

Participatory scenarios to explore local adaptation to global change in Biosphere Reserves: Experiences from Bolivia and Mexico

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Abstract

In an era of anthropogenic stress on ecological systems at multiple scales, involving rural people in planning for adaptation to social-ecological changes is crucial to strengthen local efforts in dealing with uncertainty. In protected areas, this enquiry is even more relevant since conservation regulations can impinge negatively on people's ability to adapt. In this paper we use participatory scenarios to explore the desired adaptation options of four rural communities located in two biosphere reserves in Bolivia and Mexico. We collaboratively design four plausible scenarios in each country that encompass distinct climatic, policy, and socio-economic horizons up to 2030. In Bolivia, the scenarios consider colonisation and infrastructure development as key drivers of social-ecological change, whereas in Mexico drivers include rainfall variability and conservation regulations. We discuss these scenarios at community level and highlight that winners and losers of such scenarios are significantly determined by people's ability to access land and natural resources. Communities' preferred policies and strategies for their future adaptation remain limited, thus revealing a context of restricted opportunities in both biosphere reserves. We conclude with policy recommendations to support local livelihoods in the studied protected areas and beyond.

Key words: adaptation; governance; Latin America; protected areas; participatory scenarios; vulnerability.

Highlights:

- We use participatory scenarios to explore local adaptation in biosphere reserves
- Infrastructure and colonisation are key drivers of change in lowland Bolivia
- Climate variability and conservation regulations key drivers of change in Mexico
- Access to land and natural resources influence local adaptation in both areas
- Confronting inequities in land access and decision-making is critical for adaptation

1. INTRODUCTION

In the current context of social-ecological change, adaptation policies and strategies need to be opened to continuous learning, reflection, and innovation (Kristjanson et al., 2014). This is particularly relevant in highly vulnerable areas, such as the Latin American tropical region, where changing climatic patterns, political processes, and economic globalisation are likely to increase social-environmental risks especially among rural and indigenous societies whose livelihoods are strongly reliant on natural resources (Eakin and Lemos, 2006). Adapting to social-ecological changes while protecting biodiversity and ecosystem services, which are vital for water and food security, is a challenge for governments, conservation practitioners, researchers, and communities (Brooke, 2008; Pacheco et al., 2011).

Protected areas can contribute to support adaptation if managed under more inclusive approaches and focus on strengthening the adaptation options of rural communities located within or around them (Bunce et al., 2010). Strict conservation regulations and lack of local involvement in protected areas decision-making have been found to increase local people's vulnerability (West et al., 2006). Although fifteen percent of the world's land is protected, only five percent of this area is totally governed by indigenous peoples and local communities (Juffe-Bignoli et al., 2014). Inhabited protected areas managed under other governance schemes should desirably make an effort to guide and support rural communities in managing resources sustainably, while ensuring people can progress economically and respond to continuous development challenges (Dudley et al., 2010).

Biosphere reserves, for example, and based on their constitutive mandate to be participatory and inclusionary (Bouamrane, 2007), should proactively involve local people in decision-making and become more attentive to local priorities and concerns regarding conservation challenges, as well as broader social-ecological dynamics. In this regard, co-management approaches constitute an attempt to construct collaborative networks between stakeholders at different scales (e.g., local communities, regional or national government) to deal with change and uncertainty (Tompkins and Adger, 2004). In some Latin American biosphere reserves, however, top-down management approaches prevail and constrain conditions for local adaptation due to strict land use regulations and limited local participation in decision-making (Speelman et al., 2014). Exploring "winners and losers" in the context of biosphere reserves, and identifying desirable adaptation options results then critical in advancing current debates on conservation governance and adaptation (Reed, 2008).

In this article we identify and discuss desired adaptation options in relation to future scenarios of social-ecological change in two biosphere reserves in Bolivia and Mexico using participatory scenarios. Within each reserve, we focus on two communities affected by multiple drivers of change, i.e., conservation regulations, climate perturbations, demographic, infrastructure, and/or market-related changes (Ruiz-Mallén et al., 2015). Our enquiry contributes to debates on biodiversity conservation, adaptation, and governance in two ways. First, it sheds light on how conservation policy (i.e., top-down and co-management approaches) and structural factors (e.g., access to land and resources) influence local adaptation to on-going social-ecological change,

based on communities' perceptions of "winners and losers". Second, it provides relevant lessons for future adaptation policy in the selected biosphere reserves and the neighbouring region based on local people's views and needs for institutional support.

2. ADAPTATION OPTIONS FOR GLOBAL CHANGE

Adaptation options are defined by the Intergovernmental Panel on Climate Change (IPCC) as available and appropriate strategies needed to address information, resources, and action for ensuring society safety and assets security in response to social-environmental impacts (Noble et al., 2014). In developing countries, rural communities have historically implemented adaptation strategies without or with significant support from other actors, drawing on their capacity to mobilise a diversity of assets (Armitage, 2005). Agrawal (2010) classified these locally-developed adaptation strategies as storing, diversification, common pooling, market exchange, and mobility. In the current context of dynamic change, however, the identification and implementation of effective strategies for adaptation often requires the engagement of individuals, organisations, and governments at multiple levels (UNEP, 2008). Governments and/or NGOs can support rural people's adaptation through capacity building, financing mechanisms, infrastructure, technological options, and the like (Biagini et al., 2014).

The 2010 UNFCCC Cancun Adaptation Framework¹ highlights the need to engage stakeholders in sharing knowledge on adaptation actions and in undertaking adaptation activities. However, in low income and high vulnerable regions collaboration between local people and institutions in adaptation research and policy is limited (Felton et al., 2009). Most climate change adaptation strategies across Latin America have been reported to be reactive community-based actions to short-term changes, with limited state involvement (Berrang-Ford et al., 2011). Moreover, when planning for adaptation, governments mostly rely on biophysical models overlooking socio-economic and political impacts (Burton et al., 2002) and ignoring communities' knowledge, practices, and beliefs that have historically help them to adapt to change (Berkes et al., 2000). Only Bolivia, Dominican Republic, Mexico, and Nicaragua recognise the role that local knowledge, risk perceptions, and values can play in guiding formal decision-making for adaptation, as those might explain locally preferred adaptation choices (Ruiz-Mallén et al., 2013).

Government-driven strategies for adaptation can also indirectly reinforce existing inequalities between groups of users (e.g., farmers versus pastoralists) and challenge the capacities of those more vulnerable to make their livelihoods more responsive to changing contexts (Snorek et al., 2014). These power inequalities define who will succeed or gain something (winner) and who will experience disadvantages or deprivation (loser) from climate change and economic globalisation, or from more concrete and locally experienced social-ecological changes (O'Brien and Leichenko, 2000, 2003). Power inequalities can also emerge from the less documented globalisation of conservation, or the international trend in conservation consisting of top-down designed initiatives disconnected from local conditions (Rodríguez et al., 2007).

¹ United Nations Framework Convention on Climate Change <https://unfccc.int/adaptation/items/5852.php>

Adaptation-concerned scholars and practitioners claim that more information and data on local understandings of change are needed to further recognise social vulnerability and adaptation at the local scale and to develop well-targeted adaptation policies (Noble et al., 2014). In the context of biosphere reserves, it is crucial to explore how conservation stakeholders, including local communities, see the future, which winners and losers -as locally perceived- they identify in plausible futures, and what should be done to develop and/or strengthen local adaptation strategies in conservation contexts.

3. STUDY AREAS AND METHODS

3.1. Selected communities in Bolivia and Mexico

This study was part of a larger research project on community-based management and conservation in Latin America (www.combioserve.org). In 2012, we obtained free, prior, and informed consent from regional authorities and local leaders of the four communities participating in the study. In Bolivia we worked with Alto Colorado and San Luis Chico (hereafter San Luis), two Tsimane'² villages located within the Pílon Lajas Biosphere Reserve and Indigenous Territory (PLBRIT), in Beni Department. Alto Colorado has 260 inhabitants spread across 46 households and is located along the Yucumo-Rurrenabaque road whereas the 20 households (83 inhabitants) of San Luis live more isolated along the Quiquibey river. In Mexico, we worked with the migrant *mestizo* and indigenous (mostly Chol) villages of Once de Mayo and Santo Domingo-El Sacrificio (hereafter Once and Sacrificio). Their territory partially overlaps with the buffer and core areas of the Calakmul Biosphere Reserve (CBR) in the state of Campeche. Once has approximately 260 people spread across 78 households while Sacrificio has 620 people and 134 households (Figure 1).

INSERT FIGURE 1 BY HERE

These four communities were selected based on geographic, political, and socio-economic criteria that could influence adaptation options. First, communities' lands partially or totally overlap with areas declared as biosphere reserves. The PLBRIT in Bolivia was established in 1977 and since 1992 is co-managed between the Protected Areas National Service and the organisation representing the indigenous communities living in the area (Consejo Regional Tsimane'-Mosekene) (Bottazzi, 2009). In Mexico, the CBR was established in 1989 and decision-making is entirely dominated by the government's National Commission of Protected Areas. These distinct management regimes may differently influence local communities' vulnerability and adaptation.

Second, communities are located in two Latin America countries that are distinct in terms of land tenure and indigenous rights legislation, which in turn makes them comparatively interesting, since access to land is a key adaptation factor (Adger, 2003). While Bolivia only recognised indigenous tenure systems (i.e., Tierras Comunitarias de Origen) in its 1994 Constitutional reform (Reyes Garcia et al., 2014), Mexico has guaranteed communal property for indigenous and peasants since its 1917 Constitution (Roldán-Ortega, 2004).

² The Tsimane' are a relatively autarkic indigenous society in the Amazonia (Godoy et al., 2009).

Third, the selected communities settled in their current location relatively recently (2-3 decades ago), but have experienced different socio-economic and infrastructure development processes, leading to disparate capacities for adaptation. The two Tsimane' communities depend on subsistence agriculture, gathering of non-timber forest products, hunting, fishing, and animal rearing, although in Alto Colorado the proximity to a regional road has resulted in some new income-generating activities, such as temporal employment and logging. Livelihoods in both CBR communities mostly depend on *milpa* agriculture (i.e., a form of swidden agriculture), cattle ranching, and temporal employment as agricultural labourers for nearby communities and in national and foreign cities. But these communities differ in their underlying tenure regime. Once was officially recognised as an *ejido* (i.e., a legal form of common property) in 1994, when each *ejidatario* (landowner) was provided with 50 hectares and rights on natural resource management in communal lands. Sacrificio, in contrast, is still waiting for the government to grant them with land titles, a process that has taken longer than expected due to its spatial overlapping with one of the CBR core zones.

3.2. Data collection

We used exploratory scenarios (van Notten, 2005) designed through a participatory and place-based research process. Scenarios are not predictions, but reasonable descriptions of hypothetical futures designed on the basis of a set of factors and dynamics that characterise a reality (ibid.). In social research, scenarios can be co-developed between researchers, government institutions, civil society organisations, and lay people through a process of joint data collection, analysis, and deliberation. This type of participatory scenarios aim to engage multiple stakeholders (including communities, local governments, non-governmental organisations) in thinking about the future, ultimately guiding and supporting decision-making at multiple scales. Specifically, these scenarios aim to actively involve local actors in identifying and discussing plausible future priorities, actions, and policies to be pursued in their concrete settings (Kuzdas and Wiek, 2014; Vervoort et al., 2014). They are developed to understand ongoing ecological and social dynamics drawing on both scientific and local knowledge and views (Brown et al., 2001). Although they been widely implemented for exploring conservation management (Gude et al., 2007; Palomo et al., 2011), their use in the analysis of local people's adaptation options remains limited. We drew on earlier work on participatory scenario development (e.g. Tompkins et al., 2008) and undertook five steps in the research process (Appendix 1).

We first identified biodiversity reserve stakeholders³ through semi-structured interviews with community authorities and biosphere reserve managers. Second, we invited them to a scenario-building workshop organised in the municipality of each study area in March 2014 (Table 1). By designing the scenarios through a multi-stakeholder workshop we captured different institutional views regarding the most plausible futures (Ravera et al., 2011). Eight stakeholders attended the workshop in each municipality. The starting point of the discussion was a set of four drivers of change previously

³ Biodiversity reserve stakeholders included individual actors, organizations or institutions who can directly influence natural resource management and conservation in the biosphere reserve (e.g., communities and community organizations, government, academic sector, NGOs).

identified as the most important for local livelihoods through semi-structured interviews and scoring exercises with selected communities (see Ruiz-Mallén et al., 2015 for more details). In PLBRIT, locally perceived drivers of change included extreme rainfall, colonisation by other indigenous and non-indigenous peoples, conservation regulations, and infrastructure development. In CBR, triggering factors of change included rainfall variability, conservation regulations, infrastructure development, and cash crop (chilli) price volatility. We limited the number of drivers to four in order to avoid confusion when asked stakeholders to select and motivate –according to their knowledge and experience- the two most relevant drivers of change for local livelihoods. The two collectively agreed drivers were the basis for developing four plausible scenario narratives in each study area through a two-axes approach, distinguished by varying degrees of drivers' impact (van't Klooster and van Asselt, 2006). We then engaged participants in a guided discussion on how and why drivers would potentially impact local livelihoods in each scenario, according to their experience and knowledge of the area. We used 2030 as the projected year so that participants could imagine a rather proximate future. Once the four scenarios were agreed, we asked participants to give each scenario a distinctive name.

INSERT TABLE 1 HERE

Third, the research team wrote up the scenarios' narratives, according to the storylines characterizing each scenario developed by local stakeholders. These narratives were sent to all participant stakeholders for validation without receiving further feedback. Because scenario development partially drew on local people's knowledge, experience, and views on their environment, it also helped dealing with the lack of quantitative data on ecological and social dynamics in our study areas, a challenge that researchers typically face in marginalised areas of the global South.

Fourth, we brought these storylines to the four communities as a tool to discuss local adaptation options. In March and April 2014 we organised eight two-hour deliberative focus groups with 81 participants in each area. These focus groups were conducted in Spanish and, when needed, translated to the corresponding indigenous language (i.e., Tsimane' and Chol) with the support of local translators. Given the reduced adult population and the limited attendance of villagers to previous meetings (Huanca, com. pers.), we only organised one extended focus group in each of the PLBRIT communities, opened to all interested adult men and women. Twenty-two and 29 people (including 12 and 11 women) attended the focus groups in Alto Colorado and San Luis, respectively, but only 6 individuals in each community participated actively in the discussions, which is a limitation of our study. Such limited engagement is explained by cultural factors, such as young men and women's unfamiliarity to talk in public meetings. In the more populated and heterogeneous CBR communities, where our own fieldwork had previously revealed that land rights and gender were critical determinants of intra-village socio-economic inequalities, we conducted three focus groups in each village (one with women, one with men with land rights, and one with men without land rights). Participants in each group were randomly selected and personally invited to limit the number of attendants and develop a richer debate. A total of 15 and 18 people (including 5 and 6 women) participated in Once and Sacrificio.

During village focus groups we identified and discussed participants' perceptions on who were likely to become the winners and losers under each of the plausible futures described by each storyline. We then asked participants to select the most preferred scenario and to explain their choice. We used back-casting (Dreborg, 1996; Robinson, 2003) to gather data on what adaptation strategies had to be locally-developed and which external policies or projects participants considered necessary to facilitate community members adaptation to the most preferred scenario, according to their knowledge and understanding of who had agency or responsibility for the suggested actions besides themselves. Fifth and last, we compiled locally suggested policy options to reduce their vulnerability and support desired futures in two 5-minutes videos, one for each site. Each video was sent by email to the corresponding biosphere reserves' managers and regional policy-makers in order to disseminate the results.

3.3. Data analysis

We transcribed and qualitatively analysed data from the scenario-building workshop by classifying stakeholders' motivations to choose drivers of change according to their effects on: a) land tenure, b) productive and/or material assets, c) customs or traditions, and d) the environment. Such categories were not predefined, but emerged from our data (Newing, 2011). Data from community focus groups were also transcribed and thematically analysed according to three broad categories: 1) winners and losers in each scenario; 2) potential local adaptation strategies to the most preferred scenario; and 3) policy interventions required to facilitate adaptation under that scenario. Since local perceptions on who might be the winners and losers of different futures can be influenced by the socio-political context (O'Brien and Leichenko, 2003), this question was further explored in CBR by analysing gender and land rights' groups responses. In the four communities, the adaptation strategies identified for the most preferred scenario were classified into five subcategories according to Agrawal's (2010) framework. In turn, their desired policy actions to foster local adaptation were, first, classified according to the institution or organisation responsible for implementing them (i.e., national, regional and/or municipal government, biosphere reserve management board, and NGOs) and then according to Biagini et al.'s (2014) typology of policy actions for adaptation (i.e., capacity building, management and planning, practice and behaviour, policy, information, physical infrastructure, green infrastructure, warning, financing, and technology, see Appendix 2).

4. RESULTS

4.1. Designed scenarios

PLBRIT stakeholders selected socio-economic factors (i.e., infrastructure development and colonisation) as the most important drivers of change, whereas CBR stakeholders selected climatic and institutional factors (i.e., rainfall variability and conservation regulations). PLBRIT stakeholders unanimously agreed that the colonisation process driven by national government policies would cause more land conflicts with settlers and noted that illegal settlements would continue to benefit from the lack of surveillance and enforcement of biosphere reserve regulations. They also agreed that infrastructure development, particularly road building, would improve communities' access to material assets but would also trigger inter-personal conflicts and environmental

degradation. As this stakeholder mentioned: “*Infrastructure will bring good things for communities such as better roads, communication services and electricity; but it will also bring very bad things like altered flooding patterns caused by upstream dams, new settlements and cultural changes*”.

In CBR, participants argued that climate variability would be the most decisive driver of change in the region because agricultural production and development opportunities were limited as a result of a higher rainfall variability. They provided the same argument when choosing conservation regulations as the second driver of change, as this participant explained: “*If we have enough conservation [programs] we will have more trees, the rain cycle will be regulated and we will stabilise our agricultural production.*”

Scenario storylines were based in similar rationalities (Figure 2). Thus, in PLBRIT participants discussed the four scenarios in terms of potential territorial conflicts, environmental impacts, and loss of their traditions triggered by the colonisation process and infrastructure development. In turn, participants from CBR focused the scenario-building process on the potential impacts of climatic variability on local people’s productive activities and economic development in a context of limited opportunities for natural resource management due to conservation restrictions.

INSERT FIGURE 2 HERE

4.2. Winners and losers of future social-ecological change

While PLBRIT focus groups’ participants mentioned non-indigenous settlers and extractive companies as frequent winners in future scenarios, participants in CBR referred to groups within the community (i.e., landowners, young people with access to education, forest owners) as the most likely winners. The environment and Tsimane’ communities in the PLBRIT and landless people and landowners without forests in the CBR were usually perceived as losers (Table 2).

INSERT TABLE 2 HERE

Winners and losers were differently perceived by the two Tsimane’ communities when discussing the *More of the same* scenario (S1). While Alto Colorado participants argued that community members would improve their livelihoods despite the arrival of new settlers, San Luis people perceived colonists as the winners in detriment of local people, who would lose their access to land and resources. In both the *Vulnerability and conflict* (S2) and *Change and disorder future* (S4) scenarios, participants in both communities concurred that settlers would benefit from occupying land and that this would go in detriment of the Tsimane’. When considering the S4 scenario, participants also believed that extractive companies (i.e., oil companies) would win and the environment would lose. In the case of a potential future with stable migration but improved infrastructure development (*Double edge*, S3) both communities agreed that the Tsimane’ would be the winners as they would have increased access to technology and education and health services.

In CBR, existing inequities in access to resources and decision-making among community members seem to be exacerbated in three future scenarios. In both communities landowners were perceived as winners in *Drifting* (S1), *Flexible* (S3) and *Subsidised* (S4) scenarios because they could potentially benefit from government and/or conservation subsidies. In contrast, participants from Once concurred that all community members, including landowners, would lose under the *Catalyst* scenario (S2) since changes in rainfall patters and extreme climatic events would negatively affect agricultural production and undermine local livelihoods. Landless people were perceived as frequent losers in S1, S3 and S4, since they would lack access to titled land for agricultural activities and would mostly rely on temporary work. In S4 cattle ranchers were also perceived as losers due to the increased impacts of droughts and hurricanes on water availability and related infrastructure. Women from both communities and landowners from Once highlighted that access to education was a key factor that would determine if youngsters become winners or losers because those with higher schooling degrees might have access to better jobs outside the community.

4.3. Local strategies and policy actions for future adaptation

Focus groups of the same study area differed in their preferences regarding the desirability of each scenario, although they reported very similar desired adaptation policies (Table 3). For example, participants in Alto Colorado preferred the *More of the same* scenario (S1) because similar conditions of colonisation and infrastructure development would help them maintain their current level of access to natural resources and of potential income. For these participants, the only reported adaptation strategy was to increase the cultivated area and diversify crop production. In contrast, in the more isolated community of San Luis infrastructure development was a desired driver of change and the *Double-edge* scenario (S3) was preferred over other options since it was believed that the arrival of new goods and technology (e.g., mobile phones) would result in improved livelihoods and trading opportunities. To adapt to and benefit from further market exposure, participants manifested their willingness to plant cash crops instead of traditional crops and migrate temporarily to nearby towns for income-generating opportunities. Some warned, however, that new infrastructure and market integration would also facilitate settlers' access to the area and lead to deeper socio-cultural changes and loss of traditional livelihoods.

To confront these challenges, informants from both Tsimane' communities advocated for the improvement of physical infrastructure, increased surveillance in the PLBRIT, and local capacity building as key government-led actions that can be conducive to communities' adaptation. Specifically, they suggested that biosphere reserve managers had to better enforce conservation regulations and the municipal government had to invest more in schools and health posts. NGOs were perceived as supporters in the communities' struggle against colonists and as critical actors that could help them in maintaining their traditions, which could in turn offset any cultural changes resulting from infrastructure development and improved access to formal education.

INSERT TABLE 3 HERE

In CBR, most of Once participants selected the *Drifting* scenario (S1) as the most desirable because the other scenarios included either increasing rainfall variability or

conservation restrictions which they consider would limit their productive activities. In this context, they would implement similar adaptation strategies as those prevalent today, which included mobility and market exchange actions, such as migrating temporarily to work away or abroad, and participating in incentive-based biodiversity conservation. Despite being aware of the challenges of working together, landowners and landless people also reported communal pooling strategies, but for different purposes. While landowners would organise to increase forest surveillance for deterring deforestation and receiving higher conservation subsidies in the future, landless people would work collectively to implement beekeeping projects to deal with their limited access to land. In contrast, participants from Sacrificio selected the *Flexible* scenario (S3) as their most desirable future since they argued that many families could benefit from conservation programs both directly and indirectly. Under this scenario, they mentioned market-based approaches, such as applying for conservation payments and planting new cash crops, and diversification strategies, such as investments in new productive activities related to conservation (i.e., agroforestry), as key adaptation strategies.

Regardless of gender and land ownership, participants in both Mexican communities emphasised that the governmental institutions should increase financial support through agricultural and other social development programs, and specifically improve water access so that people could adapt their productive activities to variable climate conditions. In Sacrificio, participants noted that the federal government had still to grant them with formal property titles, which could in turn ease their adaptation strategies, for instance, guaranteeing their access to conservation subsidies. The CBR was perceived as a potential source of income opportunities through management actions for adaptation such as maintaining forest management programs that employ local people in both communities. NGOs were seen as key organisations supporting communities' capacity building through technical and legal advice for accessing public and international subsidies.

5. DISCUSSION

5.1. Policy and structural challenges for local adaptation in biosphere reserves

Despite the perceived challenges for local adaptation diverge in each biosphere reserve, conservation policy and regulations and access to land and natural resources are common concerns of local future adaptation. Local villagers, however, problematize these challenges using different logics. In PLBRIT, the lack of surveillance and enforcement is perceived as facilitating further illegal settlements and extractive activities. Future adaptation options of Tsimane' communities are thus related to addressing potential land conflicts with settlers and preventing environmental degradation under a *subsistence logic* to ensure the maintenance of their traditional production systems and ecological knowledge while increasing their access to markets. In contrast, CBR communities conceptualise conservation regulations through the lens of a *market logic* and perceive them as a double-edged sword. On the one hand, conservation regulations, if stricter, are believed to limit future livelihood development opportunities, thus resulting in increased vulnerability, which resonates with widely documented concerns about the tensions between conservation and community needs in protected areas (Adams et al., 2004; Sunderlin et al., 2005). On the other hand,

conservation subsidies -as they have been proposed to local communities by the government- are perceived as a key means to support local adaptation through increased income, a possibility that has been reported in other experiences of direct conservation payments in Mexico and elsewhere (Caro-Borrero et al., 2014; De Koning et al., 2011; Rico García-Amado et al., 2013).

We suggest, however, that conservation regulations as they now stand in the top-down managed CBR mask the possibility that the most marginalised households, and particularly the non-right holders, see their adaptation options jeopardised in the future due to constrained access to land and public subsidies. The combination of conservation regulations and incentives can lead to greater external dependence and intra-communities social inequality (Corbera, 2015). We thus suggest that policy interventions simultaneously addressing biodiversity conservation and vulnerability reduction or poverty alleviation need to be informed by a careful understanding of the local context and the socio-economic, political, and cultural conditions that might influence community and/or household-based adaptation (Agrawal and Redford, 2006). In particular, we have demonstrated that conservation policies and regulations are tightly linked to communities' access to land and resources, and they are thus critical to understand not only present but also potential adaptation in biosphere reserves.

Indeed, access to land and other resources, which is a structural condition for adaptation (Adger, 2003), will play a critical role in determining who might win or lose from plausible futures in PLBRIT and CBR, since these reserves have distinct governance approaches (co-managed and government-managed, respectively) and socio-environmental contexts (O'Brien and Leichenko, 2000). In Bolivia, where usufruct rights and access to land are guaranteed to all community members, customary and formal rules regulating land and natural resources use would equally contribute to enhance adaptation of local people as winners. But, if these rights are not respected due to unregulated colonisation and lack of policy enforcement the Tsimane' will be deprived from their livelihood securities. In Mexico, communities' land tenure will deeply shape household's adaptation since competition for natural resources and access to land will continue to prevail. When comparing between communities, Sacrificio will be a clear loser if property rights are not formally granted soon and, therefore, people remain constrained in their ability to participate in development programs.

Notwithstanding, it is important to highlight that even though land rights have not yet been recognised by the government, informal rules on land "property" do exist in this community. Some households act *de facto* as legitimate landowners in front of other community members, which in turn embodies historical power relations structured around age, gender or ethnicity (Leach et al., 1999). Therefore, landowners from Once and households with hypothetical land rights from Sacrificio could be regarded as winners in futures with similar rainfall variability conditions since both groups have more options for adaptation than landless households. Landowners could use their land for crop diversification or could develop other productive activities (i.e., cattle ranching, beekeeping) whereas non-right holders will need to pay a rent to landowners for cultivating their lands and could not access most public subsidies for agriculture and conservation. In other areas of the country, landownership patterns have also been highlighted as key determinants of adaptation to environmental change (Eakin and Bojórquez-Tapia, 2008).

5.2. Enabling conditions for suggested adaptation options

The reduced number of suggested strategies and policies for future adaptation under the preferred scenarios reveals a context of limited opportunities for livelihoods and little flexibility in natural resource management in both biosphere reserves, regardless of the governance approach existing in the selected cases (Figure 3). Regardless of the preferred scenario, perceived adaptation challenges, and local context, the communities involved in the study would adopt similar strategies to deal with future social-ecological change, namely temporal migration and adjusting productive activities to (emergent) market needs through diversification, market exchange, and collective projects. Suggested policy-driven actions for adaptation would also have to address similar needs: supporting local capacity building for agricultural development, investing in physical infrastructure, and re-thinking policy and regulations related to land tenure and conservation. Capacity building and infrastructure have been usually identified as primary activities needed in developing countries to support preparation for climate change (Biagini et al., 2014). It is interesting, however, that participants from the two CBR communities emphasise that incorporating their needs and concerns in the biosphere reserve management is critical for future adaptation. They advocate for including livelihood diversification strategies in conservation planning and they stress that they would require more financial support to develop profitable agricultural activities compatible with conservation in a desired future.

INSERT FIGURE 3 HERE

According to mainstream co-management literature (Plummer et al., 2012), local people's involvement in natural resource management decision-making should facilitate adaptation. We thus argue that, for instance, in the desired scenario of new infrastructure and ongoing colonisation, PLBRIT communities could exercise greater influence indirectly on the government if involved in the biosphere reserve management board, so that their access to land and traditional livelihoods is maintained over time. However, contradictory views exist on the Tsimane's suggested adaptation pathways, since we think they could potentially result in conservation trade-offs. While suggested adaptation actions to be driven by the reserve would focus on increasing conservation enforcement to avoid illegal activities –supported by the Tsimane'–, the communities seem also keen on adapting agricultural practices to the demand of emerging local markets for agricultural and forest commodities. If appropriate measures to regulate land use and production by the biosphere reserve are not established, the large-scale adoption of market-based strategies might increase their income in the short-term but lead to land conflicts and forest degradation in the long-term (Wunder et al., 2014), undermining local well-being and resulting in maladaptation.

Improved access to formal education and technical skills might also contribute to improve natural resources management in a context of global change by complementing the Tsimane' ecological knowledge, a condition that would require the contextualisation of the school curricula (Reyes-García et al., 2010). However, empirical evidence in PLBRIT suggests that schooling is negatively correlated to the number of agricultural and forest species cultivated or gathered by the Tsimane' for their livelihoods, suggesting an adaptation trade-off between the “westernisation” of knowledge and

productive diversification (Bottazzi et al., 2014). In fact, the maintenance of traditional natural resource practices and the avoidance of deep cultural changes in the future is generally perceived by our Tsimane' participants as crucial to support local adaptation to deal with environmental change. Combining such different types of knowledge for learning to live with change and uncertainty is key to build social resilience and enhance adaptation (Folke et al., 2003).

In CBR, as discussed earlier, the uneven distribution of land rights and land access will prevail as structural conditions constraining the adaptation opportunities of many households to preferred future scenarios. We acknowledge that the recognition of formal property rights in Sacrificio is in the hands of the federal government, but we think that the biosphere reserve could still play a key role in mediating such uneven access. Through involving nearby communities in the reserve management board, local people could significantly contribute to adaptation planning with their own understanding of change and impacts (Berkes, 2010). Moreover, giving local communities more exclusive or preferential access to the biosphere reserve biophysical and financial resources could make them conservation allies (Wunter et al., 2014). For instance, and as suggested in the scenario-building workshop and the subsequent focus groups, the biosphere reserve might consider offering lands and loans to landless households for developing beekeeping or other environmentally friendly activities.

Adaptation also depends on the ability to act collectively to use and protect common resources (Armitage, 2005; Fabricius et al., 2007). Social networks allow for sharing risks through collectively adopting adaptation strategies (Agrawal, 2010). Common pooling, for example, is viewed by landowners in Mexico as a mechanism that would facilitate their access to public conservation subsidies enhancing their ability to deal with future disturbances. However, landowners are very reluctant to work together. In contrast with the Tsimane', who share a cultural background and a historical struggle for their territorial rights, the CBR communities were recently formed by families migrating from other regions of Mexico holding different traditions, experiences, and worldviews. Therefore, when developing actions to strength social capital in these heterogeneous communities, government and civil society organisations need to be aware of their history and power relations, thus finding appropriate collaboration and reciprocity strategies between potential winners and losers.

6. CONCLUSIONS

This study provides relevant insights for the design and implementation of future adaptation policies and actions in two Latin American biosphere reserves with different governance approaches (co-management and top-down). We have done so by analysing the views and needs of four rural communities through participatory scenarios. Infrastructure development and colonisation are perceived as the most important drivers of change in PLBRIT whereas rainfall variability and conservation regulations are considered more relevant for CBR communities' future. Despite the most relevant drivers of social-ecological change identified in these two contexts and the governance regimes of the two reserves are different, communities perceive their future adaptation as mainly shaped by their access to land and natural resources and the access to subsidies that come with land ownership. Our findings suggest, however, that policy actions for future adaptation should address issues related to rights' recognition and

tenure relations, as well as focus on maintaining traditional management practices that contribute to local well-being and biodiversity conservation. They should also confront local resource access inequities and power relations, and monitor the long-term impacts of conservation subsidies on livelihoods and the environment. In the co-managed PLBRIT, institutional efforts from the local to the national levels should be addressed to avoid the negative socio-cultural and environmental impacts of unregulated colonisation and a plausible transition to a market-based driven local economy, in which the Tsimane' are willing to participate. In contrast, the challenge in the top-down managed CBR is related to the lack of livelihood opportunities due to conservation restrictions, conservation payments' trade-offs, and unequal access to natural resources in the two studied communities. In this case, involving local people in the biosphere reserve management board, guaranteeing their access to land for subsistence purposes, and improving social cohesiveness will be crucial to reduce the number and intensity of intra- and inter-community conflicts and to enhance households' adaptation.

Overall, this article also demonstrates that participatory scenarios can be a powerful tool for adaptation policy planning since they allow unearthing the voice and views of those who live and dynamically configure social-ecological systems and who should in turn confront the challenges and opportunities that accompany globalisation and environmental change. Biosphere reserves management boards can use these tools to collaboratively plan policy and management actions with those more vulnerable in order to deal with the challenges that relatively fast and multi-scale social-ecological changes entail for future adaptation.

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Figure 1. Location of the studied communities and biosphere reserves

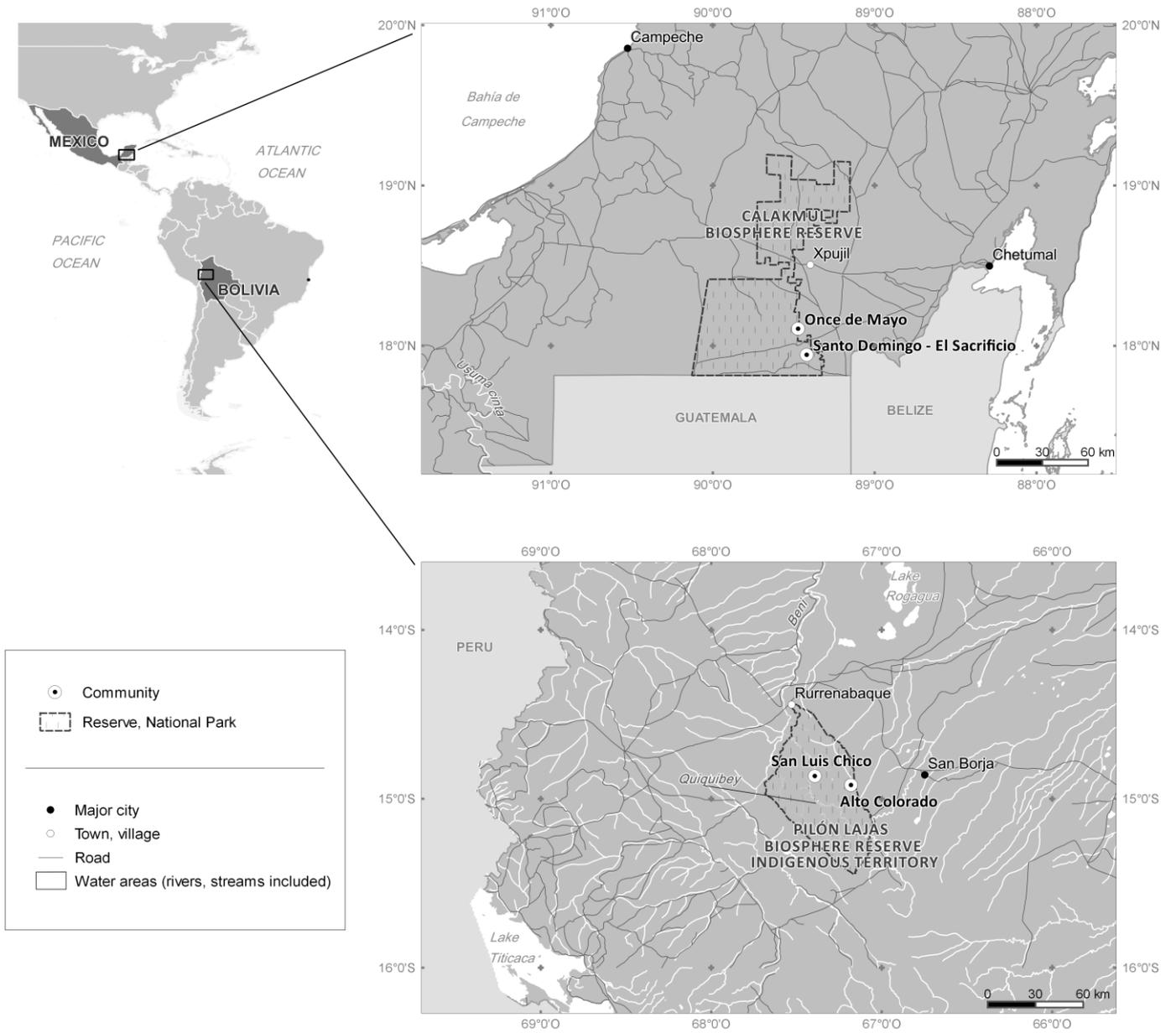


Figure 2. Narratives of scenarios built in each study area

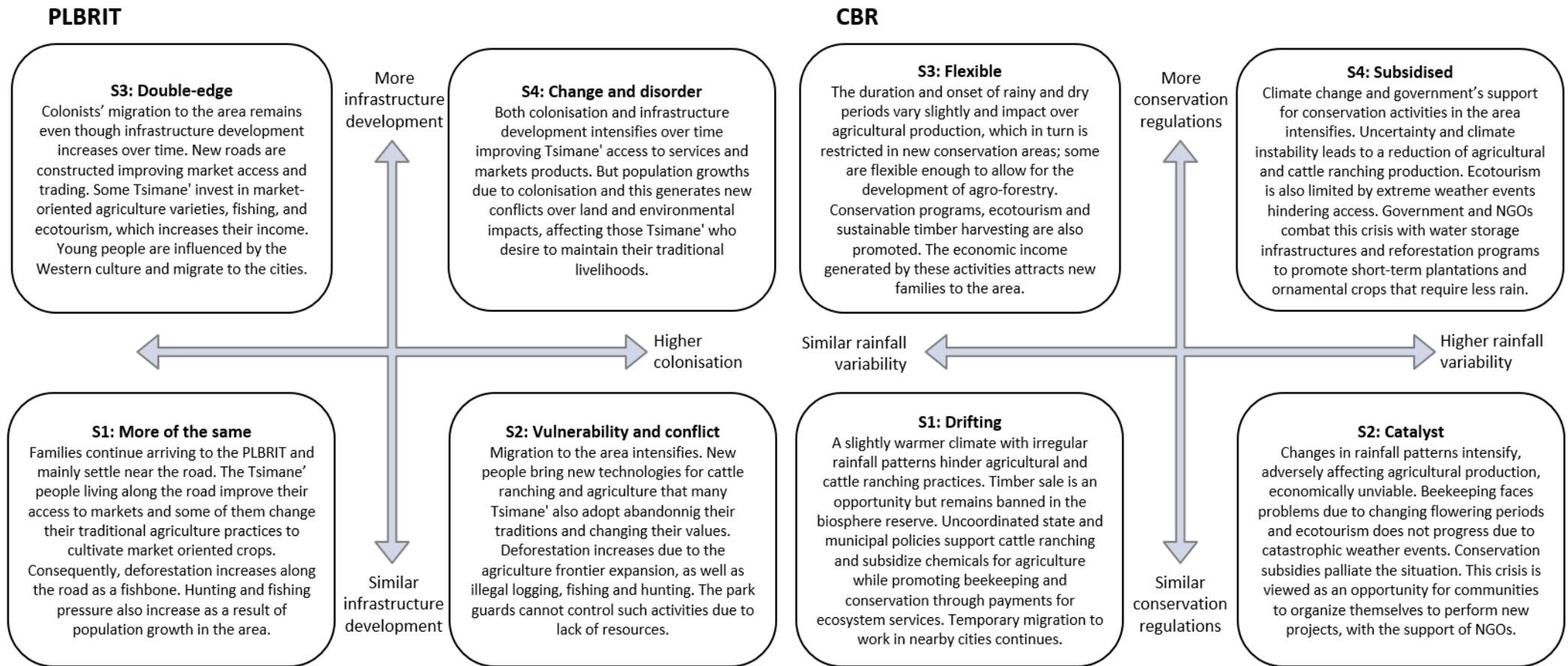


Figure 3. Enabling conditions for suggested adaptation options in selected biosphere reserves

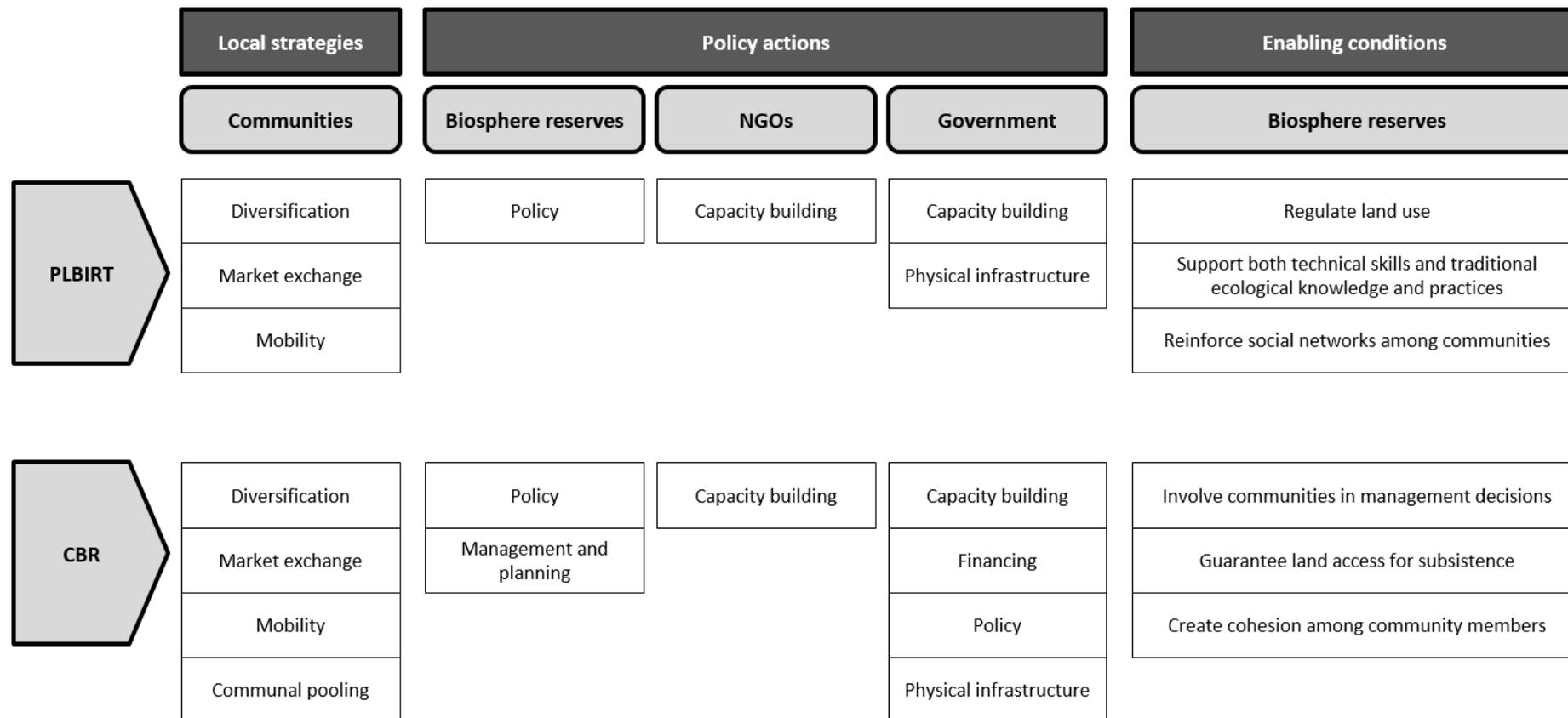


Table 1. Local stakeholders in scenario-building workshops, by study area

Stakeholders	PLBRIT	Attended	CBR	Attended
Communities and community organizations	Alto Colorado representatives.	Yes	Consejo Regional Indígena y Popular de Xpujil, S.C. (CRIPX).	Yes
	San Luis Chico representatives.	Yes	Beekeeping regional association.	Yes
	Consejo Regional Tsimane ² -Mosetene (CRTM).	Yes	Cattle ranching regional association.	Yes
Government	Rurrenabaque municipality.	No	Agriculture regional association. Xpujil municipality.	No Yes
	Beni government.	No	Campeche government.	No
	Protected Areas National Service (SERNAP)- Pilon Lajas region.	Yes	Protected Areas Commission (CONANP) –Calakmul.	No
	Protected Areas National Service (SERNAP)- Madidi region.	Yes	Nacional Forest Commission (CONAFOR) –Calakmul.	Yes
			Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) –Calakmul.	No
			Secretariat of Environment and Natural Resources (SEMARNAT) – Calakmul.	No
			National Commission for the Development of Indigenous Peoples (CDI) –Calakmul.	No
Academia	Universidad Mayor de San Simón (UMSS).	Yes	El Colegio de la Frontera Sur (ECOSUR).	Yes
			Instituto de Ecología, A.C. (INECOL).	No
NGOs	Centro Boliviano de Investigación y de Desarrollo Socio Integral (CBIDSI).	Yes	Fondo para la Paz.	Yes
	Wildlife Conservation Society (WCS).	Yes	Instituto para el Desarrollo Sustentable de Mesoamérica, S.A. (IDESMAC).	Yes
	Conservation Internacional (CI).	No		
	Liga de Defensa del Medio Ambiente. Fundación para el Desarrollo del Sistema Nacional de Áreas Protegidas (FUNDESNA).	No No		

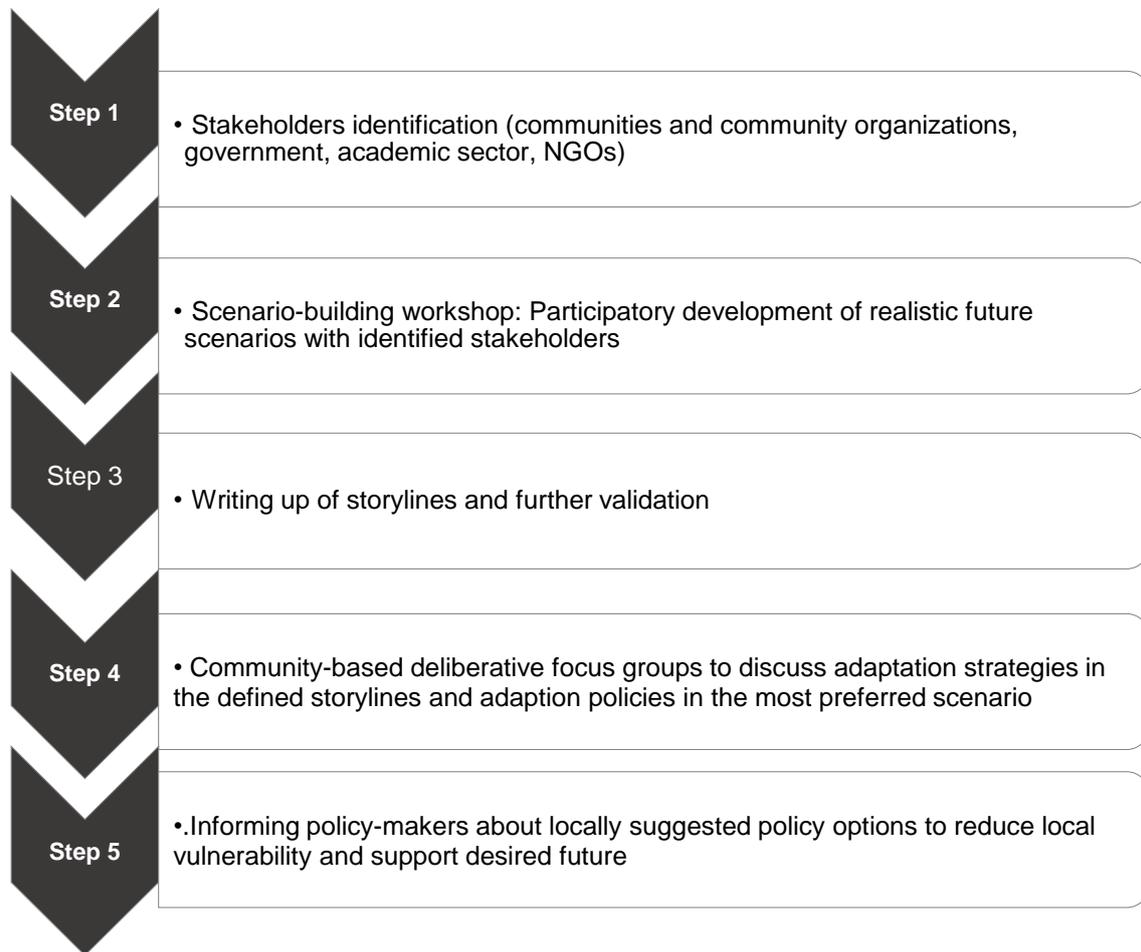
Table 2. Perceived winners and losers in each scenario, by community and/or community groups

Community (study area)	Group	Winners				Losers			
		More of the same (S1)	Vulnerability and conflict (S2)	Double-edge (S3)	Change and disorder (S4)	Drifting (S1)	Catalyst (S2)	Flexible (S3)	Subsidised (S4)
Alto Colorado (PLBRIT)	^	Community	Settlers	Community	Companies, Settlers	Settlers	Community	Not reported	Community, Environment
San Luis (PLBRIT)	^	Settlers	Settlers	Community, Settlers	Companies, Settlers	Community, Environment	Community	Environment	Community, Environment
Once (CBR)	Landowners	Young people	Not reported	Cattle ranchers, Forest owners	Government technicians	Community	Community members	Landless people	Landless people
	Landless	Landowners	Not reported	Landowners	Landowners	Landless people	Community members	Landless people	Landless people
	Women	Young people with access to education	Not reported	Landowners	Community	Young people without education, Landless people	Community members	Landless people	Cattle ranchers
Sacrificio (CBR)	Landowners	Forest owners	Forest owners	Landowners	Not reported	Landowners without forest, Landless people	Landless people	Landless people	Landless people
	Landless	Landowners	Landowners	Landowners	Landowners	Landless people	Cattle ranchers, Landless people	Landless people	Community members
	Women	Young people with access to education	Forest owners	Landless people	Forest owners	Community members	Community members	Landowners without forest, Landless people	Landless people

Table 3. Locally suggested strategies and policies needed for local adaptation in the most preferred scenario, by community

Community (study area)	Preferred scenario	Local adaptation strategies	Policy actions		
			<i>Municipal-national government</i>	<i>Biosphere reserve management board</i>	<i>NGOs</i>
Alto Colorado (PLBRIT)	More of the same (S1)	Diversification: Increase planting area.	Capacity building: Support education.	Policy: Increase conservation enforcement.	None mentioned.
San Luis (PLBRIT)	Double-edge (S3)	Market exchange: Plant market-oriented crops. Mobility: Temporal migration.	Capacity building: Support education. Physical infrastructure: Improve roads.	Policy: Increase conservation enforcement.	Capacity building: Support collective organization.
Once (CBR)	Drifting (S1)	Market exchange: Rent plots, Payments for ecosystem services. Mobility: Temporal migration. Communal pooling: Implement collective projects, Reinforce forest surveillance.	Capacity building: Support management skills. Financing: Increase financial support for agriculture. Physical infrastructure: Improve infrastructure for water storage.	Management and planning: Maintain forest fire management programs, Offer land loans for beekeeping. Policy: Establish the real limits of the reserve.	Capacity building: Support management skills.
Sacrificio (CBR)	Flexible (S3)	Diversification: Develop conservation-oriented activities. Market exchange: Plant market-oriented crops, Payments for ecosystem services	Financing: Increase financial support for agriculture. Policy: Provide with land to community members. Physical infrastructure: Improve health and education services.	Management and planning: Maintain forest fire management programs; Develop beekeeping projects.	Capacity building: Support management skills; Support education.

Appendix 1. Participatory scenario process to explore adaptation to social-ecological change



Appendix 2. Typology of adaptation options used in the analysis

Adaptation options	Type	Definition
Local strategies (Agrawal, 2010)	Storing	Pool risk across time to address food and water scarcities.
	Diversification	Allocate risk across household and collective assets and resources to improve production and/or access to income opportunities.
	Common pooling	Share labour and/or income from using resources or assets of joint ownership across households
	Market exchange	Reduce risk through specialization and increase market-related opportunities.
Policy actions (Biagini et al., 2014)	Mobility	Pooling risk across space to deal with social-environmental risks.
	Capacity building	Development of human assets through training, education, dissemination to enhance ability to adapt.
	Management and planning	Institutional planning to improve natural resource management.
	Practice and behaviour	Improvement of management practices on the ground to enhance resilience.
	Policy	Creation or revision of development policies and natural resource management policies or regulations to support adaptation.
	Information	Communication tools for supporting information sharing to deal with change.
	Physical infrastructure	Creation or improvement of infrastructure to improve adaptation.
	“Green” infrastructure	Creation or improvement of soft, natural infrastructure to support adaptation.
	Warning	Monitoring tools for controlling climate and other social-environmental risks.
Financing	Development of insurance strategies or financing schemes to prepare for disturbances.	
Technology	Development of technologies to improve natural resource use.	