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THE CIRCULATION OF PEOPLE

A CRITICAL DISCUSSION ON 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 people migration in the Bolivian Andes. In the Andean region, glacial retreat is one of the most noticeable effects of global warming. Significant acceleration in glacial melting has been observed since the 1980s and glacial runoff is vital to the region, supporting local ecosystems as well as providing water for drinking, irrigation and energy production. In academic literature, international medias and NGO reports it is often assumed that these impacts are severely affecting the livelihood of the local population who may be forced to migrate. Based upon a literature review and a case study in the Bolivian Andes, this paper brings a critical discussion on this assumption. The confrontation of two bodies of academic literature, the first on migration and climate change and the second on glacial retreat impacts allows the conceptualisation of some mechanisms to understand how the impact of glacial retreat may be considered as migration drivers. These mechanisms are then illustrated and discussed with a case study that brings empirical insights on mobility patterns of rural communities living on the edge of a retreating glacier.

KEYWORDS

Keywords: Migration, climate change, glacier, glacial retreat, Andes, mountain, Bolivia

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1. Introduction

Global warming is responsible for alterations of the hydrological cycle in snowmelt-dominated regions like the Andes. Without adequate water storage capacity, these changes may lead to regional water shortage. Glaciers are thus essential for the Bolivian highland, supporting local ecosystems as well as providing water for drinking, farming, and energy production. The accelerating glacial melting of these three last decades threatens the mountain population livelihood.

This issue is at the heart of numerous articles in the media, political narratives, NGO reports and occasionally in academic discussions. Bolivian glaciers are often taken in examples and described with an alarmist perspective assuming that the melt of the ice is leading to an important social crisis and to internal migration. Between 2009 and 2010, years of the international conferences on climate change in Copenhagen and Cancun, mountain people from Bolivia became world famous embodying the figure of climate change victim. The experience of the farming village of Khapi located at the edge of a glacier has spread worldwide through press articles and reports. The New York Times announced: "In Bolivia, water and ice tell of climate change" (13.12.2009). One year later, the headlines of an online edition of CNN Mexico said: "Melting glacier is leading to outmigration in an indigenous community in Bolivia"[1] (01.12.2010). The BBC also published articles about Bolivia: "Bolivian villagers want compensation as glaciers melt" (19.04.2010) or "Bolivia's Indians feel the heat" (29.07.2009). Most of the pictures represent rural villages and farmers in a landscape made of glaciers and white-capped summits.

Glaciers also have an important place in political narratives. Pablo Solòn, the former Bolivian Ambassador to the United Nations, 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 under water?"(New York Times, 14.12.2009). Some NGOs are very committed in this issue and action has been taken to protect those who were identified and qualified as victims. A group of NGOs (Platform of social organisations against Climate Change , Earthjustice) 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 extreme have already exacerbated emigration to neighbouring urban centres of La Paz and El Alto.

[1] In its original version:"*El deshielo empuja la emigración en una comunidad indígena de Bolivia*." (translation by the author), CNN Mexico, 2011.

Without effective adaptation, communities like Khapi could be forced to relocate."(Earthjustice, 8.12.2009).

These narratives are coming from heterogeneous fields[2] but they hold in common the depiction of glacial retreat as a potential driver of migration. However, the scientific comprehension of this underlying relation is still far from satisfactory: "In general, the study of physical processes associated with glacier retreat is more advanced than the study of the impacts of these processes on human societies; indeed, the question of impacts constitutes an important gap in our knowledge" (Orlove 2008: 12). Impacts on society are still little documented and the way these processes may lead or affect migration patterns is only an assumption.

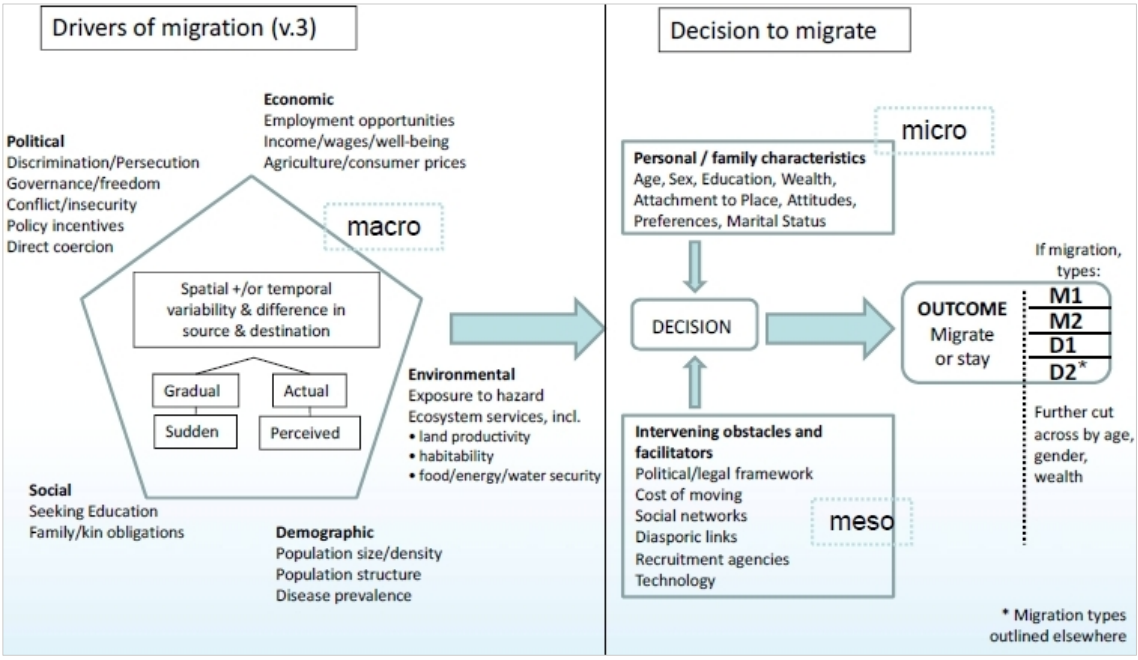
To better understand this issue, I proceed in three steps which correspond to the three parts of this paper. The first part reviews two sets of literature. The first set is the literature on migration and climate change with a focus on mountainous areas. In this literature, I try to assess the weight given to environmental drivers related to glacial retreat. The second set presents an overview of the studies on glacier issues. I briefly sketch the physical dimensions of glacial retreat in Bolivia. Then the various socio-economic impacts and the adaptation strategies related to glacier shrinkage are highlighted. In this review, I try to assess how the migration-related processes are depicted. Based on the confrontation of these two sets of literature, the third part of the paper attempts to conceptualize the relation between glacial retreat and migration. This theoretical proposition aims to disentangle how glacial impact may have a role as drivers of migration. Finally, the fourth part brings empirical insights from a case study conducted in mountain communities in the surrounding of La Paz. The migratory experiences and the way the environment drivers affecting decisions to move are assessed through a qualitative approach, combining in-depth interviews on the field and with experts. Spatially, the study focuses on the Bolivian Andes regions with empirical insights from four villages at the foot of the Illimani summit. However, the existing literature presented in the following chapters also takes stock of the knowledge from researches conducted in other mountain regions, like the Andes and occasionally the Himalayas.

[2] The way narratives on glaciers are employed by the Bolivian local and by international discourses are analysed by Kaijser Kaijser, A. 2013 (to be published). White Ponchos Dripping Away? Glacier Narratives in Bolivian Climate Change Discourse. In *Interpretive Approaches to Global Climate Governance: Deconstructing the Greenhouse,* eds. C. Methmann, D. Rothe & B. Stephan, 240. Routledge.. The author states that they aim to support a discourse of green radicalism and further political projects aiming towards strengthening the Bolivian state and national identity.

2. Literature review on migration and climate change

The terms “climate refugee” or “environmental refugee” have been widely used in both political and academic contexts over the last two decades giving rise to numerous debates amongst academics. At the beginning of the 90s the prognostics about the environmental migrants were dominated by an alarmist perspective estimating that at the end of the twenty-first century more than 150 million of refugees would be forced to flee because of climate change (Myers 1993, IPCC 1990). This first research raised public awareness about the human issues of climate changes. However, specialists in migration and other social scientists rapidly began to underline the limits of this perspective that describe the migrants as victims having no other option than to flee. A second set of studies appears on the correlation between environment disruptions and migration which tends to outline the multiplicity of factors at play in migratory processes (Castles 2002, Black 2001). It is now agreed that the deterministic position considering the environment as a direct cause of migration is highly inappropriate and that environmental factors are intertwined with social, economic, demographic and political drivers (For recent synthesis illustrating these tendencies, see Bättig et al. (2008); Foresight (2011a); Frühmann et al. (2009); Gemenne (2010); Hugo (2008); Jäger (2009); Morrissey (2009); Kniveton, Schmidt-Verkerk et al. (2008); Piguet et al. (2010); Tacoli (2009)). Based upon a literature review of the migration theories (Foresight 2011a, McLeman and Smit 2006, Perch-Nielsen 2004, Kniveton, Smith and Wood 2011, Black, Kniveton and Schmidt-Verkerk 2011) and their application in the field of climate induced migration, the Foresight report (2011a) highlights the multiple migration drivers (figure 1). The decision to migrate or not to migrate is then taken through the combination of micro- and meso- factors (personal/family characteristics, legal framework, cost of moving, social networks, etc.).

FIGURE 1 : MIGRATION DRIVERS AS REPRESENTED IN THE FORESIGHT REPORT (2011A)



Currently, the climate change migration issues are the subject of a burgeoning literature. However, the number of in-depth and empirical studies remains relatively low (Piguet and Laczko forthcoming). Among global warming impacts, the following effects are generally recognised as potentially leading to displacements: episodes of droughts and water shortages, increasing frequency and intensity of hurricanes, heavy rains and flooding, and sea level rise. Such climate change manifestations are heterogeneous: they fluctuate in scale and in potential damage and thus can lead to various form of mobility: “Migration as a response to the impacts of climate change exists along an adaptation continuum ranging from the reactive behaviour of displacement to the planned response of seasonal migration to diversify and maintain household income in the face of increased stress on livelihoods.” (Kniveton, Smith and Black 2012). A distinction is also usually made between sudden and slow onset environmental deterioration events. Sudden-onset disruptions tend to be temporary and the cause of migration is relatively clear. Migration tends to be temporary, over short distances, and sometimes return migration flows can be observed. In the case of slow-onset environmental deterioration, such as land degradation or water shortages, there is usually a set of overlapping causes at play and thus the role of the environment is complex (Leighton 2011, Piguet, Pecoud and Guchteneire 2011, Bardsley and Hugo 2010).

2.1 The weight of glacial retreat in migration and climate change literature

Studies on the influence of environmental drivers on migration that focus on mountain regions are few and the ones that specifically mention an eventual link with glacier retreat are even fewer. The only study that specifically does an assessment of the relation between migration and climate change in mountainous regions is the Foresight Report; two reports are dedicated to this issue (Kollmair and Banerjee 2011, Foresight 2011b). Among several environmental drivers of migration (besides the others non-environmental drivers) authors underline the cryosphere. However, the part devoted to it only refers to the Stern review pointing out that "alterations in the cryosphere are already leading to changes in land surface characteristics and drainage systems, and are likely to have significant implications for water availability in mountain and downstream communities" (Stern 2006). Another issue raised is that "with the continuing melting of glaciers and snow and ice cover, the supply of water to the vast land masses and billions of people may no longer be guaranteed, leading to severe water stress and potential conflict" (Kollmair and Banerjee 2011: 9). In addition, a workshop report states "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, a literature overview on population displacement from glacial melting in Nepal states that glacial outburst floods (GLOFs) and floods have so far only led to a temporary evacuation of one month for a population living downstream (Botez 2010). In Bolivia, the two 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, Zoomers 2012).

The next chapter seeks to extend these primary observations by focusing on a second set of literature on glacier issues. It starts with a brief introduction on the physical processes of glacial retreat in Bolivia and then depicts in more detail the socio-economic impacts.

3. Literature review on glacial retreat in the bolivian andes

Since 1970, glaciers in Bolivia lost almost half of their surface and the melting process tends to accelerate significantly over the years, especially between 1975 and 1980 (Rabatel et al. 2013, Soruco et al. 2009, Vuille et al. 2008, Coudrain, Francou and Kundzewicz 2005, Ramírez et al. 2001). Temperature increases due to climate change are and will be more pronounced in high-elevation mountain areas (Bradley et al. 2006,

Beniston, Diaz and Bradley 1997, Urrutia and Vuille 2009). Compared with glaciers in temperate or Polar regions, tropical glaciers are particularly sensitive to climatic variations. Two special features can be distinguished (Kaser and Ostmaston 2002): (1) They are subject to considerably higher levels of energy forcing since they are located in low tropical latitudes, but higher altitudes; (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.

A recent study on The Cordillera Real glaciers (based on photogrammetric measurements of 21 glaciers) points out that the glacier volume loss between 1963 and 2006 mounted to 43%, and the surface area loss for the period 1975-2006 was 48% (Soruco et al. 2009). An unknown number of small tropical glaciers of low and medium altitudes have entirely disappeared during this period, and projections indicate that many others are likely to vanish completely by mid-century, and possibly before. For example, the iconic Chacaltaya glacier, known for having being the highest ski slope in the world, completely vanished in 2009. The rapid retreat has resulted in a net increase in hydrological runoff, particularly in the most glacierized watersheds. However, this is a temporary effect tied to current rates of ablation (Ramirez 2006, Chevallier et al. 2011). Uncertainties remain on the state of the glaciers and on the water flows regime in a middle and long-term future (IAI 2010, Ramírez et al. 2001, Soruco 2008, Rabatel et al. 2013).

3.1 Impacts and responses associated to glacial retreat

This chapter proposes a synthesis of the current literature on impact and responses to glacial retreat with the ambition to assess the place given to migration patterns. The literature on impacts is often restricted to a deterministic approach that overlooks the way societies respond or adapt to it. This chapter also puts forward ethnographic research that underlines the way societies living on the margin of glaciers are dealing with the transformation of their environment. The ambition is to disentangle the mechanisms of a hypothetical causal chain starting from the geophysical processes of glacial retreat, to the way these transformations interfere with population livelihood and then to the way the exposed population adapt to it. Considered as an adaptation option, particular attention is given to migration. Inspired by the categorisation of Orlove and al. (2008), four families of glacial retreat impacts and responses are portrayed in the coming sections: (1) Environmental changes, (2) Hazards, (3) Water supply, and (4) Cultural Landscapes.

Environmental Changes (1)

Glacial retreat may lead to major changes in biodiversity, including plants and invertebrates, in mountain regions (Orlove and al. 2008). In Bolivia, Hoffmann points out that some ecosystems in high elevation areas are particularly sensitive to climate variations and may be seriously altered by the shrinkage of glaciers. Wetlands (bofedales) and moor (high plateau/páramos), for instance, play important roles as water storage places, as well as local climate regulators (Hoffmann 2008).

Hazards (2)

Glacial outburst floods (GLOFs) are considered one of the most direct threats resulting from deglaciation processes (Botez 2010). This phenomenon is an abrupt release of water from a glacial reservoir. Other disasters associated to glacial retreat include landslides, rockfalls and debris falls. As the ice is melting, slopes formerly frozen become more unstable and material is prone to slip and fall. Temperature changes also result in the degradation of the mountain permafrost which may lead to similar incidents. The loose material accumulation can aggravate debris flows following intense raining (Orlove, Wiegandt and Luckman 2008). In Chile, five major floods from glaciers have occurred (on Rio Colonia) in 2008 and 2009 and similar events affected Argentina (IAI 2010). One of the biggest event of this type happened in Peru in 1941; an outburst destroyed the village of Huaraz affecting 5000 people (Carey 2010). In Bolivia, the risk of disaster related to glacial shrinkage is probably lower but, according to Hoffmann and Weggenman (2012), there is a growing and legitimate concern regarding the danger of GLOFs. In 2009, a glacial lake above a small village in Apolobamba's Cordillera sent a wave of water downstream; it flooded cultivated fields, destroyed local roads and killed animals. The risks associated with these events are increased by the little awareness among the local population. Authors suggest that relocation of some parts of the most exposed villages can be an option to avoid disasters.

Water Availability (3)

The issue of water availability is probably the most obvious impact considering glacier shrinkage. Hoffmann (2008) states that the water availability decreases in Bolivia may potentially lead to land use changes, to an accelerated rate of depopulation and to an

increased level of migration towards cities. Yet, the way glacial retreat is affecting the water availability is manifold and has to be carefully depicted. Impacts on hydropower, drinking water and irrigation water are discussed in the following sections.

Hydropower (3.1)

Andean countries are highly dependent on hydropower (comprising over 50% of total energy for Ecuador and about 80% for Peru) but this contribution will be diminished in areas where basins are glacial dependent (Chevallier et al. 2011, Vergara et al. 2007). Estimates for Bolivia are less accurate but La Paz is also dependant for a major part of its energy supplies on hydroelectric power. The water-driving generators mainly come from the Huayna Potosi and the Charquiri glacial ranges; both have been subject to accelerated glacial loss in the last thirty years. Projections indicate that hydropower plants depending on Zongo glacier (part of Huayna Potosi range) will probably not be able to maintain their operation during dry season (Painter 2007, Soruco 2008, Olmos 2010). Besides, studies point out that wet season's excess precipitation would have to be stored in higher quantities than it has been done so far (Huggel et al. 2002, Barnett, Adam and Lettenmaier 2005).

Drinking water (3.2)

A significant fraction of water supply for major agglomerations of Peru, Ecuador and Bolivia is coming from the glaciers exposing these cities to seasonal water shortages risk (Chevallier et al. 2011, Vergara et al. 2007, Bradley et al. 2006, Barnett et al. 2005). According to Hoffmann (2008), the supply of water for the growing urban agglomeration formed by La Paz and El Alto represent the main issue linked to shrinking glaciers in Bolivia. Considering the demographic growth in both cities and that the glaciers around La Paz and El Alto could disappear sometime between 2025 and 2050, it is calculated that even the resources currently available are not expected to provide water of sufficient quantity and quality to both cities in the future (Soruco 2008). Since 2009, these two cities entered in a situation of "stress" concerning water supply (Ramirez, Olmos and Romàn 2007).The vulnerability of La Paz and El Alto concerning the water supply cannot only be attributed to glaciers but also to the weakness of the water distribution system. It is calculated that 40% of the water distributed by the company EPSAS (Empresa Pública Social de Agua y Saneamiento: Public utility water company for cities of La Paz and El Alto) is lost through illegal connexions and water leaks (PNUD 2011, Hardy 2009).

Irrigation (3.3)

Water for irrigation is thought to account for up to 90% of Bolivia's water demand (Ministry 2007). The area affected by glacier retreat for irrigation is the Altiplano region at the west part of the Cordillera Real (the oriental side of the Cordillera has a much more humid climate with another precipitation regime). The rural poor of this region are likely to be affected more severely by water shortages. Authors underline the accrued risk of conflicts between low land and high land users, as well as between rural and urban ones (Hoffmann 2010, Hoffmann , PNUD 2011).

By analogy, the adaptation options of a Peruvian herder's rural community living in an area where glaciers are retreating have been studied and according to the author "it's difficult to imagine alternatives to outmigration once the streams have dried up: at most, herders might retain seasonal camps in the area for the rainy season and travel elsewhere in the dry season." (Orlove 2009: 139). Orlove considers migration as an adaptation form and claim that NGOs and aid agencies may assist herders to relocate "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" (2009: 160). Another qualitative research conducted in Peru points out that glacial retreat has repercussions on the flow of some irrigation canals as well as the size of lakes and wetlands which induced a displacement of pasture for livestock: "For highland families, livelihood modifications and adaptations are imminent in the on-going landscape change associated with glacial retreat and climate change" (Young and Lipton 2006). Young men from these agricultural communities frequently out-migrated to urban areas seeking wage labour and opportunities. In Ecuador, the glacier Cotacachi completely melted in the last decade and heavily affected the tourism sector (Rhoades 2008, Rhoades, Zapata and Arangundy 2006). The area is experiencing declines in agriculture, in tourism income and a loss of biodiversity. The disappearance also has a spiritual ramification as the glacier embodies a sacred entity and communities believe that the fate of the mountain will be the fate of the people.

Cultural Landscapes (4)

Natural landscapes are often connected to meanings (religious, regional identity, etc.) and thus they can be considered as cultural landscapes. The cultural impact of glacier retreat should be considered as an important feature: "Many human societies have

strong attachments to glaciers, as they do to other features of the natural environment. These features have strong symbolic significance, and people identify with them." (Orlove 2008: 13). In Bolivia, the glacier also becomes a representation of the regional identity: the glacierized peaks of Illimani are on the background of all the pictures of La Paz. Snow-capped mountains attract many tourists willing to go trekking, climbing or sightseeing in an environment often described as a typical Andean landscape. The shrinkage of the ice may alter the tourist interest and thus the tourism-related sources of income. For instance, the Chacaltaya glacier is a tourist place known for being the highest ski slope in the world. At present, ski activities are not possible anymore as the glacier has completely disappeared. However, the impacts on tourism remain little investigated. The white summits are featured prominently on the city's official shield, on the seal of the major university in the city, on the labels for beer brewed there, and in countless other forms. As Orlove says "The residents identify not only with the city and with the nation but also with highland region of the country, embodied in the summits of Illimani. […] the Paceños identify not only with a mountain but with the glaciers that make it distinctive. […] the cultural impact of a dark Illimani rather than a gleaming white mass that watches over the city seem as serious as the economic ones" (2008: 13). The cultural dimension of glaciers also needs to be considered as a significant determinant shaping the responses of societies. As Ehrlich points out, glaciers seem to have an intrinsic value beyond any immediate usefulness that they might offer (Ehrlich 2004).

3.2 The weight of migration in glacial retreat literature

This recent literature sets out a good overview of the impacts and some adaptation examples, but it remains quite vague regarding the temporality of the interactions between glacial retreat and society. Many impacts refer to a present situation and others refer to future situations when the glacier has vanished or in an advanced stage of melting. Hence, the following figure (figure 2) synthetizes the impacts and distinguishes the temporality of the impacts. Such a synthesis comes out of a suggestion by Hoffmann (2008), where the author recommends building a "matrix" to analyse the interactions between glacial retreat and its potential socio-economic impacts. In the figure, two time scales are distinguished. First, the "observed" impacts are those that are discussed on the basis of empirical observation of present or past processes. Second, the "projected" impacts are those referring to future or hypothetical processes. It specifies the implications for livelihood and migration.

FIGURE 2 : SYNTHESIS OF THE INTERACTIONS BETWEEN THE IDENTIFIED IMPACTS RELATED TO GLACIAL RETREAT, LIVELIHOOD AND MIGRATION FRAMED ACCORDING THE TEMPORALITY OF THE PROCESSES. (N.M. = NOT MENTIONED IN THE LITERATURE OF REFERENCE).

IMPACTS	Temporality	Livelihood	Migration
Envi. Change (1)	**Observed**: alteration of wetlands and moor.	n.m.	n.m.
	Projected: degradation of wetlands and moor.	Ecosystems services: agriculture, land productivity and livestock.	n.m.
Hazards (2)	**Observed**: during the melting: GLOF's, landslides, rock falls.	Few communities are exposed, but very little awareness of the risk.	Relocation of the most exposed villages is suggested.
	Projected: once melted: n.m.	n.m.	n.m.
Hydropower (3.1)	**Observed**: During melting seasonal shortage.	n.m.	n.m.
	Projected: no operation during dry seasonal and possibly affect all year round.	Energy availability. Emergence of conflicts/insecurity.	n.m.
Drinking Water (3.2)	**Observed**: seasonal alternation of shortages and abundance.	n.m.	n.m.
	Projected: dry season with no available water	Water consumption during dry season. Potential conflicts/insecurity.	Migration to cities (internal)

Irrigation (3.3)	**Observed**: During melting, alternation of seasonal shortage and seasonal excess.	Agriculture, land productivity and livestock. Food insecurity. Emergence of conflicts/insecurity.	Outmigration to cities observed in some cases.
	Projected: Once melted, dry season with very little option for irrigation.	Agriculture, land productivity and livestock. Food insecurity. Increased conflicts.	Migration to cities (internal)
Cultural Landsc. (4)	**Observed**: change in landscape as snow and ice are receding	Place attachment (identity, religious, cultural, landscape, etc.)	n.m.
	Projected: darkening mountains	Loss or transformation of the symbolic value (identity, religious, cultural, landscape, etc.)	n.m.

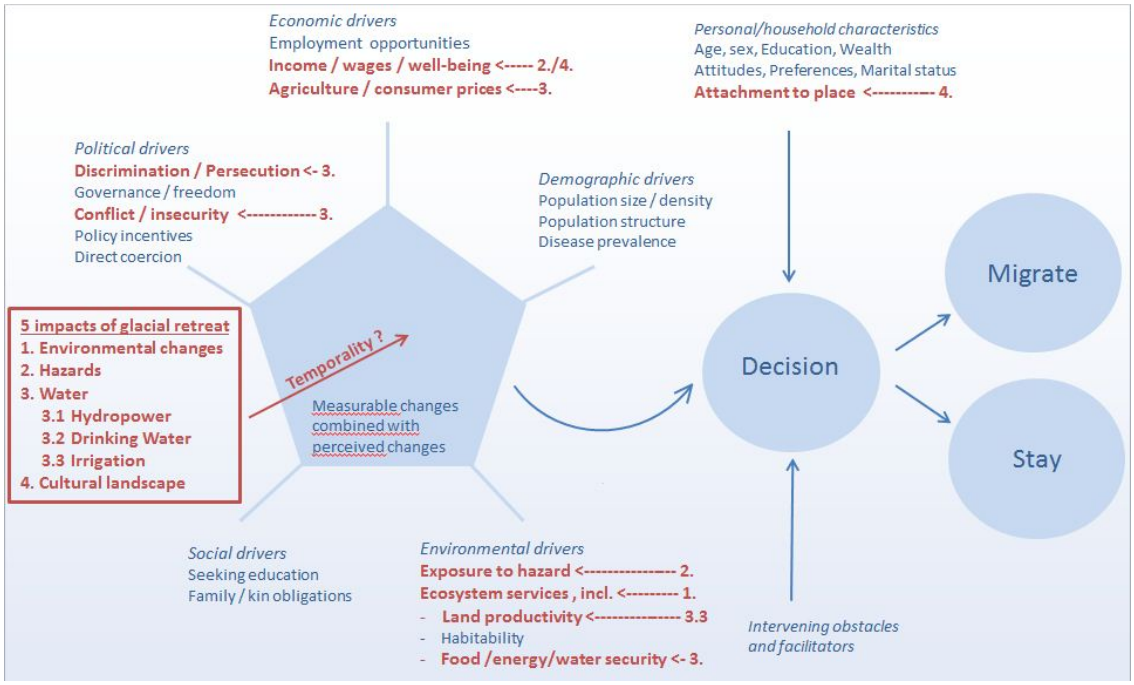
The few studies underlining migration patterns suggest that they are mostly taking place within the country and towards urban areas. Rural households in Andean societies have strong connections with urban areas as they constitute places to sell the agricultural products and places with employment opportunities during non-agricultural seasons. Furthermore, migration appears as a last option, in contrast to a perspective that would consider migration as a possible adaptation strategy.

What emerges from this first part of the paper is that there are virtually no interactions or cross-fertilizations between the two sets of literature overviewed. In the literature on migration and climate change, glacier issues are very marginally taken into consideration as a potential driver. Similarly, in the literature on impacts or responses to glacial retreat, migration is evoked sparsely. The next chapter seeks to explore the bridges that emerge from this literature overview and attempts to conceptualize the potential interferences between glacier shrinkage and migration.

4. Conceptualizing the relationship between glacial retreat and migration

To investigate the extent to which glacial retreat interferes with the multiple drivers of migration and migration decision, I propose to outline some mechanisms discussed in the two sets of literature previously depicted. The figure (figure 3) is showing the hypothetical interactions between glacial retreat and migration, the latter being considered as a possible result of a set of overlapping causes, whereby the environmental factor is only one factor among several others in explaining mobility dynamics (Piguet 2010). This modeling attempt is inspired by the work of Perch Nielsen (2008) who uses conceptual models, in a form of box-and-arrow figures, to improve the communication across disciplines and to depict the relevant connections between climate change and migration processes.

FIGURE 3 : THIS FIGURE HIGHLIGHTS THE INTERFERENCES BETWEEN THE 4 IDENTIFIED IMPACTS OF GLACIAL RETREAT (IN RED) AND THE TRADITIONAL MIGRATION DRIVERS (IN BLUE) IDENTIFIED IN THE FORESIGHT REPORT (2011A).



This model provides an illustration on the extent to which the 5 glacial retreat impacts interfere with the multiple drivers of migration identified in the Foresight report (2011a). Completing an existing model rather than drawing a new one is a more efficient way to increase our understanding of environmental change on migration. As it works from a

previously established base that has already been discussed it enables the debate to be advanced. In this model we consider that, from a theoretical perspective, all the types of impacts may have an influence on the drivers of migration whereas not all the drivers of migration are impacted by glacial retreat; the social or demographic drivers are not directly concerned.

Political drivers: Additional pressure on water availability may lead to inequalities in distribution and potential conflicts amongst users, which may seriously influence the decision to move. Energy insecurity may be increased if the hydroelectric production is put at risk. However, the concern will be much greater when the level of run-off is going to be significantly reduced (if the storage capacity is not increased).

Economic drivers: a variation in the available water for irrigation may have concrete repercussions on the agricultural production as well the market prizes. Household incomes and wellbeing may thus be affected by these variations. Second, melting glacier may affect the climbing conditions or alter the landscape leading to modification of tourist interest. The tourism in mountain areas generates incomes for villages located at the start or on the road to a frequented mountain area.

Environmental drivers: probably the driver most affected by glacial retreat. The latter increases the exposure to hazard and alters the ecosystems. Land productivity, food availability, energy production and water security are affected by the level of runoff.

The attachment to place: the symbolic dimension of the glacier evolution may have a role in the decision to migrate as this immaterial dimension is strongly related to place attachment, regional identity and religious meaning.

It is crucial to take into account the temporality of the impacts as they considerably determine the extent and the severity on livelihood and migration. Thus, the empirical part of this work examines the relevancy of impacts that are currently taken into account in migration decision in the Bolivian Andes.

5. Methodological approach

Decision-making processes are rarely exclusively based on a rational or scientific assessment of climate change. Decisions related to adaptation strategies are informed by a variety of sources including what “experts” say, what their peers say and what the media say (Grothmann & Patt 2005; Marx et al. 2006). Thus, to understand better how individuals and households respond to environmental changes it seems essential to document rigorously the physical changes but moreover to assess the way these

changes are perceived by the exposed population: « […] the perception of risks of change may be a far more important factor in decision-making than the realisation of biophysical change per se ». In his work on mountainous communities facing glacier melting, Vedwan and Rhoades developed an ethnographical approach based on the assumption that decision-making and local adaptations to global change must be understood through local people's awareness of weather and climatic change: “to understand how humans would respond to climate change, it is essential to study people’s perceptions of climate and the environment in general. Since it forms the basis of decision-making, local knowledge of climate should be incorporated into any strategy meant to mitigate the impact of climate change” (Vedwan and Rhoades 2001). In this case study, it is thus assumed that villager’s decisions regarding adaptation options, migration being one amongst others, are mostly based on their own environmental observations and perceptions.

The empirical part of the work is based on qualitative methodologies combining semi-structured interviews and field observation. Data was collected during various fieldwork journeys over several months, between 2010 and 2012. The first set of interviews was conducted with stakeholders composed of natural and social scientists, Bolivian and international NGOs staff members, water company representatives and authorities. They are all involved in activities related to the management or the study of glacial retreat issue in the Bolivian Andes. A second set of interviews was conducted in communities situated on the Illimani’s hillside, the emblematic summit surrounding La Paz. The studied area includes four different communities: Khapi, Pinaya, Cebollullo and Challasirca (municipality of Palca). All these villages are located within an area of less than 10 km next to each other, at an altitude between 2900 and 3880m. A third set of interviews took place in destination areas like La Paz and El Alto with migrants originating from these mountain communities. Statistics on migration data were also mobilised for some basic statistical and cartographical analysis.

6. Analysis: the presence of glaciers in a migrant driven region

The mountainous areas surrounding La Paz and El Alto, are characterized by dense migration dynamics (Lazar 2008, O’Hare and Rivas 2007, Andersen 2002, Cortes 2002, Cortes). Since the 1970s, the city of El Alto has grown from a small town of some thousand inhabitants to a city with an estimated population of more than 1,000,000 inhabitants (INE 2012).This massive expansion is attributed to large rural–urban

migratory processes. More than 80% of people living in El Alto are migrants coming from the surrounding highlands (Mazurek 2007, CODEPO 2004). For the studied area, the low distance separating (between 3 and 4 hours driving) the villages from the cities allows people to adopt a seasonal type of mobility or even to work in the city during the week and to come back to the village every weekend. Migrants may help relatives with farming activities, participate in traditional celebrations or accomplish their community duties within the village.

There is an absence of a strong statistical correlation (analysis of variance, single factor) between the presence of glaciers and the migration rate between municipalities with glacier and migration (Data of the 2001 census). Nevertheless the municipalities in contact with glaciers are experiencing more outmigration (mean of -9.31) than the others (mean of -7%). The municipality of Palca, where the fieldwork has been conducted has a net migration rate of -13 %. The exception is the municipality of El Alto (+ 19%) which is the most important destination for the migrants coming from all over the Altiplano. This first descriptive part is an initial step toward depicting migration patterns of the mountainous area; the next sections focus on the reasons to migrate.

6.1 Glacier as a Driver: an Initial Paradox

Based on the semi-directed interviews in the studied villages, three sets of drivers seem predominant in the migration decisions: the land fragmentation, the will to improve education and the water availability. This study focuses on the latter as it is the most directly linked to glacial retreat issues. The water scarcity is indeed virtually mentioned by all the interviewees as being one of the most significant drivers of migration in the Illimani area.

> “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!” (Khapi, man 32 y.o., 2011)

The villagers identify the lack of water availability as a serious threat. However the experts interviewed around this issue tend to deny any causal relationship. They argue that mountain communities are now beneficiating of an extra amount of water due to global warming and the water contained in the form of ice is currently increasing the glacier runoff.

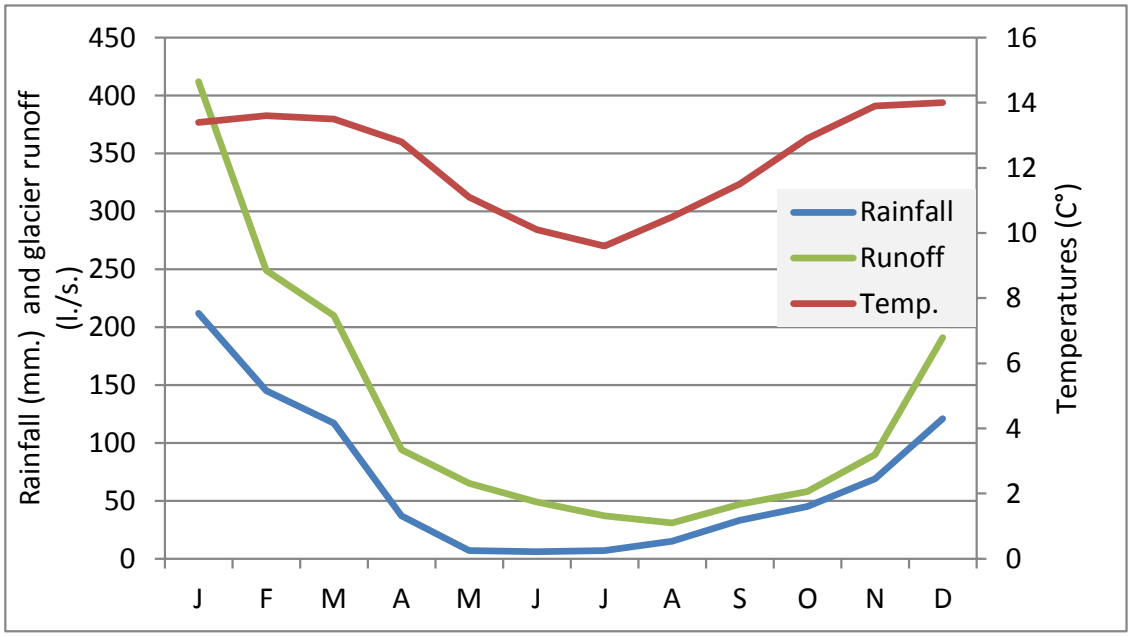
"These years, communities living at the Illimani side are enjoying an extra-amount of water. Until now, they have not experienced out-migration because of this." (Environmental NGO director, La Paz).

To explain this initial paradox on the availability of water and its consequences in terms of migration, it is necessary to take a closer look at the temporality of processes like the glacier run-off and the precipitation level.

6.2 Water issues and hazards: a matter of seasons

The glacier runoff is far from regular. As depicted in figure (figure 4), tropical glaciers mostly contribute to runoff during the rainfall season; the runoff peak discharge coincides with the peak of precipitation. In the dry season, from April to October, temperatures and precipitations are low and the runoff reaches its lowest level from May to August. The situation is thus critical for agriculture as the runoff constitutes the only source of irrigation.

FIGURE 4 : RAINFALL AND RUNOFF HAVE SIMILAR TENDENCIES AMONGST THE YEAR. THE WATER AVAILABILITY IS VERY LOW FROM MAY TO AUGUST AND INCREASES FROM DECEMBER. THESE TENDENCIES ARE ALSO STRONGLY LINKED TO TEMPERATURES. SOURCES: TEMPERATURES (MEAN PER MONTH 1975-2010, PALCA), RAINFALL (MEAN PER MONTH 1975-2010, PINAYA) AND RUNOFF (MEAN PER MONTH OF THE SIMULATED RUNOFF 1975-2009, KHAPI) (ESPINOZA ROMERO AND FUCHS 2011).



According to many interviews, the dry seasons tend to be longer and the first episodes of precipitation come later and later and they can be more intense. This statement coincides with broader climate model projections (Valdivia et al. 2010).These climatic conditions in communities of origin have direct implications in the migration cycles. During the dry season, the farming activity is less intense and people tend to stay longer in the urban areas (El Alto and La Paz) where they may have other sources of income. It has to be noted that mobility is seasonal due to the low distances separating the villages and the city. Migrants who moved to other regions or abroad have fewer contacts with the original community and their mobility is thus less dependent on the agricultural production cycle.

These observations explain the paradox previously evoked. When experts state that migration is not related to glacial retreat, they refer to the long term glacier shrinkage considering that there is currently more water. However, they tend to underestimate the importance of the seasonal variations of the runoff. The villagers from the Illimani hillside refer to water availability issues in a short run. They are suffering from water shortages during the dry season and during the rainfall season the overabundance of water may damage the 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 dragged!" (Khapi, women, 40 y.o.)

Slopes may be destabilized by an extra amount of water. In 2011, the first heavy rains episodes provoked a landslide that seriously damaged an irrigation canal constructed a few months before.

Seasonal variations of water availability have an impact on the production cycle which determines in turn the migration cycles for the migrants who are circulating between the cities and their village. Framing the triangular relationship composed of glacier; water and migration in a temporal perspective provides an efficient way to disentangle the apparent contradiction between experts and villagers narratives.

6.3 The glacier as a source of water and conflicts

The increased pressure on water during the dry seasons could be not purely attributed to environmental variables. Inequalities and relations of power are inherently part of water scarcity as well as the size of the family, the size of the plot or the way the

available water is managed and shared within the communities and amongst the communities.

> "We do not have land enough and this is making people migrate. In my case I do not have any plot of land. There is no water coming down from Illimani to sown fields, so it is, because of this many of us are going away to look for a better life." (Khapi, man 60 y.o.)

The property of land is traditionally handed down to the children. This process obtains from the agrarian reform of 1952 when agricultural lands were redistributed to Bolivian farmers and indigenous peoples. The surface of the plot is divided by the number of children and each generation has fewer agricultural surfaces. Three communities share the same irrigation tubes with a turnover system. Each community has the access to water during two days per week.

> "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. The same canal is shared for various villages: Khapi, Challasirca, Tahuapalca, etc." (Challasirca, man 40 y.o.)

The distribution system is the source of many conflicts, particularly between upstream and downstream users. Upstream users have facilitated access to the source of water and consequently they can exercise influence on the users located at lower altitude. Water availability issues are thus also related to the way that water is managed, and the influence of the glacial melting in this process should not be overestimated. The glacier rather constitutes the resource reservoir that crystallizes the tensions amongst the multiple villages that have to divide this unique resource. When articulated as a migration driver "water scarcity" cannot be naturalized; water issues are intrinsically related to social or organizational dimensions as depicted in this chapter. The pressure on water may lead to conflicting situations that undermine the social cohesion of the region. In the long run it seems highly probable that a decrease in the glacier runoff will accentuate these kinds of situations, especially during the dry seasons.

6.4 Glacial retreat as a symbolic driver

A diminishing glacier is probably the most tangible impact of climate change as it can be visually assessed. Melting glacier processes embody the evidence that climate is rapidly changing and may compromise future living possibilities. From this perspective, the glacier represents a strong climate indicator having a role similar to that of a

warning system. The image of the vanishing glacier has a strong impact for people living on the Illimani hillsides. Adults and elder people remember the location of the snow limit in the past and they can visually assess the retracting phenomena. The process of melting is often described through a temporal comparison.

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

In this quotation, the Illimani is mentioned using the possessive phrase "our glacier", emphasizing a strong attachment to it. The mountain is often personified and it can be assessed through the formulation "getting undressed" (desvestirse) when people refer to the shrinkage. As underlined by Orlove (2008), the Illimani "whiteness" is an iconic feature in the urban landscape of La Paz and the glacier is an important dimension of the Andean cosmological vision of the relationship between human being and mother earth. In the Andean believes the Apus (highest peaks) are tutelary spirits, held responsible for water sources and fertility of the fields and are the residence for the Illapaor thunder and lightning, a powerful god that is revered both for its water-producing facility and for its capability to produce damage to crops through hail (Vergara 2007).

Based on their observations, villagers express preoccupations mostly about their future livelihood. It is formulated through talking about the life conditions of 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 and that we have more worms in the seeds, in the potatoes… 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." (Khapi, woman, 50 y.o.)

People refer to their memories to assess the gradual retreat of the glacier and they refer to the future livelihood of their children to express their concerns aboutthese environmental transformations and the future livelihood. The effective impact on water availability, the glacier has an important immaterial dimension as it embodies climate change impacts and represents the difficulties that communities may face in the short-term future. This is considered when villagers are thinking about their future livelihood through the projection of the life of their children. The disappearance of the ice seems,

therefore, to perform decisions related to future livelihood and the option of migration is often expressed in this context.

7. Conclusion: from current to future issues

The current study disentangles the complex role of glacial retreat in migration decision. The analysis distinguishes four main results. First, our results suggest that glacial change has no straightforward implications on migration patterns. It has been showed that glacial retreat cannot be considered as a driver itself, but rather as an environmental change composed in multiple impacts varying across time that interfere with some drivers of migration. Second, the dynamic of glaciers are not automatically linked to the water availability issues often identified as drivers of migration. Current episodes of seasonal droughts or hazards cannot be solely attributed to glacial retreat but have to be considered in relation to the other climatic factors such as the precipitation and the temperatures and non-climatic factors, such as the governance on water distribution. That being said, the seasonality of the water availability (partially coming from glaciers) seriously affects the production cycle which in turn has a direct role on the temporality of mobility patterns (migration cycles). Third, the visual and highly symbolic dimension of the disappearing glacier raises concerns about future livelihood. In this context, migration is thus also envisaged as an anticipated adaptive strategy. Finally, impacts on energy production do not seem to raise preoccupations related to migration decision. Neither is the little touristic activities in Pinaya, where some villagers work as “muleros” (mule drivers) or “portadores” (porters). The village is indeed the starting point for mountaineers willing to climb the Illimani. According to people originating from Pinaya, income related to tourism has not yet changed and this activity only represents a supplementary income; agriculture is indeed far more important for their livelihood.

The qualitative perspective adopted in this paper induces some limitations. This approach is by definition restricted to the present time. Long-term impacts are hardly assessable with this methodological approach. Future projections are depicted through the concerns of stakeholders expressed through their children’s livelihood, for instance. Assessing the socio-economic future processes is highly complex and would require more specific approaches based on, for example, scenario building.

From this perspective, it seems crucial to frame the interactions between glacier and society with a temporal scale in order to identify the most critical periods. According to Rhoades (2008), societies living at the margin of tropical glaciers are “sitting on a

melting bomb". There may temporarily be more water in the rivers but this phase of abundance is inevitably followed by a significant decline until runoff is left to be governed exclusively by precipitation. This tipping point will be reached in Bolivia in the coming years or decades, depending on the temperature and precipitation scenarios (Vuille et al. 2008, Coudrain et al. 2005, Soruco et al. 2009). In the field of migration and environment studies, authors talk about thresholds "when environmental changes are so severe that the resilience of socio-ecological systems is breached or that the existing in-situ adaptation options either fail or are perceived as inadequate the use of migration as adaptation option may be fundamentally altered" (Bardsley and Hugo 2010). So far, it would be uncertain to state whether the non-linearity of the environmental changes that are facing mountain people would induce drastic changes in migration patterns. However, in a longer time scale the notion of threshold considers the impacts of glacial retreat not only for mountain areas but also for urban areas. Important highland cities like El Alto and La Paz constitute the main migration destination for the highland population. This added pressure on environmental resources may severely increase the vulnerability regarding basic resources like water and energy in urban areas. La Paz already experimented an episode of shortages in 2009 when water distribution had to be temporarily rationed. Will new migration flows occur or current migration tendencies be reinforced? Considering the vulnerability of the current destinations such as La Paz and El Alto, will future destinations change? Will people start to move away from these cities? These questions remain open, but urban areas, and more broadly the destination issue, should be taken into account more in studies on climate change and migration. This perspective has been highlighted by previous studies (Findlay 2011, Foresight 2011a) and starts to gain in importance in the field of migration and climate change. This also has policy implications as the adaptation policies are too often only focused on rural areas. So far no measures have been taken for water storage in Bolivia and it is probably too late to undertake mitigation measures as glacial retreat is an on-going and irreversible phenomenon. Therefore, it would seem more appropriate for policy makers, NGOs and authorities to work in parallel to increase the resilience for rural communities as well as the resilience of growing urban areas.

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