Success and Failure in the Norse North Atlantic: Origins, Pathway Divergence, Extinction and Survival

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Abstract In this chapter, we examine the iconic disappearance of the Medieval Norse Greenlanders and use qualitative scenarios and counterfactual analysis to produce lessons for policymakers. We stress the role that archaeologists and historians have in adding context to contemporary social and environmental challenges and use human-environmental histories as 'natural experiments' with which to test scenarios. Rather than drawing direct analogies with discrete historical case studies

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such as Norse Greenland, such cases form complete experiments with which to ask ‘what if’ questions and learn from a range of real (retrofactual) and alternative (counterfactual) scenarios. By testing a range of scenarios associated with climate impacts and adaptive strategies, evidence from the past might be used to learn from unanticipated changes and build a better understanding of theory and concepts, including adaptation and vulnerability, and their application to the present. The Norse Greenland case study illustrates an important lesson for climate change adaptation scenarios; even a highly adaptive society can, over the course of several centuries, reach limits to adaptation when exposed to unanticipated social and environmental change.

Introduction

The prospect of ecological or even societal collapse has become a common post-millennium discourse in western media (Diamond 2005; Vogelaar et al. 2018). Ecological collapse, resource conflict, existential risk, and social and ecological breakdown are common headlines in environmental columns and increasingly popular in academic discourse (Hulme 2008, 2016; Bostrom and Cirkovic 2011). But in spite of the increased attention to divergence from historical trends, such as species extinction (Ceballos et al. 2015, 2017), it is only in recent years that the disciplines of history and archaeology have gained attention in global change research (GCR). As Ortman (2019:1) explains, this is unsurprising seeing as it is only in recent years that “archaeologists have conducted research that is explicitly designed to address contemporary issues” (see also Jackson et al. 2018a). However, this does not mean archaeological and historical research traditions have been solely focused on the past. These research traditions have always been influenced by contemporary issues—influencing interpretation and knowledge production—and have sought to contextualise relevance through analogy and the identification of historical antecedent (cf. Lucas 2019; Cronon 1992). Instead, since the turn of the millennium we have seen archaeological research highlight the concept that, while the past may provide far from optimal analogues to current and future trends, these new social-ecological developments and attendant crises can be influenced by processes similar to those experienced by societies in the past (Dawdy 2009; Riede 2017; Hartman et al. 2017). Metaphors such as ‘laboratory of the past’ have highlighted the utility of historical and archaeological data as ‘completed’ natural experiments (Diamond and Robinson 2010; Riede 2014) with which to test the impacts of environmental hazards and climate variability on a range of different societies, each with their different cultural capacities and limitations (Dugmore et al. 2012; Dow et al. 2013; Spielmann et al. 2016; Nelson et al. 2016). It is our argument, however, that attempts to develop a more

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robust, practical framework for archaeological 'relevance' have been undermined by the deterministic nature of collapse discourse itself when considered in light of its most popular tropes, their uses and abuses. While the discourse has appeal to funding bodies its utility in helping to identify lessons from the past relevant to contemporary climate adaptation is not sufficiently established, nor particularly promising when envisaged in terms of case-to-case correspondence.

In this chapter, we recontextualise the Norse Greenland case study in its wider North Atlantic context to highlight the opportunities and limitations of using archaeology and other palaeo-sciences to find solutions to contemporary environmental and social challenges. We stress the utility of "qualitative scenario storylines" (Rounsevell and Metzger 2010)—an approach used in predictive modelling—to provide a structured method for archaeologists to construct possibilistic futures, while avoiding environmental determinism or reductive historical analogy (Riede 2019; Jackson et al. 2018a).

The Archaeological Science-Policy Interface

Recently, archaeological and historical researchers have highlighted the need to contribute datasets that link human and environmental processes and contribute to our understanding of global change (Riede 2014; Hartman et al. 2017; Hambrecht et al. 2018; Haldon et al. 2018; Ortman 2019). This goes beyond narratives that highlight lessons through broad literature reviews (for example Diamond 2005; Tainter 1988; Middleton 2012). Instead, researchers have adopted the language of global change research—particularly the human dimensions of global change (i.e. adaptation, vulnerability, resilience)—and have drawn parallels between contemporary challenges and evidence derived from historical and archaeological datasets (see for example ARCUS 1997; Sigurðardóttir et al. 2019). However, to gain purchase in policy arenas, historical sciences (including archaeology) need to draw clearer attention to relationships between evidence and specific policies—in other words, avoiding generalisation and delivering clear results (Cairney and Oliver 2020; Cairney 2016).

As Cairney and Oliver (2020) explain, there is a tendency across academic sciences to produce generalised advice that is of broad application. This generic advice has limited relevance to policy and policymaking, because it lacks contextualisation and a clear application (Boswell and Smith 2017). The challenge for historical sciences is, therefore, to show how historical data can be applied within a decision-making context while avoiding ideological biases (Cairney 2018), misconceptions or other problematic interpretations of history. Attention can be directed to historical information by problem-based research that targets specific challenges and supports policy solutions with historical evidence (Oliver and Cairney 2019). But to get here, archaeologists and historians will need to avoid the headline-grabbing narratives of collapse.

Problems of Collapse Discourse

Controversies arise from the identification of past social ‘collapse’ associated with different theoretical perspectives and whether a ‘grand’ unifying theory can explain why societies came to an end. Diamond (2005) frames collapse in terms of geographical and environmental determinism whereas Tainter (1988, 2006) frames collapse as a loss of socio-political complexity. Such theories have attracted vigorous academic debate and gained much wider attention for their focus on environmental and social determinants of population and institutional change (Butzer 2012) but they do not focus on the value of the archaeological record or expertise in the historical sciences, nor the (transient) role of archaeology in constructing the past (Lucas 2001, 2005). Archaeologists interweave multiple strands of evidence to produce narratives, often spanning extensive timescales (Gamble 2007). Archaeological information is derived from a combination of, or triangulation among, historical documents, archaeological contexts and environmental records (Lucas 2010). Although there is often a significant degree of uncertainty, the complex relationship between socio-culture and environmental change can be interpreted through the evaluation of multiple lines of physical evidence, written sources, ethnographic parallels and argument by analogy (Currie 2016). The relationship between human behaviour and the wider context of social, economic, political and environmental change can reveal multiple different scenarios that are unique to each case but can offer insights into overarching themes, such as the consequences of hierarchy, inequality, opportunity costs, and food insecurity (Vesteinsson et al. 2019; Hambrecht 2018; Nelson et al. 2016).

While this information has the potential to inform adaptation theory, the literatures that have received the greatest attention—including historical and archaeological literatures that feature in the IPCC reports—are those that fall within the ‘collapse’ genre (Kohler and Rockman 2020). Middleton (2017, 2018) has noted a burgeoning literature on what he terms ‘collapsology.’ He also notes the significant appeal of this literature across civil society and academia for the hyperbolic parallels that are often drawn between catastrophic climate impacts or other environmental hazards that face us today (Middleton 2012). However, the events described as collapse are rarely clear cut and the vague definitions used to explain all-encompassing social and environmental changes over extended periods of time cannot do justice to the nuance of human agency and decision-making when experiencing environmental change. Many archaeologists have critiqued the representation of collapse in the archaeological record, and question whether the term carries sufficient clarity as an academic concept (McAnany and Yoffee 2010; Vésteinsson 2013; Aimers 2007; Middleton 2012, 2017).

In light of these critiques, collapse can be understood as a metaphor that appeals to contemporary society’s ‘climate of fear’ about future uncertainty but provides little evidence about ‘the direction of history’ (Popper 1957: 160) and humanity’s destiny (cf. Hulme 2008, 2011). Collapse does not adequately describe the complex relationship between resource systems, demographic trends, and cultural adaptations, but operates as a heuristic for uncertainty, the end of a society or a sudden loss of socio-political complexity or population decline (Vogelaar et al. 2018; Middleton 2012, 2017; Tainter 1988). Vésteinsson (2013) has noted this recent trend in popular and academic discourse and adopts the polemical position that there is no such thing as collapse. For Vésteinsson, collapse as an idea fails to clarify what happened in the 'end game', in the years and decades preceding the putative transformative changes, and how humans attempted to respond to environmental challenges, which renders the concept unfit for purpose in historical disciplines. Recently, archaeologists have sought to distance themselves from notions of collapse—opting for concepts such as resilience and transformation to emphasise the human capacities to respond to change (McAnany and Yoffee 2010; Butzer and Enfield 2012; Strickland et al. 2018). Indeed, the lack of agency granted to human communities in deterministic narratives of environmental change is one of the most often-voiced critiques in takedowns of the collapse concept.

How Are Archaeological Data Useful Now?

Recent publications in archaeology and the palaeo-sciences have outlined the significant potential that long-term data have to improve our understanding of human impacts on ecosystems and how societies have responded to changing environmental conditions (Dunne et al. 2016; Boivin et al. 2016; van de Noort 2013). The application of these data can be divided into two categories associated with the (dis)continuity of data with the present day. First, archaeological data provide a long-term record of human–environment interaction and with it a continuous record of human impacts on the environment (Armstrong et al. 2017; d'Alpoim Guedes et al. 2016; Stephens et al. 2019). Archaeological and environmental data therefore provide an essential record of the human influences on ecosystem structures (Kwok 2017; Boivin et al. 2016) and impacts on the climate (Koch et al. 2019). In order to correlate human–environment interaction across regional-scales, and to compare the effects of human impacts and adaptation, Hambrecht and colleagues (2018) suggested compiling palaeo-environmental and palaeo-societal data to compare impacts on the environment (Fig. 1) with the most intimate association observed in site stratigraphies. Collectively, human and environmental datasets represent the long-term impacts humans have had on their environments, whether through vegetation clearance and cultural niche modification or the overhunting and extirpation of targeted species (Boivin et al. 2016; Ellis 2011). These so-called deep-time, spatially extensive datasets can be used to reconstruct human societies' long-term impact on biodiversity and ecosystem structures (Hambrecht et al. 2018). For example, long-term fishing data from west and northeast Iceland have been used to reconstruct human impact on Atlantic cod stocks (Edvardsson et al. 2019). These data can be used to reconstruct accurate environmental baselines and provide a key to the effective management and conservation of fish stocks and marine environments (Hambrecht et al. 2018; Kwok 2017).

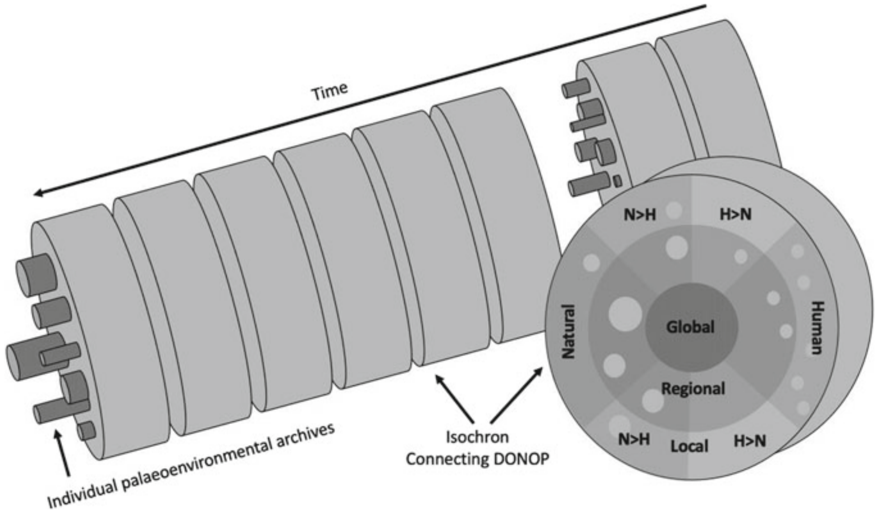

Fig. 1 Schematic representation of human and environmental datasets within Distributed Observing Networks of the Past (DONOP). Regional-scale datasets refer are more natural than human and local-scale datasets include evidence of human activity and human remains themselves (adapted from Hambrecht et al. 2018). The combination of human and environmental datasets, each with their own spatial reach, allow a reconstruction of human interaction with the environment using multiple stands of evidence

Human impacts on global environments and atmospheric chemistry have driven a rapid acceleration of warming in the Arctic and Sub-arctic, causing permafrost to thaw and records of material culture to degrade (Hollesen et al. 2015, 2016, 2017). In addition, there are now enhanced threats and impacts from flooding, fires and weathering across historical sites (e.g. Historic Environment Scotland 2019; McCaughie et al. 2020) and increased storm intensity and sea-level rise that is threatening and destroying ever more coastal heritage sites across the world (Dawson et al. 2017). Collectively, the destruction of cultural records has been termed ‘burning libraries’ (McGovern 2018), as ever greater proportions of limited, finite records of past environments and human history are lost forever. The destruction of archaeological heritage does not, however, represent solely a loss of data but also has a lasting impact on communities’ sense of place and local identity (Harvey and Perry 2015).

A significant amount of archaeological information has no continuity with the present, making the interpretation of activities and beliefs more difficult—especially with the absence of historical records. Cases of collapse, by their nature, imply a discontinuity with preceeding historical periods, which raises questions about what and how we, in the twenty-first century, can learn. One argument is that archaeological data can provide discrete records of putative limits to human adaptation and potentially identify critical degrees of vulnerability to impacts of social and ecological changes (Costanza et al. 2007; Dugmore et al. 2009). Because there is a lack of continuity with highly industrialised modern societies, these case studies cannot

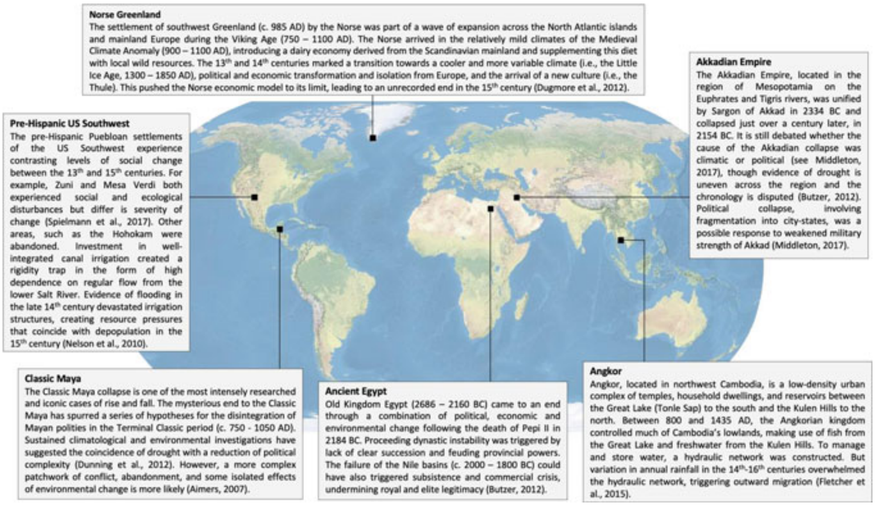

Fig. 2 Selected cases of so-called 'collapse'. These cases are selected for the influence they have had on collapse discourse and for featuring in major institutional reports, such as the IPCC Assessment Reports. Such cases provide records of human adaptation and vulnerability to environmental change (Adapted from Jackson et al. 2018a)

provide direct analogues for contemporary adaptation to environmental change. These cases do, however, provide experiments with which to understand processes, examine the dynamics of relationships between societies and environments, identify 'perfect storms' leading to collapse, learn lessons and test scenarios. Figure 2 presents six well-known cases of societal collapse (Jackson et al. 2018a). These cases feature prominently in the archaeological literature and have also played an increasing role in climate adaptation literature. Three of these case studies (Greenland and Iceland, Classic Maya, Ancient Egypt) featured in the Fifth Assessment Report of the IPCC (Working Group Two); however, it was not clear from these cases what 'relevance' historical and archaeological data has to the challenge of adapting to climate change (IPCC 2014: 920).

Climate change archaeology, a growing sub-discipline in archaeology, has developed into a broad literature that intersects with various challenges in global change and natural hazards research (Van de Noort 2011, 2013). Researchers have highlighted the potential for archaeology to contribute using its extended chronological scope on human adaptation (Riede 2014; Redman 2005) and to develop more holistic understanding of human–environment interaction over multi-generational to millennial timescales (Barnes et al. 2013; Hudson et al. 2012). However, what these studies have not addressed is how archaeology can contribute pre-modern data to social and environmental challenges that have no analogue in human history.

To resolve the discontinuity between pre-industrial and industrialised modern societies we argue that archaeological and historical records should be used as 'natural experiments' with which to examine the process of human adaptation and manifestation and implications of vulnerability. Examining the long-term human experience of social inequality, food insecurity, health inequality and numerous other social indicators can provide enhanced evidence of the potential synergistic social impacts of climate variability and environmental change (Hegmon 2016; Hegmon et al. 2018). Such information could be useful in scenario-building exercises, as longer timescales allow long-term processes to be examined across numerous case studies at multiple spatial scales over human history (Costanza et al. 2007; Fig. 2).

Getting Beyond Collapse?

In the last 5 years, future studies have grown significantly as a subdiscipline within the social sciences and humanities, exploring the potential impacts of technological change, natural hazards and climate change on society and the environment (Bostrom and Cirkovic 2008; Oreskes and Conway 2013; Urry 2015). New research centres dedicated to future studies and existential risk, including the Centre for Existential Risk (University of Cambridge), the Future of Humanity Institute (University of Oxford) and the Humboldt Forum (Berlin), have emerged with an explicit focus on major challenges facing humanity in the future (Bostrom 2013). The core research themes at these organisations encompass 'high impact/low probability' events, social interaction and disease, and catastrophic climate change and ecosystem collapse (https://www.cser.ac.uk/research/). Connection to other research communities focusing on the contemporary study and probability of societal risk offers significant ground for collaboration among academia, policy and industry (Urry 2011, 2015).

IHOPE (Integrated History and Future of People on Earth https://ihopenet.org/), a partner with Future Earth (https://futureearth.org/), has sought to highlight the importance of demonstrating the importance of the past to the future of human societies and ecosystems. Researchers in this network have demonstrated the relevance of historical and archaeological data for understanding global environmental change today, making use of the diverse tool kit of Historical Ecology (Meyer and Crumley 2011). To understand the environmental challenges today, so they argue, it is important to understand the role of domestication in land-use change (Boivin et al. 2016; Ellis 2011), uncovering long-term cultural traditions associated with food culture (Sykes 2014), reconstructing trade networks and the (over-)exploitation of marine and terrestrial species (Hambrecht et al. 2018) and understanding the long-term impacts of environmental change on the vulnerability of human communities (Nelson et al. 2016). Importantly, several IHOPE affiliated projects work directly to bring archaeological, historical, and traditional knowledge perspectives to bear on current and future land use and resource management issues (e.g. the *Herring School and Clam Garden Network* https://ihopenet.org/herring/, Thornton et al. 2010, also Peloponnese Project https://ihopenet.org/peloponnese/ Kaplan et al. 2012).

Human Ecodynamics Perspectives in the North Atlantic and Beyond

In the past 15 years North Atlantic and North Pacific researchers have increasingly adopted the perspectives of *human ecodynamics* to recognize and better articulate complex long-term interactions of humans, landscapes, and climate in the circumpolar north (Fitzhugh et al. 2019). This approach makes use of resilience discourse and the interdisciplinary tool kit of historical ecology, and from these perspective addresses questions of comparative social/environmental transformations (fast and slow, "painful" and advantageous: Hegmon et al. 2013). Particularly productive systematic human ecodynamics comparisons of contrasting cases from the American Southwest and the North Atlantic took place during 2012–18 through a series of workshops and joint meetings between teams from NABO (www.nabohome.org) and the *Long Term Vulnerability and Adaptations* project (https://ihopenet.org/southwest-us/) based at Arizona State University. These cross-regional comparisons of long-term outcomes (including 'full on collapse', 'painful transitions', and 'successful adaptation with costs') provided some valuable metrics on human vulnerability and adaptation to climate change in both desert and low arctic conditions (e.g. Nelson et al. 2016, 2017). These perspectives, as Nelson et al. (2017) argue, have the potential to inform food security planning in the IPCC reports and local adaptive management strategies. An increasing number of archaeologists and historians in different areas making explicit or implicit use of the human ecodynamics approach have sought to emphasise the explicit 'relevance' of archaeological and environmental records as deep-time experiments with which to test impacts and adaptation to climate change (Butzer and Enfield 2012; Hudson et al. 2012; Jackson et al. 2017; Riede 2017; Richer et al. 2019; Riede and Sheets 2020). The role of the North Atlantic cases (and especially the controversial collapse of Norse Greenland) in placing the perspective of long term human ecodynamics within the viewshed of groups like the IPCC represents real progress beyond the simple determinism of Diamond's 2005 account and reflects the power of interdisciplinary integration to tell stories that engage and inform on multiple levels. Can we do better in telling complex stories of humans, landscapes, and historical processes?

Qualitative Scenarios Storylines and Collaborative Conceptual Modelling

Collaborative conceptual modelling (CCM), a systems process used to map complex social-ecological feedbacks, is one such method allowing the consilience of archaeological data with existing methods of scenario planning (Newell and Proust 2019). CCM is a transdisciplinary approach that aims to bring together experts from within and outside the academy towards a common dialogue. By exploring potential threats using extended scenario storylines that incorporate historical datasets, the scope of scenarios and potential risks could be explored in further detail (Jackson et al. 2018a; Riede and Jackson 2020). Although the social impacts of environmental change and natural hazards is likely to be different to observations in pre-modern records, historical datasets provide natural experiments that can be contextualised with contemporary social-ecological systems.

The CCM process, as described by Newell and Proust (2019), involves six stages of dialogue to conceptualise possible futures (Table 1). In this six-stage dialogue, archaeologists and global change researchers together with policymakers and practitioners could work in dialogue to map the long-term effects of environmental challenges, such as climate change, food insecurity, seismic activity or volcanism, in a given regional context (Newell and Proust 2019; Riede 2017). By developing an effective inter- and transdisciplinary dialogue, there is greater potential to explore the strengths and limitations of historical data for understanding contemporary challenges. Effective scenarios are required if societies are to anticipate and adapt to the future impacts of climatic and environmental change. Representative concentration pathways (RCP) are one such way to project the possible outcomes of different emissions scenarios—with results showing the radiative forcing in W/m^2 (van Vuuren et al. 2011)—and are used, in turn, to project emissions scenario storylines (Rounsevell and Metzger 2010). The outcome of these scenarios is subject to further scenarios based on knowledge of the cause-effect relationship between biophysical

Table 1 Collaborative conceptual modelling process using historical evidence in Norse Greenland

What are the challenges?	Adapting to a cooler and more variable climate, adjusting to changing markets in continental Europe, coping with population decline, managing erosion and soil nutrient depletion, contact and potential hostilities with the Thule culture
What are the stories?	Evidence of successful colonisation, evolving adaptation to sub-arctic resource system and variable climate over multi-century timescales, but Norse society ultimately comes to an end in Greenland
Can I see how you think?	The dual challenge of recognising the relevance of environmental, historical and archaeological knowledge as an integrated evidence base that informs scenario development
What are the drivers of system behaviour?	Climate variability, political and economic change, human migration; system inheritance and inequalities between generations
Where are the leverage points?	Counterfactual strategies for negotiating environmental and social change
What future can we see?	Use of completed experiments to identify path dependency and potential rigidity traps, imagine alternative approaches to change, structure plausible scenarios and strategic responses to climatic, social, political and economic exposures in the future

and social systems. For example, the impacts of precipitation change on the French wine industry are then subject to understanding drivers, impacts/challenges and leverage points, if the industry is to adjust to different climatic conditions (Metzger and Rounsevell 2010).

Archaeologists and historians have potential to contribute a structured understanding of capacities and limitations created by a range of scenario storylines. As Dugmore and Vésteinsson (2012) have explained, historical context is essential information for understanding volcanic hazards. Discrete examples at the landscape-scale of both impacts and the absence of impacts of volcanic eruptions in Iceland, they argue, provide important lessons concerning processes of change, various forms of resilience, complex feedbacks and perceptions of risk in response to a range of eruption events. Such examples are essential to understanding volcanic hazard-risk and planning response strategies in areas prone to volcanic events (Donnovan and Oppenheimer 2010). However, historical information has been less influential in contemporary climate risk planning—a subject that has more recently gained attention in global change research (see, for example, Ford et al. 2018; Thomas et al. 2019).

For lessons about climate variability and food security, the Norse Greenland case study can provide important information about how vulnerability is assessed in the long-term (Nelson et al. 2016). Ford et al. (2018: 198) have acknowledged the need for climate change adaptation literatures to expand its scope to "focus on the long-term historic processes creating vulnerability [which] is essential for developing a richer understanding of the dynamics that shape vulnerability, representing a set of completed historical experiments on climate-society interactions". In what follows, we use the CCM approach, described by Newell and Proust (2019), to identify lessons that could have a bearing on future climate risk scenarios—bringing together a richer understanding of the long-term processes shaping vulnerability to climate change.

Norse Greenland

Using the CCM framework, we can start by identifying the challenges facing Norse society in Greenland between the tenth and fifteenth centuries. An evaluation of publications on Norse Greenland since the 1980s reveals three challenges facing Norse society: increased climate variability from the mid-thirteenth century (Dugmore et al. 2007b); European economic and world systems change from the fourteenth century (McGovern 1985, 1994); and cultural contact and potential hostility with Thule cultures (Gulløv 2008). These are similar challenges to those facing societies today, with the dual threats of climate variability and economic stagnation facing numerous societies in tandem (O'Brien and Liechenko 2000; Liechenko and O'Brien 2019). Expansionist activity, conflict and hostility are further challenges to human security and can be exacerbated by economic stagnation and climate variability (Barnet and Adger 2007; Hsiang et al. 2013).

The mysterious, unrecorded end of Norse society in Greenland, and the persistence of Icelandic society, has been discussed at great length in both academic and mainstream literatures (Buckland et al. 1996; Barlow et al. 1997; Ogilvie 1998, 2016, 2019). As discussed earlier in this chapter, common criteria for collapse, such as that set out in Jared Diamond's *Collapse,* are reflected in a mainstream discourse of fear about climate (Hulme 2008). Collapse has become a panacea for societal challenges today (Diamond 2005), where a nuanced narrative that exposes adaptive success and failure would be more appropriate (McAnany and Yoffee 2010; Dugmore et al. 2009). Focusing on why certain decisions were taken (*retrofactuals*) and why others were not taken (*counterfactuals*) is more revealing of the interplay between capacities and limits of past societies, such as Norse Greenland.

The Norse established two settlements in Greenland—the Eastern and Western Settlements—in the late tenth century. Recent interdisciplinary research has indicated that Norse settlement of Iceland ca. 880 involved intensive walrus hunting for low bulk/high value that may have depleted the native Icelandic walrus population, leading to hunters and their patrons moving to Greenland ca. 985 (Frei et al. 2015; Keighley et al. 2019). Available pastureland would have been an opportunity for chieftains to claim and award land, establishing status in the process; and walrus and other arctic exotica offered high-value commodities to trade with Europe (Vésteinsson et al. 2002; Roesdahl 2008). In the past decade, systematic GPS high resolution survey combined with a large-scale radiocarbon dating program has allowed for the development of a three-phase settlement model (Madsen 2014, 2019). The *settlement and expansion* phase (ca. 985-1160 CE) saw the initial establishment of farms and shielings in the inner fjords of the Eastern Settlement in the southwest (modern Kujalleq district) and in the smaller Western Settlement further north (modern Nuuk district). Settlement stimulated immediate localised erosion and initiated hydrological responses through vegetation cover change on what was a stable landscape. Subsequent landscape stabilization during this early phase indicates recognition and adaptation to these human mediated changes to local environments (Ogilvie et al. 2009; Golding et al. 2015). While Greenland apparently did not attract the large and rapid influx of settlers seen in Iceland (Lynnerup 1998, 2014, Vésteinsson and McGovern 2012) population growth expanded settlement into the highlands and outer fjord areas, eventually filling in virtually all areas with patches of vegetation suitable for pasture. Christianity arrived with first settlement, and a pattern of small turf and stone churches and churchyards was established. The distinctive Greenlandic subsistence economy combining sheep, goat, and cattle husbandry sustained over winter by fodder gathering and production of higher quality fodder from small fertilized and irrigated homefields (Adderley and Simpson 2006). This was integrated with caribou hunting and extensive sealing, fully established early on, as was the hunting of walrus for ivory and hide that attracted transatlantic trade (Smiarowski et al. 2017). By ca 1123 Greenlandic chieftains felt prosperous enough to exchange a polar bear for their own bishop from the King of Norway.

The following *consolidation* phase (ca. 1160–1300 CE) saw the establishment of the Episcopal seat at Garðar (modern Igaliku) with the stone cathedral as the largest manor in Greenland and political absorption of Greenland along with Iceland into the Norwegian Atlantic Realm (1262–4). This period saw the apparent "market dominance" of Greenlandic walrus products in western Europe (Star et al. 2020; Barrett et al. 2020) as the walrus hunt intensified and apparently expanded northwards into Disko Bay and perhaps beyond. This period also saw a pattern of the closing of small local turf and stone churches and the consolidation around a few larger two-cell Romanesque churches at high status farm locations, later (ca. 1250–1300) to be replaced by the large and impressive stone churches furnished with imported stained glass and church bells (some probably constructed with imported architects, perhaps as a mark of royal favour). Jette Arneborg has described this as a pattern of takeovers by a few great families, possibly paralleling a better documented competition and consolidation process in Iceland that led to a civil war among the elites.

By 1300 Norse Greenland had become a fully medieval society with a bishop, royal agents, a monastery and nunnery and tax and tithe obligations to Nidaros (Trondheim) and Rome. Comparative research (Vésteinsson et al. 2019) has suggested that Greenland ca. 1300 may have been more sharply stratified politically and economically than contemporary Iceland, with the Bishop's manor at Garðar and a few chieftain farms dominating a landscape filled with smallholders and tenants. Figure 3 illus-

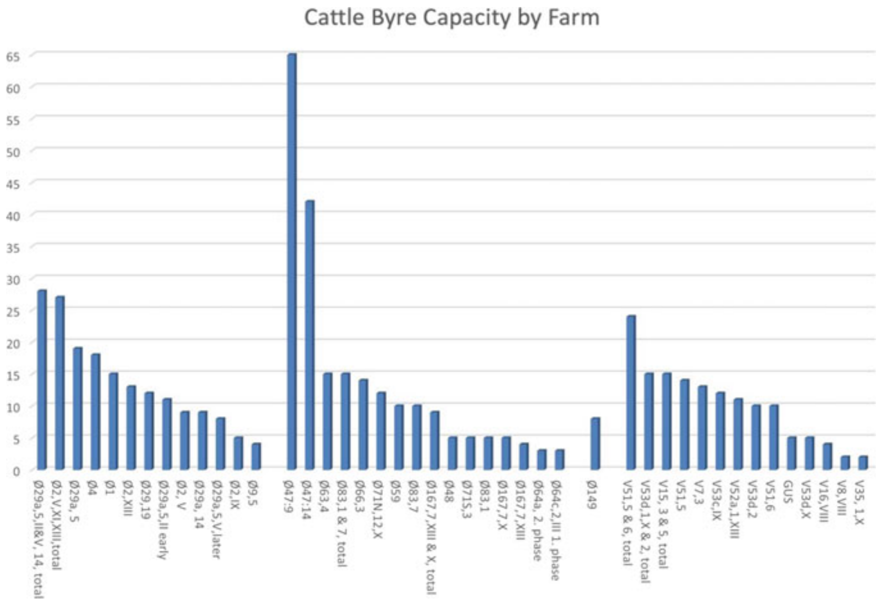

Fig. 3 Cattle byre stall capacity by farm. The first cluster of farms from Ø29a to Ø9 are around Tunulliarfik fjord with the best pastures, followed by the Igaliku fjord and Vatnahverfi (Ø47–Ø64c). Ø47 is the Bishop's farm Gardar, the other farms are from Vatnahverfi where the economy were based on sheep and goats. Ø149 is the farm of the Benedictine nunnery and the last cluster (V51–V35) represents farms in the Western Settlement. Note that the Bishop's farm (Ø47) and the chieftains´ farms (V51, Ø29a). Other high status farms with church are Ø1, Ø83, Ø66 and V7. are very atypical of the majority of smallholders such as V35, V8

trates the relative cattle byre capacities of excavated Norse farms with the two byres at Garðar far in the lead with a combined capacity of nearly 100 cattle.

Perhaps significantly, the Western Settlement chieftain's farm W51 Sandnes also has the greatest concentration of walrus ivory extraction debris, suggesting elite investment in the northern walrus hunt and the connection to European markets and society that generated church bells and ecclesiastical authority (McGovern et al. 1996; Roesdahl 2008).

The period also saw first contacts between Norse hunters in the northern hunting grounds with Thule-culture Inuit arriving ca. 1200 in their migration from Alaska. On the other side of the planet, a massive volcanic eruption at Samalas in modern Indonesia in 1257 was to trigger major climate change and a period of increased summer drift ice between Iceland and Greenland around ca. 1300 (Miller et al. 2012; Zhong et al. 2011

Severe sea-ice years at this time are also noted in documentary records from Iceland (Ogilvie 1982, 1991). Volcanic activity would have reduced solar insolation, causing increased ice delivery to the East Greenland Current (Zhong et al. 2011). On the inner fjord areas of the Eastern Settlement, increased levels of summer sea ice, correlates with increased ice-cover in the summer months (Jensen et al. 2004). The increased presence of summer sea ice and enhanced climate variability and storm activity is reflected in changes to the dietary and household economies in the same period (Arneborg et al. 2012).

The *contraction* phase (ca. 1300–1450 CE) saw the abandonment of many coastal and upland settlements and the whole of the Western Settlement. This was accompanied by a decline and sometimes rapid ending to land management for livestock fodder production. The community contracted into the early settled (and most protected) inner fjord zone of the Eastern Settlement concentrated around Tunulliarfik and Igaliku fjords, and several researchers have modelled dangerous population loss from emigration (Lynnerup 1999, 2014). The few contemporary documentary records that are extant concerning Norse Greenland were mainly written in Iceland. One of the last of these describes the solemnization of a marriage in 1408 at the site of the impressive stone at Hvalsey near modern-day Qaqortoq. Possible reasons for the lack of records after this time have been discussed elsewhere (Ogilvie 2016, 2020) but radiocarbon and paleoenvironmental data suggest an end game period lasting until ca. 1450. Thule contact seems to have intensified, with winter settlements extending progressively further south after ca. 1300 (Lund et al. 2011). Both zooarchaeology and human stable isotope research document a significant change in Norse diet, expanding sealing (with seal bone making up to 80% of some samples) after 1300 with an apparently successful intensification of communal seal drives and pooling of labor for the annual hunt (Ogilvie et al. 2009).

It is likely that a combination of factors involving the wider North Atlantic political and economic sphere and a period of relatively cold climate around 1300 reduced pasture productivity and also hindered both transatlantic contact and local travel. Nevertheless, the Norse Greenlanders showed significant resilience and adaptive capacity to intensify their existing pattern of sealing and changed diet away from dairy and domestic meat to the marine food web (Ogilvie et al. 2009; Arneborg et al.

2012; Smiarowski et al. 2017). It must be strongly emphasised that this was by no means a static society that "chose to fail" (Diamond 2005). Nonetheless, it is evident that, in one way or another, they lost their battle for survival.

Lessons from the Past

Norse Greenland can provide multiple insights into climate change adaptation and vulnerability, whether by contributing to theory (see Ford et al. 2018) or providing examples of limits and barriers to adaptation (Dugmore et al. 2012; Dow et al. 2013). Critically, the Norse settlers responded well to the Arctic climate of Greenland (very different to the climate of Iceland) by supplementing domestic shortfalls with wild resources. However, the transportation of domesticated landscapes and associated animal husbandry practices from Norway to Iceland and Greenland also transferred cultural and institutional path dependencies (Jackson et al. 2018b). Animal husbandry, iron tools, wood boats and fixed dwellings, and, from around AD 1000, Christianity, were central to the Norse way of life, but the accumulated skills and behaviours that were learned and operationalised in mainland Scandinavia and the eastern North Atlantic were not sustainable in Greenland in the long-term (Jackson et al. 2018b), and indeed of themselves may have contributed to community demise. Managing livestock would have become increasingly difficult as the climate became more variable in the fourteenth and fifteenth centuries (Ogilvie 1998; Dugmore et al. 2007a, b, 2009) modifying the critical growing season and with land management and organisation designed to increase fodder productivity instead causing its reduction. Because the Norse were not prepared to abandon farming, hunting activities would have been tethered to pastureland on the sheltered inner fjord, making hunting less efficient (Hambrecht et al. 2018). During the consolidation phase (c.1160–1300) the Norse experienced increasing social inequality and concentration of economic and religious power in the Garðar manor and the surviving major church farms. The significant investment in church architecture by this small community hints at the key role of belief and ideology in coordinating the many communal subsistence tasks and the increasingly costly northern walrus hunt, as well as representing sunk costs in immobile landesque capital investments (Lynnerup 2014; Janssen et al. 2003). When Norse managers faced the multiple challenges of the contraction phase after 1300 (declining contact with Europe, climate impacts, increased Thule competition) they did so with over 300 years of experience in living in Greenland, and with a functioning cultural landscape shaped and dominated by elites with a strong stake in the walrus hunt and the connection to Europe it maintained.

This accumulated local and traditional knowledge (LTK) and established cultural landscape and social structure and ideology provided both useful tools for adaptation but also boundaries to resilience. Path dependency in managers using existing tools for social control and mobilization may have critically limited the range of acceptable alternative choices just as some key elements in LTK (seasonal change, safe seafaring, winter travel conditions, length of winter fodder support) became increasingly devalued by environmental change (Jackson et al. 2018b). Increased social hierarchy and inequality may have empowered elite managers to enforce adaptive choices, but at the expense of closing options and (perhaps) eventually undermining their own authority and control.

This case study provides a scenario storyline that tests how modern communities and institutions respond to environmental stress. Considering cultural path dependence, environmental knowledge and limits to adaptation in contemporary communities could provide a basis with which to test climate scenarios and how adaptively communities respond (Riede and Jackson 2020). However, in order to gain greater recognition in mainstream research on global environmental change, archaeologists need to increase their visibility by writing in a format and venue that is accessible to global change researchers.

Scenarios and Counterfactuals

While a direct analogy cannot be drawn between Norse Greenland and modern societies, an assessment of adaptive capacities and limits can be translated into contemporary scenario exercises. By visualising the Norse adaptive pathway as a set of decisions that are constrained by the changing social and economic context, as shown in Fig. 4, we see that some decisions remain adaptive, such as marine hunting, but others become increasingly maladaptive, such as farming. The links between these subsistence strategies represent the interplay between path dependent strategies, that are associated with cultural limits (Dugmore et al. 2012), and innovations that are the outcome of social learning—or, perhaps more appropriately, landscape learning (Rockman 2003).

Archaeological and historical studies offer the opportunity not only to examine completed experiments, but also the interplay between continuity and change in social-ecological systems (Redman 2005; Costanza et al. 2007). A resolved and nuanced picture of the past can therefore reveal not simply cautionary tales of failure, but rather a far more vivid and revealing picture that tells of a combination of adaptive and maladaptive strategies that, when considered over discrete segments of time, show a series of alternative outcomes. Consider, for example, Norse society in Greenland between the late 10th and late thirteenth centuries: population was at its peak, walrus ivory production sustained contact and trade with the European continent, and subsistence was organised within an efficient seasonal schedule that organised production between individual farm households and communal hunting from specialised marine shielings (McGovern 1980; McGovern et al. 2014; Madsen 2014). Fast-forward to the fourteenth and fifteenth centuries: ivory trade had declined together with the decline of Norwegian political and economic power (now concentrated in the German Hansa towns), the climate has become increasingly variable and stormy, and the Western Settlement has been abandoned (Dugmore et al. 2007a, b).

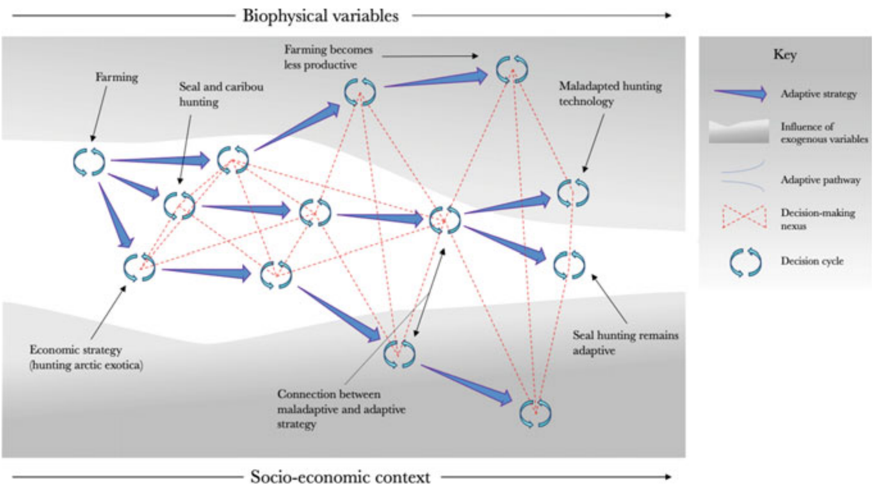

Fig. 4 Norse decision-making constrained by environmental and social-economic context (adapted from Wise et al. 2014). Above, the Norse adaptive strategy is constrained by the impacts of climate variability and landscape organisation on fodder and livestock productivity. Increased sea-ice presence also makes seal hunting less predictable and increasingly dangerous. Below, changes to European political power and markets transformation devalue walrus ivory and other arctic exotica. In the middle, the adaptive pathway that the Norse follow shows evidence of innovation (i.e. the adoption of hunting as a subsistence and market strategy) before becoming increasingly constrained by their existing decision-making strategies (path dependence) and the nexus of choices that they make (i.e. continued reliance on walrus ivory, taking up valuable time during the short, intensive summer season)

Did the Norse choose to fail, as Diamond described (and forewarned)? Or, alternatively, did the Norse settlers adapt successfully within the bounds of what was considered culturally acceptable or possible? The Norse were not passive to the changing climate, nor were they unwilling to adapt, but perhaps a more chilling conclusion is that the Norse adapted well, overcoming what Moser and Ekrstrom (2010) would term ‘barriers’ to adaptation, until they reached the cultural limits of their flexible subsistence strategy (Dow et al. 2013). Cultural limits are significant because culture is responsible for the intergenerational transmission of knowledge concerning the environment and the beliefs and values that deliver a sense of identity and place (Berkes 2017; Brace and Geoghegan 2011).

The utility and relevance of history and archaeology is in the interplay of success and failure, continuity and change. From the local to the regional scale, historical research uncovers what is likely to have happened and also asks counterfactual ‘if-and-then’ questions about why certain decisions were taken, at what cost, for whom, and why other decisions were not (see Baron-Cohen 2020). These counterfactuals are not purely hypothetical as they can still be constrained within the social and environmental context of the North Atlantic and the cultural barriers and limits to decision-making (Dugmore et al. 2012). For example, *if* the Norse abandoned agriculture *and* adopted semi-mobile seal-hunting *then* they would have had sufficient seal meat to support society. But this scenario is constrained by the cultural limits created by antecedent decisions to adopt sedentary farming and Christianity; rational subsistence strategies are constrained by the social and cultural context of the Norse diaspora in the North Atlantic. An agricultural system supplemented by wild resources could support the peak Norse populations in southwest Greenland whereas a nomadic system might have struggled to do so. This initial necessity could so reinforce a particular mind-set that by the time the population declined to a level where a nomadic system could support all, this crucial change was not perceived as appropriate even though it might have been the only route to survival.

"What if" scenarios, or counterfactuals, have been used increasingly in political methodology and history, to determine the plausible effects of different decisions (Levy 2008) and to assess the efficacy of policy choices (Harvey 2015). Harvey (2015) has explained, the utility of comparative counterfactual analysis is located ability to assess the *comparative plausibility* of different historical experiments. More broadly, as Carr (1964) has explained, counterfactuals are unavoidable in historical (and archaeological) studies: "the study of history is a study of causes" (87; cited Levy 2008). In this sense, what could have happened, but did not, can be gleaned from consideration of the range of possible decisions and outcomes. This, as Walter Scheidel (2017) has argued, helps historians and archaeologists identify, more confidently, the factors that were responsible for observed outcomes, and can, in turn, inform the range of possibilities in the future. As Fig. 4 illustrates, individual decisions could be considered adaptive, but, in combination with other constraints, become maladaptive. CCM and qualitative scenario storylines might benefit from plausible counterfactuals to develop effective adaptive strategies.

Conclusion

Archaeologists and historians are now uniquely positioned to provide relevant data for global change research and inform environmental policy and planning. As this chapter has argued, archaeologists and historians should depart from the broad narratives of collapse and focus instead on informing theory using evidence of different adaptive capacities and limits that can be observed using natural experiments. The nuance of archaeological and historical interpretation requires the explicit consideration of a range of counterfactuals to interpret human activities in the past, which undermines environmental determinism, to consider a range of potential adaptive pathways. But far from undermining the relevance of archaeological and historical information, the range of plausible and implausible scenarios, retrofactuals and counterfactuals, provide an evidence base that can inform climate change adaptation frameworks. CCM and qualitative scenario storylines require are two existing frameworks that could incorporate archaeological-historical information to consider the interplay between different climate impacts and adaptive capacities in different geographical contexts. The Norse Greenland case study illustrates an important lesson for climate change adaptation scenarios; even a highly adaptive society can, over the course of several centuries, reach limits to adaptation when exposed to unanticipated social and environmental change. Furthermore, a high adaptive capacity does not always translate as an ability (or willingness) to adapt.

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