Article:
Hannaford, M.J. and Nash, D.J. (2016) Climate, history, society over the last millennium in southeast Africa. Wiley Interdisciplinary Reviews: Climate Change, 7 (3). pp. 370-392. ISSN 1757-7780

https://doi.org/10.1002/wcc.389

WIREs CLIMATE CHANGE

Article type: **Advanced Review**

Article title: Climate, history, society over the last millennium in southeast Africa

Authors:

First author
*Matthew J Hannaford, Department of Geography, The University of Sheffield, Winter Street, Sheffield, S10 2TN, UK
Centre for Africa Studies, University of the Free State, PO Box 339, Bloemfontein, 9300, South Africa
m.hannaford@sheffield.ac.uk;

Second author
David J Nash, School of Environment and Technology, University of Brighton, Lewes Road, Brighton, BN2 4GJ, UK
School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050, South Africa

Abstract

Climate variability has been causally linked to the transformation of society in pre-industrial southeast Africa. A growing critique, however, challenges the simplicity of ideas that identify climate as an agent of past societal change; arguing instead that the value of historical climate-society research lies in understanding human vulnerability and resilience, as well as how past societies framed, responded and adapted to climatic phenomena. We work across this divide to present the first critical analysis of climate-society relationships in southeast Africa over the last millennium. To achieve this, we review the now considerable body of scholarship on the role of climate in regional societal transformation, and bring forward new perspectives on climate-society interactions across three areas and periods using the theoretical frameworks of vulnerability and resilience. We find that recent advances in palaeoclimatology and archaeology give weight to the suggestion that responses to climate variability played an important part in early state formation in the Limpopo valley (1000-1300), though evidence remains insufficient to clarify similar debates concerning Great Zimbabwe (1300-1450/1520). Written and oral evidence from the Zambezi-Save (1500-1830) and KwaZulu-Natal areas (1760-1828) nevertheless reveals a plurality of past responses to climate variability. These were underpinned by the organization of food systems, the role of climate-related ritual and political power, social networks, and livelihood assets and capabilities, as well as the nature of climate variability itself. To conclude, we identify new lines of research on climate, history and society, and discuss how these can more directly inform contemporary African climate adaptation challenges.

Introduction

In southeast Africa, the last millennium was characterized by transformative social, economic and political change. This commenced with the emergence of complex, centralized farming communities, and spanned the development, weakening and impoverishment of multiple African state structures. The penetration of European mercantile capital between the 16th and 19th centuries did much to bring about the decline of these polities, and eventually culminated in the formation of nation states under region-wide colonial rule in 1890 following the 'scramble for Africa'. The final decades of the millennium concluded with the establishment of majority rule in the post-colonial nation states that constitute southern Africa as it is known today (Fig. 1).

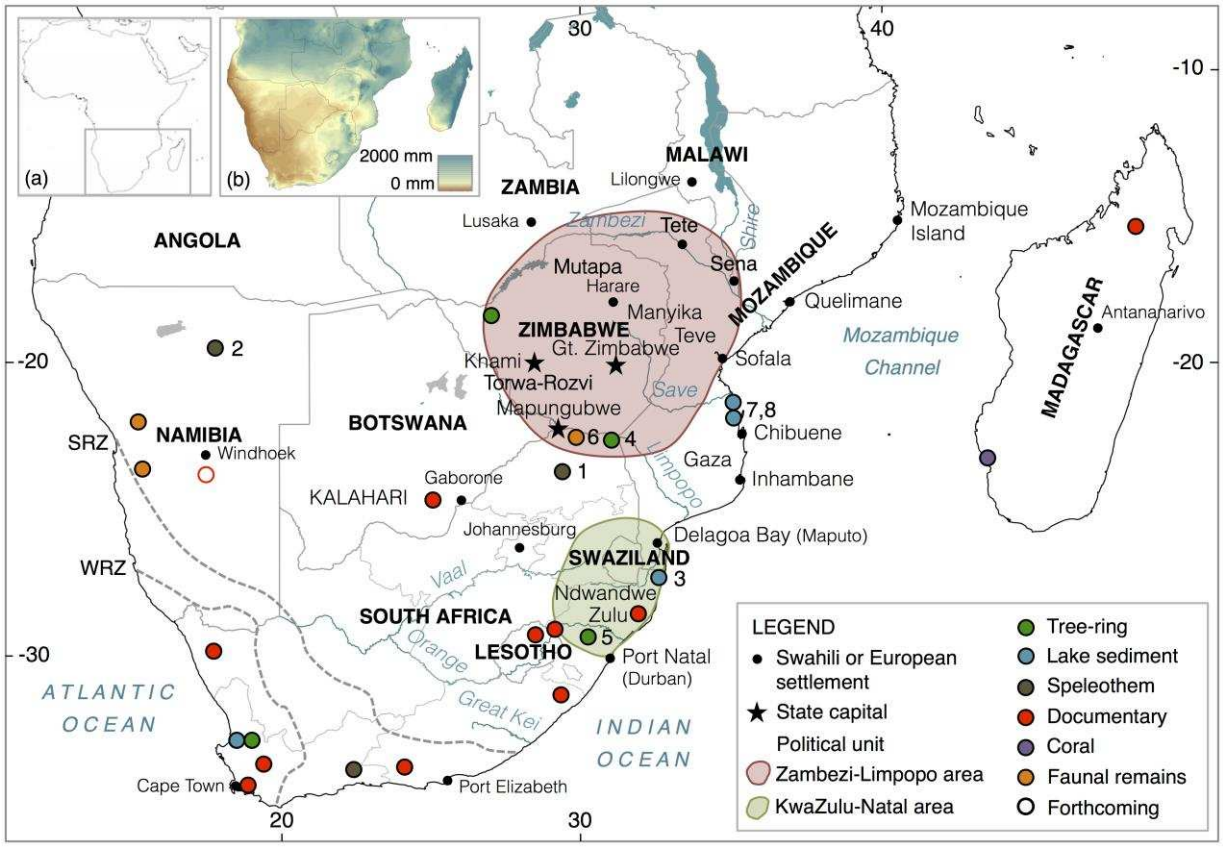

Figure 1. Map of key sites, areas and political units referred to in the text, together with proxy-documentary datasets covering the last millennium. Red and green shaded areas indicate the spatial coverage of the paper. Numbers correspond with proxy records in Fig. 2. SRZ – Summer Rainfall Zone; WRZ – Winter Rainfall Zone. Inset (a) locates the focus region; inset (b) depicts variations in mean annual rainfall (1950-2000)[1].

Historians and archaeologists of Africa have long debated the causal processes underlying such societal transformation, particularly in pre-industrial societies prior to the imposition of colonial rule. Among the factors central to this debate are the growth of economic ties with the Indian Ocean trade network on the east coast, and control over socially and politically important resources such as cattle, gold and ivory. More recently, climate has also been considered as an agent of historical change, being causally linked to the development and 'collapse' of state structures, largely prior to the written record. Yet such claims, and specifically their more 'top-down', positivist approaches and assumptions, have drawn criticism both in southeast Africa[2] and further afield[3-5]. These critical perspectives note that predominant entry point for consideration of climate-society interactions are the signals of palaeoclimate proxy data, which have been used to infer coincidence, and by extension

causation, between climate variability and societal change as observed in historical-archaeological records. Instead it is argued that the value of historical climate-society research lies in a more 'bottom-up', interpretative approach that seeks to illuminate human agency by exploring the vulnerability and resilience of societies to climate variability and extremes, and how such societies framed, responded and adapted to climatic phenomena[6].

It is against this background that we evaluate, through a synthesis of existing studies and new perspectives on vulnerability, resilience and adaptability, climate-society relationships over the last millennium in southeast Africa. In particular, our review seeks to address key questions raised elsewhere[2,3,6] on the social-ecological factors underpinning long-term changes in human responses to, and impacts of, climate variability and extremes, including:

- What was the nature and magnitude of climatic change over the last millennium in southeast Africa – and which periods of variability were of particular societal significance?
- How did human vulnerability and resilience vary across southeast African societies – and how did this change with transformations in societal organization and early colonial influence?
- How did climate-related worldviews, beliefs and framings affect responses to climatic stress?
- How did societies cope with, and adapt to, climate variability and extremes?

We begin with a state-of-the-art review of southeast African climate variability since AD 800, the first such overarching synthesis since 1992[7]. This is followed by an assessment of the above questions in three case areas and periods, each chosen to reflect available source material and major areas of academic debate. The first focusses on the opening 500 years of the millennium and evaluates ideas concerning climate, worldviews, power structures and societal transformation at Mapungubwe and Great Zimbabwe in light of recent advances in palaeoclimatology and archaeology. The second explores climate-related vulnerability, resilience and adaptability across African and Afro-Portuguese society in the Zambezi-Save area between 1500 and 1830 as recorded by Portuguese observers. The third draws upon multiple lines of evidence to assess interactions between climate variability, inequality, ritual power, conflict and state formation in the KwaZulu-Natal area of South Africa during the late-18th and early-19th centuries. These case studies are then brought together in a discussion of the factors underlying historical vulnerability, resilience, responses and impacts across the region. We conclude by highlighting major research gaps on climate, history and society between the more widespread availability of detailed written and oral records from 1830 and recent decades, and suggest how such research can inform current African climate-development challenges.

CLIMATE VARIABILITY IN SOUTHEAST AFRICA SINCE AD 800

Prior to considering past climate-society interactions, it is essential to assess current knowledge of regional climate variability – and especially variability in rainfall, as this is the most important factor affecting food production in southeast Africa[8,9] – over the last millennium.

Precipitation in southern Africa exhibits a marked east-west gradient (Fig 1; inset), and is characterized by high seasonality. The southeast portion of the subcontinent falls within the Summer Rainfall Zone (SRZ), where ≥66% of mean annual precipitation occurs during the austral summer months (October-March) as a result of the southerly migration of the Inter-Tropical Convergence Zone (ITCZ) and easterly airflow from the Indian Ocean[10,a]. In the southwest, the smaller Winter Rainfall Zone (WRZ), where ≥66% of precipitation falls between April and September, receives its rainfall from temperate frontal systems as the westerlies migrate equatorward each austral winter[11].

The relatively wet climatic conditions in the southeast are suggested to have played a key part in conditioning the extent of agropastoral settlement over much of the last millennium, which was generally limited to the miombo, savanna and grassland areas between the Zambezi and Great Kei rivers[12] (Fig. 1). By far the most frequent and serious hazards affecting human livelihoods in this area are moisture stress, drought, and to a lesser extent, excess rainfall and floods, which occur on intra-seasonal, inter-annual and longer timescales[13,14]. In order to understand long-term variability in these phenomena, extended precipitation time series are needed. Available high-resolution records for the SRZ are now discussed.

Climate variability AD 800-1800

Much of our knowledge of climate variability in southeast Africa over the last thousand years comes from natural palaeoclimate proxies; principally isotopic fluctuations within cave speleothems and tree-rings, variations in tree-ring width, and geochemical and palaeobotanical signatures of lake sediments (Fig. 2). From such records, it is known that the last millennium witnessed substantial variability in rainfall and temperature[15-17]. Early reviews of palaeoclimate datasets[7,10] advanced the hypotheses that regional wet and dry spells clustered over near-decadal periods, while coupled warm-wet and cool-dry conditions acted over multi-decadal to centennial timeframes. Such reviews also categorized a number of periods by their dominant climatic conditions; for example, the regional equivalents of the warmer Medieval Climate Anomaly (MCA) and cooler Little Ice Age (LIA) in Europe[b] were postulated to have lasted from about AD 900-1300 and AD 1300-1850, with a warming spell from approximately AD 1500-1675. Numerous higher-resolution proxy data have been published over the last two decades, and while the "warm-wet MCA/cool-dry LIA" hypothesis remains broadly supported, considerable complexity in rainfall signals has been identified.

Medieval Climate Anomaly

Climatic conditions during the MCA form the backdrop to the development of complex societies in southeast Africa, specifically those that emerged in the Limpopo valley area at the start of the last millennium. As part of their review of regional palaeoclimates, Tyson and Lindesay[7] interpreted isotopic data from a speleothem in Cango Cave[18] as showing that conditions south of the Zambezi were both warmer (by ~3°C) and wetter during much of the MCA. This suggestion is supported by pollen records[15] and isotopic analyses of faunal remains[19,20] from the Limpopo valley, which infer wetter conditions until around AD 1400.

Other proxy series suggest a more complex scenario than proposed by Tyson and Lindesay, with multi-decadal to centennial scale droughts and wetter periods evident in many records. Isotopic analyses of speleothems T7 and T8 from Cold Air Cave in northeast South Africa[21-23], for example, indicate warmer and wetter phases between approximately AD 800 and 1200 interspersed with periods of relatively drier, cooler conditions, while equivalent data from Dante Cave in the SRZ of northern Namibia[24] also suggest variable conditions during parts of the MCA. A generally wetter but highly variable MCA is evident in diatom records from lakes Sibaya[17], Nhaucati[25] and Nhauhache[16], isotopic analyses of baobab tree-rings from northern South Africa[26], and the lower-resolution pollen dataset from Wonderkrater[27]. In the latter record, peaks in more hydrophilic taxa at ~AD 980, as well as 'post-MCA' at AD 1350, are interpreted as indicating greater available moisture at these times. This bimodal moisture pattern is mirrored by $\delta^{13}C$ data from Cold Air Cave, which suggest increased vegetation cover during each of these peaks[22]. The presence of warmer and wetter phases at the start and end of the MCA in several records may infer a coherent pattern across the southern subtropics, though further high-resolution data are needed to confirm this.

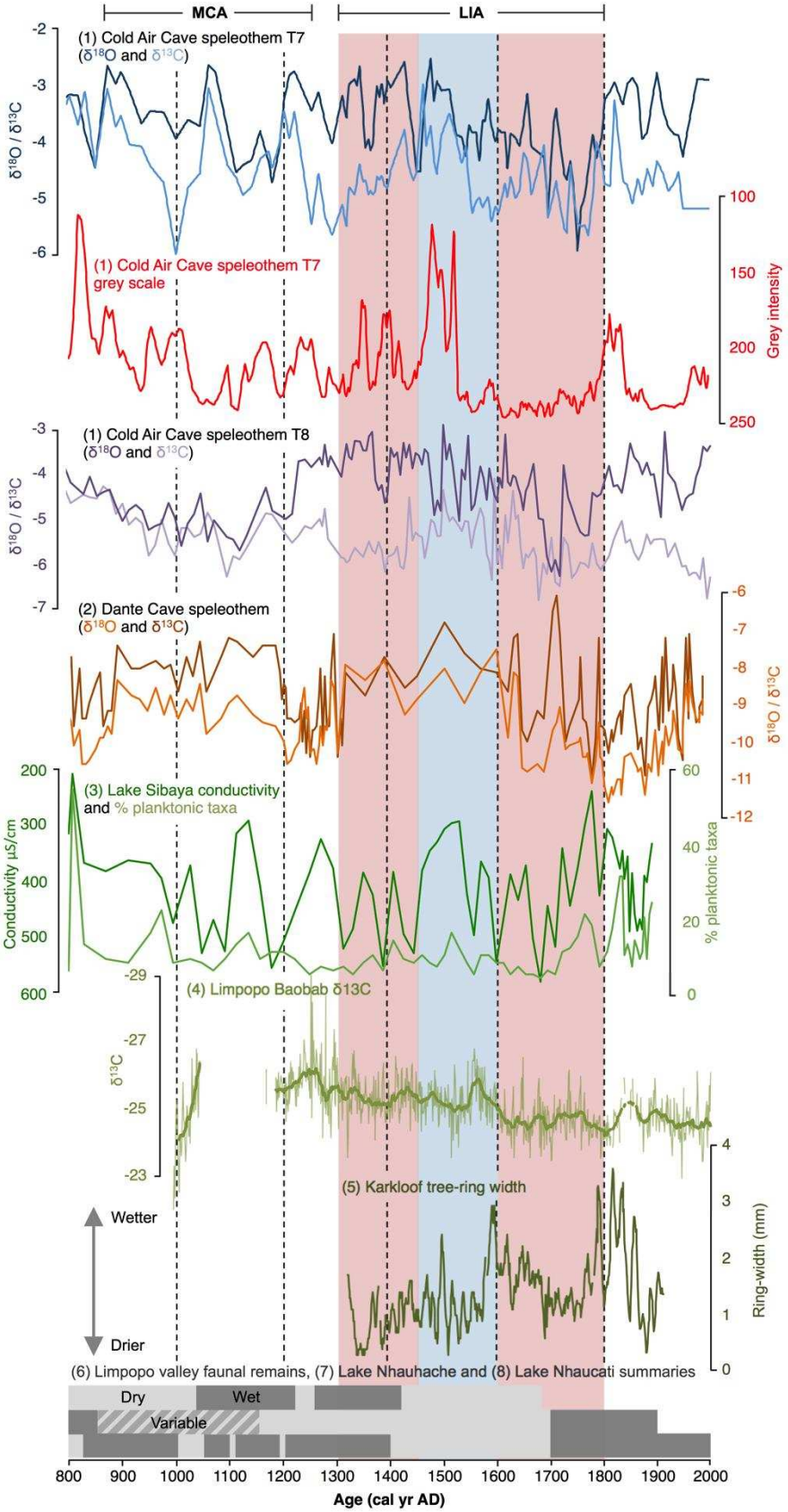

Figure 2. High-resolution (multi-decadal) southern African Summer Rainfall Zone palaeoclimate proxy series from: (1) Cold Air Cave speleothem T7[21,23] and T8[22]; (2) Dante Cave speleothem[23]; (3) Lake Sibaya diatom[17]; (4) Limpopo Baobab trees[26]; (5) Karkloof Yellowwood tree-rings[31]; (6) Limpopo valley faunal remains[19,20]; (7) Lake Nhauhache[25] and (8) Lake Nhaucati[16]. Numbered labels correspond to locations in Fig. 1. Red bands indicate drier periods, blue band indicates wetter period.

Little Ice Age

The period coinciding with the LIA witnessed the growth and gradual weakening of multiple state structures in southeast Africa, and saw the first interactions with European merchants and ultimately colonists. Tyson and Lindesay[7] concluded that during this cooler (by ~1°C) period, relatively dry conditions prevailed over most of the subcontinent. However, as in the case of the MCA, recent studies suggest significantly more complex spatial and temporal variability. The conclusions of Tyson and Lindesay were based largely on stable isotope records from Cango Cave speleothems, yet as Chase and colleagues[28,29] identify, the geographical position of Cango and its age control render these records less useful as a broad indicator of SRZ climate. Suggested adjustments to the age model bring the Cango $\delta^{18}O$ series into accordance with equivalent records from Cold Air Cave, and together indicate that cooler temperatures prevailed at least during the early (~AD 1250-1500) and later (~AD 1650-1850) LIA.

Significantly, none of the available palaeoclimate data suggest a clear onset to the LIA. Many do, however, indicate that the earliest phases of the LIA were relatively dry and the latter phases particularly cold. Allowing for a degree of error in age models, the records from Cold Air Cave[21-23,30], Lake Sibaya[17], Karkloof[31] and Dante Cave[24] all infer drier conditions from around AD 1250-1450, followed in some records by a rapid shift to more humid conditions from approximately AD 1450-1600, and subsequently an abrupt shift to protracted and severe cool-dry conditions. The timing of the end of the LIA appears to have been spatially variable, with the earliest evidence for amelioration at around ~1750 in records from Cold Air Cave, Lake Sibaya and Karkloof. The final decades of the LIA are encompassed within documentary and other reconstructions, which are considered below.

Climate variability and change 1800-present

Considerably more detailed information about past hydroclimatic variability is available from the 19th century onwards. Southern Africa has some of the earliest instrumental precipitation data for the African continent[32], with systematic records available for Cape Town from 1838 onwards. However, for many areas south of the Zambezi, the instrumental period only began in the 1850s (Angola), 1870s (Botswana), 1880s (Lesotho, Mozambique, Namibia, Zimbabwe), 1890s (Swaziland), or 1900s (Zambia), with the earliest records often fragmented and discontinuous. Much of our knowledge about rainfall variability during the 19th century comes instead from precipitation reconstructions based on historical documents, ships' logbooks and tree-rings (Fig. 3). Reconstructions combining documentary evidence and early gauge data are available for southern Africa as a whole[32], with sub-regional documentary-derived series published for the Eastern Cape[33], Namaqualand[34], the Kalahari[35,36], Lesotho[37] and KwaZulu-Natal[38]. Wind data within ships' logbooks have been used by Hannaford and colleagues to reconstruct station-based rainfall variability in the Eastern Cape and KwaZulu-Natal[39]. Analyses of tree-ring widths in western Zimbabwe[40] also provide a semi-quantitative rainfall reconstruction.

Collectively, available rainfall series indicate that the first decade of the 19th century was relatively dry. There are, however, some discrepancies between records, which have important implications for our understanding of climate-society relationships. For example, while the "South Central Africa" series[32] in Fig. 3 generated by Nicholson and colleagues suggests protracted drought from 1800-1811, the overlapping tree-ring width series for Zimbabwe[40] infers periods of average or above-average rainfall alternating with drought. A similar contrast is shown between the "Kalahari" series[32] (which encompasses the Kalahari *sensu stricto* and extends to the east coast of South Africa) and the overlapping ships' logbook-based reconstruction for Royal National Park, KwaZulu-Natal[39].

The reasons for these discrepancies are unclear, but are likely to be methodological, as the Nicholson series appear to overemphasize drought conditions – a common outcome for documentary-based reconstructions of semi-arid areas[41]. More documentary series are available from 1815 onwards, and reveal subcontinent-wide severe and/or protracted drought episodes in the early and late 1820s, late 1850s-mid 1860s, mid-late 1870s, early-mid 1880s and early-mid 1890s. Of these, the drought centred on 1861-1862 appears to have been the most severe and those of the 1820s and 1890s the most protracted. Regional episodes of above-average rainfall are less easily identified, although eastern areas of southern Africa appear to have been relatively wet during the mid-1850s, early-1890s and late-1890s.

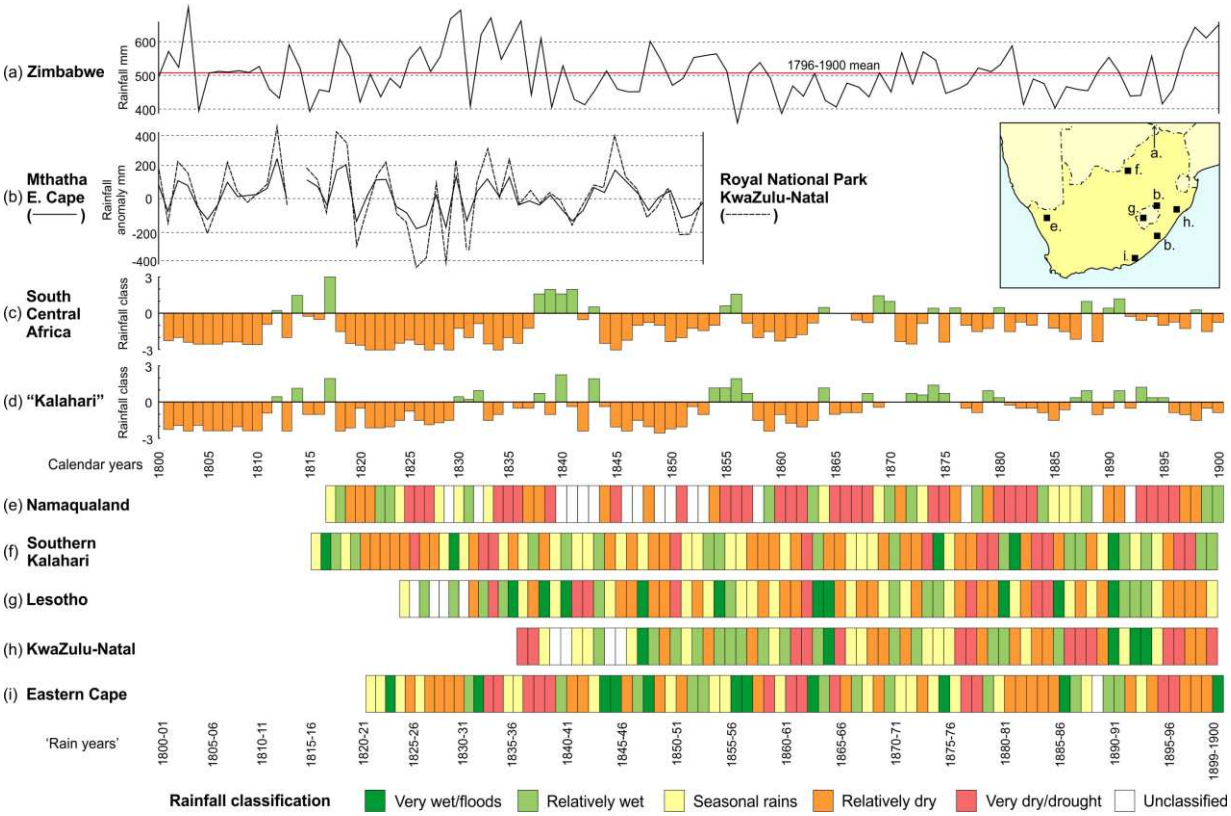

Figure 3. Annually resolved series of rainfall variability for the Summer Rainfall Zone (1800-1900): (a) tree ring-width series for Zimbabwe[40]; (b) ships' logbook-derived series for Mthatha, Eastern Cape, and Royal National Park, KwaZulu-Natal (anomaly relative to 1979-2008 mean)[39]; (c-d) documentary- and gauge data-derived series for South Central Africa (Zambia, northeast Botswana, Zimbabwe, southern Mozambique) and the "Kalahari" (south Botswana, north/east South Africa)[32] (e)-(i) documentary-derived series for Namaqualand[34], southern Kalahari[35,36], Lesotho[37], KwaZulu-Natal[38] and Eastern Cape[33]. Inset map shows locations of series.

Comparing these records with more recent instrumental data is not without its challenges. Nicholson and colleagues have attempted this using combined documentary and gauge data, and reveal fluctuating decadal-scale drier and wetter conditions over southern Africa during the 20th century[32]. Neukom and colleagues[42] have used a multi-proxy approach, combining the annually-resolved SRZ series in Fig. 3 with southwest Indian Ocean coral isotopic and trace element data[43] and CRU TS 3.0 gridded precipitation data. Their analysis – updated by Nash and colleagues[38] – identifies that, as a whole, the 19th century was wetter across the SRZ than the 20th. However, in contrast to other studies[32,44], mean annual rainfall is suggested to have declined progressively over the course of the 20th century. The implications of this emerging palaeo- and historical-climatic picture for our understanding climate-society relationships are now considered.

ZIMBABWE CULTURE STATE FORMATION (1000-1500)

The first three centuries of the last millennium in southeast Africa marked the initial transformation of small-scale chiefdoms into complex, centralized states. This began in the Limpopo valley area with the emergence of the 'Zimbabwe culture'[45,46], a term encompassing several predominantly Shona-speaking political units (Fig. 4) defined by factors such as class distinction, sacred leadership and monumental architecture.

Zimbabwe culture communities practised mixed farming livelihoods based on the cultivation of sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum americanum*), finger millet (*Eleusine coracana*), pulses and vegetables[47,48], the herding of cattle, goats and sheep[49], hunting, and gathering[50]. Cattle also held an important social role as they were used as payment in bride-price and tribute to rulers[51], while trade links with the Afro-Swahili settlement of Chibuene, established during the 10th century by Zhizo people at Schroda[52-54] (Fig. 4), were key in stimulating social stratification and reinforcing political structure[45-48]. This section considers how climate variability, worldviews and ritual power have been linked to the development and 'collapse' of the region's first state structures.

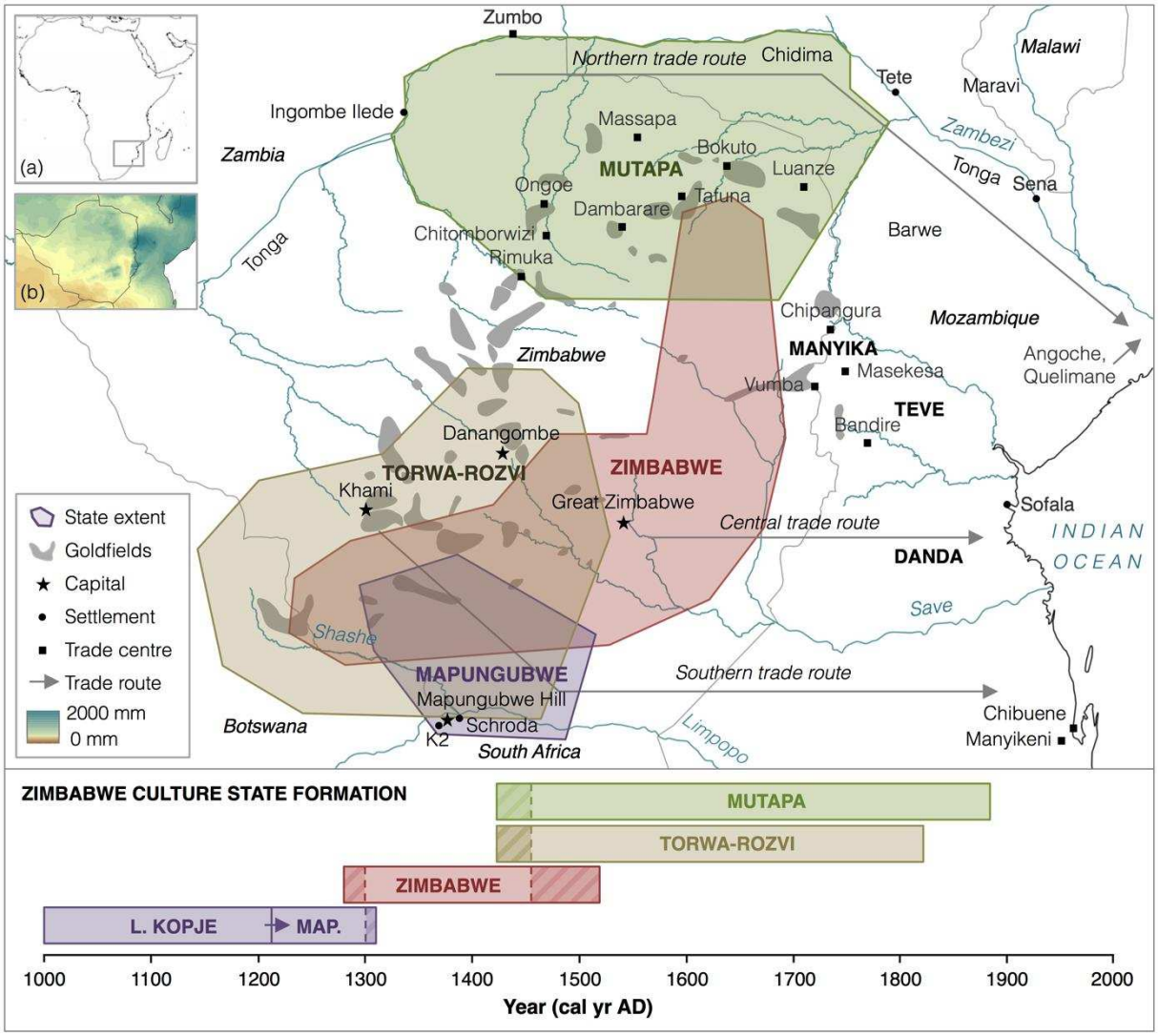

Figure 4. The Zambezi-Limpopo region and links to the Indian Ocean world: Zimbabwe culture states, Portuguese settlement and other key sites prior to 1830. Approximate state boundaries taken from Huffman[48] and Mudenge[95]. Timeline details phases of Zimbabwe culture state formation (L. Kopje – Leopard's Kopje and Map. – Mapungubwe), hatched areas represent dating uncertainty. Inset (a) locates focus region; inset (b) shows mean annual rainfall (1950-2000)[1].

'The Nile of southern Africa': climate, centralization and collapse on the Limpopo

Trajectories towards state formation emerged at around AD 1000, when Leopard's Kopje people, ancestral to the Shona-speaking inhabitants of present-day Zimbabwe, established political independence at the site of K2 at the confluence of the Limpopo and Shashe rivers (Fig. 4). As this area is at present semi-arid to arid, and in most years receives insufficient rainfall to support small-scale subsistence cultivation, Huffman[55,57] proposed that wetter MCA-like conditions between approximately 1000-1220 increased the regularity of flooding on the Shashe river and reduced exposure to drought, thus facilitating agricultural expansion and population growth[48,55-57]. Although the MCA was more variable than initially realized, palaeoclimate records from the Limpopo valley[15,20,26] affirm the hypothesis that MCA moisture conditions were wet relative to the last millennium as a whole. Archaeological evidence of extensive settlement in this area would therefore give reason to suggest that its palaeoenvironmental setting, together with the intensification of trade activity, provided opportunities for the growth of farming livelihoods, populations and social stratification[20,55-61].

Rain-control and political transformation

As Leopard's Kopje society grew economically and socially more complex, relationships between rulers and the ruled also radically changed. At around ~1220, the elite further removed themselves from commoners by relocating the capital from K2 to Mapungubwe Hill (Fig. 4); a move which culminated in the development of the region's first urban centre and state, Mapungubwe[56]. The most comprehensive reason for this shift relates to transformations in worldview, ideology and the expression of sacred leadership, where political 'control' of rain plays a pivotal role[55,62,63]. Rain-control was based on the idea that humans had the ability to influence spirits or ancestors, who brought or withheld rain, through rainmaking rituals. In K2 times, these rituals took place in the natural environment away from homesteads, and in times of extended drought specialist rainmakers were sent to hilltops, including Mapungubwe, to 'pull down the rain'[55]. Huffman[55] proposed that the Leopard's Kopje leader relocated to Mapungubwe Hill at a time of reduced rainfall to appropriate control of rainmaking and, importantly, acquire the power to intercede directly with God through his ancestors. This new system of political rain-control therefore centralized rainmaking rituals and entrenched the ruler's legitimacy to power; yet this is suggested to have brought new risks and vulnerabilities as perceptions of weather and climate became tied to his ability to insure the fertility of the land[55].

Drought, worldview and state collapse

Reduced moisture availability towards the end of the MCA has been linked to the fragmentation, or 'collapse', of the Mapungubwe state around ~1290-1310[55,64-66]. Tyson and colleagues[64], for example, interpreted the contemporaneous shift towards cool-dry conditions in the Cold Air Cave T7 series as evidence that "deteriorating climate was an important contributory factor [in state collapse]" as it undercut the viability of floodplain agriculture. By contrast, others note that different proxy records infer that seasonal crop production in the Limpopo valley was not under existential threat at this time[20,67] – certainly, some records, including lower-resolution evidence from faunal remains[19,20], point to a later transition to sustained dry conditions analogous to those experienced in the area today. Recently published high-resolution $\delta^{13}C$ evidence from baobab tree-rings[26], however, indicates that while this transition may have taken place later than 1300, highly variable rainfall conditions prevailed during the late-13th century, with a multi-decadal cluster of drier years during its last three decades (Fig. 2).

Huffman and Woodborne[68] identify responses to climate stress congruent with the decline of Mapungubwe. Specifically, they combine archaeological evidence for the ritual burning of grain bins – which they suggest signifies a cultural response to drought as part of the rainmaking process[68,69] – with the baobab $\delta^{13}C$ series, and conclude that a drought at 1310±5 contributed to the abandonment of Mapungubwe. Because changes in worldview and ideology meant that "if rain failed, the leader also failed"[68], they argue that this drought would have been interpreted as supernatural displeasure in the leadership, which may have led to a succession dispute[54]. Accordingly, political instability may have meant that Mapungubwe was unable to compete with the newly urbanizing Great Zimbabwe, whose people appear to have built up sufficient power to overrun the gold trade with the east coast, which was now centred on Sofala (Fig. 4). Criticisms of Huffman's model, however, claim it promotes 'law-like' constants in human action based upon cultural worldview rather than idiosyncratic agency[70], and therefore negates coping and adaptation capabilities[60]. Moreover, it is unclear why the more protracted droughts during the late-13th century, which are corroborated by multiple clusters of ritual burning[68], are not mentioned by Huffman and Woodborne. New perspectives on the process of state decline across Mapungubwe's wider sphere of influence, rather than a focus on capital abandonment alone, may help clarify these debates.

Environmental and political change at Great Zimbabwe

In the early-14th century, power shifted north to the Zimbabwe plateau. Here, the site of Great Zimbabwe, also formerly a rainmaking hill, grew to become an urban complex home to ~18,000 people, capital of the Zimbabwe state, and dominated power in the Zambezi-Limpopo area for at least 150 years[48,71]. Zimbabwe rulers used their newly acquired wealth to divert labor from agriculture and finance the building of elaborate stone structures at the capital, which represented the largest of many other centres (or *zimbabwe*) across its wider territory[72,73,]. These centres were crucial in the management of politically important resources such as gold, which lay at a distance from the capital[74,75] (Fig. 4). Nevertheless, farming livelihoods remained of prime importance to the majority of the population[72,76], and accordingly, the wetter south-eastern parts of the Zimbabwe plateau are suggested to have offered a more favourable environment, relative to the Limpopo valley, for the support of a large urban complex and state[45,59]. This reduced exposure may have aided the growth of the state at a time of lower rainfall (Fig. 2), despite the capital hinterland having few distinct advantages for agropastoral livelihoods[75].

The decline of Great Zimbabwe (~1450-1520) remains dominated by speculation, with most scenarios focussing on geopolitical and economic changes. Summers[74] speculated that a decline in rainfall could have reduced the navigability of the Save river sometime before 1500, which, in turn, may have impacted upon trade connections. Equally speculative are suggestions that cool-dry conditions during the early-fifteenth century inferred from the Cold Air Cave T7 stalagmite and other proxy series (Fig. 2) may have destabilized the agricultural base of the urbanizing and growing population at the capital[77]. Others[78-80] place emphasis on environmental degradation, arguing that the exploitative nature of sustaining a concentrated population degraded food, firewood and grazing supplies in the hinterland of the capital. Huffman[48] refutes these explanations, arguing that written evidence relating to later Zimbabwe culture polities (see next section) indicates that rulers established centralized social security strategies to buffer against food shortages at the capital. Yet it is unclear whether these practices can be traced back to the Great Zimbabwe period, or how effective they were in the face of environmental stress[76,81].

The major problem concerning climate-society relationships at Great Zimbabwe is that there

exists minimal 'ground-truth' information to substantiate inferences from palaeoclimate data. There is agreement, however, that political-economic factors played an important role. For instance, Phimister[82] notes that the relatively quick exhaustion of the gold deposits closest to Great Zimbabwe itself would have, in time, forced a reliance upon goldfields to the north and southwest. By the mid-fifteenth century, the Mutapa (or 'Monomotapa') and Torwa (or 'Butua') states were expanding in these areas, while the central trade route linking Great Zimbabwe to Sofala was superseded by the northern (Zambezi) route connecting the Mutapa state to Angoche, as well as the reinstatement of the southern route to Chibuene by the Torwa state[48] (Fig. 4). These developments undercut Great Zimbabwe's hegemony over the trade network, yet the inability of the Zimbabwe state, powerful and populous as it was, to assert authority over its rivals, perhaps also implies that internal factors were key in its decline. It remains possible, then, that environmental stress played a part in a multi-causal pathway that hindered the capacity of Zimbabwe elites to respond to growing competition. However, considerable further archaeological investigation, particularly relating to rainmaking and ritual burning across the Zimbabwe state, is needed to evaluate such ideas.

POLITICAL AND LIVELIHOOD CHANGE IN THE ZAMBEZI-SAVE AREA (1500-1830)

The demise of Great Zimbabwe left the Mutapa state dominant in northern Zimbabwe and the lesser-known Torwa state in control of the southwest, while three smaller polities, Manyika, Teve and Danda, established political independence between the Zambezi and Save rivers[72] (Fig. 4). Significantly, the early-16th century also marked the settlement of the Portuguese at Sofala, and a few decades later on the Zambezi, as they attempted to access the mineral resources in the interior. As a result, Portuguese traders, officials and missionaries left relatively continuous written accounts[c] of human activity and, to a lesser extent, environmental change, in the Zambezi-Save area until ~1830.

Portuguese accounts of climate-related phenomena are fragmentary, but overall describe clusters of widespread, severe and protracted events (Table 1), the majority of which coincide with periods of independently-identified regional and/or global climatic change[81]. Historians of southeast Africa have made relatively little attempt to decipher detailed climate-society connections within these sources; a situation which perhaps relates to the skewed focus of this material towards trade, exploitation and African-Portuguese relations. The work of Newitt[83-85] and Beach[76] are exceptions to this, as both interpret the written record to suggest that climatic stresses were important, alongside the destructive nature of Portuguese influence, in degrading the sovereignty and complexity of African state structures. Nevertheless, the specific pathways through which climate interacted with socio-political events in this area are often oversimplified as 'devastation', with little consideration given to human agency, adaptation and differential impacts. Written materials do, however, reveal important differences in these factors across the spectrum of African and Afro-Portuguese society in the Zambezi-Save area. These appear to have been strongly linked to the organization of food systems, individual, community and state livelihood assets and capabilities, and social networks, as well as how climate was framed culturally.

The Mutapa state and its neighbours

The 1560s commenced an extended period of socio-political instability in the Zambezi-Save area, which saw the transformation of the Mutapa state and its neighbours into Portuguese subordinates. The late-16th century was also a time of vastly increased documentation of weather extremes (Table 1). Both Shona oral traditions[86] and written evidence[87-90] suggest that drought, locust plagues and, to a lesser extent, floods, became commonplace in northern Zimbabwe and on the Mozambique coast

between 1561-1573, resulting in severe famine[9,85,91]. Climatic stress returned with similar magnitude in the late-1580s, when missionary João dos Santos wrote of "four chastisements" to affect southeast Africa[92]. These included locust plagues that "devoured all the crops, gardens, and palm groves… so that for the next two years they produced no fruits"[92], subsequent famine around 1589-90, and a severe outbreak of smallpox in the 1590s, which was possibly exacerbated by pre-existing food scarcity[81].

Table 1. Written and oral evidence of extended periods of climatic or climate-dependent phenomena prior to 1830.

Period	Area	Event	Evidence
1506-1518	Mozambique coast	Food shortages, drought, and a tropical cyclone in 1516	Quaresma[101]; Perestrello[102]; Fernandes[103]; Almada[104]; Bhila[96]
1560-1590	Southeast Africa-wide	Drought, locusts plagues, food shortages and famine	Fernandes[87]; Sousa[90]; Abraham[86]; Monclaro[89]; Carneiro[88]; Santos[92]
1730-1768	Zambezi valley	Drought, locust plagues and famine	Miranda[106]; Newitt[85]; Nicholson[13]
1795-1805	Southeast Africa-wide	Drought, food scarcity and famine, known as the *mahlatule* famine	Mudenge[95]; Newitt[83,84]; Nicholson[13,32]
1824-1830	Southeast Africa-wide	Drought, food scarcity, famine and locust plagues	Isaacs[124]; Newitt[83,84]

Vulnerability, livelihoods and social networks

Although this period of climatic stress appears to have been regional in extent, written accounts suggest that there were clear differences in the vulnerability of Zimbabwe culture polities on the one hand and smaller-scale, decentralized communities on the other. The accounts of Duarte Barbosa[93] and Francisco de Monclaro[89], for instance, describe the relative diversity of agricultural systems in the Mutapa state compared to those of the Tonga-speaking chiefdoms in the dry Zambezi valley. Santos's evidence[92] depicts similar disparities in the keeping of domestic animals and hunting, where cattle were possessed in high numbers in the Mutapa and Manyika areas, and provided an important buffer to grain shortages. Fewer cattle were possessed in the Teve area, but its population kept other domestic animals and conducted highly organized hunts which provided valuable dietary additions[92]. By contrast, Beach notes that cattle keeping was difficult in the drought-prone, tsetse fly-infested Zambezi valley, where agropastoral livelihoods were more highly exposed and sensitive to climatic shocks relative to the better-watered areas of the Zimbabwe plateau and the coast[85] (Fig. 4).

16th century accounts also reveal key differences in social networks, coping strategies and adaptive capacity at this time. For example, in the Mutapa and Teve polities, organized labor both cultivated fields in the capital hinterland and brought grain to the capital from "all the villages and all the kraals" across the territory[92,94], which, according to Mudenge[95], could be redistributed in times of scarcity. This was complemented by long-term planning and coping strategies at the household and village levels, such as grain storage and food sharing[95]. João de Barros's evidence[94] relating to the Manyika polity also suggests that livelihood activities such as gold mining were intensified as coping strategies in times of food scarcity, production from which was then traded locally for grain[96]. On the contrary, Monclaro's account of the chiefdoms and village communities in the Zambezi valley[89], while heavily influenced by colonial ideology, bemoaned the lack of long-term planning in the cultivation

process, and made no reference to social security. Rather, wild foods were relied upon extensively in times of drought[81].

These acute differences in vulnerability meant that climatic stress in the 1560s-1590s substantially weakened the Zambezi Tonga chiefdoms in the face of the increasingly militaristic policies of the Portuguese. According to Santos, the ensuing subsistence crises, together with other stresses, led large numbers of people in the valley to seek the protection of centralized political authority or the Portuguese and "sell themselves as slaves[d] merely to obtain food, and exchange their children for an *alqueire* of millet"[92]. The limited capability of chiefs and village heads to provide protection against severe climate stress, which was crucial in holding smaller groups together, thus accelerated the incorporation of the Zambezi valley into the Portuguese jurisdiction. Conversely, in the more robust Mutapa state, Pikirayi[91] notes that it was only when the cumulative impacts of drought and food scarcity combined with civil war and large-scale conflict with Maravi armies in the 1590s, that social instability became more widespread. Indeed, it was this convergence of multiple stresses led the Mutapa ruler, Gatsi Rusere, to recurrently call upon Portuguese private traders to help drive back the invaders. In return, Rusere granted the Portuguese large concessions of land and minerals, which diminished the prestige of the state and left the Portuguese with considerable influence in political affairs[85].

Resilience, migration and livelihood decline

The period 1625-1684 was the highpoint of Portuguese dominance in the interior, and hastened the trajectory of economic impoverishment and loss of complexity in the Zimbabwe culture states[72]. The Portuguese wrestled control over export-oriented sectors of the Mutapa economy such as mining, and opened new trade centres ('*feiras*') (Fig. 4) from which they forcibly recruited African mining labor to extract quick profits[72]. The loss of such wealth, together with decades of civil war and, by the admission of chronicler Antonio Bocarro[97], the brutal methods of labor coercion, encouraged large-scale migration to southern Zimbabwe[76]. Yet despite the impact of Portuguese power on the upper structure of the state, the 17th century accounts of Bocarro[97], Rezende[98], Gomes[99] and Conceição[100] suggest that food systems, social networks, political control of rain and, ultimately, the survival of the state, were minimally affected by the small number of Portuguese operating in the interior – a point which Newitt[85] puts down to the segmentary nature of political organization and the durability of village farming community in the face of political instability. This resilience may have enabled the continuation of robust responses to the drier though less variable conditions of the 17th century (Fig. 2), when there were very few reports of climate-related phenomena.

The era of Portuguese supremacy was brought to an abrupt end in the 1690s by the rise of Changamire and the Rozvi state, who reunited the Torwa area and drove the Portuguese back to the Zambezi. The key change in the Mutapa state, though, came in the second decade of the 18th century when the core of the state relocated to Chidima (Fig. 4) in the Zambezi lowlands. Pikirayi[91] tentatively linked this move to a severe drought in 1714, which Mudenge[95] claims resulted in unprecedented mortality, though evidence is insufficient to clarify this link. Whatever its causes, the decision to relocate to the dryland area of Chidima had major implications for the vulnerability and resilience of the state and its population[85] , for the presence of tsetse fly in this area made cattle-keeping difficult, while alternative livelihood options that could be intensified in times of drought were highly limited. The implications of these livelihood changes are evident in accounts of responses to severe drought from 1794-1802 and 1823-1830. The reduction in coping strategies, for example, appears to have encouraged new short-term responses to crop failure, such as banditry

and raiding[85], while poorer elements of society increasingly sought the protection of wealthier Mutapa people as 'slaves'[76]. Mudenge[95] also linked the former of these droughts to the demise of the Rozvi state, which was defeated by migratory Nguni-speaking polities arriving from south of the Limpopo in the 1820s. Rather than the violence of Nguni communities, however, the desolation reported in the interior by 19th century explorers such as Thomas Baines and Albino Pacheco reflected a process of gradual impoverishment, at times intensified and accelerated by climatic stress, which had begun two centuries earlier.

Afro-Portuguese society

In contrast to the Mutapa state, Portuguese settlement had particularly significant impacts on the vulnerability and resilience of farming communities on the Mozambique coast, and later those in the Zambezi valley, who fell under Portuguese jurisdiction from the early-16th century. Indeed, the first descriptions of possible climate-related phenomena in southeast Africa were recorded almost immediately after the Portuguese overran the Swahili settlement of Sofala in 1505. Here, demands for surplus food production from African chiefs increased markedly in order to feed Sofala's growing population. Yet if this new market provided opportunities to cultivate and exchange surpluses for cloth and beads, it also placed strain on food systems, with shortages of sorghum reported at Sofala in 1506[101], 1511[102], 1515[103] and 1516[104]. Almada's account[104] suggests that the causes of these shortages, while numerous, were mostly a result of fluctuations in population-consumption dynamics at Sofala. Bhila[96], however, points to the account of Fernandes[103], who wrote of the reluctance of chiefs to sell grain and price increases in 1515, which together with Almada's[104] evidence of a high-impact tropical cyclone in February 1516[81] suggests that climate-related stressors on the production side were also key. Food insecurity thus coalesced with political-economic factors to undermine the viability of Sofala as the chief settlement from which to access the goldfields of the interior.

The failure of Sofala resulted in the expansion of Portuguese activity and settlement on the Zambezi from the 1530s, specifically at the trading settlements of Sena, Tete and Quelimane (Fig. 4), whose populations came under the direct rule of a small number of resident Portuguese[83,85]. As the Portuguese presence and land holdings grew, farming communities underwent prominent changes in governance and the organization of food systems, and in the 17th century much of these lands were carved up into '*prazos*' (estates) (Fig. 4). *Prazos* operated on a system of lease and were populated by 'slaves', who sought protection from conflict or famine, and free Africans ('*colonos*')[83]. Portuguese *prazo*-owners effectively replaced the positions of chiefs over much of the Zambezi valley, controlling justice, collecting tribute and often taking part in rituals such as rainmaking. The ability to maintain order and a robust food supply was therefore crucial in holding these groups together. The major difference, however, was that the *prazo* system was driven by profit, meaning that the intensification of exploitation, often by short-term or absentee landowners, was commonplace, and later led to frequent breakdowns in the functioning of the system[83,85].

Despite reductions in underlying system resilience, detailed accounts of the Zambezi valley and Mozambique coast in the 17th century suggest that food systems became increasingly organized and diverse, as illustrated by a characteristically exaggerated Portuguese account claiming that "The rivers of Cuama [Zambezi] are the richest provinces the universe has"[105]. Important dietary changes also took place, including the introduction of wheat, and possibly maize[81], in the Sena area, while Antonio Gomes[99] also noted that a greater degree of long-term planning became embedded in the agricultural cycle. By the late-17th century, food production on the Zambezi was largely self-sufficient, with a wide range of crops, vegetables, fruits and domestic animals forming the staple diet

of its inhabitants. This reduction in the exposure of farming communities may account for the minimal evidence of food shortages at this time, despite an overall increase in the number and depth of written accounts, the prevalence of dry LIA conditions, and increased fragility of the system.

Climatic stress returned to the Zambezi valley in the mid-18th century, with multiple locust plagues in the 1730s, 1740s and 1760s[85], which, according to Zambezi settler António Pinto de Miranda, led large numbers to submit themselves into enslavement[106]. Significantly, Miranda also stated that by this point, hunger and famine had become the predominant reason for the existence of this practice. Of greater damage to Portuguese settlements on the Zambezi, however, was the severe, region-wide drought of the 1820s (Fig. 3). Newitt[85] argues that this drought, together with locust plagues and famine in 1827 and 1829, accelerated the decline of Sena by destabilizing food production and contributing towards the desertion of the *prazos*. This process had begun in the latter half of the 18th century with frequent breakdowns in social relations and rebellion amongst slave groups, and the growing irrelevance of the town for trade[83]. Indeed, by 1829, Portuguese official António Mariano da Cunha described the "deplorable state of decay" in Sena "because of the great famine which has reigned there for four successive years…", adding that "there are no hands to do the cultivating since all the slaves are scattered through the various lands"[84]. Desertion of the *prazos* has also been linked to the implication of the Zambezi in the increase in slave exports from Mozambique in the late-1820s[84]. It is speculative, though, to link climatic stress as a primary driver of this process (as Miller[107] proposed in Angola), which owed more to the nature of slavery agreements and the temptation of *prazo*-owners to sell slaves for quick profits[84,85,108].

SOCIETAL TRANSFORMATION IN KWAZULU-NATAL (1760-1828)

Insofar as the formation of African state structures is concerned, the Zimbabwe culture states were the exceptions to the rule in the 1000 km zone inland from the Kenyan coast to the Cape until at least 1700[72]. From the late-18th century onwards, however, highly centralized political authority began to develop amongst Nguni-speaking farming communities in present-day KwaZulu-Natal and adjacent parts of Mozambique, Swaziland and the South African highveld (Fig. 5).

Nguni-speaking communities differed substantially to the Shona- and Tonga-speaking groups north of the Limpopo. Although they cultivated a similar range of crops as part of a mixed farming economy, Nguni people placed greater importance on cattle in economic, social, cultural and political life, and institutionalized raiding. This led to frequent disputes over access to land and resources, which, according to Huffman[109], helps explain why political units prior to the late-18th century were limited to small-scale chiefdoms. As in the case of the Limpopo valley at the start of the millennium, changes in climate, agropastoral livelihoods and ritual power, together with responses to new trade opportunities and the resultant amplification of inequalities, are thought to have transformed this societal context from the late-18th century.

Climatic change, inequality and societal transformation (1760-1817)

The climatic backdrop to societal change at this time was the transition from cool-dry LIA conditions to the generally warmer and wetter 19th century (Fig. 2). Hall[31] hypothesized that this climatic amelioration increased the production potential of marginal land in the interior highland areas of KwaZulu-Natal, which were less suited to continuous exploitation during the LIA. Key to this explanation is also the introduction of maize to these areas through Delagoa Bay during the early-18th century[110-112]. Although maize is highly sensitive to water deprivation, its high production potential and ability to withstand a shorter growing season relative to slow-maturing sorghum may

have aided its expansion during the drier early- to mid-18th century[78,109]. In turn, the spread of maize as a staple crop as climatic conditions became wetter is suggested to have aided population growth, as evidenced in archaeological records[110-112,113,114].

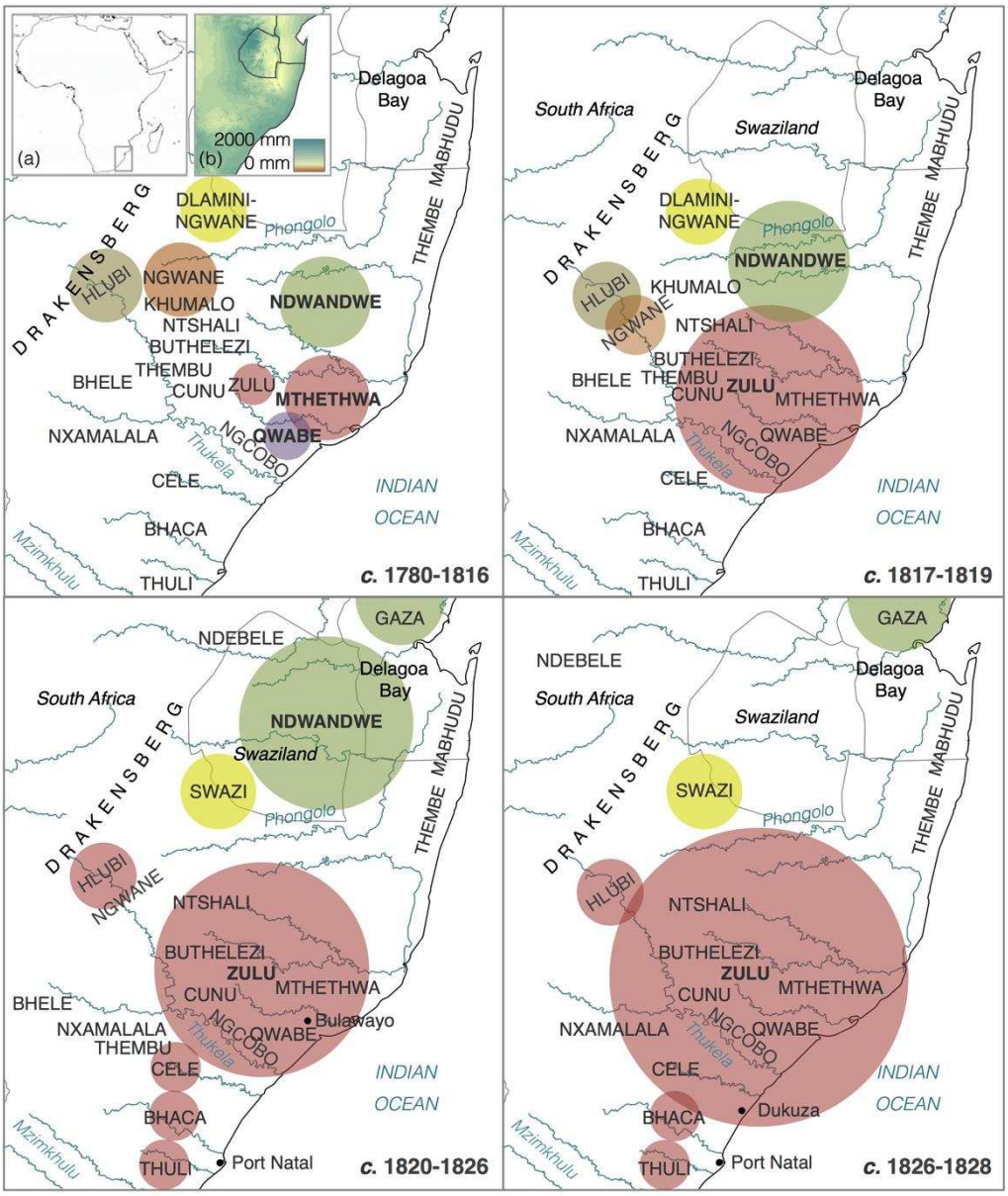

Figure 5. Political change in the KwaZulu-Natal area ca 1780-1828. Shaded circles represent political authority. Inset (a) locates focus region; inset (b) shows mean annual rainfall (1950-2000)[1].

It is questionable, however, as to how maize and population growth in these areas provided a stimulus for regional political centralization. Indeed, oral traditions[115,e] imply that maize was not yet widely cultivated in the coastal areas or in the Swazi highlands, where key changes in societal organization initiated. Rather, Wright[114] explains how these changes owed more to the development of '*amabutho*', a new system of social organization based on the recruitment of age-based groups of men, perhaps in response to new trade opportunities in ivory and cattle at Delagoa Bay. *Amabutho* could be controlled for state purposes, such as hunting and raiding, in return for protection, land and, crucially, the potential to accumulate cattle which enabled men to establish homesteads[116]. Together with a growth in trade imports, this increased the wealth, status and coercive power of some chiefs and also amplified social inequalities within and between chiefdoms[109,116-118]. The need to replace cattle exported to supply American whaling ships at Delagoa Bay also meant that raiding

acquired a new dynamic[114], enabling the more powerful groups like Zwide's Ndwandwe chiefdom and Dingiswayo's Mthethwa (Fig. 5) to consolidate their authority over weaker chiefdoms[117-119].

Building upon Hall's hypothesis, Ballard[113] and Eldredge[117] propose that such changes in food systems and social relations altered traditional response structures to drought as entitlements to cattle, food and land grew increasingly unequal, leading to loss of adaptive capacity in poorer communities. Accordingly, severe multi-year drought at the turn of the 19th century (Fig. 3), remembered vividly in Zulu oral traditions[115] as the '*mahlatule*' famine, has been conceptualized as a trigger for political revolution and reorganization[113,117,120,]. In Ballard's view, the impact of this drought on vulnerable maize-dependent communities was to "set entire families, tribes, and perhaps whole chiefdoms into a restless desperate motion", which encouraged defensive political formation as people sought "security from starving marauders". Eldredge's reading of oral evidence adds that unequal distribution of food in times of scarcity meant that more vulnerable communities, who possessed fewer cattle and lacked the ability to raid on any significant scale, were forced to rely upon wild food sources. A dependence on these resources in a prolonged drought like the *mahlatule* therefore meant that a more desirable option was to offer allegiance, or '*konza*', to more centralized units with greater food security[81,118], as observed on the Zambezi. As well as migration, then, the impacts of drought upon an increasingly unequal social terrain may have stimulated further centralization by fostering the incorporation of individuals, communities and chiefdoms into political authority that was already rapidly growing. This would have provided an opportunity for more resilient and/or powerful units to expand their power bases over weaker neighbours[81,117,119].

The second decade of the 19th century witnessed a growth in conflict between the larger, fast-growing chiefdoms, in particular the Mthethwa and Ndwandwe, as they sought to consolidate their authority[114]. In about 1817-18, the Ndwandwe attacked the Mthethwa and killed its ruler, Dingiswayo. This event was precedent to the emergence of the Zulu kingdom under its newly appointed chief, Shaka Senzangakona, who reunited the defeated Mthethwa chiefdom and expanded influence over much of the Phongolo-Mzimkhulu area over the subsequent decade (Fig. 5).

Food security and political consolidation in Shaka's Zulu kingdom (1817-1828)

The consolidation of the Zulu kingdom involved the diplomatic incorporation, often through voluntary submission, and military subordination of smaller chiefdoms into its overlordship. This gave the kingdom control of greater territory, labor and resources, while allowing its subordinates to retain a degree of autonomy. Historical scholarship relating to these events has traditionally centred on the notion of the so-called '*mfecane*' (or *difaqane*) – a term that emerged from colonial-era notions that implicate Shaka and the rise of the Zulu kingdom as the cause of unprecedented upheaval, political transformation, and intensified conflict across southeast Africa in the 1810s-1830s[116]. Yet investigation over the last two decades has convincingly shown this not to be the case[114,121,122], and there are thus few merits in retaining the *mfecane* as an organizing concept. In moving beyond these debates, however, few have investigated the large quantities of oral and, from 1824 after British settlement at Port Natal (Fig. 1), written evidence relating to the Zulu kingdom to understand the factors underlying its expansion and later instability under Shaka (1817-1828). One such factor was food security, which was affected by region-wide drought in the late-1820s.

Food security and ritual power

The ability to feed the population, and provide both adequate land and opportunities for subjects to build up holdings of cattle was crucial in the expansion and maintenance of the Zulu kingdom[116]. This

demanded a high degree of organization in the food system, a situation that becomes evident in written sources relating to the core of the Zulu kingdom during Shaka's reign. The British trader Henry Francis Fynn[123], for instance, reported that a mix of crops was grown alongside the principal staple of sorghum, while trader Nathaniel Isaacs[124] wrote of the widespread presence of storage practices and the use of techniques such as the burning of grain stalks to replace soil nutrients. This robustness at the local level was accompanied by a high level of centralization in food production and associated ritual power. One key example of this is the 'first fruits festival', or '*umkosi*', which Fynn described as "an annual feast observed when the chief eats the first fruits of the season, prior to which not even a fallen grain may be eaten under penalty of death"[123]. Isaacs[124] wrote of the efficacy of this custom in preventing crop shortages and buffering the impacts of drought, while Eldredge[118] notes that the *umkosi* became the central occasion for state military planning during the early-19th century. The elaboration and evolving function of this ritual indicates that food security became increasingly tied to military and territorial expansion to provide greater amounts of arable land and cattle for a growing middle class. Indeed, cattle raiding increased across KwaZulu-Natal during the 1820s, leading to greater accumulations of cattle by both the aristocracy and the *amabutho*, exchanges between which underpinned the functioning of the kingdom[116]. Similar to the centralization of rain-control in Zimbabwe culture society, then, agriculture- and climate-related rituals became key in reinforcing political authority.

The robustness of the food system in the Zulu heartland does not appear to have been mirrored in the chiefdoms newly subordinate to the kingdom. Fynn's evidence notes that maize was the predominant staple in the "tributary tribes", though he also reported that, in contrast to the Zulu heartland, agriculture was of far less importance relative to cattle[123]. Differences in crop dependence were matched with those in politically important rituals, notably the *umkosi*. Eldredge[118] points to oral accounts which suggest that Shaka no longer permitted subordinate chiefs who had previously performed this custom to do so, and as the kingdom expanded beyond its immediate neighbours, chiefdoms such as the Hlubi replaced this with other ceremonies that would not be perceived as imitating Shaka's authority[81]. However, evidence does not imply that such ceremonies replaced the function of the centralized *umkosi* performed by Shaka at his capitals in the wetter coastal lowlands. Instead, observations by European traders suggest that the centralization of rituals in subordinate chiefdoms became less sympathetic to local climatic, agricultural and nutritional needs. Specifically, the dependence of these chiefdoms on highly moisture-sensitive maize as opposed to sorghum, their varying harvest dates, and differences in climatic conditions across KwaZulu-Natal gave rise to problems of crop decay, and in turn, hunger[124]. Thus, Shaka's efforts to achieve ideological hegemony over a large area were countered by the overall inefficiency of centralized ritual power.

Untangling climate and conflict

Between 1824 and 1828, Shaka attempted to expand his influence over new chiefs and territories to the north, south and west. Yet the incorporation of chiefdoms and people was not always peaceful, or for that matter, successful. In some cases the breaking apart of formerly independent chiefdoms sent large numbers of people and their chiefs into migration[116], while at other times, populations remained in their location and *konza'd* Shaka[118]. Where chiefs gave allegiance to Shaka, they retained their chieftaincy as subordinates in a layered political hierarchy. Where resistance to Zulu rule was considerable, this could result in the expropriation of cattle, violent confrontation[118] and, according to some, the destruction of crops[113,119].

European traders routinely gave exaggerated accounts of these practices in the mid-1820s, in particular the apparent devastating impacts of Zulu raids on food systems, subsequent famine and the 'depopulation' of the area. That much of this evidence is overtly centred on the notion of the 'depopulation' of the Natal area, however, raises suspicion, for Fynn and his counterparts were concerned with bringing the potential of Natal for formal colonization to the attention of the Cape Colony and Britain. Claims of the deliberate destruction of food as a cause of widespread famine are thus at best exaggerated to serve as narratives of depopulation, and at worst inextricably tied to narratives of white civilising missions amongst the wars and migrations of savage tribes. It is nevertheless noteworthy that food scarcity and famine are repeatedly mentioned in European accounts at this time, and to an extent in oral testimonies. Significantly, historical-climatological evidence (Fig. 3) also suggests that widespread, severe and protracted SRZ drought occurred between 1824 and 1829; this may have been an important factor influencing the hunger and famine recorded in written sources. The impacts of this drought varied across KwaZulu-Natal, with the fringes of the Zulu kingdom seemingly hardest hit. In these areas, a more vulnerable food system dependent on highly moisture-sensitive maize, loss of cattle as a source of food, amplified conflict, growing inequality, and loss of control over politically important rituals, brought new meanings to food insecurity, whereupon vulnerability to climate variability was amplified, and consecutive years of drought exacerbated an already fragile situation causing famine and migration.

This re-interpretation further shifts the emphasis away from the view that Zulu aggression caused famine across its broad areas of influence. Certainly, the process of Zulu growth did impact on its neighbours, but in complex and often less dramatic ways than the sources suggest. Although the central Zulu kingdom was less vulnerable to late-1820s climatic stress, it still underwent a period of internal instability between 1826 and 1828, despite the breakup of its major rival the Ndwandwe kingdom. The removal of the Ndwandwe from the scene brought domestic grievances to the fore, and opposition to Shaka's rule ultimately led to his murder at the hands of his brothers in 1828[114].

DISCUSSION AND CONCLUSIONS

Climate-society interactions over the last millennium in southeast Africa

This cross-disciplinary review has revealed long-term perspectives on the complexity of interactions between climate and society in southeast Africa. Much research in this region has been 'impacts-driven', in that hypotheses of climate-related societal change directly emerged out of an increase in palaeoclimate data. By contrast, our independent synthesis demonstrates that climate impacts were seldom a function of the nature of climatic change or extreme events *per se*, and identifies both overarching patterns and context-specific peculiarities relating to the social-ecological factors underlying historical vulnerability, resilience, adaptability and response.

Although the consequences of past climate variability on southeast African society were strongly contingent upon decision-making and contemporary socio-political events, it is noteworthy that parallels in human responses emerge across different socio-cultural and temporal contexts. For instance, evidence on the organization of food systems, social networks and other livelihood assets and capabilities reveals major disparities in vulnerability and resilience between highly centralized political authority on the one hand, and smaller, decentralized groups on the other. Such differences were of key importance to the adaptability and response of individuals and communities to climatic stress. In organized systems with higher adaptive capacity and resilience, it was only when severe or protracted climate stress combined with other events (for example civil and external conflict in the Mutapa state in the 1560s-1590s), that long-term socio-political effects are evident. Conversely, in

communities under less centralized political authority, with limited food entitlements, livelihood capabilities and social security, periods of climate stress impacted upon a more fragile system and forced a reliance on wild resources. When this scarcity lasted multiple years, as in the 1590s, 1730s and 1790s, it is striking that in both the Zambezi valley and KwaZulu-Natal this led individuals to submit to authority in search of food and protection or, as a 'last resort', to migrate to less-affected areas. Historical-archaeological evidence also indicates that cultural framings and rituals relating to rainfall and food production were particularly important in complex societies as leaders sought to find new ways to assert and maintain legitimacy and authority. It appears likely that as a result of these worldviews, rulers came under strain in times of scarcity, though the nature of the historical evidence limits detailed conclusions as many observers were instead interested in resource exploitation.

Despite these similarities, there is a danger that insights from fragmentary sources can underplay complexity and reduce human agency to behavioural regularities that transcend space and time, resulting in an 'ahistorical' understanding of past climate-society relationships. Indeed, in the case of Mapungubwe and Great Zimbabwe, it is difficult to identify 'events' in the archaeological record unless they are traumatic. When written sources become available from 1505, however, it is possible to untangle complexity in trajectories of vulnerability and resilience at multiple levels alongside changes in governance and societal organization. The example of the *prazo* system in the Zambezi valley, for instance, shows that while there were reductions in individual and community vulnerability through food system diversification, attempts to build resilience were undermined by changes in the organization and functioning of the system, frequent breakdowns in which ultimately led to greater instability and contributed to the decline of Sena in the 1820s.

Lastly, it is worth noting the apparent correspondence between the relative *variability* of climate (as opposed to longer-term changes in the mean) and the clusters of periods of climate-related stress recorded by observers (Table 1). Although both written and palaeoclimate records are of variable quality and resolution, such clusters occur at times of regional and, in most cases, global climatic change. By contrast, the only cluster of recorded climatic stress during persistent LIA cool-dry conditions comprises more localized reports of dry spells and locust plagues in the drought-prone Zambezi valley. Significantly, only two references to climatic stress are made in accounts from the entire 17th century, despite consistency in the quantity of documents over this period. Many shorter-duration events could simply be beyond the resolution of available data. However, this disparity may imply that periods of multi-decadal to centennial drier conditions, with reductions in rainfall amount but low overall variability, were of less direct consequence than those with more highly variable conditions.

New directions: climate, history, society and policy

Historical climate-society research is a rich resource for understanding both the challenges that confronted societies in the past and the solutions, both successful and unsuccessful, which were devised to deal with them. With some notable exceptions[125], however, there remains remarkably little scholarship on southern Africa which addresses the questions raised at the beginning of this article for the period from 1830 up to the late-20th century emergence of mainstream climate vulnerability, impacts and adaptation studies. Neglect of this key period of history, which cuts across transformative changes in societal organization, limits the body of empirical data with which to understand social vulnerability and adaptation, while serving to reinforce the notion that climate change represents a decisive break in history, rather than the latest stage in the cultural evolution of

the idea of climate[126,127]. We therefore conclude by proposing four questions through which historical climate-society research could inform current climate adaptation and policy challenges:

- What were the long-term effects of institutional adaptation decisions on the vulnerability and resilience of communities and social-ecological systems, both in Africa and elsewhere?
- What were the dominant values, framings and worldviews underpinning decision-making, and how did these facilitate or constrain adaptation responses?
- How are past climate extremes and adaptation decisions realized in the cultural memory?
- What are the 'lessons' from the complexities of past responses to climate variability for contemporary adaptation policy?

These questions add to a growing number of calls for research in this area[128-132] but, where detailed institutional records of decision-making and community-level written and oral sources are available, as in much of southern Africa from the late-19th century onwards, could be readily addressed. In addition to reframing the conventional wisdoms of history, the resulting deeper insights into how society and culture interact with climate-related risks at multiple spatial and temporal scales could profoundly alter current understanding of responses to climate change, and help inform the context-specific design of adaptation policy itself.

Notes

a. Also of importance for summer rainfall levels in southeast Africa are sea-surface temperature (SST) anomalies in the southwest Indian Ocean, with warmer SSTs generally associated with wetter summers[38] and the modulation of SSTs and atmospheric circulation by climate modes such as the El Niño-Southern Oscillation (ENSO), the Southern Annular Mode (SAM) and the Indian Ocean Dipole (IOD).

b. For general reference, the MCA is defined here as spanning the period ca AD 950 to ca AD 1250 and the LIA from ca AD 1300 to ca 1850[133,134].

c. In contrast to much of the sub-Saharan African interior prior to the 19th century, the Zambezi-Limpopo area offers a comparatively large range of documentary material relating to African society. The accumulation of these documents was a product of the administration of the Portuguese state, church and mercantile capital across its *Estado da Índia*. As a result, detailed descriptions of mining, trade, agriculture, hunting, religion, warfare, diplomacy and village life are available from the early-16th century onwards. The bulk of these sources are held within three translated source compilations: *Records of South-Eastern Africa*[87], *Documents on the Portuguese in Mozambique and Central Africa*[88], and *The Shona and the Portuguese*[90]. Overviews of the documents and their use in historical analysis can be found in publications by David Beach[135] and Malyn Newitt[85].

d. Slavery in the Zambezian context was a form of clientship familiar in many other African societies. This arose most commonly in times of war or famine when people sought the protection of the rich or powerful in return for service. In the words of Newitt[83]: "It was understood that a man selling himself in Zambesia was like a poor man in Europe entering the service of a master. Though he lost some of his liberty he did not lose his rights".

e. Oral histories and traditions in the KwaZulu-Natal area were recorded by James Stuart, a Zulu interpreter and Chief Magistrate in Pietermaritzburg between the 1890s and 1920s. Over these three decades Stuart interviewed over 150 informants at his home, the eldest of whom had personal memories of Shaka and events during his reign. Stuart's original interview notes

have been translated, edited and published[115] by Colin de B. Webb and John Wright; the originals are held within the Killie Campbell Africana Library in Durban.

Acknowledgements

MJH acknowledges the support of the University of Sheffield, the University of the Free State and the Royal Geographical Society with the Institute of British Geographers. DJN's contributions were supported by Leverhulme Trust Research Project Grant number F/00 504/D. Both thank Tom Huffman and Wendy Voorvelt Work for providing access to translations of Portuguese documents held within '*The Shona and the Portuguese*', and the anonymous reviewers for their comments.

References

1. Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A. Very high resolution interpolated climate surfaces for global land areas. *Int J Climatol* 2005, 25:1965-1978. doi:10.1002/joc.1276.
2. Hannaford MH, Bigg GR, Jones JM, Phimister I, Staub M. Climate Variability and Societal Dynamics in Pre-colonial Southern African History (900-1840): A Synthesis and Critique. *Environment and History* 2014, 20:411-445. doi:10.3197/096734014X14031694156484.
3. Butzer KW, Endfield GH. Critical perspectives on historical collapse. *PNAS* 2012, 109:3628-3631. doi:10.1073/pnas.1114772109.
4. Livingstone DN. Changing climate, human evolution, and the revival of environmental determinism. *Bull Hist Med* 2012, 86:564-595. doi:10.1353/bhm.2012.0071.
5. Middleton GD. Nothing Lasts Forever: Environmental Discourses on the Collapse of Past Societies. *J Archaeol Res* 2012, 20:257-307. doi:10.1007/s10814-011-9054-1.
6. Carey M. Climate and history: a critical review of historical climatology and climate change historiography. *WIREs Clim Change* 2012, 3:233-249. doi:10.1002/wcc.171.
7. Tyson PD, Lindesay JA. The climate of the last 2000 years in southern Africa. *Holocene* 1992, 2:271-278. doi:10.1177/095968369200200310.
8. McCann JC. Climate and causation in African history. *Int J Afr Hist Stud Studies* 1999, 32:261-79.
9. Ekblom A. Changing Landscapes: An Environmental History of Chibuene, Southern Mozambique. Doctoral thesis, Uppsala University, 2004.
10. Tyson PD. *Climatic change and variability in southern Africa*. Oxford University Press, Oxford, 1986.
11. Chase BM, Meadows ME. Late Quaternary dynamics of southern Africa's winter rainfall zone. *Earth-Sci Rev* 2007, 84:103-138. doi:10.1016/j.earscirev.2007.06.002
12. Mitchell P. *The Archaeology of Southern Africa*. Cambridge University Press, Cambridge, 2002.
13. Nicholson SE. Environmental change within the historical period. In: Goudie AS, Adams WM, Orme A, eds. *The Physical Geography of Africa*. Oxford University Press, Oxford, 1996, 60-75.
14. Nicholson SE. The nature of rainfall variability over Africa on time scales of decades to millennia. *Glob Planet Chang* 2000, 26:137-158. doi:10.1016/S0921-8181(00)00040-0.
15. Ekblom A, Gillson L, Risberg J, Holmgren K, Chidoub Z. Rainfall variability and vegetation dynamics of the lower Limpopo Valley, Southern Africa, 500 AD to present. *Palaeogeog, Palaeoclimatol, Palaeoecol* 2012, 363-364:69-78. doi:10.1016/j.palaeo.2012.08.015.
16. Holmgren K, Risberg J, Freudendahl J, Achimo M, Ekblom A, Mugabe J, Norström E, Sitoe S. Water-level variations in Lake Nhauhache, Mozambique, during the last 2,300 years. *J Palaeolimnol* 2012, 48:311-322. doi:10.1007/s10933-012-9596-3.

17. Stager JC, Ryves DB, King C, Madson J, Hazzard M, Neumann FH, Maud R. Late Holocene precipitation variability in the summer rainfall region of South Africa. *Quat Sci Rev* 2013, 67:105-120. doi:10.1016/j.quascirev.2013.01.022.
18. Talma AS, Vogel JC. Late Quaternary paleotemperature derived from a speleothem from Cango Caves, Cape Province, South Africa. *Quat Res* 1992, 37:203-213. doi:10.1016/0033-5894(92)90082-T.
19. Smith J. Climate change and agropastoral sustainability in the Shashe-Limpopo river basin from AD 900. Doctoral thesis, University of the Witwatersrand, 2005.
20. Smith J, Lee-Thorp J, Hall S. Climate change and agropastoralist settlement in the Shashe-Limpopo River Basin. *South African Archaeological Bulletin* 2007, 62:115-125. doi:10.2307/20474967.
21. Holmgren K, Karlén W, Lauritzen SE, Lee-Thorp JA, Partridge TC, Piketh S, Repinski P, Stevenson C, Svanered O, Tyson PD. A 3000-year high-resolution stalagmite-based record of palaeoclimate for northeastern South Africa. *Holocene* 1999, 9:295-309. doi:10.1191/095968399672625464.
22. Holmgren K, Lee-Thorp JA, Cooper GRJ, Lundblad K, Partridge TC, Scott L, Sithaldeen R, Talma AS, Tyson PD. Persistent millennial-scale climatic variability over the past 25,000 years in southern Africa. *Quat Sci Rev* 2003, 22:2311-2326. doi:10.1016/S0277-3791(03)00204-X.
23. Lee-Thorp JA, Holmgren K, Lauritzen SE, Linge H, Moberg A, Partridge TC, Stevenson C, Tyson PD. Rapid climate shifts in the southern Africa interior throughout the Mid to Late Holocene. *Geophys Res Lett* 2001, 28:4507-4510. doi:10.1029/2000GL012728.
24. Sletten H, Railsback LB, Liang F, Brook GA, Marais E, Hardt BF, Cheng H, Edwards RL. A petrographic and geochemical record of change over the last 4600 years from a northern Namibia stalagmite, with evidence of abruptly wetter climate at the beginning of southern Africa's Iron Age. *Palaeogeogr, Palaeoclimatol, Palaeoecol* 2013, 376:149-162. doi:10.1016/j.palaeo.2013.02.030.
25. Ekblom A, Stabell B. Paleohydrology of Lake Nhaucati (southern Mozambique), ~400 AD to present. *J Paleolimnol* 2008, 40:1127-1141. doi:10.1007/s10933-008-9218-2.
26. Woodborne S, Hall G, Robertson I, Patrut A, Rouault M, Loader NJ, Hofmeyr M. A 1000-year carbon isotope rainfall proxy record from South Africa Baobab trees (Adansonia digitata L.). *PLoS One* 2015, 10. doi:10.1371/journal.pone.0124202.
27. Scott L. Vegetation history and climate in the Savanna biome South Africa since 190,000 ka: A comparison of pollen data from the Tswaing Crater (the Pretoria Saltpan) and Wonderkrater. *Quat Int* 1999, 57-58:215-223. doi:10.1016/S1040-6182(98)00062-7.
28. Chase BM, Quick LJ, Meadows ME, Scott L, Thomas DSG, Reimer PJ. Late glacial interhemispheric climate dynamics revealed in South African hyrax middens. *Geology* 2011, 39:19-22. doi:10.1130/G31129.1.
29. Chase BM, Boom A, Carr AS, Meadows ME, Reimer PJ. Holocene climate change in southernmost South Africa: rock hyrax middens record shifts in the southern westerlies. *Quat Sci Rev* 2013, 82:199-205. doi:10.1016/j.quascirev.2013.10.018.
30. Sundqvist HS, Holmgren K, Fohlmeister J, Zhang Q, Bar-Matthews M, Spötl C, Körnich H. Evidence of a large cooling between 1690 and 1740 AD in southern Africa. *Sci Rep* 2013, 3:1796. doi:10.1038/srep01767.
31. Hall MJ. Dendroclimatology, Rainfall and Human Adaptation in the Later Iron Age of Natal and Zululand. *Ann Natal Mus* 1976, 22:693-703.

32. Nicholson SE, Klotter D, Dezfuli AK. Spatial reconstruction of semi-quantitative precipitation fields over Africa during the 19th century from documentary evidence and gauge data. *Quat Res* 2012, 78:13-23. doi:10.1016/j.yqres.2012.03.012.
33. Vogel CH. A documentary-derived climatic chronology for South Africa 1820-1900. *Clim Change* 1989, 14:291-307. doi:10.1007/BF00134967.
34. Kelso C, Vogel CH. The climate of Namaqualand in the 19th century. *Clim Change* 2007, 83:357-380. doi:10.1007/s10584-007-9264-1.
35. Nash DJ, Endfield GH. A 19th century climate chronology for the Kalahari region of central southern Africa derived from missionary correspondence. *Int J Climatol* 2002, 22:821-841. doi:10.1002/joc.753.
36. Nash DJ, Endfield GH. "Splendid rains have fallen": links between El Niño and rainfall variability in the Kalahari: 1840-1900. *Clim Change* 2008, 86:257-290. doi:10.1007/s10584-007-9274-z.
37. Nash DJ, Grab SW. "A sky of brass and burning winds": documentary evidence of rainfall variability in the Kingdom of Lesotho, Southern Africa, 1824-1900. *Clim Change* 2010*,* 101:617-653. doi:10.1007/s10584-009-9707-y.
38. Nash DJ, Pribyl K, Klein J, Neukom R, Endfield GH, Adamson GCD, Kniveton DR. Seasonal rainfall variability in southeast Africa during the 19th century reconstructed from documentary sources. *Clim Change* 2015. doi:10.1007/s10584-015-1550-8.
39. Hannaford MJ, Jones JJ, Bigg GR. Early-19th century southern African precipitation reconstructions from ships' logbooks. *Holocene* 2015, 25:379-390. doi:10.1177/0959683614557573.
40. Therrell MD, Stahle DW, Ries LP, Shugart HH. Tree-ring reconstructed rainfall variability in Zimbabwe. *Clim Dyn* 2006, 26: 677-685. doi:10.1007/s00382-005-0108-2.
41. Nash DJ, Adamson GCD. Recent Advances in the Historical Climatology of the Tropics and Subtropics. *Bull Amer Meteor Soc* 2014, 95:131-146. doi:10.1175/BAMS-D-12-00030.1.
42. Neukom R, Nash DJ, Endfield GH, Grab SW, Grove CA, Kelso C, Vogel CH, Zinke J. Multi-proxy summer and winter precipitation reconstructions for southern Africa over the last 200 years. *Clim Dyn* 2014, 42:2713-2726. doi:10.1007/s00382-013-1886-6.
43. Zinke J, Dullo WC, Heiss GA, Eisenhauer A. ENSO and Indian Ocean subtropical dipole variability is recorded in a coral record off southwest Madagascar for the period 1659 to 1995. *Earth Planet Sci Lett* 2004, 228:177-194. doi:10.1016/j.epsl.2004.09.028.
44. Hulme M, Doherty R, Ngara T, New M, Lister D. African climate change: 1900-2100. *Clim Res* 2001, 17:145-168. doi:10.3354/cr017145.
45. Pikirayi I. *The Zimbabwe Culture: Origins and Decline of Southern Zambezian States*. AltaMira Press, Walnut Creek, 2001.
46. Chirikure S, Manyanga M, Pollard M, Pikirayi I. New Pathways of Sociopolitical Complexity in Southern Africa. *Afr Archaeol Rev* 2013, 30:339-366. doi:10.1007/s10437-013-9142-3.
47. Beach DN. The Shona economy: Branches of production. In: Palmer R, Parsons N, eds. *The Roots of Rural Poverty in Central and Southern Africa*. Heinemann, London, 1977, 37-65.
48. Huffman TN. *Handbook to the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa*. University of KwaZulu-Natal Press, Pietermaritzburg, 2007.
49. Badenhorst S. Descent of Iron Age Farmers in Southern Africa During the Last 2000 years. *Afr Archaeol Rev* 2010, 27:87-106. doi:10.1007/s10437-010-9073-1.
50. Mitchell P. Early Farming Communities of southern and south-central Africa. In: Mitchell P, Lane P, eds. *The Oxford Handbook of African Archaeology*. Oxford University Press, Oxford, 2013, 657-670.

51. Huffman TN. Archaeology and ethnohistory of the African Iron Age. *Annual Review of Anthropology* 1982, 11:133-150.
52. Burke EE. Some aspects of Arab contact with south east Africa. In Clark J, Shepperson GA, Ranger TO, eds. Historians in Tropical Africa: Leverhulme Inter-Collegiate History Conference. University College of Rhodesia and Nyasaland, Salisbury, 1962, 93-106.
53. Wood M. Interconnections: Glass beads and trade in southern and eastern Africa and the Indian Ocean – 7th to 16th centuries AD. Doctoral thesis, Uppsala University, 2012.
54. Sinclair P, Ekblom A, Wood M. Trade and society on the south-east African coast in the later first millennium AD: the case of Chibuene. *Antiquity* 2012, 86:723-737. doi:10.1017/S0003598X00047876.
55. Huffman TN. Climate change during the Iron Age the in the Shashe-Limpopo Basin, southern Africa. *J Archaeol Sci* 2008, 35:2032-2047. doi:10.1016/j.jas.2008.01.005.
56. Huffman TN. Mapungubwe and Great Zimbabwe: The origin and spread of social complexity in southern Africa. *Journal of Anthropological Archaeology* 2009, 28:37-54. doi:10.1016/j.jaa.2008.10.004.
57. Huffman TN. Archaeological evidence for climate change during the last 2000 years in southern Africa. *Quaternary International* 1996, 33:55-60. doi:10.1016/1040-6182(95)00095-X.
58. Huffman TN. Mapungubwe and the origins of the Zimbabwe Culture, Africa Naissance: The Limpopo Valley 1000 years ago. In Leslie M, Maggs T, eds. *The South African Archaeological Society Goodwin Series 8*, 2000, South African Archaeological Society, Cape Town, 14-19.
59. Meyer A. *The Archaeological Sites of Greefswald: Stratigraphy and Chronology of the Sites and a History of Investigations*. University of Pretoria, Pretoria, 1998.
60. Plug I. Overview of Iron Age fauna from the Limpopo Valley. In Leslie M, Maggs T, eds. *The South African Archaeological Society Goodwin Series 8*, 2000, South African Archaeological Society, Cape Town, 117-126.
61. Manyanga M. Resilient Landscapes: socio-environmental dynamics in the Shashi-Limpopo basin, southern Zimbabwe, c. AD 800 to the present. Doctoral thesis, Uppsala University, 2007.
62. Murimbika MT. Sacred powers and rituals of transformation: An ethnoarchaeological study of rainmaking rituals and agricultural productivity during the evolution of the Mapungubwe state, AD 1000 to AD 1300. Doctoral thesis, University of the Witwatersrand, 2006.
63. Schoeman MH. Imagining rain-places: rain-control and changing ritual landscapes in the Shashe-Limpopo confluence area, South Africa. *South African Archaeological Bulletin* 2006, 61:152-165. doi:10.2307/20474923.
64. Tyson PD, Lee-Thorp J, Holmgren K, Thackeray JF. Changing Gradients of Climate Change in Southern Africa during the Past Millennium: Implications for Population Movements. *Clim Change* 2002 52:129-135. doi:10.1023/A:1013099104598. 64.
65. O'Connor TG, Kiker GA. Collapse of the Mapungubwe Society: Vulnerability of Pastoralism to Increasing Aridity. *Clim Change* 2004, 66:49-66. doi:10.1023/B:CLIM.0000043192.19088.9d.
66. Huffman TN. Intensive El Niño and the Iron Age of South-eastern Africa. *J Archaeol Sci* 2010, 27:2572-2586. doi:10.1016/j.jas.2010.05.017.
67. Mitchell P, Whitelaw G. The archaeology of southernmost Africa from c. 2000 BP to the early 1800s: a review of recent research. *Journal of African History* 2005, 46:209-241. doi:http://dx.doi.org/10.1017/S0021853705000770.
68. Huffman, TN, Woodborne, S. Archaeology, baobabs and drought: Cultural proxies and environmental data from the Mapungubwe landscape, southern Africa. *Holocene* 2015. doi:10.1177/0959683615609753.

69. Huffman TN. A cultural proxy for drought: ritual burning the Iron Age of Southern Africa. *J Archaeol Sci* 2009, 36:991-1005. doi:10.1016/j.jas.2008.11.026.
70. Bonner PL, Esterhuysen AB, Schoeman MH, Swanepoel NJ, Wright JB. Introduction. In: Swanepoel N, Esterhuysen A, Bonner PL, eds. *Five Hundred Years Rediscovered: Southern African Precedents and Prospects*, Witwatersrand University Press, Johannesburg, 2008, 1-19.
71. Pikirayi I. The Zimbabwe Culture and its neighbours: origins, development, and consequences of social complexity in southern Africa. In: Mitchell P, Lane P, eds. *The Oxford Handbook of African Archaeology*. Oxford University Press, Oxford, 2013, 915-928.
72. Beach DN. *The Shona and their Neighbours*. Blackwell, Oxford, 1994.
73. Chirikure S, Manyanga M, Pollard MA. When science alone is not enough: Radiocarbon timescales, history, ethnography and elite settlements in southern Africa. *Journal of Social Archaeology* 2012, 12:356-379. doi:10.1177/1469605312457291.
74. Summers R. Environment and culture in Southern Rhodesia: A study in the 'personality' of a land-locked country. *Proceedings of the American Philosophical Society* 1960, 104:266-292.
75. Phimister IR. Ancient mining near Great Zimbabwe. *Journal of South African Institute of Mining and Metallurgy* 1974, 74:233-237.
76. Beach DN. *The Shona and Zimbabwe 900-1850: An Outline of Shona History*. Mambo Press, Gweru, 1980.
77. Holmgren K, Öberg H. Climate Change in Southern Africa and Eastern Africa During the Past Millennium and its Implications for Societal Development. *Env Dev Sustain* 2006, 8:185-195. doi:10.1007/s10668-005-5752-5.
78. Connah G. *African Civilizations: An Archaeological Perspective*. Cambridge University Press, Cambridge, 2001.
79. Diamond J. *Collapse: How Societies Choose to Fail or Survive*. Penguin, London, 2005.
80. Pikirayi I. The demise of Great Zimbabwe, AD 1420-1550: An environmental re-appraisal. *Post-Medieval Archaeological Monograph* 2006, 3:31-48.
81. Hannaford MJ. The consequences of past climate change for state formation and security in southern Africa. Doctoral thesis, The University of Sheffield, 2015.
82. Phimister IR. Pre-colonial gold mining in Southern Zambesia: A Reassessment. *African Social Research* 1976, 21:1-30.
83. Newitt M. *Portuguese Settlement on the Zambezi: Exploration, Land Tenure and Colonial Rule in East Africa*. Africana Publishing Company, New York, 1973.
84. Newitt M. Drought in Mozambique 1823-1831. *Journal of Southern African Studies* 1988, 15,15-35. 34. doi:10.1080/03057078808708189
85. Newitt M. *A History of Mozambique*. Indiana University Press, Bloomington, 1995, 252.
86. Abraham DP. The Early Political History of the Kingdom of Mwene Mutapa (850-1589). In Clark J, Shepperson GA, Ranger TO, eds. Historians in Tropical Africa: Leverhulme Inter-Collegiate History Conference. University College of Rhodesia and Nyasaland, Salisbury, 61-91.
87. Theal GM. *Records of South Eastern Africa*, 9 vols. C. Struik, Cape Town, 1898-1903, II, 129-152.
88. da Silva Rego A, Baxter TW. *Documents on the Portuguese in Mozambique and Central Africa, 1497-1840*, 9 vols. National Archives of Rhodesia and Nyasaland, Salisbury, 1962-1989, VIII, 228-247.
89. da Silva Rego A, Baxter TW. *Documents on the Portuguese in Mozambique and Central Africa, 1497-1840*, 9 vols. National Archives of Rhodesia and Nyasaland, Salisbury, 1962-1989, VIII, 324-429.
90. Beach DN, Noronha H. *The Shona and the Portuguese (1575-1890)*, 2 vols. History Department, University of Zimbabwe, 1980, I, 230-245.

91. Pikirayi I. Environmental data and historical process: historical climatic reconstruction & the Mutapa state 1450-1862. In Beinart W, McGregor J, eds. *Social History and African Environments*, James Currey, Oxford, 2003, 60-71.
92. Theal GM, ed. *Records of South Eastern Africa*, 9 vols. C. Struik, Cape Town, 1898-1903, VII, 319.
93. da Silva Rego A, Baxter TW. *Documents on the Portuguese in Mozambique and Central Africa, 1497-1840*, 9 vols. National Archives of Rhodesia and Nyasaland, Salisbury, 1962-1989, V, 354-371.
94. Theal GM. *Records of South Eastern Africa*, 9 vols. C. Struik, Cape Town, 1898-1903, VI, 1-306.
95. Mudenge SIG. *A Political History of the Munhumutapa c. 1400-1902.* Zimbabwe Publishing House, Harare, 1988.
96. Bhila HHK. *Trade and Politics in a Shona Kingdom: The Manyika and their Portuguese and African Neighbours, 1575-1902*. Longman, London, 1982.
97. Theal GM. *Records of South Eastern Africa*, 9 vols. C. Struik, Cape Town, 1898-1903, III, 254-435.
98. Theal GM. *Records of South Eastern Africa*, 9 vols. C. Struik, Cape Town, 1898-1903, II, 378-426.
99. Beach DN, Noronha H. *The Shona and the Portuguese (1575-1890)*, 2 vols. History Department, University of Zimbabwe, 1980, I, 35-134.
100. Beach DN, Noronha H. *The Shona and the Portuguese (1575-1890)*, 2 vols. History Department, University of Zimbabwe, 1980, II, 196-229.
101. Theal GM. *Records of South Eastern Africa*, 9 vols. C. Struik, Cape Town, 1898-1903, I, 50-56.
102. da Silva Rego A, Baxter TW. *Documents on the Portuguese in Mozambique and Central Africa, 1497-1840*, 9 vols. National Archives of Rhodesia and Nyasaland, Salisbury, 1962-1989, I, 142-143.
103. da Silva Rego A, Baxter TW. *Documents on the Portuguese in Mozambique and Central Africa, 1497-1840*, 9 vols. National Archives of Rhodesia and Nyasaland, Salisbury, 1962-1989, IV, 187.
104. da Silva Rego A, Baxter TW. *Documents on the Portuguese in Mozambique and Central Africa, 1497-1840*, 9 vols. National Archives of Rhodesia and Nyasaland, Salisbury, 1962-1989, IV, 274-295.
105. Beach DN, Noronha H. *The Shona and the Portuguese (1575-1890)*, 2 vols. History Department, University of Zimbabwe, 1980, I, 159-180.
106. Beach DN, Noronha H. *The Shona and the Portuguese (1575-1890)*, 2 vols. History Department, University of Zimbabwe, 1980, II, 83-115.
107. Miller J. The significance of drought, disease and famine in the agriculturally marginal zone of West-Central Africa. *Journal of African History* 1982, 23:17-61.
108. Alpers EA. *Ivory and Slaves in East Central Africa: Changing Pattern of International Trade in East Central Africa to the Later 19th Century*. University of California Press, Berkeley, 1975.
109. Huffman TN. The archaeology of the Nguni past. *Southern African Humanities* 2004, 16:79-111.
110. Maggs T. Mgoduyanuka: terminal Iron Age settlement in the Natal grasslands. *Annals of the Natal Museum* 1982, 25:83-113.
111. Maggs T. The Iron Age farming communities. In Duminy AH, Guest B, eds. *Natal and Zululand from the earliest times to 1910: a new history*. University of Natal Press, Pietermaritzburg, 1989, 28-48.
112. Hedges DW. Trade and Politics in Southern Mozambique and Zululand in the 18th and Early 19th Centuries. Doctoral thesis, School of Oriental and African Studies, University of London, 1978.

113. Ballard C. Drought and economic distress: South Africa in the 1800s. *J Interdiscip Hist*, 1986, 17:359-378. 369.
114. Wright J. Turbulent times: Political transformation in the north and east. In Hamilton C, Mbenga BK, Ross R, eds. *The Cambridge History of South Africa, Vol. 1. From the Early Times to 1885*. Cambridge University Press, Cambridge, 2010, 211-252.
115. Wright J, Webb C. *The James Stuart Archive of Recorded Oral Evidence relating to the History of the Zulu and Neighbouring Peoples*, 6 vols. Killie Campbell Africana Library, Durban, 1976-2014.
116. Etherington N. *The Great Treks: The Transformation of Southern Africa 1815-1854*. Pearson Education Ltd., Harlow, 2001.
117. Eldredge EA. Sources of Conflict in Southern Africa, c. 1800-1830: The 'Mfecane' Reconsidered. *The Journal of African History*, 1992, 33:1-35. doi:10.1017/S0021853700031832.
118. Eldredge EA. *The Creation of the Zulu Kingdom, 1815-1828: War, Shaka and the Consolidation of Power*. Cambridge University Press, Cambridge, 2014.
119. Eldredge EA. *Kingdoms and Chiefdoms of Southeastern Africa: Oral Traditions and History 1400-1830*. University of Rochester Press, Rochester, 2015.
120. Guy J. Ecological factors in the rise of Shaka and the Zulu kingdom. In Marks S, Atmore A, eds. *Economy and Society in Pre-Industrial South Africa*. Longman Group, London, 1980, 102-119.
121. Cobbing J. The Mfecane as Alibi: Thoughts on Dithakong and Mbolompo. *Journal of African History* 1988, 29:487-519.
122. Hamilton C. *The Mfecane Aftermath: Reconstructive Debates in Southern African History*. Witwatersrand University Press, Johannesburg, 1995.
123. Stuart J, Malcolm DM. *The Diary of Henry Francis Fynn*. Shuter and Shooter, Pietermaritzburg, 1969. 1.
124. Isaacs N. *Travels and Adventures in Eastern Africa, 2 vols*. Edward Churton, London, 1836.
125. Kelso C, Vogel C. Diversity to decline-livelihood adaptations on the Namaqua Khoikhoi (1800-1900). *Global Environmental Change* 2015, 35:254-268. doi:10.1016/j.gloenvcha.2015.09.005.
126. Adger WN, Barnett J, Brown K, Marshall N, O'Brien K. Cultural dimensions of climate change impacts and adaptation. *Nature Clim Change* 2013, 3:112-117. doi:10.1038/nclimate1666.
127. Hulme M. Climate and its changes: a cultural appraisal. *Geography and Environment* 2015. doi:10.1002/geo2.5.
128. Carey M. Science, Models, and Historians: Toward a Critical Climate History. *Environmental History* 2014, 19:355-364. doi:10.1093/envhis/emu004.
129. Endfield GH. Exploring particularity: Vulnerability, resilience, and memory in climate change discourses. *Environmental History* 2014, 19(2):282-364. doi:10.1093/envhis/emu004.
130. Adamson GCD. Private diaries as information sources in climate research. *WIREs Clim Change* 2015, 6:599-611. doi:10.1002/wcc.365.
131. Allan R, Endfield G, Damodaran V, Adamson G, Hannaford M, Carroll F, Macdonald N, Groom N, Jones J, Williamson F, Hendy E, Holper P, Arroyo-Mora JP, Hughes L, Bickers R, Bliuc A. Toward integrated historical climate research: the example of Atmospheric Circulation Reconstructions over the Earth. *WIREs Clim Change* 2015, doi:10.1002/wcc.379.
132. Adamson GCD. Institutional and community adaptation from the archives: A study of drought in western India, 1790-1860. *Geoforum* 2014, 55:110-119. doi:10.1016/j.geoforum.2014.05.010.
133. Jones PD, Osborn TJ, Briffa KR. The evolution of climate over the last millennium. *Science* 2001, 292:662-667. doi:10.1126/science.1059126.
134. Matthew JA, Briffa KR. The "Little Ice Age": Re-evaluation of an evolving concept. *Geogr Ann* 2005, 87a:17-36. doi:10.1111/j.0435-3676.2005.00242.x.

135. Beach DN. Documents and African Society on the Zimbabwean Plateau Before 1890. *Paideuma* 1987, 33:129-145.