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Article

Connecting Climate Social Adaptation and Land Use Change in Internationally Adjoining Protected Areas

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Abstract

The development of climate adaptation strategies to address social problems derived from climate change is pressing. Yet, in addition to providing means to minimise the impact of climate variability and change on livelihoods, climate adaptation strategies might exacerbate environmental change and cause negative social impacts. Systematic research has not addressed the impacts of adaptation on environmental change. In this paper, I focus on land use change as a specific type of environmental change and on three adaptation strategies: diversification, pooling and out-migration. I analyse the influence of adaptation strategies on land use change by drawing on interviews with the managers of 56 internationally adjoining protected areas in 18 countries in the Americas. The findings indicate that the impact of adaptation depends on the adaptation strategy people choose. When people out-migrate, land use change increases. Community elite control for decision-making, shorter distances between communities and markets and more communities in and around the protected areas also increase land use change. These findings show that adaptation can be a driver of further environmental change, and thus further study is needed to understand the likely impacts of adaptation on conservation.

Keywords: Americas, climate, conservation, land use change, protected areas, social adaptation

INTRODUCTION

Given the unavoidable effects climate change is expected to have on the livelihoods of millions of people, robust scholarship is needed to inform adaptation policies. Large efforts have been made to advance our understanding of social adaptive capacity and the adaptation strategies used by different societies (Eakin et al. 2014; Lemos et al. 2013; Tucker et al. 2010). Fewer efforts have been made to understand unintended outcomes of adaptation, such as detrimental environmental change and further livelihood losses (Barnett and O'Neill 2010; Fazey et al. 2011). For instance, if fishermen implement adaptation strategies that lead to overharvesting, they exacerbate negative trends in the ecosystem and threaten their subsistence (Cinner et al. 2011). Likewise, if farmers follow adaptation strategies that lead to land use change, they might affect their agricultural productivity, alternative livelihoods and adaptive capacity by contributing to soil erosion, scarcity of natural resources or loss of ecosystem services (Rodriguez-Solorzano 2014; van de Sand et al. 2014).

To contribute to the understanding of unintended outcomes of adaptation, I examine the relationship between adaptation and land use change. Drawing from environmental governance and land use change literature (Geist and Lambin 2001; Persha et al. 2011), I analysed the influence of adaptation strategies

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on land use change in 56 Internationally Adjoining Protected Areas (IAPAs) in the Americas controlling for key drivers of land use change already identified in land use change literature.

IAPAs are defined as protected areas adjacent to international borders and to neighbouring countries' protected areas (Zbicz 1999). Around the world IAPAs produce and maintain environmental goods and services supporting the livelihood of millions of people, the economies of nation states and international peace among neighbouring countries (van der Linde et al. 2001). When groups of neighbouring IAPAs are managed cooperatively they are called Transboundary Protected Areas (TBPAs), (Sandwith et al. 2001). The number of IAPAs as well as a search for cooperation mechanisms among countries for better and more cohesive management of their adjoining protected areas has been growing in recent years thanks to the international recognition of their contribution to social and ecological benefits (Dias et al. 2003; Erg 2010). IAPAs distribute the cost of protection among multiple countries and allow contiguous protection of ecosystems divided by political boundaries, which enhance their capacity to provide ecological corridors and to support ecosystem functionality. This makes IAPAs better equipped than non-adjoining protected areas to offer opportunities to flora and fauna species to adapt to ecosystem changes related to climate change and variability. These qualities enhance the importance of minimising land use change in such important protected areas and support the selection of IAPAs to understand the relationship between social adaptation to climate variability and change and land use change.

MATERIALS AND METHODS

Data collection

The data collection process started with the identification of IAPAs in the Americas. In March 2008, I called the agencies in charge of protected areas in every English and Spanish speaking country in the Americas to verify that the IAPAs listed in the latest published list of transboundary protected areas (Lysenko et al. 2007) were formally established and that they were 1) directly adjacent: adjacent to an international border and a neighbouring country protected area or 2) indirectly adjacent: adjacent to a domestic protected area that is adjacent to the border and to a neighbouring country protected area. The officials that responded to my phone calls helped me to develop a shorter and more accurate list than that provided by Lysenko et al. Through those phone conversations with national level authorities I found out that many of the protected areas previously listed were not officially recognised or were not directly or indirectly adjacent to neighbouring countries' protected areas. For this reason, I created a revised list, presented in Table 1.

The revised and shortened list resulting from this research includes 96 IAPAs composing a total of 30 TBPAs from eighteen countries. With a working list of IAPAS the next step was to create a phone book and to call the managers of the 96 protected areas. The phone interviews were conducted between March 2008 and January 2009. The response rate was 58%, with 56 managers answering a phone interview based on a structured questionnaire. The 56 IAPAs belonged to 25 TBPAs or 83% of the total number of TBPAs in the Americas by 2008. The 56 IAPAs studied are located in eighteen countries in North, Central and South America and marked in italics and with an * preceding their name in Table 1.

The research focused on English and Spanish speaking countries for practical reasons and language limitations. Extending the research to Portuguese and French speaking countries was beyond reach at the time the research was conducted. While this limits the generalisation of the findings of this research, the loss was not considered substantial given that the analysis is already focused on protected areas in the Americas, where social and ecological conditions are very different to those found in the rest of the world. Despite this limitation, the research findings are valid as there was no selection bias based on any of the studied variables. Likewise, the number of protected areas and countries studied together with the high response rate offer findings with a larger generalisation power than the findings generated through single case studies.

During the interviews protected area managers provided information about land use change, socioeconomic factors, governance and adaptation strategies that people living in and around the protected areas have used to minimise the impacts of climate variability and change on their livelihoods. Managers' answers were based on their expertise in the protected area where they work and, whenever available, on reports or scientific studies they knew. The analysis made in this paper relies entirely on the managers' responses to the questionnaire.

Relying on managers' responses is a limitation of this study. Although fieldwork and household surveys would have yielded results with greater internal validity, the prohibitive cost of conducting fieldwork across 18 countries rendered this data collection strategy impossible. Relying on the expert opinion of local managers is thus an excellent, albeit second-best, data collection strategy. This is particularly the case since unlike in Bruner et al. (2001), the research questions did not address the performance of managers, an area where self-reports are likely to be biased, but rather used managers as local experts with knowledge of their working environment.

Variables

Dependent Variable: Land Use Change

Managers assessed to the best of their knowledge or based on geographical information system measurements, whenever available, the percentage of land area experiencing land use change in the protected area between protected area establishment and the time of the interview, including nucleus and buffer zones and area of influence. Managers could choose between five categories, ranging from very low (between 0-20% of the protected area and its area of influence had experienced land use change) to very high (81-100% of the

Table 1

List of transboundary protected areas (TBPAs) and international adjoining protected areas (IAPAs)

TBPAs	Country		IAPAs	TBPAs	Country		IAPAs	TBPAs	Country		IAPAs
	North America				Central America				South America		
1	Canada	1	*Kluane National Park and Preserve	10	Belize	30	*Rio Bravo Conservation and Management Private Reserve	19	Colombia	65	*Tama Natural National Park
	Canada	2	Tatshenshini-Alsek Provincial Park		Belize	31	*Aguas turbias National Park		Venezuela	66	*El Tama National Park
	USA	3	*Wrangell National Park and Preserve		Guatemala	32	*Maya Biosphere Reserve	20	Colombia	67	*Catatumbo Bari Natural National Park
	USA	4	*Glacier Bay National Park and Preserve		México	33	*Calakmul Biosphere Reserve		Venezuela	68	*Perijá National Park
2	Canada	5	*Waterton Lakes National Park & Biosphere Reserve	11	Belize	34	*Maya Mountain Forest Reserve	21	Colombia	69	*La Paya National Park
	Canada	6	Akamina Kishienena Provincial Park		Belize	35	*Chiquibul National Park, Forest Reserve		Ecuador	70	*Cuyabeño Faunal Production Reserve
	USA	7	*Glacier National Park and Preserve		Belize	36	Cockscomb Basin Wildlife Sanctuary		Ecuador	71	Yasuni Biosphere Reserve
3	Canada	8	Ivvavik National Park		Belize	37	Bladen Nature Reserve		Peru	72	*Gueppi Reserved Zone
	Canada	9	Vuntut National Park		Belize	38	Mountain Pine Ridge Forest Reserve	22	Peru	73	*Bahuaja-Sonene National Park
	USA	10	Arctic National Wildlife Refuge		Belize	39	Vaca Forest Reserve		Peru	74	Tambopata National Reserve
4	Canada	11	*Quetico Provincial Park and Wilderness		Belize	40	Deep River Forest Reserve		Bolivia	75	*Madidi National Park
	USA	12	*Superior National Forest		Belize	41	Columbia River Forest Reserve		Bolivia	76	*Apolobamba Integrated Management Natural Area
	USA	13	*Voyageurs National Park		Belize	42	Caracol Archaeological Reserve		Bolivia	77	Pilon Lajas Biosphere Reserve
5	Canada	14	Cathedral Provincial Park and Protected Area		Guatemala	43	*Montañas Mayas Chiquibul Biosphere Reserve	23	Bolivia	78	*Kaa-iya del Gran Chaco National Park
	Canada	15	EC Manning Provincial Park	12	Mexico	44	*Lacandon Protected Areas Complex		Paraguay	79	*Medanos del chaco National Park
	Canada	16	Skagit Valley Provincial Park		Guatemala	45	*Sierra del Lacandon National Park	24	Bolivia	80	*Tariquia National Fauna and Flora Reserve
	USA	17	N. Cascades National Park	13	Mexico	46	*Volcán Tacaná Biosphere Reserve		Argentina	81	*Baritu National Park
	USA	18	Pasayten Wilderness Area		Guatemala	47	*Volcán Tacaná Permanent Closure Zone	25	Argentina	82	Sajama National Park
6	USA-Canada	19	Roosevelt Campobello International Park	14	Guatemala	48	Trifinio Biosphere Reserve		Chile	83	Lauca National Park
7	USA	20	*Cabeza Prieta National Wildlife Refuge and Wilderness Area		El Salvador	49	*Montecristo National Park		Chile	84	Las Vicuñas Natural Reserve
	USA	21	*Organ Pipe National Monument, Biosphere Reserve, Wilderness Area		Honduras	50	Montecristo Trifinio National Park	26	Argentina	85	Los Glaciares National Park and National Reserve

Contd...

Table 1
Contd....

TBPAs	Country		IAPAs	TBPAs	Country		IAPAs	TBPAs	Country		IAPAs
	North America				**Central America**				**South America**		
	Mexico	*22*	**El Pinacate y Gran Desierto de Altar Biosphere Reserve*	15	Honduras	51	Río Plátano Biosphere Reserve		*Chile*	*86*	**Torres del Paine National Park*
	Mexico	*23*	Alto golfo de California Biosphere Reserve		Honduras	52	Tawahka Biological Reserve		Chile	87	Bernardo O'Higgins National Park
8	*USA*	*24*	**Coronado National Forest*		Honduras	53	Patuca National Park	*27*	*Argentina*	*88*	**Nahuel Huapi National Park, National Reserve*
	Mexico	*25*	**Coronado National Memorial*		Nicaragua	54	Bosawas		Chile	89	Puyehue National Park
	Mexico	*26*	**Sierra de Ajos/Bavispe Flora and Fauna Protection Area*	*16*	*Nicaragua*	*55*	**Reserva Biológica Indio Maíz*		Chile	90	Vicente Perez Rosales National Park
9	*USA*	*27*	**Big Bend National Park, Biosphere Reserve*		*Costa Rica*	*56*	**Barra de colorado National Wildlife Refuge*	*28*	Argentina	91	Lanin National Park, National Reserve
	Mexico	*28*	**Maderas del Carmen National Park*		*Costa Rica*	*57*	**Tortuguero National Park, Protective Zone*		*Chile*	*92*	**Villarica National Park*
	Mexico	*29*	**Cañón de Santa Elena National Park*	*17*	*Costa Rica*	*58*	**Talamanca Range-La Amistad Reserves/La Amistad Park World Heritage Site*	*29*	Argentina	93	**Copahue-Caviahue PP*
					Panama	*59*	**La Amistad National Park*		*Chile*	*94*	**Ñuble National Reserve*
					Panama	60	Palo Seco Protected Forest	*30*	*Argentina*	*95*	**Alerces National Park, National Reserve*
					Panama	61	Volcan Baru National Park		Chile	96	Futalefu National Reserve
				18	*Panama*	*62*	**Darien NP*				
					Panama	63	Serrania de Bagre Biological Corridor				
					Colombia	*64*	**Los Katios NP*				

Protected areas listed in italics and with a *preceding their name represent the protected areas that participated in the research protected area and its area of influence had experienced land use change). As Table 1 shows, the IAPAs studied in this paper are located throughout the Americas. These protected areas cover a wide range of ecosystems, including deserts and different types of forests. Consequently, land use change refers to the replacement of natural land coverage (e.g. forest, grasslands, etc.) for humanly defined land covers, such as crops, pastures or infrastructure.

I include the area of influence in the analysis for at least three reasons. First, land use change dynamics outside of protected areas affect the sustainability of the protected areas (Hansen and DeFries 2007). Second, in most of the studied cases management goes beyond the protected area polygon. Third, protected areas' boundaries are often unclear to both managers and neighbouring communities. In some cases, the protected area boundary is not completely defined or the local communities contest it.

Independent variables

Adaptation to Climate Variability and Change

The adaptation strategies analysed in this paper are out-migration, diversification and pooling. Protected area managers identified these strategies as actions that households in and around their protected areas are taking to minimise the impacts of climate variability and change on their livelihoods. The long and wide use of these adaptation strategies is linked to their potential to enable families to distribute risks across multiple dimensions. These adaptation strategies fall within the categories that the literature has identified as strategies societies have used historically to respond to political, economic, social or climatic changes affecting livelihoods (Agrawal 2008; Halstead and O'Shea 1989). The literature has also identified exchange and storage as key adaptation strategies. Despite their historical relevance, I did not analyse these two strategies in this paper because most of the protected area managers interviewed did not have information available about their use.

Through out-migration people leave their communities to allocate livelihood risks in different locations where climate variability and change effects are differentiated (Adger et al. 2002; de Sherbinin et al. 2008). Diversification of economic activities allows people to distribute climate risks over different income sources with uncorrelated risks (Brockhaus et al. 2013; Seo 2009). Pooling refers to households sharing risks by working together as a productive group (Agrawal 2008). Adaptation was measured as a dichotomous variable. When managers reported the strategies were adopted in their protected area, they were coded with 1 and when not, with 0.

People might adopt any of the actions here described as adaptation strategies regardless of the need to adapt to climate variability. Hence, to avoid the overestimation of these strategies, they were counted as adaptation strategies only when managers identified them as responses people were adopting to address climate-related losses.

Socioeconomic Factors and Governance

Adaptation to climate variability and change cannot be analysed as if it were the only cause of land use change. Past studies have demonstrated the importance of socioeconomic and governance factors in determining the dynamics of land use change (Geist and Lambin 2001). Hence, I controlled for governance and socioeconomic factors using three variables that have been widely recognised as key drivers of land use change: number of communities, distance to the market and community elite control (Agrawal 2005, 2008; Agrawal and Varughese 2000; Carr et al. 2005; Lambin et al. 2001).

Table 2 provides the list of variables, their description and summary statistics. The variable 'number of communities' is an imperfect measurement of population size. Ideally, population size should be measured with the number of inhabitants in each protected area. Unfortunately, not all of the protected areas had that information available. IAPAs are very remote places and accurate statistics of a dynamic variable as population size are not always updated in these remote sites. However, the 'number of communities' is an available statistic that is relatively stable and well known by all of the protected area managers. Thus, given the lack of better information for every protected area analysed in this paper, I had to use 'number of communities' as a variable that provides an imperfect yet sufficient indicator of population size.

'Distance to the market' was operationalised in a straightforward manner; time to commute by car between communities and the nearest market. This measurement was chosen to account for the fact that in some protected areas there is more than one market and while markets might be specialised, the measurement assumes people would more likely go to the closest market to their community. The variable is measured in ranges 0 min to 1 hour, 1 to 2 hours and more than 2 hours. The ranges are used to account for the average distance between communities and the nearest market. By using an average measurement, I recognised that some communities are closer than others to the market.

'Community elite control' has been recognised in the literature as a key governance factor influencing land use change, biodiversity conservation and sustainability (Agarwal 2001; Persha et al. 2011). The operationalisation of this variable can take multiple forms, but in this paper, it was operationalised as a dummy variable that accounts for elite dominance in the communities in and around protected areas. Elite control of resources and decision-making processes has been identified as a problem limiting the results of decentralisation processes that are aiming to increase local participation for better environmental and livelihood outcomes (Lund and Saito-Jensen 2013; Platteau 2004; Ribot et al. 2010).

Model

I used an OLS model with six independent variables selected for their theoretical relevance to analyse the data. The total number

Table 2
Variables description and summary statistics

Variable	Description	Range (Mean, SD) N
Land use change	0: no land use change, 1: very low (land use change between1-20%), 2: low (21 to 40%), 3: medium (41 to 60), 4: high (61-80%), 5: very high (81-100%)	0-5 (1.55, 1.23) 54
Adaptation		
Out-migration	1:people in and around protected areas use out-migration to adapt to climate variability, 0: people don't use out-migration	0-1 (0.75, 0.44) 48
Diversification	1: people in and around protected areas use diversification to adapt to climate variability, 0: people don't use diversification	0-1 (0.81, 0.39) 48
Pooling	1: people in and around protected areas use pooling to adapt to climate variability, 0:people don't use pooling	0-1 (0.50, 0.50) 46
Socioeconomic		
Market distance	Time to commute by car between communities and the nearest market: 1: 0 min -1 hour; 2: 1 to 2 hours; 3: more than 2 hours	1-3 (2.15, 0.88) 47
Number of communities	Logarithm of the number of communities in and around the protected area	0-5.5 (2.51, 1.47) 53
Governance		
Community elite capture	0: in general, local elites rule the communities in and around the Protected areas; 1: there are no influential elites ruling communities	0-1 (0.35, 0.48) 49

of interviews is 56, but 2 of the interviews were incomplete and not used in the analysis. The model was calculated using the 54 observations, but the statistical package, 'STATA 13', dropped 11 observations due to missing data for some of the independent variables. The total number of observations finally used in the statistical model is thus 43. This constrained the number of variables that could be used to explain land use change. However, tests of alternative models showed that adding variables, such as protected area size, did not change the significance of the six predictors included in the model, or increase its R^2. Omitting any of the predictors included in the model would have overestimated the effect of the remaining variables. The specification tests indicated that the model is robust and constitutes the best choice. Additionally, the model residuals are normally distributed, and no influential points, heteroscedasticity or multicollinearity were found.

Table 3
Model results

Model results	Coef. (Std. Error) P
Adaptation	
Out-migration	1.109 (0.411)***
Diversification	−0.730 (0.474)
Pooling	−0.001 (0.318)
Socioeconomic	
Market distance	−0.538 (0.181)***
Number of communities	0.326 (0.106)***
Governance	
Community elite capture	−1.146 (0.322)***
Intercept	2.119 (0.582)***
No. of observations	43
R-squared	0.4912
Adj R-squared	0.4064
Prob > F	0.0003

* Indicates $P<0.10$; ** $P<0.05$, *** $P<0.01$

RESULTS

The model results presented in Table 3 indicate that 'diversification' and 'pooling' do not have a statistically significant relationship with land use change, but out-migration does. The relationship between out-migration and land use change is positive, meaning that if people choose to out-migrate to adapt, the likelihood of land use change increases. The findings also indicate that among the socioeconomic variables analysed, 'number of communities' and 'distance to market', are likely to influence land use change. When the distance between communities and markets increase, land use change is expected to decrease. On the contrary, when the number of communities increases, land use change is also expected to increase. The findings also indicate that elite control (the governance variable analysed in this paper) exercises influence on land use change. Higher levels of land use change can be expected when elites control the governance of communities.

DISCUSSION

The data supporting this research did not reveal a relationship between land use change and 'diversification' and 'pooling' adaptation strategies. The data however, shows that out-migration is likely to increase land use change. As mentioned in the methods section, land use change refers to the replacement of natural land coverage (e.g. forest) for humanly defined land covers, such as crops, pastures or infrastructure.

This finding is important for at least two reasons. First, it supports the call made by this paper to scholars and policy makers to pay attention to climate adaptation as a potential driver of environmental change. If people choose to out-migrate to adapt to climate variability and change, land use change is likely to increase. Given the potential loss of ecosystem goods and services associated with land use change, out-migration might be a counterproductive adaptation strategy that only serves immediate needs but weakens the options for people in and around protected areas in the medium to long run (Rodriguez-Solorzano 2014).

Second, this finding also supports case studies that have found that out-migration can increase land use change (de Sherbinin et al. 2008; Radel and Schmook 2008), as well as decrease it (Hecht and Saatchi 2007; Lopez et al. 2006), depending on the specific circumstances (Gray and Bilsborrow 2014). For instance, when remittances follow out-migration and these are invested on extensive uses of land, such as cattle ranching or commercial agriculture, out-migration increases land use change. With the data available from this project it is not possible to elucidate the specific mechanism explaining the increase in land use change associated with out-migration. It is only possible to speculate that in general, in the sampled IAPAs, out-migration reduces labour working the fields, but provides resources to replace such labour with technology or with workers who have lower opportunity cost, which increases the use of land.

The impact of out-migration as an adaptation strategy on protected areas' land use change is a serious concern, given that according to the interviewed managers, land use change is already the most common and serious threat the studied protected areas face. If people chose out-migration as an adaptation strategy, protected areas could have additional pressure. Consequently, adaptation would become one of the human activities that conservation policy would need to address to enhance the performance of protected areas. Anticipating this additional pressure might be a better policy strategy than addressing intensification of land use change as people adapt to climate variability and change. In this regard, bridging adaptation and conservation studies and policies could be productive. This would be particularly the case for internationally adjoining protected areas given their key role as spaces to allow flora and fauna species adaptation over biological corridors.

Governance is also important in explaining land use change in the studied IAPAs. The findings indicate that when local elites rule the communities in and around protected areas, land use change is likely to increase. This result can be explained in the light of numerous studies that have found that social participation at the community and protected area level can benefit natural resource conservation (Agarwal 2001; Ericson 2006; Gibson et al. 2000; Persha et al. 2011). When participation empowers local people and provides them ownership of the resources, local people gain incentives to conserve. The incentives emerge from people perceiving that their conservation efforts will produce fruits, contrary to what they perceive when the benefits are transferred to outsiders or community elites rule and capture the benefits.

The relationship between 'distance to markets' and land use change found in this paper has already been documented in numerous case studies and meta-analyses (Bray et al. 2008; Carr 2008; Dutra Aguiar et al. 2007; Nagendra et al. 2006; Roy Chowdhury 2006; Serneels and Lambin 2001). 'Distance to markets' tends to be associated with lower land use change. Proximity to markets can reduce production costs by bringing producers closer to input markets. Additionally, proximity can reduce transportation costs for the commercialisation of products. The reduction in costs derived from shorter distances increases the profitability of land intensive economic activities and incentivises land use change.

The statistical analysis of this paper indicates that, overall in the Americas', IAPAs land use change is larger as the number of communities increases. This finding should not be interpreted as evidence supporting efforts towards reducing the number of communities in and around protected areas, which has had very negative impacts on many communities that preceded protected areas or who protect the natural resources regardless of the conservation status of the protected area (Ghate and Beazley 2007; Rangarajan and Shahabuddin 2006). The relationship between population and the environment is mediated by multiple factors, such as institutions or socioeconomic conditions (Agrawal and Yadama 1997; Carr 2004; Sydenstricker-Neto 2012). Hence, the relationship between population and land use change can be positive or negative, depending on the context. Likewise, it is possible to say that the relationship between the number of communities and land use change can affect land use change in either direction, depending on the factors mediating the relationship. For instance, in protected areas with large number of communities where people depend on economic activities with low land requirements, land use change is likely to be lower than in protected areas with few communities where people need large extensions of land to produce their livelihoods. This would be the case of protected areas with large wild honey production dependence vis-à-vis. protected areas where people practice extensive cattle ranching or agriculture. While the analysis indicates that overall the relationship between number of communities and land use change is positive, no one size fits all recommendation can be drawn from these results (Ostrom 2007).

CONCLUSION

This paper finds evidence of the potential influence of adaptation on environmental change through land use change in protected areas. This corroborates the concern about studying adaptation not only as a response to environmental change, but also as a leading cause of further environmental change. Adaptation and environmental change are likely to influence each other. Thus, it is necessary to advance the understanding of the reinforcing relationship between environmental change and responses to it. This paper is a first step towards that end. Testing the feedback between environmental change and responses to it is beyond the scope of this paper, as data for multiple time periods is needed to understand such feedback.

The data and the analysis presented here are robust enough to show that further research needs to be done to understand how responses to environmental change, in this case climate variability and change, can lead to further environmental change. Advancing our understanding about these mutually reinforcing situations is necessary to develop policies that minimise the unintended outcomes of climate adaptation policies. Considering that adaptation will become more and more prominent among communities living in and around protected areas in the forthcoming years, advancing our understanding of the relationship between land use change and social adaptation to climate variability and change can contribute to the introduction of adaptation into the international conservation agenda and to the construction of bridges between adaptation and conservation policy makers. Further research is needed along the lines of this paper to move beyond the analysis of adaptation only as a response of environmental change. Future research lines include systematic analyses of adaption as a driver of environmental change and of the social-ecological implications of environmental change induced by social adaptation.

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