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# How do biosphere reserves influence local vulnerability and adaptation? Evidence from Latin America

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## Abstract

Resource management regulations, such as those associated with the establishment of protected areas, can increase vulnerability and compromise individual and collective agency for adaptation. In this article, we comparatively analyse how four rural communities located within two biosphere reserves in Mexico and Bolivia experience vulnerability and adaptation to global change. We use focus groups, interviews and scoring exercises to analyse the influence of reserve management practices on locally perceived changes and stresses on livelihoods, and to discuss communities' coping and adaptation strategies. We show that both reserves are perceived as a source of stress but somewhat differently. In Mexico, communities feel vulnerable to the reserve's regulations but less to climatic and economic stresses, whereas in Bolivia communities perceive the insufficient enforcement of the reserve's rules as the most relevant stress to their livelihoods. Most of household-based and collective adaptations to environmental change have been adopted without the support of the biosphere reserves. We discuss how and why the biosphere reserves contribute to local vulnerability and why their role in enhancing local adaptation is limited.

**Key words:** adaptation, biodiversity conservation, Bolivia, Mexico, protected area, social vulnerability.

## Highlights:

- We study local vulnerability and adaptation to global change in biosphere reserves
- Perceived stresses are conservation rules, climatic hazards and agricultural market dynamics
- Strict conservation rules constrain local agency to develop long-term adaptation strategies
- Lack of enforcement of co-management is an important threat for local livelihoods
- The role of biosphere reserves in enhancing local adaptation is limited

## 1. INTRODUCTION

Over the last decades, the Latin American rural sector has experienced a profound transition from a state-driven protectionist model to a neoliberal, market-oriented economy (Escobal, 2003). In particular, agriculture, livestock and forestry activities have intensified, have had increased environmental impacts and become geared toward the needs of global markets and powerful international agribusiness actors. This process has been accompanied by privatisation and increased foreign ownership of land (Borras et al., 2012). The withdrawal of the state from rural planning and development has been influenced by sustainability and decentralization discourses, and by ineffective policy reforms resulting in social inequality and associated vulnerability (Eakin and Lemos, 2006). Local elites have often benefited from land tenure reforms to the detriment of commons resource, and indigenous peoples' traditional territories have been granted recognition but de facto remained under state ownership and control. Rural and indigenous communities continued limited access to land and resources is particularly evident within protected areas, where government agencies usually have total or partial decision-making power, thus playing a decisive role in communities' vulnerability and adaptation (Berkes, 2007; Ruiz-Mallén and Corbera, 2013). This is crucial since most protected areas in Latin America are inhabited, and their area has increased from 10.5% of the region in 1990 to 20.8% in 2009 (Elbers, 2011).

In highly biodiverse but economically marginalised areas, strict protected areas can negatively affect local people's opportunities to overcome poverty (Adams et al., 2004; West et al., 2006) and undermine their ability to anticipate and respond to global change (Ervin et al., 2010). Evidence from Nicaragua, Mexico, Ethiopia, Botswana and Kenya, among others, has shown that top-down conservation interventions can also lead to people's displacement from their original territories (Adams and Hutton, 2007; Kaimowitz et al., 2003; Ruiz-Mallén et al., 2014). Forced migration in the interest of conservation increases people's vulnerability and can also result in people's dispossession from their native land (Dowie, 2009). These actions continue despite calls for more inclusive conservation approaches (Colchester, 1994; Kaimowitz and Sheil, 2007; Wells et al., 1992).

Since the late 1980s international conservation efforts have advocated for the creation of more participatory resource management approaches and biosphere reserves have been regarded as a means to foster conservation while reducing vulnerability and enhancing adaptation (UNESCO, 2008). Biosphere reserves are conservation sites established by countries and recognised under the UNESCO's Man and the Biosphere programme to promote sustainable development based on local community efforts and sound science.<sup>1</sup> Currently there are 631 reserves in 119 countries, including 14 transboundary sites.<sup>2</sup> Although biosphere reserves are considered a flagship initiative based on participatory and adaptive co-management principles, their inclusion in national protected area

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<sup>1</sup> Biosphere Reserves – Learning Sites for Sustainable Development. UNESCO. <http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/> [Accessed 10/05/2014]

<sup>2</sup> World Network of Biosphere Reserves, UNESCO. <http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/world-network-wnbr/> [Accessed 21/01/2015]

systems may mean they are implemented through top-down management approaches rather than being collaboratively managed with local communities. Understanding how biosphere reserves shape local vulnerability and opportunities for adaptation is crucial to guiding the design of adaptation strategies to support local livelihoods.

In this article, we comparatively analyse local communities' vulnerability and adaptation to global change in two biosphere reserves, one in Mexico managed by a top-down approach, and one co-managed in Bolivia. We set out to investigate how biosphere reserve policy and management influence: 1) local people's experienced vulnerability; and 2) their coping and adaptation strategies in response to multiple stresses. The contribution of this analysis is to inform the link between social vulnerability and biodiversity conservation research and how biosphere reserves' management affects local people's vulnerability and adaptation in a context of multiple exposure. We seek to understand how and why management rules and conservation regulations in biosphere reserves are perceived as a source of stress for communities' livelihoods, and what role reserves have in shaping short- and long-term adaptation.

## **2. VULNERABILITY, ADAPTATION AND CONSERVATION IN BIOSPHERE RESERVES**

Vulnerability is understood as “the state of susceptibility to harm from exposure to stresses -or difficult situations- associated with environmental and social change and from the absence of capacity to adapt” (Adger, 2006, p. 268). Stresses<sup>3</sup> can be continuous hazards, such as prolonged droughts, or discrete events such as price-shocks and land displacement. Social vulnerability studies have helped to assess the impacts of weather extremes, economic downturns and lack of entitlements on people's livelihoods, but they have often analysed a single stress (Adger, 1999; Wisner et al., 2004). The importance of examining the role of multiple stresses and cross-scale interactions in vulnerability and adaptation responses has been recently acknowledged (Eakin and Luers, 2006). For example, climate variability and foreign direct investment flows can reveal substantively different patterns of “winners and losers” across geographies and governance scales if the two processes are analysed together rather than separately (O'Brien and Leichenko, 2000).

But we know that people are not passive agents at the mercy of multiple, dynamic and evolving stresses. Adaptation, defined in this article as a process of social adjustment to stresses to avoid or moderate harm or exploit opportunities (adapted from IPCC, 2014, p. 5), has been instrumental in human development and history, and it continues to explain the co-evolution of social-ecological systems. Adaptation responses are thus mediated by social circumstances and ecological factors at different and linked scales (Folke et al., 2005; Nelson et al., 2007). In the face of rainfall variability and economic pressures, Bolivian highland farmers have for example increased household investment in adaptation through increased use of water, labour and forms of social assets (McDowell and Hess, 2012), whereas coffee growers across Mesoamerica have developed adaptation actions consisting in adopting new crop varieties and management

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<sup>3</sup> The use of the word *stress* in this article simplifies the wider range of related terms in vulnerability studies, which include disturbances, hazards, disasters, shocks and perturbations (Luers et al., 2003)

innovations (Eakin et al., 2014). Moreover, rural communities' capacity to adapt also depends on people's own skills and behaviour, mediated by cultural and psycho-social aspects, such as gender, values, beliefs, social status and attitudes to risk (Adger et al., 2009; Ribot and Peluso, 2003). For example, Zimbabwean farmers have typically chosen not to change their agricultural practices in response to a scientific forecast of dry conditions because they perceived higher risks in changing than in retaining their ongoing practices (Grothmann and Patt, 2005).

However, local people's adaptation, particularly in a rural context, will also depend on their ability to access to and benefit from natural resources (Adger, 2003; Eakin and Bojórquez-Tapia 2008). Household and community access to broader institutions and decision-making processes can also determine their adaptation choices (Agrawal, 2010). Climate change vulnerability studies have explored cross-scale dynamics in rural people's perceived exposure and adaptation responses determined by their access to resources and entitlements (Osbahr et al., 2008; Yates, 2012). Research exploring perceived vulnerability has also highlighted how national adaptation policies, including the creation of protected areas, might result in additional stresses for rural communities lacking control over resources (Bunce et al., 2010). Therefore, there remains a need to understand how and why locally experienced risk and livelihoods responses are shaped by cross-scale institutional processes that influence communities' access to land and participation in decision-making in conservation contexts.

In this regard, scholars and practitioners of biodiversity conservation have paid attention to how externally-driven resource management rules have impacted local livelihoods, analysing the extent to which such rules interact with other stresses and affect local adaptation and conservation "buy-in" (Aswani et al., 2007; Cinner et al., 2009). Rural and indigenous communities living within or around government-managed protected areas, such as national parks, have been often excluded from decision-making. Such exclusion has subsequently constrained further their access to conservation benefits and has resulted in increased vulnerability (Adams et al., 2004; Bunce et al., 2010; West et al., 2006). In contrast, collaboratively managed protected areas have more often offered a governance setting that has allowed local people to better respond and adapt to environmental changes (Olsson et al., 2004; Tompkins and Adger, 2004). Building collaborative governance systems in conservation facilitates local adaptation as long as institutional arrangements are flexible enough to allow for learning and dealing with unexpected changes (Berkes and Turner, 2006).

The latter is especially relevant in biosphere reserves since, according to UNESCO's Madrid Action Plan, such approaches have proved their value beyond other protected areas in involving local people in their management to link "biodiversity conservation and socio-economic development for human well-being" (UNESCO, 2008, p. 3). A recent survey concerned with the livelihood impacts of protected areas and involving 146 biosphere reserves' managers in 55 countries worldwide confirms that local livelihoods have been positively impacted by participatory management practices and that such participation has not affected the objective of biodiversity conservation (Schultz et al., 2011). Some case studies have shown the opposite - that biosphere reserves can also be exclusionary, disempowering and compromise local capacity for adaptation when managed under strict protection and land use restrictions (García-Frapolli et al., 2009; Speelman et al., 2014).

In this article, we contribute to these debates on vulnerability and conservation governance by comparatively analysing the interactions between conservation policy and local livelihoods adaptation in two biosphere reserves in Mexico and Bolivia with contrasting levels of local participation in their management arrangements. We analyse locally perceived environmental, socio-economic and institutional stresses and we apply and extend an existing framework to conceptualize adaptation strategies (Agrawal, 2010) to study responses to multiple stresses. In doing so, we advance our understanding of how rural and indigenous communities are exposed to multiple stresses, including conservation rules resulting from the establishment of biosphere reserves, and how these conservation regulations and governance regimes constrain or enhance their opportunities for adaptation.

In the remaining sections of this paper, we introduce the case studies and present evidence on how the context in which biosphere reserves are established and the way in which conservation rules and practice are negotiated and enforced have influenced people's own perception of conservation as a stress or as a source of both coping and adaptation strategies. The results suggest that communities perceive multiple stresses on their livelihoods, and the reserve's conservation regulations are one of them, but differ in the relative importance attributed to conservation and in the adaptation efforts pursued by the reserves. Local participation in the Bolivian co-managed biosphere reserve seems to facilitate the development of strategies for adaptation, with more or less success. In contrast, strict conservation in Mexico constrains local agency to develop long-term adaptation strategies.

### **3. METHODS**

#### **3.1. Two biosphere reserves, two management approaches**

This study is framed within a three-year European Union research project on the conditions for community-based natural resources management and conservation in Latin America ([www.combioserve.org](http://www.combioserve.org)). For comparison we conducted research in four communities located in two biosphere reserves, i.e., in Mexico's Calakmul Biosphere Reserve (CBR) and in Bolivia's Pilón Lajas Biosphere Reserve & Indigenous Territory (PLBRIT) (Figure 1). These reserves differ in the evolution of their management regimes and the resulting composition of their management boards, which offers very valuable insights on the relationship between conservation governance approaches, vulnerability and adaptation responses. Both reserves were initially managed under an exclusionary top-down approach and this has not changed in the CBR, where decisions continue to be made by the government, with no, or very minor, consultation with local communities. In contrast, the PLBRIT has shifted towards a more inclusionary approach and is now co-managed by the indigenous Tsimane' and Mosekene peoples and government officials.

INSERT FIGURE 1 HERE

The CBR is a biodiversity hotspot and one of the largest protected areas of tropical forest in Mexico (Ericson et al., 2001; INE, 2000). It occupies 723,185 hectares in the

state of Campeche and was established as a strict protected area in response to international conservation efforts in 1989. At that time the reserve aimed to deter deforestation and land use change driven by logging concessions for *chicle* (gum) and timber, agricultural expansion and cattle ranching. The country's Protected Areas National Commission (CONANP) is in charge of the reserve. But even though the reserve's management plan identified the need to involve local communities in decision-making (INE, 2000), their representatives have remained excluded from the reserve's management board. Local communities have only been considered a supporting actor for activities such as fire control management, reforestation and ecotourism (Porter-Bolland et al., 2013). The reserve encompasses two conservation core areas covering a third of its territory (34.3%) where only conservation-related research is allowed, and a buffer zone (65.7%) where neighbouring villages can develop subsistence agriculture, sustainable forestry and ecotourism (INE, 2000).

In Bolivia, the PLBRIT covers about 400,000 hectares in the departments of La Paz and Beni. It was established in 1977, also in response to international conservation efforts to deter unregulated logging in the region. It overlapped with a traditional Tsimane' and Mositene hunting area, where conflicts between indigenous peoples, illegal loggers and settlers over the access to and benefits from forest resources were common (Fundación Tierra, 2010). As other Bolivian lowland indigenous peoples, the Tsimane' and Mositene organised themselves politically in the late 1980s to defend their customary land rights. The indigenous organisation representing the communities living within and around the biosphere reserve, i.e., the Tsimane' Mositene Regional Council (CRTM), pushed the land struggle further and, in 1997, indigenous exclusive usufruct rights over the territory were granted by the state, one year after the National Institute of the Agrarian Reform had enacted the law promoting the recognition of indigenous tenure systems (TCO).<sup>4</sup> Subsequently, the government established a co-management regime between CRTM and the National Service of Protected Areas (SERNAP) (Bottazzi, 2009; Bottazzi and Dao, 2013; Reyes-García et al., 2014). The co-management regime involves local indigenous communities' representatives in the reserve management board, who have been consulted about the design and implementation of management actions proposed by SERNAP. This arrangement led to the development of a management plan in 2009. Almost half of the reserve's territory is zoned for strict conservation (42%) while communities are allowed to develop subsistence activities such as hunting, fishing, logging and extracting non-timber forest products (e.g., the *jatata* palm to make roofs) in the buffer zone (58%) (SERNAP and CRTM, 2009).

### 3.2. Selected communities

Despite being relatively isolated areas in two different countries, the recent histories of the four selected communities are somehow similar, since the biosphere reserves were established on inhabited territories with historical land rights claims. In Mexico, *Once de Mayo* (hereafter *Once*) and *Santo Domingo-El Sacrificio* (hereafter *Sacrificio*) are migrant communities that settled in the Calakmul region by the early 1980s, partially and unwillingly overlapping with the CBR. Migration to the area was driven by the

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<sup>4</sup> National Institute of the Agrarian Reform Law n° 1715, 18<sup>th</sup> October 1996.

government's promise of land distribution under the 1946 Federal 'Colonisation' Law. The village of *Once* has approximately 260 people in 78 households, and was officially constituted as an *ejido*<sup>5</sup> in 1994. In practice, being an *ejido* means that some self-selected members of the community –normally the early settlers-, known as *ejidatarios*, gain formal property rights over a parcel of land within the commons while many other families remain without formal property rights (Corbera et al., 2007). The *ejido* organises community life around a collective assembly and elected authorities. It maintains an area of forest commons for all community members. People from *Sacrificio* originally inhabited four villages (Las Delicias, 22 de Abril, San Isidro-Aguas Amargas, Aguas Turbias) and were forced to move to *Sacrificio* when the CBR core conservation areas were established in the early 1990s. The village consists of 620 people in 134 households, and is organised as an *ejido* but is not legally recognised as such. More than 60% of the people in the studied communities belong to Chol and Tzeltal indigenous groups while the rest are *mestizos*. Both communities practice subsistence and cash crop (e.g., chilli) agriculture, whilst cattle ranching and handcrafts are important sources of livelihood in *Once* (Calvo-Boyer, unpublished results).

In Bolivia we worked with the Tsimane', a relatively autarkic and previously semi-nomadic indigenous society in the Amazonia (Huanca, 2008), and specifically with the communities of *Alto Colorado* and *San Luis Chico* (hereafter *San Luis*) in the Department of Beni, which settled formally in the buffer zone of the PLBRIT in the early 1990s. *Alto Colorado*, with 260 people in 46 households, is located along the Yucumo-Rurrenabaque road, whereas people from *San Luis* –83 people in around 20 families- live in more isolated sites along the Quiquibey river. Both communities rely mainly on subsistence activities permitted by the PLBRIT management regulations, including agriculture, non-timber forest products gathering, fishing and hunting. Infrastructure development has enabled the commercialisation of some products (rice, plantain) and those introduced by some external projects (e.g., cacao), but has also facilitated the arrival of illegal loggers and other settlers who fish with dynamite and use mercury for gold mining (Huanca, comm. pers.). Land conflicts between indigenous communities and these other actors persist throughout the region. National agrarian reforms and the new Constitution allocated greater territorial autonomy and self-governance for the Tsimane' and Mosetene peoples in PLBRIT, but the 2010 Decree (DS No. 727) also allowed Andean settlers to claim land rights in the area, which may fuel existing conflicts in the future.

### 3.3. Data collection and analysis

At the beginning of the research our local partners presented the project aims and plans to local authorities and community members in the four sites, and obtained prior informed consent to undertake research. Data were collected by an international team of Bolivian, Mexican and Spanish researchers who conducted 11 focus groups, 33 interviews, and 257 scoring exercises across the four sites between September 2012 and March 2014 (Table 1). These were conducted in Spanish and, when required,

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<sup>5</sup> *Ejido* is a legal term to define a productive group of people with land given by the government for common ownership after the 1910 Mexican Revolution.



conversations were translated from the corresponding indigenous language (i.e., Chol, Tzeltal and Tsimane') with a local translator.

#### INSERT TABLE 1 HERE

Participation in focus groups was open to all community members but mostly men participated (approximately 60% in Mexico and 80% in Bolivia). Focus groups were designed to develop accurate environmental histories through capturing the broadest range of perspectives possible about perceived changes and stresses, and to explore coping and adaptation strategies, and the influence of biosphere reserves on such strategies. We triangulated the information provided by the focus groups with information from semi-structured interviews. Interviews were conducted with current and past formal and informal community leaders, and with other key informants selected through snowball sampling. In each of these interviews, we a) validated and revised the most important changes and stresses that had affected the communities since their establishment; b) discussed how these stresses had affected the community and its households; and c) investigated how they had confronted them.

Focus groups and interviews were recorded (when possible), transcribed, coded and analysed using Atlas.ti 6.2 (Newing, 2011). Data were classified, first, according to the nature of change (i.e., climatic, socio-economic, or institutional). As a result we generated one historical timeline for each community that recorded the most commonly perceived changes over the last three decades. Subsequently, data were classified according to the following criteria: 1) source of stress, 2) type of stress, 3) exposure factors, 4) perceived outcomes of such stresses, and 5) prevalent coping and adaptation responses, including information on mediating factors such as (conservation) institutions and individual perceptions of risk. We then categorised local responses to identified stresses following Agrawal's (2010) conceptual framework and its related categories, namely mobility, storage, diversification, communal pooling and market exchange strategies (see Table 2 for further explanation). We additionally identified a sixth type, institutional pooling, which involves the distribution of risk across formal and informal institutions (e.g., households, government, NGOs) through shared labour and resources.

#### INSERT TABLE 2 HERE

We distinguished coping responses, representing short-term, immediate and punctual actions that occur in situations when there are few options, from adaptation strategies that include planned, continuous and long-term practices aimed at strengthening livelihood security through sustainable and efficient use of available resources (Dazé et al., 2009). We also distinguished between externally driven strategies - those uniquely promoted by the government and/or NGOs-, and locally driven strategies that are promoted or demanded by individuals, community authorities and other community-based groups, which could be implemented jointly with non-local institutions, such as increasing surveillance of the commons by the PLBRIT. We also classified strategies according to the level of local involvement, as individual or household-based strategies (i.e., strategies developed by a limited number of households) and collective strategies (i.e., strategies selected by a majority of households). We then recorded if the biosphere

reserve management boards were involved in the strategy and how (e.g., as promoter, facilitator, implementer).

Scoring consisted of pebble distribution exercises (Sheil et al., 2002). These exercises allowed us to quantitatively assess people's perceived vulnerability for each type of stress previously identified through qualitative methods. The researcher conducted the exercise with both male and female household heads, separately, in 50% and 95% of randomly selected households in Mexico and Bolivia, respectively. Each respondent was asked to distribute 20 pebbles between each type of stress, so that more important stresses proportionally received more pebbles. We also asked the respondent to explain the reasons behind her/his choices. We then calculated the percentage of pebbles each person assigned to the stress s/he perceived as most risky.

## 4. RESULTS

### 4.1. Local perspectives of change and vulnerability

Communities' environmental histories helped us to understand and compare locally experienced changes (Figure 2) and people's related perceptions of vulnerability to multiple stresses in the two biosphere reserves, including those related to conservation policies and regulations (Table 3).

INSERT FIGURE 2 HERE

Across communities, informants' experiences of change were commonly influenced by institutional events related to land rights claims, as well as to land and natural resource conflicts, which were partly induced by the reserves rules and managerial approach. The establishment of these protected areas translated into the enforcement of conservation rules in both areas and, in the case of *Sacrificio*, these rules have been accompanied by forced displacement. One farmer from *Once* explained how such impositions affected people's feelings now and in the past: *"we are in the Reserve, and some people in the community thus think that we will not have any future here because the government comes and says that people cannot take wood and it takes people out of the forests"* (Interview #1-1, Oct 2012). The four communities have responded to this sense of hopelessness by claiming rights over land and requesting support to improve their livelihoods. While *Once*, *Alto Colorado* and *San Luis* have been somewhat successful in this regard, the government has not yet granted *Sacrificio* property titles because the community territory partially overlaps with one of the CBR core zones. Villagers from *Sacrificio* claimed that the CBR had historically been an impediment to the recognition of their land rights, and access to government subsidies for productive activities and infrastructure, which explains ongoing conservation-related conflicts and local resentment: *"since we do not have land rights we cannot apply to conservation payments programmes, we cannot have large projects here; (...) People do not take care of the forest because they have no hope; they do not want to save a heritage for their families and so they are cutting the forest"* (Interview #2-4, Oct 2012). Consequently, in the scoring exercise, there was a higher percentage of respondents identifying conservation policies and land rights conflicts as the main source of livelihood stress in *Sacrificio* (32%) than in *Once* (19%).

### INSERT TABLE 3 HERE

Beyond the land rights conflict, interviewees perceived biosphere reserves as an important source of stress for other reasons too. In both Mexican communities, people with and without land rights were often treated as illegitimate resource users by the CBR, which maintained strict rules and prohibitions. For example, this affected collection of timber and wild animal hunting in both core and buffer areas, regardless of whether for market or subsistence purposes. The interviewees also noted that the CBR made it more difficult for them to get compensation for crop and livestock losses caused by protected species, such as jaguars (*Panthera onca*), in comparison to villages outside the reserve's boundaries, since their claims had to be validated by the reserve authorities.

In contrast, the Tsimane' – somewhat surprisingly - argued that the main source of ongoing livelihood disruption was the government's weak enforcement of conservation rules and related conflicts with settlers (75% of *San Luis* and 53% of *Alto Colorado*'s respondents). In the 1990s, the government granted logging concessions to foreign companies within the PLBRIT area, which increased deforestation and harmed local livelihoods until they were expelled as a result of community pressure in the early 2000s. Since then, lack of enforcement has facilitated encroachment by settlers, who sometimes hired Tsimane' people in logging activities and thus bolstered conflicts within the Tsimane' themselves. As a community leader claimed, "*logging regulations are not respected and people [Tsimane' and settlers] always try to sell wood*" (Interview #3-4, Nov 2012). In *San Luis* this situation has reduced the number of available game and non-timber forest products, such as *jatata*, which is a key source of local income. The PLBRIT was thus perceived as a potential but ineffective ally in sustaining local livelihoods.

Climate variability and agricultural market dynamics were also identified as relevant stresses. Mexican interviewees recalled more hurricanes (1989, 1995, 1998, 2002 and 2007) than extreme droughts (1994, 1999 and 2008) but referred to drought impacts on crops and livestock more often than to impacts of extreme rainfall and hurricanes on houses infrastructure, crops and farm animals. In such a semi-arid area with limited agricultural potential, and where communities mainly rely on agricultural activities, rain is critical for local livelihoods. In *Once*, where livelihoods were based more on market-oriented agriculture and livestock than in *Sacrificio*, rainfall variability was perceived by 47 percent of respondents as their most worrying problem, compared to only 24 percent in *Sacrificio*. Similarly, among the Tsimane', 45 percent of respondents in *Alto Colorado* versus 25 percent in the isolated *San Luis*, mentioned extreme rainfall as an important livelihood stress, because crop fields near the river had been periodically flooded.

We identified important differences in the vulnerability perceptions of ongoing socio-economic change in both reserves. Cash crop price volatility was ranked as the most important stress by 34 percent and nearly 42 percent respondents in *Once* and *Sacrificio*, respectively. Lack of control over *jalapeño* chilli prices was detrimental for local small-scale agriculture and household income. As noted by an interviewee in *Sacrificio*, "*people are discouraged by the price of chilli and since they are not making any profit they have reduced chilli's plating area*" (Interview #2-7, Oct 2012). The

increasing volatility of prices in crop markets can be partly explained by the 1992 North American Free Trade Agreement and the subsequent reduction of public funds dedicated to support subsistence farming in Mexico (Schmook et al., 2013).

In Bolivia, however, only 2 percent of the respondents in *Alto Colorado* worried about socio-economic issues, which were not even mentioned in *San Luis*, probably because market access arrived later, in 2005, through the opening of a small road. The main road to Yucumo and Rurrenabaque has facilitated *Alto Colorado*'s access to markets and medicines since the late 1990s, but it has also increased population growth and changed traditional agricultural production from subsistence crops to cash crops, leading to deforestation and a decrease in agro-biodiversity. As this Tsimane' reported: "*manioc crops have changed; we produce fewer manioc for chicha [traditional beverage] and more noventón manioc for sale [market variety]*" (Interview #3-4, Nov 2012). Among other minor sources of stress, the failure of some recent development projects brought by NGOs was also a cause of livelihood disruption in *Alto Colorado*: these projects had resulted in social conflicts and had never been successfully implemented, partly due to a lack of trust in the community leader (from 1993 to 2003), problems with budget management and lack of technical assistance. In this regard, Mexican communities also had increasing expectations on the arrival of new income opportunities from NGOs and the government, and they also expressed concerns about receiving the necessary technical assistance.

#### **4.2. Adaptation and coping strategies**

Communities reported a variety of strategies to adapt to and cope with stresses. In both contexts, households undertook more strategies individually than collectively. Externally driven strategies resulted from government programmes support, including a few related to biosphere reserve management, or to NGOs activities sometimes instigated in response to community demands (Table 4).

INSERT TABLE 4 HERE

Responses to deal with conservation-induced stresses included both institutional and communal pooling actions and market-related strategies, often carried out collectively in *Once*, *San Luis* and *Alto Colorado*. The biosphere reserves in Mexico and Bolivia impacted upon these strategies differently. The CBR played a minor role in fostering local people's capacity to deal with income shortages resulting from the reserve's resource use restrictions. Instead of developing its own measures for local adaptation, the reserve just facilitated the implementation of several locally-driven strategies, such as a women-led beekeeping project subsidised by the government in *Sacrificio*. In contrast, the PLBRIT management board, lobbied by the CRTM, contributed financially to the development of community-driven adaptation and coping strategies to deal with illegal logging and encroachment by settlers. The reserve increased the presence of forest guards within the protected area as a short-term measure. It also supported NGO development projects as a communal pooling strategy to adapt to the reduction of forest resources. For instance, in *San Luis*, people worked collectively on the cacao and *jatata* production initiatives described earlier, which also helped to improve their organisation and financial situation. In *Alto Colorado*, however, adaptation strategies facilitated by the PLBRIT were ineffective. Development projects failed and the recent concession for

timber extraction provided to the community under the assumption that it would increase local control and improve forest management, resulted in increased deforestation. Unfortunately, local people extracted more timber than permitted and so in effect converted an adaptation strategy into maladaptation.

Similar to the insurance schemes for mitigating natural hazards cited by Agrawal (2010) to exemplify market-related strategies, in 2008, households with land rights in *Once* joined the Mexican government's federal programme of payments for watershed services to cope with natural resource use restrictions resulting from conservation regulations. This programme consists of delivering annual payments to communities and/or landowners over a renewable 5-year period in exchange for developing a number of locally proposed forest conservation activities (Muñoz-Piña et al., 2008; Alix-García et al., 2012). Fifty-five *ejidatarios* put 1,636 hectares of the forest commons and a few individual plots under the scheme, thus being paid annually for the implementation of patrolling and conservation activities within the targeted area. In 2013, they renewed their involvement in the programme for another five years and extended the targeted area to a further 150 hectares. This scheme can be interpreted as a short-term strategy to compensate for resource use restrictions, as well as an incentive to adopt specific conservation practices in the buffer zone. However, some interviewees warned us that the annual payments might have increased income inequality between *ejidatarios* and non-right holders, since the latter felt marginalized and disadvantaged in the distribution of benefits.

Regarding climate stresses, informants in both sites reported a wide variety of coping and adaptation strategies, but none were mediated by biosphere reserves. Responses to rainfall variability in *Once*, *Sacrificio* and *Alto Colorado* consisted of locally-driven diversification strategies focused on finding alternative agricultural or development practices. People diversified agricultural management activities, for example, by planting plots at different altitudes to adapt to droughts or to minimise flood impacts, or by changing planting periods and trying out different crop varieties. Storage strategies to specifically deal with periodic water scarcity in the long-term, such as building water tanks and artificial water bodies for livestock, were only reported in Mexico because water scarcity has so far never been an issue in Bolivia. As complementary and short-term storage strategies, some landholders in *Once* bought or rented agricultural plots with more access to water than their own plots, whereas people in *Sacrificio* bought water for agricultural activities at least once a year.

Coping and adaptation strategies to deal with socio-economic stresses were mostly undertaken at household level, generally consisting of agricultural or livestock investments adopted to respond simultaneously to climate variability concerns. In this regard, the CBR promoted fire prevention activities to temporarily employ local communities in an effort to diversify livelihood strategies in the short-term. In both Mexican communities, some households who had lost their crops or got low prices for them also worked for other families as farm labourers to compensate for income losses. Local short-term strategies were also reported in *Alto Colorado*, where some people expanded their plots to increase the area dedicated to market-oriented crops, which increased deforestation and resulted in conflicts with reserve managers.

Critically, other strategies also resulted in trade-offs between conservation and local livelihoods. In *Once*, almost half of household heads invested in livestock activities supported by government subsidies, which stressed water sources and storage facilities and compromised forest conservation within and around the biosphere reserve. In *Sacrificio* there was increased use of agrochemicals and investment in mechanised agriculture to increase productivity at the expense of soil quality, beekeeping activities and biodiversity conservation. Farmers also tried to deal with chilli price volatility by selling the crop collectively, albeit unsuccessfully. As one farmer explained, “*if we got organised, we could sell chilli directly; but some people do not cooperate and they sell chilli to the coyote [local trader] because they need the money*” (Interview #2-1, Oct 2012). Members of most households in *Once* and *Sacrificio* worked temporarily or permanently abroad, since income from agriculture proved insufficient to increase their desired level of material wellbeing. In *Alto Colorado* five households had moved to other communities, such as *San Luis*, to gain further access to land and natural resources (i.e., fish, game animals). Mobility was thus a strategy to adapt to multiple stresses.

## 5. DISCUSSION

The selected communities perceive similar sources of livelihood stress, including conservation regulations promoted by the biosphere reserves, despite having different settlement histories and climatic conditions. These findings are not surprising since exposure to multiple stresses and the existence of varied perceptions of threats, including those related to conservation policies, have been documented elsewhere (O’Brien and Leichenko, 2000; Bunce et al., 2010; McDowell and Hess, 2012; Eakin et al., 2014). However, our findings are novel from the perspective of conservation governance since we have shown that the way in which biosphere reserves are established by national conservation policy, and their management rules negotiated and implemented, have influenced communities’ perception of conservation as a stress and the role of these protected areas in undermining or enhancing local adaptation. Notably, people in Mexican communities feel vulnerable to the CBR’s strict management, whereas Bolivian communities perceive the ineffective enforcement of PLBRIT regulations on colonists as the most important threat to their livelihoods. Most of the coping and adaptation strategies adopted by the communities to deal with one or multiple stresses have been developed individually or collectively without technical or financial support from the reserve. We thus centre our following discussion on how and why biosphere reserves are perceived as a source of stress by our studied communities, and have a limited role in supporting local adaptation responses.

Our findings confirm that vulnerability can be partly explained by multi-scale, policy influenced processes (Osborne et al., 2008), such as conservation policy and the distribution of rights and power over land and resources. In our case studies, there is an evident relationship between the locally perceived and experienced vulnerability, the biosphere reserves’ management approaches and the national conservation policy context and land tenure history. Despite the prevalent discourse of inclusive and adaptive co-management, Mexico’s CBR maintains a top-down management style, informed by an exclusionary conservation approach that still considers local people’s productive activities as threats to forests and biodiversity (García-Frapolli et al., 2009; Porter-Bolland et al., 2013).

Mexican communities feel more vulnerable and limited in livelihood opportunities and adaptation options because they have not been allowed to participate in CBR's management and decision-making, and their access to resources has been de facto constrained. In such marginalized rural contexts with increasing climate variability and few alternative livelihoods, restricted access to resources can lead to permanent migration (Bunce et al., 2010), which has indeed been the case in our selected villages. Moreover, the lack of formalisation of land rights exacerbates communities' vulnerability. In *Sacrificio*, people do have reduced access to government aid for agricultural productive activities, which are only available to legally recognised *ejidos*, communities and private landowners.

This contrasts with situations where such rights exist and are not challenged by the government, and in which conservation regulations can become an ally of local people to enforce local rights against external actors (Brockington et al., 2006; West, 2006). Also, involving local communities in protected areas' decision-making can promote their compliance with conservation strategies and positively contribute to biodiversity protection in the long-term (Andrade and Rhodes, 2012). Evidence from Bolivia demonstrates that the devolution of land and resource rights to the Tsimane' by the government and the considerable efforts by SERNAP to increase local people's participation in the reserve management by involving the CRTM, have downplayed the perceived threat of conservation regulations and its effects on livelihoods. Tsimane' communities, however, feel unable to deal with the land conflicts generated by colonists, spurred by the government's continuous support for resettlement in the region (Reyes-García et al., 2014). This generates concern among indigenous peoples, who think that the reserve lacks sufficient human and financial resources to confront settlers and illegal loggers. However, it would be misleading to think that increased resources alone would lead to better social and ecological conditions within the PLBRIT, since increasing market opportunities within a rapidly changing context might encourage more intensive resource use and illegal extraction activities among the Tsimane' (Vadez et al., 2008; Schols, 2013).

The involvement of rural communities in conservation has been increasingly promoted in Latin America and worldwide through new incentive-based policy programmes, which are often used to compensate those who live within or around protected areas for their limited access to resources (Honey-Rosés et al., 2011; Caro-Borrero et al., 2014). Given the experience of the community of *Once* documented in this article, we suggest that incentives like payments for ecosystem services should not be uncritically taken as a just policy intervention to compensate for reduced resource access, but critically interrogated to understand how they can unintentionally reinforce inequalities and vulnerability that might or not exist regardless of conservation regulations (Speelman et al., 2014; Corbera, 2015). The experience of limited and controversial benefit-sharing from these payments in *Once* is not unique, since other studies have found similar outcomes in Mexico and elsewhere (Corbera et al., 2007; Hegde and Bull, 2011; Rico García-Amado et al., 2011). This suggests a need to strengthen the cooperation between biosphere reserves and local communities in order to deal more effectively with and respond to social-ecological changes in the long-term. This cooperation will not be possible if biosphere reserves continue to be managed under exclusionary approaches. However, as our findings show in the Bolivian case, involving local people in decision-making will not necessary lead to reduced vulnerability unless biosphere reserves plan

and implement management and adaptation strategies aimed at supporting local livelihood security.

## 6. CONCLUSIONS

In this article, we have discussed the ways and extent to which conservation regulations and practices in two biosphere reserves embedded in different broader policy contexts impact upon local people's vulnerability and adaptation strategies. As in other protected areas, people living within or around biosphere reserves are likely to be constrained in their access to and use of land and natural resources, which highlights the urgency of studying the linkages between conservation and adaptation in the face of global change.

In contrast to the official rhetoric of UNESCO's biosphere reserve programme, our two cases suggest that biosphere reserves can be designed without local support and in a rather top-down fashion, resulting in re-settlement (CBR) or social conflicts (PLBRIT). We have shown how the CBR has to date failed to substantially involve local communities in decision-making, which results in villagers feeling disenfranchised. This exclusionary approach has constrained the livelihood opportunities of those households that lack land rights to develop effective, long-term strategies to deal with multiple stresses. Over time, it might increase local inequalities and the vulnerability of the most disempowered social groups. In Bolivia, the PLBRIT has slowly transitioned toward a co-managed approach due to land tenure reforms and changes in national conservation policy frameworks. However, there is still some way to go before the Tsimane' benefit more substantially from conservation. Selective and insufficient conservation enforcement, coupled with contradictory national policies, and weakening biosphere management and indigenous collective action, have increased local perceptions of vulnerability and undermined the success of local adaptation strategies promoted both from the bottom-up and by the reserve authorities.

Rapid changes in rural landscapes, induced by infrastructure development, the expansion of commercial agricultural markets, and colonisation processes seem to be changing the nature and intensity of the threats that rural peoples and ecosystems in the global South are exposed to. Consequently, people's livelihoods are developing and adopting strategies to adjust to these new circumstances, and the perceptions of what constitutes important stresses are also changing. This suggests that situated understandings of rural vulnerability in conservation contexts are critical to guiding effective adaptive co-management strategies that move beyond addressing environmental hazards, to encompass interacting institutional and socio-economic perturbations at different scales and that are able to reach the most disempowered actors at the local level. Further research on the ways in which the distribution of power, access to land and participation in decision-making are shaping rural communities' vulnerability and ability to adapt in the context of co-managed protected areas is needed to inform conservation policy and to guide the necessary development support to fulfil communities' basic needs and legitimate aspirations.

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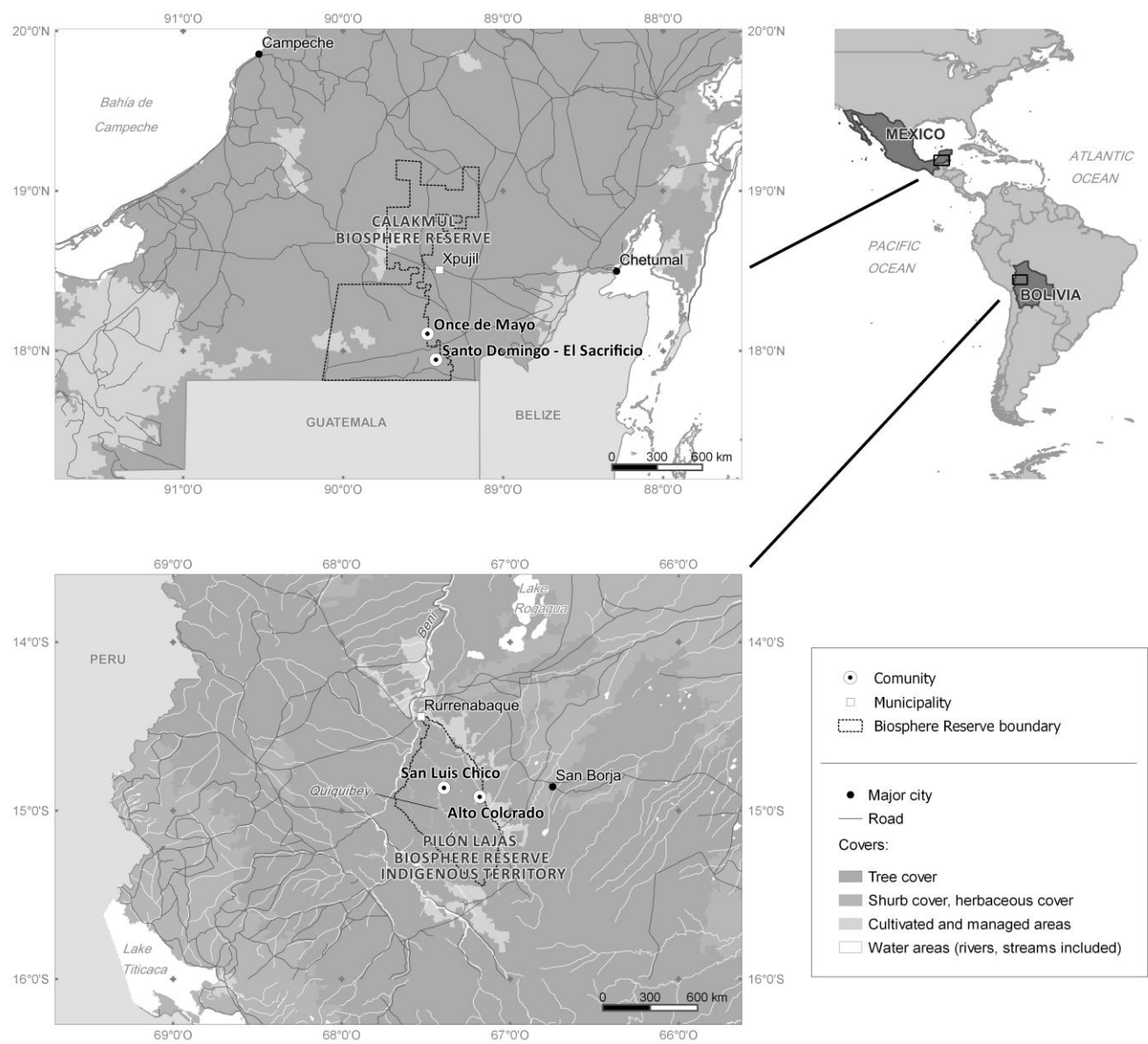
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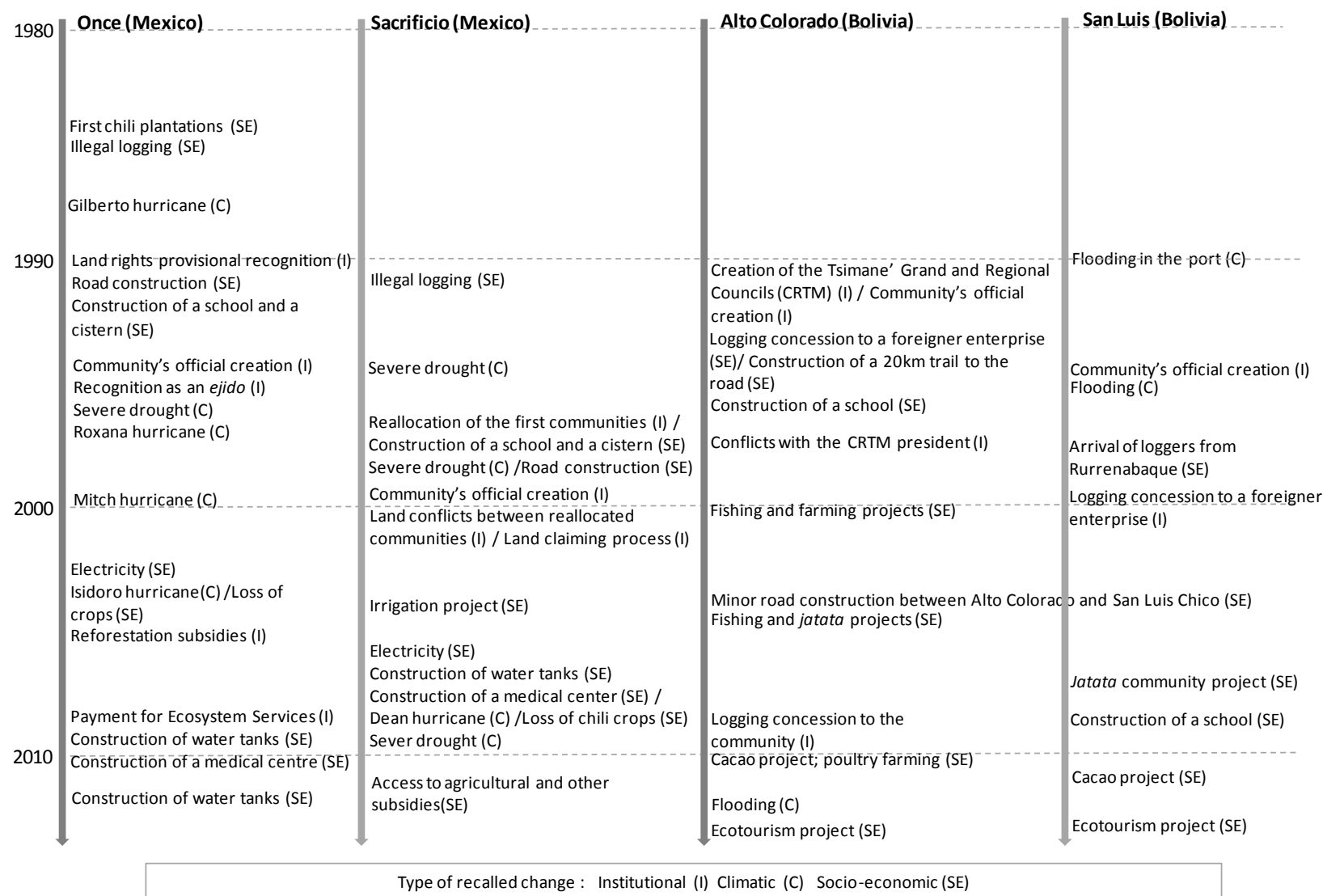
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**Figure 1. Selected communities in the studied biosphere reserves of Mexico and Bolivia**





**Figure 2. Locally perceived changes in selected communities**



**Table 1. Methods and sampling**

<b>Communities</b>	<b>Focus groups (participants)</b>	<b>Interviews</b>	<b>Scoring exercises</b>
Once	3 (13)	7	66
Sacrificio	2 (12)	13	89
Alto Colorado	3 (21)	5	74
San Luis	3 (24)	8	28
Total	11 (70)	33	257



**Table 2. Typology of coping and adaptation strategies**

<b>Coping or adaptation strategy</b>	<b>Risk pooling and/or reduction</b>	<b>Main traits</b>
Mobility	Across space	It is the most common natural response to environmental risks. It entails the temporal or permanent move of the individual, the family or the community away from the original location
Storage	Across time	It relates to strategies that aim to address food and/or water scarcities
Diversification	Across individual and collective assets and resources	It relates to productive and consumption strategies, as well as employment opportunities
Communal pooling	Across households	It involves sharing labour or income from using resources or assets of joint ownership
Market exchange	Through specialisation and increasing revenue flows	It involves selling products in markets to increase income or to exchange them for other goods. It usually substitutes other strategies when market access is available
Institutional pooling	Across formal and informal institutions	It involves sharing labour and resources between households and the government or NGOs

Source: based on Agrawal, 2010

**Table 3. Locally perceived stresses and their impacts**

<b>Biosphere Reserve</b>	<b>Communities</b>	<b>Nature of change</b>	<b>Source of stress</b>	<b>Type of stress*</b>	<b>Exposure factors</b>	<b>Perceived outcomes</b>
Calakmul (Mexico)	<i>Once de Mayo</i> (OM) and <i>Sacrificio</i> (SA)	Institutional	Land rights conflicts and land use regulations	Conservation rules Lack of land rights (OM 18.9%; SA 32.6%)	CBR formal rules and prohibitions related to the collection of timber and non-timber forest products (OM, SA) Payment for Ecosystem Services conservation rules (OM)	Marginalisation in the distribution of benefits from conservation (OM) and other subsidies (SA)
						Lack of access to forest resources and related income sources (OM, SA)
		Climatic	Climate change	Rainfall variability (OM 47%; SA 23.7%)	Periodical droughts (OM, SA) Hurricanes (OM)	Loss of crops and cattle damages due to attacks of protected species (OM)
						Less availability of drinking water (OM, SA)
		Socio-economic	Market dependence	Cash crop price shocks (OM 34.1%; SA 41.5%)	Jalapeño chilli prices unpredictability (OM, SA)	Low production and less income due to loss of crops and livestock (OM, SA)
						Shortage of profitable agricultural land (OM, SA)
Pilon Lajas (Bolivia)	<i>Alto Colorado</i> (AC) and <i>San Luis</i> (SL)	Institutional	Land rights conflicts and land use regulations	Conservation rules Presence of settlers (AC 53%; SL 75%)	PLBRIT lack of enforcement (AC, SL) Settlers' encroachment (AC, SL)	Disempowerment to manage and obtain benefits from chilli crops (OM, SA)
						Lack of benefits to invest in the next period of sowing (OM, SA)
		Climatic	Climate change	Extreme rainfall, wind and heat (AC 44.6; SL 25)	Extreme floods: (AC, SL) High temperature: 2010 (SL)	Deforestation and internal conflicts due to illegal logging (AC, SL)
						Less game animals and nearer non-timber forest products (SL)
						Low production due loss of crops and less fishing due to fish death by heat (AC, SL)

					Less income due to road cuts (no access to markets) (AC)
Socio-economic	Access to markets and market dependence	Population growth Failed development projects (AC 2.4%; SL 0%)	Market-oriented agricultural expansion (AC) NGOs bringing development projects: <i>pacu</i> (fish), cacao, citrus, chicken (AC)		Land shortage and reduction of game animals and fishes (AC) Projects failure and internal conflicts due to lack of trust and accountability (AC)

\*Percentage of informants who perceived a given stress as the most important in brackets (2.2% of SA informants did not perceive any stress)

**Table 4. Adaptation and coping responses to multiple stresses reported by informants**

Class of strategy	Type of strategy	Reported strategies	Region	Institutional stress	Climatic stress	Socio-economic stress	Driven	Level of local involvement	Biosphere reserve involvement
Institutional pooling	Adaptation	Formalised logging activities (via concession)	Pilon Lajas	✓			Externally	Collective	Promoter
	Coping	Increasing surveillance of the commons	Pilon Lajas	✓			Locally	Collective	Implementer
Communal pooling	Adaptation	Beekeeping	Calakmul	✓		✓	Externally	Household	Facilitator
		<i>Jatata</i> and cacao development projects	Pilon Lajas	✓			Externally	Collective	Facilitator
Diversification	Adaptation	Investing in livestock	Calakmul			✓	Externally	Household	No
		Planting at different altitudes	Both		✓	✓	Locally	Household	No
		Planting in different periods	Calakmul		✓		Locally	Household	No
		Planting different crop varieties	Calakmul		✓		Locally	Household	No
		Reducing planting area of cash crops	Calakmul			✓	Locally	Household	No
		Increasing planting area	Pilon Lajas			✓	Locally	Household	No
		Using pesticides and/or mechanised agriculture	Calakmul		✓	✓	Locally	Household	No
	Coping	Working in fire prevention	Calakmul			✓	Externally	Household	Promoter
		Working for other families in the community	Calakmul		✓	✓	Locally	Household	No
Storage	Adaptation	Building infrastructure to accumulate water	Calakmul		✓		Externally	Collective	No
		Buying or renting land to plant in other communities	Calakmul		✓		Locally	Household	No
	Coping	Buying water for agricultural activities (monthly or yearly)	Calakmul		✓		Locally	Household	No
		Planting market crops instead of traditional varieties	Pilon Lajas			✓	Locally	Household	No
Market exchange	Adaptation	Improving access to markets by self-organisation	Calakmul			✓	Locally	Collective	No
	Coping	Payments for Ecosystem Services	Calakmul	✓		✓	Externally	Household	No
Mobilisation	Adaptation	Migration to other communities	Both	✓	✓	✓	Locally	Household	No