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RESEARCH BRIEF

Can glacial retreat lead to migration? A critical discussion of the impact of glacier shrinkage upon population mobility in the Bolivian Andes

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Abstract This article examines the role of glacial retreat on human migration in the Bolivian Andes—a topic with virtually no scholarly focus, yet of critical importance in the era of global climate change. Glacial melting has increased since the 1980s, and popular reports often suggest there will be significant impacts on local populations, including migration. Based on interviews with local residents, both migrants and nonmigrants, as well as topical experts, this study suggests that residents do, indeed, have serious concerns about future livelihood conditions in the Bolivian Andes. Even so, glacial retreat has not triggered new migration flows and has had a limited impact on the existing migratory patterns.

Keywords Migration · Glacial retreat · Glaciers · Climate change · Livelihoods · Mobility · Mountain · Bolivia · Andes

Introduction

Climate change is responsible for alterations of the hydrological cycle in snowmelt-dominated regions such as the Andes (Magrin et al. 2014). Accelerating glacial melting over the past three decades has threatened rural livelihoods since glacial runoff supports local ecosystems while also providing water for drinking, farming, and energy production (Barnett et al. 2005; Hoffmann 2007; Mark et al. 2010; Vergara et al. 2007). This issue is at the heart of numerous articles in the media, in political narratives, in NGO reports, and occasionally in academic discussions. Bolivian glaciers are often used as examples and are described with an alarmist perspective assuming that melting ice is leading to a significant social crisis and to internal migration (Montalvo 2010). As an example, descriptions of the farming

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village of Khapi, located at the edge of the glacier Illimani, has spread worldwide through press articles and reports. In 2009, the BBC news announced: "Bolivia's Indians feel the heat" (Painter 2009) and the *New York Times* stated: "In Bolivia, water and ice tell of climate change" (Rosenthal 2009). CNN Mexico also published articles about Bolivia, for example: "Melting glacier is leading to outmigration in an indigenous community in Bolivia"[1] (Montalvo 2010). Most of the photographs in such stories focus on villages and farmers in a rural landscape consisting of glaciers and white-capped summits.

Glacial melting and its impacts also occupy a significant place in Bolivian political narratives (Kaijser 2013). As illustration, consider the speech of Pablo Solòn, former Bolivian Ambassador to the United Nations, in which he said: "We have a big problem and even money won't completely solve it […]. What do you do when your glacier disappears or your island is underwater?" (Rosenthal 2009). Also, during the COP15 in Copenhagen, Bolivia's president, Evo Morales, demanded rich countries pay climate change reparations and proposed the creation of an international court of environmental justice. In the same period, two NGOs[2] urged the Human Rights Tribunal: "to adopt an outcome recognizing the responsibility of major greenhouse-gas-emitting states for human rights violation suffered by the glacier-dependent communities of Bolivia due to climate change. […] Degradation of natural resources and the toll of climate extremes have already exacerbated emigration to neighbouring urban centres of La Paz and El Alto. Without effective adaptation, communities like Khapi could be forced to relocate" (Earthjustice 2009).

These narratives come from heterogeneous sources, but in common is the image of glacial retreat in Bolivia driving migration. Yet while detailed scientific research has examined the physical processes associated with glacial retreat (IPCC 2013; Magrin et al. 2014), little is known about social impacts and/or adaptations (Hoffmann 2008; Orlove 2009; Rhoades 2008).

The above leads to the main purpose of this study, which is to evaluate the effect of glacial retreat on human migration in the Bolivian Andes. Migration patterns and the ways in which glacier-related drivers potentially affect decisions to move are assessed using a qualitative approach involving migrants and nonmigrants residing in the surroundings of La Paz, Bolivia, at the foot of the Illimani summit. Also included are findings from interviews with experts who work (research and labor) in that area.

Literature review

Migration and climate change

The terms "climate refugee" and "environmental refugee" have been widely used over the last two decades and have given rise to numerous debates among

[1] In its original version: "*El deshielo empuja la emigración en una comunidad indígena de Bolivia*". (translation by the author).

[2] Earthjustice (USA) and Agua Sustentable (Bolivia).

researchers. The first alarmist prognostics about "climate refugees" (IPCC 1990; Myers 1993) have been counterbalanced by research underlining the multiplicity of factors at play in migratory processes (Black 2001; Castles 2002). It is now widely accepted that environmental factors are intertwined with social, economic, demographic, and political drivers to shape migration (for recent syntheses illustrating these tendencies, see Black et al. 2011; de Sherbinin et al. 2011; Gemenne 2010; McLeman 2013; Kniveton et al. 2008; Perch-Nielsen et al. 2008; Piguet 2013; Warner 2010). Currently, the connection between environmental change and migration is the subject of a burgeoning literature. Even so, for some regions, South America for instance, the number of empirical studies remains relatively low (Piguet and Laczko 2014).

Glacial retreat as a migration driver?

In 2006, the Stern Review argued that glacial changes were likely to have significant implications in mountain areas in terms of water availability, especially for downstream communities (Stern 2006). Apart from this brief mention, the only study that specifically focuses on mountain regions with regard to the relationship between migration and climate change is the Foresight report, commissioned by the UK Government (Foresight 2011b; Kollmair and Banerjee 2011). The authors identify "the cryosphere" as one of the several possible environmental drivers of migration and state that "the main rural–urban community conflicts in the Andes mountains are directly related to retreating glacier areas and water scarcity" (Foresight 2011b: 9). Yet, another study points out that in Nepal, glacial outburst floods (GLOFs) have thus far led only to a temporary evacuation of one month for a population living downstream (Botez 2010). In Bolivia, the three existent case studies with a focus on the linkages between climate change and migration do not refer to any glacier issue (Balderrama Mariscal et al. 2011; Guilbert 2005; Zoomers 2012).

To summarize, although glacial retreat is noted by some to be a possible migration driver, it is rarely considered in the general debate, and no empirical studies have thus far examined the association.

Glacial retreat in the Bolivian Andes

Since 1970, glaciers in Bolivia have lost almost half of their surface area and the melting process has tended to accelerate significantly over the years, especially between 1975 and 1980 (Coudrain et al. 2005; Rabatel et al. 2013; Soruco et al. 2009; Vuille et al. 2008). Temperature increases due to climate change are, and will be, more pronounced in high-elevation mountain areas (Beniston et al. 1997; Bradley et al. 2006; Urrutia and Vuille 2009). Further, compared with glaciers in temperate or polar regions, tropical glaciers are particularly sensitive to climatic variations since (1) they are subject to considerably higher levels of energy forcing given their low tropical latitude but higher altitude; (2) the period of maximum precipitation coincides with the summer period (high temperatures). Contrary to the Alps, in the central Andes there is no season during which the glacier could recover through precipitation (Kaser and Ostmaston 2002).

An unknown number of small tropical glaciers of low and medium altitudes have entirely disappeared since the 1960s, and projections indicate that many others are likely to vanish completely by mid-century and possibly before (Ramírez et al. 2001, Soruco et al. 2009). For example, the iconic Chacaltaya glacier, known for having been the highest ski slope in the world, completely vanished in 2009. The rapid retreat of the Bolivian glaciers has resulted in a net increase in hydrological run-off (temporary effect tied to current rates of ablation), but uncertainties remain about the state of the glaciers and water flows in the medium- and long-term future (Chevallier et al. 2011; IAI 2010; Rabatel et al. 2013; Ramírez 2006).

Impacts related to glacial retreat

This section presents a synthesis of the current literature on the impact of, and responses to, glacial retreat. The literature on impacts is often restricted to a deterministic approach that overlooks the multiple ways in which individuals, households, and societies respond, or adapt, to retreating glaciers (Hoffmann 2007; Orlove et al. 2008). This section also puts forward ethnographic research that underlines the way communities living at glaciers' edge are dealing with environmental transformations. Inspired by the categorization of Orlove et al. (2008), four glacial retreat impacts and responses are portrayed below: environmental changes, hazards, water availability, and cultural landscapes.

Environmental changes

In mountain regions, glacial retreat may yield substantial changes in fragile high-elevation biodiversity (Hoffmann 2008; Orlove et al. 2008). Such impacts have social dimensions since wetlands (bofedales) and moors (high plateau/páramos), for instance, are important for water storage, as well as local climate regulation (García et al. 2007; Squeo et al. 2006).

Hazards

Glacial outburst floods (GLOFs)—an abrupt release of water from a glacial reservoir—are considered as one of the most direct threats resulting from deglaciation processes (Botez 2010). Other hazards associated with glacial retreat include landslides, rock falls, and debris falls due to decreasing slope stability. Temperature changes also result in degradation of mountain permafrost which may lead to similar incidents, and the accumulation of loose material can aggravate debris flows after intense rainfall (Orlove et al. 2008). In Chile, five major floods from glaciers occurred on Rio Colonia in 2008 and 2009 and similar events have affected Argentina (IAI 2010). In Peru in 1941, an outpouring destroyed the village of Huaraz affecting 5,000 people (Carey 2010). In Bolivia, the risk of disaster related to glacial shrinkage is lower, but, according to Hoffmann and Weggenmann (2012), there is still concern with the danger of GLOFs in certain parts of the country. In 2009, a glacial lake above a small village in Apolobamba's Cordillera

sent a wave of water downstream, flooding cultivated fields, destroying local roads, and killing some domestic animals.

Water availability

Glacier shrinkage obviously impacts water availability (Barnett et al. 2005; Chevallier et al. 2011; Coudrain et al. 2005), although the association is perhaps more complex than at first glance. For example, the glaciers around La Paz and El Alto may disappear in the coming decades, but even the resources currently available are not expected to provide sufficient quantity and quality to both cities in the future as a result of population growth (Escurra et al. 2014; Soruco 2008). Water-related tensions have been running high during the last years (Ramírez et al. 2007). Even so, the water vulnerability of La Paz and El Alto cannot be attributed solely to glaciers but must take into account the weakness of the water distribution system as well. It is estimated that 40 percent of the water distributed by the public utility water company is lost through illegal connections and water leaks (Hardy 2009; PNUD 2011).

Andean countries are also highly dependent on glaciers for hydropower, which will clearly be reduced as glaciers retreat (Barnett et al. 2005; Chevallier et al. 2011; Huggel et al. 2002; Vergara et al. 2007). La Paz is itself dependent on hydroelectric power for a major part of its energy supplies, and projections indicate that some hydropower plants will not be able to maintain operation during dry seasons (Olmos 2010; Painter 2007; Soruco 2008).

Finally, water for irrigation accounts for up to 90 percent of Bolivia's water demand (Bolivia's Water Ministry 2007). Irrigation in the Altiplano region will be most affected, and since the region's rural poor is heavily dependent on agriculture, substantial socioeconomic challenges can be anticipated (García et al. 2008; Perez et al. 2010; Valdivia et al. 2010). Several authors have underscored the importance of the risk of conflicts between lowland and highland water users, as well as between rural and urban populations (Hoffmann 2008; PNUD 2011).

Cultural landscapes

Alongside the tangible socioeconomic consequences of glacial retreat, it is also necessary to acknowledge nonmaterial impacts. Natural landscapes are often cultural landscapes, with meanings integral to aspects of culture such as regional identity and religion. Around the world, snow-capped peaks and glaciers are often the source of strong attachment and symbolic importance for local residents (Orlove et al. 2008). In Bolivia, the Illimani glacier has become a representation of regional identity: the glaciered peaks of Illimani feature prominently on La Paz's official shield, on the seal of the city's major university, on the labels for locally brewed beer, and in countless other forms. As Orlove et al. (2008:13) state: "The residents identify not only with the city and with the nation but also with the highland region of the country, embodied in the summits of Illimani. […] the cultural impact of a dark Illimani rather than a gleaming white mass that watches over the city seems as serious as the economic ones."

In addition, snow-capped mountains attract tourists for trekking, climbing, and sightseeing in a "typical" Andean landscape. Therefore, the shrinkage of the ice may alter tourism-related sources of income. Research on this topic has predominantly focused on tourism in mountain ranges in northern countries (Abegg et al. 2007; Kaján and Saarinen 2013; Lemelin et al. 2010; Scott et al. 2006), with little focus thus far in the Andean region (Velarde Quispe 2010).

Migration as an impact of glacial retreat?

Few references to migration are made in the literature on glacial retreat. However, the following section outlines some valuable background based on empirical studies conducted in Peru and Ecuador. An ethnographic study conducted in Peru finds that glacial retreat has had repercussions for the flow of some irrigation canals as well as for the size of lakes and wetlands. These impacts resulted in the displacement of pasture for livestock, and consequently, young men frequently migrate to urban areas seeking wage labor and other economic opportunities (Young and Lipton 2006, p. 71). Another study in the Peruvian Andes similarly points out that migration is the only alternative once streams, necessary for irrigation, run dry (Orlove 2009). It is claimed that NGOs and aid agencies may assist herders in relocation to continue herding: "to allow them to return on visits to their former home and to avoid joining the masses of other migrants who leave behind their property, skills, and communities to move to the already crowded cities" (Orlove 2009: 160). In Ecuador, the glacier Cotacachi completely melted over the past decade, considerably affecting agriculture and the local tourism sector (Rhoades 2008; Rhoades et al. 2006). Finally, authors studying GLOF risk suggest that relocation is an option to avoid disasters for parts of exposed villages (Hoffmann and Weggenmann 2012).

In the above studies, migration tends to be seen as last resort—in contrast to a possible pro-active adaptation strategy, or perhaps in the form of assisted relocation. Andean societies, however, are characterized by a high level of mobility, which is a traditional and well-established practice to reduce vulnerability to risks, both environmental and otherwise (Chaplin 2009; Cortes 2000; Zoomers 2012). Examples in the Bolivian Andes show that migration forms are manifold, including temporary (or seasonal) migration, permanent movements, or multi-residency, which can increase rural–urban links (Andersen 2002; Balderrama Mariscal et al. 2011; Guilbert 2005; Mazurek 2007).

Overall, there is little empirical research that provides a foundation for assessment of the interconnections between glacial retreat and migration. This review highlights the many impacts of glacial retreat, including on irrigation, to consider their possible associations with migration.

Study area and methods

I investigated the connection between glacial retreat and migration in the Bolivian Andes using qualitative methods, specifically semi-structured interviews ($n = 54$).

Content analyses built on empirical work on migration–climate change (McLeman and Ploeger 2012; Morrissey 2013; Mortreux and Barnett 2009; Piguet 2010; Warner 2011) and on the above-mentioned research on glacial retreat and livelihoods (Orlove 2009; Rhoades 2008; Young and Lipton 2006). The interviews were aimed to discern perceptions of adaptation options, migration being one.

Four fieldwork trips were made to four study communities over several months between 2010 and 2013: The communities were Khapi, Pinaya, Cebollullo, and Challasirca (municipality of Palca, department La Paz), all located within an area of less than 10 km, at altitudes between 2900 and 3880 m.a.s.l, chosen for their location at the edge of the Illimani glacier.

Migration is common among the mountain areas surrounding La Paz and El Alto (Andersen 2002; Cortes 2000; Lazar 2008; O'Hare and Rivas 2007)—it is estimated that 30 percent of household heads migrate seasonally, and 70 percent of residents have family members living outside the village (García and Taboada 2010; Villaroel et al. 2011). Migration compensates for insecure agricultural income during the dry season. Multiresidency is common, and most migrants keep a farming activity (plots or livestock) in the origin community with relatives overseeing it in their absence (AguaSustentable 2012).

As is common in migration research, snowball sampling was used to identify further respondents through social networks (Arber 1993; McKenzie and Mistiaen 2009; Stapleton 2010). The interviews were conducted mostly in Spanish, with translator's assistance for those conducted partly in Aymara (the indigenous language of the studied area). With consent, interviews were recorded. A first set of interviews ($n = 44$, age range 17-67) was conducted in the four communities mentioned, and through these interviews, close community connections were established allowing additional recruitment. Of these original interviews, 22 were conducted with migrants engaged in a process of temporary migration, commuting between the urban areas of La Paz and El Alto and the community of origin, where they maintain farming activities. Seventeen interviews were conducted with nonmigrants that had relatives who migrated temporarily or permanently. Finally, five interviews took place in the destination area in La Paz with migrants originating from one of the four mountain communities.

These "resident" respondents were asked about the migration decision-making process and their (or their relatives) future intentions and rationale. In order to not "lead" respondents into mentioning climate change and/or glacier-related issues as factors shaping migration and other livelihood decisions, questions on these topics were not asked until the end of the interviews. Even so, one of the four communities, Khapi, has become an important symbol of climate change in the international media and in NGO reports. It also became a hotspot for journalists and for development and adaptation projects. Therefore, some villagers had been previously approached by others on the topic of climate change and glaciers, and it is possible some bias in responses resulted.

In addition to the 44 interviews described above, ten additional interviews were conducted with respondents who have worked, or undertaken research, in the Bolivian Andes. This group of "experts" included three scientists specialized in glacial retreat impacts, one representative from the regional water company, two

representatives from regional authorities and four staff members of NGOs active in the field of climate change adaptation and traditional livelihoods. Among the NGO respondents, two were involved in the implementation of local projects. These interviews focused on the respondents' professional roles and their perceptions of interconnections between glacial retreat and migration in the surrounding mountain areas.

All interviews were transcribed, and the information was coded using a preestablished framework designed to categorize the drivers of migration identified by the interviewees and as guided by prior migration–environment research (Table 1).

Results

Within the 54 personal interviews, 113 reasons were offered for the perceived drivers of migration (see Table 1). Respondents noted that glacial retreat is of particular importance because of its impact on water availability and its central role in the cultural landscape.

Four types of perceived drivers were found to be predominant in migration decision-making: "farming plot size," "water availability," "climate," and "education." The most frequent of these, farming plot size, has political roots. Since the agrarian reform of 1952, household agricultural land is divided within the family. Therefore, each generation has less agricultural acreage, and eventually, only one family member typically maintains the farm while others migrate in search of alternative income sources.

> The plots are distributed among the different children of the family. And like the surface they get is very small, most of the youths move to town. They also need to feed their own family. (migrant, man, 40 y. o.)

The second primary perceived driver relates to water availability, particularly as related to irrigation. People originating from the communities being studied underline the difficulties of not having enough water for irrigation. As the two categories of respondents (migrants and nonmigrants, and experts) associate the water availability driver with issues relating to the glacier, this driver is addressed more in depth in the discussion section. "Climate" is noted as the third most frequently perceived driver mentioned by respondents. The unpredictability of extreme events such as hail or frost episodes can lead to severe crop damage.

> Frost or hails can come whenever and then "ciao," you can lose all your potatoes! Before, my parents knew when those episodes were happening, but now there is no alarm, it is sudden (migrant, man, 22 y. o.)

The fourth perceived driver, education, represents the desire of the younger generation to undertake longer and more specialized studies. The studied villages offer only primary and secondary school, so migration is required to further one's education. Fifth, income is noted as a perceived migration driver since residents from this rural area complement their agricultural income with income from urban

Table 1 Perceived migration drivers and relevance of glacial retreat

Perceived Drivers	Mentions	Relevance of glacial retreat	
		Residents	Experts
Farming plot size	30	–	–
Water availability	28	Scarcity	Abundance
Climate	19	–	–
Education	18	–	–
Income	10	–	–
Quality of life	8	Symbolic importance	–

Multiple responses coded per respondent

employment. Men often find work in the construction sector, whereas women are typically employed as domestic workers.

Finally, "quality of life" encompasses several cultural dimensions of relevance to migration. For instance, some respondents mentioned the contrast between rural and the urban lifestyles, the latter being perceived as more attractive. This category also includes the references to religion and traditional beliefs. From this perspective, residents underlined the importance of the snow-dominated mountains for local livelihoods; these white icons are important not only with regard to water availability issues, but also because they represent protective divinities in Andean culture.

Among perceived migration drivers, glacial retreat was mentioned with regard to water availability and the quality of life. The following section offers further discussion about these interactions.

Discussion

Glacier, water, and migration: a first impression

Residents, whether migrant or nonmigrant, identify the lack of water as a serious threat to livelihoods and a perceived migration driver. Interestingly, seasonal variations of water availability shape circular migration cycles in that during the dry season, migrants tend to stay longer in urban destinations. In addition, residents link perceive water scarcity to the retreating glacier:

> Since I am born I am living here. But, I am the only one of my family. My four brothers are gone, they live in the city; because we lack terrain and we lack water. This year there is no water coming down the glacier! (non-migrant, man, 32 y. o.)

The experts interviewed also acknowledged the importance of climate impacts as perceived migration drivers. In accordance with the literature on climate change impacts and adaptation in this region (Alurralde et al. 2011; McDowell and Hess 2012; Valdivia et al. 2010), the experts refer to uncertainties related to extreme

events (hail or frost), increases in crop diseases, and increasing interannual precipitation variability. They also note that warming temperatures allow better production at a higher altitude, although with the counter effect of increasing water demand. The expert narratives also differ from residents in that they argue that even though there is a common perception of water scarcity, the melting glaciers are presently providing more water than typical:

> These years, communities living at the Illimani side are enjoying an extra amount of water. Until now, they have not experienced outmigration because of this. (expert, NGO stakeholder)

To disentangle these conflicting narratives, the following sub-sections take a closer look at the seasonality of glacier runoff and at water use and governance.

Glacier, water, and migration: a matter of seasons

Tropical glaciers contribute to runoff most significantly during the rainy season; the runoff peak discharge coincides with the peak of precipitation (Chevallier et al. 2011; Coudrain et al. 2005). In the dry season, from April to October, temperatures and precipitation are relatively low with runoff at its least in August (Terán 2009). This timing is critical for agriculture as the runoff constitutes the only source of irrigation.[3]

> What you have is the accelerated melting during the rainy season, during that time extra water is not much help. So you can say they have more water, but it's not useful. The water would be useful in the dry season. (expert, academic)

Furthermore, according to respondents, the first seasonal episodes of precipitation tend to come later than in the past, and overall, the dry seasons tend to be longer and more intense. These personal reports align with climate models (Valdivia et al. 2010). Warming temperatures can also cause challenges during the rainy season when an overabundance of water may damage crops.

> There are many droughts. There is not water enough for us. […] Between July to December it is dry. In December starts the rainfall, the river level is high, it is going out of the Illimani. When it is raining, it is abundant, tons of water! But then it drags the ground, even the good plots are washed away! (migrant, women, 40 years old)

Hence the distinction. When experts note migration is not directly related to perceived glacial retreat, they tend to refer to the long-term glacier shrinkage and higher annual water levels. On the other hand, residents from the Illimani hillside tend to refer to more immediate water availability, which exhibits strong seasonal variation. Regardless, in the end, both underline livelihood sensitivity to the availability of water.

[3] There are also complex interactions with the wetlands (bofedales) situated at a higher altitude (Hoffmann, 2008; Squeo, et al., 2006), but these hydrological interactions are beyond the scope of this paper.

Glacier, water, and migration: a matter of demand and distribution

The second point to consider in the complex interactions between glacial retreat, water, and migration is water demand and distribution outside of issues related to glacial retreat. Cultivated area in the watershed nearly doubled between 1954 and 2009; warming temperatures allow for more diversified production at higher altitudes, in combination with more frequent cropping. But additional production requires more water (Alurralde et al. 2011; García and Taboada 2010; Villaroel et al. 2011). Irrigation is now more common, including for commercial agriculture (Agua Sustentable 2012). Social tensions are arising as three communities share the same irrigation tubes with a turnover system where each community has weekly access to water for two days:

> There are many conflicts. Some villages want more land, but we are struggling for our water. More land means more water needs. We have to share the available water from the river. We all have the same water source which comes out of the Illimani. (non-migrant, man, 40 y. o.)

The distribution system is the source of many conflicts, particularly between upstream and downstream users.

Glacial retreat as a symbolic driver

For residents of the Illimani hillside, the diminishing glacier is a tangible indicator of climate change and the glacier's demise has a strong cultural impact. The melting process is usually compared temporally.

> In the past, our glacier was white every year and it was snowing until here, up to 30 cm of height […]. Every morning when I wake up, I see the Illimani and I see always more the glacier shrinkage, it will never stop! (migrant, man, 45 y. o.)

In this quotation, the Illimani is mentioned using the possessive phrase "our glacier," emphasizing strong attachment. As stated by Orlove (2008), the Illimani "whiteness" is an iconic feature in the landscape of the area of La Paz, and the glacier is an important dimension of the Andean cosmological vision of the relationship between human beings and Mother Earth. According to local beliefs, the high mountain peaks are considered to be tutelary spirits, responsible for water sources and fertility of the fields. The disappearance of the mountain's whiteness is perceived as diminishing capacity for livelihood protection.

Many residents expressed substantial concern about future livelihoods, particularly as related to the conditions that will be encountered by their children or grandchildren:

> What our sons and grandsons are going to do? They will need to leave! We are suffering that the water is not enough. But we can still have food. However, when there is no more ice, what is coming down from the mountain? Nothing!

We will have to leave, and we will migrate to the city. (non-migrant, woman, 50 y. o.)

The option of current migration is often expressed in the context of concern with future livelihoods, even across generations.

Conclusion

Building upon findings from social and natural sciences and using a combination of literature review and ethnographic fieldwork, this research aimed to critically assess common assumptions about the impact of glacial retreat on migration. Three main conclusions can be drawn.

First, the seasonality of water availability is central to understanding the sensitivity of villagers toward water issues. Although melting glaciers provide more water throughout the year, the dry season remains a critical period for farming activity. The seasonal character of water availability, as well as the unpredictability and irregularity of the rainy season, seriously affects agricultural production cycles. This, in turn, has an impact on the temporality of migration cycles.

Second, access to water resources is in part determined by nonclimatic factors such as the governance of water distribution and the increasing water demand due to expanded agricultural activity.

Third, the disappearance of the glacier conveys a symbolic meaning, which strongly affects local communities. They associate the change in the traditional landscape as threat to the future of their livelihoods as a whole. Therefore, a central finding of this research is that even if glacial retreat in the Bolivian Andes has not created substantial new migratory flows, nor have a strong impact on existing migratory patterns, there are important impacts on the perceived sustainability of current livelihoods.

In the foreseeable future, characterized by the darkening of the Andean Cordillera, glacier-related drivers may interfere more substantially with migration processes. Melting glaciers may yield a short-term phase of abundance; however, agriculture may be entirely rainfed. Such a future would leave more than 2 million people without a continuous source of freshwater. This tipping point could well be reached in the Bolivian highlands in the coming decades, depending on temperature and precipitation scenarios, as well as high-altitude conservation efforts (Coudrain et al. 2005; Escurra et al. 2014; Soruco et al. 2009; Vuille et al. 2008). In their scenario-based approach, Hoffmann and Requena (2012) suggest that the urban area of La Paz may face increased social conflicts over natural resources in the coming decades. More generally, according to Rhoades (2008), communities living at the margins of tropical glaciers are currently: "sitting on a melting bomb."

Despite wide recognition that rapid retreat of glaciers necessitates the construction and strengthening of existing water reservoirs and dams, few measures have been undertaken in Bolivia. La Paz has already experienced an episode of shortages in 2009 when water was temporarily rationed (Arancibia 2012).

In the Bolivian context, colonization and state migration programs (typically from highlands to lowlands) have been at the heart of national political issues during the last four decades (Killeen et al. 2008; Mazurek 2007; Thiele 1995). Integrating glacially related outmigration, at a regional or national level, might represent important adaptation.

So far, urban areas such as El Alto and La Paz remain major migration destinations for highlanders. These growing urban populations continue to put pressure on basic environmental resources in already vulnerable sectors such as water and energy (Buytaert and De Bièvre 2012; Mark et al. 2010).

Overall, and as highlighted by other researchers (Adamo 2010; Findlay 2011; Foresight 2011a), I argue that the urban destinations of rural migrants should be more centrally embedded in empirical studies of climate change and migration. Improved understanding of urban environmental challenges related to migration is critical for development of adaptation and development policies appropriate for urban environments.

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