Social Resilience to Climate-Related Disasters in Ancient Societies: A Test of Two Hypotheses

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Abstract

Current literature on disaster response argues that societies providing greater local participation in decision-making and which have more community coordination and governance organizations are more resilient to climate-related disasters. In contrast, recent research in psychology has argued that societies with tighter social norms and greater enforcement of those norms are more resilient. This paper tests whether one or both of these seemingly competing perspectives can be empirically supported through an examination of the diachronic impact of climate-related disasters on ancient societies. A cross-cultural research design and a sample of 33 archaeologically-known societies bracketing 22 catastrophic climate-related disasters are used to test two hypotheses about resilience to climate-related disasters. The paper finds that societies allowing greater political participation appear to provide greater resilience to catastrophic climate-related disasters, generally supporting the predominant perspective in contemporary disaster response.

1. Introduction

This paper tests two hypotheses about social resilience to climate-related disasters using data from ancient societies. The paper is in no way unique in using archaeological data to examine the societal impact of natural disasters or mechanisms of social resilience (e.g. Cooper and Sheets 2012; Fisher, Hill, and Feinman 2009; Hegmon et al. 2008; Redman 2005), but it is unique in doing so using cross-cultural comparison of ancient societies throughout the world. A strength of cross-cultural comparison using archaeological data is that it allows one to test whether or not an assumed predictive condition actually precedes its assumed effects; that is, whether a society with the predictive condition empirically changes in the predicted manner over time (Peregrine 2001, 2004; Smith and Peregrine 2012). If a predictor of social resilience to climate-related disasters can be identified and applies to societies of varying scales and complexities throughout human history, then there is good reason to believe that it can be used to create interventions applicable today (see also Cooper and Sheets 2012; Hegmon et al. 2008; Redman 2012; Redman and Kinzig 2003; Van de Noort 2011).

Social resilience here refers to the ability of a social system to absorb disturbances while retaining the same basic structures and abilities to respond to further disturbances (see Parry et al. 2007: 37, also Holling 1973: 17). There are numerous ways to more specifically define types or processes of resilience (Davidson et al. 2016). In this paper the definition used is commonly called "resistance" or "adaptability" which refers to the capacity of a social system "to successfully avoid crossing into an undesirable system regime, or to succeed in crossing back to into a desirable one" following a disaster (Walker, Holling, Carpenter and Kinzig 2004). This is opposed to "transformative resilience", which refers to the capacity of a social system "to create a fundamentally new system" following a disaster (Walker, Holling, Carpenter and Kinzig

2004). It must be noted that scalar issues are important to these definitions of resilience, as change is always occurring in social systems. These two forms of resilience focus on what occurs at the system level—does the system change in order to maintain fundamental social structures, or are those structures fundamentally transformed in order to allow the system to continue (Redman and Kinzig 2003)?

In addition, this paper focuses on catastrophic climate-related disasters—those that are caused by climatic events and disrupt an entire society. Disasters caused by geological processes, human-derived environmental degradation, asteroid strikes, or the like (e.g. Jusseret, Langohr, and Sintubin 2013; Gunn 2000; Sheets 2012; van der Leeuw et al. 2005) are not considered here as they are not examined in the literature on societal tightness, discussed below. In addition, only "catastrophic" events, defined by Lorenz and Dittmer (2016:37) as "devastating events which encompass entire societies" are focused on, as opposed to less far-reaching "disasters" or localized "emergencies" (Lorenz and Dittmer 2016). This focus is due to the limitations of the archaeological and paleoenvironmental records. These are important points to keep in mind when considering the paper's results.

a. Social Resilience

There is a vast and growing literature on social resilience to disaster. The concept of resilience has its roots in ecology and the basic idea that the ability to withstand shocks should be seen through the lens of organisms operating within a complex adaptive system (e.g. Redman and Kinzig 2003; Meerow, Newell, and Stults 2016). The basic concepts of resilience were first developed in a seminal paper by C.S. Holling (1973) and in the ensuing forty years Holling's ideas have grown into an active but extremely diverse set of specific theories about resilience (Folke 2006). Two major themes have become the subject of increasing discussion in the literature on social resilience to climate-related disasters. The first is the importance of "vulnerability"—that the impact of a climate-related disaster is in part socially created because societies frequently build structures (both social and physical) that exacerbate the impact of disaster (e.g. Comfort, Boin, and Demchack 2010; Tierney 2014). The second is that more "flexible" social structures (again, both social and physical) are more resilient to climate-related disasters than more "rigid" social structures (e.g. Aldrich 2012; Holling et al. 2002; Kahn 2005; Paton 2006)—a perspective referred to as "flexibility theory" in this paper. Both of these themes suggest that flexibility or freedom to adapt are a key to social resilience to climate-related disasters (Hegmon et al. 2008; Redman 2005; Redman and Kinzig 2003).

In contrast, Gelfand and colleagues (Gelfand et al. 2011; Harrington and Gelfand 2014; Roos et al. 2015) have recently put forward the theory that societies facing frequent natural disasters and hazards (climate-related disasters as well as conflict and epidemic disease) will tend to develop strong social norms and high levels of intolerance to deviance. They argue that strong social norms provide societies with opportunities for greater coordination to deal effectively with disasters (Gelfand et al. 2011:1101). As Roos et al. (2015:14) put it, "we expect societies evolve to have stronger norms for coordinating social interaction because they are necessary for survival" in the face of either natural disasters or manmade threats (such as invasion). Gelfand and colleagues find strong support for what is referred to in this paper as "tightness theory" of social resilience in a study of 33 nations (Gelfand et al. 2011), of the 50 United States (Harrington and Gelfand 2014), and in evolutionary game theory (Roos et al. 2015). However, "tightness theory" has not been tested in small-scale societies or non-Westphalian states, nor has it been examined in the context of catastrophic climate-related disasters.

While both “flexibility theory” and “tightness theory” focus on social adaptations to dynamic conditions, they put forward contrasting ideas about the social roots of resilience to climate-related disasters. “Flexibility theory” envisions broad political participation, open lines of communication, and fluid mechanisms of coordination as the key to resilience. “Tightness theory” envisions strong norms of behavior fostering well-coordinated responses as key.

b. Hypotheses

Measuring societal tightness-looseness is relatively straightforward, as the concept is well-defined and already has clear and robust measures (see the Supplemental Material in Gelfand et al. 2011). But measuring flexibility in social structures is more difficult (Lebel et al 2006). For this paper the widely-employed continuum from more corporate- to more network-oriented polities (Blanton et al. 1996) is to measure societal flexibility (in the remainder of this paper I use the term “exclusionary” in place of network following Feinman 2010). More corporate-oriented societies have more inclusive and participatory political structures while in more exclusionary-oriented societies elites control access to political authority and allow only limited political participation.

Measuring social flexibility through the corporate-exclusionary continuum may not have obvious face validity, but the link between participation in political decision-making and social flexibility is well-established in the disaster resilience literature through the concept of “participative capacity”. Participative capacity refers to the ability of local actors to influence decision-making (Lorenz and Dittmer 2016: 47-48). As Redman (2005:72; also Redman and Kinzig 2003) put it “management has to be flexible, working at scales that are compatible with the scales of critical ecosystem and social functions.” Because those scales range from local to societal, participation has to be equal at all those levels. A key element in participative capacity is control and flow of information. In more resilient social systems horizontal (that is, between individuals operating on similar scales) information flow appears more important than vertical flow so that control of information at high levels in a hierarchical system may lead to less resilience (Redman and Kinzig 2003). Because key definitional elements of the corporate-exclusionary continuum focus on both these features—participation in decision making and control over information and material flows—it would seem that the corporate-exclusionary continuum should be a good proxy measure for societal flexibility, at least as it is thought of within “flexibility theory”.

Using the corporate-exclusionary and tightness-looseness continuums as the independent variables, and accepting the definition of social resilience put forward above, the two hypotheses to be tested in this paper are:

> Hypothesis 1: Societies with more corporate political strategies are more resilient to catastrophic climate-related disasters.

> Hypothesis 2: Societies with tighter adherence to social norms are more resilient to catastrophic climate-related disasters.

It should be noted that these hypothesis are rather specific. They focus only on catastrophic and climate-related disasters. They do not take into account potential differences in “vulnerability” among the societies that are tested, nor disasters that are small-scale or involve non-climatic events. These are limitations, but they are necessary to match the manner in which the second hypothesis was tested in the literature on modern nations (Gelfand et. al. 2011; Harrington and Gelfand 2014) and the available archaeological and paleoenvironmental records. On the other hand, the hypotheses themselves require evaluating whether pre-existing social conditions impact resilience, which itself can be taken as a measure of vulnerability.

2. Methods

a. Sample

The sample used here is a bit unusual and requires some preliminary explanation. Because this study is focused on resilience to climate-related disasters, the sample is one based on climate-related disasters rather than disasters involving geological processes, human-induced environmental degradation, or the like. It is important to note before continuing that what is being termed a "disaster" in this study is what would be termed a "catastrophe" in the disaster resilience literature; that is, an event or series of events that lead to societal-wide disruption rather than a smaller-scale "disaster" or "emergency" (Lorenz and Dittmer 2016). Within the archaeological context this may reflect a period of repeated climate-related disasters (e.g. sequential years of drought or flooding) and not just a single event. Not all societies have experienced a catastrophic climate-related disasters, and not all of them have been the focus of archaeological research that could provide adequate data for examining resilience, so the sample had to be selected based on specific criteria rather than on random sampling. Those criteria were (1) a specific region or site that has been the focus of extensive archaeological research; and that (2) has been subjected to at least one catastrophic climate-related disaster that can be clearly identified in both the geological and archaeological record (and, again, what is visible in the archaeological and geological record is often a time period of repeated climate-related disasters rather than a single catastrophic event); and that (3) is spatially and culturally distinct from other cases in the sample in order to minimize the likelihood of autocorrelation (a formal analysis of autocorrelation effects could not be conducted here because the linguistic data normally used as a control is lacking for most archaeological cases).

To address the first sampling criterion preference was given to cases included in *eHRAF Archaeology* (ehrafarchaeology.yale.edu), a repository of primary and secondary source documents that have been indexed for content to the paragraph level and thus provides rapid access to specific information in the repository documents. To address the second sampling criterion only cases that have been discussed in the archaeological literature as having been subject to one or more catastrophic climate-related disasters were considered (except for the Ontario Peninsula and Northern Europe, which were chosen as a control cases for the analyses). And to address the third sampling criterion cases were sought from different culture areas of the world. Because the cases are from different culture areas and are spatially segregated, autocorrelation should be minimized (again, a formal test could not be conducted using a linguistic control, and a test employing location as a control is unnecessary as the cases are so distant from one another). In the end 22 distinct catastrophic climate-related disasters impacting societies in 9 regions were selected for coding (Figure 1). Individual cases coded consisted of those archaeologically-known societies inhabiting a specific region impacted by the disaster; with one case representing the time period within 100 years before the disaster, and another the time period within 100 years after the disaster (only the period preceding the disaster is analyzed in this paper, as predictive conditions are the focus of this paper). The sample cases are listed in Table 1, which also lists the focal communities and time periods as typically defined in local chronologies (the time periods coded are within these local chronological periods), and the catastrophic climate-related disasters that impacted the cases.

[Table 1 about here]

[Figure 1 about here]

b. Coding Process

Coding followed the general protocol used in most cross-cultural research (Ember and Ember 2009). Developing the codebook was done in an iterative fashion. All measures were pre-tested against sample cases, tested for reliability, and revised until reliable codes and a clear coding protocol were achieved. A total of 163 variables were coded, though only a small number of them are used in the analyses presented here. The final edition of the codebook along with the coded data are archived at the HRAF Advanced Research Center (hrafarc.org).

The coding process itself was done on electronic forms (also archived at the HRAF Advanced Research Center) by students who had been trained for the task but were unaware of the hypotheses to be tested (naïve coders in the terminology of cross-cultural research). Two coders first read through documents in *eHRAF Archaeology* on a focal site or region and time period as specified for a given case, then copied passages relating to each variable in the codebook, and arrived at a preliminary code. They then met to identify disagreements in coding, and when disagreements were found, they read through each other's collected passages to determine if they missed some information. Usually the coders came to an agreed code based on their combined reading and recording of the source materials. When they did not, the variable was coded as having missing or conflicting data (in rare instances the coders agreed on a "resolved" code to which one or both disagreed, but that both agreed should not be coded as missing or conflicting).

It is important to note that coders were only to use data for the focal region during the focal time period, which was the 100-year period before or the 100-year period following a given climate-related disaster. There were rare occasions where data were not available within that narrow range, and in those cases the focal time period was expanded to include the time periods typically used within a local archaeological chronology. Similarly, focal regions did not always have sufficient data to code all the variables, and the rare cases when additional data were required coders were allowed to look at nearby sites with better data on the variable being coded. The assumption is that these expansions of focal dates and regions added random error to the coded data rather than any systematic bias, as each coder decided individually when to look beyond the focal region and time period, so they were not systematically altering a case's parameters.

c. Variables

Two independent variables were derived from the raw coded data. The first is the "Looseness-Tightness Index" which measures the degree to which a society has strongly enforced social norms (Gelfand et al. 2011; Gelfand and Harrington 2014). The index was constructed in consultation with Gelfand and is calculated as the average standardized scores on the six variables listed in Table 2. The first two variables are intended to be proxy measures for the potential number of social norms present in a given society. The remaining four variables are intended as direct material indicators of the degree to which there appears to be adherence to social norms. It is expected that societies with lower scores on this index tend to have fewer strongly enforced norms and greater tolerance for violations of them. Societies with higher scores are expected to have more strongly enforced norms and less tolerance for violations of them.

[Table 2 about here]

The second independent variable is the "Corporate-Exclusionary Index" which measures the degree to which the political agents control access to political authority (Blanton et al. 1996). The index was constructed as the average standardized scores on the five variables listed in Table 3, and is described in more detail by Peregrine (2008, 2012) and Peregrine and Ember

(2016). In brief, the index measures the degree to which political agents encourage or discourage political participation and interaction with external polities. In more corporate societies, which score lower on the scale, agents encourage members of the society to participate in political activities, share authority broadly, and allow greater interaction with outsiders. The opposite is true in more exclusionary societies, where agents control access to political authority, share it only among a small group of peers, and prevent most members of society to interact with outsiders. The index measure for the corporate-exclusionary continuum employed here has been used to code archaeological data in several previous research projects that have produced statistically robust results (Peregrine 2008, 2012; Peregrine and Ember 2016).

[Table 3 about here]

The indexes comprising the two independent variables are statistically robust. The Looseness-Tightness Index has an alpha of .863 (6 items) and all the variables that comprise it correlate to a single factor explaining 61% of the variance. The Corporate-Exclusionary Index has an alpha of .978 (5 items) and all the variables that comprise it correlate to a single factor explaining 92% of the variance. It is interesting to note that the two indexes correlate ($r = .844$, $p < .000$), although not entirely surprising. One of the features of more exclusionary political strategies is control over prestige objects and symbols of power. This control would translate, in the material record at least, into the appearance of greater adherence to social norms. However, the indexes separate into two factors with little overlap following varimax rotation, suggesting that they do tap into somewhat different societal properties.

The dependent variables reflect the social impact of a specific catastrophic climate-related disaster on seven areas: population, health and nutrition, conflict, household organization, village organization, regional organization, and communal ritual, all coded on a 3-point none, some, much scale. These were coded based on the change observed in related variables coded for the time period before the climate-related disaster versus those for the time period following. Greater stability in the dependent variables is assumed to indicate resilience, following the definition presented earlier. It should be noted that these variables were originally coded on a five-point scale from significant decrease to significant increase, thus identifying the direction of change rather than simply whether or not change occurred. The variables were recoded into the three point scale used here because (1) a number of the relationships turned out to be curvilinear, and recoding solved this issue; and (2) since the hypotheses are related to stability and not the direction of change, the recoding did not impact the hypothesis tests, and indeed may be more appropriate than the original coding.

As discussed above, climate-related disasters were coded as reflecting either individual events or periods of repeated disasters resulting in catastrophic impact. Despite considerable work in reconstructing paleoclimate and paleoenvironment (e.g. Coats et al. 2015; Cook et al. 2016; Rein et al. 2005; Stahle et al. 2016), there remains much work to be done to link specific events with the archaeological record (but see, e.g., Douglas et al. 2015; Hegmon et al. 2008; Macklin et al. 2013; Medina-Elizalde and Rohling 2012; Munoz et al. 2015; Sandweiss et al. 2009; Weiss 2000). For this reason it was from the archaeological literature that many of the climate-related disasters were identified. These disasters are commonly discussed in the framework of settlement interruption or destruction, or of large-scale community and regional reorganization. Thus the variables chosen to describe the impact of climate-related disasters map onto what are often the archaeologically-identifiable features of such disasters.

One might be appropriately concerned that identifying climate-related disasters in this way would create a self-fulfilling prophecy—that climate-related disasters cause changes in social organization that are, in themselves, the things that lead archaeologists to identify climate-related disasters—but that concern is not wholly warranted. Each case where a climate-related disaster was suggested in the archaeological literature was independently verified through geological markers in order to be included in the sample, so these are "true" disasters, pointed at through the archaeological record, but geologically confirmed. That these disasters impacted the coded archaeological cases in an obvious way is not a serious problem for this study, as the focus here is on social resilience as indicated by variation in change and the degree to which that variation can be predicted by the independent variables.

3. Results

Two hypotheses were tested using the data produced through the methodology described above. Hypothesis 1 was that societies with more inclusive and participatory political structures are more resilient to climate-related disasters than are societies in which leaders tightly control access to political authority. Table 4 presents the results of Pearson's one-tailed correlations between the Corporate-Exclusionary Index and the seven dependent variables. One-tailed correlations are employed because the hypothesized relationships are directional. There appears to be modest support for Hypothesis 1. All but one of the correlations are in the expected direction and Conflict, Regional Organization, and Communal Ritual appear to be significantly more stable if a society has a more corporate political system preceding a climate-related disaster. This would suggest that having a more corporately-oriented political organization tends to minimize conflict following a disaster and to preserve core structures of both regional organization and the public rituals that bond groups into social units.

[Table 4 about here]

Hypothesis 2 was that societies with tighter adherence social norms are more resilient to climate-related disasters than are societies with looser adherence to social norms. Table 4 also presents the results of Pearson's one-tailed correlations between the Looseness-Tightness Index and the seven dependent variables. The results of Pearson's correlations in Table 4 indicate minimal support for Hypothesis 2. Only one correlations statistically significant, and it is in the direction opposite to that hypothesized. Indeed, all but one of the correlations are in the direction opposite to that hypothesized. One thus must reject Hypothesis 2 and conclude that adherence to social norms does not appear to provide meaningful resilience to climate-related disasters.

These results suggest that societies with more inclusive political structures tend to be more resilient to catastrophic climate-related disasters in terms of internal conflict, regional organization, and community ritual. These results support the basic tenants of "flexibility theory" (e.g. Lebel et al. 2006; Norris et al. 2008). On the other hand, the results do not offer much support for "tightness theory", at least as applied to catastrophic climate-related disasters. This is somewhat surprising, as "tightness theory" has been empirically supported through studies of 33 nations and of all 50 of the United States (Gelfand et al. 2011; Harrington and Gelfand 2014). There are, however, a number of reasonable explanations for these differing results. First, this study and the two conducted by Gelfand and colleagues are on different scales: this study examines a much longer time scale and a much wider range of societal forms. As pointed out by Davidson and colleagues (2016), strategies of resilience may differ between domains of impact (i.e. urban or community versus socio-ecological), and Lorenz and Dittmer (2016) argue that different scales of impact (i.e. societal wide versus community) may also require different strategies of resilience. It may also be that tightness provides more social resiliency in Westphalian nation-states but does not do so in smaller-scale societies and archaic states.

A second explanation for why this study and those by Gelfand and colleagues come to different conclusions is because this study focuses on catastrophic climate-related disasters rather than the more episodic ones used in the tightness studies. Gelfand and colleagues focus on climate-related disasters of much smaller scales than the ones considered here. The disasters they consider are such things as floods, tornadoes, droughts, and the like, which might impact individual communities or regions within a society, but do not have societal-wide impact (see Harrington and Gelfand 2014:7992; also Lorenz and Dittmer 2016:37). So, what may be reflected in these results is that flexibility provides greater social resiliency to catastrophic climate-related disasters while tightness provides greater resiliency to smaller-scale disasters. This itself is an interesting finding and warrants further investigation. While the archaeological and paleoenvironmental record may preclude systematic testing of the relationship between the Corporate-Exclusionary Index and smaller episodic disasters and emergencies, the Tightness-Looseness Index can be examined in relation to recent catastrophic climate-related disasters to determine if the results of this study are replicated in modern nation-states.

In any case, the conclusion that societies with more inclusive political structures are more socially resilient to catastrophic climate-related disasters must be received cautiously for at least two reasons. First, the sample size is small, and given the limitations created by the sampling criteria, it is entirely possible that the sample represents an atypical segment of the range of variation in societies that have experienced catastrophic climate-related disasters. Second, despite our best efforts to create a strict protocol, the concepts coded do not always have unambiguous archaeological indicators, and thus variables coded were of necessity coarse-grained. With these problems one would assume the resulting data would contain considerable random error. Being random, however, this error is unlikely to have created a false relationship between two variables (Type II error), but rather to make it more difficult to find true relationships (Type I error). Thus one would expect that finding support for Hypothesis 1 would be difficult given the coarseness of the data. But support was found for some of the variables, and for that reason the coarseness of the data may not have been as serious a problem as anticipated (although it may have prevented the identification of relationships in the other variables), or the relationships are so strong that the random error inherent in these coarse data did not mask them (cf. Loken and Gelman 2017).

4. Conclusions

While there are obvious problems in the methods and data employed here, the potential of cross-cultural research using the archaeological record far outweighs those problems, for in cross-cultural research we have a powerful method through which archaeology can be made obviously relevant for understanding, and perhaps addressing, contemporary social problems (Hegmon et al. 2008; Sheets 2012). Because diachronic comparative archaeology allows one to test causality across a range of cases, one can reasonably assume that the results are generalizable to many historical and cultural contexts. Not only does this provide a powerful test for the various theories about social resilience, but it also provides an excellent foundation for policy decisions, as results are likely not restricted to a particular time or place, but reflect more general patterns of human behavior, patterns that can be employed as the basis for both evaluating general hypotheses and for developing practical interventions. The archaeological record has not ordinarily been examined in such a way that it will produce such generalizable conclusions to support both basic research and policy development (but see Cooper and Sheets 2012; Fisher, Hill, and Feinman 2009; Hegmon et al. 2008; Van de Noort 2011). Beyond adding to our understanding of social resilience, my hope is that this project may lead others to explore historical questions with policy implications in a manner that produces generalizable results.

Humans have faced catastrophic climate-related disasters many times, and because of climate change it is likely that we will face such disasters within the time scale of this study (100 years). The results of this study suggest that to become more socially resilient to the catastrophic climate-related disasters we can anticipate developing through climate change societies should promote policies that encourage citizens to actively participate in governance and decision-making (Lebel et al. 2006). Such policies would appear to provide greater flexibility in decision making, the ability to communicate information and responses at appropriate scales, and perhaps to provide the entire response system with a broader range of knowledge to guide decisions (also see Fitzhugh 2012; Norris et al. 2008:142-144). This flexibility appears to have fostered social resilience in ancient societies at a variety of scales and in a variety of socio-ecological contexts, and thus there appears to be no *a priori* reason to assume that this would not be true for contemporary societies. Policies that increase political participation and communication across all social scales should be promoted by those seeking to foster a world more resilient to the catastrophic climate-related disasters expected in the next century.

This conclusion tends to support current directions in disaster response policy and practice, which is re-thinking the established “command and control” approach to disaster response (e.g. Handmer and Dovers 2007; see also Baker 2016) in favor of one that gives more weight to local actors, initiatives, and organizations, particularly those that encourage local engagement in decision making (Cretney 2016; Norris et al. 2008; Singh-Peterson et al. 2015). As Cretney (2016:37) puts it, this approach encourages “relationships between community organizations and higher-level governance institutions that allow for communities to take some level of ownership and control" over disaster response. An emphasis on local participation in decision making and implementation is expected in more corporately-oriented polities, and thus the findings presented here support this approach to disaster response. Similarly, current literature on the socio-cultural aspects of disaster resilience suggests that "social capital" in the form of such things as community empowerment, collaboration, and appreciation of diversity are important facets of social resilience (Gil-Rivas and Kilmer 2016; Kasdan 2016; Yoon, Kang, and Brody 2016). While not directly tied to corporate political strategies, these concepts are related. As Gil-Rivas and Kilmer (2016:1323) explain, in order to build resilience "Participation in decision-making and planning processes is critical...community members (both leaders and residents) need to have meaningful involvement." Such involvement is at the core of societies with more corporately-oriented political strategies. Thus this study serves as an empirical confirmation of the potential efficacy of current approaches to disaster response policy and practice in minimizing the impact of the catastrophic climate-related disasters we can anticipate climate change will produce in the next century.

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References

Aldrich, D. 2012: *Building Resilience: Social Capital in Post-Disaster Recovery*, University of Chicago Press.

Baker, N., 2016: "Making it worse than what really happened": Social chaos and preparedness as problematic mythologies in disaster communication. *Front. Commun.* 1, Article 2, doi: 10.3389/fcomm.2016.00002.

Coats, S., B. Cook, J. Smerdon, and R. Seager, 2015: North American pancontinental droughts in model simulations of the last millennium, *J. Climate* 28, 2025-2043.

Comfort, L., A. Boin, and C. Demchack, 2010: *Designing Resilience: Preparing for Extreme Events*. University of Pittsburgh Press.

Cook, B., E. Cook, J. Smerdon, R. Seager, and A. P. Williams, 2016: North American megadroughts in the common era: Reconstructions and simulations, *Wiley Interdiscip. Rev.: Climate Change* 7, 411-432.

Cooper, J. and P. Sheets, 2012: *Surviving Sudden Environmental Change: Answers from Archaeology.* University of Colorado Press.

Cretney, R. M., 2016: Local responses to disaster: The value of community led post disaster response action in a resilience framework, *Disaster Prevent. Manage.* 25, 27-40.

Davidson, J.L., C. Jackson, A. Lyth, A. Dedekorkut-Howes, C. Baldwin, et al. 2016: Interrogating resilience: Toward a typology to improve its operationalization, *Ecol. Soc.* 21(2), Article 12, http://dx.doi.org/10.5751/ES-08450-210227.

deMenocal, P. 2001: Cultural responses to climate change during the Late Holocene, *Science* 292, 667-673.

Dillehay, T. and A. Kolata. 2004: Long-term human response to uncertain environmental conditions in the Andes. *PNAS* 101, 4325-4330.

Douglas, P., M. Pagani, M. Canuto, M. Brenner, D. Hodell, T. Eglington, and J. Curtis, 2015: Drought, agricultural adaptation, and sociopolitical collapse in the Maya Lowlands. *PNAS* 112, 5607-5612.

Ember, C.R. and M. Ember. 2009: *Cross-Cultural Research Methods, Second Edition*, AltaMira.

Etayo-Cadavid, M., C.F. Andrus, K. Jones, G. Hodgins, D. Sandweiss, S. Uceda-Castillo, and J. Quilter. 2013: Marine radiocarbon reservoir age variation in *Donax obesulus* shells from northern Peru: Late Holocene evidence for extended El Niño, *Geology* 41, 599-602.

Feinman, G. 2010: Comparative frames for the diachronic analysis of complex societies: Next steps, in *The Comparative Archaeology of Complex Societies*, M.E. Smith, Ed., Cambridge University Press, 21-43. .

Fisher, C. T., Hill, J. B. and Feinman, G. M. 2009: *The Archaeology of Environmental Change: Socionatural Legacies of Degradation and Resilience*. University of Arizona Press.

Fitzhugh, B. 2012: Hazards, impacts, and resilience among hunter-gatherers of the Kuril Islands, in *Surviving Sudden Environmental Change*, J. Cooper and P. Sheets, Eds., University Press of Colorado, 19-42.

Folke, C. 2006: Resilience: The emergence of a perspective for socio-ecological systems analysis, *Global Environ. Change*, 16, 253-267.

French, C. 2010: The paleo-environments of Bronze Age Europe, in *Organizing Bronze Age Societies*, T. Earle and K. Kristiansen, Eds., Cambridge University Press, 34-56.

Gelfand, M., J.L. Raver, L. Nishii, L. Leslie, J. Lun, et al. 2011: Differences between tight and loose cultures: A 33-nation study, *Science* 332(6033), 1100-1104.

Gil-Rivas, V. and R.P. Kilmer. 2016: Building community capacity and fostering disaster resilience, *J. Clin. Psych.* 72, 1318-1332.

Gunn, J.D. 2000: *The Years Without Summer; Tracing AD 536 and its Aftermath*, BAR International Series 872.

Handmer, J.W. and S. Dovers. 2007: *The Handbook of Disaster and Emergency Policies and Institutions*, Earthscan.

Harrington, J. and M. Gelfand. 2014: Tightness-looseness across the 50 United States, *PNAS* 111(22), 7990-7995.

Hassan, F. 1997: Nile floods and political disorder in early Egypt, in *Third Millennium BC Climate Change and Old World Collapse*, (NATO ASI Series 149), H. Nüzhet Dalfes, G. Kukla, and H. Weiss, Eds., Springer, 1-23.

Hegmon, M., M. Peeples, A. Kinzig, S. Kulow, C. Meegan, and M. Nelson. 2008: Social transformations and its human costs in the Prehispanic U.S. Southwest, *Amer. Anthro.* 110, 313-324.

Holling, C.S. 1973: Resilience and stability of ecological systems, *Annu. Rev. Ecol. Syst.* 4, 1-23

Holling, C.S., L. Gunderson, and G. Peterson. 2002: Sustainability and Panarchy, in *Panarchy: Understanding Transformations in Human and Natural Systems* L. Gunderson and C.S. Holling, Island Press, 63-102.

Huckleberry, G. and B. Billman. 2003: Geoarchaeological insights gained from surficial geological mapping, Middle Moche Valley, Peru, *Geoarchaeology* 18, 505-521.

Jusseret, S., C. Langohr, and M. Sintubin. 2013: Tracking earthquake archaeological evidence in Late Minoan IIIB (~1300-1200 BC) Crete (Greece): A proof of concept, *Bull. Seismol. Soc. Am.* 103, 3026-2043.

Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson. 2007: *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press

Kahn, M. 2005: The death toll from natural disasters: The role of income, geography, and institutions, *Rev. Econ. Stat.* 87, 271-284.

Kasdan, D.O. 2016: Considering socio-cultural factors of disaster risk management, *Disaster Prevent. Manage.* 25, 464-477.

Lebel, L., J. Anderies, B. Campbell, C. Folke, S. Harfield-Dodds, T. Hughes, and J. Wilson. 2006: Governance and the capacity to manage resilience in regional social-ecological systems, *Ecol. Soc.* 11(1), Article 19, http//www.ecologyandsociety.org/vol11/iss1/art19.

Loken, E. and A. Gelman. 2017: Measurement error and the replication crisis. *Science* 355, 584-585.

Lorenz, D. and C. Dittmer. 2016: Resilience in catasrophes, disasters, and emergencies, in *New Perspectives on Resilience in Socio-Economic Spheres*, A. Maurer, Ed., Springer VS, 25-59.

Norris, F., S. Stevens, B. Pfefferbaum, K. Wyche and R. Pfefferbaum. 2008: Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness, *Amer. J. Community Psych.* 41, 127-150.

Macklin, M.G., J.C. Woodward, D.A. Welsby, G.A.T. Duller, F.M. Williams, and M.A.J. Williams. 2013: Reach-scale river dynamics moderate the impact of rapid Holocene climate change on floodwater farming in the desert Nile, *Geology* 41, 695-698.

Medina-Elizalde, M., S. Burns, D. Lea, Y. Asmerom, L. von Gunten, V. Polyak, M. Vuille, and A. Karmalkar. 2010: High resolution stalagmite climate record from the Yucatán peninsula spanning the Maya Terminal Classic period, *Earth Planet. Sci. Lett.* 298, 255-262.

Medina-Elizalde, M. and E.J. Rohling. 2012: Collapse of Classic Maya civilization related to modest reduction in precipitation, *Science* 335, 956-959.

Munoz, S., K. Gajewski, and M. Peros. 2010: Synchronous environmental and cultural change in the prehistory of the northeastern United States, *PNAS* 107, 22008-22013.

Munoz, S., K. Gruley, A. Massie, D. Fike, S. Schroeder, and J. Williams. 2015: Cahokia's emergence and decline coincided with shifts of flood frequency on the Mississippi River, *PNAS* 112, 6319-6324.

Munoz, S., S. Schroeder, D. Fike, and J. Williams. 2014: A record of sustained prehistoric and historic land use from the Cahokia region, Illinois, USA, *Geology* 46, 499-502.

Murdock, G.P. and S.F. Wilson. 1972: Settlement patterns and community organization, *Ethnology* 11, 254-295.

Paton, D. 2006: Disaster resilience: Building capacity to co-exist with natural hazards and their consequences, in *Disaster Resilience: An Integrated Approach*, D. Paton and D. Johnston, Eds. Charles Thomas, 3-10.

Peregrine, P.N. 2001: Cross-cultural comparative approaches in archaeology, *Ann. Rev. Anthro.* 30:1-18.

Peregrine, P.N. 2004: Cross-cultural approaches in archaeology: Comparative ethnology, comparative archaeology, and archaeoethnology, *J. Arch. Res.* 12, 281-309.

Peregrine, P.N. 2008: Political strategy and cross-cultural variation in games, *Cross-Cult. Res.* 42, 386-392.

Peregrine, P.N. 2012: Power and legitimation: Political strategies, typology, and cultural evolution, in *Comparative Archaeology of Complex Societies*, M.E. Smith, Cambridge University Press, 165-191.

Peregrine, P.N. and C.R. Ember, 2016: Network strategy and war, in *Alternative Pathways to Complexity*, L. Farger and V. Heredia Espinoza, Eds. University of Colorado Press, 259-269.

Peregrine, P.N., C.R. Ember, and M. Ember. 2009: Cross-cultural research in the study of migration: Cultural features and language, in *Ancient Human Migrations: A Multidisciplinary Approach*, P.N. Peregrine, I. Peiros, and M. Feldman. University of Utah Press, 31-41.

Phadtare, N. 2000: Sharp decrease in summer monsoon strength 4000-3500 cal yr. B.P. in the Central Higher Himalaya of India based on pollen evidence from Alpine peat, *Quat. Res.* 53, 122-129.

Prasad, S. and Y. Enzel. 2006: Holocene paleoclimates of India, *Quat. Res.* 66, 442-453.

Redman, C.L. 2005: Resilience theory in archaeology, *Amer. Anthro.* 107, 70-77.

Redman, C.L. 2012: Global environmental change, resilience, and sustainable outcomes, in *Surviving Sudden Environmental Changes: Answers from Archaeology*, J. Cooper and P. Sheets, Eds., University Press of Colorado, 237-244.

Redman, C.L. and A.P. Kinzig. 2003: Resilience of past landscapes: Resilience theory, society, and the Longue Durée, *Cons. Ecol.* 7, Article 14, http://www.consecol.org/vol7/iss1/art14/.

Rein, B., A. Lückge, L. Reinhardt, F. Sirocko, A. Wolf, and W-C. Dullo. 2005: El Niño variability off Peru during the last 20,000 years, *Paleoceanography* 20, PA4003, doi:10,1029/2004PA001099.

Roos, P., M. Gelfand, D. Nau, and J. Lun. 2015: Societal threat and cultural variation in the strength of social norms: An evolutionary basis, *Org. Behav. Hum. Decis. Process* 127, 14-23

Rosenmeier, M., D. Hodell, M. Brenner, and J. Curtis. 2002: A 4000-year lacustrine record of environmental change in the southern Maya lowlands, Petén, Guatemala, *Quat. Res.* 57, 183-190.

Sandweiss, D., R. Shady Solis, M. Moseley, D. Keefer, and C. Ortloff. 2009: Environmental change and economic development in coastal Peru between 5800 and 3600 years ago, *PNAS* 106, 1359-1363.

Sheets, P. 2012: Responses to explosive volcanic eruptions by small to complex societies in ancient Mexico and Central America, in *Surviving Sudden Environmental Change*, J. Cooper and P. Sheets, Eds., University Press of Colorado, 43-65.

Singh-Peterson, L., P. Salmon, C. Baldwin, and N. Goode. 2015: Deconstructing the concept of shared responsibility for disaster resilience: A Sunshine Coast case study, Australia, *Nat. Hazards* 79, 755-774.

Smith, M.E. and P.N. Peregrine. 2012: Approaches to comparative analysis in archaeology, in *The Comparative Archaeology of* Complex *Societies*, M.E. Smith, Ed., Cambridge University Press 4-20.

Stahle, D., E. Cook, D. Burnette, J. Villanueva, J. Cerano, J. Burns, et al., 2016: The Mexican drought atlas: Tree-ring reconstructions of the soil moisture balance during the Late Pre-Hispanic, Colonial, and Modern eras, *Quat. Sci. Rev.* 149, 34-60.

Stanley, J.-D., M.D. Krom, R. Cliff, and J.C. Woodward. 2003: Short contribution: Nile flow failure at the end of the Old Kingdom, Egypt: Strontium isotopic and petrologic evidence, *Geoarchaeology* 18, 395-402.

Staubwasser, M. and H. Weiss. 2006: Holocene climate and cultural evolution in Late Prehistoric-Early Historic West Asia, *Quat. Res.* 66, 372-387.

Staubwasser, M., F. Sirocko, P.M. Grootes, and M. Segl. 2003: Climate change at the 4.2 kya BP termination of the Indus Valley civilization and Holocene South Asian monsoon variability, *Geophys. Res. Lett.* 30, 1425-1428.

Tierney, K. 2014: *The Social Roots of Risk: Producing Disasters, Promoting Resilience*, Stanford University Press.

van der Leeuw, S. and the ARCHAEOMEDES Research Team. 2005: Climate, hydrology, land use, and environmental degradation in the lower Rhone Valley during the Roman period, *Comptes Rendus Geoscience* 337, 9-27.

Van de Noort, R. 2011: Conceptualizing climate change archaeology, *Antiquity* 85, 1039-1048.

Walker, B., C.S. Holling, S. Carpenter, and A. Kinzig, 2004: Resilience, adaptability and transformability in socio-ecological systems, *Ecol. Soc.* 9(2), Article 5, http://www.ecologyandsociety.org/vol9/iss2/art5.

Waters, M. 2008: Alluvial chronologies and archaeology of the Gila River drainage basin, Arizona, *Geomorphology* 101, 332-341.

Waters, M. and J. Ravesloot. 2000: Late Quaternary geology of the Middle Gila River, Gila Indian Reservation, Arizona, *Quat. Res.* 54, 49-57.

Waters, M. and J. Ravesloot. 2001: Landscape change and the cultural evolution of the Hohokam along the Middle Gila River and other river valleys in South-Central Arizona, *Amer. Antiquity* 66, 285-299.

Webster, J., G. Brook, L.B. Railsback, H. Cheng, R.L. Edwards, C. Alexander, and P. Reeder, 2007: Stalagmite evidence from Belize indicating significant droughts at the time of Preclassic abandonment, the Maya hiatus, and the Classic Maya collapse, *Paleogeography, Paleoclimatology, Paleoecology* 250, 1-17.

Weiss, H. 2000: Beyond the Younger Dryas: Collapse and adaptation to abrupt climate change in ancient West Asia and the eastern Mediterranean, in *Environmental Disaster and the Archaeology of Human Response*, G. Bawden and R.M. Reycraft, Eds., Maxwell Museum of Anthropology, 75-98.

Weiss, H., M.A. Courtney, W. Wetterstrom, F. Guichard, L. Senior, R. Meadow, and A Curnow. 1993: The genesis and collapse of third millennium North Mesopotamian civilization, *Science* 261, 995-1004.

Yoon, D.K., J.E. Kang and S. Brody. 2016: A measurement of community disaster resilience in Korea, *J. Environ. Plan. Manage.* 59, 436-460.

Table 1. List of cases coded with natural disasters, dates, and supporting sources; focal communities and general time periods; and associated eHRAF files. Focal communities include both the specific site and related sites in the area surrounding it. General time periods refer to periods in the local chronology, but coding was restricted to the 100-year period prior to and 100-year period following the listed disaster dates.

Great Lakes

- Focal region: Ontario peninsula
- Focal community: Draper 43.55.42N 79.10.32W
- Disaster: None—control case.
- Disaster Dates:
  - GLE-1: 700CE;
  - GLE-2: 900CE;
  - GLE-3: 1250CE
- Source: Munoz, Gajewski, and Peros 2010.
- Cases:
  - GLP-A: Point Peninsula Complex (300BCE-700CE);
  - GLP-B: Princess Point Complex (700-1000CE);
  - GLP-C: Early Ontario Iroquois (900CE-1250CE);
  - GLP-D: Middle Ontario Iroquois (1250CE-1450CE)
- eHRAF Files: Northeast Middle Woodland; Northeast Late Woodland; Proto-Iroquois.

Central Mississippi River Valley

- Focal region: American Bottom
- Focal community: Cahokia 38.39.18N 90.03.42W
- Disaster: Flooding
- Disaster Dates:
  - ABE-1: 280CE
  - ABE-2: 580CE
  - ABE-3: 1200CE
- Sources: Munoz et al. 2014, 2015.
- Cases:
  - ABP-A: Hopewell (150BCE-300CE);
  - ABP-B: Rosewood (300-450CE);
  - ABP-C: Mund (450-600CE);
  - ABP-E: Patrick (600-750CE);
  - ABP-F: Lohmann-Stirling (1050-1200CE);
  - ABP-G: Moorehead (1200-1275CE)
- eHRAF Files: Hopewell, Eastern Late Woodland, Mississippian

Southwestern US

Focal region: Gila River Valley
Focal community: Snaketown 33.11.19N 111.55.20W
Disaster: Drought
Disaster Dates:
SWE-1: 500CE
SWE-2: 750CE
SWE-3: 1100CE
Sources: Hegmon et al. 2008; Waters 2008; Waters and Ravesloot 2000, 2001.
Cases:
SWP-A: Pioneer/Formative (1-750CE)
SWP-B: Colonial/Preclassic (750-1100CE)
SWP-C: Classic (1100-1450CE)
eHRAF Files: Early Hohokam, Late Hohokam

Mesoamerican Lowlands
Focal region: Petén
Focal community: Tikal 17.13.24N 89.37.17W
Disaster: Drought (El Niño)
Disaster Dates:
MYE-1: 550CE,
MYE-2: 800CE,
MYE-3: 1050CE
Sources: Douglas et al. 2015; Median-Elizalde et al. 2010; Medina Elizalde and Rohling 2012; Rosenmeier et al. 2002; Webster et al. 2007.
Cases:
MYP-A: Early Classic (250-600CE)
MYP-B: Late Classic (600-900CE)
MYP-C: Terminal Classic (900-1000CE)
MYP-D: Early Postclassic (100-1250CE)
eHRAF Files: Classic Maya; Postclassic Maya

North Coastal Peru
Focal region: Moche River Valley
Focal community: Chan-Chan 08.06.21S 79.04.28W
Disaster: Flooding (El Niño)
Dates:
MOE-1: 300CE,
MOE-2: 550CE,
MOE-3: 1000CE
Sources: Dillehay and Kolata 2004; Etayo-Cadavid et al. 2015; Huckleberry and Billman 2003; Rein 2005; Sandweiss et al. 2009.
Periods:
MOP-A: Early Moche (100-300CE)
MOP-B: Middle Moche (300-550CE)
MOP-C: Late Moche (550-750CE)
MOP-D: Chimu (950-1520CE)

eHRAF files: Moche, Chimu

Egypt

Focal region: Upper Nile Valley

Focal community: Memphis 29.15.40N 31.15.03E

Disaster: drought

Dates:

- EGE-1: 3200 BCE
- EGE-2: 2200 BCE

Sources: Hassan 1997; Macklin et al. 2013; Stanley, Krom, Cliff, and Woodward 2003; Staubwasser and Weiss 2006; Weiss 2000

Periods

- EGP-1: Lower Egypt Predynastic (5000-3100 BCE)
- EGP-2: Early Dynastic Egypt (3100–2200 BCE)
- EGP-3: First Intermediate Period (2200–2000 BCE)

Traditions: Lower Egypt Predynastic, Early Dynastic Egypt, Protohistoric Egypt

Descendant community: Fellahin (MR13)

Northern Mesopotamia

Focal region: Khabur River Valley

Focal community: Tell Leilan 36.57.26N 41.30.19E

Disaster: drought

Dates:

- NME-1: 3200 BCE
- NME-2: 2200 BCE

Sources: deMenocal 2001; Staubwasser and Weiss 2006; Weiss 2000; Weiss, Courtney, Wetterstrom, Guichard, Senior, Meadow, and Curnow 1993.

Periods:

- NMP-1: Uruk (4000-3200 BCE)
- NMP-2: Sumerian (3200-2300 BCE)
- NMP-3: Akkadian (2300-2200 BCE)
- NMP-4: Old Assyrian/UR III (2200-2000 BCE)

Traditions: Late Chalcolithic Mesopotamia, Early Dynastic Mesopotamia, Akkadian

Descendant community: Kurds (MA11)

Northern Europe

Focal region: Denmark

Focal community: none

Disaster: none expected

Dates:

- NEE-1: 1100 BCE
- NEE-2: 550 BCE

Source: French 2010

Periods

- NEP-1: Early Nordic Bronze Age (1700-1100 BCE)
- NEP-2: Late Nordic Bronze Age (1100-550 BCE)

NEP-3: Pre-Roman Iron Age (500 BCE-500 CE)
Traditions: Scandinavian Bronze Age, Scandinavian Iron Age
Descendant community: [none]

South Asia
Focal region: Indus River Valley
Focal community: Mohenjo Daro 27.19.30N 68.08.00E
Disaster: drought
Dates:
IRE-1: 2200 BCE
Sources: Phadtare 2000; Prasad 2006; Staubwasswer, Sirocko, Grootes, and Segl 2003; Staubwasser and Weiss 2006; Weiss 2000.
Periods
IRP-1: Middle Harappa (3B) (2450-2200 BCE)
IRP-2: Final Harappa (3C) (2200-2000 BCE)
Traditions: Mature Indus
Descendant community: Baluchi (AT02)

Table 2. Looseness-Tightness Index codes. Community integration and community ceremonials were coded following the coding details in Murdock and Wilson (1972); for the other variables “unstandardized” implies that the range of variation extends far beyond a basic set of forms or types; “moderately unstandardized” implies that while most items follow a basic set of forms or types, they are also routinely altered or personalized to create a relatively large range of variation within those basic forms or types; “moderately standardized” implies that basic forms or types are generally followed, albeit with variation due to individual manufacture or preference; “standardized” implies strong adherence to basic forms or types with relatively little variation.

Community integration (Murdock and Wilson 1972)
- 1 = Lacking or low compared to community segments or larger polity
- 2 = By common residence only
- 3 = Common Identity, dialect, subculture
- 4 = Overlapping Kin ties
- 5 = Common social or economic status
- 6 = Common political ties
- 7 = Common religious ties
- 8 = Two or more of the above
- 9 = Three or more of the above

Prominent community ceremonials (Murdock and Wilson 1972)
- 1 = Rites of passage
- 2 = Calendrical
- 3 = Magical or religious
- 4 = Individual sponsored and communally attended (e.g., potlatch)
- 5 = Two or more of the above
- 6 = Three or more of the above

To what extent are “fineware” ceramics standardized?
- 0 = no fineware ceramics
- 1 = Unstandardized
- 2 = Moderately unstandardized
- 3 = Moderately standardized
- 4 = Standardized

To what extent are living dwellings standardized versus architecturally diverse?
- 0 = no living dwellings
- 1 = Unstandardized
- 2 = Moderately unstandardized

3 = Moderately standardized
4 = Standardized

To what extent are public structures (including bureaucratic or palace structures, defensive structures, marketplaces, etc.) standardized versus architecturally diverse?

0 = no public structures
1 = Unstandardized
2 = Moderately unstandardized
3 = Moderately standardized
4 = Standardized

To what extent are ritual structures (including mounds, temples, enclosures, etc.) standardized versus architecturally diverse?

0 = no ritual structures
1 = Unstandardized
2 = Moderately unstandardized
3 = Moderately standardized
4 = Standardized

Table 3. Corporate-Exclusionary Index codes. These variables were coded following coding details given in Peregrine (2012).

Differentiation among leaders and followers

- 0=egalitarian/no formal leaders
- 1=none
- 2=leaders have some privileges and/or access to resources others do not
- 3=leaders have extensive privileges and access to resources others do not, including special housing and sumptuary goods
- 4=leaders have exclusive privileges and exclusive access to special housing, resources, and sumptuary goods

Leader identification

- 0=egalitarian/no formal leaders
- 1=none
- 2=leaders are identified by treatment or appearance
- 3=leaders are identified by recognized symbols of power or special behaviors
- 4=individual aggrandizement and/or cult of leaders

Sharing of authority

- 0=egalitarian/no formal leaders
- 1=leaders share power extensively with others
- 2=leaders share power with a large cadre of other leaders
- 3=leaders share power with a few other leaders
- 4=leaders exercise exclusive power

Emphasis of authority

- 0=egalitarian/no formal leaders
- 1=emphasis placed on group solidarity and group survival
- 2=emphasis shared between group and leader, with greatest importance given to group survival
- 3=emphasis shared between group and leader, with greatest importance given to leader survival
- 4=emphasis placed on leaders as the embodiment of the group

External contacts (excluding warfare)

- 0=egalitarian/no formal leaders
- 1=few or unimportant
- 2=external contacts are part of leaders' authority, but not exclusive
- 3=external contacts are key to leaders' authority, but not exclusive
- 4=external contacts are exclusively controlled by leaders

Table 4. Pearson's r correlations between independent and dependent variables.

		Corporate-Exclusionary Index	Looseness-Tightness Index
Change in Population	r =	.241	.051
	p <	.160	.418
	N =	19	19
Change in Health	r =	-.029	.001
	p <	.452	.499
	N =	20	20
Change in Conflict	r =	.425*	.275
	p <	.050	.151
	N =	16	16
Change in Household Organization	r =	-.091	-.127
	p <	.348	.292
	N =	21	21
Change in Village Organization	r =	.182	.120
	p <	.209	.297
	N =	22	22
Change in Regional Organization	r =	.508**	.229
	p <	.008	.153
	N =	22	22
Change in Ritual Architecture and Organization	r =	.495**	.379*
	p <	.010	.041
	N =	22	22

*significant at the .05 level
**significant at the .01 level

Figure 1. Location of focal regions coded for social resilience to catastrophic climate-related disasters. (1) Ontario Peninsula; (2) American Bottom; (3) Gila River Valley; (4) Petén; (5) Moche River Valley; (6) Denmark; (7) Upper Nile Valley; (8) Khabur River Valley; (9) Indus River Valley.