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### Beyond collapse: climate change and causality during the Middle Holocene Climatic Transition, 6400-5000 years before present

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## Beyond collapse: climate change and causality during the Middle Holocene Climatic Transition, 6400–5000 years before present

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The twenty-first century is likely to be characterised by large changes in regional climatic and environmental conditions, with implications for the availability and distribution of key resources such as water and productive land. While the implications of such changes for human societies are potentially profound, the empirical evidence base for understanding human–environment interactions focuses largely on the relatively recent past, during which examples of rapid and severe climate change are lacking. While there are no precise past analogues for twenty-first century climate change, the Middle Holocene Climatic Transition (MHCT), from about 6400–5000 years before present, provides us with an example of a period of large-scale global climatic reorganisation, punctuated by episodes of rapid and severe climate change, at a time when human societies were beginning to resemble those of today. A survey of archaeological and palaeo-environmental data from the northern hemisphere subtropics and other regions provides us with evidence for linked climatic, environmental and societal change during the MHCT. This evidence, the strength of which varies with location, allows us to construct convincing narratives of linked climatic, environmental and societal changes that accommodate a variety of responses and outcomes, and that are much more nuanced than narratives of the proposed climate-induced collapse of individual societies. Such synthetic studies that compare contexts across time and space can help us understand human–environment interactions during times of climatic disruption, while allowing for diverse outcomes and avoiding the pitfalls of climatic determinism.

**Keywords:** climate change; Middle Holocene; societal collapse; cultural transitions; migration; adaptation; determinism

### Introduction

Under current emissions and climate policy regimes, there is a high probability that the mean surface temperature of the Earth will rise by around 4°C sometime in the latter half of the twenty-first century (Anderson & Bows, 2008; Betts et al., 2011). This would represent a warming of the same order of magnitude, but much more rapid, as that associated with a glacial–interglacial transition, and would result in the world being warmer than it has been for millions of years (Haywood & Williams, 2005; Jansen et al., 2007).

While the precise consequences of such a warming for atmospheric and oceanic circulation and regional climate change are currently quite poorly understood, there are ample grounds for assuming that such a warming would be associated with significant changes in regional climatic conditions, qualitative changes in landscapes and ecosystems, and potentially large changes in the availability and distribution of key resources such as water and productive land. Such outcomes have been suggested by a number of model-based studies of twenty-first century climate change, and are apparent in palaeo-environmental

records from previous periods of climatic transition (e.g. Armitage et al., 2007; Betts et al., 2004; deMenocal et al., 2000; Golding & Betts, 2008; Thomas et al., 2005; Williams & Funk, 2010). A key question for the twenty-first century is the extent to which changes in resource availability driven by climate change, acting in combination with population growth and economic development, may act to drive significant societal change through mechanisms such as migration, resource conflicts, and the restructuring of livelihoods, economic systems, human relations and social organisation.

Currently, debates about the role of climate change as a driver of societal change may be characterised in terms of “maximalism” and “minimalism”, terms first applied by Suhrke (1993) in the context of environmental change and migration. Extending this model to the impacts of climate change at large, maximalist narratives tend to view climate change as something that “causes” specific societal outcomes, for example migration (e.g. Myers, 2002; Myers & Kent, 1995), or conflict (e.g. Burke et al., 2009). Such views of causality are often criticised as overly simplistic and deterministic, and for ignoring the

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many complex, interacting, non-environmental factors that influence social processes – for example, people’s decisions to migrate (Buhaug, 2010; Jónsson, 2010).

In contrast, minimalist narratives maintain that it is difficult or impossible to isolate climatic or environmental changes as “dominant” drivers of social change, and indeed that there is little utility in doing so (Jónsson, 2010). The minimalist narrative is emerging as the dominant discourse in some policy contexts, for example in the UK through the recent Foresight report on Migration and Global Environmental Change (Black et al., 2011).

The minimalist perspective builds on a wealth of empirical evidence (e.g. Black et al., 2011; Jónsson, 2010). However, it might be argued that minimalist narratives risk replacing determinism with nihilism, by effectively equating any causal explanations of societal change that invoke climatic or environmental change with determinism, and thus discouraging detailed investigation of environmental influences on societal change, on the grounds that such investigation is artificially privileging one factor over others that are equally important.

A further potential problem with the minimalist narrative is that the evidence base on which it is founded extends only into the recent past; the emerging minimalist orthodoxy is most heavily informed by studies of livelihoods and migration undertaken within the context of development studies, since the 1950s (e.g. Jónsson, 2010). The extent to which such recent historical evidence can be used as a basis for understanding how human populations might respond to climate change over the coming decades, and even centuries, is highly uncertain. At the global scale, the rate and magnitude of climate change in the twenty-first century is likely to be greater than has been experienced in recorded history. At regional and local scales, this may translate into climatic and environmental changes that are completely outside the range of historical experience, at least in some parts of the world. Consequently, the historical evidence base that informs development policy and practice is extremely limited in its capacity to provide analogues for human responses to the types of climatic and environmental changes likely to occur in many parts of the world in the foreseeable future. While this does not mean that such evidence has no value, it does mean that minimalist narratives cannot be taken for granted. There is a strong case for extending the evidence base into the more distant past, to encompass episodes of more rapid and severe climatic and environmental change than have been experienced in recent decades.

### **Past analogues for twenty-first century climate change**

While there are periods in geological history when global temperatures were comparable with or greater than those projected for the late twenty-first century and

beyond (Bice & Norris, 2002; Haywood & Williams, 2005; Huber, 1998), these periods predate the emergence of modern human beings. Furthermore, with the exception of the mid-Pliocene period, some 3.3 million years ago, when global mean surface temperature was some 3 °C higher than today (Jansen et al., 2007), these periods of warmth occurred so far back in time that the Earth’s geography and topography (which play a key role in influencing climate) were significantly different from today. At the global scale, we therefore have no contextually similar physical or social analogues for twenty-first century climate change.

Nonetheless, periods of significant global climatic disruption can be identified in the recent geological past. A number of such episodes have been identified throughout the past 10,000 years, or Holocene period. Typically, these episodes recur every 1000–2000 years, last for some 100–300 years, and involve a transient pattern of cooling at middle and high latitudes, and enhanced aridity at lower latitudes, the latter particularly in the northern hemisphere subtropics and adjacent regions (hereafter denoted by the abbreviation NHST) (deMenocal et al., 2000).

A number of studies have linked these “cold-arid episodes” with societal changes. Clare et al. (2008) suggest that a well-documented major cold-arid episode around 8200 calendar years before present (hereafter abbreviated to BP) was linked with internecine warfare and population collapse at sites in southwestern Turkey. More well known is a qualitatively similar episode around 4200 BP, which has been linked with the collapse of the Akkadian Empire (Cullen et al., 2000; deMenocal, 2001), the end of the Egyptian Old Kingdom (Stanley et al., 2003), and the collapse of Neolithic cultures in north-central China (Chen et al., 2005; Wenxiang & Tungsheng, 2004). Protracted periods of drought have been linked with the collapse of other societies at this time, and throughout history (deMenocal, 2001; Weiss & Bradley, 2001).

This narrative of climate-induced collapse has been challenged on similar grounds to contemporary “maximalist” narratives as described above (e.g. Coombes & Barber, 2005). In both contemporary and historical contexts, there is thus a tension between those who see climate change as “causing” specific societal outcomes, and those who reject the idea of climatic or environmental change as a dominant driver of societal change. While the middle ground between these two extremes is occupied by investigations that seek to assess the relative roles of environmental and other forms of agency (Arkush, 2011), it might be argued that the paradigm of collapse has tended to overshadow more nuanced treatments of past human–environment interaction.

The purpose of this paper is not to challenge earlier work on climate change and societal collapse, but rather to present an argument for a more multidimensional

approach to the study of past human–environment interactions that considers a variety of possible outcomes from such interactions, based on comparative approaches examining a range of diverse linkages between climatic, environmental and cultural processes across different geographical regions and periods. The remainder of this paper builds on previous work by the author (Brooks, 2006, 2010) to present a suite of potential such linkages that allow for diverse societal outcomes from severe to abrupt climatic change, mediated by a variety of factors and varying according to local and regional environmental and cultural contexts. The period examined is the Middle Holocene, a time of profound climatic, environmental and cultural change across the globe. Through this synthetic treatment, the paper seeks a more nuanced understanding of the links between climatic, environmental and societal change that avoids simplistic determinism and that paves the way for further investigations.

### The Middle Holocene climatic transition

The Middle Holocene, and more precisely the period from around 6400 BP and 5000 BP, was a period of profound environmental change, during which the global climate underwent a systematic reorganisation as the warm, humid post-glacial climate of the Early Holocene gave way to a climatic configuration broadly similar to that of today (Brooks, 2010; Mayewski et al., 2004). The most prominent manifestations of this transition were a cooling at middle and high latitudes and high altitudes (Thompson et al., 2006), a transition from relatively humid to arid conditions in the NHST (Brooks, 2006, 2010; deMenocal et al., 2000) and the establishment of a regular El Niño after a multimillennial period during which it was rare or absent (Sandweiss et al., 2007).

This “Middle Holocene Climatic Transition” (MHCT) represented a stepwise acceleration of climatic trends that had commenced in the 9th millennium BP in some regions (Jung et al., 2004), and entailed a long-term shift towards cooler and more arid conditions, punctuated by episodes of abrupt climatic change. Around 6400–6300 BP, palaeo-environmental evidence indicates abrupt lake recessions and increased aridity in northern Africa, western Asia, South Asia and northern China, and the advance of glaciers in Europe and elsewhere (Damnati, 2000; Enzel et al., 1999; Jung et al., 2004; Linstädter & Kröpelin, 2004; Mayewski et al., 2004; Zhang et al., 2000).

Ocean records suggest a cold-arid episode around 5900 BP (Bond et al., 1997), followed in the Sahara by an abrupt shift to aridity around 5800–5700 BP, evident in terrestrial records from the Libyan central Sahara and marine records from the Eastern Tropical Atlantic (Cremaschi, 2002; di Lernia, 2002; deMenocal et al., 2000). From about 5800–5700 BP to 5200–5000 BP,

aridification intensified in the Sahara (deMenocal et al., 2000), South Asia (Enzel et al., 1999), north-central China (Zhang et al., 2000; Xiao et al., 2004) and the Arabian Peninsula (Parker et al., 2006). Over the same period, drought conditions prevailed in the Eastern Mediterranean (Bar-Matthews & Ayalon, 2011), the Zagros Mountains of Iran (Stevens et al., 2006) and County Mayo in Ireland (Caseldine et al., 2005), while river flow into the Cariaco Basin of northern South America decreased (Haug et al., 2001). An abrupt cold-arid episode around 5200 BP is evident in environmental records from Europe, Africa, western Asia, China and South America, (Caseldine et al., 2005; Gasse, 2002; Magny & Haas, 2004; Parker et al., 2006; Thompson et al., 1995).

The above evidence indicates that the MHCT was associated with a weakening of monsoon systems across the globe, and the southward retreat of monsoon rains in the NHST (Lézine, 2009). However, these changes coincided with climatic reorganisation outside of the global monsoon belt, as indicated by the onset of El Niño and evidence of large changes in climate at middle and high latitudes. The ultimate driving force behind these changes was a decline in the intensity of summer solar radiation outside the tropics, resulting from long-term changes in the angle of the Earth’s axis of rotation relative to its orbital plane. This was translated into abrupt changes in climate by non-linear feedback processes within the climate system (Brooks, 2004; deMenocal et al., 2000; Kukla & Gavin, 2004).

### Comparing the MHCT with twenty-first century climate change

The MHCT was very different in nature from the unfolding global climatic changes of the twenty-first century, and was the result of very different driving mechanisms. For example, while the twenty-first century is likely to be characterised by a large warming, global mean surface temperature appears to have fallen slightly, by some 0.4 °C, during the Middle Holocene (Jansen et al., 2007). Whereas the MHCT was driven by changes in the distribution of solar insolation across the Earth’s surface (deMenocal et al., 2000), twenty-first century climate change is being driven by an increase in the atmosphere’s capacity to absorb outgoing longwave radiation, due to elevated concentrations of greenhouse gases (Somerville et al., 2007). The physical manifestations of these climatic transitions are also different. Whereas the transition of the Middle Holocene was associated with glacial advance and a decline in atmospheric moisture content due to cooler ocean surface temperatures (at least at middle and high latitudes) (Mayewski et al., 2004; Thompson et al., 2006), that of the present day is driving a retreat of glaciers and ice and snow fields, and is increasing the amount of water vapour in the atmosphere

as a result of higher surface temperatures (Lemke et al., 2007; Trenberth et al., 2007). The distribution of impacts will also be different, and some areas that became drier in the Middle Holocene may become wetter in the foreseeable future, although the response of monsoon systems to anthropogenic greenhouse warming, and of regional rainfall regimes in general, remains highly uncertain (Christensen et al., 2007; Cook, 2008).

Nonetheless, the Middle Holocene provides us with examples of rapid climatic and environmental change, and associated increases in aridity and resource scarcity in a variety of geographic contexts. Such changes in climate, environment and resources are likely to be widespread as a result of twenty-first century anthropogenic climate change, even if they do not occur in precisely the same locations as in the Middle Holocene.

In the twenty-first century, transitions to greater aridity are expected to occur as a result of a combination of increased evapotranspiration due to higher temperatures, and declines in rainfall, with the greatest confidence in projections of increased aridity associated with locations outside of present-day monsoon regions. These regions include North Africa and the Middle East, Central Asia and the southwestern United States (Christensen et al., 2007). Modelling studies suggest that parts of southern Africa are likely to become drier (Christensen et al., 2007), and a study by Thomas et al. (2005) suggested that the Greater Kalahari region of southern Africa might be subject to severe desertification over the course of the twenty-first century as vegetation systems collapse and stable fossil dunes become mobile. Although the global climate models employed by the IPCC indicate wetter conditions over East Africa (Christensen et al., 2007), more up-to-date work in the light of recent drought and famine in the region has suggested that this region will become drier under climate change (Williams & Funk, 2010).

Despite the different drivers and geographic patterns of climate change in the Middle Holocene and today, the period centred on the 6th millennium BP provides us with the most recent physical analogue for global climatic reorganisation and widespread declines in the availability of water resources and productive land, phenomena which are likely to be associated with climate change in the twenty-first century and beyond, under current climate policy and emissions regimes.

### **Societal contexts in the Middle Holocene and present day**

Even if historically distant periods provide us with potential analogues for the regional manifestations and environmental consequences of climate change, the question remains as to whether such comparisons are valid when it comes to examining human responses to such changes. For example, social conditions and population

distributions and densities were very different in the Middle Holocene from those pertaining today.

Nonetheless, while some modern societies may be vastly different in character from those of the Middle Holocene, there are some significant similarities between the present day and the period centred on the 6th millennium BP. The latter period saw the emergence of the first large urban, state-level societies, associated with hierarchical social organisation and formal institutions of political power, in which the state enacted policies intended to ensure social stability and secure access to resources. While the scale of urbanisation today is orders of magnitude greater than during the Middle Holocene, the problem of managing and feeding people in areas of high population density in the face of environmental deterioration and resource scarcity is not a uniquely modern challenge.

Outside of the urban context, small-scale subsistence agriculture and pastoralism provide livelihoods and ensure a degree of food security for a significant proportion of the world's population today, just as they did in the Middle Holocene (Morton, 2007). For example, small-scale village agriculture was a key mode of subsistence in much of Western Asia and parts of South Asia during the 6th millennium BP, while mobile pastoralism was one of the primary subsistence strategies in North Africa and across much of subtropical Asia (di Lernia, 2006; Fall et al., 1998; Reddy, 1997; Zeder, 1994). Indeed, it has been proposed that many of the changes in subsistence and social organisation that occurred during the 6th millennium BP – a time of profound cultural as well as climatic and environmental change – initially emerged at least in part as responses to increased resource scarcity, as discussed in more detail below (Brooks, 2006, 2010; Kuper & Kröpelin, 2006).

### **Climatic, environmental and cultural trajectories during the MHCT**

Previous work by the author has examined potential links between climate change, resource scarcity and changes in livelihoods and the organisation of human societies in the Middle Holocene (Brooks, 2006, 2010). This work has focused on the NHST, and on the central Sahara, Egypt, Mesopotamia, South Asia and north-central China in particular, and has also addressed potential links between climatic and cultural change in northern coastal Peru (Brooks, 2006). These regions were originally selected as they represent the locations in which the world's earliest acknowledged large, complex, urban, state-level societies (i.e. "pristine civilisations") emerged, and as such provide opportunities for examining the role of climatic and environmental change in the development of social complexity (Brooks, 2006). Parallel regional environmental and cultural trajectories in these regions during the

MHCT are summarised below. For a fuller discussion, the reader is referred to Brooks (2006, 2010).

### Cultural transitions at the beginning of the MHCT

While correlation does not indicate causation, it is striking that in all of the above regions, independently identified cultural transitions tend to coincide with or follow soon after episodes of rapid climate change evident in global and regional records. In Mesopotamia, the beginning of the MHCT from about 6300–5900 BP coincided with the terminal phase of the long-lived Ubaid culture, and a transition from relatively egalitarian village-level farming communities to the more hierarchical society of the Uruk culture (Akkermans & Schwartz, 2003). This period saw the abandonment of agricultural settlements in the Middle Khabur river region in Northern Mesopotamia, paralleled by an early phase of urbanism at the site of Tell Brak, associated with the settlement of immigrant groups in distinct clusters (Ur et al., 2007). Widespread abandonment of sites in the wider Khabur region around 5900 BP is indicative of further out migration (Akkermans & Swartz, 2003). While further work is required in order to establish whether these demographic changes were influenced by climate change, they involved the abandonment of non-irrigated agriculture in favour of livestock husbandry and intensified use of steppe environments (including around the early urban centre of Tell Brak, which was situated in a steppe environment away from river valleys), at a time of increasing regional aridity.

The acceleration of aridity at the beginning of the MHCT also coincided with the beginning of the Egyptian Predynastic period, which was characterised by a long-term drift of population towards the Nile Valley as the adjacent eastern Saharan regions became drier (Midant-Reynes, 2000; Wendorf & Schild, 1998). The onset of the MHCT coincides with the collapse of the summer monsoon in the Gilf Kebir region of southwestern Egypt, an area occupied by nomadic pastoralists (Linstädter & Kröpelin, 2004). In the central Sahara, where aridity was less advanced than in eastern regions (Nicoll, 2004), this period was associated with the rapid spread of cattle herding in a process that has been characterised as involving the “leap-frogging” of pastoral groups from one location to another as they sought out pasture in an increasingly marginal and unpredictable environment (di Lernia, 2006).

In South Asia, Possehl (2002) locates the transition from Stage 1 to Stage 2 of the “Indus Age” around 6300 BP. Stage 2 was characterised by the development of pastoral societies and an increased reliance on seasonal or cyclical migration, a development that seems consistent with the evidence of increased aridity in this region (Enzel et al., 1999; Srivasta et al., 2003).

### Cultural trajectories throughout the 6th millennium BP

A range of archaeological evidence indicates changes in mobility, livelihoods, settlement and occupation patterns, against a backdrop of increasing aridity throughout the 6th millennium BP, in multiple regions. Dated occupation sites in the Sahara south of 23°N indicate a steady increase in human occupation throughout the 6th millennium BP (Vernet & Faure, 2000), a phenomenon that might be related to the removal of disease barriers to cattle husbandry and the opening of new areas as lakes and wetlands receded, as the region became drier (Smith, 1984). In the central Sahara, transhumance became important after an abrupt shift to more arid conditions around 5850–5600 BP, with the exploitation of lowland pastures in the summer monsoon season, and highland regions in the winter (di Lernia, 2002, 2006).

At the site of Hierakonpolis in the Nile Valley, later to become the “capital” of early Dynastic Egypt, remains interpreted as indicating the presence of a herding station suggest that previously mobile herders were attempting to integrate cattle husbandry into a sedentary lifestyle in the middle of the 6th millennium BP. At this time, the adjacent areas were experiencing a transition to hyper-aridity (earlier than in more westerly Saharan regions (Nicoll, 2004)), and key pastoral sites such as that at Nabta Playa were being abandoned (Hoffmann, 1982; Malville et al., 1998; Wengrow, 2001).

Migration out of areas experiencing aridification, and a greater emphasis on the exploitation of riparian environments, is also evident in South Asia during the latter half of the 6th millennium BP, which corresponds to the later part of Stage 2 of the Indus Age (Possehl, 2002). During this time, farmers and herders expanded eastward from Baluchistan into the Punjab, where they occupied the plains of the Indus and (now extinct) Sarasvati rivers, and herders appeared on the eastern fringes of the Thar desert (Possehl, 2002).

In Mesopotamia, the period between 5800 BP and 5200 BP saw the flourishing of the Uruk culture, and the Uruk expansion from southern Mesopotamia into northern Mesopotamia. It is during this period that the earliest cities and states emerged in southern Mesopotamia, the earlier but aborted trend towards urbanism at sites such as Tell Brak in northern Mesopotamia notwithstanding (Akkermans & Schwartz, 2003; Ur et al., 2007). It is interesting that the social context in which southern Mesopotamian urbanism developed has been characterised as one of violence and repression (Pollock, 2001). Algaze (2008) describes the political environment at this time as “fractious”, and Akkermans and Schwartz (2003) suggest that the Uruk expansion may have been driven by impoverished farmers seeking new cultivable lands. Pollock (2001) goes so far as to suggest that Uruk

colonists may have been essentially refugees fleeing “heavy demands for their labour and products” in a society that “was not, for many people, a pleasant place to live”. Johnson (1988–1989) suggests that the Uruk expansion may have been driven by demographic crises and unrest in southern Mesopotamia, associated with competition and conflict that caused displacement and migration, although this interpretation remains controversial (Akkermans & Schwartz 2003). The Uruk expansion coincides with the abandonment of villages in parts of southern Mesopotamia, with some of these areas being given over to pasture and foraging, as river courses changed significantly (Algaze, 2008). While the factors behind these changes remain unclear, climatic deterioration must at least be considered as a candidate given the evidence of extreme aridity in terrestrial areas adjacent to Mesopotamia (Bar-Matthews & Ayalon, 2011; Stevens et al., 2006), and ocean records from the Arabian Sea indicating increased export of dust (and by inference enhanced aridity) from adjacent land areas (Jung et al., 2004; Sirocko et al., 1993). Worsening environmental conditions may well have altered patterns of productivity, resulting in the abandonment of some areas, the agglomeration of populations in others, increased competition over resources, and widespread social disruption.

#### Cultural transitions at the end of the MHCT

The apparent episode of rapid climate change around 5200 BP coincided with a number of cultural transitions. In Mesopotamia, the collapse of the Uruk culture has been pinpointed to around 5200 BP, as Uruk “colonies” in the north were abandoned. In parts of southern Mesopotamia, some smaller settlements were abandoned and previously settled areas were turned over to pasture and foraging, as mobile pastoralism again increased in importance (Algaze, 2008). At the same time, a tenfold increase in population around the city of Uruk-Warka has been inferred from settlement data, suggesting a rapid influx to this part of southern Mesopotamia (Matthews, 2003; Nissen, 1988). While a number of factors may have contributed to these outcomes, including changes in river courses, increased aridity has been proposed as potential driving force behind the abandonment of some areas and the concentration of population in others (Kennet & Kennet, 2006).

In the Nile Valley, population agglomeration and a parallel increase in social complexity culminated in the unification of Egypt around or soon after 5200 BP (Midant-Reynes, 2000). The final fluvial deposits at Nekhen, near Hierakonpolis, have been dated to 5200 BP, indicating that rainfall effectively ceased after this time (Hoffmann et al., 1986). Linstädter and Kröpelin (2004) date the cessation of winter rainfall in the Gilf Kebir to around 5300 BP. While there is still considerable debate

about the unification of Egypt, it was represented in indigenous iconography as a violent act involving the subjugation of Lower (northern) Egypt by Upper (southern) Egypt, and can be understood as the culmination of a process in which competing protostate entities competed for territory and resources and coalesced through conquest or other forms of political integration (Brooks, 2006, 2010; Maisels, 1999). This occurred against a background of population agglomeration in the Nile Valley at a time of increasing climatic and environmental deterioration and uncertainty, which may have played an important role in driving competition over resources.

In the central Sahara, cattle herders were restricted to oasis areas by the end of the 6th millennium BP, with an associated reduction in mobility, as most regions became too arid to support cattle pastoralism (di Lernia, 2002). In the Sahara at large, there was an abrupt and permanent decline in the number of occupation sites north of 23°N over the period 5200–5000 BP (Vernet & Faure, 2000), indicating that people perished, migrated out of these latitudes and/or migrated into a smaller number of environmental refugia. There is a less pronounced, and temporary, decline in occupation south of 23°N, suggesting that the decline in the north was not offset by migration to the south. Evidence from the central Sahara indicates in-migration at this time to certain areas that remained productive (di Lernia, 2002; Mattingly et al., 2003). However, within such areas, increased oasis-based sedentism based on cattle husbandry was complemented by increased mobility based on sheep and goats in upland areas (di Lernia, 2002).

In South Asia, the transition to Stage 3 of the Indus Age or “Early Harappan” has been placed around 5200 BP (Possehl, 2002). At this time, transhumance intensified, and farmers and herders moved deeper into riverine zones, and the first settlement occurred at the site of Harappa, representing the beginnings of urbanism in the region (Possehl, 2002).

In China, an episode of cooling and heightened aridity occurred around 5300–5100 BP (Xiao et al., 2004; Zhang et al., 2000). This was followed by the transition from the Yangshao to the Longshan cultures on the plains of north-central China in the early 5th millennium BP. Liu (1996) describes the population of Central Henan province, where the earliest complex societies in China eventually emerged, as relatively stable during the Yangshao period. However, during the Longshan period, from about 4800 BP to 4000 BP, the population multiplied threefold as people migrated to the area of the Yellow River from surrounding regions, as the latter became drier (Liu, 1996).

By the early 5th millennium BP, the first large urban centres had emerged in the river valleys of northern coastal Peru. This followed a fall in ocean surface

temperatures evident in a shift from tropical to temperate marine taxa, linked with the onset of an El Niño Southern Oscillation cycle associated with long intervals of cold water conditions in the late 6th millennium BP (Reitz & Sandweiss, 2001). As well as changing the nature of marine food resources, more intense upwelling and colder coastal waters would have enhanced aridity associated with atmospheric subsidence along the western continental margin of South America. These marine and terrestrial changes represent a potential explanation for an increased dependence on terrestrial (as opposed to marine) resources, a shift of populations inland and a greater emphasis on the exploitation of river valleys, as observed in the archaeological record prior to the emergence of the first urban centres in these same valleys.

### **Interpreting trajectories of environmental and social change in the MHCT**

#### ***Robust outcomes of linked environmental and societal change?***

The extent to which societal change may be linked with climatic and environmental change during the MHCT varies with location, with Egypt and the Sahara providing the most convincing narratives of linked climatic, environmental and societal change, by virtue of the magnitude of the changes evident in the environmental records, and the wide body of archaeological work that has explicitly placed cultural changes within wider environmental contexts in these regions (Brookfield, 2010; di Lernia & Manzi, 2002; Kuper & Kröpelin, 2006; Mattingly et al., 2003; Midant-Reynes, 2006). In the other regions the discussed evidence is more equivocal, although it is possible to construct compelling narratives of climate-induced environmental changes influencing the development of human societies, that are consistent with the evidence and which view cultural change through the lens of adaptation. These narratives should be viewed as hypotheses to be tested, through the development of high-resolution environmental and cultural chronologies. These chronologies will allow us to identify the manifestations of climatic and environmental change at local scales, and to assess changes in livelihoods, settlements and other aspects of human culture at these same scales, within their local environmental contexts (Brooks, 2006).

Nonetheless, the evidence presented above suggests a number of robust societal outcomes of climate-induced environmental deterioration during the MHCT. In all the regions examined, it is demonstrable, likely or plausible that climate-induced aridification acted as a driver of migration, with people abandoning areas as they become less productive, and moving to areas where resources, principally water and productive land, were still

available. In Egypt, South Asia, north-central China and northern coastal Peru, the trend was one of population agglomeration in river valleys. In Mesopotamia, the situation was more complex, although such an agglomeration is evident in southern Mesopotamia in the late 6th millennium BP, for example around Uruk-Warka. In all of these instances, such population agglomeration ultimately culminated in the emergence of large, complex, highly urbanised, state-level societies – the world's earliest “civilisations” (Brooks, 2006). In the Sahara, population agglomeration is also evident in certain areas such as the Libyan Fezzan, which (albeit much later) also saw the emergence of an indigenous Saharan “civilization” in the form of the Garamantian Tribal Confederation, the development of which has been described explicitly in terms of adaptation to increased aridity (Brooks, 2006; di Lernia et al., 2002; Mattingly et al., 2003).

The agglomeration of populations in “refugia” in otherwise deteriorating environments can also be linked with increased social stratification and inequality. The earliest evidence of formal social differentiation, expressed through burial practices and funerary monuments, dates from the early part of the MHCT in Egypt, Mesopotamia and China (Akkermans & Schwartz, 2003; Liu, 2004; Wilkinson, 1999). In these regions, trends of accelerating social inequality culminated in the emergence of formal political power and class/caste systems in the world's earliest civilisations (Maisels, 1999). In the central Sahara, the expansion of cattle pastoralism at this time was associated with the spread of monumental funerary architecture, initially associated with ritual cattle burials, but which gave way to human interments by very late 6th/early 5th millennium BP, when populations had been squeezed into more restricted geographical areas (di Lernia, 2006; Sivili, 2002). This has been interpreted as indicating an increase in social stratification, as key individuals in pastoral groups were afforded special funerary rights reflecting their elevated status during life (di Lernia, 2006; di Lernia et al., 2002; Sivili, 2002). Such individuals may have emerged during times of hardship, crisis or even conflict (di Lernia, 2006), or as certain groups took advantage of economic, geographical or other advantages to enhance their social status in other areas (Brooks, 2006).

#### **Beyond collapse: diverse outcomes of human–environment interaction in the MHCT**

While many questions remain about the role of climate change in shaping human societies in the Middle Holocene, the above evidence paints a much more complex picture than is suggested by narratives of climate-induced societal collapse. While climate change may have played a role in the collapse of the Ubaid

and Uruk cultures in Mesopotamia, and while climate certainly drove the collapse of mobile pastoralism in the central and eastern Sahara, climate change also appears to have played a role in the emergence of complex societies in the Middle Holocene (Brooks, 2006).

Furthermore, the evidence presented here illustrates that similar climatic stresses can be associated with widely differing (even opposite) societal outcomes, the nature of which depends heavily on local environmental, economic, social and indeed cultural contexts. Qualitatively similar environmental trends can have very different outcomes in the same locations but at different times. For example, increased aridity appears to have been associated with a greater emphasis on mobile pastoralism in the central Sahara in the early MHCT, and throughout the MHCT in northern Mesopotamia and South Asia. However, in the eastern Sahara and Egypt at these times, aridity advanced to a point beyond which mobility was impaired, resulting in increased sedentism. The emergence of hyper-arid conditions in the eastern Sahara may be viewed as representing an environmental limit to adaptation, and as an example of how climatic or environmental change can overwhelm people's capacity to adapt *in situ*, meaning that their only recourse is to abandon an area.

An increased focus on agriculture in the riparian environments of the Nile Valley in the early centuries of the MHCT was paralleled in northern Mesopotamia by the abandonment of agricultural settlements along the Khabur River. Both of these phenomena may have been linked with climatic desiccation, with divergent outcomes resulting from different environmental or technological constraints and opportunities, and/or human agency. While productive steppe environments were accessible in northern Mesopotamia at this time, aridification was constraining such opportunities in the eastern Sahara. Assuming that reduced rainfall adversely affected settlements in the Khabur region, whose subsistence was based on rain-fed agriculture (Akkermans & Schwartz, 2003), we might speculate as to why the inhabitants of this area opted for a life of mobile pastoralism rather than offsetting rainfall deficits with irrigation. Perhaps geographic or topographic factors made irrigation impractical, or relevant skills and knowledge, or key resources, were lacking. Or perhaps pastoralism seemed a more attractive option in the particular social and environmental contexts of the time.

Diverse responses to similar environmental changes, specifically increased aridity, can be inferred from the archaeological records of the MHCT. In the central Sahara, the increased sedentism of cattle herders and the greater mobility of sheep and goat herders at the end of

the MHCT represent complementary but divergent responses to the same regional-scale environmental stress. In Mesopotamia, the abandonment of agricultural settlements in the Khabur region occurs alongside the settlement of migrant groups at early urban centres such as Tell Brak, and it is plausible that the latter was the corollary of the former. Whether increased aridity is (tentatively) associated with either increased or decreased social complexity in northern Mesopotamia during the early MHCT thus depends on where one looks.

## Conclusions

An examination of the last period during which the global climate underwent a systematic reorganisation provides us with abundant evidence for linked climatic, environmental and societal change, although the strength of this evidence varies with location. By taking a comparative approach across regions and over long timescales, we can construct convincing narratives of linked climatic, environmental and societal change that can serve as hypotheses for further testing. These narratives are much more nuanced than many previous such narratives, particularly those focusing on climate change as a trigger for societal collapse. The evidence from the Middle Holocene discussed here suggests that rapid climate change played a role in the emergence of complex societies, as well as their collapse, and that similar climatic stresses might result in very different outcomes in different societal contexts.

While the work presented here does not undermine narratives of collapse, it illustrates that attempts to link climatic, environmental and societal change need to accommodate multiple and diverse outcomes. By accommodating diverse (even apparently opposite) outcomes, mediated by geography and environment, and by social, economic and cultural contexts, we can construct narratives and models of linked climatic, environmental and societal change that move far beyond simplistic determinism, and that allow for human agency. The evidence from the Middle Holocene indicates that climate change represents a force for social transformation that may in some instances overwhelm other drivers of change. This conclusion is relevant in the context of emerging orthodoxies that reflect a "minimalist" approach to the links between climatic/environmental and societal change, which generally maintain that climate cannot be singled out as a dominant driver of change (e.g. Black et al., 2011). However, while climate change may dominate over other drivers of societal change in some instances, the nature of people's responses to climate change and the outcomes associated with these responses, will depend on a host of contextual factors associated

with constraints on, and available opportunities for, adaptation.

The study of past episodes of rapid and severe climate change can also help us identify climate change outcomes to which we might be alert from a policy perspective, which include out migration, in migration, population agglomeration in refugia, the emergence of new social forms as people adapt to new situations with respect to resource availability, and increased social stratification and inequality. Echoes of these outcomes have been identified in recent times, in areas that have experienced significant changes in climate, such as the Sahel (Brooks, 2006, 2010).

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