8-2010

Climate Change and Globalization in the Americas: Case Studies of Mitigation and Adaptation

Mary Finley-Brook
University of Richmond

Melissa Haeffner
Portland State University

Charmaine Heslop-Thomas
Massachusetts Institute of Technology

Elma Montaña
Consejo Nacional de Investigaciones Científicas y Técnicas & Universidad Nacional de Cuyo

Leah Sprain
Colorado State University

-- WHITE PAPER, PASI INSTITUTE, PANAMA CITY --

Climate Change and Globalization in the Americas: Case Studies of Mitigation and Adaptation

August 2010

Mary Finley-Brook, *University of Richmond*

Melissa Haeffner, *Massachusetts Institute of Technology*

Charmaine Heslop-Thomas, *University of the West Indies*

Elma Montaña, *Consejo Nacional de Investigaciones Científicas y Técnicas & Universidad Nacional de Cuyo*

Leah Sprain, *Colorado State University*

Acknowledgements

Our participation in the Pan-American Advanced Studies Institute on Climate Change and Hazards in the Americas in Panama City in June of 2010 was sponsored by the National Science Foundation (# OISE-0921613). Special thanks to Patricia Solis of the Association of American Geographers for organizing and facilitating this interdisciplinary institute. Susan Cutter and Brent Yarnal inspired our initial contemplation of double exposure working together as "*Team Sacapuntas.*" All four case studies in this paper used primary material from fieldwork: people interviewed must remain anonymous, but we sincerely appreciate their contributions.

Table of Contents

Executive Summary

Robin Leichenko and Karen O'Brien have proposed "double exposure" as a conceptual framework to demonstrate how processes of globalization and global environmental change (GEC) redefine risk and encourage new, interrelated responses to social and ecological transitions (O'Brien and Leichenko, 2000; Leichenko and O'Brien, 2008). In particular, the concept encourages researchers and policy makers to consider interplay between global climate change and globalization and how this is expressed unevenly across space. After reviewing the ways double exposure has been used in the literature, we consider four case studies to investigate the utility of the framework for analyzing and understanding climate change adaptation and mitigation in the Americas. Our case studies include (1) dengue and malaria outbreaks in Jamaica, (2) agriculture in the Argentinean drylands, (3) hydroelectric production in northwestern Panama, and (4) climate change mitigation through carbon offsets at a regional level in Latin America. We agree with O'Brien and Leichenko (2000) that double exposure can be used to highlight at multiple scales the so-called 'winners' and 'losers' created by current global transitions and thus we seek to apply the framework to research in new arenas.

Double exposure brings focus to human-environmental interactions. This attention could be, and often is, recognized without the use of the double exposure framework, but the use of this heuristic devise is particularly compelling in that it encourages contemplation about ways in which uneven development advantages some groups and individuals at the expense of others. For example, those that benefit from globalization and climate change economics can often be conceptually paired with those that are made more vulnerable, as we demonstrate in the agricultural and energy sectors. In addition, double exposure helps demonstrate the interrelation of development trade-offs, as we also exhibit through case study analysis. In our conclusion, to

encourage on-going engagement with double exposure as a research lens, we (1) identify potential limitations of the existing framework, (2) recommend complementary bodies of literature, and (3) discuss ethical implications of our research findings.

Introduction

In identifying, measuring, and reporting on vulnerability, we strive to consider multiple, interconnected factors that influence how and why humans are affected differently by natural hazards and climate change. Institutional, economic, social, and cultural conditions are important determinants of adaptive capacity, but each set of variables is highly complex (Trainor, Calef, Natcher, Chapin, McGuire, Huntington, Duffy, Rupp, DeWilde, Kwart, Fresco, & Lovecraft, 2009). The double exposure framework has been presented by O'Brien and Leichenko (2000, 2009) as one way to bridge our concern for equity in a connected world while sensitizing our analysis to nuanced, interwoven factors. The concept refers to instances where global environmental change couples with globalization to influence social, economic, and ecological processes in compound, multi-directional, and potentially unexpected ways. While the specific benefits and costs to winners and losers in Leichenko and O'Brien (2008) multiply as a result of the interactions among variables, there is seldom a blanket response. Ecological processes create uneven impacts, but social responses are also varied. Studies show that some places and some people are better able to take advantage of opportunities (Eakin and Lemos, 2006). Others are disproportionately vulnerable to climate-related events (Parks and Roberts, 2006; Ribot, 2010) or poverty resulting from global economic integration (Olmos, 2001; Thorbecke and Nissanke, 2006). In many instances, social processes serve to amplify negative repercussions for marginalized populations rather than to reduce them.

It is timely to engage in research pertaining to globalization and climate change given on-going policy discussions. Nearly all scientists accept evidence demonstrating human-induced climate change (IPCC, 2007). Strong general agreement among climate scientists continues to be affirmed in independent studies designed to evaluate scientific consensus (see, for example, Gillis, 2010). Nonetheless, the disappointing international climate negotiations in Copenhagen in 2009 and the continued failure of policy makers in the United States to enact national climate policy demonstrates challenges to enacting public policies to respond to shared challenges (Krosnick, 2010; Rahm, 2010). In climate programs and policy, whether locally, nationally, or internationally designed and implemented, issues of social justice and determining shared responsibility must remain forefront. For this reason, we argue double exposure analysis provides an important tool to inform policy debates. We demonstrate this utility through the analysis of social and environmental justice within four Latin America case studies.

We argue, similar to O'Brien and Leichenko (2007/2008), that equity and connectivity are central elements to applications of double exposure. With these factors in mind, to what extent can double exposure be used to identify, explain, and report on climate change mitigation and adaptation in the Americas? We seek to answer this question by first reviewing the existing literature on double exposure and then testing the applicability of this research lens through analysis of four case studies. Our conclusion presents findings on the utility and limitations of double exposure for understanding dynamic, multi-scale, human-environment interactions.

Double Exposure: A Literature Review

It is increasingly accepted that "single-stressor-single outcome" approaches to studying vulnerability fail to capture the reality of most systems (Eakin and Luers, 2006). Indeed, the influence of global economic, cultural, political, and environmental processes on the production

and management of risks in local contexts is widely accepted (Eakin, 2005). Climate change is widely recognized as a "risk multiplier," increasing the impact of a variety of risks not directly related to global environmental change (Christoplos, 2010). Likewise, Eakin (2005) argues "delineating the linkages between economic globalization, market liberalization, and environmental change at different scales is an essential task in vulnerability analysis" (p. 1923). Yet empirical analysis of this multiplication process is lacking. Some quantitative studies have attempted to identify and map the overlap of social and environmental vulnerability indicators (see Cutter (2010) for specific examples), but many cases have yet to be verified through qualitative methods. The challenge to understanding vulnerability is to identify how economic and environmental processes interact in particular places and times, and then how these interactions, in turn, shape the impacts of global change processes while simultaneously driving others (Silva, Eriksen, & Ombe, 2010).

In 2000, O'Brien and Leichenko introduced double exposure as a framework for considering the impacts of climate change and globalization. Starting with the assumption that climate change and globalization will impact regions, sectors, social groups and ecosystems differently, double exposure provides a means to identify the winners and losers from these processes. For example, consider the case of Brazil. Economic globalization and currency devaluation impacted the livelihoods of residents who lived in *favelas* (shantytowns). Simultaneously, these urban poor are also among the groups most vulnerable to climatic change since hillsides are prone to mudslides and flooding, which may increase in both frequency and magnitude with global environmental change (O'Brien and Leichenko, 2000). Increasing temperatures and heavy rains also may increase the risk of malaria and cholera outbreaks. This

example demonstrates how double exposure captures the connections of economic globalization and climate change for a social group in a specific locale.

O'Brien and Leichenko (2007/2008) argue that double exposure has two important dimensions that animate the framework: equity and connectivity. The equity dimension highlights that not all individuals, communities, regions, and nations will be equally affected by climate change. In turn, the connectivity dimension emphasizes that the security of individuals and communities is increasingly linked to those of others across space and time. Acknowledging that outcomes for one group of people are often related to outcomes for other groups orients our focus. Together, equity and connectivity make double exposure a people-based approach to understanding climate change.

Double exposure is more than a simple acknowledgement that vulnerability to climate change is influenced by multiple processes of global change. Double exposure argues that changing economic and social policies influence the capacity to cope with and adapt to climate change (O'Brien and Leichenko, 2007/2008). For example, a farmer may have an appropriate adaptation to climate change (e.g., crop rotation or diversification) that ends up being poorly compensated due to the demands of global markets. Although some places, sectors, and social groups experience higher levels of exposure, it is important to note that vulnerability is not limited to developing countries. For example, elderly populations in the United States may be at risk for death during heat waves, particularly those living on fixed incomes.

Applications and Uses

Double exposure has been used in a variety of different ways. O'Brien et al. (2009) invoke it as a theory that explains how the two global processes result in increases in inequalities and vulnerabilities and reduce resilience. More often, however, double exposure is not treated as

a theory. Instead, it is used as a framework or concept to label multiple exposures. For example, Egende-Nissen and Venema (2009) point to double feedback loops in the Arctic using the term double exposure.

> In the Arctic context, the double exposures are in double feedback: loss of Arctic ice from global warming leads to decreased albedo; and more warming and more ice loss in the Arctic, which, as noted earlier, plays a critical role in global climate regulation. Arctic policy feedback then amplifies the biophysical feedback: loss of ice allows more fossil fuel exploitation and more global warming (Egende-Nissen and Venema, 2009, p. 6).

Silva, Eriksen, & Ombe (2010) use the concept in a similar manner but are careful to point out that double exposures are different from multiple exposures as a general term.

> Double exposure is more than just the fact of multiple processes happening in the same place at the same time. It is rather that the processes interact and, in doing so, influence the exposure and capacity of people and places to respond to a wide array of stressors and shocks in a way that creates new contexts for experiencing and responding to change. Pathways to increased vulnerability (or enhanced resilience) are multidirectional, so that socioeconomic conditions may mediate the impacts of environmental change, but changing environmental conditions may also alter socioeconomic capacities to maintain particular livelihood strategies (p. 9).

Following the use of double exposure as a concept, sometimes it is simply used as a noun to describe the "double exposure" due to globalization and climate change (e.g., Eakin, 2005; Malone, 2002).

Christoplos (2010) argues that double exposure is best treated as a heuristic device that can be used to highlight the overlaps between globalization and climate change.

> Awareness of double exposures has been important as a heuristic device for drawing attention to the social, political and economic forces related to both the causes and the effects of climate change. It has highlighted that both global environmental change and globalisation are highly "transformative" in that profound changes are underway. There will be new "winners and losers" as some vulnerabilities will be reduced and others exacerbated due to the interplay between these two sets of factors (Leichenko and O'Brien, 2008, p. 8).

Much of the research using double exposure has focused on agriculture (e.g. Eakin, 2005; McGuigan, Reynolds & Wiedmer, 2002; Silva, Eriksen, & Ombe, 2010). It has also been used in

research evaluating geoengineering efforts in the Arctic (Egende-Nissen and Venema, 2009) and water scarity (O'Brien and Leichenko, 2008). O'Brien and Leichenko (2007/2008) apply double exposure to examples in various contexts, but similar breadth of application has not yet been demonstrated broadly in scholarly research.

Four Case Study Examples from Latin America and the Caribbean

The literature review suggests broad applicability of double exposure, although it has generally been applied to cases of agriculture and climate change adaptation. We offer four cases studies that help test the scope and utility of double exposure. Our cases were chosen to include diverse factors, including new sectors (health care and energy) and a range of scales (regional, national, and transnational). Moreover, we wanted to explore whether double exposures could be used to examine climate change mitigation efforts in addition to adaptation and vulnerability.

Following Leichenko and O'Brien (2008), we employ the approach of using double exposure to identify winners and losers. We must express an overall concern is with the terminology 'winners' and 'losers.' While it gets a key point across effectively, the identification of disadvantaged or marginalized population as 'losers' is potentially offensive. There is usually a negative slant associated with being a called a loser that we are certain Robin Leichenko and Karen O'Brien did not intend, and we do not wish to imply this stigma with our application of their terminology.

Our first case study focuses on the potential of dengue fever outbreaks in Jamaica, applying double exposure to the health sector on a national level to highlight 'double losers' that are more susceptible to disease due to the combined impacts of globalization and climate change. The second case study focuses on agricultural production in the Mendoza region of Argentina, pointing to the ways in which certain farmers have more options for climate change adaptation

while farmers that have already been hurt by wealth concentration due to globalization are more vulnerable to climate change. The third case focuses on the energy sector in the region of Bocas del Toro, Panama where a proposed dam project designed to mitigate the impacts of climate change contributes to the violation of Indigenous Peoples' rights. Finally, the fourth case considers the 'double winners' from mitigation windfalls from transnational carbon trading. At the same time, the analysis also points to inequities within the current and proposed trading systems that perpetuate existing disparities between social groups, nations, and regions.

Case Study One: Double Exposures in the Jamaican Health Sector

As indicated previously, O'Brien and Leichenko (2000) advanced the concept of 'double exposure' in which the two global processes of climate change and globalization will result in a set of 'winners' and 'losers.' They have expressed the view that although the concept may be especially important in situations where the negative consequences of climate change and global environmental change are highly likely to be experienced, the 'winners' and 'losers' resulting from the interaction of the two processes may be different from the set of 'winners' and 'losers,' which are identified when each of the two processes is examined independently. Development is clearly an uneven process, but some trends are evident. For example, in some instances, regional disparities in levels of economic development are accentuated by the process of globalization, including neoliberal reforms such as structural adjustment programs, as well as by climate change. These interactions are clearly occurring in Jamaica.

Although it is widely accepted that globalization and global environmental change will have significant impacts on human health and on the health sector in general, the concept of double exposure has never really been used to a large extent to highlight some of these implications for the health sector. The purpose of this section is to demonstrate the applicability

of double exposure for exploring vulnerability with specific reference to the Jamaican health sector and the threat of increased dengue fever incidence.

Background

Retrospective analysis of the climatic data by the Climate Studies Group, Mona (CSGM) at the University of the West Indies showed that the Caribbean region experienced a warming trend during the past two decades (Peterson, Taylor, Demeritte, Duncombe, Burton, Thompson, Porter, Mercedes, Villegas, Semexant Fils, Klien Tank, Martis, Warner, Joyette, Mills, Alexander, and Gleason, 2002). A similar upward trend was noted for a number of rainfall indices also calculated for the Caribbean over the past four decades. Results from CSGM have also established an association between climate change and the occurrence of dengue fever outbreaks in the Caribbean. Peaks in occurrences are associated with warmer conditions, and the seasonality of the epidemics suggests that temperature and precipitation have some explanatory value. A prospective study is under way, but preliminary results indicate a continuation of the warming trend. Caribbean islands, therefore, should brace themselves for increasing outbreaks of a disease, which is debilitating, and which, in its dengue hemorrhagic manifestations, can cause loss of life.

Results: Jamaican Health Care Study

One in-depth study conducted recently in Jamaica has shown that a substantial number of people living in conditions that are conducive to the proliferation of the vector and virus are vulnerable (Heslop-Thomas, Bailey, Amarakoon, Chen, Rawlins, Chadee, Crosbourne, Owino, Polson, Rhoden, Stennett and Taylor, 2008). It has demonstrated the vulnerability of those living in informal settlements. State data reveal that 25 percent of the population, approximately

675,000 people, lives in squatter settlements (Ministry of Environment and Housing, 2009a, 2009b). It is clear that Jamaica faces a problem of great magnitude. Beset with competing urgent claims (e.g., HIV/AIDS transmission, rising sea level, extreme poverty, organized crime, etc.), the country does not see preparation for the possibility of a large outbreak of dengue as a priority. If an epidemic occurs, state agencies do not have the capacity to contain exposure.

Not unexpectedly, the poor are the most vulnerable. In 2009, 10 percent of the population of the island lived below the poverty line, and this is expected to increase. In addition, poverty is more prevalent in rural areas (PIOJ/STATIN, 2009); these communities, which account for roughly 48 percent of the population, are more vulnerable. Contrary to popular belief, the poor are not necessarily unemployed. In fact, many of the poor work as domestic workers and earn the minimum wage.

There is merit to the view of the Ministry of Health that communities must take some responsibility for vector control. But this has to be a policy position rather than a defensive posture. As policy, calls for community responsibility must be supported by initiatives aimed at empowering communities to assume control. Public education is necessary to address the knowledge gap revealed in the study (Heslop-Thomas et al, 2008). More than a half of those interviewed in communities could not say what causes the disease, and the overwhelming majority had no knowledge of its symptoms. Vulnerable groups, therefore, do not have the tools to protect themselves from dengue outbreaks.

Despite calls for community responsibility, responsibility is shared. The *government's* responsibility is clearly outlined by WHO (1997). One area needing government intervention is with the risk associated with improper water storage. Many rural areas do not have access to pipe-borne water while squatter communities in urban areas are not, by law, to have a pipe-borne

supply. The problem of water has to be tackled on two fronts—the provision of low-cost, secure drums, and the granting of security of tenure to those who, because of their status, are denied access to running water.

There are public sector organizations that have been given the mandate to mitigate hazards in the island and to promote sustainable development. These organizations seem focused almost completely on threats posed by sea level rise. No one can deny the threat posed by this phenomenon to small islands that have their most valuable assets and most of their people on low coastal plains. This is a more attractive, more seductive area of focus than a health threat, especially when the disease is known. Nonetheless, not *all* of the public sector agencies should become so absorbed with the gradual encroaching of the sea to the exclusion of more imminent threats. They should be persuaded to broaden their concept of a hazard; to realize that the threat of an increase in the occurrence of a debilitating and possibly deadly disease is not incompatible with their mandate; to see threats to health as threats to sustainable development and include these issues in their public education programs. The Jamaican Ministry of Health, by itself, is in no position to meet the challenge of increased disease transmission in the island. There is need for a concerted effort of collaboration with various public and private sector environmental organizations. These are elements in the country's generic capacity which constitute the foundation for adaptation.

Conclusion: Double Exposure in Jamaican Health Care

The concept of 'double exposure' can be used to highlight the double whammy in so far as vulnerability to dengue fever in Jamaica is concerned. Here is a country that has been hit by globalization and deteriorating macro and micro economic conditions. As it is trying to grapple with these issues, its coping strategies will now need to include dealing with an imminent threat

of dengue epidemics. A large non-immune population with less than adequate knowledge about the disease and its transmission, and a Ministry of Health which cannot address these issues due to resource constraints are good examples of two forces working to the detriment of a people- who may now be categorized rightly by this concept as 'double losers.'

Case Study Two: Double Exposure in Agricultural Production in the Argentinean Drylands

In central western Argentina, the Mendoza River follows a quite spread out pattern in the Central Andes: it originates in the snow-crested mountain range and flows toward the lower plains, providing water for the irrigation oases developed on the foothills. This scheme develops in two opposed landscapes: on the one hand, a green oasis is lined with neat rows of grapevines, tree-bordered roads and streets, and irrigation channels and drains. This is the powerful oasis where human work celebrates having conquered a hostile nature. On the other hand, non-irrigated lands are a "no-man's land" and subordinate spaces perceived as being empty and void of interest. Whereas the oasis concentrates the dynamism of the one million inhabitants of Mendoza city and an export viticulture-based economy, the scattered population of non-irrigated lands barely survives on out-of-market economic activities, devastated by poverty and desertification processes (Montaña, Torres, Abraham, Torres, & Pastor, 2005).

Under this light, the communities developed in the eastern foothills of the central Andes could be considered as modern *hydraulic societies* in which the social tissue is strongly associated with a comprehensive and intensive water resource manipulation within an order imposed for controlling a hostile environment (Worster, 1985). As power distributions are associated to water management, water would have the capacity to express -and also model- hegemonic and subordinate social relations of a hierarchical system.

As links between water and community are very high in these areas, global environmental change (GEC) and water scarcity deepening scenarios could cause not only spatial changes but also affect social processes while also influencing the existing nature-society relationships. As in other dry lands of South America, in the Mendoza river basin water is a restricting factor for human settlement and agriculture. The intensive viticulture and horticulture are only possible if tied to water management, making use of surface water distributed by the irrigation network or pumping groundwater. But climate also imposes its conditions, as freezing and hail annually cause crop losses and warming vineyards need cold temperatures for reaching proper maturity.

Global environmental change scenarios (2020-2030) for the Mendoza River basin are similar to other rivers originating in the central Andes (Boninsegna and Villalba, 2007). They forecast a rise of 1.5°C in the mean temperature, a diminishing of precipitations over 100 millimeters, and a 150 meter rising of the 0°C isotherm, reducing the snow accumulation. As a result of these changes, the volume of flow of the Mendoza River is expected to diminish between 7 and 13%. The hydrograph of this nival regime river would also be affected. The peak discharge would be advanced one month, increasing spring flows (October and November) and lowering the summer outflows (January to March). This poses threats to agricultural and livestock activities already restricted by water scarcity, affecting farmers but also the entire agricultural-based regional economy.

Farmers facing global environmental change

Research has focused on the situations to be faced by farmers in three representative productive systems of the basin. Two of them are agricultural activities developed within the oasis irrigation system: one permanent (viticulture) and the other annual (horticulture, mostly

olericulture). The third, goat husbandry, is an extensive livestock activity taking place mainly for subsistence purposes in non-irrigated areas upstream and especially at the tail of the basin.

For these productive systems, vulnerability to global environmental change appears to be related to different factors:

A. Nature of the productive system: Oasis agriculture vs. non-irrigated extensive goat husbandry

A first analysis must differentiate between the agricultural systems (viticulture and horticulture) relying on irrigation from extensive goat husbandry developed in non-irrigated zones. Diminishing precipitation will not affect the first but will decrease the natural vegetation of the desert, affecting goat husbandry and deepening the desertification processes already in place. Drought periods hit very hard on this activity, testing its survival limits and compromising alimentary security of its domestic production units. The extreme poverty of this population could raise a paradoxical situation around vulnerability. The benefits of goat husbandry are so scarce that the incomes of these domestic production units must be complemented with others coming from temporary agricultural or urban activities and State subsidies. Thus, these producers would be more diversified than those devoted exclusively to agriculture and would be more likely to adopt a wider range of adaptive strategies. Leaving theoretical arguments aside, their extreme poverty is closely related to their vulnerability and reduces resilience, not only for facing climate change but in general terms.

The diminishing river runoff will be harder on agricultural farmers who rely on the surface irrigation network. In the context of a system that allocates water proportionally to the plot surface (independently from the land being used or the type of crop), viticulture farmers will be favored over horticulture producers because of the vineyards lower water consumption and

more resistance to water stress. On the other hand, the annual cycle of horticulture makes adaptive strategies such as moving to better locations in terms of climate and water risks easier.

Agricultural farmers will see adaptation to hydrogram alterations facilitated by the operation of the dams regulating the rivers. But ecological flows are not being considered in the dams operation, so the river regulation for favoring water consumptions in the oasis prevents water surplus from reaching the tail of the basin where the desert communities are receiving less and less water as the rural and urban oasis upstream continues its development. This subordinate position in the *hydraulic society* explains a good deal of the vulnerabilities of desert communities.

The nature of the productive system has appeared a crucial factor of the vulnerability, but the analysis gives evidence that this "nature" has strong social components not related to climate, and exposures are also leading to poverty and social power issues.

(B) Structure of the productive chain and the farmer's position in it

Mendoza's river basin horticulture is an agricultural mosaic formed by a great number of heterogeneous producers. The distribution channels are also varied in the context of a loosely regulated sector in which the informal economy is significant. The complicated and unstable decision-making processes horticultural farmers face does not encourage investments for reducing exposures. This structure also creates hurdles for implementation of institutional measures that could help the most disadvantaged producers face GEC scenarios.

In contrast, viticulture shows a clear structure with horizontal and vertical integrations and regulations set by formal institutional arrangements. Adaptive measures could be fostered here not only from the state but also by existing farmers' organizations. But, as integrated and organized as this structure is, the farmers' universe is quite polarized between the producers that

make wine and are directly involved in the wine export circuit and those small and medium farmers whose participation in the chain remains subordinate. Are state institutions potentially co-opted by the more powerful agents? This takes us to our next key factor.

(C) Farmer typology

Farmers' typology ("big/small," "capital intensive/traditional," "export/domestic," or any other construct showing power differences) is directly related to vulnerability, in goat husbandry as well as in the oasis agricultural systems. Economic wealth of big farmers allows them to overcome reduced surface water allocations by pumping groundwater. In the context of loosely regulated groundwater management, they can even become independent from the "democratic" but tedious water users organization mechanisms and just turn on the pump whenever it fits their irrigation needs, obtaining water volumes only restricted by affordable (and subsidized) energy prices. In the same way, they have a better position to adopt other vulnerability reducing measures such as pressurized irrigation to make a more efficient water use or hail net protection. Unlike the more disadvantaged farmers, they can move to better locations, an adaptive strategy that is currently being seen not only in horticulture farmers that rent the land for their annual crops but also in big winemakers buying land and building wineries in upstream foothill locations.

(D) Location in the basin

Finally, position in the basin appeared to be a vulnerability factor more related to natural explanations but also related with the social, economical and governance factors mentioned above. The more successful agricultural farmers (especially those integrated to the export sector) gradually climb the foothills to settle in the upper oasis lands, looking for lower temperatures, better standard of water rights (less likely to be cut back in a drought situation), better water

quality, and less pollution, in some cases pushing the agricultural border upstream by means of groundwater pumping. These are capital-intensive properties relatively protected against climate and water risks. On the other hand, those farmers whose benefits are not enough for affording those prime locations must resign themselves to the less attractive traditional oasis locations with fewer resources to reduce their exposure and to work out adaptive strategies. These farmers will be in greater need of institutional support to cope with the expected effects of GEC.

Double exposures, multiple exposures

In these basins, farmers' vulnerability depends upon the nature of their activity, as some of them are more water and climate sensitive to GEC scenarios than others. Beyond that, there are some other factors also affecting farmers' vulnerability (exposure and adaptive capacities) within the same productive system. Some of these factors seem to be related to power relationships and to equity issues of these *hydraulic societies*. Being wealthy and successful in the wine and food markets, having access to technology (irrigation and others), being vertically and horizontally integrated, and being favored by the use of the better and more expensive upstream lands turns out to be shielding factors and indicators of a broader availability of adaptive resources.

Factors and mechanisms that could make farmers more or less vulnerable in GEC scenarios have shown a significant similarity to those who explain their performance while facing the new challenges of the globalized agrifood markets during the 1990s. At that time, the weakest producers, those who couldn't keep pace with the new rules of the game, were negatively affected, even pushed out of business, while a concentration process took place in favor of the more powerful agents. It seems that GEC effects will affect farmers in central-western Argentina in an analogous way, this time adding its effects to the ones already produced

by globalization. Here is where double exposures are found, equity issues are raised and the process could be explained with reference to 'winners' and 'losers.'

Case Study Three: Double Exposure in the Energy Sector in Bocas del Toro, Panama

The Bocas del Toro Province in northwestern Panama provides an illustrative example of double exposure in the energy sector at a sub-national scale. News reports demonstrate widespread public discontent in the province over the lack of basic services and human rights violations. State-sponsored mistreatment and intimidation of Bocas del Toro indigenous groups is evident in media coverage (Arcía, 2009a, 2009b; La Prensa, 2010). Press reports and testimonies from local indigenous inhabitants suggest violence was used to quell local opposition to foreign-sponsored large-scale dams being constructed on Naso and Ngöbe lands (Brannan Jaén, 2008; Jordán, I. M., 2008; Jordán, O., 2008; IAHCR, 2009, pers. comm., June 7, 2009).

AES-Changuinola, a subsidiary of the US-based energy giant AES Corp, is rapidly developing Chan 75, a $560 million and 222 megawatt dam in Bocas del Toro. Chan 75 construction requires relocation of Ngöbe villages and has created the context for authoritative control of impacted populations (i.e., with fences, police checkpoints, travel restrictions, etc.) (Jordán, O., 2008; Finley-Brook and Thomas, 2010). After visiting the area, the United Nations (UN) Special Rapporteur on the Situation of Human Rights and Fundamental Freedoms of Indigenous Peoples determined that free and informed consent did not occur before the hydro concession was allocated (Anaya, 2009). Local populations have since attempted to halt the dam's construction with petitions, testimony, and court cases in front of the Organization of American State (OAS) human rights agencies.

Chan 75 hydroelectric project shifted resource management power away from local populations and toward the private sector (Finley-Brook and Thomas, 2010). AES-

Changuinola's contract with the Panama's National Environmental Authority (ANAM) transitioned responsibility for 6,000 hectares of public lands in the Palo Seco Forest Reserve to the private firm. The state decided local village populations would be permitted to remain near their original settlements within the forest reserve, but they would not receive title to their lands even though villages pre-date the creation of the protected area. Palo Seco was created in 1983 with the specific objective of safeguarding water resources for hydroelectric production (Paiemont, 2007).

AES-Changuinola and ANAM officials frequently reiterate the importance of forest cover to maintain efficient functioning of Chan 75 dam. State and company officials are planning agroforestry and tourism initiatives to redirect local production toward economic activities identified as conducive with hydroelectric energy generation and carbon sales from forested areas surrounding the dam (Blanco, 2009; Finley-Brook and Thomas, 2010). Watershed management for electricity production and emission offsets is being valued above subsistence agriculture and fishing in local communities and as a result profound restructuring of indigenous communities is occurring. According to village leaders, neighboring Naso indigenous communities face a similar situation (pers. comm., June 7, 2009). Construction of the Bonyic dam with multinational investment moves forward in spite of Naso petitions in front of international human rights tribunals aiming to stop the project. Since initiation, Chan 75 and Bonyic dams have been promoted as clean energy projects providing greenhouse gas emission reductions.

Dam construction creates double exposure for local populations because climate change has intensified the need to protect the watershed. Simultaneously global climate change has reinforced the need for a global transition to clean energy sources, and, in particular, to find

replacements for fossil fuels. While the transition to renewable energy is imperative, it does not justify authoritarianism. Since sustainable development requires participatory and inclusive processes (Chandani, 2007; Burkett, 2008; Comin, 2008), analysis of dam building in northwestern Panama suggest the importance of paying attention to not only the end product of climate change mitigation and electricity production, but also the means to arrive at that goal.

The double exposure framework is clearly broad and inclusive enough to include studies of the energy sector. The benefit of applying double exposure is that it demonstrates that those who profit and those who are harmed are impacted differently by the exact same electricity source. This connection is often ignored. While private developers suggest the dams will reduce vulnerability for Panamanian society by producing reliable and affordable energy, most energy will fed to the national grid and be sent to urban and industrial zones. Ironically, rural populations paying the highest social and ecological costs near large-scale dam sites often do not have access to basic services such as electricity (McCully, 2001).

Negative impacts identified in double exposure research (such as in O'Brien and Leichenko, 2000; O'Brien et al., 2004; Leichenko and O'Brien 2008) can frequently be identified as development trade-offs. In the case of Bocas del Toro, given pressing concerns about human rights violations, should potential vulnerabilities be ranked or somehow weighed against one another? Does double exposure help us understand how to value factors as diverse as renewable energy promotion, clean water, biodiversity, human rights, land rights, or self-determination when trade-offs are being proposed between them? For example, Chan 75 dam has been also criticized by international scientists because of probable negative impacts for biodiversity within internationally recognized protected areas located nearby, including La Amistad World Heritage Site (McLarney and Mafla, 2007). Due to the breadth of the framework,

double exposure may not be sufficiently attentive to each factor involved and it does not inform us about the relative importance of each element. To be fair, this remains a limitation in much social science research. Double exposure's central benefit to climate change policy analysis is that it reminds researchers to connect interrelated human-environment transitions in ways that are often overlooked, but individual researchers still need to decide how to interpret the importance of each factor.

The energy sector in Bocas del Toro exhibits a development dilemma with ethical underpinnings. Who defines community resilience, and whose definition matters? In the case of Chan 75, the project administrator suggests the local communities will *benefit* from relocated and restructured villages (pers. comm., June 8, 2009; Finley-Brook and Thomas, 2010). Can resilience be augmented by outsiders? Does it matter if customary practices are lost? A complaint of Bocas del Toro Indigenous Peoples is that there has been extensive tinkering with self-governance and local institutions on the part of the Panamanian state and private developers (Jordan, O., 2008; Anaya 2009; Finley-Brook and Thomas 2010). Communities have been torn apart not only by resettlement but also by intimidation of dam opponents. Moreover, impacted Ngöbe testified in front of the Inter-American Commission on Human Rights that the state influenced the selection of local leaders, and thus subsequent negotiations in 2009 affirming the project were essentially staged events lacking broad participation (IAHCR, 2009). A Ngöbe leader acknowledged that state agencies often work to erode the authority of communal leaders in the province and actively promote and knowingly recognize self-appointed individuals without the support of their people, as a means to usurp power from legitimate leaders (pers. comm., May 2, 2010). Outside intervention in local institutions has been profoundly disruptive to community cohesion in Naso and Ngöbe territories (Paiemont, 2007; Jordan, O., 2008; Anaya

2009; Finley-Brook and Thomas, 2010) and is in violation of self-determination as outlined in the 2007 UN Declaration on the Rights of Indigenous Peoples, an international norm that Panama supported. State agencies and private sector actors seek to assure their ability to control natural resource extraction and use, but their actions may promulgate new forms of vulnerability. Leichenko and O'Brien (2008) address cultural loss as one factor within double exposure, but implications for diverse ethnic and racial groups may be overshadowed by the large number of other variables simultaneously under consideration.

Case Study Four: Mitigation Windfalls in Latin America

This section examines recently established and emerging greenhouse gas (GHG) mitigation schemes to assess interrelated feedback from globalization and climate change leading to windfall profits. Groups benefiting from GHG mitigation would likely be identified as 'double winners,' in the sense of Leichenko and O'Brien (2008), since many gained their advantageous economic position from investments in the global economy prior to becoming involved in carbon markets. There has been little scholarly research on those who have profited from adaptation or mitigation programs, but see Lohmann (2005, 2008), Bumpus and Liverman (2008), Haigh (2008), and Hazlewood (2010) for a few examples. Given data limitations, we discuss social and environmental justice issues emerging in the climate change mitigation literature, with a focus on Latin America. Although global trends are evident in adaptation and mitigation, it is always necessary to be aware of regional and local differences (Leichenko and O'Brien, 2008; Eakin and Lemos, 2006).

The Rise of Emission Trading

Emission trading has grown exponentially since the mid-2000s under the Clean Development Mechanism (CDM), the European Union's Emission Trading System (EU-ETS), and other frameworks (Bumpus and Liverman, 2008; Brohé, Eyre, & Howarth, 2009; Giddens, 2009; Gilbertson and Reyes, 2009; Bulkeley and Newell, 2010; World Bank, 2010). Figures from the World Bank show more than tenfold growth in the carbon market exchanges in the past five years and record the value traded in 2009 as $144 billion dollars. A Global Business Intelligence report highlights how the global carbon market grew at compound annual growth rate of 89% to reach its 2009 level. There is considerable additional growth predicted: carbon credits linked to a reduction of even ten percent of global deforestation should be worth billions of dollars (Ebeling and Yasué, 2008). It is important to note that the price of carbon is still relatively low, usually under $15 dollars per ton. World Bank economists believe $50 dollar per ton is a more realistic estimate of true value (pers. comm., July 16, 2010).

There is a long list of economic sectors that benefit from carbon markets and a very short list of academic papers on the topic. In many instances carbon trade has emerged from a specialized branch of existing operations, but there has also been the creation of whole new entities (Bumpus and Liverman, 2008). The social and environmental impact standards and assessment tools used by each company vary greatly. Research on carbon brokers is difficult to conduct: brokers do not share prices and often prohibit their business partners from discussing specific contract details, according to project managers interviewed in Nicaragua (pers. comm., January 5-6, 2009). There are clearly profits to be made: by 2005 the World Bank anticipated its commissions from brokering carbon trades could be approximately $100 million dollars annually (McMichael, 2009).

Firms increasingly mainstream strategies to mitigate climate change into daily operations. As this process increases, many businesses actively lobby individually and/or by sector to influence climate policy in ways that assist their bottom line (Haigh, 2008). This type of self-interested or profit-motivated thinking extends beyond the private sector. Giddens (2009) identifies a tendency for everyone from politicians to the general public to select particular angles from broader climate change debates to advance their prior political or economic agenda, instead of viewing the potentially repercussions of global environmental change holistically or objectively.

Everyone wants a percentage of the profit from carbon markets, including environmental organizations. Representatives of the major international environmental groups noted that carbon markets provide an economic opportunity, stating:

> For a number of years conservation organizations have been lamenting the decline in available funding. Carbon funds, however, are growing at a phenomenal rate, and offer the potential to make up some of the shortfall (Roe, Reid, Vaughan, Brickell, & Elliott, 2007, p. 1).

Clearly not all funds from carbon sales will go directly to offsetting GHG emissions. Regulators and participants in these markets need to decide what percentage they are comfortable assigning to brokers, consultants, verifiers, and promoters. These earnings remain largely in middle and high income countries where trading and consulting operations are consolidated. Meanwhile, the high transaction costs for CDM verification, some of which is paid to intermediaries offering specialized services, are discouraging small-scale and community-based projects in developing countries with limited financial capital from pursuing verification in spite of the potential of earning carbon credits (Lokey, 2009).

A Mitigation Research Framework

Mitigation projects targeting low-cost reductions may multiply existing and new human-environment risks, with the highest costs often felt among vulnerable social groups. Applying a double exposure framework to climate change mitigation fits squarely with the research trajectory Leichenko and O'Brien (2008) propose, but it is an extension of most scholarly work concerning climate change exposures as studies have tended to focus on adaptation (for example, O'Brien et al., 2004; Thomas and Twyman, 2005; Leichenko and O'Brien 2002, 2008). Leichenko and O'Brien (2008) suggest that double exposure would fit in the case of biofuels. We suggest broader application is possible, although we identify a potential analytical weakness. While we support attention to interrelations between global climate change and economic change, we also suggest mitigation researchers should seek early on to identify the influence of politics and the roles of multi-scale political actors given the disputed nature of climate governance in multiple arenas (Harriss-White, 2008; Giddens, 2009; Bulkeley and Newell, 2010; Ribot, 2010).

Although O'Brien and Leichenko (2000) and Leichenko and O'Brien (2008) suggest that there can be 'winners' as well as 'losers' from double exposures, they never identify or expand upon the specific attributes of so-called 'double winners.' Nonetheless, double exposure presents itself as a productive and helpful lens to use to examine climate change mitigation because it shows connections between social sectors that benefit and other sectors that are harmed. Worth (2009, p.5-6) breaks key problems in climate change mitigation down into what she calls the 'triple injustices:' (1) climate change is hitting the poor first and worst; (2) those most affected did not cause it and are powerless to stop it; and (3) the polluters are not paying. If the double

exposure framework helps demonstrate how injustices such as these are interconnected, it makes important theoretical and practical contributions.

Mitigation and Multiple Exposures

We do not suggest that all GHG emission exchanges are problematic or unjust; however, exploitative and/or fraudulent trade has serious repercussions, including: (1) limitations to sustainable development, (2) threats to social and distributive justice, and (3) constraints to actual reductions in GHG emissions. It has been shown that perverse incentives in poorly designed policies can increase emissions or counterbalance effective reductions (Lohmann, 2005, 2006; Gilbertson and Reyes, 2009). Plants created to produce the potent GHG called HFC-23 are the most popular example. Although not found in Latin America, HFC-23 cases bloated the entire CDM system. Defining a fair method to value HFC-23 emission credits remains a point of contention. Perverse incentives in carbon markets waste resources: time and energy utilized to restrict HFC-23 production could have been spent reducing emissions from other sources.

There are various accuracy concerns in voluntary GHG markets: for example, news reports discuss cases of institutions reselling or double counting credits. Measurement is challenging in many environmental service markets, as Robertson (2007) describes in US wetland mitigation banking. While even national exchanges are complex, the United Nations Framework Convention on Climate Change (UNFCCC) attempts to work at a vast spatial scale when certifying thousands of transnational trades. Establishing a system of this scale and scope is an enormous challenge. As evidence that the UNFCCC system continues to have weak spots, large verification agencies working under the CDM have lost official privileges after deficiencies were found in their verification and book-keeping practices. The UNFCCC is challenged to address criticisms that it is slow to certify emissions reductions while at the same time assuring

sufficient oversight so that self-interested actors are not able to cheat the system, and that highly diverse cases are each treated fairly. As it stands, the CDM lacks due process safeguards (von Unger and Streck, 2009). However, the UNFCCC structure is constantly evolving--the complex architecture of the institution means processes require substantial time. There are still many kinks to work out, so to speak. The UNFCCC attempts to regulate transparency in CDM emissions reductions, but it is plagued by questions of fairness, particularly in terms of governance on the part of the Executive Board (Bumpus and Liverman, 2008; Millar and Wilder, 2009).

Sustainable development was supposed to be an integral part of the Kyoto Protocol. Sustainability was not achieved in any of the seventeen CDM projects Sutter and Parreño (2007) assessed in terms of rates of local employment, air quality, and distribution of Certified Emissions Reductions (CERs). Concerns about sustainability in carbon mitigation programs were also expressed in Olsen (2007) and Anderson (2009), among others. Olsen (2007) concludes that left to market forces, the CDM does not significantly contribute to sustainable development. In part, issues arise because it remains unclear in the climate regime how to balance public goods with private rights (Werksman, 2008).

Globally, there have been higher climate change costs among low income countries (Mendelsohn, Dinar, & Williams, 2006) and populations (Ribot, 2010). Nevertheless, a focus of negotiators from powerful countries has been to assure cheap carbon offsets for polluters in the industrialized world (Bumpus and Liverman, 2008; Peck, 2008). Within global environmental service markets, the search for inexpensive offsets reinforces inequity in the trading structure and who it benefits (Gilbertson and Reyes, 2009). It is often possible to identify trade-offs between carbon storage potential and resources for local subsistence (Chandani, 2007; Chhatrea and

Agrawal, 2010). In some cases, GHG mitigation projects have led to restricted resource local access to resources (Lohmann, 2006; Gilbertson and Reyes, 2009; Mate and Ghosh, 2009) or may disadvantage local knowledge (Lohmann, 2008). Another pattern is poor distribution of carbon market earnings to local communities. Some CDM projects in Latin America have been shown to disproportionately benefit national elites and foreigners (Lohmann, 2006; Lokey, 2009). These processes show that there can be 'winners' and 'losers' from the same situation at a national level concurrent to international inequities. For example, projects can become dependent on foreign expertise or equipment (Lokey, 2009). Policies and programs that are not created to fit a particular domestic situation may harm national capacity (Comim, 2008). Yet projects that create these negative impacts are often still implemented because they bring benefits to certain sectors of society. Working with a framework like double exposure helps to demonstrate that 'winners' and 'losers' are connected.

The overall oversight of ecological and social sustainability of many CDM projects remains unsatisfactory (Lohmann, 2006; Olsen, 2007; Sutter and Parreño, 2007). There is a large and growing literature on social injustice in carbon markets (Baldwin, 2009; Gilbertson and Reyes, 2009; Mate and Ghosh, 2009; Finley-Brook and Thomas, 2010). In some instances carbon trade creates new ecological and social problems, and these trade-offs generally remain poorly analyzed (Gilbertson and Reyes, 2009; Peck, 2009). With more than 2,000 CDM projects verified, there is extensive offsetting experience to learn from. Meanwhile, an international climate justice movement is growing due to lack of attention to community development and ecological integrity in many mitigation projects (Lohmann 2006; Gilbertson and Reyes, 2009; Gudnydas, 2009).

Multi-scale Climate Policy Remains Incomplete

While grassroots organizations clamor for non-market solutions to climate change in many countries of the world, most policy analysts expect carbon trade to continue as the dominant mitigation paradigm. There are a growing number of certification standards for carbon credits (e.g., the Gold Standard, the Climate, Community, and Biodiversity Standard, etc.). These provide targets, such as integral community development, participation, waste reduction, workers rights, etc., that emerged from the recognition of shortfalls in early GHG mitigation projects. Certification of standards adds to the expense of verifiable carbon offsets, but it creates oversight mechanisms for social and environmental factors that are frequently overlooked in conventional regulatory and voluntary trading schemes.

Carbon trade, according to the Kyoto Protocol, was supposed to reduce the development gap between industrial nations and the rest of the world. Early experiences have fallen short of Kyoto's objectives. However, recommendations to improve governance and equity in the climate regime abound (e.g., Ackerman, 2008; Burkett, 2008; Brohé, Eyre, & Howarth, 2009; Millar and Wilder, 2009; von Unger and Streck, 2009; Okereke and Dooley, 2010; Quirion, 2010; White, Hatcher, Khare, Liddle, Molnar, & Sunderlin, 2010). After failure to reach agreement for post-2012 climate policy in Copenhagen in December of 2009, tensions between countries and among groups of countries remain high (Doelle, 2010; Zelljadt, 2010). The unwillingness of US legislators to enact national climate policy receives international criticism as policymakers prepare for the next round of UNFCCC negotiations in December of 2010.

> The time for enabling climate justice is short, but the potential for creativity, reflexive justice and, socially inclusive orientations to climate change responses are wide open (Lotz-Sisitka, 2010, p. 87).

Addressing climate change is the responsibility of more than just state institutions (Bulkeley and Newell, 2010; Rahm 2010). In particular, *educators need to analyze and discuss*

climate injustices, particularly given our urgent need to transition to a low carbon economy and to govern the climate in an inclusive manner (Lotz-Sisitka, 2010). Further, *climate change governance needs to be a high priority on the global research agenda*. Many knowledge gaps concerning GHG emission mitigation currently exist in natural and social sciences alike. However, tendencies among policy makers and researchers to offer simplistic, normative statements arguing climate change should be at the top of the agenda should be cautioned since sustainable development is integral and multi-faceted (Christoplos, 2010). Holistic, interdisciplinary analysis of proposed solutions is clearly necessary to understand trade-offs and achieve proactive, effective, and equitable climate policy. There is great potential for research highlighting connections between double winners and double losers, but associated risks are presented below.

Conclusion

In this paper we set out to test the utility of double exposure as a concept for researching climate change and hazards in the Americas. Drawing on published research and four case studies of our own, we have demonstrated that looking for the intersections between globalization and global environmental change is in fact productive. In all of our cases, we found overlaps between these often related global change processes. But the outcomes of the interaction between the two processes were not consistent across cases. In the Bocas del Toro energy sector, we saw how efforts to mitigate the impacts of climate change in fact exacerbated the human rights abuses perpetuated under the logic of globalization. In Jamaica, we saw the same populations who were vulnerable to the increasing risk of infectious disease due to climate change were doubly at risk due to social marginalization reinforced by globalization. These different interactions—the ability to demonstrate double winners, double losers, and cases where

efforts to address one global change practice (perhaps unwittingly) expand inequity—are a powerful contribution to research on climate change and hazards because they sensitize us as researchers to system impacts that may otherwise go unnoticed. Moreover, the simultaneous attention to these two processes approximates the manner in which people actually manage risks in their communities. When making policy decisions about climate change and hazards, double exposure provides a more nuanced view that focusing on singular impacts or flows within mitigation and adaptation.

Our cases demonstrate that, as a heuristic for case study analysis, double exposure can be used in multiple sectors, including health and energy. Our cases add to arguments of Leichenko and O'Brien (2008) that double exposure can be applied to diverse situations. That said, we did find that applying double exposure as a method for analysis was less straightforward as we expanded the scale of our analysis. Particularly at the transnational scale it became difficult to determine the interacting impacts between globalization and climate change. At this scale, we doubt the utility of mapping the double exposure as was successfully done on the community level in O'Brien and Leichinko (2004).

The transnational case study of mitigation windfalls also highlighted an important tension between double winners and double losers. We started the fourth case study discussing how some companies and intermediaries are making and stand to make large profits from carbon trading. These entities are winners because of global environmental change, and they are also winners in the flow of global capital. Yet the same case study points to the simultaneous double losers: the communities, small companies, and individuals who lose autonomy over natural resources while others make profits. The framework of double exposures reveals different winners and losers in the same scenario. This is, of course, not surprising as far as winners often

mean that someone may be losing out. Our concern is that the existence of double winners in analysis and research may legitimize and justify action (in this case transnational carbon trading schemes) despite the double losers. We fear that policy analysis at various levels (local, regional, national, transnational) relies on cost-benefit analysis that does not sufficiently value 'losers' nor prioritize equity when there is profit to be made. We worry that the ability to highlight the positives surrounding double winners—or even partial winners—may overshadow double losers, even though the concept is designed to highlight equity issues. Other academic traditions, such as political economy and political ecology, may be used to minimize this shortfall and demonstrate how the trajectories are connected with windfalls for a small few leading to deprivation for others. Nevertheless, we remain cautious of how double exposure analysis might be manipulated or twisted by policy makers.

O'Brien and Leichenko (2007/2008) outline issues of equity by directly highlighting differences in gender, nationality, class, etc. of double exposure processes. Nevertheless, Castree (2010) criticizes Leichenko and O'Brien (2008) for ethical superficiality because they present double winners as if the category is ethically neutral. Nearly every development situation will likely involve trade-offs with moral consequences. Examples of trade-offs were presented in all four case studies above: issues of social equity are directly relevant in whether a Jamaican has adequate health care, an Argentinean farmer gets sufficient water, or Panamanian indigenous villages are relocated to produce hydroelectric energy. Moreover, the Jamaican case suggested that not prioritizing health care in light of rising sea-levels was itself a trade-off with associated ethical concerns. Our cases demonstrate important ethical implications that are not clearly brought into focus by the double exposure framework.

Castree (2010) uses his review of Leichenko and O'Brien's (2008) book to encourage geographers and the academic community more broadly to directly address the ethically dimension of the topics we research. This argument is reminiscent of Liberation Ecologies (Peet and Watts, 1996/2006) and several other classic political ecology works. Political ecologists tend to keep issues of power, access, and distribution central to their analysis, whether related to issues of air and water pollution or natural resource management (Bryant, 1998; Peet and Watts, 1996/2006). Many times, this involves spelling out the role of global development actors. For example, international finance institutions (IFIs) are highly involved in promoting carbon markets, while also standing to benefit from them. Access to carbon finance provides power to carbon investors and lenders. These implications need to be extensively researched and defined to promote transparency and public access to information. In contrast, processes of corporate lobbying to influence the global climate regime are poorly understood among the general public. Similarly, the responsibility of nation-states remains unclear, but states clearly remain strong actors in determining or blocking global responses, as well as in defining domestic adaptation and mitigation. The role of the state was important in each of the four case studies treated in this paper and thus we suggest it needs to be addressed directly and, when appropriate, critically. Even in the US, where the federal government has failed to play a leadership role, there have been decentralized responses at regional, state, and local governance scales (Bryne, Hughes, Rickerson, & Kurdgelashvili, 2007). Nonetheless, policy analysts are concerned with the seemingly upward shifts in governance and decision-making scales linked to climate policy. For example, the institutional architecture of GHG trade policy in the forest carbon sector in particular could create the potential for a recentralization of natural resource management after decades of movement towards decentralization and community engagement (Phelps, Webb, &

Agrawal, 2010). Governance shifts linked to climate policy need to be analyzed in greater detail within extensive cross-national and multi-scale research sensitive to issues of social justice and community development.

We recommend complementary bodies of literature to complement double exposure analysis. The centrality of scale and power issues, of which the ones mentioned above are only a small selection, suggests drawing from additional political ecology literature could be beneficial (e.g., Peet and Watts, 1996; Rocheleau, Thomas-Slayter & Wangari, 1996; Swyngedouw, 1997, 2004; Blaikie, 1999; Adger, Benjaminsen, Brown & Svarstad, 2001; Zimmerer and Bassett, 2003; Robbins, 2004; etc.). Political ecology provides an instrumental framework for the study of multi-scale, nature-society interactions that change over time (Zimmerer and Bassett, 2003). Political ecologists have successfully analyzed multiple scales without losing sight of the local (e.g., Swyngedouw, 1997, 2004). This detailed attention to scale and scope is necessary to avoid mistakes during climate change adaptation and mitigation. Cutting-edge analysis of climate change policy is imperative to improve current practices. The work of environmental geopolitical theorists, such as Sletto (2003) and Dalby (2003, 2004), could also support both domestic and foreign policy analysis of complex interactions in the realm of environmental policy.

In an effort to help refine the conceptualization and methodological application of double exposure, we offer the following limitations of double exposure as a research method. These limitations are suggested in the spirit of friendly criticism in the hopes we can contribute to refining this valuable climate change research approach.

Limitations

Researchers have identified a number of potential limitations to the double exposure research method (e.g., O'Brien et al., 2004; Castree, 2010; Christoplos, 2010). We draw from and build upon these critiques as a means to encourage ongoing engagement with double exposure.

Method. As noted in the literature review, Leichinko and O'Brien (2008) present double exposures as a conceptual framework for study, but do not detail a precise method for applying this framework in academic analysis. In a book review, Bailey (2009) notes: "The double exposure framework may strike some readers as very broad and lacking some analytical precision, but I would argue that this is necessary to capture the essence and plasticity of interactions between these two sets of forces" (p. 243). Although we are sympathetic to the argument that the double exposures framework is necessarily broad, the lack of analytical precision remains a drawback, particularly for scholars other than Leichinko and O'Brien using and contributing to the approach.

As one additional limitation, several central concepts (e.g., resilience, vulnerability) and discourses used by natural scientists to understand global environmental change are not universally accepted in the social sciences. Although it is clearly necessary to bridge the natural and social sciences and to work across disciplines, it is hard to integrate diverse discourses as they build from highly different epistemic frameworks. Klein (2009) notes related disjuncture between definitions of concepts like vulnerability among academics and development practitioners, as well as legal ambiguity in the usage of such concepts by policy makers.

Scale. As we note above, at the level of transnational scale application the researcher loses the fine-grained, place-based examples that more clearly show cause-effect relationships

between global environmental change and globalization (Hidayat & Stuhl, 2010). This poses both theoretical and methodological challenges. In terms of theory-building, regional scale analysis is more likely to use "double exposures" as a general concern with the overlapping impacts of globalization and climate change. Although this approach make prove useful for exploring individual case studies, it could end up undermining efforts to formalize double exposures as a theory about the causal relationship between the global change processes since researchers would be making a more general use of the concept as a heuristic device. In terms of method, mapping double exposures at intermediary and macro scales seems daunting due to availability of appropriate data. Activities and "flows" are changing too rapidly to be satisfactorily categorized and mapped (Malone, 2002). This is particularly true at macro scales, such as our fourth case study.

Mapping. Even moving away from the particular challenges of mapping at a macro-level, mapping double exposures poses important challenges that have yet to be fully resolved. As O'Brien et al. (2004) point out, maps can imply abrupt boundaries where fuzzy boundaries are more appropriate. This is particularly true for dynamic processes like vulnerability. Determining special representations of key indicators that determine local vulnerability (e.g. social capital, institutional relationships, etc.) remains a challenge (Eakin and Luers, 2006). Our case studies do not tackle the challenge of mapping in practice. Nonetheless, even in the case of Jamaica where economic, health, and environmental data exists at a manageable scale, actually mapping the vulnerability isn't straightforward or obvious. Mapping the interaction between the dynamic processes of global environmental change and globalization seems daunting even at the local level—despite O'Brien et al. (2004) demonstrating that it can be done. One concern with regional, meso-, or macro- scale applications, is that specific impacts from positive or negative

feedback loops can be identified more easily in particular communities or ecosystems. We note particular challenges for researchers who wish to map vulnerabilities linked to double exposures. Boundaries would likely be dynamic, porous, and heterogeneous over time and space. The nature of risk also changes over time (Silva, Eriksen, & Ombe, 2010).

Dynamics unknown. This discussion of the interactions between globalization and global environmental change points to a conceptual limitation inherent in the call to consider both processes simultaneously: is it possible to tease out the dynamics of interacting effects? In some of our cases, such as the proposed dam project in Bocas del Toro, it appears obvious that an attempt to mitigate the impacts of climate change will in fact hurt indigenous groups, although there are benefits for Panamanian society at large. The interaction between globalization and climate change is evident since the interaction centers around the proposed dam project justified by climate change and to feed increasing energy demand from Panama's rapidly expanding economy. Similarly, the economic impacts of globalization in the Mendoza region of Argentina occurred temporally before the some of the changes in water availability. Yet in Jamaica, the interactions between globalization and climate change are less clear because this is an on-going, seasonal problem that is getting worse due to global environmental changes. This case shows that it is productive to discuss how the two global change processes increase the vulnerability of particular groups; the dual attention to globalization and global environmental change is a powerful combination. Yet determining the nature of interaction effects is less straightforward. As Eakin and Luers (2006) observe, "O'Brien et al.'s model of double exposure as applied to India (72)… is attractive in that it captures visually the idea of overlapping stressors on a population, yet the nature of the interaction, the relative importance of distinct stressors for particular systems at any given time, and the possible nonlinear responses of a system to multiple

stressors remain elusive" (p. 379-380). The precise dynamics of double exposure interactions are particularly important should double exposures be developed as causal argument, but the framework is not best designed to discuss how these exposures are related. "The framework implies a linear sequence and may obscure the relationships and feedbacks among processes, contexts, exposure units, responses, and outcomes: while the framework may be constructed for the reader to comprehend the concept of double exposures, it undermines the discussion of the relatedness of double exposures" (Hidayat and Stuh, 2010, p. 87).

Oversimplification. Given the limitations above that point to the challenges in capturing the dynamics of double exposures, it may seem unfair to also call double exposures prone to oversimplification. Yet "the concept of double exposure may hide the complexity of the range of factors that hide under the multiple levels and institutions within the processes of global environmental change and globalization" (Christoplos, 2010, n.p.). Double exposure as defined and utilized currently does not sufficiently portray or clarify the interplay between governance scales and among political agents. While we expect individual researchers will uncover and communicate these important factors, we would encourage greater clarification at the onset given their central importance in several of the case studies and in much of the literature reviewed in this work.

Double exposure as currently envisioned as a research framework is so broad it could encompass most current development processes in Latin America. The overarching, conceptually inclusive of the double exposure framework could signify that important factors receive less attention than they deserve. For example, according to Castree (2010), the topic of equity, although identified as of central importance, comes across as being glossed over in Leichinko and O'Brien (2008).

Multiple exposures rather than double exposures. Even the broad categories of globalization and global environmental change do not necessarily capture all of the risks to which a community is vulnerable nor all of the factors that might be included in risk analysis. For example, natural hazards like earthquakes (Christoplos, 2010) are not related to global environmental change, yet they pose important risks to certain communities. If the goal of research is to fully assess vulnerability, adaptability, or mitigation efforts, double exposures may be too limited of a lens.

There is clearly complexity in the types and degrees of exposure. For example, case study three suggested the need to pay specific attention to human rights and to respect international norms for the protection of Indigenous Peoples' rights, including land tenure. Although while we mention that the double exposure framework has not shed light on how to weigh development trade-offs against each other, existing analytical frameworks have not been able to do that either. While double exposure has a number of strengths, there is clearly a need to continue to combine this research literature with other traditions, including political economy and political ecology. Case study four in particular suggested likely benefit from drawing on political ecology due to the tradition of using this framework to highlight scalar and power issues in dynamic, complex nature-society interactions.

Anthropogenic climate change and carbon markets create emerging human-environment interactions that bridge industrial and developing countries in intense and complicated ways. There are vast opportunities for timely research on climate change adaptation and mitigation. Natural and social scientists have important roles to play in finding sustainable pathways that contribute to the reduction of social and ecological risks associated with climate change and support social justice.

Works Cited

Ackerman, F. (2008). Climate economics in four easy pieces. *Development, 51*, 325-331.

Adger, W. N., T. A. Benjaminsen, K. Brown and H. Svarstad (2001). Advancing a Political Ecology of Global Environmental Discourses. *Development and Change,* 32, 681-715.

Anaya, S. J. (2009). Observaciones sobre la situación de la Comunidad Charco la Pava y otras comunidades afectadas por el Proyecto Hidroeléctrico Chan 75 (Panamá). Naciones Unidas. Retrieved from http://alainet.org/images/Panama%20Hidroelectrica%20Charco%20La%20Pava%202009.pdf.

Anderson, N. (2009). REDDy or not? The Effects on indigenous peoples in Brazil of a global mechanism for reducing emissions from deforestation and degradation. *Journal of Sustainable Development, 2*, 18-28.

Arcia, J. (2009a). ONU dice que se violó el derecho indígena. *La Prensa* (Panama). Retrieved from http://mensual.prensa.com/mensual/contenido/2009/05/24/hoy/panorama/1795006.asp.

Arcia, J. (2009b). CIDH ordena suspender hidroeléctrica Chan 75. *Burica Press* (Panama). Retrieved from http://burica.wordpress.com/2009/06/20/cidh-ordena-suspender-hidroelectrica-chan-75/.

Bailey, I. (2009). Book review: Environmental change and globalization: Double exposures. T*he Geographical Journal, 175*, 238-243.

Baldwin, A. (2009). Carbon nullius and racial rule: Race, nature and the cultural politics of forest carbon in Canada. *Antipode, 41*, 231-255.

Blaikie, P. (1999). A Review of Political Ecology: Issues, Epistemology and Analytical Narratives. *Zeitschrift fur Wirtschaftgeographie* 43(3-4): 131-147.

Blanco, L. M. (2009, May). Changuinola hydroelectric plant will boost ecotourism. *The Panama Post*, 25-31.

Boninsegna, J. and Villalba, R. (2007). La oferta hídrica en los oasis de Mendoza y San Juan. Los escenarios de cambio climático y el impacto en los caudales. Presentation at the *Jornadas de Investigación en Recursos Hídricos*, organized by CELA, ICA-UNCu, INTA and IANIGLA-CONICET. Mendoza, Argentina.

Brannan Jaén, B. (2008). De represas y represión. *Buscando Camino VII(162*). Retrieved from http://www.nodo50.org/caminoalternativo/boletin1/169-5.htm.

Brohé, A., Eyre, N. and Howarth, N. (2009). *Carbon markets: An international business guide*. Sterling, VA: Earthscan.

Bryant, R. L. (1998). Power, knowledge, and political ecology in the third world: A review. *Progress in Physical Geography, 22*, 79-94.

Byrne, J., Hughes, K. Rickerson, W. and Kurdgelashvili, L. (2007). American policy conflict in the greenhouse: Divergent trends in federal, regional, state and local green energy and climate change policy. *Energy Policy,* 35, 4555-4573.

Bulkeley, H. and Newell, P. (2010). *Governing climate change*. New York: Routledge.

Bumpus, A. and Liverman, D. (2008). Accumulation by decarbonization and the governance of carbon offsets. *Economic Geography, 84*, 127-155.

Burkett, M. (2008). Just solutions to climate change: A climate justice proposal for a domestic clean development mechanism. *Buffalo Law Review, 56*, 169-244.

Castree, N. (2010). Book review: Environmental change and globalization: double exposures. *Progress in Human Geography,* 34, 274-277.
Chandani, A. (2007). Distributive justice and sustainability as a viable foundation for the future climate regime. *Carbon and Climate Law Review, 1,* 152-163.
Chhatrea, A. and Agrawal, A. (2010). Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. *Proceeding of the National Academy of Science, 106,* 17667-17670.
Christoplos, I. (2010). *The multiplicity of climate and rural risk*. Danish Institute for International Studies (DIIS) Working Paper 2010, 08.
Comim, F. (2008). Climate injustice and development: A capability perspective. *Development, 51*, 344-349.
Cutter, S. (2010). Perspectives on hazards and vulnerability research. Presentation to PASI Institute, Integrated Research on Climate Change and Hazards in the Americas, Panama City. Retrieved from https://sites.google.com/a/aag.org/c2heke/calendar/preliminary-program/session-descriptions/perspectives-on-hazards-and-vulnerability.
Dalby, S. (2003). Environmental Insecurities: Geopolitics, Resources and Conflict. *Economic and Political Weekly*, 38, 5373-5079.
_____. (2004). Ecological Politics, Violence, and the Theme of Empire. *Global Environmental Politics*, 4, 1-11.
Doelle, M. (2010). The legacy of the climate talks in Copenhagen: Hopenhagen or Brokenhagen? *Carbon and Climate Law Review, 4*, 86-100.
Ebeling, J. and Yasué, M. (2008). Generating carbon finance through avoided deforestation and its potential to create climatic, conservation and human development benefits. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363,* 1917-1924.
Eakin, H. (2005). Institutional change, climate risk, and rural vulnerability: Cases from central Mexico. *World Development, 33*, 1923-1938.
Eakin, H. and Luers, M. (2006) Assessing the vulnerability of socio-environmental systems. *Annual Review of Environment and Resources.* 3, 365-394.
Eakin, H. and Lemos, M. C. (2006). Adaptation and the state: Latin America and the challenge of capacity-building under globalization. *Global Environmental Change, 16,* 7-18.
Egede-Nissen, B. and Venema, H. D. (2009). Desperate times, desperate measures: Advancing the geoengineering debate in the Arctic Council. *International Institute for Sustainable Development*. Retrieved from http://www.iisd.org/pdf/2009/desperate_times_desperate_measures.pdf.
Finley-Brook, M. and Thomas, C. (2010). Treatment of displaced indigenous populations in two large hydro projects in Panama. *Water Alternatives, 3,* 269-290.
Giddens, A. (2009). *The politics of climate change*. Malden, MA: Polity.
Gilbertson, T. and Reyes, O. (2009). *Carbon trading: How it works and why it fails*. Uppsala, Sweden: Dag Hammarskjöld Foundation.
Gillis, J. (2010, June 22). Study affirms consensus on climate change. *New York Times* online, Retrieved from http://green.blogs.nytimes.com/2010/06/22/evidence-for-a-consensus-on-climate-change/?scp=7&sq=climate%20change&st=cse.
Gudnydas, E. (2009). Climate change and capitalism's ecological fix in Latin America. In U. Brand, N. Bullard, E. Lander, and T. Mueller (Eds.), *Contours of climate justice: Ideas for shaping new climate and energy politics*, pp. 36-41. Uppsala, Sweden: Dag Hammarskjöld Foundation.

Haigh, N. (2008). A view backstage of climate change environmental markets. *Austrialasian Journal of Environmental Management, 15,* 76-83.
Harriss-White, B. (2008). Market politics and climate change. *Development, 51,* 350-358.
Hazlewood, J. A. (2010). Más allá de la crisis económica: CO**2**lonialismo y geografías de esperanza. *ICONOS-Revista de Ciencias Sociales, 36,* 81-95.
Heslop-Thomas, C., W. Bailey, D. Amarakoon, A. Chen, S. Rawlins, D. D. Chadee, R.Crosbourne, A. Owino, K. Polson, C. Rhoden, R. Stennett and M. Taylor (2008). Vulnerability to Dengue Fever in Jamaica. In L. Leary, Conde, J. Kulkarni, A. Nyong and J. Pulhin (Eds.) *Climate Change and Vulnerability*, pp.396- 415. Earthscan: London.
Hidayat, D. and Stuhl, A. (2010). Book review: Environmental change and globalization: Double exposures. *Environmental Science & Policy, 13,* 86-87.
IACHR (Inter-American Commission on Human Rights). (2009, November 2). Case 12.717/precautionary measure PM 56/08 – indigenous communities Ngöbe and others, Panama participants: Cultural Survival, State of Panama.
IPCC, 2007. IPCC, Climate change 2007: the physical science basis. In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Editors, *Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK.
Jordán, I. M. (2008, January 5). Violencia no cesa en Charco La Pava por proyecto hidroeléctrico. *Panama America* (Panama). Retrieved from http://www.pa-digital.com.pa/periodico/buscador/resultado.php?story_id=639368&page=5&texto=dudan#axzz0uv0V8eOq
Jordán, O. (2008). "I entered during the day, and came out during the night": Power, environment, and indigenous peoples in a globalizing Panama. *Tennessee Journal of Law and Policy, 4,* 467-505.
Klein, R. J. T. (2009). Identifying Countries that are Particularly Vulnerable to the Adverse Effects of Climate Change: An Academic or Political Challenge. *Carbon and Climate Law Review,* 3, 284-291.
Krosnick, J. A. (2010). The climate majority. *New York Times*. Retrieved from http://www.nytimes.com/2010/06/09/opinion/09krosnick.html?scp=17&sq=climate%20change&st=cse.
La Prensa (Panama) (2010, July 11). La violencia se impone en Changuinola. *La Prensa*. Retrieved from http://mensual.prensa.com/mensual/contenido/2010/07/11/hoy/panorama/2260577.asp
Leichenko, R. M. and O'Brien, K. L. (2002). The dynamics of vulnerability to rural change. *Mitigation and Adaptation Strategies for Global Change, 7*, 1–18.
_____. (2008). *Environmental change and globalization: Double exposures*. New York: Oxford University Press.
Lohmann, L. (2005). Marketing and making carbon dumps: Commodification, calculation and counterfactuals in climate change mitigation. *Science as Culture, 14,* 203-35.
_____. (2006). *Carbon trading: A critical conversation on climate change, privatisation and power*. Retrieved from http://www.thecornerhouse.org.uk/sites/thecornerhouse.org.uk/files/carbonDDlow.pdf.
_____. (2008). Carbon trading, climate justice and the production of ignorance: Ten examples. *Development, 51,* 359-365.

Lokey, E. (2009). *Renewable Energy Project Development under the Clean Development Mechanism: A Guide for Latin America*. Sterling, VA: Earthscan.
Malone, E. L. (2002). Hot topics: Globalization and climate change. *Social Thought & Research*, 25, 143-173.
Mate N. and Ghosh, S. (2009). The CDM scam: Wind power projects in Karnataka. *Mausam, 1-2*, 30-34.
McMichael, P. (2009). Banking on agriculture: a review of the World Development Report 2008. *Journal of Agrarian Change.* 9:2, 235-246.
McCully, P. (2001). *Silenced Rivers: The Ecology and Politics of Large Dams*. New York: Zed Books.
McGuigan, C., Reynolds, R. and Wiedmer, D. (2002, May). Poverty and climate change: Assessing impacts in developing countries and the initiatives of the international community. London School of Economics Consultancy Project for the Overseas Development Institute.
McLarney, W. O. and Mafla, M. (2007). Probable effects on aquatic biodiversity and ecosystem function of four proposed hydroelectric dams in the Changuinola/Teribe Watershed, Bocas del Toro, Panama, with emphasis on effects within the La Amistad World Heritage Site. Paper submitted to the World Heritage Committee.
McMichael, M. (2009). The Agrofuels Project at large. *Critical Sociology*, 35, 825-839.
Mendelsohn, R., Dinar, A., and Williams, L. (2006). The distributional impact of climate change on rich and poor countries. *Environment and Development Economics, 11*, 159-178.
Millar, I. and Wilder, M. (2009). Enhanced governance and dispute resolution for the CDM. *Carbon and Climate Law Review, 3*, 45-57.
Ministry of Environment and Housing: Jamaica. (2009). Low-income settlement policy design and development project. Draft final implementation plan. *Rep. IDB ATN/SF5104-JA*.
Montaña, E. (2008). Central Andes foothill farmers facing global environmental change. *IHDP Update*, 2, 36-40.
Montaña, E., Torres, L., Abraham, E., Torres, E. and Pastor, G. (2005). Los espacios invisibles. subordinación, marginalidad y exclusión de los territorios no irrigados en las tierras secas de Mendoza, Argentina. *Región y Sociedad, 32*, 3-32.
O'Brien, K. L. and Leichenko, R. M. (2000). Double exposure: Assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change, 10*, 221-232.
_____. (2007/2008). Human security, vulnerability and sustainable adaptation. Human Development Report Office, Occasional Paper.
_____. (2008). Climate change, globalization, and water scarcity. Presentation at EXPO ZARA GOZA 2008. Retrieved from http://www.expozaragoza2008.es/ContenidosAgenda/tda/ST0614.pdf.
O'Brien, K, Leichenko, R, Kelkar, U, Venema, H, Aandahl, G, Tompkins, H, Javed, A., Bhadwal, S., Barg, S, Nygard, L, West, J. (2004). Mapping vulnerabilities to multiple stressors: Climate change and globalization in India. *Global Environmental Change,* 14, 303-313.
O'Brien, K., Hayward, B., and Berkes, F. (2009). Rethinking social contracts: Building resilience in a changing climate. *Ecology and Society, 14*, 12.

Okereke, C. and Dooley, K. (2010). Principles of justice in proposals and policy approaches to avoided deforestation: Towards a post-Kyoto climate agreement. *Global Environmental Change, 20,* 82-95.
Olmos, S. (2001). Vulnerability and Adaptation to Climate Change: Concepts, Issues, Assessment Methods. Prepared for the Climate Change Knowledge Network. Retrieved from http://www.cckn.net/pdf/va_foundation_final.pdf.
Olsen, K. (2007). The Clean Development Mechanism's contribution to sustainable development: a review of the literature. *Climatic Change,* 84, 59-73.
Paiement, J. J. (2007). *The tiger and the turbine: Indigenous rights and resource management in the Naso Territory of Panama*. Unpublished PhD Dissertation, Department of Anthropology, McGill University.
Parks, B. C. and Timmons Roberts, J. (2006). Globalization, vulnerability to climate change, and perceived injustice. *Society and Natural Resources, 19,* 337-355.
Peck, J. (2008). Forgive my carbon sin. *The Ecologist, 38,* 30-35.
Peet, R. and M. Watts, Eds. (1996/2006). *Liberation Ecologies: Environment, Development, Social Movements*. New York, Routledge (1st and 2nd Eds).
Petterson T. C., M. Taylor, R. Demeritte, D. L. Duncombe, S. Burton, F. Thompson, A. Porter, M. Mercedes, E. Villegas, R. Semexant Fils, A. K. Tank, A. Martis, R. Warner, A. Joyette, W. Mills, L. Alexander, and B. Gleason (2002). Recent changes in climate extremes in the Caribbean region. *Journal of Geophysical Research, 107,* 4601-4611.
Phelps, J., Webb, E. L. and Agrawal, A. (2010). Does REDD+ threaten to recentralize forest governance? *Science, 328,* 312-313.
Planning Institute of Jamaica/Statistical Institute of Jamaica (2009a). Surveys of living conditions in Jamaica. Kingston, Jamaica.
Planning Institute of Jamaica/Statistical Institute of Jamaica (2009b). Economic and Social Surveys of Jamaica. Kingston, Jamaica.
Quirion, P. (2010). Complying with the Kyoto Protocol under uncertainty: Taxes or tradable permits. *Energy Policy, 38*, 5166-5173.
Rahm, D. (2010). *Climate change policy in the United States: The science, the politics and the prospects for change*. Jefferson, NC: McFarland & Company, Inc.
Ribot, J. (2010). Vulnerability does not fall from the sky: Toward multiscale pro-poor climate policy. In R. Mearns and A. Norton (Eds.) *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*, pp. 47-74.Washington, DC: World Bank.
Robertson, M. (2007). The neoliberalization of environmental services: wetland mitigation banking and the problem of measurement. In N. Heynen, J. McCarthy, S. Prudham, and P. Robbins (Eds.) *Neoliberal Environments: False promises and unnatural consequences*, pp. 114-125. New York: Routledge.
Robbins, P. (2004). *Political Ecology: A Critical Introduction.* Malden, MA: Blackwell.
Rocheleau, D., B. Thomas-Slayter and E. Wangari, Eds. (1996). *Feminist Political. Ecology, Global Issues and Local Experiences.* New York: Routledge.
Roe, D., Reid, H., Vaughan, K., Brickell, E. and Elliott, J. (2007). Climate, carbon, conservation and communities. An International Institute for Environment and Development (IIED)/Worldwide Fund for Nature (WWF-UK) Briefing.
Silva, J. A., Eriksen, S., and Ombe, Z. A. (2010). Double exposure in Mozambique's Limpopo River Basin. *The Geographical Journal*, 176, 6-24.

Sletto, B. (2002) Boundary making and regional identities in a globalized environment: rebordering the Nariva Swamp, Trinidad. *Environment and Planning D: Society and Space,* 20, 183-208.

Sutter, C. and Parreño, J. C. (2007). Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. *Climatic Change, 84*, 75-90.

Swyngedouw, E. (1997). Power, nature, and the city: The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador, 1880-1990. *Environment and Planning A,* 29, 311-332.

_____. (2004). *Social power and the urbanization of water: Flows of power*. Oxford: Oxford University Press.

Thomas, D. S. G. and Twyman, C. (2005). Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change, 15*, 115-124.

Thorbecke, E. and Nissanke, M. (2006). The impacts of globalization on the world's poor. *World Development, 34*, 1333-1337.

Trainor, S. F., Calef, M., Natcher, D., Chapin, F. S., McGuire, A. D., Huntington, O., Duffy, P, Rupp, T. S., DeWilde, L., Kwart, M., Fresco, N., and Lovecraft, A. L. (2009). Vulnerability and adaptation to climate-related fire impacts in rural and urban interior *Alaska. Polar Research, 28*, 100-118.

von Unger, M. and Streck, C. (2009). An appellate body for the clean development mechanism: A due process requirement. *Carbon and Climate Law Review, 3*, 31-44.

Werksman, J. D. (2008). The legitimate expectations of investors and the CDM: Balancing public good and private rights under the climate change regime. *Carbon and Climate Law Review, 2*, 95-104.

White, A., Hatcher, J., Khare, A., Liddle, M., Molnar, A., and Sunderlin, W. D. (2010). Seeing people through the trees and the carbon: Mitigation and adapting to climate change without undermining rights and livelihoods. In R. Mearns and A. Norton (Eds.) *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*, pp. 277-301.Washington, DC: World Bank.

Wilbanks, T. J. (2003). Integrating climate change and sustainable development in a place-based context. *Climate Policy, 31*, 147-S154.

World Bank (2010). *State and Trend of the Carbon Market*. Washington, DC: Carbon Finance Unit.

World Health Organization (WHO) World Health Report (1997). Communicable disease surveillance and response. *Dengue hemorrhagic fever: diagnosis, treatment, prevention, and control*, 2nd ed. Geneva, Switzerland: WHO.

Worster, D. (1985). *Rivers of empire: Water, aridity and growth of the American West*. New York: Pantheon Books.

Worth, J. (2009). Power politics. *New Internationalist, 419*, 4-7.

Zelljadt, L. (2010). Development countries and the carbon market: An ambivalent relationship. *Carbon and Climate Law Review, 4*, 101-103.

Zimmerer, K. S. and Bassett, T. J., Eds. (2003). *Political ecology: An integrative approach to geography and environment-development studies*. New York: The Guilford Press.