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Unravelling local adaptive capacity to climate change in the Bolivian Amazon: The interlinkages between assets, conservation and markets

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Abstract

This paper examines household adaptive capacity to deal with climatic change among the Tsimane', an indigenous society of the Bolivian Amazon, and explores how exposure to conservation policies and access to markets shape such capacity. We surveyed Tsimane' adults (77 men and 34 women) living in four communities with different accessibility to the regional markets. The four communities were located in indigenous territories, but two of them overlapped with a co-managed biosphere reserve. We compared households' capacity for adaptation through indicators of access to social, financial and natural assets, entrepreneurial skills and human resources. We also assessed how conservation and markets condition such capacity. Our results show that, across communities, households clustered in four groups with differentiated adaptive capacity profiles: *commoners* typically participating in community meetings, *vulnerable* characterized by low shares of adaptive capacity indicators, *leaders* typically holding community positions, and *subsidized* mostly relying in government remittances. Overlap with the biosphere reserve was significantly associated with the adaptive capacity profile of *vulnerable* households. In contrast, access to markets does not seem to be related to household adaptive capacity. We discuss relevant behavioral and structural factors for current adaptation to climatic changes and priority measures to foster local adaptive capacity in indigenous territories overlapping with protected areas.

Key words: adaptation, climate change, Latin America, market integration, protected areas.

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1. INTRODUCTION

Local capacity to adjust and respond to the consequences of climatic changes depends on the ability to mobilize a diversity of assets that range from financial and natural resources to schooling and social networks (IPCC 2014; Walker et al. 2002). Researchers have identified assets enabling such capacity in rural areas, mostly focusing on farmers. For instance, in northeastern Mexico farmers with crop insurance, access to credit, or involved in farmer organizations are more likely to recover from climate hazards than those without such assets (Eakin and Bojórquez-Tapia 2008). Similarly, in South Africa, access to credit, education, tenure security, and off-farm employment opportunities enhance farmers' adaptive capacity to climate risks (Gbetibouo et al. 2010). In Tanzania farmers' adaptive capacity is boosted by both social capital and government investment in infrastructure and agricultural technological inputs (Below et al. 2012). Thus, individual and collective assets are interlinked with the broader institutional context in which they are embedded (Brown and Westaway 2011).

Few studies have focused on indigenous communities whose adaptive capacity depends on livelihood strategies other than farming. Among these, research with hunting societies in northern Canada and fishing communities in Indonesia suggests that knowledge networks and participation in resource management and decision-making enable learning for adaptation (Armitage 2005). A study among Basarwa communities in the Kalahari Desert of Botswana shows that social ties embedded in a culture of reciprocity are key for developing successful coping strategies to deal with extreme drought events (Maru et al. 2014). Indigenous peoples' ability to deal with change is also mediated by government policies and market interventions, which might favor or hamper adaptive capacity, sometimes leading to conflicts over natural resources (Fabricius et al. 2007). For instance, the establishment of protected areas with strict regulations limits indigenous peoples' access to land and resources, and may diminish their ability to adapt (Adams et al. 2004). More adaptation opportunities might exist where conservation regulations are collaboratively defined and agreed between governments and local communities, such as in co-management regimes (Ruiz-Mallén et al. 2015a). Given that markets are often concomitant with education and health opportunities, increasing access to markets can also shape local capacity to face disturbances (Doughty et al. 2010). However, market dependence may also reinforce local vulnerability, as documented in the Peruvian Amazon where communities increasingly depend on the sale of crops to obtain extra cash to deal with climate-related crop losses (Hofmeijer et al. 2013).

In this article, we explore if and how conservation policies and/or access to markets explain households' adaptive capacity to climatic changes among the Tsimane', a society of hunter-horticulturalists living in Bolivian Amazonia, where climate change is expected to be a threat to indigenous groups directly relying on natural resources (Espinoza-Villar et al. 2009; Marengo et al. 2009; Fernández-Llamazares et al. 2015). Bolivia provides an excellent case study to explore how conservation and markets shape local adaptive capacity to climate change. First, up to 55% of the country's protected areas overlap with indigenous peoples' traditional territories (Cisneros and McBreen 2010). And second, many indigenous communities are increasingly exposed to regional markets due to infrastructure development (Paneque-Gálvez et al. 2013). Drawing on previous work (Ruiz-Mallén et al. 2015a; Fernández-Llamazares et al. 2016), we develop 10 indicators of Tsimane' adaptive capacity. We then identify household adaptive capacity profiles and examine potential associations with conservation policies and access to markets. We hypothesize that where the indigenous territory overlaps with a co-managed protected area, conservation regulations support local ability to develop new livelihoods, thus enhancing households' capacity for coping with climatic changes. We also hypothesize that integration into the market economy leads to degradation of natural resources and dependence on external resources, thus exacerbating households' vulnerability to climate change.

The importance of this study is threefold. First, we contribute to debates on indigenous peoples' vulnerability and adaptive capacity in the face of climate change by providing empirical evidence on individual and collective assets that might enhance or constrain Tsimane' ability for adaptation. Second, we cast light on how the political and economic conditions faced by the Tsimane' shape household assets (or lack thereof) for adaptation. And third, we provide relevant insights for future adaptation policy action to climatic changes in the context of biosphere reserves.

2. THE TSIMANE' IN THE FACE OF CLIMATE CHANGE

2.1. Social-ecological context

The Tsimane' are the third largest ethnic group in Bolivia's lowlands with ca. 14,000 people living in about 125 villages, mostly in the Beni Department. They live in small communities (ca. 20 households), along riverbanks and logging roads (Reyes-García et al. 2014). Despite having been contacted by Jesuit missionaries more than 300 years ago, the Tsimane' remained relatively isolated from Western influence until the mid-20th century, when the logging boom, the construction of new roads, and the arrival of highland colonist farmers gradually transformed Tsimane' ancestral territory into fragmented forests (Paneque-Gálvez et al. 2013) and political territories (Reyes-García et al. 2014). Being traditionally a non-hierarchical society, the need to acquire legal land titles pushed them to elect village representatives, who soon gained high social status within the community (Reyes-García et al. 2010). Because village representatives need to regularly attend meetings in town with local politicians, candidates are generally literate, Spanish-speaking men willing to sacrifice time from their own livelihood activities to serve community's interests.

As other Amazonian indigenous peoples, the Tsimane' are experiencing the effects of climate change in the form of increased rainfall variability and frequency of dry spells, with an overall rise in the prevalence of drought throughout the year (Fernández-Llamazares 2015). Quiroga et al. (2009) also report an increasing flood frequency throughout Bolivian Amazonia, with our study area being located in high-risk areas of fluvial flooding. Moreover, data from the two local weather stations of the National Service of Meteorology and Hydrology (SENAHMI) in the nearby towns of San Borja and Rurrenabaque show a pronounced increasing trend in the average annual temperatures in the last 50 years and a clear decreasing trend in the mean precipitation in the rainy season, accompanied by an increasing occurrence of floods (Fig. 1, see also Appendix 1).

FIGURE 1

Such climatic changes are likely to have disrupted the ecosystems upon which the Tsimane' depend. Several rivers and streams seem to be gradually drying due to changes in the hydrological regime with potential consequences in Tsimane' fishing grounds. Similarly, phenological changes have been reported in the area affecting the timing of different harvesting events (Fernández-Llamazares et al. 2015). Moreover, the effects of these changes might be aggravated considering their synergistic interaction with deforestation and forest fragmentation (Paneque-Gálvez et al. 2013; Pérez-Llorente et al. 2013).

2.2. Adaptation trends amongst the Tsimane'

Theoretical works and previous empirical evidence from vulnerability and adaptation research highlight different behavioral and structural factors influencing local people's access and use of resources for engaging in adaptation to climate change that could contribute to explain Tsimane' adaptive capacity (Adger et al. 2004; Eakin and Bojórquez-Tapia 2008; Mountjoy et al. 2013; Notenbaert et al. 2013; Thornton and Manasfi 2010). Local ecological knowledge continues to be at the core of Tsimane' livelihood (Reyes-García et al. 2003, 2013), conferring capacity for adaptation (Luz et al. 2014). Detailed ethnographic accounts show that the Tsimane' rely on such knowledge to develop a number of self-governed arrangements regulating and adjusting their harvesting activities to adapt to resource depletion and rapid ecosystem change (Fernández-Llamazares et al. 2016). Individual behaviors such as paying someone to clear forest for agriculture or buying a motorbike to access markets also increase Tsimane' adaptation options. Such behaviors allow diversification of traditional livelihoods (i.e., fishing, hunting, subsistence agriculture, gathering of non-timber forest products) towards market-oriented activities (Godoy et al. 2005; Reyes-García and Huanca 2015; Ruiz-Mallén et al. 2015b). Tsimane' adaptive capacity is also enhanced by a culture of strong social support with dynamic social networks and high participation in local governance (Reyes-García et al. 2006). Moreover, in the current context of increased recognition of the rights of indigenous peoples, some Tsimane' communities seem to be experiencing a sense of self-determination, which strengthens social capital and entrepreneurship (Fernández-Llamazares et al. 2016).

Among structural factors, the Tsimane' relative sovereignty over their territories, with recognized land rights (Bottazzi 2009), as well as their increased access to formal education and financial resources (e.g., subsidies) can improve their adaptive capacity (Ruiz-Mallén et al. 2015a). However, the different political and economic conditions in which Tsimane' communities are embedded (i.e., protected areas, access to markets) may also underlie unexplored differences in their capacity for adaptation to climate change.

3. METHODS

3.1. Sample selection

We worked in four Tsimane' communities that resemble each other in their dependence on subsistence activities (e.g., hunting, fishing), but vary in the conservation status of their lands and in their level of integration into the market economy.

Two communities are located in the Pilón Lajas Biosphere Reserve and Indigenous Territory (PLBRIT), Alto Colorado and San Luis Chico, with 46 and 20 households respectively. As they are settled within the buffer zone of a biosphere reserve, these communities co-manage resources with the National Service of Protected Areas (SERNAP), with whom decisions on land use and management are collaboratively convened. SERNAP technicians periodically visit both communities to inform local people on regulations referred to the reserve, discuss their concerns, or collect information on illegal activities observed by local people. Subsistence activities (e.g., hunting, fishing, forest products extraction) are only allowed in the buffer zone covering 58% of the reserve (SERNAP and CRTM 2009). Yet, all subsistence activities are banned in the core area (42%), posing threats to local livelihood security (Ruiz-Mallén et al. 2015a). In contrast, the two communities located in the Tsimane' Indigenous Territory (TICH), Yaranda and Dunuy, with 45 and 13 households respectively, directly take decisions on resource management. According to the law, they had the right to hunt, clear land, and extract timber and non-timber forest products for consumption from their indigenous territories, but these are inalienable through sale or rental. Moreover, commercial timber extraction needs approved forest management plans (Chumacero et al. 2009).

In each setting, one of the two communities has a higher level of integration into the market economy than the other. Alto Colorado increased its level of participation into the market economy after 2005, when a road linking two local towns was constructed in its proximity; a similar process occurred in Yaranda since 2010 when the arrival of canoe motors transformed river transport. Commercial agriculture in Alto Colorado and logging and temporal outside-employment in Yaranda are becoming important income-generating activities. The other two communities, San Luis Chico and Dunuy, remain more isolated since it takes up to 6 and 48 hours by canoe from the nearest town to reach them (Fig. 2).

FIGURE 2

3.2. Data collection

We obtained Free, Prior and Informed Consent from regional and local authorities of the four selected communities and individual informed consent before data collection. Data were collected from August to November 2013. In the PLBRIT, trained Bolivian researchers surveyed available household heads (63 individuals from 63 households). In the TICH, both household heads from randomly selected households were interviewed (48 individuals from 25 households) and responses were aggregated at household level.

We drew on previous theory and ethnographic research among the Tsimane' to identify five relevant dimensions of household adaptive capacity to reported climatic changes (e.g., drought prevalence) and to generate related indicators, including both behavioral and structural aspects. Selected dimensions (and indicators) are 1) governance and social assets (community participation and position), 2) human assets (formal education and local ecological knowledge), 3) financial assets (savings and remittances), 4) natural assets (forest and fallow lands cleared for agriculture), and 5) entrepreneurship (short and long-term investments). The selected indicators measure access to and use of different resources and other capacities for engaging in adaptation-related processes (Thornton and Manasfi 2010). We designed survey questions to gather data about each indicator from our sample (Table 1).

TABLE 1

3.3. Data analysis

For each indicator, we normalized data transforming it to values between 0 and 1. To examine the linkages between indicators across communities, we used a Principal Component Analysis (PCA). We then used the five factors from the PCA with an eigenvalue higher or equivalent to 1 to run a hierarchical cluster analysis that allowed us to identify groups of households sharing similar values in the adaptive capacity indicators (see Appendices 2 and 3). We calculated the share of positive values in each indicator and for each group of households.

We also ran a multinomial logistic regression with relative risk ratios to assess whether and how (i) conservation (settlement in the biosphere reserve) and (ii) markets (proximity to the regional market-town) were associated to adaptive capacity groups.

4. RESULTS

4.1. Tsimane' capacity for adaptation to climate change

Indicators of households' adaptive capacity showed low overall values in the four Tsimane' communities (Table 2). Adaptive capacity was mainly supported by governance and social assets (73% of households participated in community meetings), although relevant differences existed among communities. All households in both TICH villages were involved in community meetings, whereas attendance was lower in PLBRIT communities (70% of households in San Luis Chico and 58% in Alto Colorado). In contrast, the percentage of households holding authority positions was higher in PLBRIT (31%) than in TICH communities (17%).

TABLE 2

Household heads had low formal education levels (25% on average), being Alto Colorado the community with the highest share (32%) and Dunuy the one with the lowest (6%). Local ecological knowledge was similar among communities; in those with higher market access (Alto Colorado and Yaranda) 20% and 21% of households were recognized as having high knowledge about hunting, medicinal plants, and/or agriculture, and 23% and 25% in those more isolated (Dunuy and San Luis Chico).

Households in the studied communities had also limited access to financial and natural assets. On average, results show low shares of savings (13%) and remittances (7%), with only 56% of the households receiving government subsidies. Moreover, an analysis of outliers showed that two households in Alto Colorado had the highest values for savings and remittances, suggesting large social differentiation in access to financial assets (results not shown). Regarding natural assets, household clearing for cultivation was lower in forests than in fallow lands (5% and 17% on average). The use of old-growth forest for agriculture was particularly restricted in the PLBRIT villages (2%).

Finally, indicators of entrepreneurship also showed low values in both short-term and long-term investment (21% and 13% of households), but with differences among communities. In TICH, short-term investment had a zero value since no household hired people to cultivate their land, while 37% of the households in Alto Colorado and 10% in San Luis Chico reported having invested in agricultural labor.

4.2. Household adaptive capacity profiles

Through cluster analysis we identified four groups of households with differentiated adaptive capacity to climate changes (Fig. 3).

FIGURE 3

Group 1 was the largest, with 45 households scattered across the four communities. Most households (98%) participated in community meetings, so we call them *commoners*. When compared to other groups, they also displayed the highest shares in the indicator of forest cleared for agriculture (10%).

Group 2 included 21 households from all communities except Dunuy. Households were characterized by low shares of adaptive capacity indicators, and specifically indicators related to financial and social assets: savings (6%), remittances (3%), community participation (5%), and community position (19%). They presented the highest shares of local ecological knowledge (27%) and long-term investment (19%). Because of their overall low performance, we call them *vulnerable*.

Group 3 included 16 households from all communities. Households showed the highest shares in community positions (93%) so we call them *leaders*. They also had the highest shares of formal education (46%), short-term investment (38%), fallow land cleared for agriculture (35%), and savings (22%). Households in this group presented zero values in long-term investment.

Finally, group 4 was the smallest one, composed by only six households from Alto Colorado and Yaranda, the two communities closest to town. Households in this group were mostly characterized by the highest shares of government subsidies (60%), so we called them *subsidized*. Like *commoners*, households in this group participated in community meetings (100%) and, like *leaders*, had zero values in long-term investment.

4.3. Co-management and markets influence on adaptive capacity

Multinomial logistic regressions showed that overlap with the biosphere reserve was significantly and positively associated with the adaptive capacity profile of *vulnerable* households when compared to *commoners* (p=.017). Specifically, households located within the biosphere reserve had a relative risk of 12.94 times more likely to belong to the *vulnerable* group rather than the *commoner* group (holding market access constant). We did not find significant associations between any of the groups of households and access to regional markets (Table 3).

TABLE 3

5. DISCUSSION AND CONCLUSION

In this study we identify profiles of households with different adaptive capacities to climatic variability. The largest group of households falls within the profile of *commoners*, or those who can potentially use social assets (community participation) and natural resources (clearing forest for agriculture) to adapt to climatic changes. Different social assets (holding community positions) combined with human assets (education) and financial resources (savings) provide the *leaders* with a number of opportunities to face climatic uncertainty. The smallest group of *subsidized* households can potentially rely on social assets (community participation) and financial assets (government remittances) to cope with climatic changes. Finally, the group of *vulnerable* households shows the lowest shares in most of the adaptive capacity indicators. We acknowledge that some methodological limitations, such as differences in sampling strategy, omitted variable biases (i.e., health), and unweighted indicators, might have affected our results. However, we argue that our findings are indicative of the heterogeneity and social differentiation of Tsimane' households' capacity for adaptation. In this sense, our results unravel some of the behavioral and structural conditions that drive such differentiation. Moreover, findings show that the overlap with the biosphere reserve is significantly associated with the adaptive capacity profile of *vulnerable* households. Access to markets seems to be less important than conservation regulations in shaping Tsimane' adaptive capacity profiles, but it might be crucial for the adaptation of *subsidized* households, who essentially depend on government subsidies that need to be collected in local towns as cash transfers (Reyes-García et al. 2012).

Behavioral factors related to community kinship and structural conditions linked to access to forest, education and subsidies seem to be promoting heterogeneity in households' adaptive capacity. *Commoner* and *subsidized* households have a greater ability to rely on social networks, which are needed to develop pooling strategies to cope with climate risks; *commoners*, however, have more access to forest for cultivation than the *subsidized* and can thus have more opportunities to diversify their income strategies. Trade-offs between financial and natural assets indicators might exist since *subsidized* households mostly include old people and children who receive subsidies but are not able to clear forest and increase their planting area as an adaptation strategy to deal with flooding (Ruiz-Mallén et al. 2015b). In turn, the *leaders* are households with more potential for developing adaptation strategies based on diversification, market exchange, storing, and communal pooling. *Leaders'* investment in education, an attitude associated to patience (Reyes-García et al. 2009), might enhance their capacity to hold community positions, but kinship seems to be more relevant than wealth and education to be elected for such a position (von Rueden et al. 2014). Moreover, in a traditional and egalitarian society such as the Tsimane', motivations or self-perceived abilities shown by a candidate to serve community's interests are also important traits to hold a community position, and can also play a relevant role in supporting adaptation (Brown and Westaway 2011).

By contrast, *vulnerable* families show limited attendance to community meetings and do not hold community positions, thus lacking some of the social ties needed to develop common pooling strategies to cope with climate risks. These households also show low shares of savings, government remittances, and short-term investment, which suggests that adaptive capacity assets might not be independent from the broader institutional environment (Smit and Wandel 2006). Moreover, being settled within a protected area seems to further undermine the adaptive capacity of *vulnerable* households. Several works show that conservation institutions can actually constrain local agency to develop long-term adaptation strategies (Ruiz-Mallén et al. 2015a, b). Our findings seem to confirm that community members' participation in decision-making (e.g., community assemblies) is lower in the case of the co-managed PLBRIT. Our ethnographic understanding of the co-managed area suggests that most of the decision-making actually occurs through hierarchized systems of governance, with some people holding community positions and most likely benefiting from the incentives of conservation through a process of elite capture (*sensu* Platteau 2004). Participation in conservation requires the consideration of aspects of community hierarchy and power structure. Confronting such inequities in both decision-making and benefit-sharing is critical for improving future local adaptation to climate change within the biosphere reserve. Our results suggest that the Tsimane' traditional systems of decision-making are now better suited to support climate change adaptation than the current governance system of PLBRIT, which seems to undermine the adaptive capacity of a group of *vulnerable* households, reinforcing structural vulnerability at least at short-time scales. However, the increasing fragmentation of Tsimane' traditional institutions, together with their still-limited influence on regional governance issues, facilitates the presence of encroachers exploiting natural resources within indigenous territories (Bottazzi 2009; Reyes-García et al. 2010, 2012); both elements potentially hamper Tsimane' adaptive capacity mainly outside of protected areas. More research is needed to understand the linkages between conservation and adaptation further, particularly with regard to trade-offs between present and future adaptation.

In sum, our findings suggest that Tsimane' adaptive capacity to climatic changes is not homogenous across communities nor across households. We argue that such social differentiation is due to both behavioral factors (e.g., maintaining strong social networks) and structural conditions (e.g., overlap with a biosphere reserve) that differently shape households' and communities' access to economic, human, and other resources supporting local adaptive capacity to climatic changes. Future adaptation policies should embrace actions addressed to overcome such structural challenges and support adaptation among the most vulnerable households (e.g., changing subsidy provision). Furthermore, as the exposure to the co-managed biosphere reserve seems to undermine the adaptive capacity of the most vulnerable households, when planning conservation actions, management boards of protected areas overlapping with indigenous territories should engage on continuous dialogue with local communities −and not only with local leaders− to identify their needs and constraints in order to co-design effective measures for supporting local adaptation to climate change while promoting conservation.

Figure captions

Fig. 1 Climatic trends in the study area

Fig. 2 Study area

Fig. 3 Adaptive capacity indicators by group of households identified in the cluster analysis