Rediscovering lessons of adaptation from the past

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Title: Rediscovering lessons of adaptation from the past

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Title Rediscovering lessons of adaptation from the past

Abstract

We argue that the deep time perspectives offered by historical disciplines, such as archaeology and history, provide important human-scale data about climate-adaptation over long timescales, and that these insights are currently lacking in global change research and Intergovernmental Panel on Climate Change reports. Pre-modern societies are not comparable with contemporary societies, but the completed experiments they represent can offer evidence of the consequences of climate change, the challenges of uncertainty and socio-cultural limits to adaptation. The limited visibility of data on long-term human interactions with climate change in global change research could be overcome through a 'new social contract', a two-way movement between global change and historical disciplines to, 1) make use of, and apply, historical data to contemporary climate-related challenges; 2) to design robust interdisciplinary and transdisciplinary research, 3) publish synthesised research in high-impact climate-adaptation journals and 4) communicate research to the public in cultural history museums.

1. Introduction

Anthropogenic climate change is having profound impacts on social and cultural practices, requiring novel approaches to understand the interaction between culture and climate (Hulme, 2009, 2016). In the last decade, numerous authors have highlighted the need for a critical integration of the social sciences and humanities into Global Change Research (GCR) and associated institutional bodies, such as the Intergovernmental Panel on Climate Change (IPCC; see Hulme, 2011; Castree et al. 2014). Archaeology and history, however, have received little attention in mainstream the climate-adaptation literature and institutional reports despite significant research at the interface between human and natural systems (Riede, 2014a; Hudson et al., 2012; Hambrecht and Rockman, 2017). In this paper, we address this lack by proposing a new social contract; a two-way movement by GCR and historical disciplines to make use of and apply historical data to contemporary climate-related challenges.

2. Global Change Research

GCR examines the impacts of human activities on bio-geo-physical processes (IPCC, 2014). Integrated monitoring efforts have recorded significant changes to these processes, and the crossing of environmental thresholds that define safe operating spaces for humanity (Rockström et al., 2009). While substantial progress has been made towards understanding physical changes to Earth system processes since Assessment Report (AR) 1 (1990) of the IPCC, until IPCC AR4, the social sciences and humanities had limited influence over the consideration of human dimensions within GCR (Corbera et al., 2016). It is now recognised that successful responses to climate change need to overcoming socio-cultural limits and barriers (Moser and Ekstrom, 2010; Barnett et al., 2015). This highlights crucial issues, that include how to adjust social practices to avoid dangerous climate change and to understand cultural capacities to adapt to change (Adger et al., 2013a).

The limited visibility of archaeology and history in GCR is perhaps unsurprising because recognisable changes to climate, driven by human activities, are a modern phenomenon and societies of the past differ from those of the present in terms of world views, technology, demography and governance structures. Hence, climate change adaptation might be considered solely a challenge for modern societies and thus modern science. Indeed, global production, economic systems, demographic and population trends, and—critically—modes of knowledge have changed dramatically since the Enlightenment (Withers, 2005) and industrial revolutions (Urry, 2014). This development has been so profound that in the case of Western societies, Hannah Arendt (1998) has characterised a new *human condition* capable of ever-greater destruction. Linked to this, the 'Anthropocene' concept has sought to define humanity's transformed relationship with the Earth system (Crutzen, 2006). The industrial revolution's influence on global atmospheric composition (c. 1750-1800 AD), socio-economic trends of the post-1950 'great acceleration' (Steffen et al., 2015) and the creation of an artificial global radionuclide marker horizon from atomic detonations (Zalasiewicz et al., 2008) are used as evidence for a post-industrial global environmental threshold. But defining this threshold potentially shifts attention from antecedent processes of cultural-ecological change (Erlandson and Braje, 2013) and past human resource-use and decision-making in response to climate stimuli. As argued by Hartman et al. (2017), the notion of the new human condition is in need of updating in light of past human-environment interactions, and how these impinge on the present and future of human planetary stewardship.

Anthropologists Smith and Zeder (2013) have challenged the post-industrial designation of Anthropocene, arguing "focus should be on cause rather than [a measurable] effect" (p.11), such as a 'golden spike'. The cause in question is, for Smith and Zeder (2013), the 'agricultural revolution' of ~11,000-9000 yr BP. This period marked a significant transition in human impacts, from those of hunter-gatherers to the domesticators of plants and animals (Zeder, 2015). The social and ecological consequences of agriculture are significant, and their imprint is discernible today. The adoption of agriculture increased and expanded human population and human-favoured taxa across the globe — primarily the newly domesticated plant and animal species common to modern diets (Boivin et al., 2016). Major environmental impacts from Holocene agricultural expansion, such as the transformation of central Eurasian forests and grasslands through grazing, are responsible for engineering the familiar cultural landscapes of today (Miehe et al., 2009).

The spread of agriculture is significant to modern GCR because it fundamentally altered human adaptive responses to climate variability. Whereas hunter-gatherer societies used mobility to respond to climate-induced shifts in wild resource distribution, agriculturalists use past experience to inform local economic decisions (Kennett and Marwan, 2015). Decisions about cropping, harvesting, grazing, irrigation, grain storage, trade and political-economic integration require the navigation of economic constraints and memory of climatic variability as important today as long ago. Likewise, managing private and local common-pool resources is as much a socio-environmental and economic challenge of the present as it was in the past (Ostrom et al., 1994, 2007).

Climate change, political and economic stability, food security and human migration have been major concerns to past as well as contemporary societies, but examples of how these problems become interrelated, and 'wicked', are missing from future scenario planning (Palmer and Smith, 2014). History can tell us how vulnerable societies functioned before and after disaster events (Riede, 2014b), what impact cultural limits played in long-term adaptation to climate variability (Dugmore et al., 2012; Speilmann et al., 2016), and how multiple exposures undermined societal resilience (Dugmore et al., 2013).

3. The Use of the Past in the Present

In the 21st century, archaeology and history have increased their efforts to apply long-term data to contemporary social and environmental challenges—including climate-adaptation and sustainability (Redman, 2005; Costanza et al., 2007). New and expanded archaeological methods, such as those using stable isotopes, statistical models and microfossil analysis, have enhanced reconstructions of human-environment interaction, human dietary response to changing resource abundance, human migration and settlement abandonment (Boivin et al., 2016; d'Alpoim Guedes et al., 2016); historians have shown how culture shapes changing ideas of climate (Adamson et al., 2018; Hulme, 2008).

Developing more effective interdisciplinary collaborations can provide holistic information on climate-adaptation using extended timescales to explain how vulnerabilities develop across different spatial and socio-cultural contexts—to reconstruct a global perspective on climate impacts and adaptation in the past. Box 1 provides six well-known examples of environmental and social change. North Atlantic researchers from the geosciences, historical ecology, environmental humanities and social sciences have outlined the benefits of long-term integrative approaches using the comparative cases of Medieval Greenland and Iceland (Box 2). In the following subsections we explore two further cases of societal transformation (Classic Maya and the pre-Hispanic US Southwest) to illustrate the potential of historical records and their completed experiments to inform contemporary and future climate-adaptation scenario planning.

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Box 1

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Box 2

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3.1. Classic Maya: Climate Variability, Uncertainty and Conflict

The decline of Classic Maya (~750-1050 AD) is among the most widely discussed cases of societal "collapse" (Middleton, 2017). Recent comparative climate and archaeological research supports the hypothesis that prolonged, multiyear drought triggered regional political disintegration during the Terminal Classic (9^{th}-10^{th} centuries CE) (Kennett et al., 2012; Hoggarth et al., 2016). In wealthy Maya polities, conflict and tribute-based status encouraged population agglomeration. This escalated environmental stress, increasing the chance of local-scale soil erosion and reduced crop yields (Turner and Sabloff, 2012). In the elevated interior of the Yucatan, an extensive dry season made settlements dependent on household and urban reservoirs to store water (Dunning et al., 2012). Multiyear drought increased resource stress, triggering conflict for political and economic gain over neighbouring polities (Kennett and Beach, 2013). This resulted in increased political disintegration and population decline as resource stress and conflict reinforced one another in a 'risk spiral' (Hoggarth et al., 2016, 2017; Dunning et al., 2012).

3.2. US Southwest: Climate Variability and Infrastructure Rigidity

Research focused on the pre-Hispanic ancestral Puebloan communities of the US Southwest has examined decision-making and actions that contributed to both vulnerability and adaptive capacity (Nelson et al., 2016). Using archaeological records and climate reconstructions, multidisciplinary approaches have compared long-term records of social-ecological stability and change across the US Southwest (Kohler et al., 2012). In the Mesa Verde region, there is a strong correlation between maize-niche size and ancestral Puebloan populations. From 1200 AD, declining maize productivity contributed to food shortages followed by violence and regional social collapse (Schwindt et al., 2016). In the Phoenix basin, Hohokam, communities successfully managed interannual water scarcity using large-scale canal networks. The irrigation capacity they generated for agricultural productivity supported the creation of a regional-scale economy, but over-dependence on a predictable water supply formed *rigidity traps*. Extreme climatic events in the 14th century, including floods that disrupted channel-head connections to the river, devastated irrigation infrastructures that supported agriculture (Nelson et al., 2012). At a broader scale, regional networks became balkanized by social-ecological change, triggering depopulation and the collapse of trade networks. A comparative study by Hegmon et al. (2008) found more rigidly organised settlements—including those of Mesa Verde and the Phoenix Basin—to be more prone to severe transformation than less integrated and less hierarchical societies such as Mimbres (and Zuni; see Speilmann et al., 2016).

These case studies illustrate how unanticipated and unprecedented low-frequency, multiyear drought undermined powerful institutions that managed predictable, high-frequency variability with substantial infrastructure investment (Kennett and Marwan, 2015; Nelson et al., 2012). Systems that attempt to manage social-ecological variation are more likely to become rigid and homogenous (Scheffer et al., 2012; Carpenter et al., 2015). Flexibility and redundancy is integral to social-ecological resilience; helping societies withstand low frequency, high-magnitude events (Carpenter and Brock, 2008). In both Central America and the southwestern USA, medieval climate variability exacerbated food shortage, leading to conflict and the decentralization of power. In the contemporary world, changing patterns of resource access driven by climate have caused human displacement and violent conflict (Barnett and Adger, 2010; Eriksen and Lind, 2009), but there remain major gaps in climate-conflict research—and a timely opportunity for collaboration between GCR and historical disciplines (Solow, 2013; Adger et al., 2013b; Hsiang et al., 2013; Ide, 2015).

3.3. Scenario Planning: Historical Data and QSS

Within archaeology and history, an increasing number of publications consider the use of historical data for scenario-based planning and risk reduction (Riede, 2014b, 2017a, 2017b; Kennett and Marwan, 2015; Rohland, 2017; Adamson et al., 2018). Many suggest that coupled climate models are required to understand human-environment interaction (Riede, 2014a; Palmer and Smith, 2014), but few focus on direct channels of engagement in existing GCR frameworks (Beckage et al., 2018). Qualitative Scenario Storylines (QSS) are used by global change researchers in IPCC reports, to add information about the potential social effects of modelled climate impacts (Rounsevell and Metzger, 2010). The addition of history's long-term perspective would provide valuable extra information on potential outcomes of multiple, complex changes for human populations.

QSS are used to explore uncertainties about the impacts of climate model projections on societal resilience (Rounsevell and Metzger, 2010). The scenario method offers plausible impact narratives in the *storyline* and *simulation* approach (Metzger et al., 2010). In IPCC AR5, a range of temperature and precipitation scenarios are modelled using the Special Report on Emissions Scenarios (SRES) and Representative Concentration Pathway (RCP) frameworks. Model outputs are used to indicate potential social-ecological impacts, such as those from heatwaves, droughts, flooding and land-use change (Kovats et al., 2014). The potential outcomes of model projects are then explored using the QSS method (Rounsevell and Metzger, 2010). For example, temperature and precipitation scenarios have been used to inform potential impacts on the European wine industry (Metzger and Rounsevell, 2011), flood risk (Rojas et al., 2013) and transport and infrastructure hazards (Palin et al., 2013).

Qualitative scenarios are not predictions, but potential outcomes of climate change, based on hitherto observed phenomena (Bryson et al., 2010). Historical data cannot be incorporated in the same way but could have great relevance as 'possibilistic' scenarios (Clarke, 2007; Riede, 2014b).

As some archaeologists have argued, without sufficient time-depth, contemporary scenarios can be constrained by the lack of diachronicity (Redman, 2005). A combination of hazard frequency and how they are remembered—in collective memory and cultural knowledge (Riede, 2017a)—is likely to influence society's preparedness and capacity to absorb and adjust to impacts (Wisner et al., 2004). Icelanders, for example, are alert to the effects of volcanic eruptions on aviation, settlements, and economic activities (Donovan and Oppenheimer, 2011). As a result of both long experience and effective memory (Dugmore and Vésteinsson, 2012), Icelandic society has developed suitable crisis management protocols. In contrast, continental Europe was ill-prepared for the synergistic effects of the 2010 eruption of Eyjafjallajökull, persistent winds towards Europe and limited crisis management (Alexander, 2013). This illustrates a key limitation of short-term datasets—they are unlikely to include synergistic or conjunctive impacts of low-frequency, high-magnitude events (Dugmore and Vésteinsson, 2012; Riede, 2017b). Completed experiments of the past can, however, provide effective knowledge of far-reaching impacts on vulnerable social groups, critical infrastructure and resources systems.

Historical data could be incorporated into QSS as examples of long-term human response to climate impacts. For example, food shortages in the Medieval Norse settlements of the North Atlantic and the pre-Hispanic US Southwest resulted as a consequence of socio-political and demographic instability and limited access to dependable resources (Nelson et al., 2016). In these long-term cases, high adaptive capacity is not equal to low vulnerability. The Greenland Norse, for example, adjusted to declining home-field yields by utilising abundant marine and terrestrial wild resources (Dugmore et al., 2012). Rare periods of climate variation and cooling, however, created unanticipated barriers to domestic and wild resources. Unanticipated hazards, such as these, can also be reinforced by the conjuncture of social, economic and political uncertainty (*see* Box.2). Long-term records could hereby provide qualitative information for considering potential vulnerabilities arising from the interaction of human and biophysical processes.

A New Social Contract for Archaeology and History

There are concerns that GCR requires better communication of 'matters of fact' to reach politically uncomfortable conclusions and cultivate 'solution-oriented' research regarding 'matters of concern' (O'Brien, 2012; Stewart and Lewis, 2017). Designing research that attends to societal concerns and engages with policy-makers, demands changes to practices of GCR (Castree, 2016). These arguments are not new, and stem from earlier calls for a 'social contract in science' that engages with public concerns (Lubchenco, 1998). Disciplinary social contracts have encouraged open-access communication of research (Björk et al., 2010), interdisciplinary collaboration to embolden holistic thinking (Barnes et al., 2013), and problem-based knowledge transfer to policy-makers (Turner et al., 2016).

In environmental archaeology and history, similar questions have been raised, about what historical disciplines can offer and what obligation there is to "engage with debates… at [the] interface between politics, public affairs and science." (Riede et al., 2016a: 1; Armstrong et al., 2017). The (sub)sections that follow form the basis for a 'new social contract'; a two-way movement in GCR and historical disciplines to (i) make use of and apply historical data to contemporary climate-related challenges, and (ii) for archaeology and history to increased engagement with GCR and climate-adaptation research.

Research design and collaboration

A key challenge for global change researchers is to use climate change as an opportunity to engage in new collaborations with archaeologists and historians, and vice versa. Many disciplines, including history and archaeology, already engage in interdisciplinary research with the natural sciences—to understand human interactions with changing environments—and with the humanities—to examine environmental knowledge through art, literature and historical texts (Hartman et al., 2017; Holm and

Brennan, 2018). Existing research frameworks of historical ecology and environmental humanities, have forged integrated projects that combine past climate, environment and human datasets—for example, IHOPE (Integrated History and Future of People on Earth, http://ihopenet.org) and PAGES (Past Global Changes, http://www.pastglobalchanges.org). Organisations such as these aim to build understanding of the past to inform future projections and strategies for sustainability (Costanza et al., 2012), but more could be done to design projects that integrate historical disciplines and GCR.

Field-based research, for example, offers opportunities for engagement across disciplines (e.g. Normand et al. 2017) and with local and indigenous groups (Barnes et al., 2013). Protecting heritage sites from the impacts of climate change—such as rain, frost damage or sea-level rise— is both a cultural and academic concern, and also offers an opportunity to engage and educate the public using tangible evidence of climate impacts on their heritage (Dawson et al., 2017). Likewise, anthropologists (including archaeologists) and geographers can learn from traditional knowledges of climate-adaptation in indigenous communities, such as Inuit communities in the circumpolar north, by engaging in reciprocal information exchange (Ford et al., 2015; Krupnik, 2002).

Historical social perspectives in GCR Journals

While many archaeologists and historians have turned their attention to contemporary climate challenges, their studies still lack visibility in climate-adaptation journals and thus connections with global change researchers. In AR5, for instance, 'historical perspectives' are limited to a single-page box with a broad overview of climate-induced stress in past societies (IPCC, 2014: 920). Historical perspectives of human interactions with environmental change are framed around the 'collapse' thesis and research papers cited in this section are mostly collected from Butzer and Enfield's (2012) special feature in *PNAS* about historical transformation in pre-modern societies. Several historical case studies are cited, but restrictions on space limit a full appraisal of what historical perspectives offer to climate-adaptation research.

Following the lead of Butzer and Enfield (2012), we consider it necessary for historians, archaeologists and anthropologists to publish in high-impact GCR journals cited in the IPCC reports. A challenge in this type of publication is to ensure that papers are framed and written in a suitable way to synthesise historical and natural scientific data into concise research articles that highlight the relevance of long-term perspectives and the lessons learned from past societies (Altschul et al., 2017). This provides some exciting opportunities for new collaborative research between GCR and historical disciplines. Table 1 shows a rank of journals publishing climate-adaptation research. Journals highlighted in dark grey have aims and scope suitable for historical perspectives relevant to global change, and so present a suitable opportunity to enhance these perspectives in GCR and IPCC Assessment Reports.

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Table 1

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GCR and Public Engagement – Museums

In the last 30 years, museums have shifted focus from collection to educational and public engagement (Black, 2005), but focus on contemporary environmental issues remains rare (Payne, 2015). As scientific evidence alone is insufficient to overcome public inaction, public communication and inspiring action requires evidence presented as practical and relatable 'matters of concern' (Marshall, 2011; Stewart and Lewis, 2017). Museums are trusted educational spaces with large public attendance figures (Cameron et al., 2013). The British Museum (6.42M, http://www.alva.org.uk), Smithsonian Museum of Natural History (7.1M, https://newsdesk.si.edu/about/stats) and National Museum of China (7.55M, TEA, 2017) each engaged in excess of 6 million visitors in 2016. But museums continue to play a limited role at engaging the public with the human impacts of climate change (Rees, 2017; Cameron et al., 2013). Cultural history museums have the potential to exhibit meaningful information (matters of fact and concern) to the public because they communicate tangible stories—using material evidence—of human history (Hebda, 2007).

Cultural history museums could seize a much-needed opportunity to use their potential as spaces for critical thinking about current societal concerns (Cameron, 2011; Sandell, 2011), rather than following linear narratives—such as the rise and fall of civilizations. Material artefacts together with historical research have been used to construct accessible climate narratives, offering 'windows into the past' (Hebda, 2007: 329). The 'Mild Apocalypse' exhibition at Moesgaard Museum (Denmark), for example, invited visitors to explore artefacts dating from the 1950s 'golden spike', as an entry point into the Anthropocene debate (Riede et al., 2016b, http://anthropocene.au.dk/exhibitions/mild-apocalypse-2016/). Exhibitions at Moesgaard Museum use multi-media displays to examine material artefacts. This is also an essential tool for communicating climate-impacts and adaptation. The *Preserving Maya Heritage* project between the British Museum and Google Arts and Culture, used virtual reality to engage the public with archives and 'what the Maya story tells us about global warming and urbanisation' (https://artsandculture.google.com/theme/HgIy1yrF4KwFJg). Narratives and storylines that trace human interaction with climate, and its punctuated history, have been widely discussed (Nikoleris et al., 2017), but have seen little explicit application in museums (Cameron et al., 2013). This presents a major opportunity to communicate matters of concern through themed exhibitions showing diachronic evidence of socio-cultural and environmental change imprinted on materials, texts and other records.

Conclusion

To date, historical perspectives have limited influence in GCR, and this seems to relate in part to the disjunction between pre-industrial and modern societies, and the limited visibility of historical data to global change researchers. Historical data has the potential to offer lessons and practical examples for scenario planning, but to offer this critical perspective research must be more visible to key audiences: global change researchers, policy-makers and the public. To promote this, we suggest a social contract is necessary, a two-way movement in GCR and historical disciplines to make use of and apply historical data to contemporary climate-related challenges, in order for (1) for new collaborations between the humanities, social sciences, natural sciences to engage archaeologists and historians and to connect with the public, (2) to gain visibility for historical perspectives by targeting high-impact climate-adaptation journals, cited in the IPCC reports and across GCR, and (3) to communicate GCR through museums of cultural history to offer the public critical and tangible evidence of climate-adaptation and human modification of environments over human history.

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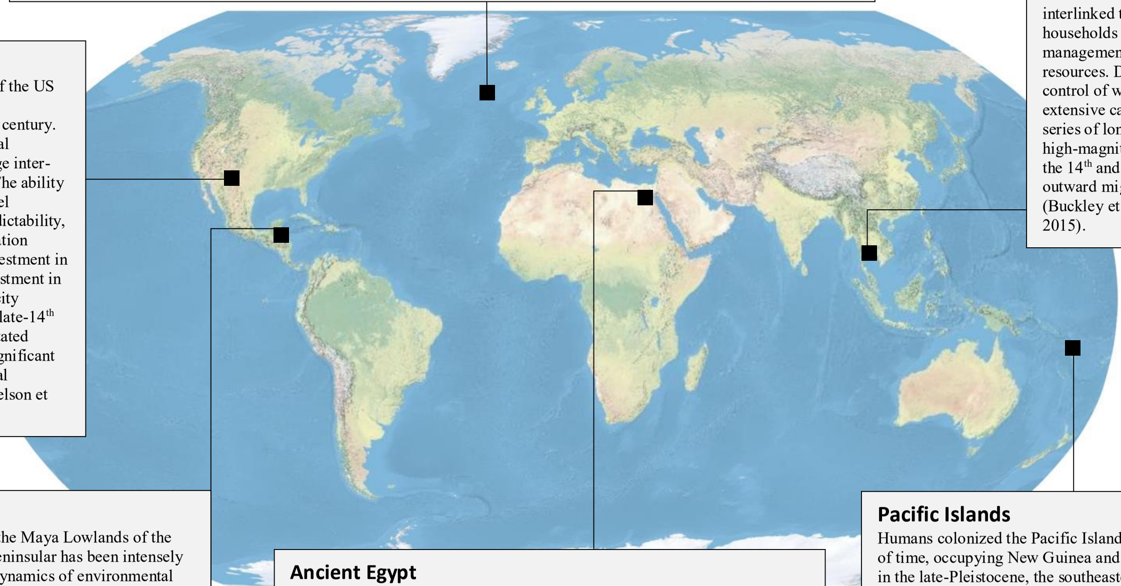
Box 1



North Atlantic Settlements

The Norse settled the North Atlantic islands in the 9th and 10th centuries. Settlements on the Faroe Islands and Iceland persist to this day, but the Greenland settlement came to an end some time in the late 15th century. A conjuncture of exposures to changing climate, environmental conditions and economic isolation from Europe undermined attempts to adapt subsistence to changing resource systems and vulnerabilities created by successful prior adaptations (Dugmore et al., 2012).

Angkor

Greater Angkor, located in modern Cambodia, was a vast low-density urban complex with an extensive hydraulic network established by the Khmer rulers. The canal network interlinked temples, shrines and households and enabled the management and storage of water resources. Despite the physical control of water resources using extensive canals and reservoirs, a series of long, severe droughts and high-magnitude monsoons between the 14th and 16th centuries, triggering outward migration and abandonment (Buckley et al., 2014; Fletcher et al., 2015).

US Southwest

The late pre-Hispanic settlements of the US Southwest experienced large-scale demographic changes from the 13th century. In the Hohokam, investment in canal irrigation allowed farmers to manage inter-annual variations in precipitation. The ability to manage high-frequency, low-level droughts increased subsistence predictability, triggering inward migration, population increase and concentration, and investment in public infrastructures. But overinvestment in this technology to abate water scarcity reduced system redundancy. In the late-14th century, extreme streamflow devastated irrigation infrastructures causing significant resource pressure leading to regional depopulation in the 15th century (Nelson et al., 2012).

Ancient Maya

The so-called collapse of the Maya Lowlands of the Mesoamerican Yucatán peninsular has been intensely debated for the complex dynamics of environmental change, degradation, resource management, socioeconomic change, conflict and governance. The coincidence of intensified resource use and amplified aridity with socioeconomic change is a likely cause of social conflict and reduced control of the Mayan elite. In the 9th century, Central Maya was abandoned (Turner and Sabloff, 2012).

Ancient Egypt

Collapse in the old kingdom of Ancient Egypt resulted from a combination of complex sociopolitical, economic and environmental triggers leading to rapid social and political transformations. Failure of the Nile basin to flood between 2000 and 1800 BCE is was a likely cause of subsistence stress. This in turn caused economic decline and conflict among elite groups, which undermined royal authority and triggering the end of the sixth Dynasty (Butzer, 2012).

Pacific Islands

Humans colonized the Pacific Islands over an extensive period of time, occupying New Guinea and the Bismarck archipelago in the late-Pleistocene, the southeastern Solomon Islands from 2000 BC and the remote southwestern archipelago from 1300 BC. The complex process of colonization and colonial occupation have stirred intense academic debate over the degree of environmental degradation caused by pre-European settlers, especially in the case of the Easter Islanders' who, according to some scholars (such as Jared Dimaond), degraded their resource base leading to social conflict.

Box 1: An example of a global perspective on climate change adaptation in the past. Here we offer just a few examples, but archaeological and historical data has the potential for long-term global coverage. *Base map: World Physical Map [US National Parks Service] created using ArcGIS® software by Esri.*

Box 2 *Integrated Historical Research in the North Atlantic Context*

Integrated historical research in the North Atlantic can help us address research questions about long-term climate impacts, cultural limits to adaptation and exposures to multiple climate-related environmental and socio-political challenges. Treating these examples as 'completed experiments' of the past offers empirical evidence of extended exposure to social and environmental stressors. Examples such as this could offer scenarios of political, economic and environmental uncertainty that are equally possible in integrated market economies.

Norse societies in Greenland and Iceland, both settled in the Viking Age (793-1066), had a shared cultural and biological heritage (Jesch, 2015). Icelandic society has survived environmental, economic and demographic transformations to become a highly developed 21st century economy (Karlsson, 2000). Norse Greenland, by contrast, came to an end in the mid-15th century (Arneborg, 2003). Evidence of the impacts of climate on subsistence/resource management have become increasingly resolved through modern archaeological investigations and climate reconstructions (Hartman et al., 2017). Zooarchaeological studies and stable isotope analyses provide evidence of a changing diet at the settlement scale—evidence of adaptation to food scarcity (Smiarowski et al., 2017; Arneborg et al., 2012). Multidisciplinary studies have combined human-scale data from Greenland with regional-scale environmental and political-economic data. This suggests that the Norse became increasingly dependent on a narrow marine-focused diet, which increased vulnerability to food shortage in the mid-15th century (Nelson et al., 2016). Historical evidence indicates that this coincided with Greenland's isolation from the Norwegian crown, an essential trade partner, as walrus ivory become devalued on European markets (Frei et al., 2015). The combination of declining food security with economic isolation to support subsistence failure left the Norse with few options in the 15th century. Modern societies could learn from such scenarios playing out in contemporary political economies. Declining trade, energy security and political instability at national and regional scales, in tandem with the social and physical impacts of climate change, could present major adaptive challenges for policy and governance.

In the last 10 years, researchers from the North Atlantic Biocultural Organisation (NABO) have increased engagement with global change researchers; examining historical data through concepts of 'human security' (Dugmore et al., 2013; O'Brien et at., 2013), social and cultural limits to adaptation (Dugmore et al., 2009; Adger et al., 2009), and multiple exposures (Dugmore et al., 2012; Liechenko and O'Brien, 2008). North Atlantic researchers have applied GCR concepts to studies of the past to better understand complex human-environment interaction and, in turn, to extend the scope of human climate-adaptation using deep-time perspectives. Contemporary studies, for example, warn that exposure to multiple stressors are likely to produce winners and losers as societies experience global environmental change (O'Brien and Liechenko, 2000). In Medieval Greenland, the climate-economy conjuncture undermined the capacity of Norse settlers to adapt subsistence and resort to imports for food provisions (Dugmore et al., 2012). This lesson from the Greenland case is although the Norse adjusted to climate change, cultural practices limited the level of adaptive flexibility in response to climate volatility and economic change.

North Atlantic researchers have more recently outlined channels for integration with global change research programmes (Hartman et al., 2017; Holm and Brennan, 2018). Integrating research from a number of disciplines and spatial-temporal scales has provided opportunities for long-term analysis across local and regional scales (Hambrech and Rockman, 2017). Long-term historical-archaeological records and historical literatures have been combined with natural and earth science data to understand how humans understood environmental change and influenced terrestrial and marine environments (Kwok, 2017).

IPCC AR5 WG2 Part A – Global and Sectoral Aspects			Scopus Search			Journal	Overall Rank
Rank	Journal Name	Citation Frequency	Rank	Journal Name	Publications: ‘*adapt*’ & ‘Climate Change’		
1	*Climatic Change*	481	1	*Climatic Change*	648	*Climatic Change*	1
2	*Global Environmental Change*	426	2	*PLoS ONE*	378	*Global Environmental Change*	2
3	*PNAS*	267	3	*Global Environmental Change*	326	*PLoS ONE*	3
4	*Global Change Biology*	260	4	*Regional Environmental Change*	289	*Global Change Biology*	3
5	*Nature Climate Change*	175	5	*Global Change Biology*	288	*PNAS*	5
6	*Mitigation & Adaptation Strategies for Global Change*	116	6	*Mitigation & Adaptation Strategies for Global Change*	286	*Mitigation & Adaptation Strategies for Global Change*	5
7	*PLoS ONE*	83	7	*Environmental Science & Policy*	211	*Regional Environmental Change*	7
8	*Environmental Science & Policy*	80	8	*Climate & Development*	182	*Environmental Science & Policy*	8
9	*Ecological Economics*	75	9	*PNAS*	167	*Climate & Development*	9
10	*Regional Environmental Change*	70	10	*Climate Research*	165	*Nature Climate Change*	10
11	*Climate Research*	66	11	*Forest Ecology & Management*	158	*Climate Research*	10
12	*Natural Hazards*	58	12	*Ecology and Society*	152	*Climate Policy*	12
12	*Climate Policy*	58	13	*Shengta Xuebao Acta Ecologica Sinica*	131	*Ecology and Society*	13
12	*Climate & Development*	58	14	*Climate Policy*	124	*Natural Hazards*	14
15	*Ecology and Society*	54	15	*Environmental Research Letters*	121	*Wiley Interdisciplinary Reviews: Climate Change*	15

Table 1: Journal citation frequency analysis of IPCC Assessment Report 5, Working Group 2, Global and Sectoral Aspects and journal publication frequency in Scopus research results [TITLE-ABS-KEY(“*adapt*” AND “climate change”)]. Using a comparative methodology for selecting high-impact climate change adaptation literatures applied by Bassett and Fogelman (2013) and Lorenz et al. (2014), journal citation and publication results were ranked and an average rank across both fields was used as a measure of impact. Journals in dark grey have sufficient aims and scope and publication history to include historical perspectives.