The eruption of Laki in Iceland in 1783 was followed by an immediate famine in Iceland and food shortages on virtually a global scale.[69] Finally, the crisis of 1816–1817 has occurred after the eruption of Mount Tambora (in Indonesia), in the wider context of the 'Dalton Minimum.'[70] Allegedly, the connection between climate and extreme weather events on the one hand and famines on the other is too apparent to be dismissed. But were these famines *caused* by climate, or are they merely *strongly correlated* to it?

Obviously, from the perspective of historians, correlation does not mean causation. Although many social scientists often taken a well-tested correlation, based on a robust econometric analysis, as the very best indicator of causation, such assumption can be problematic. It should be borne in mind that even the most robust regression analysis cannot go beyond establishing the relation between the explanatory and dependant variables and it cannot explain *why* there is such relation. In other words, it does not account for all the intermediary factors separating the initial cause (climate) and the ultimate outcome (famine). To make things even worse, however, many social scientists tend to invoke the *ceteris paribus* mantra, which assumes that all things being equal. But diverse manifestations of the impact of climatic shocks and human responses to them imply that all things do not have to—or indeed, cannot be equal. To understand the relationship between the two variables, it requires more than just establishing that most famines happened (and happen) during periods of climatic change or short-term weather shocks. It is far more important to know *precisely why and how* humans, human values, decisions and institutions transform climatically induced food shortages into full-fledged famines.

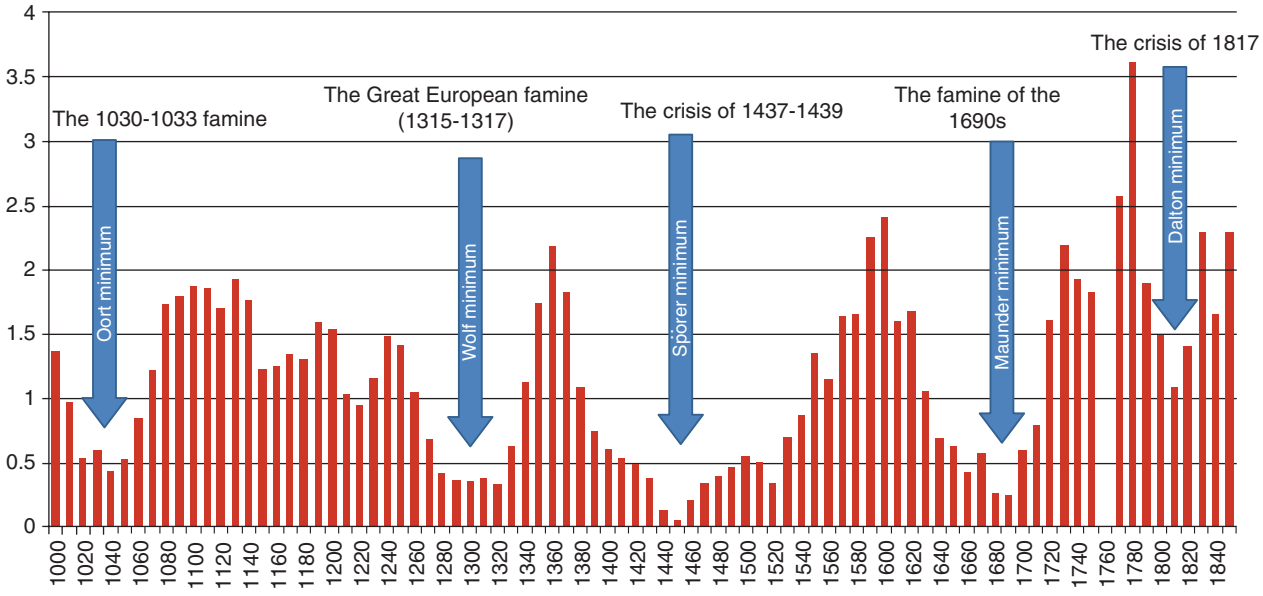


**FIGURE 1** | Solar activity levels and major subsistence crises in Europe, 1000–1850 (indexed on 1000–1500).[124]

  

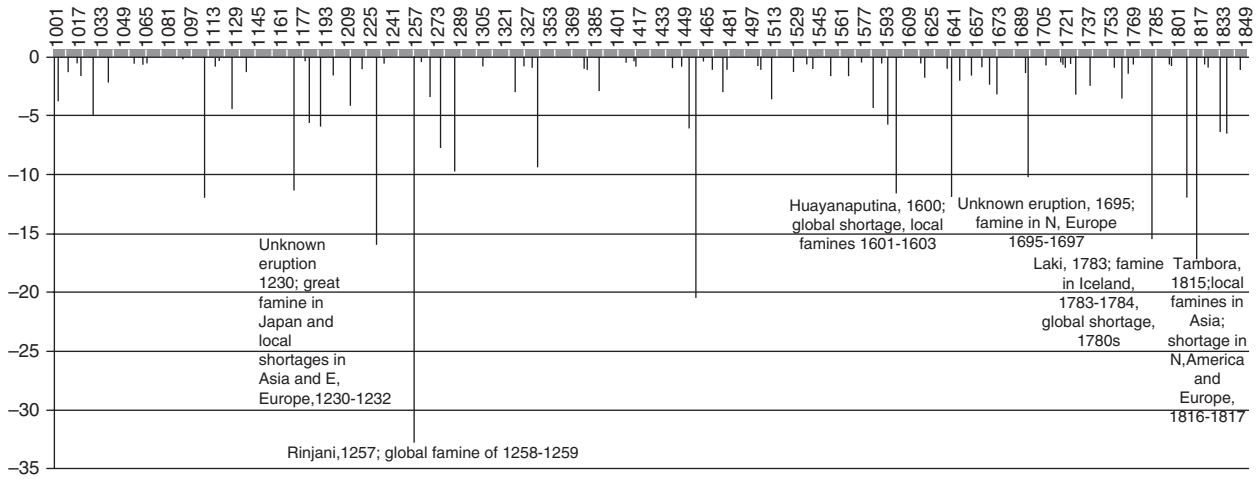


**FIGURE 2** | Volcanic eruptions and major subsistence crises, 1000–1850.[125]

To achieve that, an in-depth analysis of available evidence is required. A close reading of the source material reveals that both long- and short-term climatic shifts, which implied increased instances of extreme weather, tend to create almost invariably socioeconomic tipping points, rather than famines. True, torrential rain, frost, or excessive drought can ruin annual harvests. Those harvest shortfalls alone, however, cannot account for famines: they bring about food shortages, but not famines. To blame climate as the universal trigger of cataclysm means to reduce a historical argument to the oversimplified level of environmental determinism, which does not account for other, no less decisive factors. As Sen has convincingly shown, famines happen not because of 'FAD', but because of 'FED', whereby better-off elements use their wealth to seize the meager food resources under their control, thus, denying poorer elements of their natural right of entitlement to food.[1] In other words, humans and anthropogenic institutions play an enormous role in making famine. To put it differently: there is indeed a *connection* between climate and famines. Indeed, climatic anomalies can *initiate* preconditions for famine by reducing the available food resources and creating omnipresent socioeconomic stress. But this obvious connection is mediated by a long number of other factors, anthropogenic (institutional) and demographic alike. To stress this point, I shall refer to several such anthropogenic aspects in the context of historical famine.

One widespread tendency during severe shortages is grain hoarding. Thus, during the Great European Famine of 1315–1317, there were numerous instances of withholding of grain resources by better-off producers, who chose to store crops until the later parts of the agricultural year (Spring-Summer), in pursuit of excessively high prices and hence, enormous financial gains.[71] According to one narrator, during the Great Russian Famine of 1601–1603, many lords (including the Patriarch of Moscow) and better-off peasants had grain surplus to serve them for 3 or 4 years. Yet, they refused to deliver their stocks to local markets, fearing that they would miss the opportunity to drive up the prices even higher.[72] Likewise, hoarding and speculation were omnipresent during the Great Irish Famine of 1845–1852.[73] Food hoarding has also been an omnipresent feature of many contemporary famines of the Third World. In the course of the Bengali famine of 1942–1943 and the Bangladeshi famine of 1974–1975, piles of rise were stored by both wealthy individuals and colonial authorities.[74,75] During the Sudanese famines of 1984–1985, 1998, 2005–2006 and 2011–2012, local banks stockpiled considerable amounts of crops.[76] Similarly, ubiquitous hoarding activities have been reported during the 2002 famine in Malawi.[77,78] As recently as in 2011–2012, food speculation appeared to be a paramount factor in East African famine.[79] Many more examples can be added.

One obvious consequence of food hoarding is a rise in food prices. The reluctance of crop-producers or crop-owners to release their stocks onto local markets creates a commercial vacuum, with prices going up in a reverse correlation with the available food supply.[80] The excessively high prices imply the decline of collective purchasing power of commoners, on the account of their lack of financial resources, or other means of exchange. In other words, fewer and fewer people can now afford to buy food, because of the widening gap between the commodity prices and

  

the available funds to buy them. How badly the collective purchasing power is compromised is largely determined by the real wages and by the size of a deprived population, *in relation to the available resources*. That the population size has an impact on the degree of vulnerability to famine has been already stated by Malthus in his classic 1798 *Essay on the Principle of Population*.[5] According to the Malthusian logic, the more poor people there are the more likely it is for a shortage to become an acute famine. Indeed, as Sen has convincingly shown, poverty is a decisive factor here: the bigger the proportion of poor people is, the more vulnerable the society becomes to various socioeconomic stresses.[1] Several historical examples might suffice. At the time of the failed harvest of 1315, the first of the three back-to-back harvest shortfalls, the population of England might have been in the area of some 4.75–5.25 million people, with various estimates currently vary between 4 and 6 million.[81,82] This figure was too high to be sustained, given the scarcity of landed resources, and, as recent research has shown, over 50% of the population were living well below the poverty line.[83] Similarly, the signs of overpopulation and poverty were apparent in parts of the Low Countries (where the population levels reached about 2 million c.1300) and northern France.[84] In 1845, on the eve of the outbreak of potato blight (an event which appears to have been precipitated by extremely wet summer weather) there were some 8.5 million people living in Ireland.[85] Just as England, the Low Countries and northern France in the early 14th century, Ireland c.1845 was a classic Malthusian society, with over three-fourths of the population holding little or no land.[85] In the case of both early 14th-century northwestern Europe and early 19th-century Ireland, the share of poor and landless people grew much faster than the population as a whole.

An altogether different situation prevailed in Scotland. Just as other parts of northern Europe, Scotland experienced the short-term climatic anomaly of the early 14th century, and just as Ireland, it had the potato blight in the 1840s.[86] Yet, in neither case there is any evidence about famine. It appears, therefore, that the lack of demographic pressure may have been a key factor in saving Scotland from famine. There were about 1.3 million people in 1315 and some 2.7 million people in 1845, which may be translated into the respective figures of about 43 and 88 people per square mile.[87] The population density in England c.1315, on the other hand, was more in the order of some 90–100 people per square mile. In Ireland c.1845, the situation was even more stressful: there were about 264 people per square mile.[88] In other words, the number and proportion of the poor and landless is by far a better indication of famine vulnerability than total population.

The short-term climatic anomaly of the early 14th century was by no means limited to England, the Low Countries and Northern France.[89] Nor did the potato blight spare other parts of Europe.[90] Both environmental disasters befell upon Scotland. Indeed, as Oram has most recently shown, on the basis of paleoclimatological data, the increased storminess in the North-Atlantic from c.1250 onward has drastically reduced and marginalized the agricultural capacity of Scotland by c.1300.[55] In both cases—and especially in the case of the Scottish Highlands in the 1840s, there was a pronounced deficiency of food. Yet, as we have seen, Scotland experienced famine in neither 1315–1317, nor in the late 1840s. As Devine has stated, in explaining the resilience of the Highlanders to the potato blight, 'a higher proportion [of the Highland population] than in the west of Ireland in 1846–1847 had the purchasing power to make good some of the deficiencies in subsistence brought about by the failure of the potatoes.'[91] In other words, a relative lack of demographic pressure implied higher living standards and hence, less vulnerability to climatic shocks and food deficiency.

Demographic pressure is only one such decisive factor, but it cannot be a universal variable. For instance, although the potato famine was an omnipresent phenomenon all over Ireland, it was precisely the least densely settled counties of the west that suffered the most.[92] In order to understand this paradox, one has to account for a number of other aspects determining whether food shortage would turn into a famine or not. One such factor is agricultural and dietary structure of a population-at-risk. Almost as a rule of thumb, a strong dependence on one sector of agriculture, which is devastated by climatic changes or short-term weather anomalies, is more likely to contribute to the creation of famine. Conversely, more diversified agricultural and dietary portfolios tend to prevent food shortages from unfolding into a full-fledged famine, when populations have more room and resources to manoeuver across different food schedules, in the event of a failure of *one* of several sectors. This model helps understanding why northwestern Europe in the 1310s and Ireland in the 1840s were hit by devastating famines, while Scotland managed to avoid a catastrophe in both instances. The diet of English, Flemish, north-French (and other north European) commoners in the early 14th century was strongly dominated by crops, primarily in the form of bread and ale/beer. In

  

England, crop-based foods contributed about 70% to the total calorific intake. Although arable cultivation (predominantly of oats and barley) has been an important feature of local economies in parts of the south-east and the eastern coast of late-medieval Scotland, elsewhere in the country it was pastoral husbandry and to a certain extent fisheries that supplied the vast majorities of kilocalories to the intake of the commoners.[93,128] Similarly, although potatoes were the single most important crop in the Scottish Highlands by c.1845, local populations were still able to supplement their food with fish, dairy products and oats. This is in a sharp contrast with many regions in western Ireland, which practiced potato monoculture. Conversely, the eastern and central parts of Ireland had more diversified diet portfolios, with crops playing a more significant role. This, in turn, may partially explain why starvation and mortality rates during the varied across regions during the Great Famine in Ireland.[94]

Political instability is yet another factor that can make the whole difference. Military conflicts or social upheavals can decrease food supplies either through environmental destruction or through extraction. Thus, during the Great European Famine, northern English counties were plundered by Scottish marauders,[95] while Flemish countryside was ravaged by French soldiers.[96] Furthermore, to finance his war with Scotland, Edward II of England (1307–1327) taxed his subjects both in 1315 and 1316, and sent his officials to purchase or, in some cases, collect grain from local producers.[97] This meant a further deprivation of local communities of their food entitlement. To make things even worse, however, piracy was flourishing in the North, Celtic and Irish Seas, targeting ships laden with food or raiding coastal communities.[98] All these factors have decreased the measly amounts of food even further. In the course of the famine of 1328–1330, north- and central-Italian countryside was plundered by the invading army of Emperor Louis IV of Bavaria, thus exacerbating the crisis even further.[99] The pan-Mediterranean famine of 1374–1375, characterized by regional variances in short-climatic anomalies, coupled with violent warfare in that region. In particular, the countryside of Perpignan and Siena was ravaged, which intensified the crisis a great deal.[100,101] During the Nine Years' War (1594–1603) and the Irish Confederate Wars (1641–1653), which both occurred during short-term climatic anomalies marked by excessively cold and wet weather,[102] Irish countryside has been repeatedly plundered by English soldiers.[103] These attacks have reduced the already meager food supply even further and transformed shortages into famines. In the same vein, warfare plays an enormous role in intensifying food crises in the Third World countries. The forced exports of Bengali rice, whose 1942–1943 harvest has already been devastated by weather-induced-blight, to other parts of India and to the Burma campaign, was a major factor in creating the Bengali Famine of 1942–1943.[104] The Ethiopian famines of 1972–1973 and 1983–1985 have occurred in the middle of extreme drought, but it was civil war that deprived local communities of their access to food.[105] Likewise, the Somali famines of 1991–1993 and 2010–2012 may have been initiated by catastrophic drought, but they were clearly intensified by the ongoing civil war.[106,107] As Parker has shown in his study of the global crisis of the 17th-century, states often tended to give a priority to the successful prosecution of war over famine relief.[108]

## CONCLUSIONS AND WIDER IMPLICATIONS

All the cases cited above strengthen the view that climate and short-term weather anomalies do not create famines. All the same, it would be erroneous to claim that climatic factors have no impact on human vulnerability to food crises. They indeed create environmental contexts, which may lead to food shortages, or, to use Sen's terminology, the 'FAD'. Thus, the climatic change in North-Atlantic in the late 13th- and early 14th century, marked by the increased storms and cooling, reduced the geographic range and sheer scale of Scottish agricultural capacity. The torrential rain of 1314–1316 brought about three back-to-back harvest failures in northwestern Europe. The drought of 1373–1374 created a harvest shortfall in Spain and other parts of the western Mediterranean. The wet weather of summer 1845 encouraged the disastrous blight that killed much of the potato crops in Ireland and other parts of Europe in the 1840s.[109] The unusual drought of 1931–1932 appears to have reduced the Ukrainian crop harvest of 1932 by some 40%.[110] Similarly, excessive cloudiness, heavy rainfall and high humidity in late 1942 ruined much of the rice harvest in Bengal in 1942–1943.[111] Drought remains the dominant environmental factor in creating shortages in Africa.

Decreased food production levels stemming from crop harvest shortfalls, caused by climatic anomalies, alone do not reach beyond food shortage (or, 'FAD'), at worst. Even some harshest weather anomalies are highly unlikely to destroy an entire harvest in a given community, let alone in an entire

  

region. Moreover, pre-Industrial societies often tended to carry over crop surpluses, as a measure of security against a potential harvest shortfall.[112] In other words, after a prolonged torrential rain, or a freezing winter, or a dry year, *some* food would still be available for distribution and consumption. For instance, the torrential rain and freezing winters of 1314–1316, which ruined three back-to-back harvests, reduced the gross crop supply (that is, the sheer amounts of produced crops) in England by 25, 36, and 16%. After the deduction of seed-corn, which, during the famine years was disproportionally large, the respective production levels still stood at some 40, 50, and 25% below average.[113] When the Irish potatoes failed miserably and the aggregate output levels declined from about 13 million tons in 1844 to some 9 million tons in 1845 to 3 million tons in 1846 and the abysmal 2 million tons in 1847 (only to rise slightly to 3 million tons in 1848 and 4 million tons in 1849),[114] there were still fair amounts of grains (most notably, oats), in addition to dairy products and herring that could sustain, at least partially, the Irish populace.[115] Similarly, the people of the Ukraine may have avoided the famine of 1933 (the *Holomodor*), had Stalin's government not procured a nonnegligible share of the 1932 harvest, to keep up with its planned economy.[116] When the damp and humid winter of 1942–1943 ruined the three seasonal rice harvests in Bengal, the sheer amounts of collected rice were still large enough to feed the local population, especially given that rice, wheat and millet were imported to Bengal during the famine years.[117] Yet, despite the theoretical availability of *some* food, a shortage turned into a famine in all four instances, because of the adverse combination of demographic pressure, low living standards, and the loss of food entitlements through failed market performance, widespread hoarding, governmental transfer of food resources and, in the case of the Great European Famine and the Bengali Famine, also military conflict. In other words, it is a series of complex anthropogenic and demographic factors, which, when taken together, represent that invisible beast that creates famines.

Almost invariably, famines occur in the context of long-term climatic changes, or short-term weather anomalies. This led some historians, economists and political scientists to take the link between the two for granted and see the chronological concurrence as a causation, rather than correlation. Thus, in 2007 Zhang et al. 'spotted' a strong correlation between the cycles of climate change, wars, and population decline (whether due to wars, or disease and famine). These findings were published in *PNAS* and judging by a sheer number of citations, this study has been accepted by a large number of scholars.[118] What this study, just as many other economic and political science studies quoted earlier in this paper, failed to conceive is that correlation does not mean causation. This is just one of many examples of how social scientists tend to fall into what Mike Hulme has aptly called the 'climate reduction' trap.[119]

To understand *why* wars, famines and excessive mortality tend to dominate human history in the period of climatic changes requires a much more detailed investigation of *historical* anthropogenic and demographic factors, rather than oversimplified and overreaching theoretical models. A good grasp of historical contexts, backed up by solid historical data and historical methodologies can yield some promising and more convincing results in this field. In other words, there is indeed a clear connection between climate and famines. But this connection alone does not account for the incredible complexity of famine. Nor can it blame climate as the single root-cause of famines. To understand the incredibly complex nature of famines, one has to divert from the oversimplified and reductionist perspective, satisfied by a mere econometric prediction or economic model holding all things equal, and focus on a long chain of intermediary links between the initial cause (climate) and the final outcome (famine). But at the same time, Nature should still be taken seriously as the same initial cause, without which the same chain of intermediary links toward famine would not have been unfolding: precisely, because it sets the stage to it, by creating the first link—shortage. This is, perhaps, an admonition to those historians, who tend to be strongly biased toward the endogenous explanations of famine. In other words, it is vital to counterbalance between the exogenous, endogenous and demographic factors, to appreciate the complexity of the phenomenon and avoid any generalization and, consequently, distortion.

All this brings to one last point. For good reason, the topic of climate change and global warming has been dominating both the public and scholarly discourse for some two decades now. All the available climatological data point to the unquestioned (and indeed worrisome) rise in annual temperatures all over the world, which, if not addressed properly, can have some negative environmental, biological, political, and socioeconomic implications, on a global level. However, despite frequent admonitions, global warming *alone does not* and *will not* create famines. It is true that the catastrophic drought in east Africa of the last five or so years has had a

  

pronounced impact on the aggregate levels of food production in that region. In other words, it created food shortage. The east-African drought, however, should be seen as a part of a larger, global climatic context, marked by increasing aridity in different parts of the world. For instance, Indian subcontinent had its own drought in 2011–2014,[120] while in North America (especially in California and the southern states of the United States), drought has been an ongoing problem since 2012.[121] Yet, in both cases, all the drought did was to depress the sheer levels of agricultural output; it created neither shortage, nor famine.[122,123] Why, then, there is famine in east Africa, but not even food shortage in India and North America? Again, the answer lies in humans and human institutions. Both the United States and India are democratic countries, which discourage corruption and speculation and protect property rights. Both countries pursue capitalist economy and free trade with other countries, which implies that food imports can always be replied upon. High agricultural yields in the United States, stemming from its unquestioned technological superiority, and a large agricultural sector in India, mean that in both countries there are enough food surpluses for a rainy or dry day. But perhaps most importantly, there is political and military stability in both countries, which means that food supplies are protected. An altogether opposite situation prevails in east African countries: corrupt and nondemocratic governments; weakly developed property rights; sectarianist societies; family based small-scale economies; very limited (and in some cases, nonexistent) exchange of goods with other countries; de-industrialized agriculture; overdependence on a limited range of foodstuffs; and, most importantly military conflicts inflicting much damage upon food resources. In other words, climate can lead to 'FAD,' but it is humans, who reduce the situation to famine, by making 'FED' an omnipresent reality.

All these facts suggest that the existing approach to the concepts of global warming and climate change needs a perceptive and methodological revision. Climate and environment do play a pronounced role in human societies, and especially in pre/non-Industrial world, but their impact often tends to be exaggerated. This is especially true in the case of environmental determinism, which almost nullifies the role and place of humans and human institutions and cultures in history. Just as any other ideological bias, environmental determinism, too, tends to dangerously oversimplify complex processes and phenomena and distort facts and figures. Instead of regarding climate (and, indeed, Nature) as the trigger and cause of famines, and assuming a straightforward connection between the two variables, it is perhaps now time to consider climate and Nature as the first (and by no means the most decisive) link in a long and perplexing chain of factors and phenomena which lead to famine. Famine, after all, is a highly complex phenomenon, as hopefully the present study has shown.

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## REFERENCES

1. Sen AK. *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford: Clarendon Press; 1981.
2. Rangasami A. Failure of exchange entitlements theory of famine 1 and 2. *Econ Polit Wkly* 1985, 20:1747–1752; 97–801.
3. De Waal A. *Famine Crimes: Politics and the Disaster Relief Industry in Africa*. Bloomington, IN: Indiana University Press; 1997, 2–6.
4. Devereux S. Sen's entitlement approach: critiques and counter-critiques. *Oxf Dev Stud* 2001, 29:245–263.
5. Malthus TR. *An Essay on the Principle of Population*. New York: Norton and Co.; 1976.
6. Campbell BMS. Nature as historical protagonist: environment and society in pre-industrial England' (the 2008 Tawney Memorial Lecture). *Econ Hist Rev* 2010, 63:281–314.
7. Newfield T. The contours, frequency and causation of subsistence crises in Carolingian Europe (750–950). In: Benito i Monclús P, ed. *Crisis Alimentarias en la Edad Media: Modelos, Explicaciones y Representaciones*. Lleida: Milenio; 2013, 117–172.

  

8. Howe P, Devereux S. Famine intensity and magnitude scales: a proposal for an instrumental definition of famine. *Disasters* 2004, 28:353–372.
9. Campbell BMS, ÓGráda C. Harvest shortfalls, grain prices, and famines in preindustrial England. *J Econ Hist* 2011, 71:859–886.
10. Smith RM. Demographic developments in rural England, 1300–48: a survey. In: Campbell BMS, ed. *Before the Black Death: Studies in the 'Crisis' of the Early Fourteenth Century*. Manchester: Manchester University Press; 1991, 25–77.
11. Downing TE. Vulnerability to hunger in Africa: a climate change perspective. *Glob Environ Change* 1991, 1:365–380.
12. Kelly PM, Adger WN. Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Clim Change* 2000, 47:325–352.
13. Challinor A, Wheeler T, Garforth C, Craufurd P, Kassam A. Assessing the vulnerability of food crop systems in Africa to climate change'. *Clim Change* 2007, 83:381–399.
14. Fischer G, Frohberg K, Parry ML, Rosenzweig C. Climate change and world food supply, demand and trade: who benefits, who loses?'. *Glob Environ Change* 1994, 4:7–23.
15. Reilly J, Hohmann N, Kane S. Climate change and agricultural trade: who benefits, who loses? *Glob Environ Change* 1994, 4:24–36.
16. Bohle HG, Downing TE, Watts MJ. Climate change and social vulnerability: toward a sociology and geography of food insecurity. *Glob Environ Change* 1994, 4:37–48.
17. Rosenberg NJ, Scott MJ. Implications of policies to prevent climate change for future food security. *Glob Environ Change* 1994, 4:49–62.
18. Ruttan VW, Bell DE, Clark WC. Climate change and food security: agriculture, health and environmental research. *Glob Environ Change* 1994, 4:63–77.
19. Ribot JC, Magalhães AR, Panagides S, eds. *Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics*. Cambridge: Cambridge University Press; 1996.
20. Norse D. Multiple threats to regional food production: environment, economy, population? *Food Policy* 1994, 19:133–148.
21. Mendelsohn R, Dinar A. Climate, water, and agriculture. *Land Econ* 2003, 79:328–341.
22. Mendelsohn R, Dinar A, Dalfelt A. *Climate Change Impacts on African Agriculture [Mimeo]*. New Haven, CT: School of Forestry and Environmental Studies, Yale University; 2003.
23. Verdin J, Funk C, Senay G, Choularton R. Climate science and famine early warning. *Philos Trans R Soc Lond B Biol Sci* 2005, 360:2155–2168.
24. Khasnis AA, Nettleman MD. Global warming and infectious disease. *Arch Med Res* 2005, 36:689–696.
25. Rosenzweig C, Iglesias A, Yang XB, Epstein PR, Chivian E. Climate change and extreme weather events; implications for food production, plant diseases, and pest. *Glob Change Hum Health* 2001, 2:90–104.
26. Chakraborty S, Newton AC. Climate change, plant diseases and food security: an overview. *Plant Pathol* 2011, 60:2–14.
27. Fogel RW. Second thoughts on the European escape from hunger: famines, chronic malnutrition and mortality rates. In: Osmani SR, ed. *Nutrition and Poverty*. Oxford: Clarendon Press; 1992, 243–286.
28. Abel W. *Massenarmut und Hungerkrisen im vorindustriellen Deutschland*. Gottingen: Vanderhoeck und Ruprecht; 1972.
29. Persson KG. *Grain Markets in Europe, 1500–1900: Integration and Deregulation*. Cambridge: Cambridge University Press; 1999.
30. Devereux S. *Theories of Famine*. Hemel Hempstead: Harvester Wheatsheaf; 1993, 184.
31. Vestal TM. Risk factors and predictability of famine in Ethiopia. *Polit Life Sci* 1991, 9:187–203.
32. Osmani S. Famine, demography and endemic poverty. In: O'Neill H, Toye J, eds. *A World without Famine? New Approach to Aid and Development*. London: Macmillan Press Ltd; 1998, 161–198.
33. http://earthzine.org/2013/03/23/key-phrase-trends-in-climate-change-research-and-communication/. (Accessed October 1, 2015).
34. Pfister C. Climate and economy in eighteenth-century. *J Interdiscip Hist* 1978, 9:223–243.
35. Pfister C. Die Fluktuationen der Weinmosterträge im schweizerischen Weinland vom 16. bis ins frühe 19. Jahrhundert. Klimatische Ursachen und sozioökonomische Bedeutung. *Schweiz Z Gesch* 1978, 31:445–491.
36. Pfister C. An analysis of the Little Ice Age climate in Switzerland and its consequences for agricultural production. In: Wrigley T, Farmer G, eds. *History and Climate*. Cambridge: Cambridge University Press; 1981, 214–248.
37. Pfister C. Fluctuations du climat et prix céréaliers en Europe 16ème–20ème siècles. *Ann Écon Soc Civil* 1988, 43:25–53.
38. Le Roy Ladurie E. *Times of Feast, Times of Famine: A History of Climate since the Year 1000*. New York: Doubleday and Co.; 1971.
39. Lamb H. Some comments on the drought in recent years in the Sahel-Ethiopian zone of North Africa. In: Dalby D, Harrison-Church RJ, Bazzaz F, eds. *Drought in Africa 2: African Environment Special Report*. London: International African Institute; 1977, 33–37.


  

40. Davis M. *Late Victorian Holocausts: El Niño Famines and the Making of the Third Word*. New York: Verso; 2001.
41. Holmgren K, Öberg H. Climate change in southern and eastern Africa during the past millennium and its implications for societal development. *Environ Dev Sustain* 2006, 8:185–195.
42. Damodaran V. Famine in Bengal: a comparison of the 1770 famine in Bengal and the 1897 famine in Chotanagpur. *Mediev Hist J* 2007, 10:143–181.
43. Saito O. Climate and famine in historic Japan: a very long-term perspective. In: Kurosu S, Bengtsson T, Campbell C, eds. *Demographic Responses to Economic and Environmental Crises*. Kashiwa: Reitaku University Press; 2010, 272–281.
44. Broadberry S, Campbell BMS, Klein A, Overton M, van Leeuwen B. *British Economic Growth, 1270–1870*. Cambridge: Cambridge University Press; 2015, 373–383.
45. Fagan B. *The Little Ice Age: How Climate Made History 1300–1850*. New York: Basic Books; 2000.
46. Stothers RB. Climatic and demographic consequences of the massive volcanic eruption of 1258. *Clim Change* 2000, 45:361–374.
47. Campbell BMS. Nature as historical protagonist: environment and society in pre-industrial England' (the 2008 Tawney Memorial Lecture). *Econ Hist Rev* 2009, 62:281–314.
48. Campbell BMS. *The Great Transition. Climate, Disease and Society in the Late Medieval World*. Cambridge: Cambridge University Press; 2016.
49. Hoyle RW. Famine as agricultural catastrophe: the crisis of 1622–4 in east Lancashire. *Econ Hist Rev* 2010, 63:974–1002.
50. White S. *The climate of rebellion in the early modern Ottoman Empire*. Cambridge: Cambridge University Press; 2011.
51. The WS. Little Ice Age crisis in the Ottoman Empire: a conjuncture in Middle East environmental history. In: MIkhail A, ed. *Water on Sand: The Environmental History of the Middle East*. Oxford: Oxford University Press; 2012, 70–90.
52. Alfani G. Climate, population and famine in Northern Italy: general tendencies and Malthusian crisis, ca. 1450–1800. *Ann de Démogr Hist* 2010, 120:23–53.
53. Alfani G. The famine of the 1590s in Northern Italy: an analysis of the greatest "system shock" of sixteenth century. *Histoire Mesure* 2011, 26:17–50.
54. Slavin P. The Great bovine pestilence and its economic and environmental consequences in England and Wales, 1318–50. *Econ Hist Rev* 2012, 65:1239–1266.
55. Oram R. 'The worst disaster suffered by the people of Scotland in recorded history': climate change, dearth and pathogens in the long fourteenth century. *Proc Soc Ant Scotland* 2015, 144:223–244.
56. Fraser EDG. Travelling in antique lands: using past famines to develop an adaptability/resilience framework to identify food systems vulnerable to climate change. *Clim Change* 2007, 83:495–514.
57. Devereux S, Edwards J. Climate change and food security. *IDS Bull* 2004, 35:22–30.
58. McCormick M, Büntgen U, Cane MA, Cook ER, Harper K, Huybers P, Litt T, bManning SW, Mayewski PA, More AFM, et al. Climate Change during and after the Roman, Empire: reconstructing the past from scientific and historical evidence. *J Interdiscip Hist* 2012, 43:169–220.
59. McCormick M, Dutton PE, Mayewski PA. Volcanoes and the climate forcing of Carolingian Europe, AD 750–950. *Speculum* 2007, 82:865–895.
60. Crowley T, Lowery TS. How warm was the Medieval Warm Period? *AMBIO* 2000, 29:51–54.
61. Hughes MK, Diaz HF. Was there a 'medieval warm period, and if so, where and when? *Clim Change* 1994, 26:109–142.
62. Büntgen U, Tegel W, Nicolussi K, McCormick M, Frank D, Trouet V, Kaplan JO, Herzig F, Heussner KU, Wanner H, et al. 2500 years of european climate variability and human susceptibility. *Science* 2012, 331:578–582.
63. Holman SR. *Beggars and Bishops in Roman Cappadocia: Oxford Studies in Historical Theology*. Oxford: Oxford University Press; 2001.
64. Landes R. The fear of an apocalyptic year 1000: Augustinian historiography, medieval and modern. *Speculum* 2000, 75:135.
65. Dawson AG, Hickey K, Mayewski PA, Nesje A. Greenland (GISP2) ice core and historical indicators of complex North Atlantic climate changes during the fourteenth century. *The Holocene* 2007, 17:427–434.
66. Clark P, ed. *The European crisis of the 1590s: essays in comparative history*. Allen and Unwin: London; 1985.
67. Verosub KL, Lippman J. Global impacts of the 1600 eruption of Peru's Huaynaputina Volcano. *Eos* 2008, 89:141.
68. Cuellen K. *Famine in Scotland—The 'Ill Years' of the 1690s*. Edinburgh: Edinburgh University Press; 2010.
69. Thordaldson T, Self S. Atmospheric and environmental effects of the 1783–1784 Laki eruption: a review and reassessment. *J Geophys Res* 2003, 108: D140111.
70. Oppenheimer C. Climatic, environmental and human consequences of the largest known historic eruption: Tambora volcano (Indonesia) 1815. *Prog Phys Geogr* 2003, 27:230–259.


  

71. Slavin P. Market failure during the great famine in England and Wales (1315–1317). *Past Present* 2014, 222:9–49.
72. Dunning C. *Russia's First Civil War: The Time of Troubles and the Founding of the Romanov Dynasty*. University Park, PA: Penn State University Press; 2001, 90–108.
73. ÓGráda C. *Ireland Before and After the Famine: Explorations in Economic History, 1800–1925*. Manchester: Manchester University Press; 1993, 101–2–120.
74. Ravallion M. *Markets and Famines*. Oxford: Clarendon Press; 1987, 19.
75. ÓGráda C. *Famine: A Short History*, vol. 168–71. Princeton, NJ: Princeton University Press; 2009, 175–178.
76. Sudan Nationwide Famine. Culpable negligence in the management of food security, war, and the use of food as a political weapon: an africa watch report, November 7, 1990. Available at: http://www.hrw.org/reports/pdfs/s/sudan/sudan90n.pdf. (Accessed October 1, 2015).
77. Devereux S. Why does famine persist in Africa? *Food Secur* 2009, 1:29.
78. Devereux S. The Malawi famine of 2002. *IDS Bull* 2002, 33:70–78.
79. Jorio L. Food speculation blamed for East Africa famine, SWI. November 22, 2011. Available at: http://www.swissinfo.ch/eng/politics/foreign_affairs/Food_speculation_blamed_for_East_Africa_famine.html?cid=31607472. (Accessed October 1, 2015).
80. Wrigley EA. Some reflections on corn yields and prices in pre-industrial economies. In: Walter J, Schofield R, eds. *Famine, Disease and the Social Order in Early Modern Society*. Cambridge: Cambridge University Press; 1989, 235–278.
81. Smith R. Plagues and people: the long demographic cycle, 1250–1670. In: Slack P, Ward R, eds. *The Peopling of Britain: The Shaping of a Human Landscape*. Oxford: Oxford University Press; 2002, 177–209.
82. Broadberry S, Campbell BMS, Klein A, Overton M, van Leeuwen B. *British Economic Growth, 1270–1870*. Cambridge: Cambridge University Press; 2015, 3–22.
83. Campbell BMS. Land markets and the morcellation of holdings in pre-plague England and pre-famine Ireland. In: Béaur G, Schofield PR, Chevet J-M, Pérez-Picazo MT, eds. *Property Rights, Land Markets and Economic Growth in the European Countryside (13th–20th Centuries)*. Turnhout: Brepols; 2013, 198–201.
84. van Bavel B. *Manors and Markets: Economy and Society in the Low Countries, 500–1600*. Oxford: Oxford University Press; 2010, 278–279.
85. Campbell BMS. Land markets and the morcellation of holdings in pre-plague England and pre-famine Ireland. In: Béaur G, Schofield PR, Chevet J-M, Pérez-Picazo MT, eds. *Property Rights, Land Markets and Economic Growth in the European Countryside (13th–20th Centuries)*. Turnhout: Brepols; 2013, 200.
86. Devine TM. Why the highlands did not starve: Ireland and Highland Scotland during the potato famine. In: Connolly SJ, Houston RA, Morris RJ, eds. *Conflict, Identity and Economic Development. Ireland and Scotland, 1600–1939*. Preston: Carnegie Publishing; 1995, 77–88.
87. Bruce MS. Campbell, benchmarking medieval economic development: England, Wales, Scotland, and Ireland circa 1290. *Econ Hist Rev* 2008, 61:927.
88. http://homepage.tinet.ie/~cronews/geog/census/codense1841.html. (Accessed October 1, 2015).
89. Jordan WC. *The Great Famine: Northern Europe in the Early Fourteenth Century*. Princeton: Princeton University Press; 1996, 7–23.
90. Paping R, Vanhaute E, ÓGráda C, eds. *When the Potato Failed: Causes and Effects of the Last European Subsistence Crisis, 1845–1850*. Brepols: Turnhout; 2007.
91. Devine TM. Why the highlands did not starve: Ireland and Highland Scotland during the potato famine. In: Connolly SJ, Houston RA, Morris RJ, eds. *Conflict, Identity and Economic Development. Ireland and Scotland, 1600–1939*. Preston: Carnegie Publishing; 1995, 88.
92. Flaherty E. Assessing the distribution of social-ecological resilience and risk: Ireland as a case study of the uneven impact of famine. *Ecol Complex* 2014, 19:35–45.
93. Gibson A, Smout TC. Food and hierarchy in Scotland, 1550–1650. In: Leneman L, ed. *Perspectives in Scottish Social History*. Aberdeen: University of Aberdeen Press; 1988, 33–52.
94. Devine TM. Why the highlands did not starve: Ireland and Highland Scotland during the potato famine. In: Connolly SJ, Houston RA, Morris RJ, eds. *Conflict, Identity and Economic Development. Ireland and Scotland, 1600–1939*. Preston: Carnegie Publishing; 1995, 81–84.
95. Slavin P. Warfare and ecological destruction in early fourteenth-century British Isles. *Environ Hist* 2014, 19:528–550.
96. Jordan WC. *The Great Famine: Northern Europe in the Early Fourteenth Century*. Princeton: Princeton University Press; 1996, 20.
97. Maddicott JR. *The English Peasantry and the Demands of the Crown, 1294–1341*. Oxford: Oxford University Press; 1975.


  

98. Heebøll TK. *Ports, Piracy and Maritime War: Piracy in the English Channel and the Atlantic, c.1280–c.1330*. Leiden: Brill; 2013, 33–54.
99. Grundman J. Documenti umbri sulla carestia degli anni 1328–1330. *Arch Stor Ital* 1970, 128:207–253.
100. Franklin-Lyons A. Famine—preparation and response in Catalonia after the Black death. PhD Thesis, Yale University, 2009, 136
101. Caferro W. *Mercenary Companies and the Decline of Siena*, vol. 27. Baltimore: The Johns Hopkins University Press; 1998.
102. Pfister C, Brázdil R. Climatic variability in sixteenth-century Europe and its social dimension: a synthesis. *Clim Change* 1999, 43:5–53.
103. Clarkson LA, Crawford EM. *Feast and Famine: Food and Nutrition in Ireland 1500–1920*. Oxford: Oxford University Press; 2001, 123–124.
104. Greenough PR. *Prosperity and Misery in Modern Bengal: The Famine of 1943–1944*. Oxford: Oxford University Press; 1982, 261.
105. de Waal A. *Evil Days: Thirty Years of War and Famine in Ethiopia*. New York: Human Rights Watch; 1991, 4–6.
106. Binet L. *The 'Somalia 1991–1993: Civil War, Famine Alert and a UN "Military-Humanitarian" Intervention*. Médecins Sans Frontières; 2013.
107. http://www.bbc.co.uk/news/world-africa-22380352. (Accessed October 1, 2015).
108. Parker G. *Global Crisis: War, Climate and Catastrophe in the Seventeenth Century*. New Haven, CT: Yale University Press; 2013.
109. Reddy PP. *Climate Resilient Agriculture for Ensuring Food Security*. New Delhi: Springer; 2015, 152.
110. Tauger MB. The 1932 harvest and the famine of 1933. *Slav Rev* 1991, 50:70–89.
111. Padmanabhan SY. The great Bengal famine. *Annu Rev Phytopathol* 1973, 11:11–24.
112. Slavin P. *Bread and ale for the brethren. The provisioning of Norwich Cathedral Priory, 1260–1536*. Hatfield: University of Hertfordshire Press; 2012, 130–136.
113. Slavin P. *Communities of Famine: Environment, Economy and Society in Early-Fourteenth Century Britain*. Turnhout, Brepols; 2017.
114. Bourke PMA. The extent of the potato crop in Ireland at the time of the famine. *J Stat Soc Inq Soc Ireland* 1959, 20:11.
115. ÓGráda C. *The Great Irish Famine*. Cambridge: Cambridge University Press; 1995, 18–20.
116. Conquest R. *The Harvest of Sorrow: Soviet Collectivization and the Terror-famine*. Oxford: Oxford University Press; 1986, 217–320.
117. Greenough PR. *Prosperity and Misery in Modern Bengal: The Famine of 1943–1944*. Oxford: Oxford University Press; 1982, 118–138.
118. Zhang DD, Brecke P, Lee HF, Yuan-Qing H, Zhang J. Global climate change, war, and population decline in recent human history. *Proc Natl Acad Sci USA* 2007, 104:19214–19219.
119. Hulme M. Reducing the future to climate: a story of climate determinism and reductionism. *Osiris* 2011, 26:245–266.
120. Parmeshwar U, Ichikawaa Y, Manandharb S, Ishidairaa H, Kiem AS. Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *Int J Disaster Risk Reduct* 2014, 10(A):250–269.
121. California Drought. Farm and food impacts. Available at: http://www.ers.usda.gov/topics/in-the-news/california-drought-farm-and-food-impacts.aspx. (Accessed October 1, 2015).
122. Howitt R, MacEwan D, Medellín-Azuara J, Lund J, Sumner D. Economic analysis of the 2015 drought for California agriculture. UC Davis Center for Watershed Sciences, ERA Economics, UC Agricultural Issues Center, August 17, 2015. Available at: https://watershed.ucdavis.edu/files/biblio/Final_-Drought%20Report_08182015_Full_Report_-WithAppendices.pdf. (Accessed October 1, 2015).
123. Udmale PD, Ichikawa Y, Kiem AS, Panda SN. Drought impacts and adaptation strategies for agriculture and rural livelihood in the Maharashtra state of India. *Open Agric J* 2014, 8:41–47.
124. Muscheler R, Joos F, Beer J, Müller SA, Vonmoos M, Snowball I. Solar activity during the last 1000 yr inferred from radionuclide records. *Quat Sci Rev* 2007, 26:82–97.
125. Sigl M et al. Timing and climate forcing of volcanic eruptions for the past 2,500 years. *Nature* 2015, 523:543–549.
126. Bourke A, Lamb H. *The Spread of Potato Blight in Europe 1845–6 and the Accompanying Wind and Weather Patterns*. Dublin: Meteorological Service; 1993.
127. Lamb H, Frydendahl K. *Historic Storms of the North Sea, British Isles and Northwest Europe*. Cambridge: Cambridge University Press; 1991.
128. Blakeway A. The sixteenth-century price rise: new evidence from Scotland, 1500–85. *Econ Hist Rev* 2015, 68:171–175.

  