Climatic Variation and Society in Medieval South Asia: Unexplored Threads of History and Archaeology of Mandu

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Instabilities of the monsoon climate system, along with alternating periods of severe dryness and wetness, are known to have punctuated and disrupted the lives of peoples and institutions across Asia during medieval times. As far as India is concerned, the topic has attracted little attention from historians and archaeologists.

Did climatic variations play a determining role in societal changes in medieval times? The aim of this article is not to answer, but to raise and

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refine this question by calling for new interdisciplinary initiatives which would enrich our reading and understanding of the past and contribute different threads to the narratives of medieval history and archaeology. While doing so, it highlights two lingering 'lacks' underlying the well-established historiography: the lack of attention to nature, and thus to climate; and the lack of archaeology. Attention is then focused on recent advances in palaeoclimatology and in research linking climate and society, in which India is yet to find a substantial place. Finally, the article outlines prospects and openings for the study of the medieval past as it relates to the climate-water-society nexus, by presenting an ongoing project called MANDU exploring histories and archaeologies of the land-waterscapes of Mandu in Central India.

Introduction

In recent years, knowledge of the history of our planet's environment has considerably increased and offers unprecedented perspectives on the past. We now know that at times different regions of the globe were subjected to climatic and meteorologic disturbances, including extreme events; and these are believed to have played a significant role in the history of societies. Determining the causes and processes of these disturbances, the share of external forces, whether natural (solar activity, volcanic eruptions) or anthropogenic, and that of the internal variability of climate systems, is an immense challenge for researchers.[1] Identifying the effects on ecosystems and *a fortiori* human society in the past is also challenging given (a) the multiplicity of variables, scales, and levels of analysis to consider and confront and (b) the resolution of data at our disposal.

[1] In this article, climatic variation, also referred to as disturbance or anomaly, falls into 'climatic variability', which relates to the natural fluctuations of the climate system. These fluctuations can be generated by internal causes (like the ocean atmosphere during the various El-Niño/La Niña oscillations) and natural forcing and particular events (in a very large range of duration) during which the climate characteristics (temperature, precipitation, wind…) significantly differ from their long-term average and usual variability. The article also mentions 'climate extreme' such as severe drought, periods of heavy rainfall (and associated floods), heat waves. This notion refers to both extreme weather events and extreme climate events and comprises a facet of climate variability (under stable or changing climate conditions). The characteristics of what is called extreme weather may vary from place to place in an absolute sense. See annexe III in IPCC, *Climate Change 2013,* for the definition of various key terms. Also Clift and Plumb, *The Asian Monsoon Climate*.

Archaeologists and historians, who have long feared the spectre of environmental determinism and avoided the topic, are now more open to studying the possible links between modifications in environment and shifts in political, socio-economic, and cultural orders and dynamics (including resource use strategies). Issues of vulnerabilities, fragility, capacities, adaptations, and resilience in the face of climatic variability and disasters, lie at the heart of the concerns of a growing part of the scientific community, particularly the one interested in transition and change in complex human societies over certain periods.[2] The scholarly (and popular) literature, now prolific, is marked by a trend to focus on events and periods described as dramatic in relation to climate and on how environmental forces can shape historical processes. Significant attention has been notably given to notions such as decline, failure, and collapse to tackle the big question surrounding the social impacts of and responses to climatic disturbances.[3] Yet, away from the climatic determinism of past generations, scholars apprehend climate in dynamic interplay with several human and non-human factors and strive towards more nuanced ways of interpreting climate-human interactions and the role of climate in society change.

Climate has received unequal attention in different regions of the world and depending on the historical periods considered. In the case of South Asia, research on the role of climate in Harappan times is well developed, whereas it remains particularly weak when it comes to the study of the medieval in India. While the importance of monsoons is acknowledged—even well studied, notably in relation to human–environment relationships around water and agriculture, in the history of conquest, and in the

[2] A significant body of theoretical and empirical scholarship is now available. The extent to which these have reached the study of the Indian medieval is in its infancy. Among early seminal works, see notably Tainter, *The Collapse of Complex Societies*. Among recent works, for example, Campbell, *The Great Transition*; Faulseit, *Beyond Collapse*; Giosan et al., *Climates, Landscapes, and Civilizations*; Yoffee, *The Evolution of Fragilities*; Middleton, *Understanding Collapse*; McAnany and Yoffee, 'Questioning Collapse'.

[3] The role of climate in the Maya 'Collapse' is a classic case of attributing major demographic changes and abandonment of city-states throughout Mesoamerica to climatic anomalies (along with many other factors). However, extremes and collapse are not the sole modality of climate. While many studies on ancient climate impacts focus on major negative effects, others discuss how climate change aided certain societies. For example, Chepstow-Lusty et al., 'Putting the Rise of the Inca Empire'.

religious components of life—,[4] the occurrence and impact of climatic variations and extremes in society and history is rarely subject to investigation within interdisciplinary initiatives at the intersection of both natural, social and human sciences. In mainstream historiography, the scope of the environment is often reduced to a passive, if not immutable, backdrop to societal dynamics and change. Little attention has been paid to environmental disturbance; this is not just because of the lack of clear 'proof', but also because historians have long disregarded the environment as a potential (co-)driving force of change at different levels of society.

There are many ways to narrow down the role of climate in societal development to specific scales and issues in the field of human–environment interaction and explore it theoretically and empirically. But did climatic variation contribute to shifts in political and other orders which took place in medieval times? What were the diverse social impacts and responses to the disturbances of climate? The aim of this article is not to answer, but to raise the questions and the methodological difficulties they entail, and to call for new interdisciplinary initiatives to enrich our reading and understanding of the past and follow different threads in the narratives of medieval history and archaeology. While aiming to do so, it draws attention to two lingering 'lacks' underlying the well-established historiography: the lack of nature, and thus climate; and the lack of archaeology. In the historiography of climate, the lack of human agency and the tendency toward overly deterministic interpretations (following narratives such as 'arid periods cause social collapse') is what characterises many studies in palaeoclimatology linking climate and society.

Attention is then focused on recent advances in which India is yet to find a significant place.[5] Finally, the article outlines some of the challenges and openings for the study of the medieval past as it relates to the climate-water-society nexus, by presenting an ongoing interdisciplinary research project called MANDU. This project explores histories and archaeologies of the land-waterscapes of Mandu in Central India, a famous historical place known as the capital of the Malwa Sultanate

[4] For example, Chapple et al., *Hinduism and Ecology.*

[5] In this article, the section on historiography and those reviewing some of the evidence and scholarship from the field of palaeoclimatology and society-climate interactions partly draw on an earlier work: Casile, 'Pour une histoire de l'Inde'.

from *c.* 1400 CE. Untouched by recent urbanisation, the area of Mandu contains rich archaeological records of long-term human activities, cultural and institutional changes underpinned by a variety of processes and offers stimulating potential from scientific perspective to investigate facets of the society-climate-water interplay through a wide array of data.

Historiography of Medieval South Asia Without Climate: The Enduring Rupture Between Environment and Historical Processes

It is a striking feature of the mainstream historiography of medieval times in South Asia to be rather quiet on the issue of climate and its role as a potential disruptor of political, economic, and other orders, as a (co-) driver or (co-)agent of change in society. With a few notable exceptions, recent historical and historiographical syntheses do not offer any hypothesis nor raise any questions on the matter.[6] If we browse recent works of global climate history, it is noteworthy that very little space is devoted to India in medieval times.[7]

From the beginnings of European scholarship on India's past, the reading of the thousand years that span the medieval has imposed a clear-cut divide along politico-religious lines between an early period (circa seventh to twentieth centuries) characterised by the emergence and decline of various 'Hindu' kingdoms, and a late 'Indo-Islamic' period (circa thirteenth to mid-sixteenth centuries) inaugurated by the Ghurid conquests of India and marked by the advent of new 'Islamic' kingdoms with the spread of Sultanate systems. Under colonial and

[6] For example, Asher and Talbot, *India Before Europe*; Singh, *A History of Ancient and Early Medieval India*; Schug and Walimbe, *A Companion to South Asia;* Eaton, *India in the Persianate Age*. Among historians of the medieval who were attentive to environmental geography, André Wink devoted much to place geography and environment at the centre of social history. Pointing to the devastating potential of environmental forces and disturbances on demographic and socio-economic dynamics in medieval times, he is also one of the few historians who has highlighted the necessity to study them. See Wink, *Al-Hind*, vol. 3. A recent volume edited by Mukherjee and Seshan, *Indian Ocean Histories*, also approaches climate shifts and historical events in a synthetic manner, while aiming to avoid simplistic or deterministic explanations.

[7] For example, Clift and Plumb, *The Asian Monsoon*; Brooke, *Climate Change*; McNeill and Mauldin, *A Companion to Global Environmental History*; White et al., *The Palgrave Handbook of Climate History*.

nationalistic historiography, this late period has long been considered as one of generalised decline. Scholarship on one or the other of these two periods has followed different and increasingly divergent trajectories, entrenched thematically and methodologically in several disciplinary perspectives with little connections and interactions between them. The 'transition' from early to late medieval times—and by extension the many changes that took place within the medieval—has been interpreted mostly with reference to textual sources, rather than archaeological data, and to a large extent through the prism of conquests, invasions, and raids.

Due to the primacy of textually defined approaches, the study of other topics peripheral to the main thrust of historiography has been confined to other disciplines, such as the history of art and architecture. This has led to a myopic understanding of many interconnected developments. Yet, over recent years, scholars have begun to bring down disciplinary barriers and explore the potential of combining different sources and thematic approaches. Their work allows to challenge dichotomies (Hindu–Muslim and others), reductionist models (such as outdated and politically divisive models of invasion), and lingering stereotypes (e.g., the notion of India being territorially bounded and historically isolated, an essentially self-generated Hindu civilisation and not a hybridised composite).[8] But owing to the continued absence of archaeological scholarship, a point which this article highlights, many studies are only partially grounded, whether materially or in space and time.

Much has been written on the genealogy of the early and late medieval as periods in the historiography of India and the politics of time;[9] much less on the fact that in the history of about a thousand years, nature has long been banished to the margins, either as a passive reality or as a storehouse of resources for the human economy.[10] Climate, *a fortiori*, is stable. An outline of the main features of its characteristics is often all

[8] See, for example, Prange, *Monsoon Islam*. For the past 10 years or so, transdisciplinary research efforts have marked an important turning point in the manner of thinking about medieval society in relation to the development of Islam, aiming to restore it to its complex reality through the study of material culture. Scholarship works are rich and expending. See, for example, Flood, *Objects of Translation*, focusing on the potential of objects histories. Other research unfolds in the field of architectural history or examines the development of urbanism during the medieval period.

[9] For example, Ali, 'The Historiography of the Medieval in South Asia'.

[10] Chakrabarty, 'The Climate of History'.

that is necessary to describe the geographic contexts in various studies of regional history, site monographs, or historical syntheses. Being largely ignored, the possibility of environmental interferences at various scales in the course of history has rarely been hypothesised and explored, which is striking given the importance of the environment, especially climate, in research on the Indus Civilisation.[11]

In the field of both archaeology and historical ecology, the medieval is among the most poorly documented pasts in the history of India. During the twentieth century, among the questions that have preoccupied most historians in search of models, those that deal with the nature and conduct of states, the making of kingdoms and empires, are addressed in a literature impressive for its abundance and longevity.[12] With the rise of social and economic history, many attempts have been made to expand the scope of historical research beyond the universe of politics and state formation and create a wide-ranging historiography: under the influence of human geography and the French Annales School which called for a radical opening of the concept of document beyond the written to involve other kind of vestiges from the past, including transformed landscapes, a closer dialogue developed between geography and history, notably in the study of settlement patterns, and sacred and religious landscapes citation. Still, most historical works on medieval times paid little attention to the biophysical dimensions and issues of rhythms, complexities, vulnerabilities, and unpredictability. In the wake of environmental movement and subaltern studies, and the works by pioneer scholars in India from the 1990's onwards, advance in environmental history mostly concerns later periods, with a strong focus on colonial times (a great deal of work on land use and forest, water manipulation, wildlife fate, the role of the state, famine and diseases, and pastoralism).[13]

[11] M. K. Dhavalikar suggested that adverse climatic conditions contributed to 'decline' and 'degeneration' following the Golden Age of Gupta times. See Dhavalikar, 'The Golden Age and After'. His work is the reflection of a historiography that has been amply criticised and no longer applies today. About research on climate in Harappan times, see in Middleton, *Understanding Collapse*; Yoffee, *The Evolution of Fragilities*; Giosan et al., *Climates, Landscapes, and Civilizations*.

[12] A summary may be found in Sinopoli, *The Political Economy*: 38–62.

[13] See anthologies such as Grove et al., *Nature and the Orient*; Rangarajan and Sivaramakrishnan, *India's Environmental History*; and the introduction in Kapur, *Environmental History*.

However, it would be wrong to say that historians have no interest in the ecological dimensions of social life or that environmental history is absent from research concerns on the medieval.[14] In close connection with agrarian, economic, politico-religious, cultural, and conquests history, central questions of environmental importance in historical processes have been addressed on the basis of texts and other material sources, but little using archaeological bases.[15] Water, as a productive and symbolic resource, has been a recurrent subject of enquiry in the field of political economy—notably in relation to processes of agricultural extension and intensification (through irrigation) and the formation of regional power networks—and cultural history.[16] From the point of view of written documents again and ethnographical enquiries on 'traditional' knowledge and studies in water structures, topics pertaining to adaptations and land-water conservation have also been explored. This includes recent research on the ways social, political, and agrarian institutions have been shaped by hydroclimatic risks.[17] In terms of the 'built', more than 'natural' environment, water is also studied as an aspect of art, architecture, and social practice.[18]

Despite its richness in content and questioning, scholarly production in environmental history pertaining to medieval times is limited in contrast to the colonial and later periods (and even to the 'prehistoric' periods).[19] Major contributions have been made, but have not yet allowed

[14] See the helpful introduction and anthology of various seminal essays in Kapur, *Environmental History*, which provides an overview of earlier research on India's environment.

[15] For example, Trautmann, *Elephants & Kings*. See also the various seminal essays relying on literary documents and chronicles in Kapur, *Environmental History*. About garden cultures, for example, Ali and Flatt, *Garden and Landscape Practices*.

[16] For example, the seminal essays by Ranabir Chakrabarti (who refers to the work of palaeoclimatologists to highlight the monsoon's effects throughout all regions of India) and David Ludden which probe into the topic of water management, in Kapur, *Environmental History*: 55–62 and 63–71. See Ali and Flatt, *Garden and Landscape Practices*. Also, see the special section of *The Medieval History Journal* on 'Water and Waterscapes in South Asian History'. Parthasarathi, 'Introduction'.

[17] Kumar, M., *Monsoon Ecologies*.

[18] For example, Morrison, 'Doorways to the Divine'.

[19] Kapur, *Environmental History*; Rangarajan and Sivaramakrishnan, *India's Environmental History*; and Chakrabarti, *Critical Themes*. These collections of seminal essays, while highlighting the many efforts by scholars to engage with the issue of human–environment relationship, underscore the need for more studies in environmental history.

to think about the environment as a force at work in the history of society even though historians of the late medieval, such as André Wink, have emphasised the necessity of looking at droughts and famines so as to understand the movements and displacements of population, and the social and political difficulties.[20]

As far as climate is concerned, the links between climate and human history seem almost absent, although recent works of environmental history intend to reverse this trend.[21] Both earth scientists and historians have failed to engage with one another, and this explains the sometimes overly deterministic interpretations found in environmental studies that tend to elide historical complexities.[22] Several reasons can be invoked to explain this persistent divide between society and environment in historical research endeavours. The longstanding compartmentalisation of disciplines and categories of analysis, on the one hand, and perhaps a certain reluctance to engage with scholarship on human–environment interactions beyond the field of Indian studies, on the other hand, have made it difficult to correct the short-sightedness that characterises our view of medieval India and our understanding of the many possible factors at work in the political, socio-economic, and religious transformations during that period. While primacy is given to the study of texts and monumental remains, whole sections of social history embedded in landscape and its materiality (including archaeological arte- and ecofacts) are made invisible.

[20] Wink, *Al-Hind*: 166–69.

[21] For example, Kumar, M., *Monsoon Ecologies*. See also his essay in Chakrabarti, *Critical Themes*: 17–52. For a recent interdisciplinary attempt, see Shanmugasundaram et al., 'Societal Response'. This work examines the contribution and influence of variations in monsoons associated with ENSO events (El Niño Southern Oscillation) in the development of the kingdom of the Chola dynasty of South India, as well as the adaptation strategies implemented to deal with these variations between about 850 and 1280 CE, a period coinciding with the medieval global climatic anomaly. Their approach combines paleoclimatic reconstructions, a spatio-temporal analysis of temples and reservoirs construction, and the study of the evolving status of reservoir systems in the context of the nineteenth-century climatic anomalies and the recent floods in Tamil Nadu.

[22] Palaeoclimate papers contain passing but simple references to the role of climate events (such as MCA and LIA) in social change in India but fail to consider the complex social or historical mechanisms in place. For example, Sinha et al., 'A Global Context for Megadroughts'.

The limited attention paid to environmental variability is perhaps also due to the lack of decisive 'proof' of historically incontestable 'facts'—coming from the field of historical palaeoclimatology and geoarchaeology—which would allow historians to weave relationships. But if 'proofs' are lacking, indicators about past vulnerabilities are not: they are found in the immense repertoire of beliefs associated with climate variability and unpredictability, drought, famine, pandemics, and other disasters, which various literary sources, archives, mythological stories, and oral memories echo.[23]

That historiography of medieval India evinces little interest in environmental factors, especially climatic ones, could also be due to the inhibition inherited from the fear or refusal of environmental determinism with which the social and climatic sciences were tainted during the colonial period, especially in the attempts to establish a dialogue between history and Darwinian biology.[24] Within textual scholarship, environmental determinism has long imbued Orientalist notions of political economy. From Montesquieu to Karl August Wittfogel, via Karl Marx, Elsworth Huntington and others, different theoreticians engaged with rather simplistic observations about climate and water based on which they attempted to explain essential and persistent differences amongst cultures, between regimes of political economy, and between Orient and Occident:[25] the theory of climates, the Asiatic mode of production, hydraulic societies, and oriental despotism. These models have generated numerous debates and a large amount of scholarly writing, critical and theoretical in approach, with little assessment on the ground of archaeological observations (not just excavations, but also landscape studies) and no interdisciplinary perspectives. Excesses of environmental determinism in colonial times, followed by robust rebuttals in the Humanities in post-colonial times, had longstanding effects on the development of history and archaeology as disciplines: scholars seem to have too perfunctorily rejected all environmental explanations for societal changes, preferring to insist upon the plurality and complexity of social, economic, and political factors. Such a positioning vis-à-vis environmental determinism has played its part in contributing to the rupture,

[23] For example, Kumar, M., *Monsoon Ecologies*.
[24] Dove, *The Anthropology of Climate Change*: 107–14.
[25] For example, about the Muslim world in India: Curtis, *Orientalism and Islam*.

deeply rooted in intellectual history, between environmental sciences and social-human sciences.

The legacy of practices and academic precedence from colonial times also played an active role in the fact that medieval archaeology barely developed during the twentieth century. Useful to history whose theories it supports with 'proof', and to art history that it provides with material data in 'context', archaeology as a discipline has long been subsumed. This is not to say that archaeology is absent, but the paucity of critical archaeological research and the scarcity of archaeological evidence pose serious epistemological problems.[26]

Yet, recent years have seen significant advances in the archaeology of medieval times, notably under the impulse of landscape and spatial studies revolving around a wider range of topics related to agriculture, urban settlements, hinterlands, rivers, religious history. In India, archaeologists have long been concerned with various aspects of water, particularly hydraulic infrastructures, recognised in material, social, semiotic, and environmental terms, but also as a prime element in human–environment interactions, especially in agricultural contexts. Sustained archaeological research has shed significant light on the water-scape of the semi-arid Southern Deccan plateau from late medieval times onwards, essentially in the area of Vijayanagar, and in Sri Lanka in the area of Anuradhapura.[27] Other works focus on water management in terms of the built environment and making of the religious landscape.[28] Interdisciplinary research integrating archaeology and geosciences remains rare in India, although various sub-disciplines of environmental archaeology, long absent from the study of the medieval, have recently entered the field.[29]

Despite these various advances engaging with water and other sub-jects common to environmental history, the long lack of archaeology is not without consequences as the range of questions—about the nature,

[26] See Hawkes, 'Finding the "Early Medieval"'; Hawkes and Casile, 'Back to Basis'.

[27] Entering the study of landscape, water has become an area of intense interest, featuring research on irrigation, soils, agricultural strategies, plants, and political ecology in this region of the Deccan. See Morrison, 'Archaeologies of Flow'. For research in Sri Lanka, see Strickland et al., 'Hydraulic Complexities'.

[28] For example, Morrison, 'Doorways to the Divine'; Shaw, *Buddhist Landscapes of Central India*.

[29] Pokharia et al., 'Variable Monsoons'. From the perspective of palaeoflood studies, see Panja et al., *Living with Floods*.

levels, scales, and rhythms of change—that can be brought to bear on the study of pivotal time frames within the medieval has never been explored fully. The historiographic weight of various subjects dear to historians (the nature and formation of states, the forms of politico-religious legitimisation and so on) played its part in inhibiting the development, not only of medieval archaeology, but also of other forms of enquiries and scientific practices to overcome dichotomies along the great divide between nature and society, between human and non-human.

Emerging Pictures of Climatic Variation in Medieval Asia

Over the past two decades or so, the number and spatial coverage of climatic reconstructions has considerably augmented. The increasing extraction of various proxies (indicators)—obtained from the biological, physico-chemical, and statistical analyses of 'natural archives' (continental and marine) and from the study of historical archives—and the production of increasingly more complex digital models have allowed for significant advance in the description and comprehension of the evolution of climate throughout the late Holocene.

This growing body of evidence shows that centennial-scale climatic oscillations have affected broad areas of the Earth during the past millennium. Global climate history distinguishes two major periods of fluctuation, which have been defined in terms of temperature anomalies: the first, known as the Medieval Climatic Anomaly (MCA), also referred to as 'the medieval optimum', is characterised by warming and the retreat of glacial tongues between the tenth and fourteenth centuries; the second, called the 'Little Ice Age' (LIA), lasted from about the fifteenth to the middle of the nineteenth century and is marked by long and substantial glacial thrusts.[30] In fact, the variations were much differentiated, more spread in space and time than this chronological breakdown would suggest.[31] Their effects included strong hydroclimatic perturbations in regions under monsoon climates.[32]

[30] Mann et al., 'Global Signatures'.

[31] According to global syntheses recently published, there is no neat concordance or spatio-temporal coherence between climate phases, particularly at decadal or centennial scales. See Neukom et al., 'No Evidence'.

[32] Graham et al., 'Support for Global Climate'.

The Indo-Asian monsoon system is defined as the most complex of all climatic systems. The study of its dynamics and mechanisms in response to various types of forcing is central to the concerns of a growing number of scientists and shows that monsoons are subject to considerable variability on a large range of temporal-spatial scale.[33] Over the past two decades, aspects of the Asian monsoon behaviour over the last millennium have been unravelled through an emerging network of proxy records. Manifested in these is an evolving and complex picture of monsoon's natural variability, including a repeated tendency to get locked in extended dry and wet phases at various temporal and spatial scales.[34]

The Indian subcontinent is particularly susceptible to shifts in climate and extreme events, notably under the El-Niño-like conditions.[35] Palaeoclimatic reconstructions highlight the occurrence of major disturbances of summer monsoons.[36] Two data set-based reconstructions are especially important for grasping the extent of these variations and for situating the intervals of climatic anomalies and extremes during the medieval period on the Indian subcontinent. One derives from 327 tree-ring chronologies, which form the base of the Monsoon Asia Drought Atlas (MADA);[37] the other results from the isotopic analysis of speleothem samples, which are major archives of terrestrial paleoclimates and paleoenvironments.[38]

The MADA database offers an annual reconstruction of monsoon variability over the last 700 years. It shows the occurrence of phases of

[33] Clift and Plumb, *The Asian Monsoon*, for a detailed description of the Asian monsoon system. And for a definition of key terms, see footnote 1 in the article.

[34] Current knowledge about the Indo-Asian climate of the past 1,000–1,500 years rests on a detailed collection of data through the analysis of ice cores from west and northeast areas of Tibet, of speleothems and tree rings, marine and terrestrial sediments, and (few) historical archives. Cook et al., 'Asian Monsoon Failure'; Buckley et al., 'Monsoon Extremes'. For a useful synthesis and assessment of the past millennium hydroclimate variability in India inferred from proxy records from regions affected by the Indian Summer Monsoon (ISM), see Dixit and Tandon, 'Hydroclimatic Variability'.

[35] Li et al., 'El Niño Phases Embedded'; Dixit and Tandon, 'Hydroclimatic Variability'.

[36] Cook et al., 'Asian Monsoon Failure'; Liang et al., 'Panigarh Cave Stalagmite Evidence'; Sinha et al., 'The Leading Mode of Indian Summer Monsoon'; Sinha et al., 'A Global Context for Megadroughts'. For a useful overview of the response of the ISM to forcing factors and climate variables, see Banerji et al., 'Holocene Climate Variability'.

[37] Cook et al., 'Asian Monsoon Failure'.

[38] Kumar et al., 'Contribution'; Kumar et al., 'Modeling of Indian Monsoon'.

extreme dryness towards the end of the fourteenth and beginning of the fifteenth century, as well as of extreme wetness. Based on absolute dating, the annual-resolution reconstruction from isotopic signals of the Dandak Cave speleothem (central-eastern India) exposes a wide palette of monsoon behaviours with a significant interdecadal, decadal, and multidecadal variability of summer precipitations over the core monsoon region of India.[39] Over the entire medieval period, geochemical records delimit several phases of lesser precipitation, lasting from a few years to several decades, especially during the seventh, ninth, eleventh and thirteenth centuries, and the beginning of the fifteenth century. Around 1370–1400 CE, a drought episode might have lasted for about three decades. Echoes of this are found in Persian chronicles which mention drought and famine in India in the thirteenth–fifteenth centuries CE.[40] The intensity and long-lasting nature of these droughts have led scholars to qualify them as 'megadroughts'.[41] Among the dynamic forces at work, correlated with or significantly influencing the Indo-Asian climatic system, the meteorological phenomenon called ENSO (*El Niño Southern Oscillation* of the Pacific Ocean) has been identified as one of the major periodic disturbances associated with the interannual and interdecadal Indian Summer Monsoon variability.[42] Reconstructions based on the speleothem of Dandak further suggest that, between 950 and 1250 CE, precipitation must have been more intense.[43] Isotopic records of the past two millennia from two stalagmites extracted in Sahiya Cave in north India, without contradicting those of Dandak, show an interval of heavy rains around 1100 CE.[44] Other multi-proxy analyses of sediment give evidence of severe floods during the medieval period.[45] Analyses of marine sediments, pollens and other indicators further indicate, though with less temporal resolution, that the Indian monsoon climate was extremely variable during the medieval period.[46]

[39] Sinha et al., 'The Leading Mode of Indian Summer Monsoon'; Sinha et al., 'A 900-year (600 to 1500 AD) Record'.

[40] Maharatna, *The Demography of Famines*; Wink, *Al-Hind*: 167–69.

[41] Cook et al., 'Asian Monsoon Failure'.

[42] Li et al., 'El Niño Phases Embedded'.

[43] Sinha et al., 'The Leading Mode of India Summer Monsoon'.

[44] Sinha et al., 'Trends and Oscillations'.

[45] For example, Sridhar et al., 'Late Holocene Flooding History'.

[46] For example, Laskar et al., 'Late-Holocene Climate'.

Climatic variations and extremes were not limited to India. The isotopic analysis of another speleothem from Wanxiang cave (north-central China), and the study of a tree-ring chronology of a specimen from Bidoup Nui Ba National Park (Southern Vietnam) have enlarged the spatial signature of abnormally dry or wet periods in other regions of China and South-East Asia.[47] The similarities between palaeoclimatic reconstructions based on speleothems isotope and tree-rings chronologies mentioned above are striking: the spectral analyses show periods that are contemporaneous with the aforementioned variations.[48]

Many scholars from various disciplinary horizons are now trying to investigate the spatio-temporal scales of these instabilities and the nature and levels of their impacts, and to probe the ways societies coped with climatic extremes and natural disasters. Resisting simplistic observations, reductionist approaches and overhasty conclusions, researchers have embarked on studying connections between climatic anomalies and societal upheavals such as political, economic, and subsistence crises, conflicts, rebellions, site abandonment, migration, and pandemics. Many aim to decipher the complexity of these connections, detecting their various spatio-temporal scales, and enhance our understanding of the multiple factors at stake in societal changes, whether political, economic, institutional, or religious.

For instance, in Angkor (Cambodia), scientists are tracking water after having successively enquired into the history of wars and then climate changes. Scholars analyse in parallel paleoclimatic records, LiDAR and archaeological data on the great hydraulic infrastructures which bear the scars of substantial damages that seemingly could only have been caused by unusually torrential rains.[49] In addition to the disastrous impact of drought on harvests and health, the devastating force of floods would have made people vulnerable, while damaging the management system of hydroclimatic risk on which the 'operational logic of the urban complex' of Angkor depended. It is thus by the superimposition of multiple factors upon climatic anomalies that scholars are now tending to explain the demise of Angkor.

[47] Buckley et al., 'Climate as a Contributing Factor'.

[48] Sinha et al., 'A Global Context for Megadroughts'.

[49] Buckley et al., 'Monsoon Extremes'. For a critical appraisal, see Middleton, *Understanding Collapse: 306–8*.

Elsewhere in Asia, the role of events and climatic anomalies is central to recent works focusing on the progression of the Mongolian empire in the thirteenth century CE, or the collapse of the Yuans (thirteenth–fourteenth centuries CE) and then that of the Mings (fourteenth–seventeenth centuries CE) in China.[50] In light of various historical documents and palaeoclimatic reconstructions, researchers have identified diverse episodes of prolonged climatic deterioration and various disasters including droughts, floods, tornadoes, locust invasions, epidemics, earthquakes, harvest failures, famine and plague.[51] Evidence testifying to these leads to reflect on vulnerabilities and the limits of adaptation in the face of extreme climatic conditions, environmental disasters, and the various crises that they trigger, generate or accelerate.

Using dendrochronological analyses to reconstruct the climate of Mongolia in the medieval period, other scholars have associated the political and economic history of the Mongols with that of climatic fluctuations.[52] From the late to the early thirteenth century CE, extreme political instability, characterised by the erosion of established hierarchies and the emergence of a new political order under Genghis Khan (c. 1162–1227 CE), coincided with an ongoing dry climate. In terms of temperature and precipitations, climate conditions appear to have then changed during the century CE, becoming warmer and persistently wetter than they had ever been in the preceding millennium. Grassland productivity increased considerably. Surplus energetic resources allowed by favourable ecological conditions would have indirectly contributed to Mongol expansion, providing Genghis Khan with the means to form an army and a government, concentrate military and political power in various localities, mobilise nomads, and achieve military expeditions.

India, meanwhile, was the theatre of significant shifts of various natures in the thirteenth–fifteenth centuries CE. 'Hindu' kingdoms associated with longstanding dynastic powers (Paramara, Chola, Kakatiya…) declined; new politico-religious orders emerged, starting with the establishment of a Sultanate in Delhi (1206 CE); powerful states developed in the Deccan in mid-fourteenth century CE (the Bahmani Sultanate and the Vijayanagar kingdom). History was also punctuated by climatic events and disturbances. Mentions are found in Indo-Persian

[50] Pederson et al., 'Pluvials'; Brook, *The Troubled Empire.*

[51] Brook, *The Troubled Empire.*

[52] Pederson et al., 'Pluvials'.

chronicles and other textual sources about conquests, conflicts, wars, 'natural' disasters, and related difficulties under the pressure of climate and its vagaries, and other circumstances. Droughts and floods were amongst the worst scourges that society had to face.[53] Both could lead to crop failure and famine, illnesses (malaria, cholera, plague), locust invasions, human and livestock deaths, abandonment of settlements and displacement of populations, migrations, and conflicts: many critical situations whose cumulative ricochet effects likely left traces in memories, writings, and landscapes histories up to the present day.[54]

The role of climatic anomalies was complex and indirect, depending upon numerous factors which are difficult to isolate or to correlate. While it is problematic to precisely attribute specific crises or difficulties of the past to climate, drought and floods were in all likelihood important players in the history of societal vulnerability, political and socio-economic instability, and violence. That said, the diversity of ecological contexts on the subcontinent allows us to posit that effects of climatic anomalies on society were very different from one region to another, from one population to another that were profitable in certain cases but devastating in others, depending on circumstances and preconditions. It is at various scales of time and space, through interdisciplinary and multi-proxy approaches, that the topic should be documented and thought through. As far as medieval India is concerned, texts and monuments are the principal sources from which historians have probed the past, overlooking environmental dimensions. Archaeological sciences have a long way to go in the field of medieval studies and much care is needed in building models of historical change from them.

The MANDU Project: An Introduction

We now join this article's discussions of climate and history with the description of an ongoing research programme involving interdisciplinary approaches to investigate the past land-waterscapes of Mandu and

[53] '[…] in medieval times drought-famines were among the most common catastrophes affecting the peasantry nearly everywhere in Hind, often with terrible severity, leading to incalculable numbers of deaths and having a profound impact upon the settlement histories of many regions': Wink, *Al-Hind*: 167.

[54] Famine and related 'natural' difficulties should not be linked to climatic and/or meteorological events alone. War, conflicts, military campaigns and so on were also major factors and players in the making of disasters.

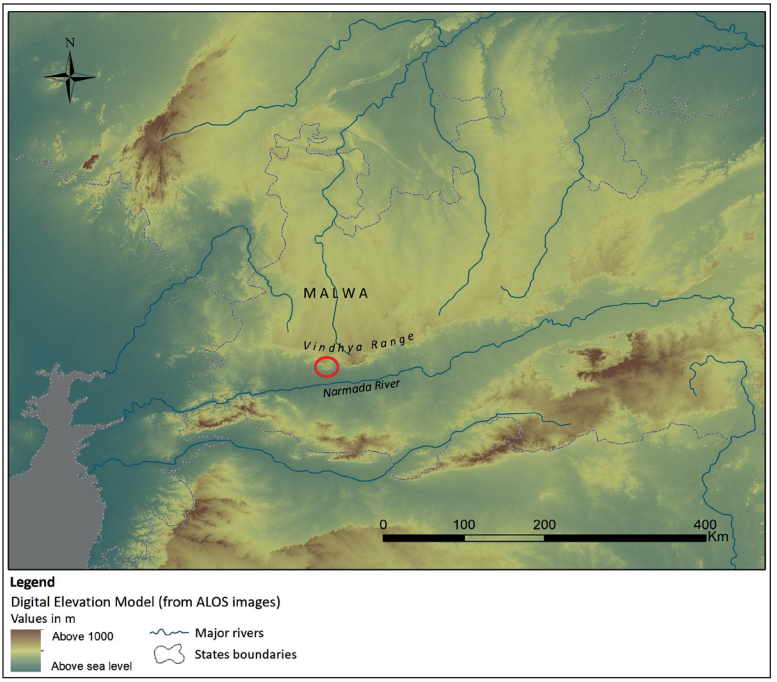

Figure 1. Location of Mandu in Central India, South of Malwa region, in the Narmada River Basin.

Source: The author.

its hinterlands in Central India (22°20'26.08"N - 75°24'5.62"E) (Figure 1).[55] Mandu is best known as the capital of the Malwa Sultanate but its history goes back to earlier times and extends beyond the late medieval. Situated in the South-Western part of Madhya Pradesh, the site falls in the lower Deccan Traps and is a vast elevated plateau,

[55] The MANDU research programme is the synthesis of a project funded by the French National Research Institute for Sustainable Development (IRD) and French National Research Agency (ANR, https://anr.fr/Projet-ANR-18-CE03-0006, accessed on 2 July 2021), and an Indo-French Archaeological Mission funded by the French Ministry of Europe and Foreign Affairs (2020–24) in partnership with the Jawaharlal Nehru University (JNU, India), the French Institute of Pondicherry (IFP, India), and the Shiv Nadar University (SNU, Greater Noida).

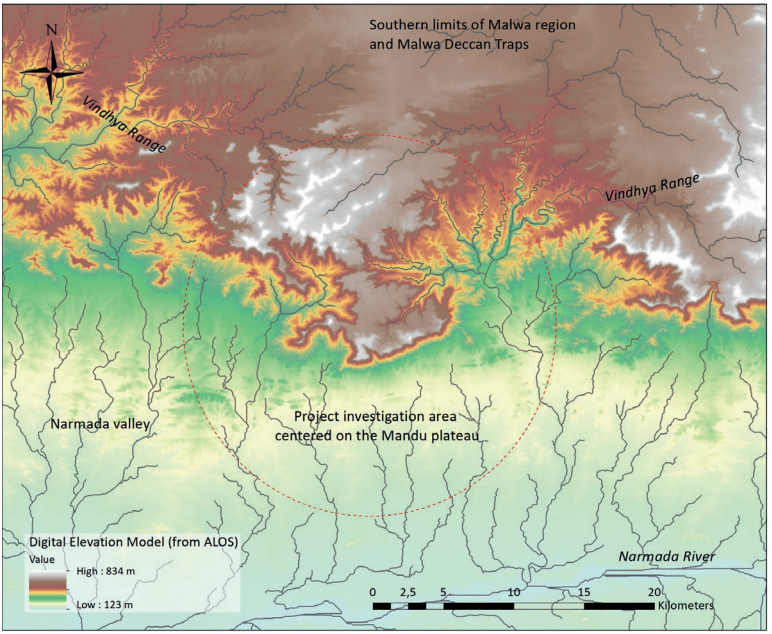

Figure 2. Location of Mandu as a lone outcrop of the Vindhya hill-range.

Source: The author.

perched on an outcrop of the Vindhya Hill-range, overlooking the Nimar Plains in the watershed of the Narmada River (Figure 2 and 3).

This area is of particular interest due to (a) the history of the place as a major power centre along chief highways of communication and trade; (b) the wealth of archaeological and palaeoenvironmental records of long-term human occupation, cultural and institutional changes underpinned by processes that continue to operate today; (c) the fact that the area has been spared from recent urbanisation; (d) the history of its current population belonging to the Bhil 'tribal community'; (e) the geographic context—in the Narmada basin, on the southern edge of Malwa—made of various watersheds and ecological settings (highlands of the Vindhya range, lowlands of the alluvial Narmada valley and Malwa Deccan traps), which offer the opportunity to examine through a wide array of data (archaeological, palaeoenvironmental, ethno-anthropological, spatial) the diversity of past activities and changes, of

Figure 3. Drone Perspective Photo of the Plateau of Mandu (taken from the northeast).

Source: The author.

social and environmental phenomena, of ways of settling and tapping into resources; and (f) the type of environment, being semi-arid, which allows to explore the lands and watersheds sensitivity and vulnerability to hydroclimatic variation and extremes.

While trying to engage with the larger topic, but with no intention of embracing the convenience of environmental determinism, the project aims to delve into aspects of the complex interplay and multivalent nexus between human adaptations, water management, and climate, and the mechanisms that link environmental conditions and social activity, especially around water. To achieve this aim, the project intends to probe the 'archives' of the land-waterscape and document (a) the ways people and society in the past diversely adapted to hydroclimatic risks and managed vulnerabilities in different settings, (b) the ways dynamics of change, power, and control over resources fashioned the use of space, land, and water and (re-)shaped the built environment, and (c) the long-term lives of the water bodies (the system made and managed over time in interaction with the hydrological climate and the wider environment to harness and harvest water) as signatures of both the hydrosystem and agrosystem (Figure 4).

These dimensions are all inherent in land-waterscape histories. To investigate them, the project draws on several disciplines, data sets, concepts, approaches (field and laboratory), and techniques, and seeks to trace continuities and discontinuities in the historical land-waterscape formation and analyse them in ways that provide insights into the nature of change, vulnerability, and adaptation, and into the ability to absorb perturbations while maintaining or transforming essential structures and

Figure 4. View of the Sagar Talab and the Remains of a Tomb from Sultanate Times (west bank of the reservoir), Mandu Plateau.

Source: The author.

functions. The objective is not to see whether historical data can be organised in a given framework drawn from environmental records and archaeological evidence, but to examine the scales, contents, and contexts of changes, explore the possible links (and ways of linking) between heterogeneous data, and see whether the environment—while contributing to the long-term development of society—provided structural conditions for social, political, cultural, institutional shifts, and the reorganisation of resources management-related practices (including crop patterns and so on).

The study of water and of human communities facing the combined effects of social (water need) and environmental constraints (water capacity, availability) is key to this project and draws on various interdisciplinary scholarships on coupled human-water systems (notably in sociohydrology, historical and political ecology). Research and field approaches revolve around spatial and landscape archaeology, ethnology, monumental, textual, and other artefactual studies, geography, geomorphology, hydrogeology, and geoarchaeological investigations, and involve surveys, excavations, samplings, and the use of aerial and satellite imagery and other geospatial technologies. Through combined geoarchaeological and micromorphological studies—based on the principle that properties and archives of soils and sediments in key location of the archaeological stratigraphies and contexts reflect the natural and cultural environments in which they have been formed (including the organisation and movement of water)—laboratory approaches are also implemented and designed to reconstruct aspects of the environment which communities lived in, adapted to, and modified through time, and to

study the evolving and dynamic nature of water management systems and the formation of (and changes in) the land-waterscapes at local scale. To understand the functioning of the water system and its modification over time, under the double pressure of climatic variability and human control, activities further involve the collection of climatic, groundwater ages, and circulation processes (via isotopes). Continuous records of groundwater levels variation—a major component of the hydrological cycle—is being implemented to provide information on subsurface geo-environmental changes due to withdrawal of groundwater. Systematic sampling for chronology, water and sediment analysis, and palaeobotanical investigation are yet to be conducted in different but connected environments.[56]

While focusing its main analysis on medieval times, the archaeological land-waterscapes shaped through human–environment interactions in the *longue-durée* are analysed from both diachronic and synchronic perspectives, and at different space scales: from micro archives and morphology of soils and sediments to wider aspects of the terrain, including layouts, features, and imprints of human–environment interactions on surface (land cover and land use patterns, erosion, water flow and so on) (Figure 4). Activities around mapping, satellite and aerial image processing, and spatial analysis, using geospatial technologies and data sets—including remote sensing imageries and GIS-based application—are of critical importance for all disciplines involved in the project and in the process of building interdisciplinary knowledge.[57] Combined with hydrological and pedological information, remote sensing data sets would notably allow the identification of various physical field data mastering surface and groundwater flows (e.g., stream networks, slopes, land cover, permeability) and the detection of possible relict watercourses and irrigation networks as part of palaeohydrological mapping. The full archaeological survey which is ongoing over a wide area encompassing the plateau of Mandu and surrounding, including forest areas, will provide

[56] Field investigations started in 2020 during the dry season but were prematurely interrupted due to the pandemic situation in India. Fieldwork will likely resume in 2022 only.

[57] The use of remotely sensed data sets is crucial to characterise land surface dynamics and the hydroclimate of the region. Multi-satellite observations providing multispectral and multitemporal images allow not only to study landscape transformations, but also to document the seasonality and variations of the climate and hydrology of Central India, and to detect relic watercourses, channels, and bodies.

context to these various environmental archives within a dense record of 'urban', 'rural', and other past life activities which are otherwise unavailable, invisible, in texts, but arise from material practice.

Furthermore, ethnological studies—involving the collection of data from archives, field observations, interviews, and the recording and interpreting of folk songs, legends, and stories from oral traditions—focus on water, plants, and husbandry management-related practices, knowledge, and memory, with the objective to document the different livelihood strategies and the ways people in recent history and in the present cope with their erratic semi-arid environment and manage the risk. Based on open-ended oral history, interviews, and informal discussions, the field approach also investigates the continuities and discontinuities in the use of ancient water infrastructure and bodies, the social significance of water associated with ancient water bodies, and the use of technologies.

To tackle issues of more regional and supra-regional significance, research also delves into the knowledge at our disposal (historical and palaeoclimatological) beyond the spatial and archival perimeters of the land-waterscape of Mandu. Regional data are being compiled to enhance our understanding of the history and archaeology of Central India and beyond in medieval times; evidence about political instability, war campaigns, historical floods, drought, famines, pandemics, and earthquakes, which are known from textual sources, are being looked at; and current archaeological research and theories on societal change, vulnerability, adaptation, sustainability, and resilience in the face of environmental disturbances in medieval times elsewhere in Asia, and in Mesoamerica (known to be vulnerable to the global El Niño oscillations) are being explored. Settlement archaeology, surveys, excavations, geoarchaeological and geohydrological analyses, and the ensuing interdisciplinary interaction hold promise of testing notions, concepts, metanarratives, and assumptions of change, extremes, and collapse against the meticulously investigated land-waterscapes of Mandu.

Knowledge from climatology will also be mobilised. Prior to the period of instrumental records, palaeoclimatic indicators are rather scarce for Central India compared to other regions of the world which have been under greater scientific investigations.[58] The issue of scale and

[58] See Dixit and Tandon, 'Hydroclimatic Variability'. This article highlights the gaps in data, which restrict interpretation of the spatial pattern of the hydroclimatic variability in the last millennium on the Indian subcontinent.

resolution of data at our disposal poses a difficulty which the project is aware of. Nevertheless, among the existing evidence available for the core monsoon zone, we have a ^{230}Th-dated stalagmite oxygen isotope proxy record reconstructed from the Dandak cave deposits (Kanger Ghati National Park, Orissa). Other data are available, which reveal the importance of regional variability.[59] For the Mandu region, climate and vegetation aspects of the late-Holocene have also been inferred from multi-proxy studies on sedimentary records, documenting century-scale variations of floods.[60] Palaeoclimatic data are being combined with modern data through the use and study of two different data sets: remote sensing and instrumental data. Coupled with direct and indirect indications, such as modelling, the use of these records can help assessing vulnerabilities and the role of water structures.

While the ambition is to produce new archaeological, ethnological, palaeoenvironmental, and spatial data, the project is also about delving into the methodological and theoretical problems in articulating knowledge and evidence about processes at different space-time and resolution scales, and about learning interdisciplinarity. Building interdisciplinary knowledge is about 'negotiating' between disciplines, concepts, analytic frameworks, and field-based experiences. It is a challenge that the project intends to tackle by sharing a common space (land-waterscape) of investigation, allowing the dialogue and flow of data and observations, and undertaking common field surveys among the scholars of different disciplinary horizons and through an integrated, empirical, and inductive field and laboratory research; a research which also engages with scholarship in the field of climate change sciences beyond India.[61]

To have the past and present conversing with one another and informing each other is another ambition of the project. Studies on past and present-day issues around water and society often tend to ignore each other. Yet, asking questions about vulnerability, adaptation, resilience, sustainability cannot ignore the past, its heritage, and 'lessons'; looking

[59] For example, Laskar et al., 'Late-Holocene Climate'.

[60] For example, Sridhar et al., 'Late Holocene Flooding History'. This study among others reveals a clustering of large floods during the late Holocene period, but also the conspicuous absence of extreme floods in late medieval times.

[61] See notably Massuel et al., 'Inspiring a Broader Socio-Hydrological Negotiation Approach'.

at past events, processes, dynamics, responses cannot ignore the present-day landscapes, where signatures have been inscribed through time till now.[62] Finally, along with the production of interdisciplinary historical and archaeological knowledge about water management, the project hopes to contribute to research on water (un)sustainability in India, especially in Mandu, where its population face water access problems and recurrent water scarcity.

Like the vast majority of medieval cities and their hinterlands on the Indian subcontinent (with the notable exception of Vijayanagar), Mandu has attracted little attention (not to speak of its regional setting) in the field of archaeology, beyond the political and architectural history. The activities of spatial and landscape archaeologies and mapping undertaken in the frame of the MANDU project reveal that the area is far richer than what is known from the available scholarship.[63] Field activities have been delayed by the COVID-19 pandemic. So far, only a portion of the plateau has been covered systematically through archaeological explorations, and much remains to be surveyed. The number and variety of vestiges and settings is impressive (Figure 5). Remains are from multiple water-related built and 'natural' features (wells and stepwells, ponds and lakes reservoirs, cisterns, pools, springs, house water-tank, check-dams, channels, aqueduct, retention walls, and other water-related features), and from numerous tombs and funerary steles, graveyards, mosques, temples, and other sacred sites, domestic structures, paved roads, boundary walls, defensive infrastructures, and various undefined structures (Figure 6). To help deciphering the signatures of the material conditions of social and cultural life and allow for a better understanding of water flows and land characteristics, aerial images taken from a drone through systematic flights are being assessed. These will further enable to smooth and speed the process of field documentation.

Primary paleoenvironmental analysis of test samples and the identification of various physical field data mastering surface and groundwater flows for palaeohydrological mapping and sampling confirms the depth

[62] For example, Håkansson and Widgren, *Landesque Capital*; Morrison, 'The Human Face of the Land'.

[63] On the architecture and landscape design of Mandu, the most recent and advanced study is from the doctoral thesis of C. Rubini, who undertook intensive architectural analysis of the best-preserved monuments. See Rubini, *Shadiabad Mandu*.

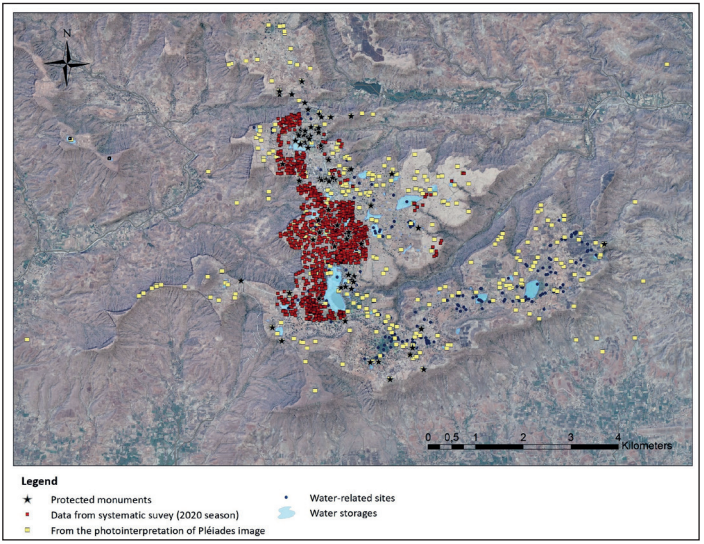

Figure 5. Pléiades Satellite Images with Sites Distribution (in red, what has been surveyed so far).

Source: The author.

Figure 6. Reservoir with the Remains of a Dam Dating from Paramara Times, on the Plateau of 'Old' Mandu (Bhuri Mandu).

Source: The author.

and interest of available data, but also hint at challenges to overcome.[64] A preliminary survey was conducted which aimed at exploring distinct early water management infrastructures of different scales and connectivity's and assessing their viability for further geoarchaeological investigations based on key-hole excavations. In different settings, these excavations would enable definition and sampling of stratigraphies for dating and sediment analyses. Key sites have been identified during the 2020 first collective fieldwork to collect artefacts and ecofacts for geoarchaeological analysis and dating by OSL and radiocarbon and produce data about the temporal development of Mandu and the history of its environment and land use. The study (texture, age, composition) of soils, occupation deposits, and sedimentary context will provide crucial evidence to understand environmental changes (whatever their origins), and their impacts on the transformation and evolution of land-waterscapes.

Challenges and Prospects for Future Research on the Medieval Past in India

The relationship between climate and society is complex, multidimensional. The task of defining the content and dynamics of this relationship, its spatio-temporal nuances, is immense and calls for interdisciplinary and multiscale approaches. It requires understanding not only how various natural phenomena have unfolded, but also how populations in non-egalitarian societies and with unequal access to landscape resources have differentially felt, interpreted, and coped with environmental turmoil and uncertainties.[65]

It is also crucial to consider that the topic is more than just the relationship between society and climate. Social and political processes are equally important and require a close attention to politics, culture, and agency. As local variations in environment and climate are to be examined, we need to also consider disparities based on location, which may result from social and political dynamics extending across large scales.

[64] Study of water circulation and hydrogeological mapping are notably challenged by current usages impacted by electrical pumps and the use of various water structures as storage relay.

[65] As often reminded by scholars, it is critical to remember that communities are segmented in innumerable ways, consisting of actors with different goals and motivations, leading to differing responses to environmental factors. For example, Bauer, 'Questioning'.

The link between political economy, people, and environment is central to political ecology, a theoretical framework most often applied to modern contexts but equally relevant to the past.[66]

How can we grasp this relationship, pinpointing markers indicating that such and such historical time frame, series of events, or change may be linked to or have its origin in a modification of the climate? The question is complex, for the 'contemporaneity' and correlation are extremely difficult to establish between (a) climatic fluctuations that can last for decades, even centuries, with changing spatial coverage and (b) shifts in society's trajectories that are multifactorial and can span several generations. The complexity is further increased by the fact that the chronological resolution in archaeological data and paleoenvironmental archives are limited, not to mention the paucity of evidence at our disposal due to the lack of archaeological research on the medieval in India. Climate records can also be from distant places and hence may not be applicable. The interpretations of palaeoenvironmental proxies may also be subject to critique, which is not without consequences for archaeological interpretations.

Establishing correlation, and then moving from correlation to causation, is therefore a challenge that is as much theoretical as it is methodological, and necessitates analyses on distinct scales and with varying resolutions.[67] Embracing the challenge, while avoiding simple environmentally determinist perspectives or searching for unidirectional causality which would privilege environmental drivers at the expense of social ones, requires building interdisciplinary knowledge, crossing the divide between the two 'cultures' of humanities and natural sciences. In addition, it requires bridging the local, regional, and supra-regional, connecting histories, and having recourse to multiple scales of analysis and interpretation and to a variety of disciplines, data sets, concepts, and technologies. It calls for collective and collaborative efforts of scholars to explore methodologies, co-produce new data, and confront

[66] Morrison, 'Empires as Ecosystem'; Bauer, 'Questioning', which invites archaeology to take a materialistic approach mirroring historical and political ecology.

[67] See Contreras' thoughtful introduction to the challenge in Contreras, *The Archaeology of Human–Environment Interactions*, which reflects on the crucial and complex question of scale and resolution in the articulation between archaeology and paleoenvironmental sciences, between human and environmental processes. Environmental parameters are discussed at specific scales of space-time and analysis which fundamentally differ from those underlying archaeological interpretations of human activities.

understandings and analyses on common objects. Such efforts across and between scales would aim at identifying connections between environmental and human trajectories, and at developing arguments that explain the links between the multiple factors at play, and the complex interactions through the scales of time, space, and human experience. Embracing the challenge also requires time and funding for fieldwork and analyses, sharing of information, and the long-term curation of recovered material for reanalysis.

There are multiple ways to tackle the challenge and extract well-framed research questions and approaches—the design of which would depend not only on time, funding, context, and constraints of various natures, but also on our ability to rethink the nature-culture divide and critically assess our knowledge, practices, and analytic categories and schemes, including the problematic periodisation implying rigid historical divides, which we continue to use for convenience. As aforementioned, our understanding of the medieval past in India suffers from a scarcity in both archaeological and historical ecological evidence. Research in these fields has been limited for a long time. Given the current state of scientific advances and the multiple gaps in our knowledge, it is imperative to produce new evidence and build precise chronologies—a fundamental for any understanding of human–environment interactions and correlation-based narratives. It is therefore necessary to focus on micro and local investigations.[68] Efforts should also be extended to a wider range of sites (involving 'on-site', 'near-site', and 'off-site' palaeoenvironmental archives relating to archaeological sites) to allow scaling up high-resolution observations and in due course detect potential correlations at larger scales. To understand persistent socioenvironmental trends, it is also essential not to limit our analysis to the medieval past, but also look at the longer term histories.

Research from this perspective on the medieval in South Asia has the potential not only to transform the ways in which we approach the past, but also to think about innovative modes of co-producing interdisciplinary knowledge and break down barriers between sectoral approaches that are often implemented in historico-archaeological studies. In the long term, success will depend on access to large data sets incorporating

[68] See the introduction and various essays that reflect on the importance of addressing local questions in Contreras, *The Archaeology of Human–Environment Interactions.*

different lines of high-resolution archaeological and paleoenvironmental evidence at different scales.

Conclusion

This article draws attention to several key issues regarding (a) the historiography without climate (which, being ignored, is *a fortiori* stable), the lack of archaeology and historical ecology, and the lack of engagement between historians and earth scientists, and (b) the difficulty on both methodological and theoretical grounds to tackle the complex and multidimensional relationship between climate and society, and the need for to develop interdisciplinary and multiscale approaches. There are many ways to narrow down the role of climate to specific scales and issues in the field of human–environment interaction and to explore it theoretically and empirically, not just in the frame of deductive/hypothesis-driven studies, but also in inductive data gathering. Archaeological and environmental archives have been discarded for too long in the reconstruction of historical process in medieval and later times in India. The problem of missing data, of knowledge gaps, needs to be solved through extensive archaeological and historical ecological research based on micro and local investigations in different contexts.

In this article, attention was also drawn to the fact that the response to environmental perturbations varied greatly according to places, contexts, and time across the world, from a region to another. Collapse models, although sophisticated and increasingly diverse, appear limited in various ways to address the societal responses to climatic variation in medieval South Asia, one being the insufficiency of empirical data about environmental, political, and socio-cultural resilience or readaptation, about differences of social transformation, sustainable practice, choices about subsistence and social organisation, about the historical role of leaders and ideology. Interdisciplinary projects, such as MANDU, are necessary to capture finer-resolution evidence to build pictures of climate–society interaction not tied as much to variation but also to dwelling, process and social difference, long-term experience, and to thus contribute to the production of more measured and refined estimates of change and transformation.

In the archaeological landscape of central India, Mandu and its hinterlands are a crucible for medieval Indian history, offering the opportunity

on both archaeological and environmental grounds to investigate many historical facets of the complex climate–society–water interplay through a wide array of data, and to question extant assumptions from various perspectives.

As argued by historian Dipesh Chakrabarty, global climate change presents a fundamental challenge to the way we study the past.[69] It is time for medieval studies in India to engage with current research development on 'socioecological' systems and 'human ecodynamics', not only to enrich our scientific understanding of the medieval past, but also for people today. Research on climate change cannot ignore the past, and it is now largely recognised that archaeologists and historians have a role to play, not just for the sake of revealing the past, but also for informing the future. They have a role to play in global climate change research and discourse, not only in providing data for climate modelling studies and in understanding the ways societies responded and adapted to environmental difficulties in the long-term, but also in influencing the terms of current debates (e.g., on sustainability, on the Anthropocene) and in contributing to rethink the Eurocentric nature-culture divide, co-build awareness about environmental links, and co-explore differing responses to climate change.[70]

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[69] Chakrabarty, 'The Climate of History'.

[70] Hudson et al., 'Prospects and Challenges'; Barton et al., 'Looking for the Future'; Bauer and Bhan, *Climate Without Nature*; Rick and Sandweiss, 'Archaeology, Climate, and Global Change'.

ANR-18-CE03-0006), and the MEAE (French Ministry of European and Foreign Affairs).

References

Ali, D. 2012. 'The Historiography of the Medieval in South Asia'. *Journal of the Royal Asiatic Society*, vol. 22 (1): 7–12.

Ali, Daud and Emma J. Flatt. 2012. *Garden and Landscape Practices in Precolonial India: Histories from the Deccan*. New Delhi: Routledge.

Asher, C. B., and Talbot, C. 2006. *India Before Europe*. Cambridge: Cambridge University Press.

Banerji, U. S., P. Arulbalaji, and D. Padmalal. 2020. 'Holocene Climate Variability and Indian Summer Monsoon: An Overview'. *The Holocene*, vol. 30 (5): 744–73.

Barton, C. Michael, Isaac I. T. Ullah, Sean M. Bergin, Helena Mitasova, and Hessam Sarjoughian. 2012. 'Looking for the Future in the Past: Long-Term Change in Socioecological Systems'. *Ecological Modelling*, vol. 241: 42–53.

Bauer, Andrew M. 2018. 'Questioning a Posthumanist Political Ecology: Ontologies, Environmental Materialities, and the Political in Iron Age South India'. *Archeological Papers of the American Anthropological Association*, vol. 29 (1): 157–74.

Bauer, Andrew M., and Mona Bhan. 2018. *Climate Without Nature: A Critical Anthropology of the Anthropocene*. Cambridge: Cambridge University Press.

Brook, T. 2010. *The Troubled Empire: China in the Yuan and Ming Dynasties*. Cambridge: Harvard University Press.

Brooke, J. L. 2014. *Climate Change and the Course of Global History. A Rough Journey*. New York, NY: Cambridge University Press.

Buckley, B. M., K. J. Anchukaitis, D. Penny, R. Fletcher, E. R. Cook, M. Sano, Le C. Nam, A. Wichienkeeo, T. T. Minh, and T. M. Hong. 2010. 'Climate as a contributing factor in the demise of Angkor, Cambodia'. *Proceeding of the National Academy of Sciences*, vol. 107 (15): 6748–52.

Buckley, B. M., R. Fletcher, S.-Y. S. Simon Wang, B. Zottoli, and C. Pottier. 2014. 'Monsoon extremes and society over the past millennium on mainland Southeast Asia'. *Quaternary Science Reviews*, vol. 95: 1–19.

Campbell, B. M. S. 2016. *The Great Transition. Climate, Disease and Society in the Late Medieval World*. Cambridge: Cambridge University Press.

Casile, Anne. 2017. 'Pour une histoire de l'Inde médiévale face aux variations du climat'. *Les Nouvelles de l'archéologie*, vol. 149: 15–23.

Chakrabarti, Ranjan, ed. 2020. *Critical Themes in Environmental History of India*. New Delhi: SAGE Publications and the Indian Council of Historical Research.

Chakrabarty, Dipesh. 2009. 'The Climate of History: Four Theses'. *Critical Inquiry*, vol. 35 (2): 197–222.

Chapple, C. K., M. E. Tucker, and J. Grim, eds. 2000. *Hinduism and Ecology: The Intersection of Earth, Sky, and Water*. Cambridge: Harvard University Press.

Chepstow-Lusty, A. J., M. R. Frogley, B. S. Bauer, M. J. Leng, K. P. Boessenkool, C. Carcaillet, A. A. Ali, and A. Gioda. 2009. 'Putting the Rise of the Inca Empire Within a Climatic and Land Management Context'. *Climate of the Past*, vol. 5 (3): 375–88.

Clift, P. D., and R. A. Plumb. 2008. *The Asian Monsoon: Causes, History and Effects*. Cambridge: Cambridge University Press.

Contreras, Daniel, ed. 2016. *The Archaeology of Human–Environment Interactions: Strategies for Investigating Anthropogenic Landscapes, Dynamic Environments, and Climate Change in the Human Past*. New York, NY, and London: Taylor & Francis.

Cook, E. R., K. J. Anchukaitis, B. M. Buckley, R. D. D'Arrigo, G. C. Jacoby, and W. E. Wright. 2010. 'Asian Monsoon Failure and Megadrought During the Last Millennium'. *Science*, vol. 328: 486–89.

Curtis, Michael. 2009. *Orientalism and Islam: European Thinkers on Oriental Despotism in the Middle East and India*. Cambridge: Cambridge University Press.

Dhavalikar, M. K. 1999. 'The Golden Age and After: Perspectives in Historical Archaeology'. *Proceedings of the Indian History Congress*, vol. 60: 1–18.

Dixit, Y., and S. K. Tandon. 2016. 'Hydroclimatic Variability on the Indian Subcontinent in the Past Millennium: Review and Assessment'. *Earth-Science Reviews*, vol. 161: 1–15.

Dove, M. R., ed. 2014. *The Anthropology of Climate Change. An Historical Reader*. Chichester: John Wiley & Sons.

Eaton, R. M. 2019. *India in the Persianate Age: 1000–1765*. London: Penguin Books.

Fauslseit, R. K., ed. 2016. *Beyond Collapse: Archaeological Perspectives on Resilience, Revitalization, and Transformation in Complex Societies*. Occasional Paper 42. Carbondale: Southern Illinois University.

Flood, F. B. 2009. *Objects of Translation. Material Culture and Medieval 'Hindu-Muslim' Encounter*. Princeton, NJ: Princeton University Press.

Giosan, L., D. Q. Fuller, K. Nicoll, R. K. Flad, and P. D. Clift. 2012. *Climates, Landscapes, and Civilizations*. Geophysical Monograph Series 198. Washington, DC: American Geophysical Union.

Graham, N. E., C. M. Ammann, D. Fleitmann, K. M. Cobb, and J. Luterbacher. 2011. 'Support for Global Climate Reorganization During the "Medieval Climate Anomaly"'. *Climate Dynamics*, vol. 37 (5–6): 1217–45.

Grove, Richard, ed. 1997. *Nature and the Orient: The Environmental History of South and Southeast Asia*. New Delhi: Oxford University Press.

Håkansson, N. T., and M. Widgren. 2014. *Landesque Capital: The Historical Ecology of Enduring Landscape Modifications*. Walnut Creek: Left Coast Press.

Hawkes, J. 2014. 'Finding the "Early Medieval" in South Asian Archaeology'. *Asian Perspectives*, vol. 53 (1): 53–96.

Hawkes, Jason D., and Anne Casile. 2020. 'Back to Basics: Returning to the Evidence and Mapping Knowledge in South Asian Archaeology'. *Asian Archaeology*, vol. 3 (1): 95–123.

Hudson, Mark J., Mami Aoyama, Kara C. Hoover, and Junzō Uchiyama. 2012. 'Prospects and Challenges for an Archaeology of Global Climate Change'. *Wiley Interdisciplinary Reviews: Climate Change*, vol. 3 (4): 313–28.

IPCC. 2013. *Climate Change 2013: The Physical Science Basis*. Cambridge and New York, NY: Cambridge University Press.

Kapur, N. S., ed. 2014. *Environmental History of Early India. A Reader*. New Delhi: Oxford University Press.

Kumar, Mayank. 2013. *Monsoon Ecologies. Irrigation, Agriculture and Settlement Patterns in Rajasthan during the Pre-colonial Period*. New Delhi: Manohar.

Kumar, P., A. P. Dimri, and S. K. Tandon. 2021. 'Modeling of Indian Monsoon Extremes During 850–2000 AD Using the Proxy-data from Speleothems'. *Quaternary International*, vol. 599–600: 117–27.

Kumar, P., J. Sanwal, A. P. Dimri, and R. Ramesh. 2019. 'Contribution of Diverse Monsoon Precipitation over Central and Northern India During Mid to Late Holocene'. *Quaternary International*, vol. 507: 217–23.

Laskar, A. H., M. G. Yadava, N. Sharma, and R. Ramesh. 2013. 'Late-Holocene Climate in the Lower Narmada Valley, Gujarat, Western India, Inferred Using Sedimentary Carbon and Oxygen Isotope Ratios'. *The* Holocene, vol. 23 (8): 1115–22.

Li, J., S.-P. Xie, and E. R. Cook. 2014. 'El Niño Phases Embedded in Asian and North American Drought Reconstructions'. *Quaternary Science Reviews*, vol. 85: 20–34.

Liang, Fuyuan, George A. Brook, Bahadur S. Kotlia, L. Bruce Railsback, Benjamin Hardt, Hai Cheng, R. Lawrence Edwards, and Selvaraj Kandasamy. 2015. 'Panigarh Cave Stalagmite Evidence of Climate Change in the Indian Central Himalaya since AD 1256: Monsoon Breaks and Winter Southern Jet Depressions'. *Quaternary Science Reviews*, vol. 124: 145–61.

Maharatna, A. 1996. *The Demography of Famines: An Historical Perspective*. New Delhi: Oxford University Press.

Mann, M., E. Zhihua Zhang, S. Rutherford, R. S. Bradley, M. K. Hughes, D. Shindell, C. Ammann, G. Faluvegi, and F. Ni. 2009. 'Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly'. *Science*, vol. 326: 1256–60.

Massuel, S., J. Riaux, F. Molle, M. Kuper, A. Ogilvie, A.-L. Collard, C. Leduc, and O. Barreteau. 2018. 'Inspiring a Broader Socio-Hydrological Negotiation Approach with Interdisciplinary Field-Based Experience'. *Water Resources Research*, vol. 54 (4): 2510–22.

McAnany, P. A., and N. Yoffee, eds. 2009. *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire*. Cambridge: Cambridge University Press.

McNeill, J. R., and E. S. Maudlin, eds. 2014. *A Companion to Global Environmental History*. Chichester: John Wiley & Sons.

Middleton, Guy D. 2017. *Understanding Collapse: Ancient History and Modern Myths*. Cambridge: Cambridge University Press.

Morrison, K. D. 2012. 'Doorways to the Divine: Vijayanagara Reservoirs and Rural Devotional Landscapes'. *South Asian Studies*, vol. 28 (2): 157–69.

———. 2013. *The Human Face of the Land: Why the Past Matters for India's Environmental Future*. NMML Occasional Paper, History and Society, New Series 27. New Delhi: Nehru Memorial Museum and Library.

———. 2015. 'Archaeologies of Flow: Water and the Landscapes of Southern India Past, Present, and Future'. *Journal of Field Archaeology*, vol. 40 (5): 560–80.

———. 2018. 'Empires as Ecosystem Engineers: Toward a Nonbinary Political Ecology'. *Journal of Anthropological Archaeology*, vol. 52: 196–203.

Mukherjee, R., and R. Seshan. 2020. *Indian Ocean Histories: The Many Worlds of Michael Naylor Pearson*. Milton Park: Taylor & Francis.

Neukom, R., N. Steiger, J. J. Gómez-Navarro, J. Wang, and J. P. Werner. 2019. 'No Evidence for Globally Coherent Warm and Cold Periods over the Preindustrial Common Era'. *Nature*, vol. 571 (7766): 550–54.

Panja, Sheena, Arun K. Nag, and Sunando Bandyopadhyay. 2015. *Living with Floods: Archaeology of a Settlement in the Lower Ganga Plains, C. 600–1800* CE. New Delhi: Primus Books New Delhi.

Parthasarathi, P. 2020. 'Introduction'. *The Medieval History Journal*, Special Section: 'Water and Waterscapes in South Asian History', vol. 23 (2): 291–95.

Pederson, N., A. E. Hessl, N. Baatarbileg, K. J. Anchukaitis, and N. Di Cosmo. 2014. 'Pluvials, Droughts, the Mongol Empire, and Modern Mongolia'. *Proceedings of the National Academy of Sciences*, vol. 111 (12): 4375–79.

Pokharia, A. K., J. S. Kharakwal, S. Sharma, M. Spate, D. Tripathi, A. P. Dimri, X. Liu, B. Thakur, S. K. Basumatary, and A. Srivastava. 2020. 'Variable Monsoons and Human Adaptations: Archaeological and Palaeoenvironmental Records During the Last 1400 Years in North-Western India'. *The Holocene*: 1–13.

Prange, Sebastian R. 2018. *Monsoon Islam: Trade and Faith on the Medieval Malabar Coast*. Cambridge: Cambridge University Press.

Rangarajan, M., and K. Sivaramakrishnan, eds. 2011. *India's Environmental History*. *Volume 1: From Ancient Times to the Colonial Period*. New Delhi: Permanent Black.

Rick, T. C., and D. H. Sandweiss. 2020. 'Archaeology, Climate, and Global Change in the Age of Humans'. *Proceedings of the National Academy of Sciences*, vol. 117 (15): 8250–53.

Rubini, C. 2014. *Shadiabad Mandu. Forme e strutture di un individuo territoriale. La strutturazione organica dell'età sultanale Khalji. La ristrutturazione seriale contemporanea*. PhD Thesis in 3 volumes, dICAR, Politecnico di Bari.

Schug, G. R., and S. R. Walimbe, eds. 2016. *A Companion to South Asia in the Past*. Chichester: John Wiley & Sons.

Shanmugasundaram, J., Y. Gunnell, A. E. Hessl, and E. Lee. 2017. 'Societal Response to Monsoon Variability in Medieval South India: Lessons from the Past for Adapting to Climate Change'. *The Anthropocene Review:* 1–26.

Shaw, Julia. 2007. *Buddhist Landscapes in Central India: Sanchi Hill and Archaeologies of Religious and Social Change, c. Third Century* BC *to Fifth Century* AD. London: The British Association for South Asian Studies.

Singh, U. 2013. *A History of Ancient and Early Medieval India: From the Stone Age to the 12th Century*. New Delhi: Pearson.

Sinha, A., G. Kathayat, H. Cheng, S. F. Breitenbach, M. Berkelhammer, M. Mudelsee, J. Biswas, and R. L. Edwards. 2015. 'Trends and Oscillations in the Indian Summer Monsoon Rainfall over the Last Two Millennia'. *Nature Communications*, vol. 6: 6309.

Sinha, A., K. G. Cannariato, L. D. Stott, H. Cheng, R. L. Edwards, M. G. Yadava, R. Ramesh, and I. B. Singh. 2007. 'A 900-year (600 to 1500 AD) Record of the Indian Summer Monsoon Precipitation from the Core Monsoon Zone of India'. *Geophysical Research Letters*, vol. 34 (16): L16707.

Sinha, A., L. Stott, M. Berkelhammer, H. Cheng, R. L. Edwards, B. Buckley, M. Aldenderfer, and Manfred Mudelsee. 2011. 'A Global Context for Megadroughts in Monsoon Asia During the Past Millennium'. *Quaternary Science Reviews*, vol. 30 (1–2): 47–62.

Sinha, A., M. Berkelhammer, L. Stott, M. Mudelsee, H. Cheng, and J. Biswas. 2011. 'The Leading Mode of Indian Summer Monsoon Precipitation Variability During the Last Millennium'. *Geophysical Research Letters*, vol. 38: L15703.

Sinopoli, C. M. 2003. *The Political Economy of Craft Production: Crafting Empire in South India, c. 1350–1650*. Cambridge: Cambridge University Press.

Sridhar, A., A. Laskar, V. Prasad, A. Sharma, J. K. Tripathi, D. Balaji, D. M. Maurya, and L. S. Chamyal. 2015. 'Late Holocene Flooding History of a Tropical River in Western India in Response to Southwest Monsoon Fluctuations: A Multi Proxy study from Lower Narmada Valley'. *Quaternary International*, vol. 371: 181–90.

Strickland, K. M., R. Coningham, P. Gunawardhana, and I. Simpson. 2018. 'Hydraulic Complexities. Collapse and Resilience in Sri Lanka'. *Water and Society from Ancient Times to the Present: Resilience, Decline, and Revival,* edited by . Sulas and I. Pikirayi. London and New York: Routledge: 259–82.

Tainter, Joseph A. 1988. *The Collapse of Complex Societies*. Cambridge: Cambridge University Press.

Trautmann, Thomas R. 2015. *Elephants and Kings. An Environmental History*. Chicago, IL: University of Chicago Press.

White, Sam, Christian Pfister, and Franz Mauelshagen. 2018. *The Palgrave Handbook of Climate History*. London: Springer Nature.

Wink, A. 2004. *Al-Hind: The Making of the Indo-Islamic World. Volume 3: Indo-Islamic Society, 14th–15th centuries*. Leiden: Brill Academic Publishers.

Yoffee, Norman, ed. 2019. *The Evolution of Fragility: Setting the Terms*. Cambridge: McDonald Institute for Archaeological Research.