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Climate change and the threat to civilization

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The consequences of climate change are likely to be dire—and in some scenarios, catastrophic. Scholars need to start discussing the mechanisms whereby climate change could cause the actual collapse of civilizations. Image credit: Flickr/Spencer.

In a speech about climate change from April 4th of this year, UN General Secretary António Guterres lambasted "the empty pledges that put us on track to an unlivable world" and warned that "we are on a fast track to climate disaster" (1). Although stark, Guterres' statements were not novel. Guterres has made similar remarks on previous occasions, as have other public figures, including Sir David Attenborough, who warned in 2018 that inaction on climate change could lead to "the collapse of our civilizations" (2). In their article, "World Scientists' Warning of a Climate Emergency 2021"—which now has more than 14,700 signatories from 158 countries—William J. Ripple and colleagues state that climate change could "cause significant disruptions to ecosystems, society, and economies, potentially making large areas of Earth uninhabitable" (3).

Because civilization cannot exist in unlivable or uninhabitable places, all of the above warnings can be understood as asserting the potential for anthropogenic climate change to cause civilization collapse (or "climate collapse") to a greater or lesser extent. Yet despite discussing many adverse impacts, climate science literature, as synthesized for instance by assessment reports of the Intergovernmental Panel on Climate Change (IPCC), has little at all to say about whether or under which conditions climate change might threaten civilization. Although a body of scientific research exists on historical and archeological cases of collapse (4), discussions of mechanisms whereby climate change might cause the collapse of

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current civilizations has mostly been the province of journalists, philosophers, novelists, and filmmakers. We believe that this should change.

Here we call for treating the mechanisms and uncertainties associated with climate collapse as a critically important topic for scientific inquiry. Doing so requires clarifying what "civilization collapse" means and explaining how it connects to topics addressed in climate science, such as increased risks from both fast- and slow-onset extreme weather events. This kind of information, we claim, is crucial for the public and for policymakers alike, for whom climate collapse may be a serious concern. Our analysis builds on the latest research, including Kemp *et al.*'s PNAS Perspective, which drew attention to the importance of scientifically exploring the ways that climate outcomes can impact complex socioeconomic systems (5). We go further by providing greater detail about societal collapse, for instance, distinguishing three progressively more severe scenarios. Moreover, we emphasize avoiding doom-saying bias and recommend studying collapse mechanisms in conjunction with successful adaptation and resilience, seeing these as two sides of the same coin.

Collapse Scenarios

We define civilization collapse as the loss of societal capacity to maintain essential governance functions, especially maintaining security, the rule of law, and the provision of basic necessities such as food and water. Civilization collapses in this sense could be associated with civil strife, violence, and widespread scarcity, and thus have extremely adverse effects on human welfare. Such collapses can be wider or narrower in scope, so we consider three representative scenarios.

Moreover, we emphasize avoiding doom-saying bias and recommend studying collapse mechanisms in conjunction with successful adaptation and resilience, seeing these as two sides of the same coin.

In the first, climate change causes collapse in specific, vulnerable locations while civilization elsewhere is largely able to adapt to climate impacts. Call this *local collapse*. The Syrian civil war has been suggested as an example of climate collapse on a local scale. Model simulations indicate that the kind of drought implicated in the war was more than twice as likely to happen given anthropogenic climate change (6). This example illustrates that climate collapse need not be determined by environmental factors alone: other causes, such as pre-existing political conflict and incompetent government, may be crucial. The example also illustrates the dire consequences for human welfare that collapse may have and that local collapses can contribute to political instability in non-collapsed places, as illustrated by rising right-wing populism in Europe in response to the influx of Syrian refugees.

In our second scenario, urban- and sometimes even national-level collapses are widespread, but some large urban centers and national governments still exist. These existing centers experience negative climate impacts such as persistent water and food scarcity. In his book discussing the ethics and politics of a potential post-apocalyptic world, philosopher Tim Mulgan refers to this type of scenario as the *broken world* (7); we adopt his label here. The broken world differs from local collapse in its more widespread scope and in the worldwide impaired functioning of non-collapsed places. Concerns that climate change could render "large areas of the Earth uninhabitable" suggest an outcome at least as bad as the broken world.

In our third scenario, which we label *global collapse*, all large urban areas across the globe are virtually abandoned, functioning nation states no longer exist, and the world's population undergoes a significant decline. This catastrophic situation is perhaps what the phrase "civilization collapse" evokes for most people. However, it is helpful to see global collapse as an extension of the broken world, wherein the remaining non-collapsed states and urban centers, which have by then become highly vulnerable, are pushed over the brink by further climate impacts. Climate collapse, then, might not be an abrupt event but rather an extended process that starts small and plays out over the course of a century or more.

Representing climate collapse as an extended process raises ethical and scientific complexities. On the ethical side, some places are at more imminent risk of collapse than others. Hence, what's regarded as catastrophic climate change may differ according to one's location. For instance, the Maldives might view mean global temperature increase of 1.5°C as an intolerable collapse risk, whereas Canada does not. Thus, although climate collapse may threaten shared global catastrophe, it can nevertheless create difficult ethical questions about how to balance conflicting interests. On the scientific side, cases of collapse studied by historians and archeologists have been local whereas more severe climate collapse scenarios, such as the broken world or global collapse, would be worldwide phenomena. Consequently, mechanisms whereby local collapses might ramify into the broken world or global collapse are inevitably somewhat speculative.

Collapse Mechanisms

The scenarios described above are not predictions. An important starting question is whether there are plausible mechanisms whereby scenarios like the broken world or global collapse might occur, and if so, what might be done to counteract them. Several mechanisms that might cause global collapse or a broken world have been discussed. We group these into three types: *direct impacts*, *socio-climate feedbacks*, and *exogenous shock vulnerability*.

Direct impact mechanisms hypothesize that severe and compounding climate impacts—rising sea levels, drought, flooding, extreme heat, and so forth—could undermine agriculture, water availability, and other essential bases of civilization (8, 9). These mechanisms often involve climate feedbacks or tipping points in which, for instance, a global temperature increase of 2°C triggers irreversible rapid collapse of Antarctic ice sheets, releases of methane from permafrost or forest diebacks (10). In contrast, socio-climate feedback mechanisms propose that adverse climate change impacts, especially on food production, may cause political conflict and

dysfunction that undermines capacity for adaptation while leading to actions, such as bans on food exports or warfare, that spread destabilization and hasten collapse (11). Finally, exogenous shock vulnerability mechanisms suggest that climate change might weaken adaptive capacities through processes described in the first two mechanism types, thereby leaving global society vulnerable to collapse triggered by other types of shocks, such as wars or pandemics (12).

Historical and archeological research suggests that past societal collapses have rarely been the result of direct climate perturbations but instead were more commonly attributable to a combination of stressors (13, 14). However, this does not mean that the risk of climate collapse is overstated. To the contrary, it suggests that collapse could result from climate impacts to which global civilization might have adapted. That indeed is the message of the socio-climate feedback and exogenous shock vulnerability mechanisms: The risk to civilization is not from direct climate impacts alone but rather those impacts occurring together with dysfunctional social feedbacks and other destabilizing factors. Finally, the rarity of collapse as a direct result of climatic changes in the past may be a poor guide to a future outside the stable climate of the mid-Holocene (9).

In-depth connections between climate collapse mechanisms and scientific literature on social, economic, and political aspects of climate change are quite limited (15). Moreover, discussions of socio-climate feedbacks and exogenous shock vulnerability mechanisms tend to focus on collapse risks without considering historical cases of successful adaptation to environmental challenges of similar magnitude as some potential climate impacts. Cases of relative sea level rise owing to subsidence, for example, have often not resulted in the abandonment of urban centers but rather the construction of major sea defenses and the extension of coastlines (16). Similarly, discussions of collapse mechanisms rarely discuss economic factors, especially declining costs of wind and solar energy, that might provide incentives for a rapid transition away from fossil fuels (17).

Given the above, we offer two recommendations for how research on the risk of climate collapse can more fruitfully proceed. First, we suggest that more scientific effort be devoted to studying socio-climate feedback and exogenous shock vulnerability climate collapse mechanisms. Among other things, this involves greater attention to pathways whereby direct climate impacts might interact with social, economic, and political factors to threaten societal collapse. Second, collapse mechanisms should be systematically examined in tandem with causal processes involved in successful adaptation to environmental challenges as well as economic forces and policies that could drive a green transition. Consideration of the complex interplay of social, environmental, and other factors as well as the active role of societal resilience is already well established in historical and archeological research on collapse (13, 14). The challenge is to bring the study of mechanisms that might cause the collapse of current civilization up to that standard of scientific rigor.

Serious Risks?

Some may object that levels of warming capable of yielding severe collapse scenarios such as the broken world or global collapse don't merit serious consideration. For example, some argue that high-end emission scenarios considered by the IPCC assume increases in coal use throughout the 21st century that are implausible given declining costs of renewable energy (18). And an article recently published in *Nature* finds that current climate pledges, if all fully implemented on schedule, may keep global heating just below 2°C (19).

Although declining costs of renewable energy and carbon neutrality pledges are welcome signs, we think it is much too soon to brush aside concerns about the broken world or global collapse. Both of the high-emission pathways considered in the IPCC's most recent Working Group I report contain 4°C increases in the "very likely" range for 2081 through 2100 (20), a level of heating that many scientists regard as a significant threat to civilization (21). Furthermore, past experience suggests that climate pledges may not translate into effective, timely policies, and without concerted efforts by governments there is no certainty that market forces will drive a fossil fuel phase-out quickly enough to avert climate collapse. Energy markets are often difficult to forecast, as the resurgence of coal use to an all-time high in 2021 illustrates (22). Meanwhile, the IPCC's highest-end greenhouse gas concentration pathway, RCP 8.5, remains close to observations and might stay that way if negative feedback loops, such as emissions from melting permafrost and forest die-backs, kick in sooner than expected (23, 24). Finally, low emission scenarios considered by the IPCC involve more than a fossil fuel phase-out: They also assume sustained negative emissions from about mid-century onward that may not be technologically or economically feasible (25).

A sober assessment of the risk of climate collapse and the pathways by which it can be kept at bay, we suggest, may help to settle nerves and spur action.

There is, in sum, no solid basis at present for dismissing the broken world and global collapse as too unlikely to merit serious consideration. Given the moral and practical importance of these scenarios, we believe that science should endeavor to learn more about mechanisms that might lead to them.

As a topic of urgent concern to humanity, the risk of climate collapse demands careful scientific investigation. And research on closely related topics—such as past cases of collapse, limits to adaptation, and systemic risk—makes it difficult to argue that climate collapse is impossible to study scientifically. Still, some may worry that pursuing scientific study of climate collapse will cause anxiety and encourage emotional disengagement from action on climate change.

We disagree. Warnings about climate collapse issued by scientists and scientifically informed public figures are already present in the public discourse, whereas survey data suggest that climate change is a source of widespread public concern and anxiety (26, 27). Against this backdrop, careful scientific study of climate collapse might act as a counterweight to discussions of climate collapse that are sensationalistic or biased towards portending doom. And, depending

on the results of the research, it might serve as a rebuttal to skeptics who refuse to take the possibility of climate collapse seriously at all. A sober assessment of the risk of climate collapse and the pathways by which it can be kept at bay, we suggest, may help to settle nerves and spur action.

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