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Links between media communication and local perceptions of climate change in an indigenous society

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Abstract

Indigenous societies hold a great deal of ethnoclimatological knowledge that could potentially be of key importance for both climate change science and local adaptation; yet, we lack studies examining how such knowledge might be shaped by media communication. This study systematically investigates the interplay between local observations of climate change and the reception of media information amongst the Tsimane’, an indigenous society of Bolivian Amazonia where the scientific discourse of anthropogenic climate change has barely reached. Specifically, we conducted a Randomized Evaluation with a sample of 424 household heads in 12 villages to test to what degree local accounts of climate change are influenced by externally influenced awareness. We randomly assigned villages to a treatment and control group, conducted workshops on climate change with villages in the treatment group, and evaluated the effects of information dissemination on individual climate change perceptions. Results of this work suggest that providing climate change information through participatory workshops does not noticeably influence individual perceptions of climate change. Such findings stress the challenges involved in translating between local and scientific framings of climate change, and gives cause for concern about how to integrate indigenous peoples and local knowledge with global climate change policy debates.

Keywords

climate change communication; climate change perceptions; ethnoclimatology; experiments in social sciences; indigenous peoples; local knowledge

1. Introduction

> “The temperatures are rising, because the Government is selling the wind”
>
> Tsimane’ elder, Bolivian Amazonia

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Indigenous and rural societies have developed first-hand, unique, and complex systems of empirical knowledge about climate variability and strategies for responding to it (Moran et al. 2006; Stigter et al. 2006). Such knowledge is of great importance in the planning of livelihood activities such as hunting, planting or harvesting (Orlove et al. 2000; Godoy et al. 2009) and may situate indigenous and rural peoples as potential allies in our quest to better understand anthropogenic climate change and its effects at local and regional scales (Salick & Ross 2009; Cochran et al. 2013). However, because the trends of climatic variability may be beyond the threshold of human perception over the course of a lifetime – at least without instrumental records (Spence et al. 2011; Weber 2013) –, indigenous peoples might not necessarily be aware of current climatic change.

Indeed, there are two predominant schools of thought with regard to the human perceptibility of climate change. On the one side, the *invisibilists* assume climatic change to be undetectable to the lay observer and invisible to the naked eye (Doyle 2009; Swim et al. 2009). They argue that local understandings of climate change are the product of the dissemination of climatic information via scientific, technical or institutional networks (e.g. through mass media or workshops) rather than based on actual observations (Mormont & Dasnoy 1995). In contrast, the *visibilists* claim that the effects of anthropogenic climate change are visible and have already been reported by local people worldwide (Riedlinger & Berkes 2001; Green et al. 2010). For these scholars, climate change can be tracked based on personal experience (Howe & Leiserowitz 2013; Weber et al. 2013). Meanwhile, a third school of thought is emerging with the argument that local reports of climate change reflect a combination of both observation and reception of climate information (Rudiak-Gould 2013). This third claim, coined *constructive visibilism*, assumes climate change not to be inherently visible or invisible, but *made* visible through its tangible features and/or external knowledge of it (Marin & Berkes 2012).

Research addressing this debate has been mostly conducted using data of a non-experimental nature (e.g. Leduc 2007; Green et al. 2010); furthermore, as pointed out by Rudiak-Gould (2014), to date, most local reports of climate change have been predominantly qualitative. To provide a complementary view to further our understanding of how climate change perceptions are constructed and reappraised, in this work, we set an experimental design. Analyzing to what extent climate information reported by local people is based on their direct experience of the environment, versus the adoption of a discourse framed by scientific and media accounts, is of relevance for scientists using local knowledge to understand climate change at the local scale (e.g. Green & Raygorodetsky 2010).

The work presented here seeks to systematically investigate the confluence of climate change observation and reception amongst the Tsimane', a highly autarkic society of foragers-farmers in Bolivian Amazonia where the scientific discourse on anthropogenic climate change has barely reached. Specifically, this work has two objectives. First, we extensively document Tsimane' ethnoclimatological knowledge, with a focus on climate change perceptions. Second, we study the possible effects of media communication on such knowledge by conducting a controlled experiment to assess changes in Tsimane' climate change perceptions before and after participating in a workshop on climate change. With up to 65% of the Tsimane' being monolingual in their own language (Godoy et al. 2007) and

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with very limited –if any– access to mass media, externally-sourced information on anthropogenic climate change is almost completely absent. This sets an ideal test-case scenario to examine if information dissemination is likely to transform local understandings of climate change as a reproduction of science popularized through the media. The setup of the experiment allowed for testing to what degree the Tsimane' local accounts of climate change are influenced by externally built awareness around it, or –rather– are purely a result of local observations.

2. Materials and Methods

2.1. Case study

Scientific evidence documents the effects of anthropogenic climate change in Bolivian Amazonia. Several studies report an increase in the mean temperatures in the region of more than 0.08°C per decade from 1900 to 2001 (Mahli & Wrigth 2004; Seiler 2009) and decreases in the average annual rainfall (Kamiguchi et al. 2006; Wenhong et al. 2008). The latter are argued to be related to the *El Niño Southern Oscillation*, which in turn could be responsible for increased frequencies of extreme events and increased cold season duration and strength (Ronchail 2005). The frequency of floods has also risen in several rivers of Bolivian Amazonia, with the whole area being increasingly vulnerable to flood risk (Quiroga et al. 2009).

These climatic impacts are believed to be a direct threat to local societies, particularly to native indigenous groups that rely directly on natural resources for their livelihoods (Nordgren 2011). Bolivian Amazonia hosts a large number of indigenous groups (INE 2012), amongst which we study the Tsimane', a society inhabiting a large territory in the southwestern Department of Beni. Predominantly hunter-gatherers, the Tsimane' also practice small-scale slash-and-burn agriculture. In this study, we worked only with villages within the Tsimane' Territory (*Tierra Comunitaria de Origen*, *TCO*, *Territorio Tsimane'*), a communal land comprising ca. 400,000 hectares (Fig. 1). The climate of the region is thermotropical with rains from October to April and a cold season from June to August, when polar winds from the South Pacific sweep through the area (Ronchail 1989). Most of the territory is covered with *terra firme* rainforest (Guèze et al. 2014).

The Tsimane' political organization, *Gran Consejo Tsimane'*, gave its informed agreement to this research. The project was especially welcomed as it matched the aims of the *Initiative of Communication for the Sustainable Development of Bolivia*, promoting the application of communication strategies for climate change adaptation (ICDS 2008). We obtained Free Prior and Informed Consent from each village and individual participating in the study. Research adhered to the Code of Ethics of the International Society of Ethnobiology.

2.2. Contextual ethnographic information

Accurate weather forecasting has long been important for the Tsimane' in order to better plan their subsistence activities. Indeed, daily weather forecasting has been shown to inform Tsimane' use of time (Godoy et al. 2009). For instance, rainfall seems to discourage hunting and fishing, due to its undermining effect on productivity. As such, accurate prediction of rainfall might increase the likelihood of successful hunting, fishing and wild plants gathering. Weather forecasting also serves a purpose in relation to agricultural activities: without irrigation systems, the Tsimane' are highly dependent on rainfall to produce crops.

Despite the number of works studying different domains of the Tsimane' Local Environmental Knowledge such as ethnobotany (e.g. Reyes-García et al. 2003; Guèze et al. 2014), accounts of their ethnoclimatological knowledge are rare. Godoy et al. (2009) provided the first and to date only descriptive account of the ethnoclimatological knowledge held by the Tsimane' assessing their ability to predict rainfall in relation to their livelihood strategies. However, records provided in this work were only partial and incomplete.

To fill these gaps and in order to thoroughly document Tsimane' ethnoclimatological knowledge, we conducted semi-structured interviews with 25 key informants (11 men and 14 women) of different ages (*min*=17 and *max*=91) in six villages. In each interview, we asked informants to explain how they forecasted weather and to describe the precise bio-temporal signals they used. We also asked them to describe any recent changes in the weather that render it difficult to predict. The interviews lasted 20 to 40 minutes each, during which we took detailed field notes. We used the responses given to inform the research design and to contextualize our results (see subsequent sections).

2.3. Research design

We used a Randomized Evaluation to assess the effects of information dissemination on the climate change perceptions of the Tsimane'. Randomized Evaluation is an experimental approach for evaluating the impact of an intervention (Duflo 2003). In our case, we aimed to assess the impact of disseminating information (through workshops) on the climate change perceptions of the Tsimane'. Several works have stressed that the individual climate change perceptions are sensitive to features of the judgement context at the moment of elicitation, such as transient local temperatures (Weber 2013; Zaval et al. 2014). In such a context, empirical studies with a randomized experimental design, such as ours, are less likely to be biased (Duflo 2003).

The sample consisted of 424 people in 12 villages in the Tsimane' Territory (Fig. 1) other than the ones where we collected ethnoclimatological data. Villages participating in the study were assigned to two groups: treatment (n=6) and control (n=6). First, we conducted a baseline (or pre-intervention) survey (Table 1) between July and December 2008. The survey included questions on individual perceptions of climate change since childhood (see Section 2.4). After the baseline survey, we conducted a set of workshops providing information on anthropogenic climate change (i.e. *intervention*). The workshops took place in the six treatment villages only, between May-June 2009. Following the workshops, between April-September 2009, we conducted a post-intervention survey with identical questions to those in the baseline survey for all 12 villages, both control and treatment. For the sake of equity, following the post-intervention survey we conducted the same set of workshops in the six villages previously assigned to the control group (i.e. *follow-ups*). Thus, at the close of the project, we had conducted the workshops in all participant villages.

2.4. Pre- and post- intervention survey

We administered identical pre- and post-intervention surveys to 424 household heads (54% women; 46% men). We asked respondents to report if they had perceived changes in five specific climatic phenomena: rainfall, temperature, flood frequency, cold season duration, and cold season strength (Table 1). These phenomena were selected based on their saliency and cultural relevance, as well as on their higher probability of manifesting notable changes in the region due to anthropogenic climate change (Fernández-Llamazares et al. 2014). In all the surveys, we asked about changes that have occurred since the informant's childhood (i.e. decade after birth). For each phenomenon, we coded responses categorically (*1* if the informants perceived an increase; *0* if they perceived no change; and *−1* if they perceived a decrease).

2.5. The intervention: workshops on climate change

The intervention consisted of a village workshop on climate change carried out initially only in the six treatment villages. The workshops provided up-to-date information on climate change and were both designed and led by a team composed of a researcher and a Tsimane' technician, who also served as translator. The workshops were first pilot-tested in a Tsimane' village not participating in this study. The team rehearsed the delivery of the workshop to ensure that the same message was consistently conveyed. Attendance to the workshops was free, informed and voluntary.

Climate change communication research identifies three steps when shaping climate change communications: *framing*, *targeting* and *tailoring* (see Bostrom et al. 2013 for definitions). The communication strategy employed here included framing and targeting, but not tailoring. We framed climate change as in the media (e.g. explaining the global and anthropogenic dimensions of the phenomenon) and we targeted the Tsimane' with the aim of reaching them directly with pertinent, salient and understandable messages. However, to emulate the media coverage of the topic, the information provided was not tailored to the Tsimane' cultural context, i.e. we did not link the information provided to their cultural values, local knowledge or belief system. While the contents of the intervention were conceived to emulate the mass media, the communication channel (i.e. workshops) was designed to mimic communication strategies launched by government agencies and NGOs in developing nations, often involving workshops (ICDS 2008; Wall et al. 2008; Godfrey et al. 2010). In this sense, the communication channel consisted on a single one-off intervention in each village, based on *in vivo* communication without relying on local understandings of the concept (Nisbet 2009).

The workshops involved three stages (see Appendix S1): (i) introduction; (ii) definition of key concepts; and (iii) technical information on the topic of climate change. The two first stages were devoted to discussing the importance of weather forecasting and to facilitate participation (see Chambers 2002 for more details). They also enabled us to collect contextual information for use in interpreting the results. The third stage consisted entirely of presenting up-to-date information on climate change as framed by the media.

The presentation of the climate change information was interactive (with the aid of simple games and discussions; see Appendix S1 for details on the workshop contents). The explanation of anthropogenic climate change as communicated through the media was done with the aid of different graphs and images obtained from mass communication media (e.g. Gore 2006). These were shown to the audience and presented in a popular language and style. After providing some insights into the notion of global warming as an anthropogenic phenomenon, we focused on the climatic changes reported in the area. In accordance with the scientific evidence of climate change in Bolivian Amazonia, the information provided for the five selected variables being assessed specified the following: (a) decreased rainfall, (b) increased temperatures, (c) increased flood frequency, (d) increased cold season duration, and (e) increased cold season strength.

Each workshop lasted on average three hours. All in all, 74 people (40 men and 34 women; 17.5% of the total sample) in the six treatment villages attended the workshops.

2.6. Data analysis

To analyze the effect of the intervention, we created a binary variable called "*agreement*" that captured whether the individual perception of the informant matched the information presented in the workshop (coded as *1*) or not (coded as *0*). With this variable, we analyzed the effect of information dissemination on climate change perceptions using bivariate and multivariate statistics, taking the individual –not the village– as the unit of analysis (see Appendix S2 for the validation of the method).

The bivariate analysis was used for obtaining preliminary estimates of the magnitude of effect of the intervention. We also ran difference-in-difference estimations using multivariate techniques. The difference-in-difference estimation consisted of a set of logistic (i.e. *logit*) regressions of our outcome variables (one at a time) against (a) a dummy for treatment [*1* = treatment; *0* = control], (b) a dummy for the time of the survey [*1* = after intervention; *0* = before the intervention], and (c) an interaction term [treatment*after]. The estimations were used to test the statistical significance of the trends observed. Even though the experimental design did not require the incorporation of any control (due to the randomization), we decided to include villages of residency to control for geographical biases. We ran the regressions using robust standard errors with clustering by village and also controlling for village of residency (with a set of dummy variables). Statistical analyses were performed with Stata 12.1 (StataCorp 2011).

3. Results

3.1. Tsimane' ethnoclimatological knowledge

The Tsimane' reported to rely on up to 43 converging biotemporal signals, defined as determining events upon which people have acquired capacity to anticipate climate fluctuations and to make short-term decisions on time investment (Appendix S4). The Tsimane' rely on such signals –be they visual (67%), auditory (30%) or tactile (3%)– to organize their livelihood activities through the year. Various sources of biotemporal signals relevant to weather prediction were also reported, mainly phyto-indicators (44%), zoo-indicators (42%), atmospheric indicators (7%), and astronomical indicators (7%).

In concordance with Godoy et al. (2009), we found that about half (54%) of the *rule-of-thumb* methods that the Tsimane' use to forecast weather are for the short-term, i.e. from one to three days into the future. In addition, certain bio-indicators (9%) are used to predict long-term weather oscillations (e.g. inter-annual weather variation) while others (37%) are used for the medium-term (e.g. seasonal variation; delays in season onset). Up to ca. 26% of the indicators reported by the Tsimane' have also been reported by other indigenous groups, both in Amazonia and in the Andean highlands (Appendix S4).

3.2. Tsimane' perceptions of climate change

Results from the semi-structured interviews indicate that the Tsimane' perceive a number of different changes in the climate. Many Tsimane' expressed concern over the climate trends in the area and their potential impacts on their livelihoods. One local informant stated that "*Streams are drying*; *even the trees die because of the drought*. *We will lose our harvests*." In fact, we found that the reduction in rainfall is perceived by the Tsimane' as the biggest challenge for their livelihoods, since hunting, gathering and farming are crucially dependent on it. That said, not all the Tsimane' perceive drought as negative. As one Tsimane' woman reported: "*Now we live much better*, *because there are almost no floods*. *Long ago*, *we had to climb over the rooftops of our house not to drown*."

Irrespective of whether change is viewed as positive or negative, the most commonly held perception seems to be that weather patterns are changing and that accurate weather forecasting is getting harder. As one local elder from one of the villages said, "*Times are changing*. *Now it is much more difficult to know when the rainy season will start*." In general, the Tsimane' do not necessarily attribute these changes to a global-scale anthropogenic phenomenon, although they recognise different human-induced dimensions of it. For instance, local peoples tend to link the recent increases in temperature with deforestation, as illustrated in some of their statements: "*Trees retain the water and cool the forest*" or "*There are less trees*, *and therefore less shadows*; *that is why it is warmer now*." Moreover, interpretations anchored in the cultural belief system, such as anger by the spirits for "*felling too many trees*," also seem to be very common.

Table 1 contains summary statistics for the weather variables measured before the intervention. Although there is considerable variation amongst individual perceptions, overall, the Tsimane' consider that: (a) rainfall has decreased; (b) temperatures have slightly increased; (c) flood frequency has decreased; (d) the cold season duration has shortened; and (e) the cold season strength has remained unchanged. The perceptions reported by the Tsimane' did not always match the changes documented in the available scientific literature. For instance, while local perceptions of temperature and rainfall aligned with reported scientific evidence, mismatches were found for flood frequency, cold season duration and cold season strength, which, in contrast to local perceptions, appear to have been increasing in the last 30 years. Furthermore, during the workshops, many informants showed skepticism and incredulity towards some of the scientific data presented, particularly for information at odds with local perceptions.

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3.3. Difference-in-difference multivariate estimates

Table 2 presents the results of the difference-in-difference multivariate estimate of the effect of the intervention on the climate change perceptions of the workshop attendees (see Appendix S3 for the results of the bivariate analysis). Cells show the coefficient for the interaction term (treatment*after), which captures whether the intervention (i.e. the workshop) has an effect on the individual perception of change in the outcome variables. We first conducted the analysis without accounting for village differences (Table 2, Column [1]). To test the robustness of our findings, we then repeated our analysis with the inclusion of a set of village dummy variables (Table 2, Column [2]).

The most important finding is that the intervention had no significant effect on perceptions of change. After the workshop, the response of the interaction variable (treatment*after) with the outcome variables amongst respondents who had and had not attended the workshop was not significant for any of the climate variables measured ($p>0.05$). This indicates that the perceptions of change do not vary significantly with increased externally-obtained scientific information. With the exception of cold season duration (for which a slightly significant effect was found when controlling for a set of village dummies; $p<0.05$), our robustness analysis suggests consistency in the main finding, as the results found in the core model [Column 1] were reproduced in several robustness tests [Column 2].

4. Discussion

We structure the discussion around the main findings related to our two objectives: (a) reporting Tsimane' ethnoclimatological knowledge; and (b) testing the effects of media communication on such knowledge.

4.1. Ethnographic insights on climate change observation

Results from the ethnographic phase suggest that the Tsimane' have a long tradition of close monitoring of climatic conditions, probably because such knowledge helps them in planning their subsistence activities (in concordance with Godoy et al. 2009). The Tsimane' hold a great deal of ethnoclimatological knowledge that (a) has *both qualitative and quantitative features*: some indicators are only descriptive (e.g., the fructification of a tree signals the end of the rainy season), while others are quantitatively measured (e.g., the altitude of a particular bird species flying over the river indicates the height of an upcoming flood); and (b) provides *an integrative and holistic forecast*: bio-temporal signals are interpreted jointly, suggesting an inter-linkage and convergence of different indicators, and framed in their traditional belief system. These results refute some previous assumptions underrating local reports of climate change as compromised or unreliable. The fact that individuals completely unaware of the scientific notion of climate change can nonetheless report change consistent with it –at least some of the time– has deep theoretical implications and calls for additional research to understand this further.

4.2. Effects of information dissemination on climate change perceptions

To our knowledge, this work is the first to empirically assess the effects of information dissemination on the climate change perceptions of an indigenous society. Our results suggest that providing climate change information to individuals, through a one-off workshop, does not noticeably influence their perceptions of climate change. Thus, local reports of climate change by indigenous peoples –at least for our test-case– do not seem to be re-shaped in the light of information provided by media or scientific accounts.

Before discussing our main finding, we highlight four methodological limitations of our experimental design. The first relates to *pseudo replication* (i.e. multiple samples from a single treatment unit), as the unit of analysis chosen (individual) differed from the randomization unit (village). To avoid pseudo replication we would have needed to run the experiment at a larger scale (e.g., with a randomized sample of some 100 villages), which was beyond our budget. The second caveat relates to *measurement error*, since our proxy figures only account for overall quantitative agreement with trends reported in scientific studies. A more refined analysis would have also included qualitative elements and scales, which are generally of great value for the local interpretation of climatic changes. The third limitation arises from the *self-selection bias* occurring when participation in the intervention is voluntary (Ziliak & McCloskey 2008). We accounted for this by not stating *a priori* the topic of the workshops, in order not to bias participation by attracting only concerned individuals. However, we cannot disregard the possibility that only people with particular characteristics chose to participate in the workshops. The final caveat relates to the two month delay between the intervention and the post-intervention surveys. Ideally, to assess information retention complications, we should have assessed climate change perceptions both immediately after the workshop and two months later, but we could not do so for budgetary reasons. Yet, our study is still meaningful as it shows it is possible to assess the impact of a climate change communication at the medium term, in line with Howell (2014). To our knowledge, this approach has never been tried before, so our study opens the way for promising future research in this field. It is important to note that the results found in this research cannot be extrapolated to other types of intervention than that here presented (see Section 2.5), nor do they directly inform about the effectiveness of other types of interventions, such as those composed of multiple exposures to new information.

Despite these potential biases, our results sit well within the growing bulk of the literature devoted to investigating media framings of climate change (Lorenzoni & Pidgeon 2006; Goodwin & Dahlstrom 2014; Moser 2014). According to such work, media communications often fail to present climate change information in a locally salient and credible way (i.e., tailored to the local context). As a result, media framings are unlikely to distort local observations of climate change because their coverage of the topic is usually too general or decontextualized from local realities, failing to penetrate the wide epistemological gap between the information portrayed and the one perceived, particularly in indigenous cultures (Hulme 2009; Marin & Berkes 2012). Other than the epistemological gap between the two knowledge systems, another factor influencing uptake of science is trust (Hmielowski et al. 2013). For example, Rudiak-Gould (2011) notes that trust in scientific experts may be as important in determining how communications about climate change are received as whether or not the information presented is integrated into local beliefs. This aligns well with the more general research on climate change communication, which has shown that people's trust (or lack thereof) in scientific experts hold considerably more sway over their

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beliefs in climate change than previously thought (Goodwin & Dahlstrom 2014). Thus, if externally-generated knowledge on climate change is perceived as at odds with local understandings and the convener is perceived as an outsider, this might lead to a lack of credibility amongst stakeholders (Cash et al. 2003). Such a hypothesis is consistent with our results for the variables where local perceptions of change did not match the information presented and agreement was low (e.g. flood frequency or cold season strength).

The climate change information provided did not seem to have reached the targeted population. Potential explanations for this result could be the lack of trust between the audience and the convener or a certain degree of *epistemic vigilance* (*sensu* Sperber et al. 2010) from the people attending the workshops, who might have been skeptical about purported experts pressing their views upon them. The term *climate change*, as presented in the workshop, stood for different local climate changes that the Tsimane' did not necessarily interpret as part of the same phenomenon. This epistemological misfit is an important extension of the debates on (a) what counts (and what does not) as legitimate knowledge in the context of global anthropogenic climate change (see Moore 2001); and (b) the well-recognized tendency of climate change studies to underrate traditional sources of knowledge (as pointed out by Simpson 2004).

Given these results, we posit the need to distinguish between the *experiential knowledge* acquired through daily observation and the *descriptive knowledge* that one gains through the uptake of scientific information. Our results align with those of previous studies depicting how experiential knowledge will often override descriptive knowledge (Weber et al. 2013; Zaval et al. 2014; Patt and Weber 2014). For example, reporting in the workshops that the patterns of extreme events had increased globally did not prevent people from showing scepticism towards this information, or from later describing a local decline in the frequency of floods. Two issues are relevant here: whether externally given information (a) is converted into a locally relevant form; and (b) corresponds with local observations. Where external information and local perceptions are not consistent, reporting of change is likely to remain the same after information dissemination (e.g. flood frequency). Importantly, our finding provides evidence that, at least in this instance, claims of indigenous peoples mechanistically repeating a well-studied discourse as framed by science communication when they report local manifestations of anthropogenic climate change are not justified.

Moreover, these examples seem to confirm the profound and symptomatic mismatches between globally-framed media accounts and locally-detailed understandings of climate change by indigenous peoples (Marin & Berkes 2012). For instance, during one interview, a Tsimane' informant, when being asked about the reason behind the recent increase of temperatures, stated that the Bolivian Government was *"selling the wind."* Such a rhetoric affirmation, consonant with the carbon dioxide trading mechanisms and the REDD+ debate in Bolivia, proves to be illustrative of the challenge and difficulty of integrating concepts from the paradigm of scientific knowledge into other knowledge systems stemming from heterogeneous worldviews, mental models and epistemologies, and/or *vice versa* (Brodt 1999; Berkes 2009).

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Along the lines of Rudiak-Gould's (2014) work, we posit that, while the Tsimane' perceive climate change, it may be beneficial for them to understand the scientific construct of such phenomenon. Scientific data predicts larger levels of climate change than what the Tsimane' observe. Furthermore, scientific and local understandings of the drivers of change differ, which may hamper local receptivity regarding adaptation strategies (Moser 2014). Results of this work open promising areas of research that can be of particular and immediate use in climate change communication practice. For instance, some questions rife for further study include: (a) How can climate change information be made locally relevant in different epistemic/cultural contexts?; (b) How do local peoples attribute causes to observed changes?; and (c) How can this attribution be used to benefit public engagement on adaptation in contexts where there is no pre-existing knowledge of the scientific discourse of climate change?

5. Concluding remarks

The role of indigenous peoples in global climate policy has already been widely discussed (see Thomas & Twyman 2005), yet if indigenous peoples are to be engaged in global climate negotiations (as proposed, see Schroeder 2010), a first step requires translating both local and scientific interpretations and understandings of climate change into a common language (Riedlinger and Berkes 2001). Previous research has shown that the way people perceive changes influences how they respond to them (Spence et al. 2011), and that in the context of climate change this means that people's perceptions can determine their behaviour towards proposed mitigation actions (Patt and Weber 2014). In this sense, if tailored knowledge (i.e. salient, legitimate and credible) is more likely to be influential (Bostrom et al. 2013), current framings of climate change in the media need to be rethought. As Cash et al. (2003) perceptively state, linking knowledge to action requires not only open channels of communication between the different stakeholders, but also that the participants in the resulting conversation actually *understand each other.* Attempts at successful translation between local and scientific framings of the concept of climate change -and its implications- need to be taken more seriously if we want to mobilize both scientific and local knowledge to the critical and compelling arena of climate change adaptation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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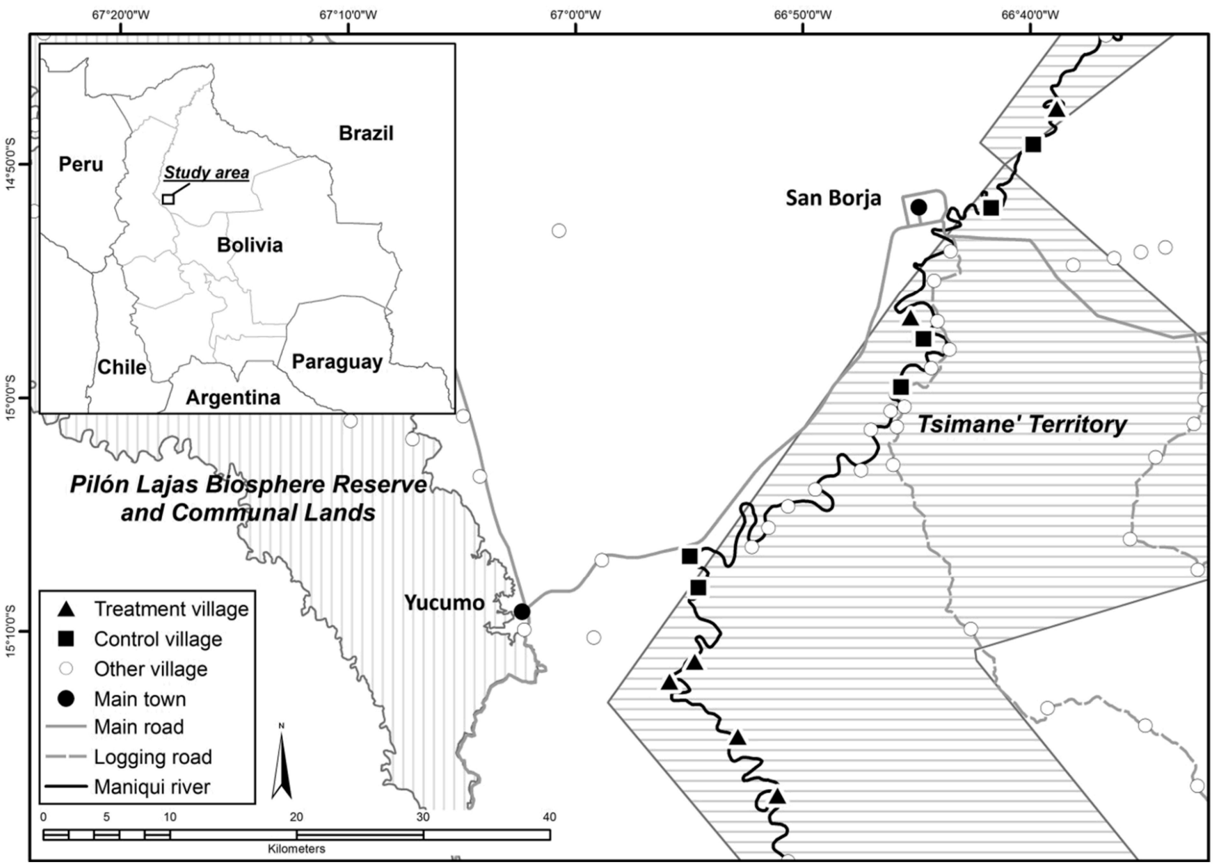

Fig. 1. Region under study

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Table 1
Research Design and summary statistics of variables

A. Outcome variables	Description	Frequency table		
		Decrease	Same	Increase
Rainfall	Reported change in rainfall	50%	42%	8%
Temperature	Reported change in temperature	20%	45%	35%
Flood frequency	Reported change in flood frequency	59%	27%	14%
Cold season duration	Reported change in the cold season duration	42%	43%	15%
Cold season strength	Reported change in the cold season strength	45%	40%	15%

B. Other variables of interest	Description	Descriptive statistics			
		Mean	SD	Min	Max
Age	Age of the interviewee	36.98	16.17	16	85
Sex	Sex of the interviewee	Male=54% Female =46%			
Village Treatment After	Village where the interviewee lives Treatment group (0=Control; 1=Treatment) Interviewed before (0) or after (1) the intervention				

C. Schedule	Date
Baseline Survey	July – December 2008
Intervention: Workshop in treatment villages	May –June 2009
Post-intervention Survey In control villages In treatment villages	 April – June 2009 July–September 2009
Follow-up: Workshop in control villages	September – November 2009

D. Sample size	Control	Treatment
Villages (n=12 total)	6	6
Individuals (n=424 total)	350	74

Note: For all the outcome variables: −1=decrease; 0=same; 1=increase. All information refers to changes since the age of childhood (i.e. decade after birth).

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Table 2

Difference-in-Difference multivariate estimations: Effects of intervention on outcome variables (n=848)

Outcome Variable	Robustness	
	[1]	[2]
Rainfall	−0.185 (±0.371)	−0.273 (±0.454)
Temperature	0.431 (±0.390)	0.523 (±0.648)
Flood frequency	−0.691 (±0.622)	−0.106 (±0.466)
Cold season duration	−1.022 (±0.559)	−1.142 (±0.501)*
Cold season strength	−0.308 (±0.462)	−0.353 (±0.536)

Note: Outcome variables (previously transformed into *agreement* measures, see Section 2.6) logistically regressed against *treatment* and *after* binary dummy variables, and interaction of treatment*after. Coefficient reported (Standard Error in parenthesis) refers to the difference-in-difference coefficient (treatment*after). Treatment = 1 if the person received treatment; treatment = 0 if the person was control. After = 1 if year 2009 (after intervention); after = 0 if year = 2008 (before intervention). [1] Raw model. Controls for [2] A full set of village dummy variables.

* significant at ≤0.05 and ≤0.01, respectively.

** significant at ≤0.05 and ≤0.01, respectively.

See Table 1 for definition of variables.