Weather and Climate Extremes 5-6 (2014) 29–39

Contents lists available at ScienceDirect

Weather and Climate Extremes

journal homepage: www.elsevier.com/locate/wace

Weather and climate extremes: Pacemakers of adaptation?

William R. Travis *

Department of Geography, Institute for Behavioral Science, 488 UCB, University of Colorado, Boulder, CO 80309, USA

ARTICLE INFO

Article history:
Received 17 February 2014
Received in revised form
10 June 2014
Accepted 29 August 2014
Available online 9 September 2014

Keywords:
Extreme events
Climate change
Adaptation

ABSTRACT

Weather and climate extremes might propel adaptation both to a stable climate and its characteristic extremes, as well as to underlying changes, if they reveal vulnerabilities, cause damage, and make slow change more noticeable. In theory, extremes act as focusing events that overcome barriers to adaptation and accelerate policy responses. This pace-making might be attenuated by uncertainty in interpreting trends, and extremes might also miscue decision makers, perhaps pointing in the wrong direction or evoking over-adaptation. Cases from a data-base of the most costly weather and climate extremes in the United States over the past three decades are employed to develop a propositional typology of such pace-making effects. Some adaptations in response to extremes result in reduced vulnerability, while other cases yield little effective adaptation or hint at mal-adaptation. Even the most-extreme events do not necessarily yield significant adaptation, despite calls for change and explicit attribution to climate change.

1. Introduction

For variety of reasons, extremes of weather and climate are thought to propel adaptation to climate change (Intergovernmental Panel on Climate Change, 2012; Füssel, 2007). In the simplest formulation of this logical assertion, extremes make societal vulnerability manifest, and thus overcome widely-recognized (Adger et al., 2007; Adger and Barnett, 2009; Moser and Ekstrom, 2010) social and economic barriers to adaptation. The same effect is thought to hold for a stationary climate, whereby extreme events override people's tendency to disregard low probability, and thus infrequent, risks, and adopt mitigations that were deferred during spells without damaging events. Hazards managers have long counted on the "window of opportunity" following occurrence of an extreme to propel mitigation (Birkland, 2006; Platt, 1999). For climate change per se, extreme weather and climate events might transcend a hypothetical signal-to-noise threshold and make climate trends evident to decision-makers and, thus, elicit adaptation, or, at least, awareness of the need for adaptation (Moser and Boykoff, 2013). An underlying trend in, for example, mean temperature, may be difficult for any decision-maker to discern, but more frequent excursions into conditions rare, or even unknown, in the past, especially if they cause acute impacts like heat waves, make underlying climate trends more tangible. Framed by a discourse on climate change, an extreme event becomes not just a reminder that climate distributions have tails, but a harbinger of increasing extremes.

Extremes have come to be framed descriptively as propelling adaptation and prescriptively as useful signals that the climate is changing and society should be adapting. It is postulated that adaptation to extremes, even when not associated with climate change, still serves to prepare society for climate change. The title of an Intergovernmental Panel on Climate Change special report (Intergovernmental Panel on Climate Change, 2012), "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation," invokes this prescriptive role of extremes, in addition to signaling a hypothesized "adaptation deficit" that the report uses to argue for hazard reduction actions now despite large uncertainties about the future evolution of the climate and its statistical tails.

Though intuitively appealing, experience and limited research cast some doubt on these propositions. Our understanding remains murky: extremes like Superstorm Sandy in the Northeastern United States (Blake et al., 2013) and Australia's "Millennial Drought" (Heberger, 2011), now routinely evoke increased public discourse about climate change and climate adaptation (Leiserowitz et al., 2012), yet theorists and practitioners alike still struggle with the role of extremes in adaptation to either stable or changing climate. Countervailing evidence includes cases of little actual adaptation after repeated disasters (White et al., 2001), or even the acceleration of trends that appear mal-adaptive (Kates et al., 2006). This paper develops a typology of theoretical pace-making effects of extremes in shaping adaptation to climate and to climate change. It then explores case studies from a sample of the most costly weather and climate extremes in the United States, explicating these effects in a range of hazards and resource management contexts.

* Tel.: +1 303 492 6312.
E-mail address: william.travis@colorado.edu

http://dx.doi.org/10.1016/j.wace.2014.08.001

2. Pace-making theory and mechanisms

Adaptation to climate is, like other decision-making processes, variously conceptualized depending on disciplinary perspective, sector, and the divide between diagnostic and prescriptive analysis (Adger and Barnett, 2009). But it can broadly be captured by a small set of dimensions including anticipatory vs. reactive; autonomous vs. planned; individual vs. collective; and incremental vs. transformative (Smit and Wandel, 2006; Kates et al., 2012; Jones and Preston, 2011; Pelling, 2010). Less attention has been paid to tactical aspects of adaptation; besides offering rosters of possible adaptations in everything from water resources to international security, the U.S. National Research Council in a recent assessment cited a lack of, and called for more, research on processes of adaptive decision-making and the timing of adaptive actions as climate change unfolds (National Research Council, 2010). The Intergovernmental Panel on Climate Change (IPCC) fifth assessment report also calls for more attention to how adaptation is implemented in response to climate risks (Intergovernmental Panel on Climate Change, 2014); the IPCC and others (Patt et al., 2010; Jones, 2001; Jones and Mearns, 2004) have specifically noted the role of extremes in the adaptation process.

Ironically, extremes played a dominant role in the early climate and society literature (Heathcote, 1985); initial work on climate and history was mostly built on a range of extreme climate episodes (Wigley et al., 1981). The pre-eminent historical case of extreme events viewed as pacing adaptation in the U.S. was recurrent drought on the Great Plains, illustrated by Warrick (Warrick, 1975) in a graphic (Fig. 1), widely emulated and extended in subsequent drought studies (Riebsame, 1991; Bowden et al., 1981), illustrating how adaptation was stoked by each recurrent drought. In current climate adaptation parlance this process might be called learning loops (Intergovernmental Panel on Climate Change, 2012) or adaptation action cycles (Park et al., 2012), but it can also be seen more prosaically as a ratchet effect.

The recent literature and hazards theory provides a range of propositions for the pace-making role of extreme events in climate adaptation (Table 1). Extremes might serve to ratchet autonomous, even inadvertent, adaptation, without the necessity for any decision-maker to explicitly recognize a worsening trend in impacts. A more common framing viz. climate change is of extremes as an alarm signal, convincing decision-makers that (a) social systems are becoming more vulnerable, (b) natural systems are becoming more extreme, or (c) both, and setting in train purposeful and targeted adaptation. Extremes can damage infrastructure and other forms of wealth and provide the "creative destruction" opportunity for adaptation in the recovery and reconstruction process, adaptation that in some formulations would be accounted as reducing an existing "adaptation deficit" rather than preparing for future change. Finally, extremes may evoke innovations in institutions and governance that, perhaps already proposed by some analysts, were too innovative to be adopted without some external pressure. These propositions are next briefly explored conceptually, and then are refracted through a set of case studies.

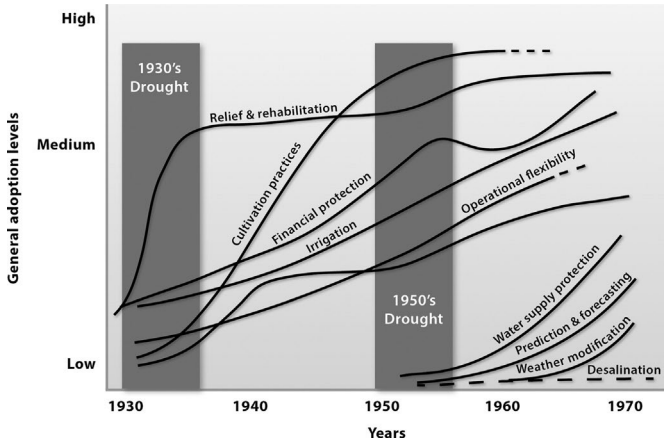

Fig. 1. An early illustration of the pace-making effect of extremes was used by Warrick (1975) to identify adoption of specific responses to historic droughts in the United States. In subsequent work (Bowden et al., 1981) Warrick and colleagues extended the analysis back to the 1890s and forward to the 1970s, arguing that even though different adaptations marked each drought episode, the net effect was a lessening of societal impacts over time. Used with permission from the Natural Hazards Center, Institute of Behavioral Science, University of Colorado.

2.1. Adaptive ratchet

The simplest pace-maker model is the ratchet, whereby individuals and systems add coping capacity, scaled to each extreme event, so as to enlarge the coping range of the system at risk. For a changing climate, this mechanism was implied in the adaptation story-lines illustrated by Füssel (Füssel, 2007). Drawing on a conceptual framework suggested by de Vries (1985), Füssel (2007) laid out a hypothetical planned-adaptation time line (Fig. 2) in which extreme events evoke actions that enlarge the tolerance limits of a given resource system. Füssel describes a hypothetical situation when a community experiences an extreme (E_1) outside the coping range:

> The community wonders whether E_1 is still an expression of natural variability or whether it is already a harbinger of more climate change to come. If the first, the community would be willing to accept the damage because the return period of a similar event would be very long. If the second, the community would prepare for costly extension of their coping range because a previously "unusual" event like E_1 would become increasingly "normal" in the future (Füssel, 2007 p. 267).

Although the extended coping range is typically illustrated as a permanent extension, experience suggests that physical and social adaptations occasioned by extremes may also degrade over time, slipping back toward the pre-event status. Variants of this graphical approach are used later in this paper to illustrate some of the case studies.

In a ratchet effect, the enlarged coping range becomes a normal part of the system, which can then absorb future extremes and underlying climate change at a lower probability of failure. In pacemaker theory, each event that appears to be consistent with the assumed climate trend would act as a trigger to overcome barriers to adaptation. Bigger events would yield more adaptation, but the key difference is that the community which Füssel invokes now assumes that the extreme is a signal of more to come. Thus the community becomes more open to adaptive responses that expand tolerance levels in the designated direction, and less convinced by the assumption of climate stationarity. Furthermore, the event-driven pattern of adaptation might quicken infrastructure replacement cycles, and, assuming that infrastructure most in need of adaptation is more likely to be compromised or damaged by extremes worsened by climate change, provides a *de facto* prioritization of adaptive intervention, re-design, and shoring up. This adaptation strategy could be seen as an informed, efficient "muddling through" (Lindblom, 1959): adaptation that is both reactive and a bit forward looking, actuated more by acute impacts and losses instead of anticipated loss of expected utility, but also enjoying the option value to wait-and-see, while acquiring the information and greater certainty of climate trends and risks that comes packaged with extremes.