

READING CLIMATE CHANGE AND CLIMATE GOVERNANCE AS POLITICAL ECOLOGIES

Diana Liverman

Introduction

Political ecology provides powerful insights into understanding the causes, consequences and responses to climate change from local to global scales – interweaving material nature with the structural drivers of emissions and vulnerabilities, as well as with the agency of individual and institutional actors and the narratives they embrace to describe, explain and debate what is happening to climate and what should be done about it. Climate change is an issue that highlights questions of environmental and social justice and can connect many political ecologists to activism and policy. It is distinguished by its global reach through the atmospheric commons, by the existential scope of the threats and solutions, and by a research community that is institutionally well connected to international policy.

This chapter explores how political ecology can analyze the geographical causes of climate change, including the differential responsibilities of countries for fossil fuel consumption and land use change. Second, the chapter focuses on climate change vulnerability where political ecology has provided valuable insights into the political economy of drought and other climate extremes in different regions, and the ways in which a changing climate intersects with other stresses, such as those of neoliberalism on peasant farmers. Third, it considers responses to climate change and how political ecology can be used to analyze mitigation – through energy policy and carbon offsets for example – and adaptation.

I will argue that climate change offers a wealth of questions for political ecology in a diverse critical literature. I suggest that climate change connects political ecology back to some of its origins in efforts to understand hazard vulnerability and the intersections between poverty and environmental degradation – but also takes us forward into highly politicized debates about the future of development, energy and land use. A political ecology perspective can counter an over-emphasis on the political economy of climate that can erase the agency of individuals and communities or fail to take science and nature seriously. Political ecology can also provide insights into changing attitudes to climate, including climate skepticism, through understandings of culture, discourse and science studies. However, most critical research on climate is not self-identified as political ecology and often overlooks the spatiality, materiality and embodiment of climate change causes and consequences.

Although there are several scholars of climate change who explicitly embrace political ecology as the frame for their work, in many cases a political ecology approach has to be read from the ways in which key dimensions of political ecology – political economy, human agency, material nature and discourse; critical analyses of environmental degradation, conservation, and conflict; governmentality and the creation of environmental subjects, networks, and political actors (Robbins 2012) – are reflected in climate research. Political ecology has much to gain from the broader critical approaches to climate change and especially in analysis of climate governance. Critical work on climate change shares historical origins with political ecology in the emergence of political economy approaches to hazards and famine and an early focus on marginalized populations and social justice (Hewitt 1983, Blaikie et al. 1994, Bohle et al. 1994). There is a growing community of practice that collaborates and communicates about critical approaches to climate change, with scholars connecting to practitioners from environmental organizations and governments to uncover and challenge the politics and discourses of climate politics. And as a counterpoint to a gender imbalance in much of academia, many of those showing a long-term commitment to understanding the political ecologies of climate change are women – such as Karin Bäckstrand, Harriett Bulkeley, Hallie Eakin, Karen O'Brien, Petra Tschakert, or Coleen Vogel.¹

The international consensus on climate change research is commonly associated with the regular reports of the Intergovernmental Panel on Climate Change, with Working Group II focusing on impacts vulnerability, and adaptation (IPCC 2014a) and Working Group III reviewing research on responsibility for greenhouse gas emissions and mitigation (IPCC 2014b). The most recent reports include several chapters that draw extensively on critical work in political economy and political ecology on vulnerability, climate and development, equity and carbon markets.² Other political ecologists have kept their distance from mainstream climate research and policy, delivering intense critiques of climate models and politics (Demeritt 2001, Swyngedouw 2010).

The causes of anthropogenic climate change

While climate has changed and varied over the millennia in response to the geophysical influences that initiated ice ages and warmer periods, the human influence on climate is relatively recent, and is mostly associated with the development of fossil fuels, agriculture, and deforestation since about 1850 – a period now termed the Anthropocene. The greenhouse gases released by these activities are causing the planet to warm and the continuing upward trend in emissions will lead to significant changes and warming in climate, including greater extremes, within the next few decades (IPCC et al. 2013).

Political economy of emissions

The political ecologies underlying emission trends are clear – a global political economy dependent on oil, coal and gas, on cement construction and livestock, and on converting forests to cropland, fuel, settlement, and commercial lumber. An overarching political economy of emissions is associated with capitalism and colonialism exploiting forest and then fossil fuels across the globe for accumulation, and to a multinational fossil fuel industry supported by states through subsidy, warfare, and special interests. The link between political economy and greenhouse gases is evident in Figure 1 when the worldwide recession hit in 2008. The signal of global economic slowdown was reflected in a temporary drop in atmospheric emissions, which then however returned to an even higher growth rate. The overall upward trend demonstrates the failure to control emissions since 1990.

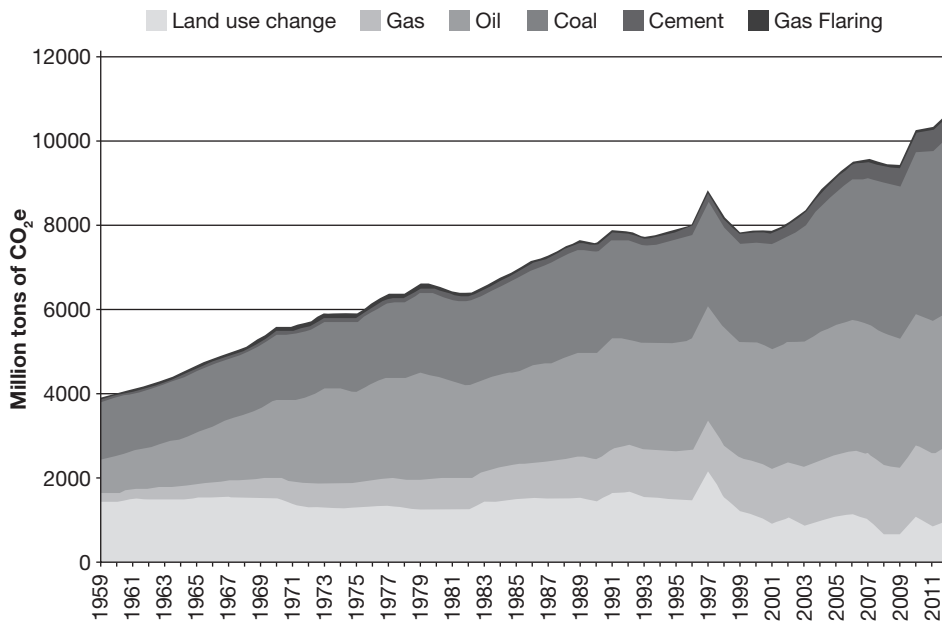


Figure 23.1 Trends in greenhouse gas emissions, 1959–2012

Nature and materialities

Although greenhouse gases mix throughout the atmosphere, sources have varied across time and space, with patterns of responsibility linked through international trade to production and consumption. Responsibility is also associated with the differing radiative potentials (heat trapping) of different greenhouse gases, with CO₂ trapping less energy per unit than methane, but remaining in the atmosphere for many more years. The processes of radiation, precipitation, and carbon cycling are all material and active components of the earth system, interacting with and constraining human activities. Political ecology draws attention to such materialities; showing how the biophysical characteristics of water, wetlands and biodiversity can make them difficult to manage, commodify and trade (Castree 2003, Robertson 2000, Bakker and Bridge 2006).

The materialities of greenhouse gases manifest in their differing impacts on climate, and in their spatial patterns and origins in nature – in the fossilized and living plants that are burned as fossil fuels or woodfuel and produce carbon dioxide, the decomposing wastes and rice paddies that produce methane, the millions of cows and sheep that generate methane in their digestive systems, and the chemicals and geological materials that release a range of greenhouse gases in the manufacture of cement, petrochemicals and other products. The characters of these various greenhouse gases and their origins pose scientific and technical governance challenges for measurement and monitoring and when climate change response includes sequestering them or converting them into tradable commodities.

An initial accounting step in climate mitigation was to create a common unit of CO₂e – which converts some (but not all) greenhouse gases into a single unit or currency of carbon expressed as ‘carbon dioxide equivalents.’ As Bumpus (2011) argues, a ton of carbon is very

much a virtual and abstract commodity – estimated as the difference between emissions that might have occurred (a counterfactual) and lower emissions as a result of a carbon offset project. He and others note the challenges in measuring baselines and additionality of carbon reductions, for communities trying to demonstrate their curation of material carbon reductions, and in the complex accounting and trading systems for an invisible (Lansing 2012, Lovell et al. 2013).

Global carbon budget studies show major uncertainties about whether, on balance, forestry, grasslands, and agriculture release or sequester carbon in different regions (Dilling et al. 2003). This uncertainty over land use as a source or sink of greenhouse gases means that emissions accounting often separates overall national or per capita emissions into emissions with and without land use change. This has significant political implications for countries with significant forest cover, rapid deforestation or reforestation.

International agreements also struggle with accounting for land use change. For example, carbon trading under the Kyoto Protocol initially only included credits for afforestation and reforestation and not for protecting existing forests. Pressure from conservationists and forest nations led to proposals for trading and funding of forest protection in the form of REDD (Reduced Emissions from Deforestation and Degradation) where considerable critical debate has centered on how to measure and account for land use change (Gupta et al. 2012, Leach and Scoones 2013). The recognition that other land uses – grassland, peat lands, agriculture – also influence the carbon budget, brings even more complexity, trading options and governance challenges into the climate regime.

The scientific challenges of understanding the carbon budget have brought many physical scientists into debates about the management of the carbon cycles, and into partnerships with social scientists in studies to explore the political ecologies of land use emission (cf. Chapter 11, this volume). For example, geographers Petra Tschakert and Susanna Hecht engaged with earth science to understand soil carbon in West Africa and forestry in El Salvador (Hecht and Saatchi 2007, Tschakert and Tappan 2004). Emerging questions include how to measure and manage the important role of the oceans in the carbon cycle and whether ‘blue carbon’ can be sequestered or released through the geoengineering, management, or protection of coasts and oceans (Dilling and Hauser 2013, Locatelli et al. 2014).

Responsibility for emissions

Debates about responsibilities for climate change contrast the role of north and south, rich and poor, and business, individuals and governments based on a variety of calculations and claims. For example, different patterns of national emissions and blame are associated with ‘historical emissions’ (accumulated emissions), ‘per capita emissions’ (average emissions per person) and ‘current emissions.’ The 1991 benchmark paper ‘Global warming in an unequal world: a case of environmental colonialism’ argued for a distinction between ‘survival’ and ‘luxury’ emissions which would provide the poor with an entitlement of emissions necessary for basic human security but would penalize high per capita emissions of excess consumption of richer people and countries (Agarwal and Narain 1991). The United States and Europe bear greater responsibility historically, and India and China rank much lower on both historical and per capita emissions while playing a large role in current and future shares (Table 23.1). Taking an environmental justice perspective, Paul Baer and colleagues argue for ‘Greenhouse Development Rights,’ which combine estimates of ‘climate debt’ (historical responsibility) and countries’ capacity to act (national income) to allocate emissions responsibility above a baseline development threshold that provides for the needs of the poor (Baer 2013).

Table 23.1 Calculating responsibility for climate change

	<i>Total GHG emissions 2011 mTCO₂e</i>	<i>GHG per capita 2011 Tons</i>	<i>Cumulative historical (1850–2011) mTCO₂e</i>	<i>Net traded emissions mTCO₂e (negative is imports)</i>
Europe	7,631	10.3	467,628	
North America	7,266	21.0	389,076	
Latin America and Caribbean	3,310	5.5	50,587	
Asia	21,425	5.2	338,916	
Sub-Saharan Africa	2,391	2.7	21,608	
USA	6,550	21.0	361,300	-479
China	10,552	7.8	140,860	1329
India	1,861	1.5	35,581	94

The globalization of trade and the possibilities of carbon trading further complicate this debate as responsibility for emissions alters with ‘embodied’ emissions in the import and export of goods or with carbon offsetting. Recalculations of emissions responsibility estimate the role of trade and shows that 10–25 percent of China’s emissions are associated with exports to countries like the United States that are, in turn, net importers of embodied emissions (Peters et al. 2011).

An alternative to the national basis for responsibility in a globalized world is to assign blame to the corporations who extract, burn, or distribute energy and other products that release greenhouse gases. A study that examined the role of major multinational corporations calculated that 90 major corporations – mostly oil and coal – are responsible for two-thirds of carbon emitted in the last 150 years (Heede 2014). Some responsible corporations use a greenhouse gas protocol to distinguish and reduce their onsite emissions and emissions embodied in electricity use from their supply chains (Green 2010).

The scientific community is struggling to marshal more accurate data on emissions and biogeochemical cycles and to associate these with activities in different regions and sectors. Meanwhile governments, nongovernmental organizations and corporations are selecting those data, images and reports that represent and advance their interests and, perhaps, reduce their responsibilities (Lovell et al. 2009). Emissions information appears in corporate reporting, the media, international negotiations, and NGO campaigns and, as with other aspects of contemporary environmental policy, one of the more problematic discourses is that which makes individuals bear primary responsibility for their own emissions and carbon ‘footprints’ (Hobson 2013, Lorenzoni et al. 2011).

Climate change impacts and vulnerability

Political ecology is central to understanding how climate changes affect people and places, with approaches rooted in a cultural ecology which reacted to climate determinism by showing how people adapted to extreme environments, and a political economy of hazards that showed the importance of colonial legacies and inequality in creating vulnerability to drought and other hazards (cf. Chapters 2 and 3, this volume).

Political ecology of climate vulnerability

Political ecologist Piers Blaikie's coauthored book *At Risk: Natural Hazards, People's Vulnerability, and Disasters* (Blaikie et al. 1994) analyses several climate hazards including drought, floods and severe storms from a political economy perspective and defines vulnerability as 'the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard.' Explanatory variables include class, occupation, caste, ethnicity, gender, health, age, land tenure, immigration status, and social networks with vulnerability measured in terms of loss of life, property and livelihoods (pp. 11–12) (see also Liverman 1990b, Ribot 2014; Chapter 22, this volume).

Vulnerability to climate change became pivotal in the work of the Intergovernmental Panel on Climate Change and in the campaigns of many climate activists. The IPCC defined vulnerability as 'the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes' and identified three components of vulnerability as exposure, sensitivity, and adaptive capacity.

While this definition has framed much subsequent work on vulnerability, some political ecologists worry that the concept of vulnerability has been plagued with contested definitions and a lack of conceptual clarity, especially with regard to how to measure the relative role of political economic, individual, and biophysical factors (Eakin and Luers 2006, O'Brien et al. 2007, Smit and Wandel 2006). Partly in response to this concern, the concept of resilience was introduced as an alternative and more affirmative measure of people's ability to cope with environmental stress (Turner 2013, Cote and Nightingale 2012). Participatory research has provided local knowledge on vulnerability (Roncoli 2006, Tschakert 2007).

My own view is that we spent too much time on academic debates on vulnerability and resilience and too little time on listening to how people define their own experience of climate change. I also believe that using simple proxy measures of vulnerability (such as income or food security) and empirically evaluating their connection to losses and suffering may provide more immediate insights and solutions.

The most vulnerable populations often include the poor, women, people of color, and indigenous groups because of historical structures and discourses that have marginalized their rights. Gendered vulnerability analyses have documented the ways in which women are differentially harmed by climate – because they do not have access to land and other resources, suffer discrimination within households and communities, or do not receive warnings (Alston and Whittenbury 2013, Sultana 2013). But care must be taken not to erase the agency of the poor, women or indigenous peoples by seeing them as passive victims without knowledge or capacity to respond to climate change (Arora-Jonsson 2011, Tschakert and Machado 2012, Whyte 2014) and it is important to recognize the multiple identities and intersectionality of people who may be poor but are also leaders, networkers and key sources of community knowledge (Kajiser and Kronsell 2013, Nightingale 2011). Thinking of vulnerability as an embodied experience prompts more nuanced, feminist, post-development methodologies that are an important way forward in research on the political ecology of climate change.

Political ecology perspectives on changing human–environment relations as a result of neoliberalism and globalization (Castree 2008, Liverman and Vilas 2006) influenced work on climate change. For instance, Hallie Eakin has explained climate vulnerability in Mexico in terms of the neoliberal processes of free trade, structural adjustment, and changes in land tenure, showing how they have affected peasant farmers in central Mexican communities (Eakin 2006). Karen O'Brien and Robin Leichenko captured the intersecting risks of global environmental change and economic globalization with their influential concept of 'double exposure'

(Leichenko and O'Brien 2008). Others have drawn on Sen's theory of entitlement to goods and services to see vulnerability as a lack or failure of entitlements to, for example, food, land or disaster relief (Ribot 2014).

Empirical analyses of vulnerability

Empirical analyses of vulnerability range from global and regional to local studies and from GIS indices and maps to qualitative ethnographies. The numerous case studies of local vulnerability are often difficult to compare because of very different contexts and survey questions and hence thwarted attempts at meta-analysis.

While household studies can acquire a wide range of information, climate vulnerability researchers can find that climate change and variability are less salient than other risks or that some questions are culturally inappropriate or invasive. For example, in our fieldwork in the Southwestern United States and Mexico, we understood that American Indian communities see weather and climate as private and connected to the spiritual realm, and that ranchers do not want to reveal the number of cattle they have or have lost because it is too close to revealing their incomes (Austin et al. 2000, Vasquez-Leon et al. 2003).

At broader scales, empirical analysis of vulnerability is often limited by the type, frequency and spatial detail of the data that is collected by governments and others. For example, demographic and agricultural censuses are only conducted every ten years and rarely measure climate losses, making it difficult to trace the dynamics of changing vulnerability along with a lack of information below the state or county level. Researchers use yields as a proxy for climate impacts, and irrigation as a proxy for technology that reduces vulnerability including in my own work comparing climate vulnerability at the local level in Mexico where climate impacts were only expressed in terms of area lost to various hazards (Liverman 1990a). In the United States, Susan Cutter used census data in an index of social vulnerability to hazards that includes information on poverty, education, income, age, employment, race and gender (Cutter and Finch 2008). The index shows pockets of vulnerability in the Deep South and Southwest, with race and ethnicity a strong influence on vulnerability in the Mississippi Valley and Texas–Mexico border and age in the Great Plains and Florida.

Preston et al. (2011) provide a helpful review of vulnerability mapping and its challenges. They note the benefits of GIS and maps in supporting land use planning and public education through visualization, but note that the maps will reify particular understandings and snapshots of vulnerability, create a false sense of confidence and accuracy, provide little information on dynamics or the future, or overlook key social, cultural or contextual factors. However, they and others involved in vulnerability mapping have not addressed the concerns of other political ecologists about the potential use of the maps by powerful others, the appropriation of local knowledge, and the rights of surveillance (Bryan 2011).

Some of the more apocalyptic visions of future climate change suggest that it will trigger mass migrations and violent conflict, supported by correlation analyses that link drought to outmigration and to civil or interstate conflict and rooted in a form of climate determinism (Feng et al. 2010, Homer-Dixon 1994, Hsiang et al. 2013). Political ecology offers a more nuanced vision of these connections, especially when we talk to migrants, take account of historical influences, and take careful measure of the spatial patterns and impacts of environmental changes (Hartmann 2010, Dalby 2013, Pigué 2013). It can show that migration is a temporary and logical adaptation to extremes or is driven mostly by economic factors, and that tensions over water are more likely to drive cooperation than conflict (Farbotko and Lazrus 2012, Wolf 2007).

Discourses of vulnerability

The understanding of how people view and discuss climate vulnerability has ranged from more positivist and behavioral survey work to post-structural analyses of climate discourse, performance, art, and representation. A large body of work on how climate change is perceived, communicated, and narrated use surveys of public opinion and media coverage to track and compare views of climate change over time and geographies. It links to political ecology in the analysis of environmental narratives and the structural influences on perception and news. For example, Max Boykoff uses empirical analysis of news and digital media to show discursive biases and their political and cultural implications (Boykoff 2011). Tony Leiserowitz's influential work on changing American attitudes to climate change pays explicit attention to the role of political affiliation, income, ethnicity, religion, and region. Saffron O'Neill provides some provocative analyses and reviews of climate change imagery and its influences, noting the influence of NGOs, the prevalence of arctic imagery – especially the polar bear – and of melodramatic climate impacts that promote fear such as flooding or fire (O'Neill and Smith 2014). And, O'Brien and colleagues argue for the policy impacts of vulnerability discourses, contrasting a scientific discourse focused on climate model results and recommending emissions mitigation and technical adaptation measures with a human security narrative about differential access to assistance, markets and irrigation recommending addressing inequality in order to reduce vulnerability (O'Brien et al. 2007).

Post-structural approaches to understanding vulnerability include discourse and actor network based analyses that show how countries and people are constructed as vulnerable and studies that highlight how some groups and countries are 'performing' their vulnerability in order to justify access to international financial assistance (Cannon and Muller-Mahn 2010). For example, Yamane shows how data, stories and maps in Sri Lanka were used to demonstrate vulnerability to the international climate community in the hope of financial assistance (Yamane 2009). Webber examines how government in Kiribati enacts vulnerability to secure international financing through an assemblage of facts, experts and objects (Webber 2013).

Mike Hulme is interesting for his shift from climate scientist to cultural theorist of science and technology studies. He now sees social construction of knowledge and deep cultural influences in how we see climate change (Hulme 2010). He raises concerns about the use of climate models, the framing of climate change, and the ways in which climate change is used politically, recently arguing against technosolutions of geoengineering (Hulme 2014). Finally, the artistic response to climate change has been critically evaluated for its representation, activism, and role as a site for engagement between art and science (Miles 2010, Dixon 2013, Liverman 2009b).

Responses to climate change

The last decade has seen an expansion in the critical literature on responses to climate change, paralleling a proliferation of general research on the topics of climate mitigation/emissions reductions, climate adaptation, and geoengineering. While political ecology had its origins in critiques of environmental policies relating to forests, water, agriculture, fisheries, biodiversity, conservation and land there was little initial attention by political ecologists to climate policy in foundational texts or elsewhere³. More recently political ecology has turned its attention to climate mitigation and adaptation, with sessions at the Association of American Geographers and contributions to journal special issues. (Leichenko et al. 2010, Boykoff et al. 2009, Ford and Furgal 2009).

Mitigation policies – governing greenhouse gas emissions

Several important critical texts on climate mitigation and governance have been written from theoretical perspectives that include global governance, political economy –drawing on Marx, Gramsci and Polanyi – and post-structuralism – drawing on Foucault and Derrida (Okereke et al. 2009, Stripple and Bulkeley 2013). There are strong parallels with political ecology – especially in the analysis of power, discourse, agency, the state, and governmentality.

The history of climate mitigation is usually traced to the international negotiations that led to the signing of the UN Framework Convention on Climate Change (UNFCCC) at the Rio conference in 1992 (Gupta 2010, Liverman 2009a). The UNFCCC – an intergovernmental treaty – had the goal of preventing dangerous anthropogenic interference with the climate system and established principles of common but differentiated responsibility, a focus on the most vulnerable countries, the precautionary principle, and the right to sustainable development and an open economic system. The 1997 Kyoto Protocol created the framework for implementation, committing signatories from industrial nations to emission reductions, setting up mechanisms for carbon trading and offsetting, and creating a modest adaptation fund. Meanwhile non-nation state actors – states, cities, private firms, international banks, NGOs and individuals – were making commitments to reduce emissions or convincing others to do so. Because most commitments were far less than the 50 percent emission reductions needed to reduce warming, and because emerging economies such as China were rapidly increasing emissions, by the time of the 2009 UNFCCC Copenhagen climate negotiations, there was a renewed sense of urgency for further emission reductions, especially from small islands at risk from sea level rise, from NGOs and from the scientific community. New proposals for emission reductions were emerging including efforts to protect forest carbon through REDD (Reduced Emissions from Deforestation and Degradation) and for more substantial financial transfers to poorer countries for both mitigation and adaptation.

All of these developments provided a rich landscape for critical scholars to analyze the structures of power and influence of state and non-state actors in the international negotiations, the discursive and material emission pledges, and the curious mechanisms of trading carbon. Of the scholars who have engaged the political ecology of climate mitigation Harriet Bulkeley and Peter Newell stand out for their sustained critical attention, together with their collaborators. Bulkeley began with a focus on the politics of climate change in Australia using concepts of discourse coalitions and the risk society to explain links between government and industry in Australia (Bulkeley 2000). She then initiated the work for which she is best known – on how cities were governing climate change through local actions, energy policy, transnational networks, rescaling, and public–private partnerships – using methods that include interviews, discourse analysis of texts, and empirical data on policy outcomes (Bulkeley and Betsill 2003, Bulkeley and Broto 2013, Broto and Bulkeley 2013). Peter Newell’s work is rooted in political economy and has examined, in particular, the intersection of climate policy with NGOs, business and capital (Newell 2000, Levy and Newell 2005, Newell and Paterson 2010) and the political economy of the carbon markets, especially Kyoto’s Clean Development Mechanism (CDM) that creates carbon credits from investments in greenhouse gas reductions in developing countries. His particular contributions are to explain the logics of business action and inaction on climate change, and to document the powerful interests involved in the CDM that often overlook local needs, energy access, and sustainability. The European version of carbon markets – the Emissions Trading System (ETS) – has been similarly criticized for serving powerful business interests (Bailey 2007). Swedish scholars have employed concepts of governmentality to uncover the discourses,

technologies and rationalities of forest carbon, carbon sinks, carbon markets, REDD, and carbon offsets (Lövbrand and Stripple 2011, Paterson and Stripple 2010).

I have argued that carbon offsets are a fascinating topic for political ecology, created 'as a new commodity that links north and south through a complex set of technologies, institutions and discourses' (Bumpus and Liverman 2011). We studied the political ecologies of carbon offsets from a variety of perspectives and in different places on the ground, exploring the global geographies of the CDM, recommending policies that would provide a greater advantage to poorer regions and local technologies. We proposed the notion of 'Accumulation by Decarbonization,' tracing how both the CDM and the voluntary carbon offset markets produce carbon credits through a commodity chain that links offset consumers in the rich world to project developers and local communities in poorer regions. We show how carbon offers opportunities to profit from offsets, governed beyond the state by supranational and private actors (Bumpus and Liverman 2008). The construction of carbon subjectivities for offset consumers and the agency of different carbon reduction technologies also links climate mitigation to new developments in political ecology (Lovell et al. 2009, Lovell and Liverman 2010). Our work on the greenhouse gas reductions and social impacts of local carbon projects paints a complex picture in which offsets are not always detrimental where renewable and efficiency projects provide income, jobs and reduced air pollution within communities.

Carbon offsets provide critical fodder for others who see them as a form of neocolonial and unequal exchange that privatizes the atmosphere and damages local communities. Larry Lohmann and Patrick Bond provide vigorous arguments against offsetting, engaging with communities and activist groups (e.g. www.carbonradewatch.org/) who were opposing offset projects (Lohmann 2005, 2012, Bond 2008). Kathy McAfee and Elizabeth Shapiro have been especially critical of offsets in their work on payments for environmental services in Mexico (McAfee and Shapiro 2010; Shapiro-Garza 2013).

Forest offsets are especially interesting to political ecologists, given the sizeable literature on the political ecology of forestry around the world. Emily Boyd, Esteve Corbera, Tracey Osborne and Dave Lansing began their studies of forest offsets with PhD dissertation case studies in Latin America informed by political ecology (including one in Chiapas financed by Formula 1 racing to offset its emissions!). They identify issues with the distribution of funds, property rights, labor allocation, monitoring, and state institutions and have continued the debate around REDD (Boyd 2002, Corbera and Brown 2008, Corbera and Schroeder 2011, Osborne 2011, Lansing 2011). Arun Agrawal and Ashwini Chhatre raise important questions about centralization and governance of REDD (Agrawal et al. 2011, Phelps et al. 2010) with Connie McDermott and Heike Schroeder focusing on REDD governance and implementation (McDermott et al. 2012, Schroeder and McDermott 2014). A controversial article on REDD projects displacing local residents in Tanzania prompted a strong reaction from the NGO community (Beymer-Farris and Bassett 2012, Burgess et al. 2013)

Political ecologies of adaptation

Climate adaptation has been defined as adjustments to reduce vulnerability and increase resilience, through technologies such as irrigation and coastal defense, social networks of sharing and disaster warning and relief, and financial strategies such as insurance. Climate adaptation has been linked to the concept of adaptive capacity – the potential to respond to climate risks. Many studies of vulnerability also include a component of adaptation. While some see climate adaptation as a new field, others have pointed out the legacies from cultural ecology in

geography and anthropology and the risks of reinventing the wheel (Bassett and Fogelman 2013, Head 2010, Tschakert 2012).

Studies of community and agricultural adaptation dominate; usually based on observations and interviews with local decision makers and residents and often focusing on adaptation to current climate variability rather than future climate changes. Bassett and Fogelman (2013) claim that the majority of adaptation studies focus on technical adjustments or modest development reform and do not pay attention to transformative adaptation that tackles the social roots of vulnerability. I would suggest, however, that there are studies that pay considerable attention to the deep-rooted institutional barriers to successful adaptation and to the differential ability to adapt within society by women and the poor. For example, Mark Pelling studies the political ecology of flooding in Guyana in historical and political context, arguing that development programs have undermined grassroots agency and options for adaptation (Pelling 1999). On the Mexican Caribbean coast he shows how structures of legitimation and domination have produced rigid governance that impedes transformative adaptation in communities (Manuel-Navarrete et al. 2011).

Neil Adger, who sometimes identifies as a political ecologist, is perhaps the best-known scholar of adaptation. He tends to approach adaptation from a political economy perspective, with attention to issues of equity and justice, and his empirical work – often with colleagues from development studies at the UK Tyndall Center – includes studies in Vietnam and the UK (Adger et al. 2009, Conway and Schipper 2011, Few et al. 2007, Osbahr et al. 2008).

Indigenous adaptations are another emerging area of inquiry using concepts from political ecology – including regional work in Australia (Leonard et al. 2013, Petheram et al. 2010), South Africa (Ziervogel et al. 2014) and the Arctic (Ford et al. 2010).

Climate adaptation is one topic where insights from scholars have had a significant impact on public policy and on international climate governance. For example, Saleemul Huq has published many articles where he argues for the value of local knowledge and adaptation strategies developed in the global South and for equity in climate financing (Ayers et al. 2014, Schipper et al. 2014). But he also participates in the climate negotiations – helping to draft text and advising negotiators and activists – and started a grassroots adaptation program in Bangladesh. Geographer Richard Klein has been influential at European and international levels in pushing for just climate adaptation and helped start ‘Adaptation Watch’ to promote transparency in the governance of adaptation funds (Klein et al. 2005, Smith et al. 2011). In the United States, Susi Moser is well known for her commitment to co-producing her research with communities and is a voice for the need to clearly communicate adaptation research to citizens and policy makers making it relevant on the ground (Moser and Dilling 2007, Moser 2010).

The onset of climate change, and the risks that warming will exceed 4 degrees C, means that adaptation is joining mitigation and carbon markets in the world of international development, finance, and local, national and international politics. There are many unresolved questions for the political ecology of climate adaptation (Liverman and Billett 2010). Who should be eligible for adaptation assistance and who will pay for it? How can we ensure that high technology and large-scale options (such as sea walls or large dams) do not swamp effective small-scale local actions (such as crop diversity or ecosystem protection)? Should we meet what has been called the ‘adaptation deficit’ – from vulnerability to current climate variability – before focusing on climate change? And how can we ensure that aid for climate adaptation is appropriate, equitable, accessible to women and people of color, and does not divert from other human development priorities? How can we connect our critical scholarship to action on the ground or to influence policy?

There is a movement that suggests perhaps reducing emissions will be so difficult, and the risk of warming so great, that we should consider options for geoengineering the planet as a

response to climate change. This might involve managing incoming solar radiation (e.g. through altering atmospheric composition to create clouds or changing the surface to reflect sunlight) or carbon capture (e.g. through new technology, fertilizing the oceans to take up more CO₂). As yet political ecology has hardly begun to engage with questions about the governance and socio-ecological impacts of geoengineering although there is a growing literature from science studies and critical international relations (Lövbrand et al. 2009, Hulme 2014).

Conclusion

This chapter set out to show that political ecology has a lot to offer in how we understand the human dimensions of climate change – whether explicitly named, or reflected in research that takes political economy, human agency, and nature seriously, revealing narratives that can create or oppose injustice. Although one might view political ecology and critical climate change research as following parallel paths there are important examples of cross-fertilization and future opportunities. The influence of political ecology on vulnerability is perhaps the most significant, not only in the early impact of critical hazards scholars but also in the flow of ideas from political ecology work on governmentality, feminist political ecology and neoliberalism.

In the case of emissions and of climate policy the flow of ideas has been more from critical international relations and political economy to political ecology in the critique of emission responsibilities and of carbon markets. Political ecology has potential when it comes to carbon offsets and proposals for REDD in the way it examines the interaction between institutions across scales, the critique of practices and discourses of market environmentalism and development, and in the importance of material nature as an actor and explanation. The debate about carbon offsets continues – although the market has not grown as fast as anticipated because of carbon market uncertainties, low prices, and a backlash against offsetting. Moving forward I would suggest that there is need for well-designed comparative case studies, more space in academic papers to the voices of those affected by mitigation policy, attention to whether material carbon savings are truly additional, and more rigor in assessing offsets embraced or opposed by NGOs and the private sector. REDD+, in particular, has been popular with the conservation community as one of the only strategies they think might save tropical forests, and is strongly opposed by some indigenous rights movements.

Students in a recent graduate seminar – looking to design their own studies – were frustrated at how many articles in political ecology and environmental governance argued mostly from theory and were thin empirically, and how few critical articles discussed research design, methods, or positionality, provided summary statistics on fieldwork, analyzed biophysical data, or used quotes from interviews as evidence or to give voice to local people. In discussion we identified reasons that included a desire to demonstrate theoretical sophistication, innovation and anti-positivist stance, normative commitments to telling a convincing story and making a strong argument, lack of time and resources to extend case studies to comparative cases and baselines or to analysis of material nature, protecting individual informants, or poor record-keeping. In order to address these frustrations and provide clearer guides to others, political ecologists could do a better job of discussing their methodology in their publications and include more quotes and references to field data.

What political ecology gains from a focus on climate change is an engagement with one of the most existential and political environmental issues of our time – with serious implications for global geographies, social and environmental justice – and with a growing community of scholars and publics who wish to understand and act in small and larger ways to influence the future.

Notes

- 1 Space constraints mean that I am only able to cite a small sample of the dozens of articles by some of the key scholars but their other relevant work can easily be found through online literature searches.
- 2 For example, Neil Adger, Arun Agrawal, Kirstin Dow, Karen O'Brien, Mark Pelling, Petra Tschakert, Coleen Vogel, Julian Agyeman, Paul Baer, Emily Boyd, Esteve Corbera, Richard Klein, Larry Lohmann, Matt Paterson, Chuks Okereke and Timmons Roberts.
- 3 With the exception of Tim Forsyth who did some work on forest offsets (2003).

References

- Adger, W.N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D.R. Nelson, L.O. Naess, J. Wolf and A. Wreford (2009) Are there social limits to adaptation to climate change? *Climatic Change*, 93, 335–354.
- Agarwal, A. and S. Narain (1991) *Global Warming in an Unequal World: A Case of Environmental Colonialism*. New Delhi: Centre for Science and Environment.
- Agrawal, A., D. Nepstad and A. Chhatre (2011) Reducing emissions from deforestation and forest degradation. *Annual Review of Environment and Resources*, 36, 373–396.
- Alston, M. and K. Whittenbury (2013) *Research, action and policy: Addressing the gendered impacts of climate change*. Netherlands: Springer.
- Arora-Jonsson, S. (2011) Virtue and vulnerability: discourses on women, gender and climate change. *Global Environmental Change*, 21, 744–751.
- Austin, D.E., S. Gerlak and C. Smith (2000) *Building partnerships with Native Americans in climate-related research and outreach*. Tucson: Institute for the Study of Planet Earth.
- Ayers, J.M., S. Huq, A.M. Faisal and S.T. Hussain (2014) Mainstreaming climate change adaptation into development: a case study of Bangladesh. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 37–51.
- Baer, P. (2013) The greenhouse development rights framework for global burden sharing: reflection on principles and prospects. *Wiley Interdisciplinary Reviews: Climate Change*, 4, 61–71.
- Bailey, I. (2007) Neoliberalism, climate governance and the scalar politics of EU emissions trading. *Area*, 39, 431–442.
- Bakker, K. and G. Bridge (2006) Material worlds? Resource geographies and the matter of nature. *Progress in Human Geography*, 30, 5–27.
- Bassett, T.J. and C. Fogelman (2013) Déjà vu or something new? The adaptation concept in the climate change literature. *Geoforum*, 48, 42–53.
- Beymer-Farris, B.A. and T.J. Bassett (2012) The REDD menace: resurgent protectionism in Tanzania's mangrove forests. *Global Environmental Change*, 22, 332–341.
- Blaikie, P., T. Cannon, I. Davis and B. Wisner. 1994. *At risk: Natural hazards, people's vulnerability and disasters*. London: Routledge.
- Bohle, H.-G., T.E. Downing and M. Watts (1994) Climate change and social vulnerability: the sociology and geography of food insecurity. *Global Environmental Change*, 4, 37–48.
- Bond, P. (2008) The state of the global carbon trade debate. *Capitalism Nature Socialism*, 19, 89–106.
- Boyd, E. (2002) The Noel Kempff project in Bolivia: gender, power, and decision-making in climate mitigation. *Gender & Development*, 10, 70–77.
- Boykoff, M.T. (2011) *Who speaks for the climate? Making sense of media reporting on climate change*. New York: Cambridge University Press.
- Boykoff, M.T., A. Bumpus, D. Liverman and S. Randalls (2009) Theorizing the carbon economy: introduction to the special issue. *Environment and Planning A*, 41, 2299–2304.
- Broto, V.C. and H. Bulkeley (2013) Maintaining climate change experiments: urban political ecology and the everyday reconfiguration of urban infrastructure. *International Journal of Urban and Regional Research*, 37, 1934–1948.
- Bryan, J. (2011) Walking the line: participatory mapping, indigenous rights, and neoliberalism. *Geoforum*, 42, 40–50.
- Bulkeley, H. (2000) Discourse coalitions and the Australian climate change policy network. *Environment and Planning C-Government and Policy*, 18, 727–748.
- Bulkeley, H. and M.M. Betsill (2003) *Cities and climate change: Urban sustainability and global environmental governance*. Abingdon: Routledge.
- Bulkeley, H. and V.C. Broto (2013) Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, 38, 361–375.

- Bumpus, A.G. (2011) The matter of carbon: understanding the materiality of tCO₂e in carbon offsets. *Antipode*, 43, 612–638.
- Bumpus, A.G. and D.M. Liverman (2008) Accumulation by decarbonization and the governance of carbon offsets. *Economic Geography*, 84, 127–155.
- Bumpus, A. and D. Liverman (2011) Carbon colonialism? Offsets, greenhouse gas reductions, and sustainable development. *Global Political Ecology*, 203–224.
- Burgess, N.D., S. Mwakilila, P. Munishi, M. Pfeifer, S. Willcock, D. Shirima, S. Hamidu, G.B. Bulenga, J. Rubens and H. Machano (2013) REDD herrings or REDD menace: response to Beymer-Farris and Bassett. *Global Environmental Change*, 23, 1349–1354.
- Cannon, T. and D. Muller-Mahn (2010) Vulnerability, resilience and development discourses in context of climate change. *Natural Hazards*, 55, 621–635.
- Castree, N. (2003) Commodifying what nature? *Progress in Physical Geography*, 27, 273–297.
- Castree, N. (2008) Neoliberalising nature: processes, effects, and evaluations. *Environment and Planning, A*, 40, 153.
- Conway, D. and E.L.F. Schipper (2011) Adaptation to climate change in Africa: challenges and opportunities identified from Ethiopia. *Global Environmental Change*, 21, 227–237.
- Corbera, E. and K. Brown (2008) Building institutions to trade ecosystem services: marketing forest carbon in Mexico. *World Development*, 36, 1956–1979.
- Corbera, E. and H. Schroeder (2011) Governing and implementing REDD+. *Environmental Science & Policy*, 14, 89–99.
- Cote, M. and A.J. Nightingale (2012) Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Progress in Human Geography*, 36, 475–489.
- Cutter, S.L. and C. Finch (2008) Temporal and spatial changes in social vulnerability to natural hazards. *Proceedings of the National Academy of Sciences*, 105, 2301–2306.
- Dalby, S. (2013) The geopolitics of climate change. *Political Geography*, 37, 38–47.
- Demeritt, D. (2001) The construction of global warming and the politics of science. *Annals of the Association of American Geographers*, 91, 307–337.
- Dilling, L. and R. Hauser (2013) Governing geoengineering research: why, when and how? *Climatic Change*, 121, 553–565.
- Dilling, L., S.C. Doney, J. Edmonds, K.R. Gurney, R. Harriss, D. Schimel, B. Stephens and G. Stokes (2003) The role of carbon cycle observations and knowledge in carbon management. *Annual Review of Environment and Resources*, 28, 521–558.
- Dixon, D. (2013) Placing climate change. *Science*, 342, 1171–1172.
- Eakin, H. (2006) *Weathering risk in rural Mexico: Climatic, institutional and economic change*. Tucson: University of Arizona Press.
- Eakin, H. and A.L. Luers (2006) Assessing the vulnerability of social-environmental systems. *Annu. Rev. Environ. Resour.*, 31, 365–394.
- Farbotko, C. and H. Lazrus (2012) The first climate refugees? Contesting global narratives of climate change in Tuvalu. *Global Environmental Change*, 22, 382–390.
- Feng, S.Z., A.B. Krueger and M. Oppenheimer (2010) Linkages among climate change, crop yields and Mexico-US cross-border migration. *Proceedings of the National Academy of Sciences of the United States of America*, 107, 14257–14262.
- Few, R., K. Brown and E.L. Tompkins (2007) Public participation and climate change adaptation: avoiding the illusion of inclusion. *Climate Policy*, 7, 46–59.
- Ford, J.D. and C. Furgal (2009) Foreword to the special issue: climate change impacts, adaptation and vulnerability in the Arctic. *Polar Research*, 28, 1–9.
- Ford, J.D., T. Pearce, F. Duerden, C. Furgal and B. Smit (2010) Climate change policy responses for Canada's Inuit population: the importance of and opportunities for adaptation. *Global Environmental Change*, 20, 177–191.
- Forsyth, T. (2003) *Critical political ecology: The politics of environmental science*. London: Routledge.
- Green, J.F. (2010) Private standards in the climate regime: the greenhouse gas protocol. *Business and Politics*, 12, 1469–1569.
- Gupta, A., E. Lövbrand, E. Turnhout and M.J. Vijke (2012) In pursuit of carbon accountability: the politics of REDD+ measuring, reporting and verification systems. *Current Opinion in Environmental Sustainability*, 4, 726–731.
- Gupta, J. (2010) A history of international climate change policy. *Wiley Interdisciplinary Reviews: Climate Change*, 1, 636–653.

- Hartmann, B. (2010) Rethinking climate refugees and climate conflict: rhetoric, reality and the politics of policy discourse. *Journal of International Development*, 22, 233–246.
- Head, L. (2010) Cultural ecology: adaptation-retrofitting a concept? *Progress in Human Geography*, 34, 234–242.
- Hecht, S.B. and S.S. Saatchi (2007) Globalization and forest resurgence: changes in forest cover in El Salvador. *BioScience*, 57, 663–672.
- Heede, R. (2014) Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010. *Climatic Change*, 1–13.
- Hewitt, K. 1983. *Interpretations of calamity: From the viewpoint of human ecology*. Boston: Allen & Unwin.
- Hobson, K. (2013) On the making of the environmental citizen. *Environmental Politics*, 22, 56–72.
- Homer-Dixon, T.F. (1994) Environmental scarcities and violent conflict: evidence from cases. *International Security*, 19, 5–40.
- Hsiang, S.M., M. Burke and E. Miguel (2013) Quantifying the influence of climate on human conflict. *Science*, 341, 1235367.
- Hulme, M. 2010. *Why we disagree about climate change*. Cambridge: Cambridge University Press.
- Hulme, M. 2014. *Can science fix climate change? The case against climate engineering*. Cambridge: Polity Press.
- IPCC. 2014a. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge, UK and New York: Cambridge University Press.
- IPCC. 2014b. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
- IPCC, T. Stocker, Q. Dahe and G. Plattner. 2013. Climate change 2013: the physical science basis. In *Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers (IPCC, 2013)*.
- Kaijser, A. and A. Kronsell (2013) Climate change through the lens of intersectionality. *Environmental Politics*, 1–17.
- Klein, R.J.T., E.L.F. Schipper and S. Dessai (2005) Integrating mitigation and adaptation into climate and development policy: three research questions. *Environmental Science & Policy*, 8, 579–588.
- Lansing, D.M. (2011) Realizing carbon's value: discourse and calculation in the production of carbon forestry offsets in Costa Rica. *Antipode*, 43, 731–753.
- Lansing, D.M. (2012) Performing carbon: materiality: the production of carbon offsets and the framing of exchange. *Environment and Planning-Part A*, 44, 204.
- Leach, M. and I. Scoones (2013) Carbon forestry in West Africa: The politics of models, measures and verification processes. *Global Environmental Change*, 23, 957–967.
- Leichenko, R. and K. O'Brien (2008) *Environmental change and globalization: Double exposures*. New York: Oxford University Press.
- Leichenko, R.M., K.L. O'Brien and W.D. Solecki (2010) Climate change and the global financial crisis: A case of double exposure. *Annals of the Association of American Geographers*, 100, 963–972.
- Leonard, S., M. Parsons, K. Olawsky and F. Kofod (2013) The role of culture and traditional knowledge in climate change adaptation: Insights from East Kimberley, Australia. *Global Environmental Change*, 23, 623–632.
- Levy, D.L. and P. Newell. 2005. *The business of global environmental governance*. Cambridge, MA and London: MIT Press.
- Liverman, D.M. (1990a) Drought impacts in Mexico: Climate, agriculture, technology, and land tenure in Sonora and Puebla. *Annals of the Association of American Geographers*, 80, 49–72.
- Liverman, D.M. (1990b) Vulnerability to global environmental change. In *Understanding global environmental change: The contributions of risk analysis and management*, eds. J.X. Kasperson and R.E. Kasperson, 27–44. Tokyo: UNU Press.
- Liverman, D.M. (2009a) Conventions of climate change: constructions of danger and the dispossession of the atmosphere. *Journal of Historical Geography*, 35, 279–296.
- Liverman, D.M. (2009b) Seeking inspiration: a scientist turns to the cultural sector. In *Long horizons: An exploration of art and climate change*. London: Julie's Bicycle and British Council.
- Liverman, D. and S. Billett (2010) Copenhagen and the governance of adaptation. *Environment*, 52, 28–36.
- Liverman, D.M. and S. Vilas (2006) Neoliberalism and the environment in Latin America. *Annual Review of Environment and Resources*, 31, 327–363.

- Locatelli, T., T. Binet, J.G. Kairo, L. King, S. Madden, G. Patenaude, C. Upton and M. Huxham (2014) Turning the tide: How blue carbon and payments for ecosystem services (PES) might help save mangrove forests. *Ambio*, 1–15.
- Lohmann, L. (2005) Making and marketing carbon dumps: commodification, calculation and counterfactuals in climate change mitigation. *Science as Culture*, 14, 203–235.
- Lohmann, L. (2012) Financialization, commodification and carbon: the contradictions of neoliberal climate policy. *Socialist Register*, 48, 85–107.
- Lorenzoni, I., G. Seyfang, M. Nye, I. Whitmarsh and S. O'Neill (2011) Carbon budgets and carbon capability: lessons from personal carbon trading. In *Engaging the public with climate change: Behaviour change and communication*, eds. L. Whitmarsh, S.J. O'Neill and I. Lorenzoni, 31–46. London: Routledge and Earthscan.
- Lövbrand, E. and J. Stripple (2011) Making climate change governable: accounting for carbon as sinks, credits and personal budgets. *Critical Policy Studies*, 5, 187–200.
- Lövbrand, E., J. Stripple and B. Wiman (2009) Earth system governmentality: reflections on science in the Anthropocene. *Global Environmental Change*, 19, 7–13.
- Lovell, H. and D. Liverman (2010) Understanding carbon offset technologies. *New Political Economy*, 15, 255–273.
- Lovell, H., H. Bulkeley and D. Liverman (2009) Carbon offsetting: sustaining consumption? *Environment and Planning A*, 41, 2357–2379.
- Lovell, H., J. Bebbington, C. Larrinaga and T.R.S. de Aguiar (2013) Putting carbon markets into practice: a case study of financial accounting in Europe. *Environment and Planning C: Government and Policy*, 31, 741–757.
- Manuel-Navarrete, D., M. Pelling and M. Redclift (2011) Critical adaptation to hurricanes in the Mexican Caribbean: development visions, governance structures, and coping strategies. *Global Environmental Change-Human and Policy Dimensions*, 21, 249–258.
- McAfee, K. and E.N. Shapiro (2010) Payments for ecosystem services in Mexico: nature, neoliberalism, social movements, and the state. *Annals of the Association of American Geographers*, 100, 579–599.
- McDermott, C.L., L. Coad, A. Helfgott and H. Schroeder (2012) Operationalizing social safeguards in REDD+: actors, interests and ideas. *Environmental Science & Policy*, 21, 63–72.
- Miles, M. (2010) Representing nature: art and climate change. *Cultural Geographies*, 17, 19–35.
- Moser, S.C. (2010) Now more than ever: the need for more societally relevant research on vulnerability and adaptation to climate change. *Applied Geography*, 30, 464–474.
- Moser, S.C. and L. Dilling (2007) *Creating a climate for change: Communicating climate change and facilitating social change*. Cambridge: Cambridge University Press.
- Newell, P. (2000) *Climate for change: Non-state actors and the global politics of the greenhouse*. Cambridge: Cambridge University Press.
- Newell, P. and M. Paterson (2010) *Climate capitalism: Global warming and the transformation of the global economy*. Cambridge: Cambridge University Press.
- Nightingale, A.J. (2011) Bounding difference: intersectionality and the material production of gender, caste, class and environment in Nepal. *Geoforum*, 42, 153–162.
- O'Brien, K., S. Eriksen, L.P. Nygaard and A. Schjolden (2007) Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy*, 7, 73–88.
- Okereke, C., H. Bulkeley and H. Schroeder (2009) Conceptualizing climate governance beyond the international regime. *Global Environmental Politics*, 9, 58–78.
- O'Neill, S.J. and N. Smith (2014) Climate change and visual imagery. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 73–87.
- Osahr, H., C. Twyman, W. Neil Adger and D.S. Thomas (2008) Effective livelihood adaptation to climate change disturbance: scale dimensions of practice in Mozambique. *Geoforum*, 39, 1951–1964.
- Osborne, T.M. (2011) Carbon forestry and agrarian change: access and land control in a Mexican rainforest. *Journal of Peasant Studies*, 38, 859–883.
- Paterson, M. and J. Stripple (2010) My space: governing individuals and carbon emissions. *Environment and Planning. D, Society and Space*, 28, 341.
- Pelling, M. (1999) The political ecology of flood hazard in urban Guyana. *Geoforum*, 30, 249–261.
- Peters, G.P., J.C. Minx, C.L. Weber and O. Edenhofer (2011) Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences*, 108, 8903–8908.
- Petheram, L., K. Zander, B. Campbell, C. High and N. Stacey (2010) 'Strange changes': indigenous perspectives of climate change and adaptation in NE Arnhem Land (Australia). *Global Environmental Change*, 20, 681–692.

- Phelps, J., E.L. Webb and A. Agrawal (2010) Does REDD+ threaten to recentralize forest governance. *Science*, 328, 312–313.
- Piguet, E. (2013) From ‘primitive migration’ to ‘climate refugees’: the curious fate of the natural environment in migration studies. *Annals of the Association of American Geographers*, 103, 148–162.
- Preston, B.L., E.J. Yuen and R.M. Westaway (2011) Putting vulnerability to climate change on the map: a review of approaches, benefits, and risks. *Sustainability Science*, 6, 177–202.
- Ribot, J. (2014) Cause and response: vulnerability and climate in the Anthropocene. *Journal of Peasant Studies*, Online.
- Robbins, P. (2012) *Political ecology: A critical introduction*. Chichester: Wiley Blackwell.
- Robertson, M.M. (2000) No net loss: Wetland restoration and the incomplete capitalization of nature. *Antipode*, 32, 463–493.
- Roncoli, C. (2006) Ethnographic and participatory approaches to research on farmers’ responses to climate predictions. *Climate Research*, 33, 81.
- Schipper, E.L.F., J. Ayers, H. Reid, S. Huq and A. Rahman (2014) *Community based adaptation to climate change: Scaling it up*. New York: Routledge.
- Schroeder, H. and C. McDermott (2014) Beyond carbon: Enabling justice and equity in REDD+ across levels of governance. *Ecology and Society*, 19, 31.
- Shapiro-Garza, E. (2013) Contesting the market-based nature of Mexico’s national payments for ecosystem services programs: four sites of articulation and hybridization. *Geoforum*, 46, 5–15.
- Smit, B. and J. Wandel (2006) Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16, 282–292.
- Smith, J.B., T. Dickinson, J.D. Donahue, I. Burton, E. Haites, R.J. Klein and A. Patwardhan (2011) Development and climate change adaptation funding: coordination and integration. *Climate Policy*, 11, 987–1000.
- Stripple, J. and H. Bulkeley (2013) *Governing the Climate: New Approaches to Rationality, Power and Politics*. Cambridge: Cambridge University Press.
- Sultana, F. (2013) Gendering climate change: geographical insights. *The Professional Geographer*, 1–10.
- Swyngedouw, E. (2010) Apocalypse forever? Post-political populism and the spectre of climate change. *Theory, Culture & Society*, 27, 213–232.
- Tschakert, P. (2007) Views from the vulnerable: understanding climatic and other stressors in the Sahel. *Global Environmental Change-Human and Policy Dimensions*, 17, 381–396.
- Tschakert, P. (2012) From impacts to embodied experiences: tracing political ecology in climate change research. *Geografisk Tidsskrift-Danish Journal of Geography*, 112, 144–158.
- Tschakert, P. and M. Machado (2012) Gender justice and rights in climate change adaptation: opportunities and pitfalls. *Ethics and Social Welfare*, 6, 275–289.
- Tschakert, P. and G. Tappan (2004) The social context of carbon sequestration: considerations from a multi-scale environmental history of the Old Peanut Basin of Senegal. *Journal of Arid Environments*, 59, 535–564.
- Turner, M.D. (2013) Political ecology I: an alliance with resilience? *Progress in Human Geography*, 38, 616–623.
- Vasquez-Leon, M., C.T. West and T.J. Finan (2003) A comparative assessment of climate vulnerability: agriculture and ranching on both sides of the US-Mexico border. *Global Environmental Change*, 13, 159–173.
- Webber, S. (2013) Performative vulnerability: climate change adaptation policies and financing in Kiribati. *Environment and Planning A*, 45, 2717–2733.
- Whyte, K.P. (2014) Indigenous women, climate change impacts, and collective action. *Hypatia*, 29, 599–616.
- Wolf, A.T. (2007) Shared waters: conflict and cooperation. *Annu. Rev. Environ. Resour.*, 32, 241–269.
- Yamane, A. (2009) Climate change and hazardscape of Sri Lanka. *Environment and Planning, A*, 41, 2396.
- Ziervogel, G., M. New, E. Archer van Garderen, G. Midgley, A. Taylor, R. Hamann, S. Stuart-Hill, J. Myers and M. Warburton (2014) Climate change impacts and adaptation in South Africa. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 605–620.