

Weather Landscapes and Archaeology: Material Weathering Practices and Tangible Climates

Paysages météorologiques et archéologie : Pratiques météorologiques matérielles et climats tangibles

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ABSTRACT. Climate and climate change can be impenetrable statistical concepts and the sometimes hegemonic scientific narratives around them can make them seem the purview of specialists, while at the same time create an epistemic, geographic and temporal distance between the individual and possible future consequences. However, the climate has already changed and communities throughout the world have most closely experienced it through weather. Weather is the medium through which the statistical reality of climate is felt immediately, is re-socialised, given cultural meanings and functions, and through which long-term environmental knowledge is gathered. Communities build social institutions through which they make long-term weather and climate manageable. Moreover, these experiences are part of identity, local histories and landscapes, key themes that effective climate discussions need to include. Archaeology, with its broad audiences and histories of resilience, has the potential to be an effective tool in climate change messaging. Its focus on local narratives and the material outcomes of human experiences goes beyond the economic discussions surrounding climate change, making it a social issue. In this paper we discuss why weather needs to become more prominent in archaeological narratives and discuss the ways weather can be directly or indirectly included in archaeological analyses and interpretations. Although climate research has been prominent in archaeology, an explicit focus on weather has been almost completely absent. By highlighting weather-centred materialities and practices in the past on the East Africa coast at Kilwa Kisiwani, we show how experiences of weather shape daily life, the built environment and social networks and how it makes the consequences of climate change much more tangible. Archaeologies of weather offer the chance to make archaeology a key partner in projects addressing community values around climate and environment through tangible and relatable components.

RÉSUMÉ. Le climat et le changement climatique sont étudiés à travers des concepts statistiques qui peuvent paraître impénétrables. Les récits scientifiques parfois hégémoniques qui les entourent peuvent aussi donner l'impression qu'ils sont l'apanage des spécialistes. Cela amène une distance épistémique, géographique et temporelle entre l'individu et les éventuelles conséquences futures du changement climatique. Pourtant, le climat a déjà changé et les communautés du monde entier en ont fait l'expérience par le biais de la météo. Cette dernière est le moyen par lequel la réalité statistique du climat est ressentie immédiatement, est resocialisée et se voit attribuer des significations et des fonctions culturelles. C'est aussi le moyen par lequel des connaissances environnementales à long terme peuvent être recueillies. Les communautés construisent des institutions sociales qui leur permettent de gérer leur relation au temps et au climat sur le long terme. Ces expériences font partie de l'identité des sociétés, de l'histoire locale et des paysages, thèmes clés, que des discussions sur le climat devraient inclure pour être améliorées. L'archéologie, avec son large public et ses exemples de résilience des sociétés sur le long terme, est potentiellement un outil efficace pour faire passer des messages sur le changement climatique. L'accent qu'elle met sur les récits locaux et sur les résultats matériels en rapport avec les expériences humaines passées permet de dépasser les discussions purement économiques entourant le changement climatique. L'archéologie fait de celui-ci une question sociale. Dans cet article, nous discutons des raisons pour lesquelles la prise en compte du temps (météorologique) doit devenir plus importante dans les récits archéologiques et nous

examinons les façons dont ce temps peut être directement ou indirectement inclus dans les analyses et les interprétations archéologiques. Bien que la recherche sur le climat ait été très présente en archéologie, une attention portée explicitement au temps a été presque totalement absente. En mettant en évidence les matérialités et les pratiques passées centrées sur la côte de l'Afrique Est à Kilwa Kisiwani, nous montrons comment les expériences du temps façonnaient la vie quotidienne, l'environnement bâti et les réseaux sociaux et comment elles rendent les conséquences du changement climatique beaucoup plus tangibles. Les archéologies de la météo offrent la possibilité de faire de l'archéologie un partenaire clé dans les projets qui abordent les valeurs communautaires liées au climat et à l'environnement à travers des éléments matériels et des récits.

KEYWORDS. Weather, Swahili coast, Kilwa, Climate change, Archaeological narratives

MOTS-CLÉS. Météo, Côte swahilie, Kilwa, Changement climatique, Récits archéologiques

1. Introduction

Climate is a mathematical abstraction and statistical average of meteorological measurements (and other proxy evidence in the case of palaeo-climates) across thirty years (IPCC, 2014 : 120). Any changes to it can scarcely be reduced to an observable event or even a series of events (see e.g., Arias *et al.*, 2021; Boulton, 2016). It is too big, too slow, and too uneven and thus invisible, making it the purview of specialists and minimising the role of the public in how it is perceived and experienced (Adger *et al.*, 2011; Fleming *et al.*, 2014; Rudiak-Gould, 2013). Yet, life threatening climate change and associated global warming are manifesting as extreme, unseasonal or uncharacteristic weather, much of which cannot be labelled as random anymore (Hansen, 2012; Seneviratne *et al.*, 2021), but the “tyranny of the [statistical] mean” (Livingstone, 2012 : 92) continues. As research from the climate change communication field and elsewhere established, the dominant communication paradigm of a universal climate narrative brings with it challenges of a lack of a sense of immediacy and epistemic distancing between oneself and the issue; defeatist narratives and imagery; portrayals of climate change as largely ‘natural’; and a belief in technocratic solutions that will mitigate and insulate us from the environment, thus continuing to disregard the harm being caused. This global narrative is, at best, merely informative and is less likely to yield solutions to local problems and experiences (Moser 2010; 2016; Pearce *et al.* 2015; 2017; Schneider 2012).

In an effort to redress this, the humanities have been called on to help with ‘meaning-making’, addressing local experiences of climate change, and to create/re-imagine narratives that offer and engender ‘responsibility’ within climate affected societies (Boulton, 2016; Doyle, 2020). The inclusion of ideas around local histories, connectedness to local landscapes and a sense of community have been found to be particularly important (Cynnal Cymru - Sustain Wales, 2012; Marshall *et al.*, 2017; Webster *et al.*, 2020). Weather and its links to cultural meanings and traditions is also a key medium through which climate change is made real, understandable, immediate and felt, especially if it does not conform to people’s expectations (Nuttall, 2016; Demski *et al.*, 2017; Endfield, 2019; Rudiak-Gould, 2013). Ultimately, the aim is to create actionable cultural information; information on which individuals, communities, and institutions can act to mitigate and address climate change and unusual weather.

Archaeology, much of which is enamoured with hard sciences approaches to understanding past human-environment-climate relationships (see e.g., discussion in Hussain & Riede, 2020; Kohler & Rockman, 2020), has also contributed to the invisibility and exclusivity of climate change. However, with its broad audience and unique insights into landscapes, traditions, identities and the “local”, the discipline can create evocative and tangible narratives that make past climates real, experienced, and filled with cultural meaning and symbolism and which can be central to ‘meaning-making’ and ‘response-ability’. Archaeology’s potential can clearly be seen in the three-fold increase in the broadcasting of archaeological content between 1998 and 2002 in the UK (Kulik, 2006; Piccini & Henson, 2006), the popularity of cultural museums (Association of Leading Visitor Attractions, 2020), historical and archaeological computer games (e.g., Assassin’s Creed and Tomb Raider

series, Visby Archer), as well as the hijacking and misrepresentation of archaeological narratives (extensively covered at the conference *How Jared Diamond Stole the Grand Narrative: Reclaiming Social Complexity in Global Perspective*, Cambridge 11-13/1/2019).

Archaeologists have tried to communicate the results of their research about long-term environmental and climate impacts of human actions, but most popular outputs have focused on (spectacular) discoveries and scientific interpretations (Morrison *et al.*, 2021; Stephens *et al.*, 2019; *cf.* Williams, 2017). In museums, climate change is also commonly presented as a matter-of-fact and a backdrop to social changes. Generally missing in the discussion are the cultural norms and values that contributed to successful adaptations or socio-environmental degradation (Collins, 2019; but see Lincoln *et al.*, 2020). The information and interpretations also lack local relevance and are commonly not built into landscape and historical narratives with which people can identify. While the risks (and possible opportunities) that climate change represents to economic, physical and biological systems are discussed and accounted for, the same accord is not given to material, symbolic, identity or meaning-making components of societies and cultures and their historicity (Adger *et al.*, 2011; Riede, 2018 and replies). Climate change and its effects are most commonly represented objectively and reduced to numbers, which obfuscates the human role in the current emergency. There is a need, therefore, for climate change to be re-socialised and discussed as a social and human issue in the past as well as in the present (Hulme, 2015; Lane, 2018; Neimanis & Loewen Walker, 2014; Riede, 2018).

To help enhance archaeology's contribution, there is certainly scope for developing different (and new) ways of communicating knowledge about the past and the present that weaves in local narratives, human-environment entanglements, and future-making imaginaries (Petek-Sargeant & Lane, 2021). These should also aim to engage with specialists in climate change communication with a focus on linking the material traces of past societies to current practices, identities, and sensibilities and address the values of communities that often drive responses to climate change. Weather, due to its cultural meanings, immediacy, and experiential aspects, can be a particularly productive lens to approach this challenge and can bring about novel engagements with lay audiences, policy makers, and communicators, and contribute to future climate contingencies.

In this paper, we endeavour to make a case for why weather, the medium through which people most relate to climate change in their everyday lives, needs to become more prominent in archaeological narratives and discuss the ways weather can be directly or indirectly included in archaeological analyses and interpretations. More specifically, our reframing of archaeological and palaeoecological data from the Swahili coast, with weather playing a more central role, aims to show the vicissitudes and opportunities offered by short- and medium-term weather events and their potential role in shaping material traces and routine practices. Such reframing has the potential to make archaeology a more suitable partner for climate change communicators and activists, environmental humanities, and future scenario builders/modellers among others. It will also benefit partners who want to address values based around communities, local histories, and landscapes by including real and tangible remnants of climate change.

2. Weather and climate

Climate is difficult to grasp because it is (among other things) an accumulation of data that is averaged, removed of outliers and smoothed, and rendered as a statistical reality impenetrable to the majority (Brace & Geoghegan, 2011 : 291). It is, therefore, pertinent to make the issue of the climate emergency feel immediate (geographically and temporally), personal, and place-based (Endfield, 2019; Neimanis *et al.*, 2015; see also Simonetti, 2020). An abstract climate becomes tangible, relatable, and expressed through weather and it is through weather that humans experience climate (De Vet, 2013 : 198). Personal experiences of weather are also commonly seen and used by individuals as good indicators of climate change (Demski *et al.*, 2017; Kahan, 2014). The direct experience of floods in the UK in 2013/2014 led to increased salience of climate change and intentions to prepare for other climate impacts (Demski *et al.*, 2017). Livingstone (2012 : 91–92) notes that a

single hot or cold season can shape “a local community’s immediate encounter with climatic realities, but also casts lengthy shadows over future memories”, as did the British (golden) summer of 1976 that brought with it new modes of outdoor socialising in people’s gardens (Waites, 2018). Moreover, how individuals perceive weather shapes how they understand the climate to be changing, although those perceptions might be different from actual recorded weather (Goebbert *et al.*, 2012; Kahan 2014).

That imagined climate futures and dystopias are most easily approached through weather and also exemplified by the cli-fi genre. Approximately 40% of films categorised as cli-fi use extreme weather events as their theme and plot tool (Svoboda, 2016). Among novels, the most common plot events are flooding and sea-level rise (Trexler & Johns-Putra, 2011). Other common themes include melting of ice/poles, an Ice Age, and droughts with famines, while weather events are now also presented dramatically as disease vectors, as in the TV series *The Rain* (IMDb, 2018). That climate change is best illustrated and understood through extreme weather events is exploited by the entertainment industry and there has been a steady-rise in the portrayal of post-apocalyptic futures (Svoboda, 2016; Trexler, 2015), although this may change in the light of the impacts and legacies of the COVID-19 pandemic.

The focus on weather in popular culture as well as the human predisposition to relate to climate through it, can rightly be seen as an impediment to how climate change should be understood (Rudiak-Gould, 2013). Climate change is not to be understood as the threat of extreme weather and such a misconception runs counter to the gradual changes that it actually causes (Findlater *et al.*, 2019). Any discussion of weather is also absent in recent review papers on climate communication (Moser, 2010; 2016; Pearce *et al.*, 2015; 2017). However, the current delineation between weather and climate and the view that they are widely separate phenomena also creates a ‘no man’s land’ where links between global warming and specific weather events, or a series of these, can consistently be denied and questioned – as is commonly observed in politics (e.g., Culbertson, 2019; see also Hulme, 2014; Rudiak-Gould, 2013). Moreover, the denial of a relationship between natural disasters, weather and climate change also obfuscates the far-reaching and long-term ways humans have been contributing to climate change (Malm, 2016).

Climate change is, then, a wicked problem and a hyperobject (a thing that is massively distributed through time and space, is only experienced through intermediaries, and also operates through ideas, cultural stories and historical memories) (Boulton, 2016), and the many hegemonic narratives associated with it do not reflect the ways in which people experience it or make meaningful associations with their land and history. It is necessary to attend to the specific temporal moments and locales through which communities understand their climatic realities (the intermediaries), meaning we need to include weather in our narratives and climate change communication (Livingstone, 2012). Also, because the realisation of climate change threats will be expressed as weather (and its consequences), it needs to be included in discussions on local vulnerabilities. As Schneider (2012 : 192) and Yussof (2006) point out, the catastrophe, damage and harm of climate change remain largely invisible in the imagery and models of future scenarios. However, increasing temperatures are increasing maximum rainfall events in Western Europe, which contributed to the floods in July 2021 (Kreienkamp *et al.*, 2021), while the most recent Intergovernmental Panel on Climate Change (IPCC) report states that many observed heat extremes were extremely unlikely to have occurred without human contributions to climate change (Seneviratne *et al.*, 2021).

Anthropologists, although sometimes lamenting that their data is taken as anecdotal when discussing climate change, already talk about weather and weather changes with source communities (as do many archaeologists working with living communities), and how it affects understandings of place, history, and community (Crate & Nuttall, 2016 and contributions within; de Wit, 2018; Hastrup, 2009; Turner & Clifton, 2009). Ingold (2011; 2007) also identifies the weather as the medium through which humans relate to and become entangled with the material world, that helps them see things and places differently, and through which they experience changes. Weather also plays a role in memories or long-term memorialisation of places and events, becoming embedded

in the architecture, movements, activities and social structures of a place and key to the identities of communities that lived in or through them (Endfield, 2019; Endfield & Naylor, 2015; Neimanis & Hamilton, 2018; Vannini *et al.*, 2012).

Weather is the lens through which the relationship between culture and climate can be understood and environmental imaginaries addressed. Weather is observed and experienced and it is through it that we mediate our relationship with the landscape (Endfield, 2019; Ingold, 2011; Petek-Sargeant & Lane, 2021). Communities have social institutions that “control” weather and connect it to broader imaginaries about the world, thus making it governable (Mahony & Randalls, 2020). Only by studying and including the multiple experiences of weather across space and time can we fully consider the experiences and responses to climate change. Schnegg (2019) discusses how Namibia’s Damara pastoralists enmesh the winds and rain as things to be used in everyday activities, with different types of rains having different effects on the landscape and possibilities of food production enabled by knowledge gained through generations of observations. The Damara, uniquely in their region, relate longer-term weather changes to transformations in the social and political world. In the UK, eighteenth and nineteenth century diarists benchmarked droughts, floods or other unusual weather against previous such occurrences in their areas (as do many other communities using oral histories (e.g. Strauss & Orlove, 2003); floods regularly receive markers along riverbanks to mark their recurrence and severity, while places and folklore serve as mechanisms to memorialise, reproduce and normalise weather (Endfield, 2019; Hall & Endfield, 2016; Pillatt, 2016). Like climate, weather has a past and it tends to be so familiar to and intimately associated with the identities, histories, and places of local communities that it becomes a component of these themes (Vannini *et al.*, 2012).

By talking about weather, we can foreground human agency in how a society deals with vicissitudes as well as make the environment more than an inert backdrop and climate as a structuring element of human action and adaptation. Nowhere is this more necessary than in archaeology. In Pleistocene archaeology and early prehistory, the environment (and climate) are often invoked as structuring elements of human action, cognition, and adaptation in an almost deterministic sense. This contrasts with historical, indigenous, and later archaeologies where any ecological reductionism or strong environmental determinism can be regarded as presenting preliterate or indigenous communities as ahistorical and thus perpetuating colonial notions of communities having little to no agency and at the mercy of any environmental changes. It is therefore more common for the environment and climate to remain in the background or presented as something to be acted on (Contreras, 2017; Hudson *et al.*, 2012; Hussain & Riede, 2020).

It might therefore be better to talk about ‘long-term weather change’ than climate change and there is a need for a transition and translation from the unseeable realm of climatological abstraction into the seeable realm of local narratives (Rudiak-Gould, 2013). This might require the making of local ‘icons’, which frame the long-term weather change and address local priorities, such as the abovementioned winds and rains of the Damara, Tuvalu’s marine resources (McNeeley & Lazrus, 2014), or the memorial re-enactments and heritage events in US National Parks that have been affected by warming weather (Rockman & Maase, 2017).

3. Archaeologies of Weather

Archaeology is the most extensive compendium of human experiences of changing environments and climate and it has invested heavily in research on climate change and human-environment interaction (Cooper & Sheets, 2012; Dawson *et al.*, 2017b; Isendahl & Stump, 2015; Van de Noort, 2013). Archaeology has much to contribute to climate change research as it can help us think through the nature-culture divide (Hudson *et al.*, 2012); show how past communities managed decline and recovery (Nelson *et al.*, 2010; Spielmann *et al.*, 2011); highlight how social differences affected responses to climate/environmental change and the longer-term consequences of those responses (Thomas *et al.*, 2019); and it deals with issues of power, lifestyles, and

environment and builds places of meaning that resonate with the present and can potentially help wronged communities to heal (Atalay, 2019a).

However, although archaeology's presence has been steadily growing, it remains inconspicuous in the climate change discourse and not widely recognised as a central component of responses and adaptations to climate change (Kohler & Rockman, 2020; Richer *et al.*, 2019). This absence is most apparent in the IPCC reports, although more recent IPCC and country-level reports have been using more and more archaeological results and have particularly become more inclusive of indigenous knowledge. There nevertheless remains a discrepancy in the use of the data among IPCC's Working Group 1 (concerned with the physical science of climate change over time) which uses hard science archaeological data and Working Group 2 (concerned with the effects of climate change on societies) where archaeology is almost completely absent (Jackson *et al.*, 2018; Kohler & Rockman, 2020; Rockman & Hritz, 2020; Rockman & Maase, 2017). A reason for this absence is that archaeologists are not members of groups writing the reports and because national and regional institutions contributing data to the IPCC, for example, are not prioritising archaeology and heritage data, making it easier to ignore or discount it in subsequent, higher-level reports as well (Rockman & Hritz, 2020).

Similar absences of archaeology have occurred with the environmental turn in the humanities and in UK museums when discussing the climate crisis (Collins, 2019; Hussain & Riede, 2020; Riede, 2018). Moreover, while there is an increasing number of archaeological projects explicitly designed to address present issues, they have had little effect on policy discussions. This may be because the results might lack practical relevance for the issues faced today or the necessary information to make an informed decision, or that potential stakeholders fail to recognise their value. While it remains important for archaeology to continue to research the human influence on and adaptation to climate change and the environment, direct applicability of results might be limited and should not be overstated (Lane, 2015; Richer *et al.*, 2019). There is, nonetheless, a need to change the social environment of archaeology, who it engages with, and how (Lane, 2018; Riede, 2018; Rockman & Hritz, 2020). As mentioned in the introduction, the broad public interest in the discipline offers significant potential to reach new and diverse groups, while discrepancies in use of archaeological data such as between IPCC's Groups 1 and 2 present further opportunities to engage archaeological data in more practical and policy-oriented ways.

People draw on archaeology to construct local and national identities, build social capital, and gain a sense of place and community and archaeologists should continue to support narratives that address these values, since there are many benefits to it as shown by outreach and public archaeology projects, like the travelling exhibitions conducted in East Africa (Morton and Oteyo, 2015; Petek-Sargeant, *in prep.*) or community-led heritage actions by ShoreDIG in Scotland (Dawson *et al.*, 2017a). Because archaeology operates at the grass-roots level and highlights the local, its narratives are of greater value than complicated global models. This also applies to climate change, and a way archaeology could 'localise' climate change and relate it to identities, places, landscapes, and community (values that people look to archaeology for guidance and information and to which they are more likely to respond to) could be through weather.

A discussion of weather has already been included implicitly in some research. The architecture of dwellings can include discussions on weather-proofing constructions or 'keeping the weather outside', and how vernacular architecture creates comfortable spaces in spite of the weather and climate (Dahl, 2010; Pacheco-Torgal & Jalali, 2012). Materials such as turf roofs are chosen based on their characteristics protecting against rain and wind in harsh northern or arctic environments, and in Scotland 18th and 19th century houses would have up to 2 m thick walls to separate the warm interior from the cold exterior while being positioned to protect from the prevailing winds or anticipating them to create draughts where required (Arneborg, 2008; Dixon, 2002; Jim, 2017; Oliver *et al.*, 2016). Construction was then also about harnessing anticipated weather conditions. By looking at the climatic changes of the Little Ice Age (and later) in Sweden, Eriksdotter (2013) and Eriksdotter &

Legnér (2015) also discuss how people adapted their dwellings to inclement winters, summer-less years and the spatiality of rooms in different seasons and weather.

Well-recorded storms, gales and floods moved dunes across the British landscape causing either gradual abandonment of economic areas and settlements over weeks or months, or catastrophic events (Griffiths, 2015). The same processes are now also exposing archaeological sites. In the US Southwest, precipitation reconstructions have also been used to show how communities dealt with weather variability (Nelson *et al.*, 2010). A combination of palaeoecological, archaeological and historical data also shows how adverse weather like increased storms, late springs and wet periods alongside socio-political processes were causing land and settlement abandonment in Scotland during the Little Ice Age, rather than the lower climatic temperatures (Davies, 2007; Dodgshon, 2005). At the landscape scale, Petrie (2017) addresses the ‘predictable unpredictability’ of rain, how Indus Valley civilisations buffered against this, and the impact of climate on water availability.

Similarly, and more notably, research in southern Africa has dealt with expressions of rainmaking in archaeology, such as rock art, as well as the material culture of rain control and its association with wisdom and power among hunter-gatherers and farmers. Shamans could produce socially desirable benefits, and abundant rains or lack thereof was linked to good/bad deeds and rulership (Challis *et al.*, 2008; Kinahan, 1999; Schoeman, 2009; 2006). Pillatt (2016; 2012a; 2012b), with a focus on Ingold (2007)’s ‘weather world’, has used historical diaries and climate to explore weather as a material condition of the landscape and an integral part of how people viewed and used the landscape in Cumbria in the UK. This work highlights how weather changes material realities for people, and how people’s understanding of climate is embedded in their sense of identity and community and is accumulated through experiences of weather. The weather ‘*in which one stands can be as much responsible for generating a sense and use of place as the ground on which one stands*’ (Pillatt, 2012a : 34). Equally important is social memory through which weather knowledge is filtered and remembered, and which allowed pre-Columbian communities to improve their resilience to extreme weather events of the North Atlantic over time (Cooper, 2012a; 2012b).

Ingold (2011) has also noted the lack of focus on the weather in archaeological research and the new interpretive possibilities it opens up. Moreover, by zooming in from climate to micro-events of the weather and hypothesising how that climate would be expressed and experienced, archaeology can move beyond correlation between climate change or instability and cultural collapse and reformulation. Collapse is rarely monocausal and a changed climate would have involved certain weather events, such as droughts or increased rainfall with less wet days, that caused stress, as in Caracal city where increased droughts coupled with political instability led to its demise (Contreras, 2017; Cooper, 2012a; Haldon *et al.*, 2018). A stronger emphasis on weather events can also shift the focus away from ‘collapse porn’, especially commonly used by those outside of archaeology (e.g. Diamond, 2005), and towards management of weather and climate, and cultural continuity.

4. Archaeologies of Weather and Climate at Kilwa Kisiwani from c. 800 CE

The Swahili landscape stretches along 3000 km of the East African coast, roughly from Mogadishu in Somalia to Sofala in Mozambique (**figure 1**). The coast and its islands are characterised by different ecosystems that include dunes, floodplains, mangrove forests, marshlands, cave systems, sand beaches and volcanic islands (Lane & Breen, 2018). The history of the Swahili landscape is also steeped in the weather world. Instances of landscape modification and the utilisation of architecture as a weather archive show how weather (and climate) knowledge were used to advance economic activity and provide safety at sea. Wind, a medium that Ingold (2007) sees as particularly important in giving objects agency and allowing humans to move and interact with them (e.g., kites or sails), was key in the case of the various city-states, such as that centred on Kilwa Kisiwani, in providing momentum to build prosperous trading ports during a time of environmental and climatic changes of the Little Ice Age.

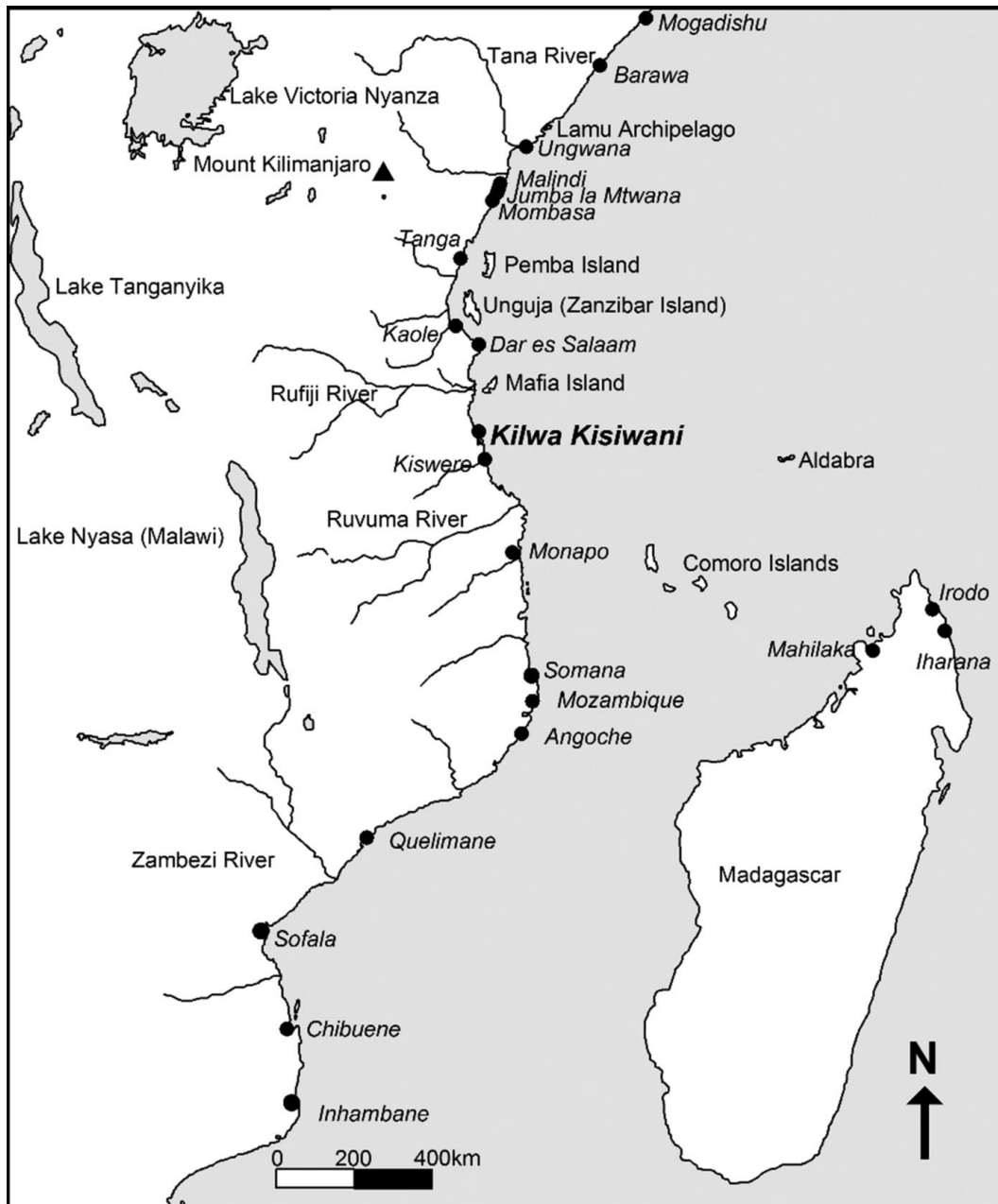


Figure 1. Map of the East African coast and islands showing the major Swahili stone towns and trading ports.

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Much of the coast has a bimodal rainfall pattern, for example, which is driven by the twice-yearly passage of the Intertropical Convergence Zone (ITCZ), the area where the northeast and southeast trade winds meet, and its movement between the Ethiopian Highlands and the northern Sofala coast, or approx. 20° N and S of the equator. As the ITCZ moves slowly south due to the prevailing winds from the northeast from March to May, the region experiences the long rains, while stronger winds from the southeast between October and November bring short rains, moving the ITCZ north (Nicholson, 2000; 1996). As well as regulating the timing of different agricultural tasks, the predictability of these winds was especially significant for the development of maritime trade and East Africa's connection to the Indian Ocean rim. Although there is evidence of Indian Ocean trade from the early first millennium, increasing trade connections are evidenced from the ninth century onwards initially with the Persian Gulf and later with India and Southeast Asia, and eventually China as well (Chami,

1994; LaViolette & Wynne-Jones, 2018; Sinclair, 1987; Zhao & Qin, 2018). Equally important was contact with Islam, which became increasingly influential, culminating in its adoption by the majority of inhabitants of coastal trade towns and settlements (Horton & Middleton, 2000; Insoll, 2003). The coast saw major cultural shifts from the 11th century that resulted in a more maritime society (Fleisher *et al.*, 2015). There was a significant expansion of trade both inland and with the Indian Ocean (Wynne-Jones, 2016); wealthy traders built coral stone houses, which were previously reserved for religious and civic buildings (Horton, 1996; Horton & Middleton, 2000); changes in diet included more deep sea fish taxa (Quintana Morales, 2013; Quintana Morales & Prendergast, 2018) and adoption of rice and other SE Asian domesticates (Walshaw 2010; Quintana Morales *et al.*, 2022); and a growth of towns and the emergence of more distinctive coastal regions and city-states (Kusimba, 1999; Wynne-Jones & LaViolette, 2018 and contributions within).

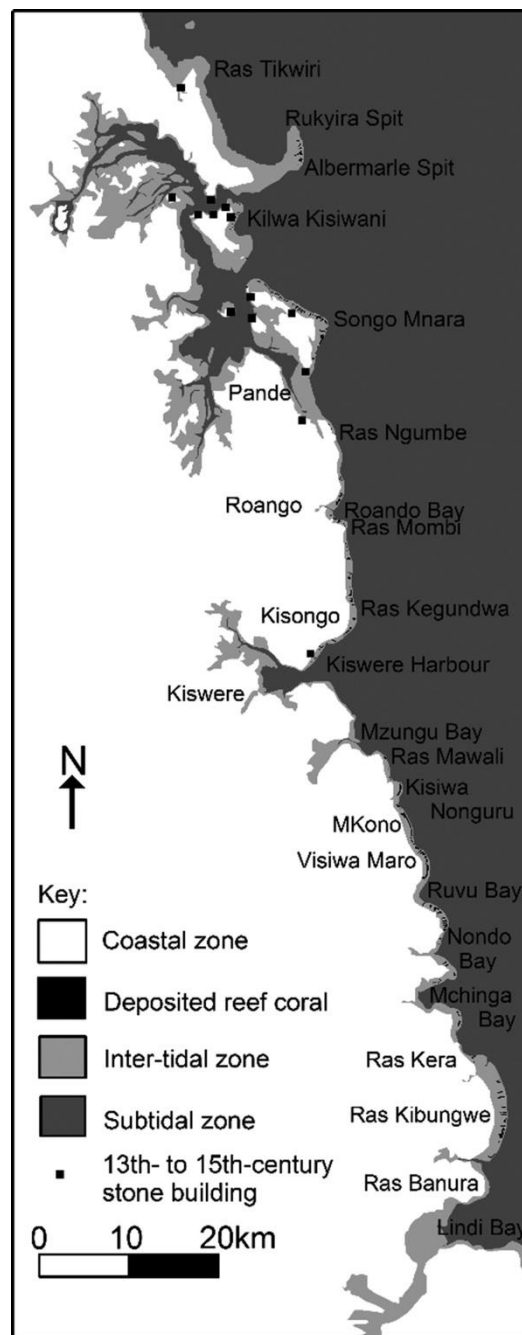


Figure 2. The distribution of causeways from Kilwa to Lindi on the Tanzanian coast.

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Kilwa Kisiwani was a prominent Swahili port town and city-state located in modern-day Tanzania, and occupies a special place in the history of the Swahili coast. It was most likely initially settled in the 9th century (Horton et al., 2022) and, due to its extensive trade network, experienced significant expansion in the 13th and 14th centuries, which included the founding of the nearby town of Songo Mnara. It was also during the 14th and 15th centuries that monumental building took place, as 120 km of the East African coast north and south of Kilwa became lined with coral causeways and likely indicates Kilwa's expanding influence (Pollard *et al.*, 2012; Pollard, 2011 ; 2008) (**figure 2**). In addition to trading luxury items such as gold from inland Africa, the town contained many craft workshops, such as for metalworking, and was well-connected to the immediate rural mainland (Wynne-Jones, 2007; Baužytė et al. 2021). The decline of the city-state started at the beginning of the 16th century with the arrival of the Portuguese in 1505 (Wynne-Jones, 2018).

The city-state achieved prominence during the environmental changes brought on by the end of the Medieval Warm Period (MWP, c. 1000-1270 CE), characterised by more arid conditions, and the transition to the Little Ice Age (LIA), which in East Africa lasted approximately between 1250 and 1750 CE and in general resulted in a more humid climate with higher precipitation, although a few severe droughts are recorded in regional palaeoecological records (Marchant *et al.*, 2018; Verschuren, 2004). The climatic changes of the LIA influenced cultural and environmental changes across the globe, yet its timing varies from region to region and how global changes are related to regional and local climates requires further discussions, as well as investigations into causality and correlation of societal shifts in settlement and land-use patterns (Davies 2007; Haldon *et al.*, 2018; Lane & Petek-Sargeant, in press). This is also the case for East Africa, where a broad regional climatic picture is well established but local patterns might vary. For example, wetter conditions were also present on the coast, although they appear only to have lasted until about the end of the 15th century with another shorter pluvial between 1680 and 1760 (Lane & Breen, 2018; Punwong *et al.*, 2013a; 2013b; 2012).

The LIA was also characterised by rising sea levels, culminating in the Late Holocene Highstand, with sea levels beginning to rise along the Tanzanian coast after about 800 CE until c. 1500 CE (Punwong *et al.*, 2018). Punwong (2013c : 231–232) estimates that sea levels were around 4.8 and 1.8 m below mean sea level (msl) until around 1200 CE and rose to between 0.4 and 0.8 m below msl until around 1400 CE or approximately 1 m below present levels based on records from ruins at Kilwa (Mörner, 1992 as cited in Punwong *et al.*, 2018). Sea levels began to fall after 1500 CE until the 19th century, as indicated by raised terraces located along the Kenya coast, while Tanzania also experienced localised land uplifting (Åse, 1981 as cited in Punwong *et al.*, 2018; Muzuka *et al.*, 2004 as cited in Punwong, 2013c). Sea levels began to rise again from the 19th century with a 1.3°C rise in sea-surface temperature (Lane & Breen, 2018).

Kilwa was among other things built around and grew from the seasonal use of monsoon winds, and utilising or mitigating against the different weather conditions that the environmental changes of the LIA brought. It was an easily reachable point to travel to from the Persian Gulf and return within the year. The town was also a good transfer point for goods coming from the Sofala coast, further south in what is now Mozambique, like the gold from Great Zimbabwe and other inland states. The difference in reliability of winds north and south of Kilwa and the knowledge required to navigate them is one of the major reasons that the town was such an important harbour (Pollard & Ichumbaki, 2016). The winds were part of the highly predictable weather patterns of the coast with little interannual variability in the timing of their occurrence, allowing communities of the Indian Ocean rim to build vast trade networks, which over centuries allowed Kilwa to expand connections from the Persian coast to India and eventually China. The monsoon winds are an example of how stable and predictable weather over centuries can be part of the foundation of expansive continental networks that enable migration and transfer of cultural ideas.

The changes brought by the rising sea levels of the late MWP and LIA would also have had a particularly drastic effect on the landscape and how it was perceived during different weather conditions. Due to the relatively flat continental shelf fringing East Africa's Indian Ocean coast, the tidal zone can extend over several

hundred metres. Sea level rise during the LIA would hide the dangers posed by the reef-lined coast and the shoals and narrowing of the intertidal zone, while also opening up new approaches to the harbour and new economic opportunities as the Swahili started fishing more deep sea taxa, moving away from the reefs (Lane & Breen, 2018; Pollard, 2016; 2008; Quintana Morales, 2013; Quintana Morales & Prendergast, 2018). However, the LIA also brought new dangers, as the rising sea levels combined with the more pluvial weather made the hidden coral limestone fringing the coast a bigger threat to the lightly built dhows (for which weather conditions were already unsuitable between mid-May and mid-August), increased storminess, and was more likely to cause settlement inundations (Pollard, 2016; Punwong *et al.*, 2013b).



Figure 3. Causeway across Matuso Lagoon to a reef crest platform near Kilwa Kisiwani Harbour.
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One of the purposes of the stone causeways (as well as islets and platforms) which lined the Kilwa's coast, as has been noted by Pollard (2016; 2011; 2008), was to warn sailors of the threat (**figure 3**). The now grey coral structures would have been white when they were built. These structures were there to aid navigation and made the offshore landscape better visible by reflecting light in the commonly sunny coastal weather, marking the reef edge and guiding ships into harbours. Moreover, as they were set against the dark mangrove forests, the white coral would have remained clearly visible in darker and stormier conditions, and some also offered shelter against adverse wind conditions.

These weather conditions were archived in the causeways (see discussions on how the built environment is an archive of weather conditions in Endfield, 2019; Ingold, 2007; Neimanis & Hamilton, 2018; Neimanis & Loewen Walker, 2014), since modern communities were not aware that they were humanly made, but nevertheless continued to use them as navigational aids, as did European ships sailing along and mapping the

coast. Similarly, the mosques at Sikitiko and Ras Rongozi also provided navigational aid by directing dhows in certain winds. Although it is unknown if they were built with this intention, it is a meaning they acquired through prevailing weather conditions (Pollard, 2016; 2011). Many of the stone houses in Kilwa are also oriented north, to protect against the strong SW monsoon winds and had a shimmering white plaster that made the town visible from afar (Gensheimer, 2018). Wind, on the other hand, was quite likely harnessed, as it is today in the Swahili town of Lamu on Kenya's northern coast, to provide natural ventilation and breeze in the town's stone-built quarters, where the narrow alleys would have also provided shade from the sun especially during hot weather (Hillewaert, 2018). Weather would also have affected the far more common wattle-and-daub houses in Kilwa town and its hinterland, which remain common today (*figure 4*). Although built from less permanent materials, these houses could still be occupied for a few decades and while there are many reasons why such houses are razed or abandoned and people moved (Fleisher & LaViolette, 1999), the faster weathering of walls caused by increased rains during the LIA could have been an additional factor to the increase in the number of short-lived settlements on the mainland in the 14th century even though the same general areas remained occupied (Wynne-Jones, 2005).



Figure 4. A weathered Swahili wattle-and-daub house on Juani Island in Tanzania's Mafia Archipelago.
© Nik Petek-Sargeant

Essential for many East African coastal towns were also considerations of water management, as they were located on islands and in environments where fresh water was hard to come by and spoiling of sources has been suggested as a reason for abandonment of stone towns in Kenya, such as Gedi (Kirkman, 1964; Sassoon, 1981). At Songo Mnara, there were only a few wells, which most likely contained brackish water as they do today, but there are many more cisterns used to collect the water from the seasonal rains. This water was extremely important also to comply with religious and cultural norms and ideals of cleanliness, as is evident from the many water management structures associated with mosques, lavish lavatories, and the regular cleaning of floors (Sulas & Madella, 2012; Wynne-Jones & Fleisher, 2014). The wetter climate of the LIA would have allowed Songo Mnara's inhabitants to better follow those ideals with sufficient rain year-on-year and the investment into the infrastructure indicates a need for it to sustain the inhabitants over decades and through the adversities of seasonal droughts. However, a possible extreme multi-year drought and lack of rain between 1380 and 1420 was unlikely to have been anticipated and mitigated against (Verschuren, 2004). It could have resulted in people seeing themselves as 'unclean', deepening or creating new cultural divisions which could potentially persist even after the drought, unlike the effects of seasonal events.

The environmental and climatic changes of the LIA brought new pluvial weather regimes that lasted centuries and which increased the threat to coral limestone, while the occurrence of a positive Indian Ocean Dipole (seasonal events lasting up to six months with higher sea-surface temperatures in the western Indian Ocean resulting in increased rainfall over East Africa and associated flooding) likely added to the urgency to make the growing Indian Ocean trade safer, as exemplified by the causeways. The increased occurrence of rains also gradually chipped away the integrity of mud walls, the effects of which would only be apparent years later. Conversely, a multi-year drought or even a single severe drought as those created by a negative Indian Ocean Dipole might impede daily rituals important to identity and a cohesive community. Weather is historical, and individual weather events might be hard to extricate from multi-year and decadal weather patterns, but it nevertheless forms part of individual and community memories and experiences. These are used to (re-)domesticate weather and build institutions, architecture, and rituals through which it can be managed and integrated into daily life, as done by the inhabitants of Kilwa and preserved in the archaeological record (Janković, 2000; Mahony & Randalls, 2020; Orlove *et al.*, 2010).

5. Conclusion: from present and future weather changes to archaeology and back again

Many East African communities perceive the weather as unpredictable because rains can be localised, droughts common, and their periodic experiences of significant flooding events, which have become more frequent in the last decade. At the same time, dry seasons have become longer and the number of rainy days has decreased although the rains have also become more intense (Kipkorir, 2002; Pinho, 2020). It is therefore hard for some to relate to and identify with ideas of climate change since climate (as understood through weather) has always been unstable and fast changing, but the weather experience of increased rainfall variability has been one of the main drivers of land-use change in the present East African savanna (de Wit, 2018; Kariuki *et al.*, 2021). As noted above, good or bad weather is also understood as a consequence of people's actions, which itself might represent a disconnect from the scientific understanding and definition of climate. However, by integrating indigenous knowledge about weather, people are more willing to listen and engage with narratives of climate change (Orlove *et al.*, 2010; Radeny *et al.*, 2019). This has certainly been Nik Petek-Sargeant's experience during his historical ecological research and associated outreach in Kenya's Baringo County (Petek-Sargeant, in prep.; Petek-Sargeant & Lane, 2021).

Archaeology has made great strides in community archaeology and engagement (Atalay, 2019a, 2019b; Atalay *et al.*, 2019; Pikirayi & Schmidt, 2016), but its relevance remains questioned in many geographical, social and scientific contexts (Chirikure, 2021; Kohler & Rockman, 2020; Ortman, 2019; Richer *et al.*, 2019). To address this, the knowledge and skills from community engagements should be utilised more explicitly in

climate communication, storytelling, and efforts to get policymakers, other specialists, and different stakeholders to take action. Much of the archaeological research focusing on environmental, sustainability, and climate change issues is done with the intent of ‘using the past to inform the present’ with the hope of finding information that can be usable and applicable in the present. This might not be the best use of archaeological efforts and results in every context due to the significantly different socio-economic and ecological circumstances today compared with even the relatively recent past (Lane, 2015; 2018; Richer *et al.*, 2019). As archaeologists, we therefore urgently need to consider how we can best harness the considerable interest of archaeology’s public audiences and partner with climate activists, government agencies and policy makers to create and contribute climate narratives that resonate with communities and deliver actionable cultural information that will support transformation and strengthen socio-ecological resilience.

By sharing local climate change narratives focused around weather, the dangers and opportunities it brings and how people have mitigated against them as sketched out here with reference to the area around Kilwa Kisiwani, archaeology can become a better communicator and provide information usable by others, such as storytellers (including for many communities where oral histories continue to be important). Moderate and strong positive Indian Ocean Dipole occurrences are likely to become more common in the future, with more storms and rains, and the rising sea levels can cause inundation and salination of farms, bringing new challenges for coastal communities (Abram *et al.*, 2020; Cai *et al.*, 2021; Lane & Petek-Sargeant, *accepted*). The causeways helped mitigate against the more pluvial weather and utilised the generally sunny days to warn of dangerous reefs, but they also required considerable economic input and labour allocation (Pollard *et al.*, 2012). They continue to be part of fishing strategies today, and they may become even more significant in future adverse conditions. Additionally, by weaving cultural priorities into our communication, such as notions around cleanliness during a drought at Songo Mnara, archaeology can create locally relatable stories where possible consequences are clearly stated and issues of identity and personal perception are clearly addressed. The modelled increases in positive Indian Ocean Dipole occurrences and associated floods, are also associated with increased prevalence of malaria and mortality (Uddenfeldt Wort *et al.*, 2004).

As Adger and colleagues (2011) discuss, the interface between climate science and the social world is dominated by a materialist paradigm, as the consequences of climate change are discussed in terms of cost, mitigative construction projects, resources etc., that typically neglects the cultural and non-material impacts. Archaeology works at the interface between the material and the non-material and can act as a valuable bridge between the two. It provides long-term context on how landscapes and culturally-specific understandings of the environment have developed, which can be extremely useful in developing culture- and society-specific targeted messages on how to address climate change, and shape behaviour and decisions by governments, policymakers and communities.

Archaeology can also offer introductory paths to addressing difficult questions about climate change, like the aforementioned issues of cleanliness, but it will continue to face the present challenges of finding objects that ‘speak’ to climate change and unpacking them so that the objects and landscapes themselves (or an assemblage of them) can be narrators of the story. This is a particular problem for museum environments which can attract large audiences but where communicators might not be present (Collins, 2019). This issue could be addressed through a focus on weather, since many environmental vicissitudes are expressed as shorter or medium-term weather events (e.g. Lincoln *et al.*, 2020).

As we have argued here, by focusing on experiences of weather, climate is rendered in more social and less statistical and physical terms, and the climatic and social changes observed in the archaeological record are more readily linked to how people confronted changing environmental and material conditions, as well as what the (material) outcomes were. We can start to interpret how people historicised the climate through weather, and how that shaped perceptions and interactions with landscapes, and how communities built up their resilience toward prevailing, rare but devastating or unusual and unpredictable weather events. This will ultimately allow

archaeologists to apprehend the full breadth of interactions (Petek-Sargeant & Lane, 2021; Pillatt, 2012b) and create meaningful narratives that interact with values of local community, landscape, history and others.

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No conflicts of interest to declare.

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