8

LOCAL PERCEPTIONS OF CLIMATE CHANGE IN THE CONTEXT OF SOCIOECONOMIC AND POLITICAL CHANGES IN A HIGH ANDEAN COMMUNITY FROM THE ARGENTINE PUNA

Andrea E. Izquierdo and Anna Schlingmann

Introduction

Indigenous Peoples and local communities in isolated mountainous areas are among the most vulnerable groups to global climate change impacts (Beniston et al., 1997; Beniston, 2003, 2005; IPCC, 2022). This is the case of pastoralist communities in the Argentine Dry Puna, part of the High Andean Plateau at altitudes between 3,200 and 6,700 m. a.s.l. Most climate scenarios for this alpine ecosystem predict a 2°– 4°C temperature increase by the end of the 21st century (Urrutia & Vuille, 2009). While models uncertainties are greater with regard to precipitation trends, the most plausible scenarios predict a decrease in precipitation and cloudiness for the subtropical Andes (Vuille et al., 2008), as well as decreasing water availability and longer dry seasons (Buytaert et al., 2010). This coincides with dendroecological reconstructions of water balance and ecosystem productivity over the past 30 years (Carilla et al., 2013) and centuries (Morales et al., 2015).

At the same time, the Argentine Puna is undergoing rapid socioeconomic changes (Izquierdo & Grau, 2009; Izquierdo et al., 2018a). Historically a very remote area, governmental investments since 1983, when the current democratic period started, have fostered the expansion of transport and communications infrastructure, mainly of road networks and most recently of internet coverage, thereby increasing mobility and access to information, markets, governmental institutions, and labor (Izquierdo et al., 2018a). Extreme environmental conditions in the Puna have determined past patterns of human settlement and land use. Since the establishment of the first inhabitants, estimated about 11,000 years ago, the main subsistence activity in the area has been pastoralism (Martınez, 2018; Olivera, 2018), primarily of sheep and llamas (Quiroga Mendiola & Cladera, 2018). At present, the main growing economic activity is mining, particularly lithium extraction (Izquierdo et al., 2015, 2018a). Lithium reserves in the Argentinian Puna are part of the so-called "lithium triangle"—the largest global reserve of lithium, which extends across northern Chile,

DOI: 10.4324/9781003356837-11

southwestern Bolivia, and northwestern Argentina. Interest in lithium has boomed in recent years due to the rising demand for cell phones and electric vehicle batteries (Dresselhaus & Thomas, 2001; Scrosati & Garche, 2010; Gielen, 2021). While prospects for lithium mining are promising, its environmental consequences are poorly understood (Wanger, 2011; Izquierdo et al., 2015). The future economic, social, and environmental impacts, and the (un)fair distribution of benefits and negative consequences from the lithium industry will highly depend on whether or not local communities will have a say in the decision-making process surrounding lithium extraction activities (Prior et al., 2013; Jerez et al., 2021).

Climatic, socioeconomic, and political factors (e.g., demographic changes, politics, globalization) have widely influenced and transformed local living conditions and livelihoods. In the study area, increased connectivity and access to off-farm work have led to rural–urban migration, a decrease in pastoralist activities, and related land-use changes (Izquierdo & Grau, 2009; Izquierdo et al., 2018a). Climate change adds an additional challenge to the socioeconomic complexity, which offers both opportunities and risks. Climate change and socioeconomic and political changes interact in non-linear ways and can amplify or attenuate the overall impacts on the local environment, and hence, affect local livelihoods and living conditions of local communities and Indigenous Peoples in diverse and unpredicted ways (Pörtner et al., 2021). Vulnerability and resilience to climate change are therefore not only defined by exposure to climate hazards, but also by the changing socioeconomic conditions of the system of concern, which determine its sensitivity and adaptive capacity. Consequently, research on the vulnerability and resilience of social-ecological systems has increasingly recognized the need for multiple stressor approaches by considering all relevant drivers instead of focusing on a single stressor (e.g., Reid & Vogel, 2006; Tschakert, 2007; Räsänen et al., 2016).

Due to their strong dependence on nature through their natural-resource-dependent livelihoods, culture, and place connection, Indigenous Peoples and local communities can be keen observers of environmental changes in their surroundings (Reyes-García et al., 2016). They also know best the context-specific positive and negative impacts of socioeconomic, political, and environmental changes that drive and shape changes in local livelihoods, living conditions, including culture and worldviews (Salick & Ross, 2009). Nonetheless, several studies underline the persistent lack of recognition of Indigenous and local knowledge into research and policy agendas (Ford et al., 2016; Yap & Watene, 2019; Chakraborty & Sherpa, 2021; Reyes-García et al., 2022). The assessment of local reports and evaluations of the relative importance of such drivers of local changes based on their negative and positive impacts is crucial to understanding people's concerns, viewpoints, and well-being aspirations; and – based on that – to improve future adaptation planning by bridging local, Indigenous, and scientific knowledge (Tengö et al., 2017; Reyes-García et al., 2019).

In direct response to this need, this chapter assessed the perceptions of Kolla-Atacameños People and local communities in an area from the Argentine Puna ecoregion. The chapter focuses on understanding the relative importance of climate change in relation to other drivers that shape changes in and imply impact on the local environment, livelihoods, and living conditions. For this, we (1) describe observed changes in the local environment, livelihoods, and living conditions, (2) identify the main drivers of such changes, (3) assess the relative importance of each of the drivers regarding their impacts from a local perspective, and (4) determine the associated positive and negative local impacts of such drivers. The chapter ends with a discussion of the potential differences in prioritization between Indigenous Peoples and the local community in a region of the Argentine Puna and the research and policy agendas.

Methodology

Study area

This study was carried out in an the Argentine Puna in the department of Antofagasta de la Sierra (between 25°10′ and 26°55′S; and 66°30′ and 68°35′ W) in the province of Catamarca (Figure 8.1). The department of Antofagasta de la Sierra is an area of roughly 29,000 km^2 with a population of about 2,000 inhabitants according to the latest published national census (INDEC, 2022). The capital and market center of the department is the homonymous town Antofagasta de la Sierra. In addition to the capital, there are only three more villages in the department: El Peñon, Antofalla, and Los Nacimientos, and some dispersed settlements, permanently or semi-permanently inhabited, locally known as 'puestos'. Puestos are generally associated with 'vegas', a type of key wetland which provides main ecosystem services such as freshwater provision, carbon storage, and pastures for livestock (Izquierdo et al., 2018b).

The Argentine Puna is part of the High Andean Plateau, with an average altitude of 3,500 m.a.s.l. The area is an arid climate region according to the Köppen-Geiger climate classification, with an annual mean temperature of 8°C and annual precipitation between 100 mm in the northeast and 400 mm in the southwest. Most rainfall concentrates in the summer months from December to March (Burkart et al., 1995).

The region of Antofagasta de la Sierra was already inhabited 11,000 years ago by the Diaguitas and Kolla-Atacameños Indigenous peoples (Martinez, 2018). The first inhabitants were hunters and gatherers organized in small groups which concentrated mainly in ravines and meadows. Currently, the area is inahited by Indigenous Peoples who recognize themselves as Kolla-Atacameños and local community who recognizee themselves as "criollos". Their main livelihood is the traditional

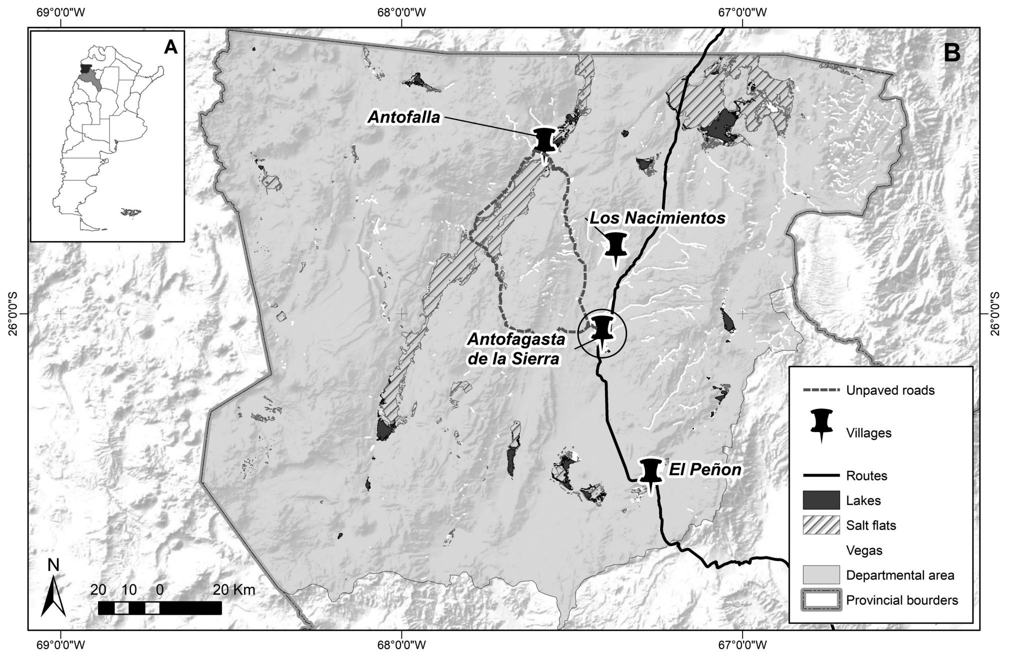

Figure 8.1 Study site location in Argentine and Catamarca borders (A) and in the Antofagasta de la Sierra department (B).

pastoralism of llamas and sheep. Until recently, people in the area practiced transhumant pastoralism, keeping the livestock in pastures at lower altitudes, near the main houses, during the winter and moving it to higher and remote fields during the summer months, a practice well adapted to the extreme climate and environmental conditions of the Puna. However, traditional pastoralism in the Argentine Puna is decreasing. First, current climatic trends toward a decrease in humidity and an increase in drought events imply adverse and threatening climate conditions for traditional livelihoods (Morales et al., 2015, 2023). Second, due to different factors such as increasing employment in mines, easier access to technologies and amenities in urban areas, and resulting rural–urban migration, pastoralism is decreasing, and transhumance is being abandoned (Izquierdo et al., 2018a). Although the region has been important for mining activities since the Jesuits' time (1608–1767), in recent years, the mining industry has experienced an unprecedented boom, especially due to a growing interest in the lithium reserves in the area (Izquierdo et al., 2015, 2018a).

Methods

Data collection took place in the town of Antofagasta de la Sierra, and the three villages El Peñon, Antofalla, and Los Nacimientos. We followed the LICCI protocol (Reyes-García et al., 2023) and divided the research into two phases. In the first phase, from October 2019 to February 2020, we used qualitative data collection methods to identify perceived changes in the local environment, livelihoods and living conditions, and the associated drivers of these changes. We conducted a total of 23 semi-structured interviews (SSI) and three focus group discussions (FGD) with three to seven participants. We used quota sampling for the categories of gender, age group, and livelihood (expertise) to select participants. SSI and FGD lasted between 1 and 1.5 hours and were conducted in Spanish, the national language, spoken by all participants. We first asked generally about any observed changes, and for each reported change, we asked about the potential drivers of such change. We then asked explicitly about changes and their drivers in the local natural environment (atmospheric, physical, and life system, including flora, fauna, and human activities), with a special focus on climate-driven changes. Using information from the interviews, we identified five main drivers of local change: climate change, technology, transport, mining, and migration.

In the second phase, we conducted 78 surveys to collect individual perceptions of positive and negative impacts that arise from the five main drivers of change. All interviewees were household heads. The number of selected household was proportional to the population size of each village. Households were selected based on simple random sampling, while household heads were selected based on convenience quota sampling to achieve an approximately even distribution across gender and age groups. First, we assessed how the interviewees perceived the relative importance of the five main drivers of changes in the local environment, livelihoods, and living conditions. We did so by asking participants to rank the different drivers of change on a scale from 1 (most important) to 5 (least important), according to the impacts they have on their livelihoods and living conditions. Then, we asked if those drivers imply any positive or negative impacts, and which ones.

Results

Observed changes in the local environment, livelihoods, and living conditions, and their main drivers

Through the semi-structured interviews, we identified 31 changes in the local environment, livelihood, and living conditions. Reported changes include changes in precipitation and snowfall (e.g., fewer but more extreme rainfalls), changes in water availability (e.g., a decline in the water volume in streams and wetlands), changes in the pastures (e.g., a decrease in the quality and quantity), changes in the behavior of wild fauna (e.g., increase in the cougar predation on livestock), changes related to invasive species and pests (e.g., the appearance of weeds or insects), and changes related to housings (e.g., increasing roof damages). Twenty-four of those reported changes were directly linked to climate change. For example, a decline in the size of wetlands was directly associated with a decrease in snowfall and rainfall, while damaged roofs were linked to more frequent heavy rainfalls. Other observed changes include higher temperatures and sunshine intensity. Some climate-related changes relate to soil (e.g., greater and faster drying) and ice (e.g., less ice formation or thickness). Informants also reported changes in livestock and crop cultivation, mainly a decrease in pasture and crop productivity as a direct consequence of higher aridity. Seven observed changes were not associated with climate change but with socioeconomic and political drivers such as technology, infrastructure, mining activities, and rural–urban migration. For example, people related new pests and insects with the arrival of trucks that bring products from other areas.

In total, we identified five main drivers of change on the local environment, livelihoods, and living conditions in the study area: (1) the arrival of technology (i.e., electricity, water network) and communications infrastructure (i.e., phone coverage and internet connection) (hereafter technology); (2) improvements in the transport system and road networks (i.e., road paving, traffic) (hereafter transport); (3) extension of mining activities (hereafter mining); (4) rural–urban migration (hereafter migration); and (5) climate change (Table 8.1).

Ranked importance of main drivers of local changes

When asked about the relative importance of each of the five main drivers regarding their impacts on the local environment, livelihoods, and living conditions on a scale from 1 (most important) to 5 (least important), interviewees evaluated changes generated by technology and transport as the most important drivers of change (weighted mean 1.9, respectively), followed by mining (weighted mean 3.4), climate change (weighted mean 3.5), and rural–urban migration (weighted mean 4.4).

Table 8.1 Reported changes in the local environment, livelihoods, and living conditions related to climate change and unrelated to climate change and the number of times each was mentioned in the semi-structured interviews. The direction of change is shown with arrows indicating (increase), (decrease), (later), (temporality changes)

Reported changes in the local environment, livelihoods, and living conditions.	*System*	*Direction*	*Times mentioned*
Climate change related			
Changes in the intensity/strength of rainfall (not further specified).	Atmospheric	↑	12
Changes in the temperature during the day.		↑	9
Changes in sunshine intensity.		↑	6
Changes in the amount of snowfall.		↑	6
Changes in the timing (onset or end) of seasons.		→	5

(*Continued*)

Table 8.1 (Continued)

Reported changes in the local environment, livelihoods, and living conditions.	*System*	*Direction*	*Times mentioned*
Changes in the length/duration of rainfall events.		↓	3
Changes in the amount of rainfall in a given season.		↓	8
Changes in the length/duration of drought.		↑	4
Changes in mean rainfall (not further specified).		↓	7
Changes in temporal distribution of rainfall.		↔	5
Changes in the predictability of rainfall.		↑	8
Changes in mean temperature (not further specified).		↑	7
Changes in freshwater availability.	Physical	↓	9
Changes in freshwater transparency.		↓	1
Changes in river/stream water flow, volume, level, and/or depth.		↓	5
Changes in the thickness of ice in lakes or rivers.		↓	1
Changes in wetland surface.		↓	4
Changes in river/stream water flow, volume, level and/or depth.		↓	4
Changes in soil evaporation.		↑	7
Changes in the abundance of terrestrial fauna (mammals, birds, reptiles, insects, etc.).	Life	↓	2
Changes in pasture productivity.		↓	11
Changes in crop productivity/yield.		↓	5
Changes in the frequency of crop 'pests' (insects, birds, larvae, etc.).		↑	2
Changes in the frequency or occurrence of weed species stated as invasive.		↑	2
Unrelated to climate change			
Changes in infrastructure (routes, transport).	Physical	↑	4
Changes in public services access (electricity, internet, freshwater network).		↑	6
Changes in herbivory interspecific competition (livestock vs. vicuña).	Life	↑	3
Changes in the abundance of terrestrial fauna (mammals, birds, reptiles, insects, etc.).		↑	22
Changes in predation rates (livestock predation by cougar).		↑	13
Demographic changes (rural–urban migration).		↑	7
Changes in availability of paid jobs (mining).		↑	5

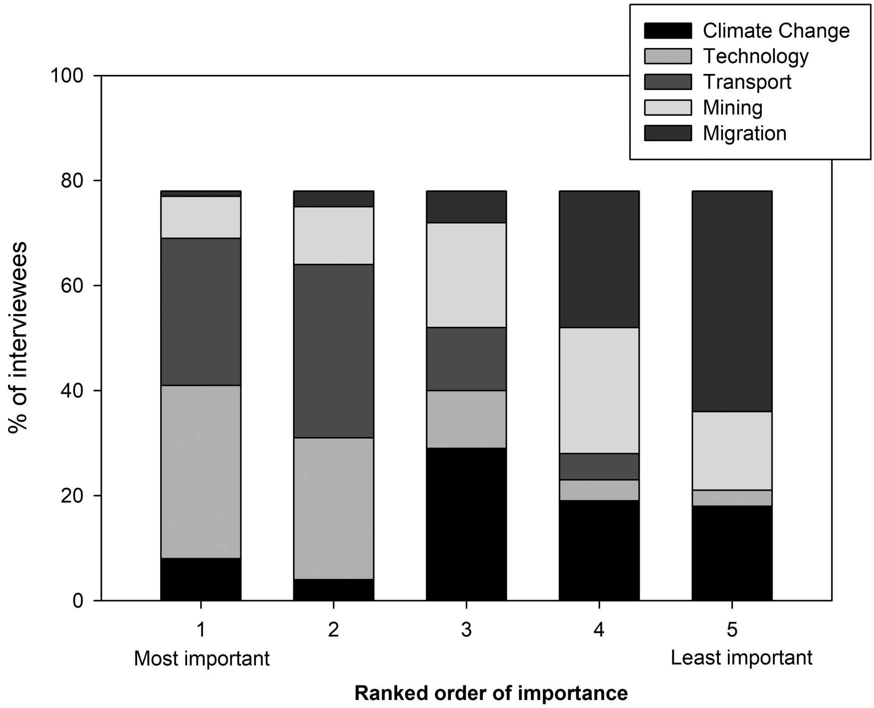

Figure 8.2 Ranking of the different drivers of change according to locally perceived impact on local livelihoods.

While technology and transport were more often ranked under the categories 'most important' (rank 1) and 'very important' (rank 2), migration was the most frequent driver ranked under the category 'least important' (rank 5). Climate change was most often ranked as 'medium important' (rank 3), while mining was in most cases considered as 'less important' (rank 4). Specifically, 42% of the interviewees considered technology as the 'most important' and 35% as 'very important' driver, while 37% of the interviewees ranked transport as 'most important', and 42% as 'very important'. On the other hand, 33% of the interviewees evaluated migration as 'less important' and 54% as 'least important'.

A total of 85% of informants ranked climate change as medium to least important, with a clear tendency toward 'medium important' (37%). Similarly, 76% of the interviewees ranked mining between 'medium important' and 'least important', with the highest frequency under 'less important' (31%) (Figure 8.2).

Perceived positive and negative impacts associated with the five main drivers of local changes

The results show that study participants considered drivers of positive changes as more important than drivers of negative or ambiguous (positive and negative) changes. Technology and transport were overwhelmingly evaluated as drivers of positive changes – by 95% and 96% of the interviewees, respectively (Figure 8.3). In turn, climate change was mostly perceived as a driver of local changes with negative impacts (in 90% of the interviewees), with only 9% of the respondents

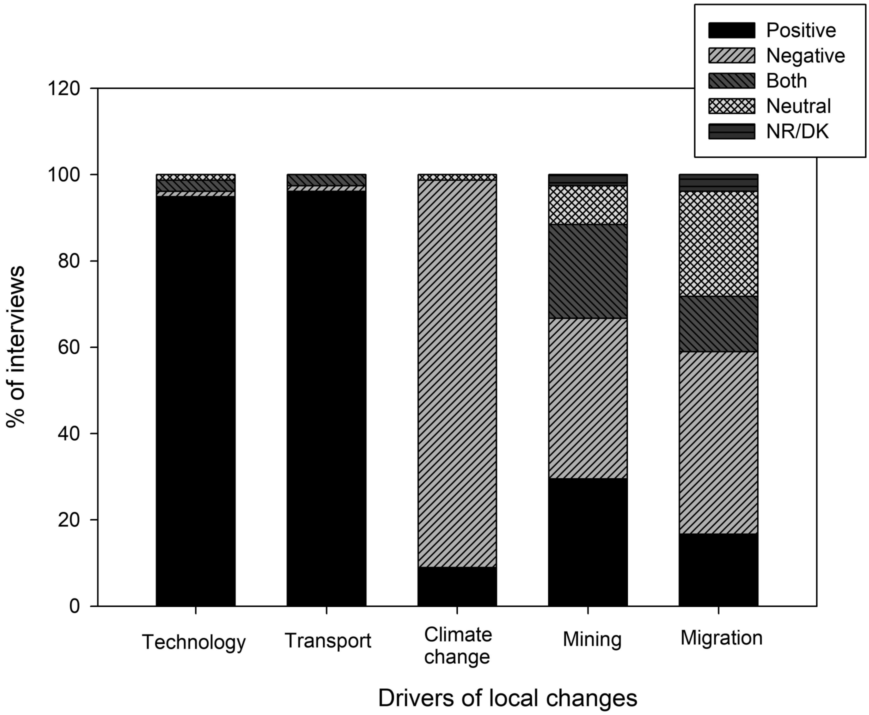

Figure 8.3 Distribution of interviewees' responses regarding the impacts generated by each driver of change in four different directions: positive, negative, both, and neutral; and percentage of non-responders.

perceiving climate change as entirely positive, and 1% of the respondents considering as both, positive and negative (Figure 8.3). Mining was classified more heterogeneously: 37% of the interviewees perceived it as a driver generating negative changes, 29% as a driver of positive changes, 22% as a driver of both negative and positive changes, 9% considered it as neutral, and 3% of the interviewees did not respond or didn't know what to answer (NR/DK). The impacts of migration were considered by 42% of the interviewees as negative, by 24% as neutral, by 17% as positive, and by 13% as both, negative and positive. 4% of the interviewees did not respond or didn't know what to answer (NR/DK).

The different positive and negative impacts reported by interviewees for each driver of local changes are presented in Figure 8.4. When discussing the benefits of technology, interviewees argued that new technologies (e.g., mobile phones, internet) are the best and easiest means of communication (53% of the interviewees) and increase their connectivity with the world, thereby allowing them to meet and make themselves known to other cultures (41%) (Figure 8.4).

The positive impacts of transport included eased mobility (36% of the interviewees), better access to and from the region (29%), better conditions for commerce (23%), and regional development (8%) (Figure 8.4). One interviewee reported exclusively negative impacts referring to the increase in traffic, which disturbs the characteristic peace and tranquility of the region (Figure 8.4).

Among the negative impacts of climate change, interviewees reported a decrease in water availability (69% of the interviewees), harsher living conditions (15%), and other impacts such as higher unpredictability of rainfall or health impacts (4%) (Figure 8.4). The only perceived benefit

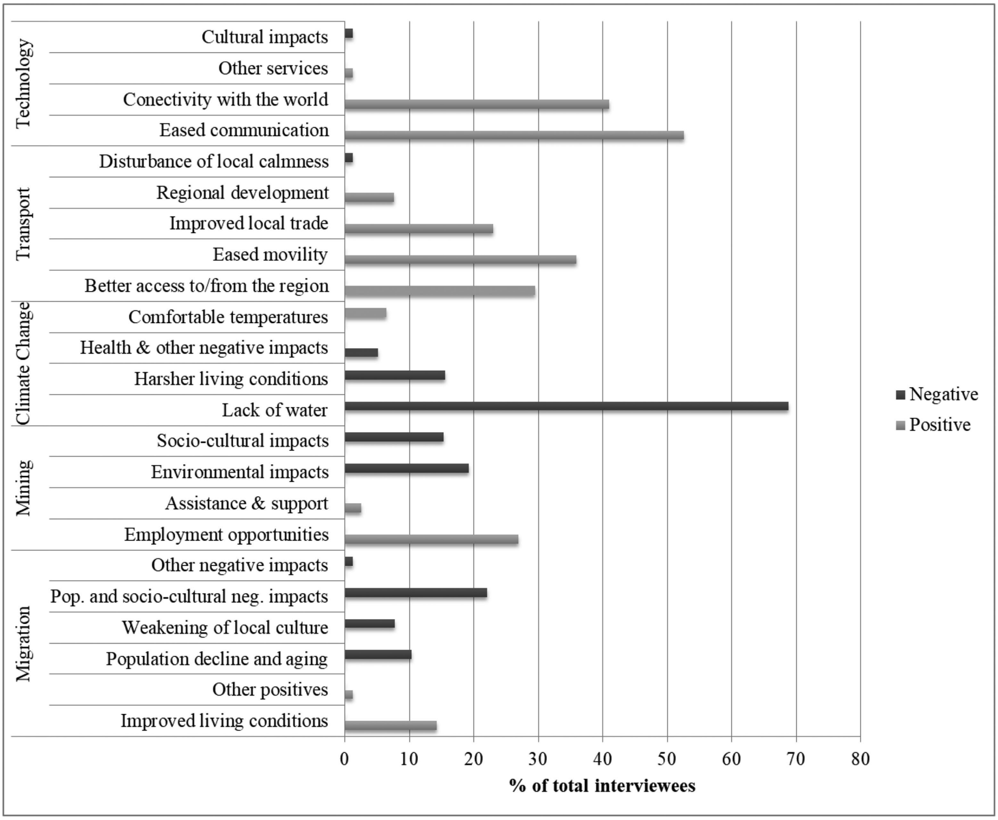

Figure 8.4 Perceived negative and positive impacts of local changes associated with technology, transport, climate change, mining, and migration.

of climate change was that the increase in temperature makes people feel less cold, so they can wear less clothing (6%).

The most heterogeneous responses were provided for the potential impacts and benefits of mining. Interviewees perceived the increased employment opportunities (27% of the interviewees) and assistance (through corporate responsibility programs) (3%) as positive, while environmental (19%) and socio-cultural (15%) impacts were perceived as negative (Figure 8.4).

Responses with respect to migration were also heterogeneous. Some interviewees reported exclusively positive impacts – mainly the improvement of living conditions (14%) and the value of the cultural exchange (1%) –, while others focused on negative impacts, such as population aging and the loss or weakening of local culture (42%) (Figure 8.4).

Discussion

Results show that, although Kolla-Atacameños People and local communities Antofagasta de la Sierra reported more observations of changes in the local environment, livelihoods, and living conditions that are directly driven by climate change, they considered technology and transport as the most important drivers of local changes, while climate change, mining, and migration were considered less important. At the same time, the drivers of changes perceived as most important (i.e., technology and transport) have mostly positive impacts according to interviewees, while less important drivers are associated with rather negative (i.e., climate change) or ambiguous impacts (i.e., mining and migration). This does not only show that the Kolla-Atacameños People and local communities in the study area recognize changes in the living conditions that are directly linked to technology and transport as beneficial, but also that such improvements play a major role and are a priority for them.

The apparent contradiction between the number of reported changes associated with climate change and the lower relative importance people assign to it as a driver of local changes might be due to the fact that parts of the data collection specifically focused on climate change and its impacts on the local environment and livelihoods. In this regard, our results could be understood as a certain discrepancy between the current concerns of Indigenous Peoples and local communities and the scientific agenda. Our results show that Kolla-Atacameños People and local communities in Antofagasta de la Sierra experienced changes and impacts in their local environment, livelihoods, and living conditions from multiple socioeconomic and biophysical drivers. Other studies confirm that climate change, although experienced, is not necessarily perceived as the most impacting local driver, but one among many (e.g., Nyantakyi-Frimpong & Bezner-Kerr, 2015). Hence, our study highlights that climate change impacts are entangled in complex and interacting socioeconomic, cultural, and political processes and dimensions, and need to be addressed as such (Adger et al., 2013; Ensor et al., 2019). Increasingly, climate change research has acknowledged this need and called for more integrated and holistic approaches that frame and understand climate change impacts, vulnerability, and adaptation in a broader social, economic, and political context of multiple drivers, including stressors (e.g., O'Brien et al., 2004; Bennett et al., 2016), resulting in a recently growing number of publications on the topic (Räsänen et al., 2016). Our results reinforce this trend in which a growing number of case studies around the world acknowledge and assess local impacts and adaptation beyond just climate change (e.g., McDowell & Hess, 2012; Porcuna et al. (2024); Reyes-García et al., 2024).

Understanding, challenges, and opportunities derived from multiple drivers, including socioeconomic, political, and environmental transitions, are especially relevant for Indigenous Peoples and local communities who used to live in very isolated and harsh living conditions in mountainous regions and are now confronting unprecedented transformations in the context of globalization (Dhakal & Kattel, 2019). On the one hand, it is recognized that globalization brings some positively evaluated benefits, such as technological advances and new income opportunities in the mining and tourism sector (Izquierdo et al., 2018a). On the other hand, the lower relative importance assigned to climate change is also found in other studies (e.g., Nyantakyi-Frimpong & Bezner-Kerr, 2015). In fact, it could be a co-product of simultaneous trends toward off-farm work and migration that lowers climate change vulnerability by reducing the direct dependency on natural resources (Antwi-Agyei et al., 2014; Cannon, 2014). However, most benefits come along with some trade-offs that should not remain without critical reflection. In this regard, the circumstance that Kolla-Atacameños People and local communities in the study area evaluate changes that improve their lives of higher relevance should not downplay and detract from the fact that they express serious cultural, social, and environmental concerns related to climate change, mining, and migration. Concerns such as cultural and social uprootedness associated with switching from traditional livelihoods to off-farm work and migration expressed by study participants are supported by other studies (Adger et al., 2013). Several studies highlight additional economic and social risks, such as income dependencies on international markets and price fluctuation and a decrease in food sovereignty (Galappaththi & Schlingmann, 2023). Furthermore, a weakening or even loss of Indigenous and local cultures impacts biocultural diversity (Fernández-Llamazares et al., 2020), for which Indigenous and local knowledge is a key component of adaptation strategies. For instance, even though the Argentine Puna ecoregion is experiencing an aridization trend (Morales et al., 2015), a study that analyzed the productivity of 'vegas' (i.e., natural wetlands and key pastures for livestock in the region), indicated that the adoption of management practices traditionally used by Indigenous Peoples and local communities can enhance the productivity, stability, and resilience of these crucial ecosystems (Navarro et al., 2020). Additionally, the current trends toward an expansion of lithium mining activities in the Argentine Puna ecoregion in direct response to a growing global demand for electric vehicles fostered by current climate mitigation policies (Voskoboynik & Andreucci, 2022) are a major concern for both scientists and decision-makers. Scientists point to the socio-environmental impacts (i.e., competition for the limited freshwater resources) (Izquierdo et al 2015, 2018a; Liu & Agusdinata, 2021) or nature conservation issues (Gajardo & Redón, 2019; Marconi et al., 2022); while decision-makers emphasize socioeconomic benefits arising from mining (e.g., local and regional jobs, national royalties) (Ministerio de Desarrollo Productivo, 2021; Díaz Paz et al., 2023). Interestingly, those who are directly affected by the mining activities, that is, Kolla-Atacameños People and local communities in the Argentine Puna region, bring together the views of scientists and decision-makers by referring to both the positive and negative impacts of mining. Importantly, the fact that one-fifth of the study participants report environmental impacts derived from mining, specifically referring to excessive water extraction, while almost 70% expressed concerns about lack of water due to climate change, should be understood as a warning of potential water conflicts between different actors and demands (e.g., mining, livestock, drinking water) (Jerez et al., 2021). To avoid Kolla-Atacameños People and local communities in the Argentine Puna region being left empty-handed and suffering most of the negative consequences, it is important that they are integrated as main actors in decision-making processes surrounding future regional development planning, that should consider potential negative and interacting impacts deriving from climate change and lithium mining (Sovacool, 2021).

The need to bridge different knowledge systems in climate change research and decision-making has been established in political instruments, such as the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), and scientific articles (e.g., Reyes-García et al., 2016). Nonetheless, how to best realize this integration is still debated (see Salick & Ross, 2009), given the manifold challenges in transferability, integration, and scalability of different systems of knowledge (Reyes-Gracía et al., 2019), and the complexity and potential discrepancies of perceptions at local (Byg & Salick, 2009), regional and global scales, and across different actors (Finnis et al., 2015). These discrepancies do not necessarily mean a problem and should rather be understood as a warning, especially for decision-makers, to be aware of global trends that may produce urgent, critical, and relevant impacts in the future (e.g., Pörtner et al., 2022), without neglecting the priorities and concerns of Indigenous Peoples and local communities. We advocate that the primordial step is to recognize first-hand Indigenous and local knowledge and worldviews and to scale Indigenous Peoples and local communities' primary concerns to the political and research agendas. For this, we should ask these stakeholders about their priorities and urgencies, consider their views from the beginning into the research design, and acknowledge the complexity of multiple drivers that shape and impact the local environment, livelihoods, and living conditions.

Acknowledgments

We thank all the study participants for sharing their thoughts, views, and knowledge with us. We thank Elvira Casagranda, Fernanda Chiappero, Olga Ramos, and Silvina Vazquez for their field assistance and support and we thank Victoria Reyes-García, Reinmar Seidler, and Ramin Soleymani for their valuable reviews and comments on a previous version of this book chapter.

This study has been supported by the National Council of Sciences and Technologies (CONICET) and the National Science and Technology Agency of Argentina through which the fieldwork was financed with the grant PICT2018-04228 (PI: A.E. Izquierdo). Against delivery of the data, the researcher leading to this paper has received funding from the European Research Council under an ERC Consolidator Grant (FP7-771056-LICCI). This work contributes to the 'María de Maeztu' Programme for Units of Excellence of the Spanish Ministry of Science and Innovation (CEX2019-000940-M).

References

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change, 3*(2), 112–117. https://doi.org/10.1038/nclimate1666

Antwi-Agyei, P., Stringer, L.C. & Dougill, A. J. (2014). Livelihood adaptations to climate variability: insights from farming households in Ghana. *Regional Environmental Change, 14*, 1615–1626. https://doi-org.are.uab.cat/10.1007/s10113-014-0597-9

Beniston, M. (2003). Climatic change in mountain regions: a review of possible impacts. *Climate Variability and Change in High Elevation Regions: Past, Present & Future*, 5–31. https://doi.org/10.1007/978-94-015-1252-7_2

Beniston, M. (2005). The risks associated with climatic change in mountain regions. In *Global Change and Mountain Regions. Advances in Global Change Research*, *23*, 511–519. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-3508-1

Beniston, M., Diaz, H. F., & Bradley, R. S. (1997). Climatic change at high elevation sites: an overview. *Climatic Change*, *36*(3), 233–251.

Bennett, N. J., Blythe, J., Tyler, S., & Ban, N. C. (2016). Communities and change in the anthropocene: understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. *Regional Environmental Change*, *16*(4), 907–926. https://doi.org/10.1007/s10113-015-0839-5

Burkart, R., Bárbaro, N. O., Sánchez, R. A., & Gómez, D. A. (1995). Eco-regiones de la Argentina (Ecoregions of Argentina). Programa Desarrollo Institucional Ambiental, Buenos Aires, Argentina, 42 pp.

Buytaert, W., Vuille, M., Dewulf, A., Urrutia, R., Karmalkar, A., & Célleri, R. (2010). Uncertainties in climate change projections and regional downscaling in the tropical Andes: implications for water resources management. *Hydrology and Earth System Sciences*, *14*(7), 1247–1258. https://doi.org/10.5194/hess-14-1247-2010

Byg, A., & Salick, J. (2009). Local perspectives on a global phenomenon—climate change in Eastern Tibetan villages. *Global Environmental Change*, *19*(2), 156–166. https://doi.org/10.1016/j.gloenvcha.2009.01.010

Cannon, T. (2014). Rural livelihood diversification and adaptation to climate change. Community-based adaptation to climate change. *Emerging Lessons*, 55–76. https://www.researchgate.net/publication/300232311_4_Rural_livelihood_diversification_and_adaptation_to_climate_change

Carilla, J., Grau, H. R., Paolini, L., & Mariano, M. (2013). Lake fluctuations, plant productivity, and long-term variability in high-elevation tropical Andean ecosystems. *Arctic, Antarctic, and Alpine Research*, *45*(2), 179–189. https://doi.org/10.1657/1938-4246-45.2.179

Chakraborty, R., & Sherpa, P. Y. (2021). From climate adaptation to climate justice: critical reflections on the IPCC and Himalayan climate knowledges. *Climatic Change, 167*(3–4), 49. https://doi.org/10.1007/s10584-021-03158-1

Dhakal, B., & Kattel, R. R. (2019). Effects of global changes on ecosystems services of multiple natural resources in mountain agricultural landscapes. *Science of the Total Environment*, 676, 665–682. https://doi.org/10.1016/j.scitotenv.2019.04.276

Díaz Paz, W. F., Escosteguy, M., Seghezzo, L., Hufty, M., Kruse, E., & Iribarnegaray, M. A. (2023). Lithium mining, water resources, and socio-economic issues in northern Argentina: We are not all in the same boat. *Resources Policy, 81*, 103288. https://doi.org/10.1016/j.resourpol.2022.103288

Dresselhaus, M. S., & Thomas, I. L. (2001). Alternative energy technologies. *Nature*, *414*(6861), 332–337.

Ensor, J. E., Wennström, P., Bhatterai, A., Nightingale, A. J., Eriksen, S., & Sillmann, J. (2019). Asking the right questions in adaptation research and practice: seeing beyond climate impacts in rural Nepal. *Environmental Science & Policy, 94*, 227–236. https://doi.org/10.1016/j.envsci.2019.01.013

Fernández-Llamazares, Á., Benyei, P., Junqueira, A. B., & Reyes-García, V. (2020). Participation in biocultural diversity conservation: insights from five Amazonian examples. In: Baldauf, C. (eds) *Participatory Biodiversity Conservation*. Springer, Cham. https://doi.org/10.1007/978-3-030-41686-7_11

Finnis, J., Sarkar, A., & Stoddart, M. C. (2015). Bridging science and community knowledge? The complicating role of natural variability in perceptions of climate change. *Global Environmental Change*, *32*, 1–10. https://doi.org/10.1016/j.gloenvcha.2014.12.011

Ford, J. D., Cameron, L., Rubis, J., Maillet, M., Nakashima, D., Willox, A. C., & Pearce, T. (2016). Including indigenous knowledge and experience in IPCC assessment reports. *Nature Climate Change, 6*(4), 349–353. https://doi.org/10.1038/nclimate2954

Gajardo, G., & Redón, S. (2019). Andean hypersaline lakes in the Atacama Desert, northern Chile: between lithium exploitation and unique biodiversity conservation. *Conservation Science and Practice, 1*(9). https://doi.org/10.1111/csp2.94

Galappaththi, E. K., & Schlingmann, A. (2023). The sustainability assessment of Indigenous and local knowledge-based climate adaptation responses in agricultural and aquatic food systems. *Current Opinion in Environmental Sustainability, 62*, 101276. https://doi.org/10.1016/j.cosust.2023.101276

Gielen, D. (2021). Critical minerals for the energy transition. *International Renewable Energy Agency: Abu Dhabi, United Arab Emirates*. ISBN 978-92-9260-366-3.

INDEC [Instituto Nacional de Estadısticas y Censos] (2022). Censo nacional de población, hogares y viviendas 2022: resultados provisionales/1a ed. – Ciudad Autónoma de Buenos Aires: Instituto Nacional de Estadística y Censos. https://www.indec.gob.ar/ftp/cuadros/poblacion/cnphv2022_resultados_provisionales.pdf

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama, Eds.). Cambridge University Press.

Izquierdo, A. E., Aragon, R. M., Navarro, C. J., & Casagrandra, E. (2018b). Humedales de la Puna: principales proveedores de servicios ecosistémicos de la región. In: Grau, H. R., Babot, J., Izquierdo, A. E., Grau, A., (Eds.) *La Puna Argentina: Naturaleza y Cultura. Serie Conservación de la Naturaleza 24*. Fundacıon Miguel Lillo, Tucumán, pp 96–111. ISSN 0325-9625.

Izquierdo, A. E., & Grau, H. R. (2009). Agriculture adjustment, land-use transition and protected areas in Northwestern Argentina. *Journal of Environmental Management*, *90*(2), 858–865. https://doi.org/10.1016/j.jenvman.2008.02.013

Izquierdo, A. E., Grau, H. R., Carilla, J., & Casagranda, E. (2015). Side effects of green technologies: the potential environmental costs of lithium mining on high elevation Andean wetlands in the context of climate change. *Newsletter Global Land Project*, *12*, 52–56. ISSN 2316-3747.

Izquierdo, A. E., Grau, H. R., Navarro, C. J., Casagranda, E., Castilla, M. C., & Grau, A. (2018a). Highlands in transition: Urbanization, pastoralism, mining, tourism, and wildlife in the Argentinian Puna. *Mountain Research and Development*, *38*(4), 390–400. https://doi.org/10.1659/MRD-JOURNAL-D-17-00075.1

Jerez, B., Garcés, I., & Torres, R. (2021). Lithium extractivism and water injustices in the Salar de Atacama, Chile: the colonial shadow of green electromobility. *Political Geography*, *87*, 102382. https://doi.org/10.1016/j.polgeo.2021.102382

Liu, W., & Agusdinata, D. B. (2021). Dynamics of local impacts in low-carbon transition: agent-based modeling of lithium mining-community-aquifer interactions in Salar de Atacama, Chile. *The Extractive Industries and Society, 8*(3), 100927. https://doi.org/10.1016/j.exis.2021.100927

Marconi, P., Arengo, F., & Clark, A. (2022). The arid Andean plateau waterscapes and the lithium triangle: flamingos as flagships for conservation of high-altitude wetlands under pressure from mining development. *Wetlands Ecology and Management, 30*(4), 827–852. https://doi.org/10.1007/s11273-022-09872-6

Martınez, J. G. (2018). Sociedades prehispanicas de la Puna Argentina: desde el poblamiento temprano hasta los inicios de la produccion pastoril y agrıcola. In: Grau, H. R., Babot, J., Izquierdo, A. E., Grau, A., (Eds.) *La Puna Argentina: Naturaleza y Cultura. Serie Conservación de la Naturaleza 24*. Fundacıon Miguel Lillo, Tucuman, pp 273–294. ISSN 0325–9625.

McDowell, J. Z. & Hess, J. J. (2012). Accessing adaptation: multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change, 22*(2), 342–352. https://doi.org/10.1016/J.GLOENVCHA.2011.11.002

Ministerio de Desarrollo Productivo. (2021). Plan Estrategico para el Desarrollo Minero Argentino. Secretaria de Mineria, Buenos Aires. https://www.argentina.gob.ar/sites/default/files/memoria-viva-avance-2021.pdf

Morales, M., Carilla, J., Grau, H. R., & Villalba, R. (2015). Multi-century lake area changes in the Andean high-elevation ecosystems of the Southern Altiplano. *Climate of the Past*, *11*, 1821–1855. https://doi.org/10.5194/cpd-11-1821-2015

Morales, M. S., Crispín-DelaCruz, D. B., Álvarez, C., Christie, D. A., Ferrero, M. E., Andreu-Hayles, L., Villalba, R., Guerra, A., Ticse-Otarola, G., Rodríguez-Ramírez, E. C., Locclla-Martínez, R., Sanchez-Ferrer, J. & Requena-Rojas, E. J. (2023). Drought increase since the mid-20th century in the northern South American Altiplano revealed by a 389-year precipitation record. *Climate of the Past*, *19*(2), 457–476.

Navarro, C. J. Izquierdo, A. E., Araoz, E., Fogguet, J., & Grau, H. R. (2020). Rewilding of large herbivores communities in high elevation Puna: geographic segregation and no evidence of positive effects on peatlands productivity. *Regional Environmental Change, 20*, 112. https://doi.org/10.1007/s10113-020-01704-8

Nyantakyi-Frimpong, H., & Bezner-Kerr, R. (2015). The relative importance of climate change in the context of multiple stressors in semi-arid Ghana. *Global Environmental Change*, *32*, 40–56. https://doi.org/10.1016/j.gloenvcha.2015.03.003

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., & West, J. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global Environmental Change, 14*(4), 303–313. https://doi.org/10.1016/j.gloenvcha.2004.01.001

Olivera, D. E. (2018). Arqueologıa del formativo: los inicios de la agricultura y la ganaderıa. In: Grau, H. R., Babot, J., Izquierdo, A. E., Grau, A., (Eds.) *La Puna Argentina: Naturaleza y Cultura. Serie Conservación de la Naturaleza 24.* Fundacıon Miguel Lillo, Tucumán, pp. 297–318. ISSN 0325-9625.

Porcuna, A., Guillerminet, T., Klappoth, B., & Schlingmann, A. (2024). Agricultural adaptation to multiple stressors in a climate change context. A case study in south-eastern Senegal. In V. Reyes-García, S. Álvarez-Fernández, P. Benyei, L. Calvet-Mir, D. García-del-Amo, A. B. Junqueira, X. Li, V. Porcher, A. Porcuna-Ferrer, A. Schlingmann, & R. Soleymani (Eds.), *Routledge Handbook of Climate Change Impacts on Indigenous Peoples and Local Communities*. Oxfordshire & New York: Routledge. Chp 13, pp 227–243.

Pörtner, H. O., Roberts, D. C., Poloczanska, E. S., Mintenbeck, K., Tignor, M., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., & Okem, A. (2022). IPCC, 2022: summary for policymakers. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK and New York, NY, USA pp. 3–33.

Pörtner, H. O., Scholes, R. J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W. L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M. A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P. A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A. P. F., Popp, A., Reyes-García, V., Sankaran, M., Settele, J., Shin, Y. J., Sintayehu, D. W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A.L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D.C., Rogers, A. D., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N., Ngo, H. T. (2021). *Scientific Outcome of the IPBES-IPCC Co-Sponsored Workshop on Biodiversity and Climate Change*; IPBES Secretariat, Bonn. https://doi.org/10.5281/zenodo.4659158

Prior, T., Wäger, P. A., Stamp, A., Widmer, R., & Giurco, D. (2013). Sustainable governance of scarce metals: the case of lithium. *Science of the Total Environment*, *461*, 785–791. https://doi.org/10.1016/j.scitotenv.2013.05.042

Quiroga Mendiola, M., & Cladera, J. (2018). Ganaderıa en la Puna Argentina. In: Grau, H. R., Babot, J., Izquierdo, A. E., Grau, A., (Eds.) *La Puna Argentina: Naturaleza y Cultura. Serie Conservación de la Naturaleza 24.* Fundacıon Miguel Lillo, Tucumán, pp. 387–402. ISSN 0325-9625.

Räsänen, A., Juhola, S., Nygren, A., Käkönen, M., Kallio, M., Monge, A., & Kanninen, M. (2016). Climate change, multiple stressors, and human vulnerability: a systematic review. *Regional Environmental Change*, *16*(8), 2291–2302. https://doi.org/10.1007/s10113-016-0974-7

Reid, P., & Vogel, C. (2006). Living and responding to multiple stressors in South Africa—Glimpses from KwaZulu-Natal. *Global Environmental Change*, *16*(2), 195–206. https://doi.org/10.1016/j.gloenvcha.2006.01.003

Reyes-García, V., Álvarez-Fernández, S., Benyei, P., Junqueira, A. B., Labeyrie, V., Li, X., Porcher, V., Porcuna-Ferrer, A., Schlingmann, A., & Soleymani, R. (2023). Local indicators of climate change impacts described by indigenous peoples and local communities: study protocol. *PLoS One, 18*(1), e0279847. https://doi.org/10.1371/journal.pone.0279847

Reyes-García, V., Benyei, P., Junqueira, A.B., Huanca, T., Conde, E. (2024). A complex matrix. Reports of environmental change and its drivers by the Tsimane', Bolivian Amazon. In V. Reyes-García, S. Álvarez-Fernández, P. Benyei, L. Calvet-Mir, D. García-del-Amo, A. B. Junqueira, X. Li, V. Porcher, A. Porcuna-Ferrer, A. Schlingmann, & R. Soleymani (Eds.), *Routledge Handbook of Climate Change Impacts on Indigenous Peoples and Local Communities.* Oxfordshire & New York: Routledge. Chp 10, pp 164–179.

Reyes-García, V., Fernández-Llamazares, Á., Guèze, M., Garcés, A., Mallo, M., Vila-Gómez, M., & Vilaseca, M. (2016). Local indicators of climate change: the potential contribution of local knowledge to climate research. *Wiley Interdisciplinary Reviews: Climate Change*, *7*(1), 109–124. https://doi.org/10.1002/wcc.374

Reyes-García, V., García-del-Amo, D., Benyei, P., Fernández-Llamazares, Á., Gravani, K., Junqueira, A. B., Labeyrie, V., Li, X., Matias, D. M., McAlvay, A., Mortyn, P. G., Porcuna-Ferrer, A., Schlingmann, A., & Soleymani-Fard, R. (2019). A collaborative approach to bring insights from local observations of climate change impacts into global climate change research. *Current Opinion in Environmental Sustainability*, *39*, 1–8. https://doi.org/10.1016/j.cosust.2019.04.007

Salick, J., & Ross, N. (2009). Traditional peoples and climate change. *Global Environmental Change*, *19*(2), 137–190. https://doi.org/10.1016/j.gloenvcha.2009.01.004

Scrosati, B., & Garche, J. (2010). Lithium batteries: status, prospects, and future. *Journal of Power Sources*, *195*(9), 2419–2430. https://doi.org/10.1016/j.jpowsour.2009.11.048

Sovacool, B. K. (2021). Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. *Energy Research & Social Science, 73*, 101916. https://doi.org/10.1016/j.erss.2021.101916

Tengö, M., Hill, R., Malmer, P., Raymond, C. M., Spierenburg, M., Danielsen, F., Elmqvist, T., & Folke, C. (2017). Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. *Current Opinion in Environmental Sustainability*, *26–27*, 17–25. https://doi.org/10.1016/j.cosust.2016.12.005

Tschakert, P. (2007). Views from the vulnerable: understanding climatic and other stressors in the Sahel. *Global Environmental Change*, *17*(3–4), 381–396. https://doi.org/10.1016/j.gloenvcha.2006.11.008

Urrutia, R., & Vuille, M. (2009). Climate change projections for the tropical Andes using a regional climate model: temperature and precipitation simulations for the end of the 21st century. *Journal of Geophysical Research: Atmospheres*, *114*(D2). https://doi.org/10.1029/2008JD011021

Voskoboynik, D. M., & Andreucci, D. (2022). Greening extractivism: environmental discourses and resource governance in the 'Lithium Triangle'. *Environment and Planning E: Nature and Space, 5*(2), 787–809. https://doi.org/10.1177/25148486211006345

Vuille, M., Francou, B., Wagnon, P., Juen, I., Kaser, G., Mark, B. G., & Bradley, R. S. (2008). Climate change and tropical Andean glaciers: past, present and future. *Earth-Science Reviews*, *89*(3–4), 79–96. https://doi.org/10.1016/j.earscirev.2008.04.002

Wanger, T. C. (2011). The Lithium future—resources, recycling, and the environment. *Conservation Letters*, *4*(3), 202–206. https://doi.org/10.1111/j.1755-263X.2011.00166.x

Yap, M. L. M., & Watene, K. (2019). The sustainable development goals (SDGs) and indigenous peoples: another missed opportunity? *Journal of Human Development and Capabilities, 20*(4), 451–467. https://doi.org/10.1080/19452829.2019.1574725