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# The Evolving Landscape of Inquiry: Climate's Growing Importance in Reconstructing Ancient China

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**Abstract:** This paper examines the growth of climate change discussions in narratives concerning the development and evolution of human societies in Ancient China over the past two decades. This shift reflects climate's ascension from a marginal factor to a central player in reconstructions of past human actions and societies. We provide an overview of the expanding research on ancient human–climate interactions in China's prehistory and early history, emphasizing the increasing importance attached to climate as a major player in the rise and, significantly, the collapse of these societies. Through a meta-analysis of publication trends in the last two decades, we identify the chronological periods and topics where climate has come to be interpreted as having a notable impact.

**Keywords:** climate change; ancient China; bibliometrics; publication trends



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## 1. Introduction

In recent years, human–climate relations have become a central research focus in many fields worldwide, including in China. Studies on contemporary periods and the recent past have examined how humans have affected their environments—either through taming natural forces on unprecedented scales, such as the Three Gorges Dam project on the Yangtze River, or, more commonly, by highlighting environmental degradation as populations extract more than the land can sustain and efforts to combat these effects [1–3]. Some scholars are extending this analysis into the deeper past by combining climate-modeling with historical and archaeological work [4–6]. In recent decades, such research on human–climate interaction in China's past has exploded, with hundreds of papers, books, and projects investigating the relationships between climatic shifts and milestones in human history. Climate change has emerged as a prominent explanation for political, social, and economic change, with some researchers finding correlations between climatic shifts and the rise and fall of Chinese dynasties [7–9], or earlier archaeological cultures [10–13].

Given the present climate crisis, it is not surprising that research into climate change past and present, and its impact on human societies, is at the forefront of research in many fields around the world. While archaeologists and historians have long recognized the impact of climate—as well as local environmental conditions—on human societies, direct collaboration with climate scientists, and vice versa, has been rare [14]. In some cases, this lack of collaboration has resulted in an inadvertent return to environmental determinism, a theoretical paradigm that archaeologists have largely rejected [15–18]. In a recent paper [14], our bibliometric analysis revealed that studies connecting climatic, environmental, and archaeological data in research on early China (i.e., prehistoric and early historic periods from the Paleolithic to the early states) predominantly appear in

Earth and planetary science journals and multidisciplinary publications, rather than in archaeological or anthropological periodicals, and that they tend to emphasize the natural science aspects of their research and spend less time and effort on the sociocultural context. This publication pattern appears shaped by several factors: journal ranking systems both within and beyond China, researchers' aims to emphasize natural science aspects of their work, and their desire to engage with diverse academic and public audiences.

The present paper builds on our previous work to analyze trends in English-language publications addressing human–climate interactions in China's past. While our forthcoming paper [14] focuses on the cultural, historical, and socio-cultural context of knowledge production, pointing out pressures created by publication the requirements, career progression demands, and expectations of funding agencies, as well as political frameworks and public discourse, here, we focus on the academic end of the matter. To better understand the main research questions that are being asked at the juncture of archaeology and climate sciences, the way research trends have developed over time, and to gain insights into the general state of the field, we focus on journals where articles at the intersection of archaeology and climate science are most often published, examining how researchers present their work and engage with the topic of human–climate interaction. Our analysis of published research, presented below, reveals characteristic patterns in how human–environment interactions have been conceptualized across different time periods. We examine these patterns and discuss major research trends in detail, first based on bibliometric data and then via an in-depth review of major research publications and their insights in a more traditional state-of-the-field assessment, before using this information to consider future directions at the intersection of these fields.

## 2. Research Methods and Bibliometric Analysis

In recent years, bibliometric studies have become popular, proving a useful tool for identifying research trends in various fields and tracing the underlying causes in an attempt to highlight potential issues and predict future developments. Such papers have identified biases in citation networks or funding allocation [19,20] and in the case of Chinese archaeology, they have tended to focus on the internationalization of the discipline [21,22] and general overviews on specific research topics. Our own forthcoming paper mentioned above [14] shows how publication trends in research linking archaeology and paleoclimate studies are connected to pressures on (especially young and mid-career) scholars to publish in high-impact journals, which are often natural-science focused. They are impacted by the ability to obtain research funding, which is more readily available for studies with a natural science component, especially when touching on pressing present-day issues, such as climate change and human adaptation to extreme environments.

Our present body of papers is the same as that compiled in [14], where we first used the bibliometric analysis websites Web of Science (WoS) and ScienceDirect to determine which journals were publishing significant numbers of articles at the intersection of archaeology and climate science and which journals were considered especially impactful. We used the following keywords in our searches, which included searches of article titles, keywords, and abstracts: archaeology, China, Neolithic, Paleolithic, Bronze Age, settlement, collapse, climate/climatic, environment(al), paleoclimate, paleoenvironment(al). We set our date range to 2000–2020. We found 14 journals that regularly published articles at the intersection of these topics. However, the total number of articles over the last 20 years for each journal varied significantly, from 10 to 200. Most of the journals with the lowest numbers of articles were in very high impact venues such as *Nature*, or were archaeology-specific, so we opted to keep these due to their potential impact generally and within archaeology, despite the lower number of publications.

For each article returned in our search, we recorded detailed information on the authorship, which is analyzed in detail in another publication [14]. We also collected information on the contents of the article based on the keywords, titles and abstracts, which we analyze here. Our comprehensive analysis of 405 English-language publications that engage with human–environment interaction in early China reveals nuanced patterns of research development from 2000 to 2020. Notable growth in scholarly publications can be seen over the past two decades (the output increased from 18 papers in the early 2000–2005 period to 205 papers by 2016–2020), with an increasing diversity of research themes and methodological approaches that reflect a more complex understanding of human–climate interactions in early China. To assess what these studies reported and the main research questions they were addressing, we tabulated and summarized the keywords and terms used in the paper titles and the keywords listed by the authors for their papers. Broad topics and terms, such as agriculture and periods (e.g., Neolithic, Paleolithic, etc.), were clearly observed. Additionally, we also searched for terms we expected to see on human–environment interaction, namely reliance, collapse, adaptation, and sustainably, but these, surprisingly, were not nearly as common (Figure 1, and see more below).

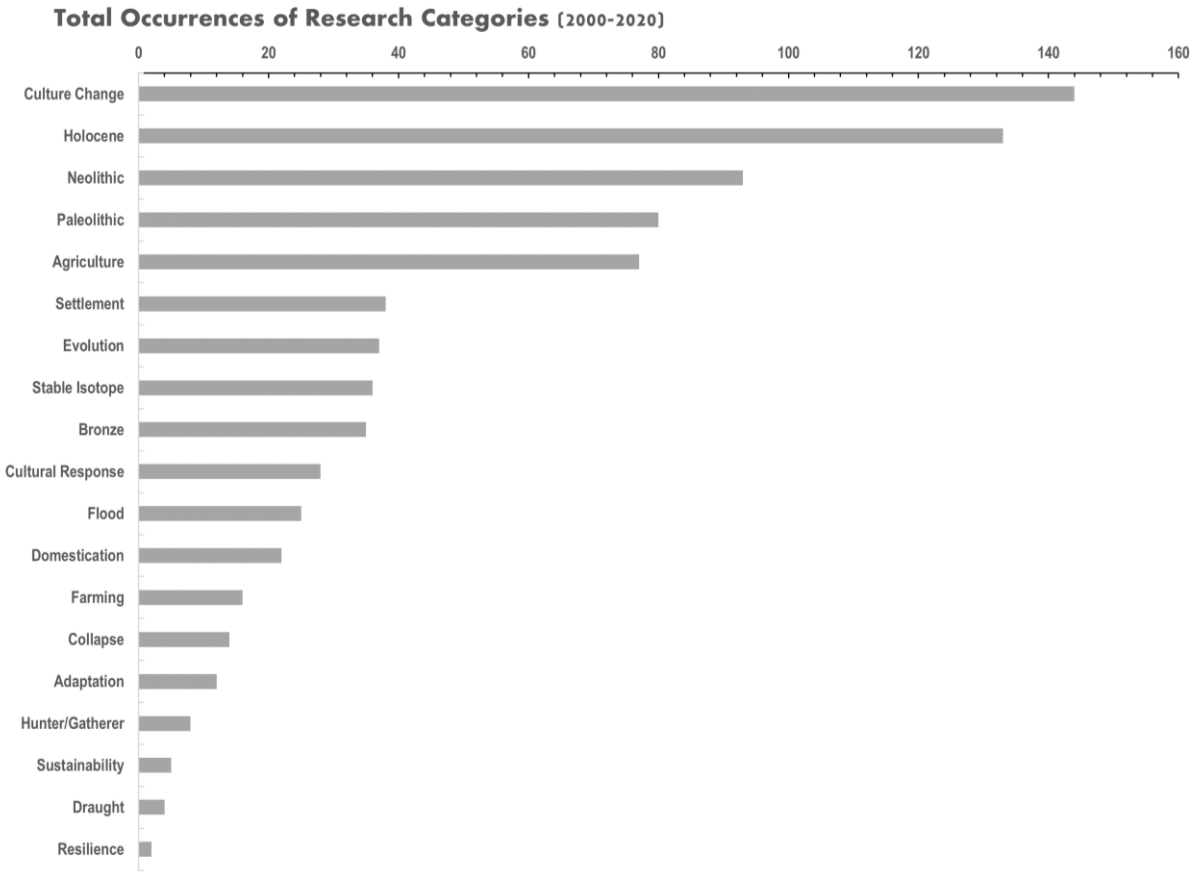


**Figure 1.** Total occurrences of selected research terms (2000–2020).

Looking at where archaeological papers (i.e., papers with a primary focus on archaeological data aiming to reconstruct past human behaviors, socio-historical developments, and sociocultural phenomena) were published and the topics and issues they inspect in relation to human–environment interaction, we can see a number of trends. Figure 1 shows the main terms and research categories discussed and their total number of cooccurrences over these years.

When we look at paper topics by publication venue (Table 1), a number of key trends emerge. The publication landscape in terms of research on human–climate dynamics

focusing on archaeological data is dominated by journals in the Quaternary sciences, with *Quaternary International* leading the way with 119 papers, followed by *The Holocene* with 70 publications. This is not so much a reflection of an interdisciplinary approach to understanding human–climate interactions in early Chinese contexts but rather a research thrust led by paleoclimatologist [14]. *Quaternary International* emerges as the most prolific publication venue, with 119 papers spanning a wide range of keywords. Its research breadth is particularly notable, with strong representations of culture change (51 papers), Holocene period studies (46 papers), and Paleolithic research (35 papers). This journal appears to provide the broadest coverage of archaeological research on early China. *The Holocene* journal takes a more focused approach, with a concentrated emphasis on culture change (37 papers), Holocene period studies (30 papers), and Neolithic research (24 papers). Its publications suggest a more targeted exploration of environmental and cultural dynamics during specific historical periods. In contrast, journals like *PLoS ONE* and *PNAS* show more specialized research profiles. *PLoS ONE* demonstrates a balanced approach with agriculture (11 papers), culture change (8 papers), and Paleolithic studies (6 papers). *PNAS* appears to have a more selective publication strategy, with fewer papers but a focus on critical themes like agriculture and domestication. *Nature* and *Science* have minimal representation, suggesting they publish only the most exceptional or groundbreaking research in this specific field of early Chinese archaeological research, however that may be defined. Considering the profile and aims of these two journals, this is not surprising.

**Table 1.** The publication venues investigated in this study and the top 3 research themes among papers focusing on archaeology and climate. Please note that some of the keywords co-occur, so the numbers add up to more than the total number of papers in each journal.

| *Journal* | *Total Papers* | *Keywords* | | |
|---|---|---|---|---|
| *Quaternary International* | 119 | Culture Change (57) | Holocene (46) | Paleolithic (35) |
| *The Holocene* | 70 | Culture Change (37) | Holocene (30) | Neolithic (24) |
| *Quaternary Science Reviews* | 51 | Holocene (30) | Culture Change (19) | Paleolithic (12) |
| *PLOS ONE* | 40 | Agriculture (11) | Culture Change (8) | Paleolithic (6) |
| *Journal of Archaeological Science* | 30 | Agriculture (8) | Neolithic (8) | Domestication (5) |
| *Quaternary Research* | 21 | Culture Change (11) | Holocene (11) | Neolithic (6) |
| *Catena* | 24 | Culture Change (6) | Holocene (7) | Stable Isotopes (3) |
| *PNAS* | 17 | Agriculture (5) | Culture Change (3) | Domestication (3) |
| *Nature* | 6 | Paleolithic (3) | Holocene (1) | Agriculture (1) |
| *Antiquity* | 6 | Neolithic (3) | Culture Change (2) | Agriculture (2) |
| *Quaternary Geochronology* | 6 | Paleolithic (3) | Neolithic (2) | Holocene (1) |
| *Science* | 2 | Holocene (1) | Culture Change (1) | Settlement (1) |

When we look at developments from 2000 to 2020, the data reveal distinct patterns in how scholars have studied human–climate interactions in early China through English-language publications (2000–2020). Notably, while new theoretical frameworks and methods emerge, traditional research interests (e.g., culture change, chronology, emergence of agriculture, and general changes in subsistence practices) remain robust and even expand (Figure 2—composite figure).

Early publications (2000–2010) engaged in human–environment interactions are relatively sparse and focused primarily on basic culture change and chronology (particularly in papers published in the journal *The Holocene*). The papers are largely descriptive, focusing on period-specific studies rather than theoretical frameworks or specific environmental responses (see discussion below for a more detailed description of these research trends with specific references). From 2010 to 2015, there was a notable diversification in how human–climate interactions were studied. While "culture change" remained a dominant

focus, the integration of stable isotope analysis marked a shift toward more precise methods of climatic or environmental reconstruction. The increased attention to agriculture and settlement patterns might suggest a growing interest in understanding specific mechanisms of human–climate relationships rather than just their outcomes in terms of changes over time. This may have something to do with chronologies becoming increasingly fine and precise, freeing up research capacity to investigate new questions rather than focusing on establishing basic chronological foundations.

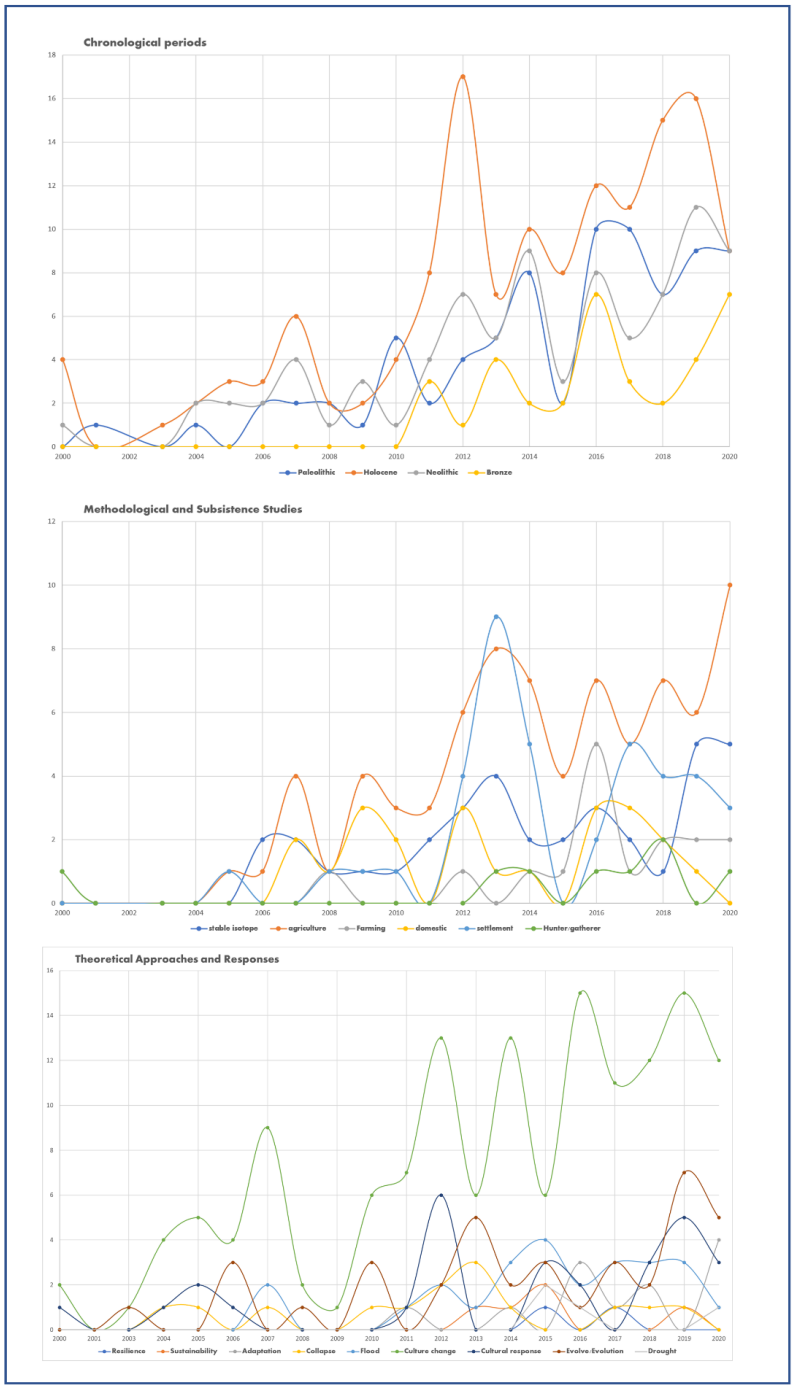


**Figure 2.** Research themes on human–climate interaction in Chinese archaeology by year (2000–2020), in English-language publications.

"Culture change" stands out as important and even shows growth over time, particularly after 2010. This suggests that rather than being replaced by newer theoretical

frameworks, broad culture change perspectives remain central to understanding human–climate relationships. Interestingly, "cultural response" appears less frequently than "culture change," perhaps indicating a distinction between general observations of change and specific responses to environmental pressures. When newer concepts, like adaptation, resilience, and sustainability, began appearing (post–2015), they did not replace culture change studies, even though during 2013 to 2015, there was a small dip in their prevalence when new themes were first introduced—instead, they seem to have complemented them. This suggests that these newer concepts are being integrated into existing frameworks rather than replacing them. The sustained and growing attention to agriculture and related subsistence practices alongside newer theoretical approaches is particularly telling. Rather than being superseded by newer frameworks, agricultural studies have been enhanced by them, integrating more sophisticated methods, like stable isotope analysis, while maintaining focus on fundamental questions of human–environment relationships.

Chronologically, Holocene studies dominate but show interesting patterns of co-occurrence with other periods. While Paleolithic research maintains a consistent presence, notably less attention is paid to hunter–gatherer adaptations despite their relevance to human–environment interactions. Bronze Age studies show periodic spikes rather than steady growth, often coinciding with peaks in agriculture and culture change studies, suggesting focused interest in this period's environmental transitions. The relationships between Bronze Age studies, theoretical frameworks, and methodological approaches reveal a complex pattern of scholarly development. Bronze Age research shows distinct intensification during periods of methodological innovation, particularly when stable isotope studies became more prevalent. The years 2016 and 2020, which saw the highest numbers of publications on the Bronze Age (7 each), coincided with significant agricultural studies and the application of new analytical methods.

Culture change has remained a dominant framework, but its relationship with specific approaches has evolved over time. While early peaks in culture change studies (2012–2014) correlate strongly with settlement pattern research, later peaks (2016–2020) show stronger relationships with stable isotope analysis and agricultural studies. Studies focusing on cultural responses to climate fluctuations follow a different pattern, reaching their heights in 2012 and 2019, periods when the application of various methodologies in a single study can be seen, along with a focus on Holocene studies. This suggests that cultural response might be conceptualized differently from general culture change, perhaps reflecting a more specific focus on human–environment relationships that benefits from multiple analytical approaches.

Finally, about two thirds of the papers combine multiple keywords listed among our search terms, and the publication trends reveal nuanced interconnections across multiple themes (Table 2). Notably, culture change emerges as the most interconnected keyword, strongly linked with the Holocene period (72 papers) and showing significant connections to the Neolithic period and agricultural research. This suggests cultural transformation is thought to be tied to climatic and technological shifts. The Holocene period has proven to be central to interdisciplinary research on human–climate interactions, with strong connections to culture change, the Neolithic period, and agricultural studies. Agricultural research itself is tightly linked with culture change and shows strong associations with the Holocene and Neolithic periods, indicating agriculture as a key driver of culture change. The Neolithic period particularly stands out, bridging culture change, agriculture, and climate research as a transformative era in human development. To better understand the correlation between these patterns and their impact on the field, we now delve into specific trends that we have identified via our bibliometric research.

**Table 2.** Research theme connections/top keyword co-occurrences.

| Theme Pairs | Number of Co-Occurrences |
|---|---|
| Culture change—Holocene | 72 |
| Holocene—Neolithic | 38 |
| Culture change—Neolithic | 35 |
| Culture change—Agriculture | 29 |
| Agriculture—Holocene | 27 |
| Agriculture—Neolithic | 27 |
| Stable Isotopes—Paleolithic | 10 |
| Domestication—Neolithic | 6 |
| Adaptation—Paleolithic | 3 |
| Flood—Holocene | 13 |

## 3. Discussion—Dominant Trends in Early China Human–Climate Scholarship: Climate Change, Agriculture, and Culture Change over Time

Based on the above analysis, we have identified several key trends within the research concerning the intersection of climate and archaeology in early China, with the most common focus on the topics of culture change and agriculture. Here, we look in more detail at the narratives within these trends, discussing specific approaches and results as observed, primarily from papers identified via our bibliometric analysis, before discussing how these foci may impact future research trajectories.

A dominant topic that emerged from our analysis above is agriculture, particularly in relation to the Holocene and to culture change. The origins of agriculture in China—as anywhere in the world—are intricately linked to various environmental factors, including climatic changes, geographic features, and ecological conditions [23,24]. These factors played a crucial role in shaping the agricultural practices that emerged in different parts of what is now China and neighboring regions. One of the primary environmental influences on the origins of agriculture in China were the climatic conditions during the Holocene, which explains the strong connection with this keyword.

The relationship between climate and humans is complex, and the archaeological record shows a gradual transition from foraging to farming over thousands of years in various parts of China [25–27]. This extended timeline suggests a more nuanced role for human agency in this process, one that consists of experiments with various strategies rather than abrupt and complete changes to subsistence practices and/or social organization in response to changing climate conditions [28–30]. Plant and animal domestication processes varied significantly across regions, shaped by local environmental and ecological conditions, as well as sociocultural factors [31]. In the Lower Yangtze region, the transition from wild to domesticated rice involved a complex interplay of ecological knowledge and experimentation. Millet, in the north, was likely domesticated across multiple centers, while pigs—generally adaptable creatures that excel at extracting food resources from various environments, except in hot and dry climates—may have been bred in a single northern Chinese region [32]. As communities transitioned to agriculture, they developed new technologies for managing water resources, including irrigation systems essential for sustaining agricultural productivity [33]. Periods of drought and changing rainfall patterns necessitated adaptations in farming techniques and crop selection to maintain viable subsistence practices in specific locations [34]. Subsequent climatic shifts allowed for

more growing days and optimal crop management periods, enabling human expansion into previously challenging zones [35].

Another major research trend is the focus on connecting climatic change to culture change, as demonstrated by culture change being one of the top keywords from 2010 to 2020, with particularly strong relations to the keywords Holocene and Neolithic. This may be connected to general concerns with establishing a strong chronological framework that traces change (in material culture and archaeological evidence, more broadly speaking) over time, but also with the perennial "why" question of archaeological and historical narratives. Why did societies change over time in terms of social structures, subsistence systems, beliefs, and other aspects of "culture" broadly conceived? Throughout the Holocene, multiple global climatic shifts have been identified, many of which have been considered as drivers behind major shifts in subsistence systems and/or sociopolitical organization in certain parts of China. The main events occurred around 8.2 kya, 4.2 kya, and 3.2/2.8 kya BP, with other significant events noted at 7.2/7.0, 6.0, and 5.5/5.0 kya BP [36–43]. In this context, it is crucial to note that in relation to climate, the term "event" can mean a variety of things and can extend over shorter or longer periods. It can be something short, such as a one-season draught or heatwave, however, the events mentioned most commonly in the context of debates on human–climate relations in the past are a lot longer in duration, have fluctuations within them, and vary tremendously in intensity and impact among different areas. This is rather different from the way that the term "event" is used for instance in history or other fields in the humanities or social sciences or in everyday speech, a fact that has led to significant misunderstandings in communication among archaeologists, historians, and climate scientists.

Among these events, the 4.2 kya or 4.0 kya cal BP cooling event is the most widely discussed period, with significant implications for culture change, especially shifts in social organization and settlement patterns [44]. Based on archaeological and climatic research, this period of climate change is believed by many to have triggered a widespread collapse of Neolithic cultures across China in the late 3rd millennium BCE, with previous sociopolitical structures giving way to the first Bronze Age states [36,45–56]. These changes are often seen to have instigated widespread cultural, dietary, and agricultural shifts, such as the adoption of hardier barley and millet crops, and the adoption of more mobile forms of pastoralism [57–62] for an overview of these topics). It is worth noting that the somewhat vague and general term "culture change" assumes a narrower definition in the context of the emergence of state societies, in this case, meaning major sociopolitical and socioeconomic shifts if not complete breaks with the past. This narrower view of "culture change" might be linked to the historiographic traditions that draw on textual accounts emerging from the Late Shang period onward (~1250–1050 BCE) but include some allusions to earlier periods. Indeed, several scholars have suggested that the establishment of the Xia Dynasty, often considered China's first dynasty (predating the Shang, dating anywhere from the late 3rd to the middle of the 2nd millennium BCE), is closely linked to climatic changes, citing narratives of great floods and their control by Yu, and forming the founding myth of the Xia Dynasty [63,64]. However, such hypotheses of wholesale collapse and change are not universally accepted. Critics point to the unequal impact of this and other climate events across China and mismatches of scale among paleoclimatic, archaeological, and historical datasets, which are often too coarse to establish connections, let alone causal relationships [15–18,60,65]. Both uneven impacts of these climate shifts and varied reactions to climate change are consistently demonstrated [66–70] while evidence of continuity and resilience appears across the ancient landscape [60,71–74]

Interestingly, based on our analysis, research papers focusing on the later Bronze Age and Iron Age (late 2nd and throughout the 1st millennium BCE), generally do not

see climate as an important catalyst for change. For example, only a few papers have attributed the fall of the Shang to climate change, and only a small number of studies have argued that climate change drove the Shang "over the edge" and led to their downfall by the Zhou [75–79]. These publications are rare and have yet to make their way into the wider archaeological discourse. In the current literature, standard explanations for the shift from the Shang to the Zhou dynasty focus on political and sociocultural factors. When scholars investigate relationships among environmental conditions, climate changes, and subsistence practices, they typically are not concerned with wholesale regime changes (such as the collapse of a dynasty). Instead, they examine how shifting environmental conditions required adaptations to continue flourishing, such as transitioning to hardier crops or animal husbandry [80–84]. Additionally, in these analyses, climate is usually not viewed as a determining factor, but rather as one aspect among many.

## 4. Conclusions

The research on publication trends at the intersection of archaeology and climate science reveals a clear evolution of the scholarly approach from 2000 to 2020. Beginning with a modest 18 papers in the first five-year interval, the field experienced exponential growth, culminating in 205 papers between 2016 and 2020. Throughout this period, a consistent set of keywords dominated the research landscape, with culture change and Holocene emerging as the most prominent themes. The early years showed a tentative, exploratory approach, with limited interdisciplinary connections. By 2006–2010, research began to diversify, introducing more complex relationships among concepts like agriculture, domestication, and culture change. The 2011–2015 period marked a significant turning point, characterized by more sophisticated, multi-dimensional research that deeply explored the interconnections between environmental and cultural themes. The final interval (2016–2020) represented the peak of interdisciplinary research, with intricate links between Holocene, culture change, Neolithic, Paleolithic, and agricultural themes.

Overall, scholars investigating human–climate interactions in early China have approached the topic through various lenses, examining the complex relationships among climatic changes, agricultural development, and cultural transformations. Researchers have explored how these environmental shifts have influenced human adaptation, utilizing diverse methodological approaches, including archaeological evidence, paleoclimatic reconstructions, and isotopic analyses. The scholarly discourse has centered on the gradual transition from foraging to farming, emphasizing regional variations in domestication processes and highlighting unique agricultural developments across different ecological zones, such as rice domestication in the Lower Yangtze and millet cultivation in northern China.

The general pattern indicates that the field has evolved through accumulation rather than replacement. Newer approaches and methods are being integrated into persistent research interests in culture change and agricultural development, while maintaining traditional period-based frameworks. The continuing dominance of culture change studies, alongside growing methodological sophistication and new theoretical frameworks, suggests that researchers are finding ways to combine broader interpretive frameworks with more precise analytical tools and contemporary theoretical perspectives. Each successive five-year period demonstrates increasingly nuanced approaches to understanding human–environment interactions in early Chinese societies. The research trajectory reflects a profound shift from isolated disciplinary investigations to a holistic, interconnected understanding of cultural evolution, environmental adaptation, and human development. This progression highlights the field's growing complexity, with researchers increasingly recognizing the intricate relationships between archaeological, climatic, and cultural phenomena.

Based on this trajectory to date, we expect that papers emphasizing the role of a changing climate in the adoption of new technologies, including agriculture, water management systems, and new forms of social organization in early China, will continue at pace. However, we also hope that scholars will continue to challenge simplistic narratives of climate and environmental determinism. The present analysis demonstrates that scholarship engaging with climatic and environmental factors maintains considerable ambiguity—while 'culture change' emerges as the predominant theme in our analysis, its extent, intensity, and impact remain open-ended. This framing reflects, we believe, a tension between acknowledging significant causal feedback mechanisms affecting human societies, while circumventing the methodological pitfall of positing overarching deterministic outcomes—a theoretical position now largely abandoned. What is needed are more nuanced interpretations of human–climate interactions and scrutinizing potential impacts while acknowledging the complexity of climatic influences on human societies. In this way, research on human–climate interaction can not only shed light on the development of complex societies and early states in ancient China but can also provide valuable information on human responses to climate change that are relevant for our present climate crisis.

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