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Environmental Research Letters

EDITORIAL

Resilience to climate shocks in the tropics

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Keywords: resilience, climate change, El Niño-southern oscillation, interdisciplinary, land-use, governance

OPEN ACCESS

RECEIVED
20 January 2020

REVISED
3 February 2020

ACCEPTED FOR PUBLICATION
21 August 2020

PUBLISHED
30 September 2020

Abstract

This focus collection on resilience to climate shocks in the tropics draws together 16 papers that predominantly examine the impacts of, and responses to, the 2015/2016 El Niño-Southern Oscillation event, in a range of contexts. This introductory synthesis contextualises the collection of papers by reviewing important concepts and highlighting some important insights that emerge from the collection. The papers in this collection collectively highlight: the value of longitudinal and interdisciplinary research in understanding both the roots of, and responses to, resilience challenges; the critical interaction between climatic and land-use changes; and the ways in which governance arrangements underpin societal decision-making across a range of scales and contexts to shape resilience.

1. Introduction

This focus collection on resilience to climate shocks in the tropics draws together 16 papers that predominantly examine the impacts of, and responses to, the 2015/2016 El Niño-South Oscillation (ENSO) event. This episodic warming of sea surface temperature in the central-east equatorial Pacific has implications for extreme weather patterns across the globe, particularly in the tropics (Timmerman *et al* 2018). The papers in this collection reflect the diversity of impacts associated with El Niño events and draw on both the natural and social sciences to investigate a range of social and ecological systems including marine, coastal and riverine environments, intact and converted forests, human settlements and multi-ecosystem landscapes. These ecosystems underpin several important economic sectors explored in this collection, particularly, agriculture, forestry and fisheries. This introductory synthesis contextualises the collection of papers by reviewing important concepts and highlighting some important insights that emerge from the collection.

The concept of climate resilience has gained prominence in a range of research and development-related fields in recent years (Adler *et al* 2015, Brown 2015). Although the term resilience is contested (Cote and Nightingale 2012) and often overlaps with related terms such as vulnerability and adaptive capacity, its flexibility has helped facilitate a confluence of different knowledge communities (Beichler *et al* 2014). As a result, a range of framings are employed in research on resilience. These include differences in emphasis placed on absorbing and coping with shocks and the ability to adapt and transform; the boundaries of systems examined; (*i.e.* what should be legitimately included in resilience studies); differing levels of focus, and perspectives on the distinction between social, ecological or social-ecological systems and temporal framings. Despite efforts to reconcile approaches to resilience (e.g. Allen *et al* 2019), different framings may be mutually exclusive or have strongly divergent approaches to distributional and social processes and outcomes. This highlights the importance of questions concerning resilience 'of what?' 'to what?'.

Increasingly, 'climate change' has become the focus of 'resilient to what?' questions. Climate change refers to both changes in average weather conditions (the climate) and the variance of weather patterns so the terms climate resilience and climate shocks include droughts, floods and storms within their

scope. The 2015/2016 El Niño provides an excellent case for studying climate resilience across contexts because of the varied range of weather extremes (rainfall distributions and quantities, and high and low temperature anomalies) through which it manifests. Furthermore, as Rifai *et al* (2019) show, continued warming associated with anthropogenic climate change means that future El Niño events will expose ecosystems and communities to novel climatic extremes, even if the magnitude of climate variability remains the same. El Niño events are an important source of extreme weather in a changing climate. It is timely, therefore, that this collection draws on analyses of 2015/2016 El Niño event to profile new findings and articulate future directions with respect to climate resilience in the tropics.

With respect to resilience 'of what?' questions, the papers in the collection contain a diversity approaches with some papers focussing on ecological responses to El Niño, others focussing primarily on social impacts and responses, while a third group examine the intersection of ecological and social dimensions. We synthesise these papers by discussing the collection's key contributions across the following themes: (1) The value of longitudinal studies; (2) The importance of interdisciplinary research; (3) How land-use change amplifies climate shocks; (4) The role of scale; and (5) The centrality of governance.

2. The value of longitudinal studies

Understanding resilience requires engaging with contexts where there are a range of social and ecological processes interacting over different temporal scales. For example, 'short-term' climate shocks occur within longer-term changes associated with climate change (Whitfield *et al* 2019). A significant limitation on advancing knowledge of how environments and societies respond to climate change and shocks is the relative paucity of long-term data sets, particularly in tropical contexts. The skill in forecasting El Niño events and related climate anomalies and the relatively long time gap between El Niño conditions being confirmed and the impacts being felt provides an opportunity to research climate shocks that otherwise are often over before research teams are able to mobilise. Insights from such studies also provide value in forecasting or preparing for impacts of future El Niño events on climate and society (Glantz 2015). Several of the papers in this collection draw on data collected before, during and after climate shocks. Taken together these papers highlight the value of longitudinal studies.

This strength is clearly illustrated by Qie *et al* (2019) who monitored seedling dynamics in logged and unlogged forests in Malaysia before, during and after the El Niño. They show that whilst the drought impacted seedling development in all forests, in logged forests recovery after droughts was characterised by species specialising in establishing on severely disturbed areas, suggesting the land may not recover to its original forested state without management intervention.

In Ethiopia, Macdonald *et al* (2019) draw on longitudinal data to compare the performance of various water sources for rural communities where water scarcity is linked with violent conflict, missed meals, school absences and poor health. Their analysis demonstrated shallow boreholes with handpumps were the most reliable, and importantly, they showed that the performance and recovery of other sources such as hand-dug wells and springs declined as the drought progressed. In southern Africa, the most intense drought event in the historical record occurred during 2015–16, suppressing groundwater recharge and leading to a major decline in groundwater storage in the Limpopo river basin (Kolusu *et al* 2019). Widespread socio-economic impacts of drought were also recorded in regional capital cities Gaborone and Lusaka, associated with disruption to public water supply and electricity generation from hydropower in the Zambia river basin, respectively (Gannon *et al* 2018). In both these cases, impacts were exacerbated by drought in the preceding year, highlighting the importance of antecedent conditions in influencing impacts of specific El Niño events.

As future research plans on climate resilience are developed, it is imperative that they incorporate strategies to support long-term research and data collection campaigns to facilitate more longitudinal research, establish baselines and develop increasingly robust evidence-bases for interventions.

3. The importance of interdisciplinary research

Several papers in the collection draw on interdisciplinary methods to understand the deep interactions between the ecological and social dimensions of resilience. Although the distinction between the 'ecological' and the 'social' has been increasingly blurred, this does not mean that different components of systems respond uniformly to climate shocks.

Wilkinson *et al*'s (2019) contribution demonstrates this clearly in their analysis of freshwater fish (*Nematabramis everetti*) populations in Borneo. They find that while fish stocks were resilient to the drought and may actually more vulnerable to land-use change, the provision of ecosystem services related to fish (*i.e.* fish availability to communities) was negatively impacted as a result of the difficulty in fishing in shallower water.

Interdisciplinary research can also help develop technical insights that incorporate, for example, environmental and economic considerations. Smith *et al* (2019) exemplify the kinds of insights that can

be generated by such approaches when they examine how different treatments of manure can address the impacts of droughts on agricultural yields and carbon storage. They demonstrate that using anaerobic digesters to produce biogas and applying the nutrient-rich slurry to the soil generates the greatest benefits, but, importantly, many households face economic and environmental (water availability) constraints. Boillat *et al* (2019) assess the compare the on-farm effects of different Conservation Agriculture practices (reduced tillage, permanent ground cover and crop diversification) under ENSO-driven rainfall variability in Kenya and Malawi. They show that conservation agriculture practices can have a positive impact on resilience either in isolation as well as when undertaken together. They highlight the variety of ways in which farmers adopt agriculture to illustrate that agricultural interventions are not 'one size fits all' and should adapt to consider agro-ecological and social conditions and flexibility in adoption guidelines should be encouraged.

The significance of recognising the social components of resilience is highlighted in broader terms by Morel *et al* (2019). They show how the location of farmers' plots in the landscape, as well as issues such as income diversification, gender dynamics and government policies all interact to shape farmers' vulnerability. As well as providing a rich understanding of the dynamics of resilience, many of the studies in this collection demonstrate, and emphasise the importance of, moving beyond technical considerations of how to optimise production in efforts to pursue climate resilience in agricultural communities.

Further illustrating the value of interdisciplinary research, Beauchamp *et al* (2020) show in their cross-case synthesis of factors affecting farmers' adaptive capacities that purely quantitative approaches provide limited insights to climate resilience in a general sense. This is because factors determining adaptive capacity are set within specific socio-ecological settings, each of which are characterised by incommensurability in terms of the meaning and influence of driving variables such as gender or land rights. In addition to integrating quantitative and qualitative methods and ecological and social science approaches to climate resilience, Nunes *et al* (2019) show how methodological diversity is essential to advancing disciplinary understanding, in their case, by combining remote sensing and field-based studies to examine leaf functional traits in rainforest canopy trees.

4. Land-use change amplifies climate shocks

Climate shocks do not occur in isolation from their social and ecological contexts, they interact with a range of other factors. Decisions about the framing and scope of research and relevant policy arenas have a profound influence on outcomes; conceptual framings, whether explicit or implicit, dictate what is seen and unseen, and consequently the issues that societies (attempt to) address and how. A key interaction that several papers in this collection highlight, and which resonates with the wider literature, is between land-use change and climate change and climatic shocks. Gregory *et al* show (2019) for example, how fine scale differences in micro-climate driven by interactions between weather and land-use difference (such as between logged forests and oil palm) influence mosquito life-cycles and subsequent disease transmission patterns. These interactions are not linear, as rising temperatures for example, can push organisms such as mosquitoes towards and beyond what is optimal for their reproduction.

The interactions between land-use and climate are vital to understanding future changes to ecosystems and their contributions to societal resilience. As Qie *et al* (2019) show, seedling development is determined by interaction of drought and logging intensity. And as Rifai *et al* (2019) discuss, fires in the Amazon have been increasing in recent years because of the interaction of land use with a warming climate, despite the decade-long (until 2019) reduction in deforestation rates (Aragão 2018). These interactions feed into wider climate-carbon cycle dynamics associated with land because of its role as an important potential source of carbon dioxide. A key implication of these interactions is that building resilience to climate shocks also entails engaging with the wider context in which shocks occur and developing an understanding of the interacting drivers of change which may be predominantly social, as in the case of land-use change.

5. The role of scale

Many of the papers in this collection articulate the challenges associated with scale, an issue that has also received increasing attention in the literature (Whitfield *et al* 2019). Eggen *et al* (2019), for example, demonstrate the importance of understanding sub-seasonal rainfall variability (short duration extremes that can have large impacts on yields). They show in a study of sorghum in Ethiopia how crop responses differ between sub-seasonal extremes and seasonal drought. At a finer scale, Kreppel *et al* (2019) show that strong causal linkages have not been established between large-scale climatic variation driven by, for example, El Niño, and micro-climatic conditions that influence mosquito behaviour, a critical consideration for insect-borne diseases such as malaria. Strengthening the evidence base for causal linkages between El Niño events and socio-ecological impacts is crucial to underpin forecasting of, and preparation for, future events.

Shocks vary in the temporal duration. Wendling *et al* (2019) draw on a data set going back to 1955

to constrain a system dynamics model to represent the ecohydrological evolution of a Sahelian tiger bush over decades. The region experienced a prolonged drought from the 1970s to the mid-1990s. They explore the paradox between decreased rainfall and increased run-off. They show that the ecohydrological system has two alternative stable states and that during the drought it shifted from a high-vegetation/low-runoff regime to the alternative low-vegetation/high-runoff one. Although recovery may be possible, the antagonistic effects of mean rainfall and rainfall variability make predicting future resilience of the system uncertain.

Nkiaka *et al* (2019) show that timescale issues are also at the heart of understanding user needs with respect to weather and climate information. Providing climate information services (CIS) that align with the timely needs of different types of users across agricultural, disaster management and water management sectors is crucial for beneficiaries to make livelihood decisions that enhanced their resilience. Against a backdrop of low uptake of weather and climate information, their findings show that greater capacity building of personnel working for National Meteorological and Hydrological Services and Agricultural Extension staff is essential for improving the uptake and utility of CIS.

Spatial scales are also critical. Beauchamp *et al* (2019) demonstrate how the factors that influence the components of adaptive capacity are set within their specific socio-ecological settings. Reflecting on the value of synthesising analyses they argue that such efforts might have more robust results if they are done at the landscape or regional, rather than global, scale as well as benefitting from *a priori* planning.

6. The centrality of governance

Questions associated with planning and the production and use of science are central to governance. Governance broadly refers to processes by which society steers itself, including the norms, institutions, and systems that shape how power and responsibilities are exercised, and how decisions are taken, by whom and why. Governance arrangements, mediate, *inter alia*, the link between knowledge and decisions, and are therefore central to questions of resilience and adaptation.

In this collection, O'Neill *et al* (2019) show patron-client relationships in small-scale fisheries, which are a central organising feature of many small-scale markets, help buffer short-term shocks such as drought, by providing loans to fishing communities to aide their recovery and re-establishment of activities. However, these arrangements tend to entrench particular forms of governance and (fishing) practices which, in this particular case, threaten the ecological integrity of fisheries and generally do not promote or facilitate changes in practices or broader adaptive capacity. Such arrangements, while underpinning communities' ability to cope with shock, risk constraining agency, collective action and self-determination within communities, and prove to be maladaptive or to weaken resilience over longer time periods.

Similarly, Touza *et al* (2019) highlight how short-term coping responses to drought in mangrove and marsh dependent communities in the Caribbean can lead to system 'lock-ins' (Cinner *et al* 2011). These include adopting fishing practices that over-exploit particular species and cause deterioration of essential fish habitat, that might exacerbate future vulnerability. They highlight that addressing such maladaptive responses (see Juhola *et al* 2016) to shocks is particularly challenging in contexts that are characterised by perceived state abandonment and high levels of mis-trust in authorities. However, they also argue that opportunities to reduce vulnerability exist if collaborative and coordinated arrangements between different organisations can be fostered.

7. Concluding remarks

Papers in this collection, and in the wider literature, highlight a nuanced message; that while prevailing governance arrangements underpin existing patterns of resilience, they also pose a significant barrier to 'doing things differently' in order to support more transformative adaptation. This reflects a core tension within resilience framings; the potential contradiction between absorbing shocks and adapting to future shocks. The challenge for people aiming to address climate resilience is, therefore, how to understand and disentangle different components of governance systems and their effects. And how to do so in ways which are context-specific, that integrate insights from the social and natural sciences and support local resilience efforts. This challenge is particularly acute when the incentive structures facing researchers and policy-makers are often orientated around large global-scale work. This risks research being disconnected from the communities most impacted by climate shocks. This is particularly important in the context of increasingly widespread authoritarian regimes that marginalise scientific communities (Neimark *et al* 2019).

The challenges associated with building climate resilience are many. As the final paper in the collection (Beauchamp *et al* 2020) highlights, addressing concerns of resilience to climate shocks will require developing longitudinal and interdisciplinary work in closer and wider collaborations across organisations, sectors and scales. This collection contains many outputs of such collaborations and demonstrates the multifaceted insights that come from drawing on the rich and diverse range of disciplines engaged with questions of climate resilience under a variety of framings.

Acknowledgments

The guest editors would like to thank all the authors who contributed to this collection. Most papers in this collection have their genesis in the 'Understanding the impacts of 2015/2016 El Niño programme' funded by the UK Natural Environmental Research Council (NERC) and Department for International Development (DFID). This collection was facilitated by a synthesis and dissemination grant under this programme (Project Code: NE/P00394X/1).

Data availability statement

Any data that support the findings of this study are included within the article.

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