Rural livelihoods, location and vulnerable environments:

Approaches to migration in mountain areas of Latin America

DISSERTATION

to obtain the degree of Doctor at the Maastricht University,

on the authority of the Rector Magnificus,

Prof. dr. L. L. G. Soete

in accordance with the decision of the Board of Deans,

to be defended in public

on Friday 24 June 2016, at 14.45 hours

by

Andrea Milan

Supervisor
Prof. dr. Ronald Skeldon

Co- Supervisors
Dr. Melissa Siegel
Dr. Koko Warner (United Nations University Institute for Environment and Human Security)

Assessment Committee:
Prof. Hein de Haas (chairman)
Prof. Han Entzinger (Erasmus University)
Prof. Khalid Koser
Prof. Etienne Piguet (Université de Neuchâtel)

The United Nations University Institute for Environment and Human Security (UNU-EHS) contributed financially to the creation of this thesis.

Dedication

This dissertation is dedicated to the memory of Giulio Regeni, the most passionate PhD student I have ever met. The long discussions on our balcony have undoubtedly enriched this dissertation.

Thank you, Giulio. You left this world too soon.

Acknowledgements

I would like to thank Dr. Koko Warner who has made a great contribution to my academic, personal and professional growth in the past five years, both as my work supervisor and as co-supervisor for my PhD. Koko is the most inspiring team leader I have ever worked with. In early 2012, during a long meeting in her office, she convinced me to drop the idea of an MBA and get a PhD instead. She was right, and I am glad I listened to her.

I would also like to express my great appreciation to my supervisor Professor Ronald Skeldon and my co-supervisor Dr. Melissa Siegel. I learned a lot from their knowledge and professionality. They made my life easier though their constant support as well as through clear and constructive supervision at every stage of my PhD.

The members of my assessment committee Professors Hein de Haas, Han Entzinger, Khalid Koser and Etienne Piguet provided great constructive comments that enriched this dissertation. I feel privileged that such a distinguished assessment committee reviewed my work, and I am proud that they approved it.

This thesis would not have been completed without the support of many colleagues at UNU-EHS. A special thanks goes to Tamer for believing in me and for being a great supervisor. Thanks to Cosmin, Rob, Noemi, Kees, Michael, Sonia, Sobiah, Kehinde, Kristina, Christina, Janine, Sijia, Aarti, Randa and all other colleagues who accompanied me in my wonderful journey at UNU-EHS.

My support team in Bonn consisted of great friends too. I have truly appreciated the friendship and encouragement of Famil, Mauro, Nunzio, Daniele, Emanuele, Enrico, Stefan, Max, Francesco, Fabrizio, Jian, Manuela, and many others.

I regret not spending enough time in Maastricht, yet I always had a great time here. A special thanks goes to Mindel, Carlos, Guney, Charlotte and Saba for the great management of the GPAC program, and to Camilo and Silvia for making me feel home in Maastricht. I would also like to thank Clovis, Corinne, Natalia, Brenda, Ali, Mutinta, Paul, Julia and all other GPAC PhD fellows for the great time together and their feedback to my presentations. Katie, Katrin, Michaella, Sonja, Victor, Craig, Elaine, Jennifer and the other researchers from the migration team have provided very helpful inputs and comments to my dissertation.

Many people have been supportive in the course of my PhD, but Vale and Mali deserve special credit. Their help in a critical moment of my studies meant a lot to me.

I would also like to thank my former work supervisor Sami who gave me the first assignment on the topic of my dissertation back in 2009. Sami believed in me from the first to the last day of my internship, when he told me "I don't say goodbye to you because I know one day you will get a job with the United Nations". He was right.

I was privileged to grow up in Caltanissetta, a small town in Central Sicily, within a wonderful family. I would like to thank my mother for encouraging me to learn and explore. My father for teaching me the importance of passion and perseverance. My sister for showing me how to learn and grow from hard times. My grandmother Anna for her affection and her efforts to always bring the family together. I left Caltanissetta almost twelve years ago but I have always felt the full appreciation and support of every single member of my family.

Growing up in Caltanissetta was also special because of Antonio, Gianluca and Salvatore. Calling them friends would not be enough: they are brothers to me. Our tennis trainings under the Sicilian heat taught me the importance of working hard to achieve success. Our tournaments helped me accept losses and appreciate wins. I learned that the outcome of a tennis

game depends on many factors that we cannot control, and a good player always focuses on doing his best.

Several other friends from Caltanissetta made my high school a great experience and I know I can always count on their support. Among others, I want to mention Ettore, Giancarlo, Debora and Emanuela.

The last and greatest thanks goes to my wonderful partner. She supported me with all her love and energy during the hardest times of this academic journey. She inspires me to be a better person every day.

Contents

Figures

Tables

1. INTRODUCTION[1]

1.1 Previous research on the topic

Research on the interaction between migration and global environmental change dates back to the late 19th century, when many of the "founders" and early scholars of migration studies included environmental and climatic considerations among determinants of migration decision-making (Huntington, 1907, 1922; Kropotkin, 1902; Ratzel, 1882; Ratzel, 1903; Ravenstein, 1889; Ravenstein, 1891; Semple, 1911). Between the 1920s and the 1980s, economic and political drivers of migration took center stage in the development of migration theories and policies; economics-based approaches and refugee studies were at the heart of migration debates (Castles et al., 2014; Martin, 2014; Piguet, 2013).

Public interest in the environment-migration nexus started growing again in the 1980s and 1990s both because of a general growth in public interest on migration (Koser, 2009) as well as the publication of few influential studies specifically on migration and the environment. El Hinnawi (1985) was the first author to bring the issue of "environmental refugees" to a wide public and his paper boosted the very early debate on the relationship between environmental change and migration both among academics and international institutions (he published his article with the United Nations Environment Programme). Findley (1994) challenged the (then prevailing) simplistic view of the relationship between environmental change and migration (environmental stress factors pushing people to migrate) by bringing evidence of decreasing migration in the face of the 1983-1985 drought in Mali. Finally, Homer-Dixon (1999) published a book on the link between environmental scarcity and violence; his analysis of the importance of understanding migration patterns and impacts was picked up widely in the broader literature on environmental pressures and conflicts, including research focusing on climate change, conflict and

[1] The introduction draws on: Milan, A., Areikat, S. & Afifi, T. (2011). Environmentally Induced Migration and Sustainable Development, Paper presented at the 18th Annual Conference of the European Association of Environmental and Resource Economists, 29 June – 2 July 2011, Rome (Italy).

migration (see Barnett & Adger, 2007: 648; Burrows & Kinney, 2016; Reuveny, 2007, 2008).

The years 2006 and 2007 marked a turning point as climate change became a more prominent scientific issue. In 2006, the Stern Review on the Economics of Climate Change presented climate change as the greatest market failure ever and its economic analysis showed that the benefits of early action against climate change would more than outweigh its costs (Stern, 2006). A year later, the Intergovernmental Panel on Climate Change (IPCC) and Al Gore were awarded the Nobel Peace Prize for their efforts to build and disseminate knowledge on climate change as well as for laying the foundations to adopt measures to deal with it.

As climate change gained media, political and scientific attention, the number of methodological, conceptual and empirical articles on environmental change and migration began to increase substantially. Notably, Lackzo and Aghazarm (2009) published the most extensive review of available evidence on migration, environment and climate change; in the same year, Jäger et al. (2009) published a synthesis of the most interesting results from the Environmental Change and Forced Migration Scenarios (EACH-FOR) project, the first multi-country empirical project in the field. Two years later, the topic was featured in the most prestigious scientific journals, with Black et al. (2011b) and De Sherbinin et al., (2011) publishing articles for *Nature* and *Science*.

The latest (Fifth) Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2013/2014[2] confirmed what its previous reports had already shown: the global climate is changing and human activities contribute significantly to that change (IPCC, 2013a). Human-induced climate change is caused by greenhouse gases (GHGs) which have been increasing substantially over the last decade: the most reliable source of data on GHGs, the Mauna Loa climate station in Hawaii, has shown that they grew from 315 parts per million (ppm) in 1958 to reach 400ppm for the first time in May 2013 and they keep growing. Moreover, global temperatures continued to climb (2001-2010 was the warmest decade

[2] The IPCC Assessment Reports consist of four parts (one for each of its three working groups and a final synthesis report) which are not released simultaneously. The Fifth Assessment Report was released in four parts between September 2013 and November 2014.

on record) and sea levels are rising: they have risen by 3.2mm per year in 2001-2010, double the observed 20th Century rate (WMO, 2013).

Building on an emerging literature, the Nobel Prize Laureate Paul Crutzen argued that the central role of human activities in geology and ecology should be emphasized by calling a new geological era in which we are living "Anthropocene". While Crutzen believed that the beginning of the new era could be identified with the beginning of the industrial revolution at the end of the 18th Century, and particularly with James Watt´s invention of the steam engine, more recent studies have suggested alternative dates such as 1610 and 1964 as more appropriate from a scientific point of view (Crutzen, 2002; Crutzen & Stoermen, 2012; Lewis & Maslin, 2015).

In 2011 (when I developed the idea of this thesis), the literature on migration and global environmental change was under theorized and characterized by a very lively debate on the relative importance of environmental drivers of migration with respect to other drivers (see for example Afifi & Warner, 2008; Afifi, 2011; Jonsson, 2010; Morrissey, 2009). Academics were also debating the possible revision of the international definition of refugees to cover people forced to migrate because of environmental or climatic stressors, including natural hazards. Some scholars made the case for a new global protocol to fill protection gaps of what they called "climate refugees" (Biermann & Boas, 2008; Dochert & Giannini, 2009; Hodgkinson et al., 2009) while others opposed the idea, mostly because of the lack of an agreed definition of "climate refugees" as well as the concern that extending the refugee discipline could be a threat to the rights of those who are most in need (Hulme, 2008; McAdam, 2011).

At the time, the starting point for most researchers interested in what was often called "environmental migration" was the following definition suggested by the International Organization for Migration (IOM): "*Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad*" (IOM, 2007). However, this definition was too broad to be meaningful for researchers, practitioners and policy makers in the field.

Renaud et al. (2010) offered a more nuanced definition and they classified 'environmentally induced migrants' in the following three categories:

- *Environmental Emergency Migrants* who flee the worst of an environmental impact to save their lives;
- *Environmentally Forced Migrants* who have to leave to avoid inevitable and grave consequences of environmental degradation;
- *Environmentally Motivated Migrants* who may leave a steadily deteriorating environment to pre-empt the worst.

Academics and United Nations Agencies also debated the number of present and future "environmental migrants". In 2002, the Office of the United Nations High Commissioner for Refugees (UNHCR) estimated approximately 24 million "environmental migrants" worldwide, defined as "people who have fled because of floods, famine and other environmental disasters" (UNHCR, 2002). Forecasts on the number of potential environmental migrants by 2050 varied from 50 million to 350 million; the most cited estimate was provided by Myers, who predicted 200 million potential environmental migrants by 2050 (Myers 1993; Myers 1997; Myers 2001).

From a conceptual point of view, the literature focused on the relative weight of environmental factors as determinants of migration in the global South and it was characterized by two main schools of thought (Suhrke, 1994):

1. **The "minimalists"** believed that the environment should have been seen as a contextual factor in the decision to migrate, because - most of the time - people moved for economic, social and political reasons (for example: Bates, 2002; Bilsborrow, 1991; Black, 2001; de Haas, 2011; Hugo, 1996; Lonergan, 1998; McGregor, 1994).

2. **The "maximalists"**, by contrast, highlighted migration as a direct result of environmental factors. These authors believed that environmental factors were key factors that pushed people to move (for example: Döös, 1997; El-Hinnawi, 1985; Perch-Nielsen et al., 2008; Ramlogan, 1996; Westing, 1992; 1994).

From an empirical point of view, in spite of its well-known limitations (De Haas, 2014a; 2014b), many studies were taking a *push-pull* theoretical approach. Environment- and climate-related push factors (from regions of origin of migrants) included natural disasters, gradual climate-driven environmental changes, land issues and armed conflicts over shrinking natural resources. Pull factors (from destination regions) often included better economic opportunities, better ecosystems and networks in the destination regions. While environmental push factors could be clearly identified in certain contexts, researchers recognized that pull factors were very often economic (e.g. higher income and better standard of living) rather than environmental (Afifi, 2011). This led to the prevalence of studies in areas of origin of migrants, with very few studies looking at transit and destination areas (for example Findlay, 2011; Van der Geest, 2011). Moreover, studies on migration in the context of environmental change often ignored the importance of land tenure systems as well as land availability, distribution and use as determinants of migration patterns with few exceptions, especially in Latin America (for example Gray, 2009; Moran-Taylor & Taylor, 2010).

Attempts to draw general lessons learned from different case studies were limited, an exception being the Environmental Change and Forced Migration Scenarios (EACH-FOR) Project, the first multi-country project focusing on the relationship between environmental change and forced migration (Jäger et al., 2009). EACH-FOR was carried out from January 2007 through March 2009 by a consortium of researchers that conducted case studies in 23 countries worldwide. The objective of EACH-FOR was not only to study the causes of forced migration with respect to environmental degradation and climate change, but also to provide plausible future migration scenarios (Entzinger et al., 2010; Jäger et al., 2009; Warner et al., 2009). Several important lessons learned from EACH-FOR were taken into account in the design of the "Where the Rain Falls" (Rainfalls) project which constitutes the main source of primary data for this thesis.

By the time I started research for my PhD (in the Fall of 2012), estimates of the possible number of "environmental migrants" had been proven to be

scientifically weak, particularly because they were based on a series of unrealistic assumption on direct links between environmental stressors and migration (Gemenne, 2011; Jakobeit and Methmann, 2012). Moreover, recent work has suggested a broad conceptual agreement between "minimalists" and "maximalists" on the relative importance of environmental drivers of migration.

In the most comprehensive review of the debate from a political ecology perspective, Morrissey (2012) shows that the discursive debate ("proponents" and "critics") has been prioritized over the conceptual one in order to understand different positions on the relationship between migration and the environment (see also Bettini, 2013; Bettini & Andersson, 2014; Hartmann, 2010; Mayer, 2014; McNamara, 2007; McNamara, 2008; Piguet, 2013). These developments are in line with political ecology literature that has stressed the importance of discourse analysis to understand global environmental debates (for example Adger et al., 2001; Forsyth, 2003)

Building on Surkhe (1994) and Morrissey (2012), Piguet (2013) described the two sides of the current discursive debate as "alarmist discourse" and "sceptics' response" rather than minimalists and maximalists. He stated that a third "pragmatic" stance is now emerging between alarmists and sceptics which is exemplified by the work presented in the Foresight Report on Migration and Global Environmental Change (Black et al., 2011a; Foresight, 2011). One of the main suggestions from Piguet (2013) is to re-embed the environment into mainstream migration studies, without trying to shed light specifically on "environmental migrants".

In line with Piguet´s "pragmatic stance", this thesis builds on more recent literature which tends to avoid using typologies and defining environmental migrants as a separate category of migrants.

In particular, this dissertation builds on four key points which emerge from the recent literature and the case studies presented later in this manuscript (Milan et al., 2015a: 378):

1. In the context of climate change, environmental change is expected to have an increasing impact on migration in the future through its interrelationship with other demographic, economic, political and

social drivers of migration and in the context of rising national inequalities (Foresight, 2011). Migration decision-making is always complex and researchers should be careful in establishing any direct relationship between climatic and environmental stressors and migration (Afifi, 2011; Bettini, 2013; Mortreux & Barnett, 2009; Piguet, 2012; Wrathall, 2012);

2. Most migration in the context of environmental change is and will be internal and relatively short distance rather than international, with the notable exception of border areas (including mountains) and small states (particularly small island developing states) (Adamo & Izazola, 2010; Hugo, 1996);
3. While migration is often understood and framed as a failure to adapt to environmental and climatic changes, it can also be part of successful livelihood risk management strategies (Afifi et al., 2015; Bardsley & Hugo, 2010; Black et al., 2011b; McLeman & Smit, 2006; Tacoli, 2009; Warner & Afifi, 2014a);
4. In the upcoming decades, millions of people who would like to move might be unable to leave locations in which they are vulnerable to environmental change (Black & Collyer, 2014; Murphy, 2015).

1.2 "Where the Rain Falls" (Rainfalls): the main data source for this thesis

I joined the United Nations University Institute for Environment and Human Security (UNU-EHS) few days before the launch of the "Where the Rain Falls"[3] (Rainfalls) project in February 2011. In the same year, I made a substantial contribution to the development of the research methodology for the project (and co-authored its research protocol) and I was then

[3] The "Where the Rain Falls" ("Rainfalls") project was a three-year programme (2011-2013) of research, policy and advocacy on changing weather patterns, hunger and human mobility in rural areas of Africa, Asia and Latin America. The project was conducted in cooperation between the United Nations University Institute for Environment and Human Security (UNU-EHS) and CARE International and supported by MacArthur Foundation and AXA Group.

research leader for the two Latin American case studies (Guatemala and Peru), including data collection, management and analysis.

One year later (October 2012), I applied for the Dual Career Training Programme to obtain a PhD in Governance and Policy Analysis (GPAC²) with UNU-MERIT and the Maastricht Graduate School of Governance (MGSoG). My proposal suggested that I could build on data collected within the Rainfalls project to shed light on the specificities of migration in mountain areas of Latin America.

1.3 Organization and contents of the thesis

The next (second) chapter will present the methodology for this study. After a first section on the main research question and sub-questions associated to each chapter (2.1), section 2.2 presents the case study methodology and its application in Guatemala and Peru. This methodology includes three main components: Participatory Rural Appraisal (PRA) (2.2.2), household survey (2.2.3) and expert interviews (2.2.4). These three sub-sections are preceded by a short presentation of the pre-testing approach (2.2.1) and followed by a discussion of the limitations (2.2.5) of this methodological approach.

The organization of the rest of this manuscript reflects the chronological order of my work and the evolution of my research over the 2012-2015 period.

The following two chapters were developed in 2012 and 2013 and they will present two case studies based on data collected in Cabricán, Guatemala, in August-September 2011 (chapter 3) and Huancayo, Peru in October-November 2011 (chapter 4). Each of the chapters consists of six sections (3.1 to 3.6 and 4.1 to 4.6): introduction of the case study; brief presentation of the country context; characterization of the research area and particularly of the communities where the study took place; presentation of the study results; discussion of their implications and how they relate to previous literature on the topic; and conclusions and reflections for further research.

The fifth chapter was developed during and after my stay as a visiting scientist at Sussex University (UK) in June 2013. This chapter builds on the

results on past and present migration patterns in the case study area of Huancayo, Peru and it simulates possible migration scenarios from 2015 to 2050 through an Agent-Based Model (ABM) of migration. After the introduction (5.1), the second section (5.2) presents conceptual design (5.2.1) and assumptions (5.2.2) of the agent-based model, followed by primary data collection and parameterization (5.2.3), rainfall scenarios (5.2.4) used in the model and model limitations (5.2.5). The third section of the chapter presents the model results and how they relate to household vulnerability (5.3). The fourth part discusses the external validation of the model (5.4), followed by a discussion of the implications of the model and how they relate to the case study results presented in chapter 4 and the broader literature (5.5) and a conclusion (5.6).

The last main chapter (6) was written between 2014 and 2015 and it broadens the analysis of the previous chapters by looking at empirical research on migration in the context of global environmental change in other mountain areas of the global South. The chapter starts with an introduction (6.1), a review of past empirical approaches to study migration and environmental change in mountain areas of the global South (6.2) and a brief discussion of the contribution of the chapter to the academic debate (6.3). After a presentation of the theoretical background (6.4), the chapter summarizes the main findings from a Rainfalls case study in Tanzania (6.5) as well as a case study conducted in Pakistan with a similar methodology to Rainfalls (6.6). Both sections consist of four sub-sections (6.5.1 to 6.5.4 and 6.6.1 to 6.6.4 respectively): methodological approach; linking methods to results; questions remaining open; and lessons learned (6.5.4 and 6.6.4). Section 6.7 discusses the results of the three Rainfalls case studies in mountain areas (Guatemala, Peru and Tanzania) as well as the Pakistan case study results in a comparative perspective (6.7.1), particularly to reflect on the potential of linking household vulnerability measured through a correlation-sensitive multidimensional index with migration (6.7.2), and how this analysis could be complemented with other methodologies such as agent-based modelling (ABM), Geographic Information System (GIS) and remote sensing (6.7.3). The chapter ends with a short conclusion (6.8).

The final chapter of this thesis presents the discussion and conclusion (7) in which I place my research in the context of other relevant research and

suggest ideas for future research. The chapter consists of a summary of the main findings of this thesis (7.1), followed by reflections for further research (7.2).

After the references, this manuscript ends with a summary of my thesis, followed by an addendum on valorization to the dissertation and my curriculum vitae.

2. CASE STUDY METHODOLOGY

2.1 Main research question and sub-questions

From a theoretical perspective, this thesis builds on both the Sustainable Livelihoods Approach (SLA) and the New Economics of Labor Migration (NELM) (Kniveton et al., 2008). In fact, "both approaches can be easily integrated if we see internal as well as international migration as part of a broader household livelihood strategy to diversify income and overcome development constraints in the place of origin" (De Haas, 2010: 245).

NELM is based on the idea that migration is a household strategy to maximize as well as diversify the income streams (Massey & Parrado, 1998; Stark & Levhari, 1982; Taylor, 1999). Spatial diversification of labor and of household resources help the household mitigate risks such as crop failure (Arango, 2000). Migration as a risk minimizing strategy acts as a form of household-level insurance (Massey et al., 1993; Yang & Choi, 2007). Another key innovation brought by NELM scholars to migration debates has been its focus on the importance of remittances (Lucas & Stark, 1985; Stark, 1980) which had been largely ignored by neoclassical studies (De Haas, 2010: 243).

SLA also takes the household as its main unit of analysis to understand people's livelihood choices, including on migration. The SLA is built on the idea that households possess a variety of natural, physical, financial, human and social assets, all contributing to the household's livelihood. In this context, migration is seen as one of the strategies households employ to diversify their livelihoods (Bebbington, 1999; Carney, 1998; Ellis, 2000; McDowell and De Haan, 1997).

In this context, the rationale behind the geographical focus on mountain areas of Latin America is that the interaction of environmental changes with other drivers of livelihood change in mountain areas (such as population dynamics and economic globalization) is of great importance yet relatively understudied. In particular, the relationship between migration and environmental changes is a crucial determinant of rural livelihoods which has barely been studied in a systematic way. In particular, this thesis aims at answering the following research question:

Under which circumstances do people in vulnerable mountainous environments of Latin America migrate as a livelihood risk management strategy in the context of high rainfall variability and food insecurity?"

Vulnerable environments are defined as areas with the following characteristics:

- High rainfall variability and/or recurrent extreme rainfall events;
- Population highly vulnerable to rainfall variability;
- High percentage of people living in conditions of poverty or extreme poverty;
- Previous evidence of seasonal and permanent migration.

I try to answer this research question through two case studies (chapters 3 and 4) to understand past and present patterns of migration in two mountainous areas of Latin America as well as an agent-based model (chapter 5) which simulates possible future migration. On the one hand, chapter 3 looks at the circumstances under which people *can* migrate. Among other things, the chapter discuss the impact of relative geographic and economic isolation and lack of migratory options for the Guatemalan communities under study. On the other hand, chapters 4 and 5 look at the circumstances under which people *do* migrate in an area that is characterized by high mobility, particularly short-term and short-distance mobility to the nearby city of Huancayo. In the rest of this sub-chapter, I will present the chapter-specific research sub-questions.

The case study in Cabricán (Guatemala) presented in chapter 3 aims at answering the following sub-question:

"Under which circumstances can people in marginal mountainous environments of Latin America migrate as a livelihood risk management strategy in the context of high rainfall variability and food insecurity?"

Marginal areas are defined as remote and physically isolated areas, characterized by fragile resources with low productivity as well as several

barriers to participation in "mainstream" patterns of activities, including the market economy (Jodha, 1992: 45)

The case study in the Huancayo Province (Peru) presented in chapter 4 aims at answering a slightly different sub-question:

Under which circumstance do people located at different altitudes and with different levels of access to urban opportunities migrate as a livelihood risk management strategy in the context of high rainfall variability and food insecurity?

The Agent-Based Model (ABM) of possible outmigration from 2015 to 2050 in the same three communities in the Huancayo province (chapter 5) is based on the following sub-question:

How will expected changes in rainfall scenarios influence outmigration from 2015 to 2050?

Building on chapters 3, 4 and 5 as well as on the broader literature, chapter 6 discusses how to move beyond understanding of context- and time-specific case studies to draw some general lessons on migration in mountain areas of the global South. In particular, the chapter addresses the following sub-question:

How can the next generation of empirical research move beyond understanding of single case studies to draw general lessons on the relationship between household vulnerability and migration in mountain areas of the global South?

The rest of this chapter presents the case study methodology and its application in Guatemala (chapter 3) and Peru (4). The methodology for the agent-based model will directly be presented in the relevant chapter (5).

2.2 Case study methodology

A case study is "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident…The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one

result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis." (Yin, 2009: 18).

Three methods were used for primary data collection for the two case studies:

- Household Survey
- Participatory Rural Appraisal (PRA)
- Expert interviews

Table 1 - Research methodology - triangulation approach

Overarching theme	PRA sessions	Survey sections	Experts Interviewed
General spatial & temporal information	Transect walk, timeline, trend analysis	Economic activities, livelihood-related issues, household assets/resources, housing	All experts at the regional, national and local level
Impacts of rainfall variability	Seasonal calendar, Coping strategies ranking, impact diagram	Rainfall variability, Coping and adaptation strategies	Meteorological officers, local NGOs, farmers' organizations
Food (in)security	Livelihood risk ranking, seasonal calendar, Venn diagram	Food security, consumption and livelihood	Local NGOs and farmers' organizations
Migration	Seasonal calendar, Venn diagram, mobility map	All migration-related sections	Migration scholars, relevant international and national institutions

The rationale behind this mixed methodology is that a standardized household survey across the Rainfalls case studies (with only minor

additions in cases where they were needed) would allow for comparability across case studies[4]. The Participatory Rural Appraisal (PRA), implemented in cooperation with a team of local researchers and practitioners, would allow researchers to gain in-depth understanding of local livelihoods and migration patterns. Finally, expert interviews could be used to triangulate survey and PRA data and to ask science and policy-related questions to which local communities might not have had an answer (Matthew & Ross, 2010). Table 1 shows the structured triangulation approach which was the key for combining the different components of the methodology in an effective way.

The choice of the research area was not aimed at national statistical representativeness for each of the case studies; it was rather chosen through purposive sampling. In particular, the study took place in vulnerable environments, defined as areas with the following characteristics:

- High rainfall variability and/or recurrent extreme rainfall events;
- Population highly vulnerable to rainfall variability;
- High percentage of people living in conditions of poverty or extreme poverty;
- Previous evidence of seasonal and permanent migration.

I selected, in cooperation with local counterparts and in consultation with local and national experts, three or four communities within one province for each country which constituted our research areas. Within each area, a simple random sampling approach was used for the household survey. Sampling for PRA was purposive and adapted to the different case studies. In Peru and Guatemala, together with a senior national researcher, I coordinated a team of four (Guatemala) to five (Peru) local junior researchers that helped with data collection (paper surveys) and data entry through the software EpiData.

[4] For the application of the methodology in the Rainfalls case studies that are not presented in chapters 3 and 4, see: Afifi et al., 2014; Etzold et al., 2014; Etzold et al., 2016; Murali & Afifi, 2014; Rademacher-Schulz et al., 2014; Sakdapoldrak et al., 2014; Schraven & Rademacher-Schulz, 2016; Van de Geest et al., 2014.

In Guatemala, data were gathered through 136 household surveys, 17 interviews with local, regional and national experts and 36 Participatory Rural Appraisal (PRA) sessions, involving 298 people. The selection of households to be surveyed was done through a two-stage random sampling. Firstly, each sector of each community was assigned a percentage of surveys corresponding to its percentage of the total population. Secondly, within each sector, households were selected randomly[5].

Table 2 - Surveys and PRA sessions in Guatemala

Community	Total no. of households in the community (N)	No. of households surveyed (n)	PRA sessions
El Cerro	404	74	Transect walk, map of threats, livelihood risk ranking, timeline, trend analysis, mobility map, seasonal calendar, Venn diagram (food security), impact diagram (rainfall variability), adaptation strategies ranking, focus group discussions
Buena Vista	219	39	Transect walk, map of threats, livelihood risk ranking, impact diagram (rainfall variability), adaptation strategies ranking,
El Durazno	31	5	Transect walk, focus group discussions
Quiquibaj	80	18	Transect walk, focus group discussions
Total	734	136	

Source: Milan & Ruano, 2014: 63.

[5] Each village is divided into sectors by the local administration and all households are numbered within each sector. El Cerro, Quiquibaj, Buena Vista and El Durazno have ten, five, four and one sector respectively.

In Peru, data were gathered combining 150 household surveys, 14 expert interviews and 23 participatory rural appraisal (PRA) sessions involving approximately 150 people[6]. For the survey analysis of differences between lowland and highland (see 4.4.3), I identified 71 households based on lowland and 43 based on highland; 36 households from Paccha were excluded from the analysis because they were either based on both floors or it was not possible for me to determine where they were located.

Table 3 - Surveys and PRA sessions in Peru

Community	**Total no. of households in the community (N)**	**No. of households surveyed (n)**	**PRA sessions**
Paccha	300	88	Transect walk, livelihood risk ranking, timeline, trend analysis, mobility map, seasonal calendar, Venn diagram, impact diagram (rainfall variability), adaptation strategies ranking,
Acopalca	162	46	Transect walk, seasonal calendar, impact diagram (rainfall variability), adaptation strategies ranking,
Chamisería	40	16	Transect walk, seasonal calendar, focus group discussions, adaptation strategies ranking, Venn diagram
Total	502	150	

Source: Ho & Milan, 2012: 29

While the Rainfalls methodology is described in detail by Rademacher-Schulz et al. (2012), including full text of the household survey, guide to all PRA sessions and list of questions for the semi-structured expert

[6] Some people took part to more than one session so I cannot provide the exact number of participants.

interviews, in the rest of this chapter I present some of the key characteristics of each method used.

2.2.1 Pre-testing methods

The pre-testing of methods was done in locations which were similar to the ones where the main research was to be conducted, in most cases somewhere nearby the research area (Rademacher-Schulz et al., 2012: 20).

The pre-testing had the following objectives:

- Testing the time needed to conduct the PRA workshops and household survey;
- Assessing whether the PRA and survey questions were translated properly, understandable and appropriate to the local context;
- Determining whether additional questions were needed to adapt the Rainfalls survey, guide to PRA workshops and expert interviews to the local context.

The local research teams were provided a glossary with operational definitions of key concepts (for example household, livelihoods and food security) which they reviewed for local applicability before the main fieldwork phase (Rademacher-Schulz et al., 2012: 98-101).

In Peru, the Spanish version of the survey which had been previously translated for the case study in Guatemala was reviewed to ascertain its fit with the local context through a pre-test of the survey in a community (Cochas Grande) near the research area that was not analyzed during the main fieldwork phase.

2.2.2 Participatory Rural Appraisal (PRA)

The Participatory Rural Appraisal (PRA) emerged in the field of development studies and particularly from the Institute for Development

Studies (IDS) at Sussex University in the 1980s (Chambers, 1996). PRA is not just a single method, but includes a cluster of approaches and tools to address different topics of interest.

Table 4 below shows the set of PRA methods that were used within the Rainfalls project, their objectives and the topics they focused on[7]. These complemented the household survey by asking the groups open questions for more detailed and in-depth answers.

Table 4 - Summary of Rainfalls PRA tools

PRA session	Objective	Main topics
Transect walk	Exploring the spatial dimension of livelihoods	Land issues, main crops, wealth distribution, natural resources
Timeline	Understanding temporal dimension of livelihoods	Chronology of the community
Trend analysis	Depicting changes in climatic and social processes	Rainfall patterns, agricultural cycle, migration
Seasonal calendar	Showing perceptions regarding seasonal variations	Rainfall patterns, agricultural cycle, non-farming activities, migration
Livelihood risk ranking	Eliciting people´s perceptions of the main risks they face	Livelihood risks
Coping strategies ranking	Learning how people cope with livelihood risks	Livelihood risks, coping strategies
Venn Diagram on migration	Depicting key institutions, organizations and individuals playing a role in migration processes	Migration, formal and informal institutions

[7] For a step-by-step guide on each of these methods, please refer to Rademacher-Schulz et al., 2012: 46-65.

Venn Diagram on food insecurity	Depicting key institutions, organizations and individuals playing a role in times of food crises	Food insecurity, formal and informal institutions
Mobility map	Exploring the mobility patterns of the community	Migration
Impact diagram	Learning about direct and indirect impacts of rainfall variability	Rainfall variability, livelihoods
Focus Group Discussions	Gaining in-depth information on specific topics	All

Sources: Kumar, 2002; Narayanasamy, 2009; Rademacher-Schulz et al., 2012.

The PRA considered the gender, age and income aspect / livelihood type by having mixed but also separate groups, in order to ensure a fair representation in the research and to ensure that all participants could express themselves freely.

In the case of Guatemala, Participatory Rural Appraisal (PRA) workshops and focus group discussions were employed in all communities. A total of 36 PRA sessions were held with 298 individuals; among them, 163 (55%) were women and 135 (45%) were men. All exercises (with the exception of the timeline which was conducted with men only) were conducted in parallel with men and women working in two separate groups. Moreover, specific focus group discussions were conducted with young men and young women to learn about their views on rainfall variability, food security and migration. Not all of the PRA sessions held in the largest community (El Cerro) were replicated across all communities for several reasons: time limitations; because the four communities were deemed very similar in terms of their food production systems as well as the problems they faced and livelihood strategies; and, finally, given the small population of the communities it would not have been possible to organize multiple focus groups without inviting the same people several times.

A total of 23 PRA sessions were held in Peru (twelve in the largest community, Paccha; four in Acopalca; and seven in Chamisería). Only four PRA sessions were held in Acopalca because of difficulties in convening the sessions. A total of almost 150 people participated in the sessions, among them 25 men and approximately 125 women.

2.2.3 Household Survey

Building on the EACH-FOR experience as well as on the New Economics of Labor Migration (NELM), the survey was administered at the household level under the assumption that migration follows a household decision which is influenced by the characteristics and propensity to migrate of individuals within each household (Stark & Levkari, 1982; Stark & Bloom, 1985; Stark & Hitzyaki, 1988; Stark &Taylor, 1989; Warner & Afifi, 2014a).

The Rainfalls household survey included questions about the following topics[8]:

- Household demographics
- Economic activities and livelihood related issues
- Rainfall variability and its effect on livelihood and food security
- Food security, consumption, and livelihood
- Migration patterns of household members
- Migration perceptions on household and community level
- Migration decision, destination & networks
- Reasons/factors that affect migration decisions
- Institutional affiliation & support
- Migration & remittances
- Non-migration and Reasons for staying at home
- Household "assets"/ resources

In Guatemala, the plan was to conduct 150 household surveys. However, due to theoretical saturation, sampling was reviewed during fieldwork to reduce the sample size to 130 (without compromising sample distribution

[8] For the full text of the Rainfalls survey, please refer to Rademacher et al., 2012: 66-88.

and randomness). The final number of 136 surveys depended on updated data on population per village which the team was only able to access during fieldwork[9]. In Peru, a total of 150 surveys were conducted.

2.2.4 Expert interviews

Interviews were held at the national, regional and local level with persons engaged in development policies, international organizations and NGOs, policy makers, academics/researchers and civil society representatives[10]. Interviewees included local leaders, agricultural extension workers, representatives of community-based organization such as farmers' groups or water committees, and teachers or mayors. Interviews were semi-structured and based on a set of questions to facilitate more in-depth discussions around three themes that are central to this investigation: variability of rainfall and climate change; livelihood and food security; and migration dynamics.

In Guatemala, expert interviews were carried out at three geographic and institutional levels: the local level (Cabricán); the regional level (Quetzaltenango); and the national level (Guatemala City). A total of seventeen experts were interviewed[11]:

- Three local experts including the leader of one of the study communities (Buena Vista) and two people working in Cabricán;
- In the city of Quetzaltenango, six people from different organizations, most of whom were taking part in the regional roundtable on climate change;
- In Guatemala City, eight experts who worked in different organizations on topics related to the main focus of this study. These interviews were conducted after the fieldwork stage had been finalized.

[9] The six additional surveys had already been conducted in Quiquibaj (4) and El Cerro (2) before the team could access the correct population data.

[10] For the full semi-structured Rainfalls interview guide, please refer to Rademacher-Schulz et al., 2012: 89-90.

[11] For the full list of the experts interviewed in Guatemala, see Ruano & Milan, 2014: 64-65.

In Peru, interviews were conducted with fourteen experts, ten local and four national persons from various public and private institutions, including an international NGO, an international organization and several academics[12].

2.2.5 Limitations

Availability of secondary data was limited, especially for the Guatemala case study. While the case study in Peru was conducted in an area characterized by a rich literature dating back to the 1960s, it was difficult to find academic sources of information regarding livelihoods and migration patterns in Cabricán. Moreover, census data in Peru are more detailed and available online at a lower administrative scale (district) than it is the case in Guatemala, where demographic analysis is also hindered by the fact that only the last census includes age quintiles while previous censuses simply reported data for broader age groups that can be used to calculate dependency ratio (0-14, 15-64, 65+).

Regarding primary data collection, the study incurred several time-related and space-related limitations (Skeldon, 1990: 11-26).

Firstly, human mobility is complicated to measure, especially in a highly mobile context such as the rural communities around the city of Huancayo where few human movements are characterized by a clear change of residency of the migrant and households are often bi-local, with two usual places of residency (one in the rural community of origin, one in the city of Huancayo). The Peruvian case study showed that the most common form of human mobility is short-term mobility to Huancayo; however, an in-depth study of determinants and patterns of such short-term mobility is beyond the reach of this thesis which focused on migration defined as a movement of at least one month outside the migrant's home province. The issue is complicated by the growth of the urban area of Huancayo which is constantly changing the rural/urban boundary.

[12] For the full list of the experts interviewed in Peru, see Ho & Milan, 2012: 30-31.

Secondly, field work was only conducted in areas of origin of migrants which limits understanding of the complex migratory process, including the role of social networks. This is an important limitation in a context such as the Peruvian communities under study which have been characterized by high outmigration flows for decades as well as by a complex network of rural-urban, inter- and intra-household connections (Smith, 1984).

Moreover, I could only go to the field at one point in time. On the one hand, this implies that I could only see the communities in one specific moment of the year which might affect the results of the research. On the other hand, without time-series data, I had to ask respondents about the past which implies recall problems. The recall issues were exacerbated by the fact that a household head/representative was responding to the survey on behalf of the entire household.

Another time-related limitation is that the household survey only collected information on the first and last migratory movement of each individual within the sample. Nevertheless, the survey recorded the place of birth as well as the current location (place of interview/elsewhere) of each household member. Even the full migration history of each individual collected in 2013 through a second round of data collection (only in Peru) offered a limited picture of demographic and migratory patterns. In fact, the household head/representative could only respond about past migration of the household and its members as they had been defined at the time of the first interview in 2011. This implies that the survey data did not cover households that left the communities in the previous years.

The use of the same survey for different geographic, socio-economic and political contexts proved very challenging. While combining it with a Participatory Rural Appraisal (PRA) provided a reasonable compromise, a context-specific survey would have given more information on issues that were identified within each case study which I could only learn about through expert interviews and PRA (for example, details on short-term short-distance mobility in Peru).

Regarding the PRA, the research protocol (Rademacher-Schulz et al., 2012) recommended forming groups differentiated by age, sex, welfare or by type of livelihood or economic activity, according to the topic at hand. For

example, when working on the chronology of historical events, a group of elders would be advised. In the case of classification of risks or threats to livelihoods, the protocol would recommend the formation of up to four distinct groups: farmers, non-farmers, most-vulnerable people and a group of women who undertake mixed activities. This could only be done partially in the two Latin American case studies because of pragmatic constraints. Sessions had to be arranged on the basis of the availability of people at that particular moment.

The main way in which I tried to overcome these issues was through a structured triangulation of the four main components of my research methodology: household survey, PRA, expert interviews and the literature (see table 1). In practice, this meant that whenever results from the household surveys were not in line with the outcomes of PRA sessions, I tried to find an explanation either through the outcomes of the expert interviews or by reviewing the relevant literature.

Aside from the general limitations of the Rainfalls approach, the research team faced several limitations which were specific to the case studies.

Guatemala

In Guatemala, the research team faced the following limitations:

- The year before the research took place was characterized by heavy rains, due to extreme climatic events (Agatha and Frank tropical storms); therefore, people had in their mind more vividly the high rain events leaving the drought events in a secondary place;
- The team faced the reluctance of the population to mention migrants in their families[13];
- A total of 46 households based in one of the four sectors of Quiquibaj, one of the communities under study, had to be excluded

[13] Few years before fieldwork took place, the Government conducted interviews regarding migration in order to decide who complied with the requirements to receive governmental support. Those who claimed to have relatives in the United States were not granted access to the program.

from the total population from which the sample for the household survey was drawn because of inaccessibility due to their distance, topography and dispersion of the houses. This meant that eight surveys which were supposed to be done in those sectors were subsequently randomly redistributed among the other three sectors of Quiquibaj.

Peru

The research site selected before fieldwork in Peru proved problematic. Vilcacoto, which is located in the lower part of the Shullcas sub-basin, was supposed to be the main community in which research took place, but as soon as I arrived there I noticed it had been virtually surrounded by the urban sprawl of Huancayo and local livelihoods were mostly dependent on urban activities. As a consequence, it did not meet the required site selection criteria. Right before starting fieldwork, in consultation with local counterparts, I decided to replace Vilcacoto with Paccha. Changing at the last minute brought practical disadvantages in terms of access to the community: CARE Huancayo, the Non-Governmental Organization that was helping us with the logistics, was not working in Paccha so its staff had to establish contacts very quickly.

During field activities, difficulties were encountered in defining the sample size for each community, because no reliable demographic information was available, especially in the case of Paccha. The search for population data in the district municipality of El Tambo, where Paccha is located, was unsuccessful and I had to count the houses before I could start data collection in Paccha's seven neighborhoods.

An additional difficulty for the implementation of surveys in the three communities was the overlapping of fieldwork with the beginning of the sowing season. Most men were absent, either because they were sowing in the fields or doing other work, so I worked mostly with women. A more balanced gender representation would have been ideal but the beginning of the planting season created serious obstacles to that, despite the fact that the research team was instructed to follow respondents to their fields whenever necessary in order to conduct surveys with men as well.

Last but not least, in the case of Paccha and Acopalca, many of the villagers who take part in the *comunidad campesina (comuneros)* live scattered in the highlands and only visit their villages periodically. For example, in Acopalca, *comuneros* who live grazing their herds of cattle go down to "town" every four months when community meetings are held to agree on the "*faenas*" (collective-type activities, such as the repair of roads, canals or the election of working committees). For those who live furthest, it takes up to six hours to get to the village center and due to time limitations the household survey could not cover them.

3. RAINFALL VARIABILITY, FOOD INSECURITY AND MIGRATION IN CABRICÁN, GUATEMALA[14]

3.1 Introduction

The 2011 Foresight report on Migration and Global Environmental Change, the most comprehensive review of the literature on the topic, shed light on two relatively understudied issues in the literature on migration and global environmental change. Firstly, it emphasized the importance of studying the specificities of mountain areas in order to understand the nexus between environmental change and migration in those areas (Kollmair & Banerjee, 2011). Secondly, it showed that future environmental change is equally likely to lead to an increase or a decrease in migration flows. In this context, those who might be willing but unable to move ("trapped") will be extremely vulnerable (Foresight, 2011).

However, the Foresight report did not bring any new empirical evidence to support its theoretical work. This chapter aims at providing an empirical contribution by answering the following research question: "Under which circumstances can people in marginal mountainous environments of Latin America migrate as a livelihood risk management strategy in the context of high rainfall variability and food insecurity?" In particular, it presents the results of the Guatemalan case study of the Rainfalls Project which took place in August/September 2011 in four Guatemalan mountain communities in Cabricán whose populations are exposed to the risk of becoming "trapped" in the near future in a place where they are extremely vulnerable to climatic and environmental stressors. In fact, in case of future crises which threaten the sustainability of local livelihoods, migration is likely to be a crucial determinant of the success of the local response (Eakin et al., 2006; Tucker et al., 2010). However, as this chapter shows, the profitability of livelihood diversification options in Cabricán is decreasing and combined with decreasing *ex situ* opportunities.

[14] This chapter is based on: Milan, A. & Ruano, S. (2014). Rainfall variability, food insecurity and migration in Cabricán, Guatemala, *Climate and Development 6*(1), 61–68; Ruano, S. & Milan, A. (2014). Climate change, rainfall patterns, livelihoods and migration in Cabricán, Guatemala. *UNU-EHS Report 14*. Bonn, Germany: UNU-EHS.

3.2 The Guatemalan context

The name Guatemala is derived from the Náhuatl word quauhtlemallan, which means "place of many trees" (Luján Muñoz, 1993). The country is located in the Central American Isthmus, with a territory extending over 108,889 km^2 bordering to the north-west with Mexico, to the east with Belize and the Gulf of Honduras, to the south-east with Honduras and El Salvador and to the south with the Pacific Ocean. The country is crossed from west to east by a mountainous chain of volcanic origin called the Sierra Madre with altitudes between 1,000 and 4,220 meters. Moreover, its territory is characterized by lakes and rivers which drain towards both the Pacific Ocean and the Caribbean Sea.

The 2011 report on human development, published by the United Nations Development Programme (UNDP), showed a medium human development index (0.574) for Guatemala; this value is the second lowest among Latin American countries (after Haiti which is 158th with 0.454) and ranks 131st in the world (UNDP, 2011a).

Table 5 – Latin American countries with low and medium Human Development Index in 2011

Rank	Country	HDI value
1	Haiti	0.454 (low)
2	Guatemala	0.574 (medium)
3	Nicaragua	0.589 (medium)
4	Honduras	0.625 (medium)
5	Bolivia	0.663 (medium)
6	Paraguay	0.665 (medium)
7	El Salvador	0.674 (medium)
8	Dominican Republic	0.689 (medium)

Source: Data from UNDP, 2011a.

A key social issue in Guatemala is the high prevalence of food insecurity and malnutrition. In 2011, 19% of its children where underweight[15] which is more than double the average for Latin America (7%) (UNICEF, 2011). Indigenous children suffered disproportionately, with rates of stunting and underweight almost twice that of non-indigenous children (WHO/PAHO, 2008). In 2011, 14.4% of Guatemalans were severely food insecure; in the department of Quetzaltenango the percentage was slightly lower (13.4%) than the national average (INE, 2011b).

3.2.1 Climate

Guatemala is located within the tropical zone of the Northern hemisphere and its wide variety in terms of altitudes results in diverse environmental conditions. According to the Holdridge classification, the Central American country has approximately 360 microclimates and 14 life zones (Holdridge, 1967). Biotemperature and rainfall vary in relatively small areas of land because of its steep topography (FAO, 2003).

Guatemala has two weather seasons: the dry season (summer) and the rainy season (winter). Annual rainfall is mostly concentrated in the period from May to October (with a short dry period in July or August called *canícula*) and the country is characterized by warm tropical weather that changes extensively depending on the altitude. Seasonal temperatures are scarcely different from each other; hence, Guatemala is known as the "Land of Eternal Spring" (INSIVUMEH, 2010). In the central and western high-altitude areas (such as the research area Cabricán), the rainy season starts in June and it lasts until October. The season is characterized by its clear skies before and after heavy rains, which generally occur during the afternoon due to convective rainfall (Foëhn effect), which warms the air while moving through the mountain chains (FAO, 2009).

[15] Percentage of children aged 0–59 months who are below minus two standard deviations from median weight for age of the NCHS/WHO reference population.

3.2.2 Climate change

The second working group for the IPCC's Fourth Assessment Report (AR4) collected and analyzed the scientific literature on the impact, adaptation and vulnerability to climate change in Latin America. The report they produced showed that climate variability and extreme events have severely affected the Latin America region in recent years (Parry et al., 2007). Climate change is a central economic problem for Latin America and the Caribbean (and Guatemala in particular) "has a considerable challenge to adapt to climate change while redoubling efforts to reduce poverty, inequality and socio-economic and environmental vulnerability" (ECLAC, 2010: 1). The adaptive capacity of human systems in Latin America is low, particularly regarding extreme climatic events, while vulnerability is high.

The first studies on vulnerability to climate change in Guatemala were conducted in late 2001, under the framework of the First National Communication on Climate Change, which concluded that Guatemala was highly vulnerable in the following areas: 1) human health, 2) forest resources, 3) water and 4) agriculture (grain production) (MARN, 2001). Moreover, Guatemala is among the most vulnerable countries to extreme weather events: according to the 2012 Global Climate Risk Index, Guatemala was the second most affected country in the world in terms of the impact of extreme weather events in 2010, and the twelfth most affected in the 20-year period from 1991 to 2010 (Harmeling, 2011). Guatemala is also listed as the nineteenth most vulnerable country to climate change worldwide in the 2011 Climate Change Vulnerability Index (Maplecroft, 2010). In both rankings, most countries which have higher climatic vulnerability/are exposed to higher climatic risks than Guatemala are situated in Asia and Africa.

Several social, economic and environmental factors explain why rural Guatemala is highly vulnerable to environmental and climate change: among them, marginal and difficult terrains, high population growth and high exposure to climatic and environmental stressors. The majority of the rural population lives in marginal and isolated areas; for instance, it is estimated that 60 % of the communities in the western highlands are located in steep areas and at least one third of them are at high risk of natural disasters. Most of the rural population depends on agriculture for subsistence, yet they also rely on crop systems which are grown on

marginal and vulnerable lands due to the lack of alternatives in better-suited zones (IARNA, 2005; IARNA 2009).

In Guatemala, the agricultural sector alone represents about one-eighth of GDP but two-fifths of exports and half of the workforce. Aside from the direct impact of climatic variables on agricultural production, the land rent for Guatemalan households is sensitive to climate: a marginal increase in the average temperature of just 1°C reduces the monthly rent of land by about US$6 per hectare. Similarly, a 10mm increase in the annual accumulated rainfall leads to an increase in the land rent of US$2 per hectare. Climatic variability is already lowering Guatemalan production levels, where yields and incomes are decreasing. Unless adaptive measures are taken, these losses might become more substantial in the near future. Rural Guatemalans are often vulnerable and have few resources to endure bad seasons, or more generally, to cope with climate variability (ECLAC, 2010). In the words of Castellanos and Guerra, "temperature variation and rainfall can surpass, year after year, the autochthonous capacity of agricultural workers to adapt, which is nothing more than a trial and error exercise for the modification of the conditions and sowing and harvesting times in the face of a variable environment" (Castellanos & Guerra, 2009: 32).

A study by the Ministry of Agriculture of Guatemala illustrates how climatic variability – in particular, the substantial rainfall increase during the last few years – has affected yields for 15 of the 27 crops it examined. The study indicates that at least 56,128 farmed hectares were directly impacted by the changes in 2011, affecting 86,599 farming families. Maize was among the most affected crops, with average yields decreasing from 2.58 (2006/2007) to 1.99 tons per hectare (2011), a 30% reduction (Trejo, 2012).

Guatemala is also located between two great continental masses and two oceans in the inter-tropical convergence zone. As a result, it suffers from events with a hydro meteorological origin, such as droughts, hurricanes, intense rains and storms; the consequences of such events include floods and landslides (IARNA, 2005). In the western highlands at altitudes between 1,800 and 3,200 meters above sea level, hydro meteorological

events such as frost directly affect the production of maize, beans, broad beans and potatoes.

Another environmental issue for the Central American country is deforestation which has direct negative consequences on the soil of Guatemala's mountainous regions, including the area of Cabricán where most soil is suitable for forest vocations and is highly susceptible to erosion because of its physical and chemical characteristics. While producing their staple food, farmers tend to leave the soil exposed leading to its gradual deterioration and the problem is exacerbated by the high demand for wood and firewood. As a result, an important part of the soil in the mountainous regions of Guatemala is already severely degraded (CARE, 2011).

3.2.3 Population

Guatemala's territory is divided into 22 departments and 338 municipalities, and its capital Guatemala City is located 1,500 meters above sea level. In 2011, the estimated total population of Guatemala was 14,813,763. In the same year, 51% of its population lived in rural areas, primarily in the central and western highlands. The indigenous population represented 40% of all Guatemalans, but in some municipalities of the western highlands (including Cabricán), the entire population is indigenous (INE, 2011b).

In 2012, Guatemala's total fertility rate (TFR)[16] was 3.8 children per woman, the 44th highest rate worldwide and the highest of Latin America, followed by Bolivia (55th, 3.3) and Haiti (56th, 3.2). The male to female ratio is 0.97, lower than the global average of 1.01 (CIA, 2015).

In 2011 (when fieldwork took place), the population in Guatemala was growing at a decreasing yet relatively high rate of 2.45% (approximately double the pace of the rest of the world, 1.21%) (INE, 2011b; UNPD, 2015). Within Guatemala, the department of Quetzaltenango's annual population growth (2.29%) is slightly lower than the average while the population in

[16] The Total Fertility ate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates (World Bank, 2015).

the municipality where research took place, Cabricán was growing at a slightly higher than average rate (2.5%).

Table 6 - Population growth rates data (and projections)

Year	Total Guatemala	Annual increase (%)	Quetzaltenango Department	Annual increase (%)	Cabricán Municipality	Annual increase (%)
2008	13,677,815		737,593		23,292	2.51
2009	14,017,057	2.48	754,457	2.29	23,878	2.50
2010	14,361,666	2.46	771,674	2.28	24,474	2.50
2011 *	14,713,763	2.45	789,358	2.29	25,085	2.50
2012 *	15,073,375	2.44	807,571	2.31	25,713	2.48
2013 *	15,438,384	2.42	826,143	2.30	26,351	2.44
2014 *	15,806,675	2.39	844,906	2.27	26,994	2.51
2015 *	16,176,133	2.34	863,689	2.22	23,292	2.50

Source: Data from INE, 2011b. Data were collected in 2011 so the numbers from 2011 onwards (*) are estimates based on expected population growth.

3.2.4 Migration

Human mobility in Guatemala has been documented since the so-called liberal revolution in 1871, when coffee production became an important

export crop, often at the expense of indigenous lands. Since then, the indigenous population from the highlands has constituted the main source of labor in coffee fields. In addition to coffee, migrants travelled to the south-west of the country where other traditional crops for export were produced, including cotton (in the past), sugar cane, rubber and tropical fruits.

Migration can be an important strategy for reducing household vulnerability, and it can enable households to accumulate assets (Aguilar-Støen et al., 2016). In many cases, however, the poorest and most vulnerable Guatemalans cannot move, even if they would like to, because of their lack of financial means and networks (IOM, 2008: 29).

Most migrants are young men, even though an increasing number of women are migrating: for example, in 2010, an estimated 30% of Guatemalan migrants to the US were women (IOM, 2010). Two main hindrances to mobility for women are their limited language skills and their expected role within the household. Approximately one-third of rural indigenous women are monolingual in their local language. However, language barriers for rural women are declining statistically over time as access to schooling increases for the younger generations (USAID, 2009).

Until 1996, internal migration was the prevailing migratory form in Guatemala (IOM, 2013). Poverty, lack of economic opportunities, illiteracy, social exclusion, social and ethic discrimination and the agrarian relationship between small and large landholders have been the main factors causing internal migration in the twentieth century (Caballeros, 2006). Another main driver of migration during the 1960s, 1970s and 1980s was the internal armed conflict which is estimated to have caused about one million internally displaced persons. Moreover, an estimated 400,000 people left the country during the 36 years of conflict (Beristain, 1998).

During the 1960s and 1970s and 1980s, few thousands of Guatemalans went to the United States where they were free to study and where they often found jobs in sectors such as domestic work, construction, gardening, restaurants. No data on the total number of migrants to the United States until the 1970s is available; permanent residents of Guatemalan origin in the country grew from 14,357 in the 1960s to 23,837 in the 1970s (IOM,

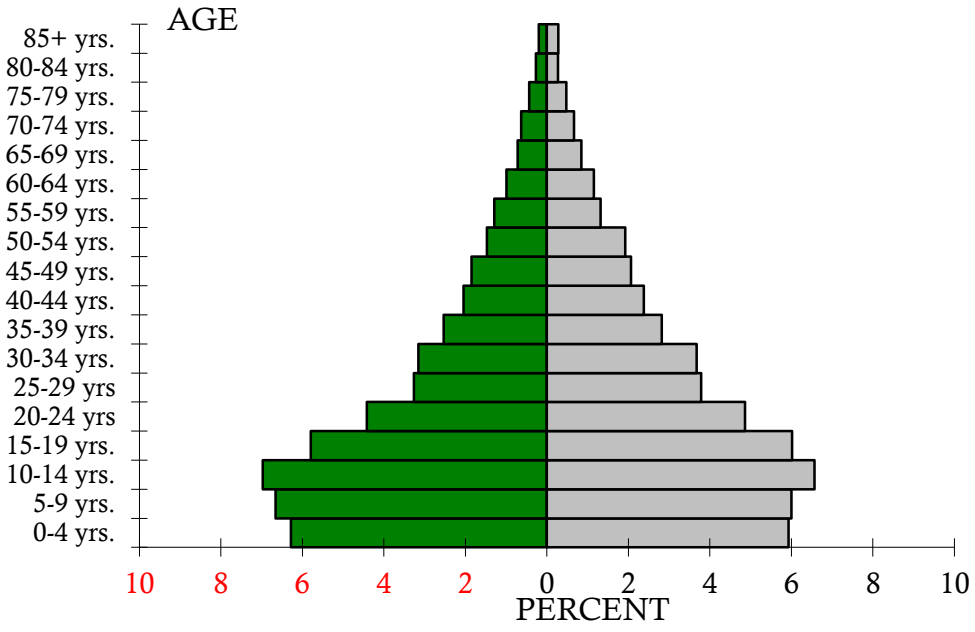
2013). In the 1980s, Guatemala was characterized by low economic growth and internal conflict and the number of Guatemalans in the United States grew from 63,073 in 1980 (first data point on total number of migrants) to 225,739 in 1990. The late 1990s were characterized both by the return of Guatemalan refugees to their country of origin and by an increase of migrants going to the United States where strong economic growth led to increasing work opportunities for Guatemalan migrants, which reached the number of 372,487 in the year 2000 (Homeland Security, 2011; IOM, 2013).

From 1996, the main migration trend is international outmigration. An emerging and important aspect of recent and current migration in Guatemala is return migration which reflects both an increase in irregular migration and in immigration controls in Mexico and the United States (IOM, 2013: 17-18).

The population pyramid of Guatemala in 2011 (figure 1) follows a standard Christmas tree shape yet it shows a slight fertility decline (the percentage of 0-4 years old is lower than 5-9 years old and the same holds for 5-9 with respect to 10-14 years old). Moreover, the pyramid suggests that the Central American country might be facing substantial outmigration of young men which is reflected in a clear change in the men to women ratio for the 15-19 age group and above. In fact, the ratio is higher than 1.05 in the three youngest age groups (0-4, 5-9, 10-14), meaning that there are more men than women of that age, but it drops to 0.96 (15-19 years old), 0.91 (20-24) and 0.86 (25-29) for the young adults age groups where women outnumber men.

In fact, in 2010, 1,637,119 (11.4% of Guatemala's population) was living abroad (IOM, 2013) which is a higher number than internal migrants which in 2002 (latest data point available) were estimated at 1,236,062 (INE, 2002). These numbers are to be taken with caution, particularly because some Guatemalan migrants in the United States (most common destination with an estimated 1,044,209 migrants) are not registered as migrants in the United States hence they are hard to count (IOM, 2008). Data on Mexico, the second most common migrant destination, are not available. The third most common destination is Belize with 20,070 Guatemalan migrants, followed by Canada (18,282) while no other country hosts more than 10,000 Guatemalans (IOM, 2013).

Figure 1 - Population Pyramid of Guatemala in 2011



Source: Data from INE (2011a). Men are on the left and women on the right.

An important element shaping international outmigration patterns among Guatemalans is thus the increasingly stringent immigration laws of the United States. In December 2005 and March 2006, under the framework of immigration reform, the United States Congress authorized a significant increase in the border patrol force, the incorporation of the National Guard into immigration control and the construction of a wall along the border between the United States and México. However, this has not implied a reduction in migration flows from Guatemala to the United States which grew from 372,487 in 2000 to 1,044,209 in 2010. While the stringent immigration laws seem not to have reduced migratory flows to the United States, the number of yearly repatriations of Guatemalans in the US went from 4,778 in 2002 to 30,855 in 2011 and 40,467 in 2012 (IOM, 2013).

In 2001, Mexico approved the Plan Sur policy, a more stringent migration policy aimed at increasing control over migration flows in the entire country and its borders. While the effect of this policy on migration flows cannot be ascertained (no data available), it is interesting to note that, in contrast with what happened in the US, the number of forced repatriations from Mexico to Guatemala went down from 67,336 in 2002 and 99,315 in 2005 to 28,924 in 2009 and 33,609 in 2011 (IOM, 2013).

In Guatemala, the number of immigrants is substantially lower than the number of migrants leaving the country: the latest census data on immigration available only reports 49,966 immigrants in the entire country, half of which (49%) come from other Central American countries. The most common country of origin is El Salvador (25%), followed by Mexico (23%). Other common countries of origin include Honduras, Nicaragua and United States, each of which is the source of approximately 11% of immigrants (INE, 2002).

In 2011, annual remittances (US$4.4 billion) constituted 9.4% of the country's GDP (IOM, 2013). In 2008 (latest data point), approximately 30% of the population received remittances (44% of them in urban areas and 56% in rural areas). In his widely cited work on the impact of remittances in Guatemala, Adams (2004; 2006) built on a large survey to show that both internal and international remittances (from the US) reduced the level, depth and severity of poverty in Guatemala. His papers show that remittances have a greater impact on reducing the severity rather than the level of poverty in Guatemala. In fact, for households in the lowest income decile group, receiving remittances changed their income status dramatically. Adams' results on the impact of remittances on poverty reduction in Guatemala seem to be in line with other studies in Latin America (Acosta et al., 2008) and worldwide (Adams & Page, 2005; World Economic Outlook, 2005).

The Department of Quetzaltenango, where the research area is located, is one of the departments with the strongest migratory traditions to the United States: its population constitutes 5.4% of the total of Guatemala but it sends 6.1% of the country's international migrants to the United States (INE, 2011b; IOM, 2013: 49). However, its overall rate of internal and

international outmigration (11%) is slightly lower than the national average (11.6%) (INE, 2011b; IOM, 2010).

3.3 Research area

Fieldwork was conducted in August and September 2011 in four rural communities belonging to the municipality of Cabricán (region of Quetzaltenango): Buena Vista, El Cerro, El Durazno and Quiquibaj.

Figure 2 - Location of Cabricán, research area in Guatemala

Source: Map prepared by Milan and Rossow

San Cristóbal Cabricán (original name) was founded in 1664 as part of the neighbouring municipality of San Juan Ostuncalco. According to oral tradition, its name comes from a two-headed snake, which in the Mam language is known as *kabekan*. Cabricán officially became a municipality in 1825 and it is located at 2,625 meters above sea level on the Western Highlands of Guatemala. In 2011, it had an estimated 25,085 inhabitants and its population is growing over time: in 1994, it amounted to 14,881 but it is expected to reach 30,000 by 2020 (INE, 1996; INE, 2010). The entire population of the research area belongs to the Mam ethnic group, and its mother tongue is also Mam (Juarroz, 2004). The municipality is divided into 6 *aldeas* (communities) and 27 *caseríos* (hamlets); 60% of its population lives in a rural area (INE, 2010). The four communities of Buena Vista, El Cerro, El Durazno, Quiquibaj have 1,314; 2,424; 186 and 480 inhabitants respectively (Ruano & Milan, 2014: 37).

Cabricán is a typical smallholdings zone, where approximately 94% of the parcels measure less than 0.7 hectares and most extend to just a few *cuerdas*[17] (Ministerio de Educación & SESAN, 2009). These characteristics are primarily the result of the broken topography of the area, as well as the prevailing soil types which are volcanic in origin and highly susceptible to erosion and land- and mudslides. Cabricán's soil is steep, highly susceptible to erosion and characterized by low capacity of moisture absorption. The soil potential is for perennial crops, such as forests or pasturelands. This implies that annual crops face serious limitations and soils require intensive conservation practices such as terraces and level curves (Juarroz, 2004: 8).

Until 2001, seasonal migration to the southern or Pacific coast was a common strategy implemented by local households in order to obtain cash to complement their subsistence rain-fed agricultural production. Migration to the United States was an incipient phenomenon at that time, but it now constitutes the most common current destination for migrants (CARE, 2011).

[17] A cuerda is a local measurement, which is a fraction of a manzana (0.7 ha). One cuerda measures 21x21 meters.

3.4 Results of the case study

3.4.1 Socio-economic context

In 2002 (latest data point available), the Human Development Index of Cabricán was 0.64 (the national average was 0.7) and 84% of its population was poor (UNDP, 2011b). Cabricán is also highly vulnerable to chronic malnutrition: 69.8% of its school children face height retardation. The municipality has the 34th highest rate of stunting in Guatemala (out of 338 municipalities) and very high nutritional vulnerability of children (MINEDUC & SESAN, 2009). As consequence of this vulnerability, shortly after fieldwork took place, Cabricán was one of the 166 municipalities which were identified and targeted for the government's 2012-2015 *Plan hambre cero* or "zero hunger plan".

Historically, livelihoods have been based on a subsistence economy with farming (mostly oriented towards the production of food staples) as the main activity. Agricultural production is not irrigated (only 1.5% of survey respondents work on irrigated land) which implies that all farming systems are rain-fed and completely dependent on weather conditions, including rainfall. PRA participants unanimously stated that all households whose main activity is agricultural depend on rainfall rather than on irrigation. In the household survey, 98% of the respondents stated that they only produce food for household consumption, while only 2% said that they also produced food to sell it on the market.

Exactly three-fifths of survey respondents indicated their income and they all fall below the poverty line. Among them, 88% declared an income per capita below US$ 1 (extreme poverty line) while only 12% earn between US$ 1 and US$ 2 (poverty line).

The average land holding size in the sample, in line with MINEDUC/SESAN data (2009), is 0.54 hectares and only 6% of households own more than one hectare of land. During the transect walk, I immediately saw a clear difference between old and new houses. A local expert explained to me that all of the latter have been built thanks to remittances from one or more persons living in the United States. The widespread use of remittances for home construction is in line with the

findings of Davis & Lopez-Carr (2010) who conducted a study in the same region.

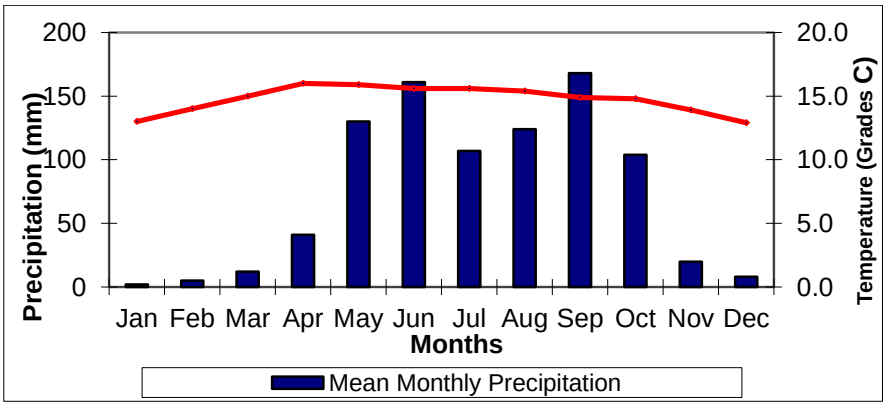
Agriculture is the most important economic activity for two-thirds of the households surveyed (66%); weaving is the most important one for 22% of them while 5% mentioned other activities (and 7% did not reply). Through PRA sessions, I found that the typical agricultural production subsystem is called *milpa*, or maize field, which is practiced by all families. *Milpa* is a combination of maize (main crop), beans, *piloy* (a legume similar to and larger than beans), lima beans and *ayote* (a variety of squash known as *cucurbiaceae*). Maize is the only crop that follows a defined spatial order while the other crops are sowed randomly. In addition to this subsystem, in certain cases, temperate deciduous fruits such as apples, apricots and plums are also produced for household consumption or sale. PRA participants agreed that growing potatoes and wheat is no longer profitable because of the excess of humidity: fungus diseases (and lack of money to buy fungicides) make production very risky.

Outcomes of participatory research approach (PRA) sessions show a clear division of labor within households: men are responsible for most agricultural activities, while women take care of livestock and the housework. Both men and women are engaged in textile-related work.

3.4.2 Rainfall patterns

The average annual rainfall for the 1977/2010 period recorded in the closest meteorological station (Labor Ovalle, 27 km away from Cabricán) is 880.6 mm/year. Figure 3 shows that rainfall patterns in the research site, similarly to the rest of the country, are bimodal, with peaks in June and September, the latter being the wettest month.

Figure 3 - Mean monthly rainfall (mm) and mean monthly temperature (°C) in the study area (years 1977-2011)



Source: Milan and Ruano, 2014: 64.

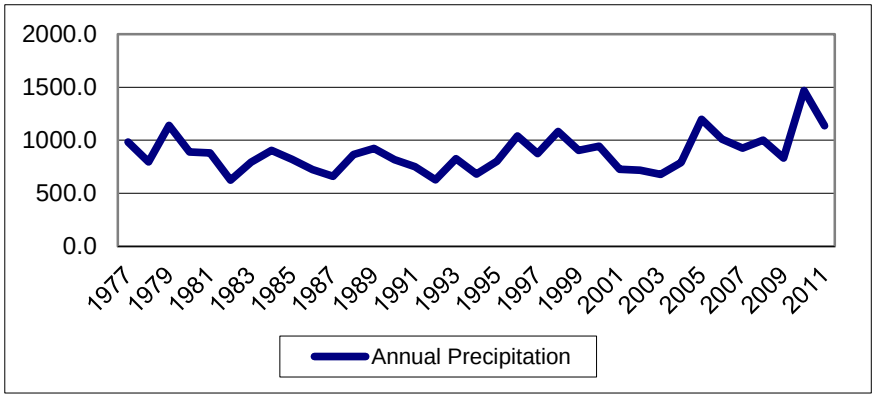
Table 7 - Perceived climatic changes over the last 20 years

	More drought/dry spells?	More flood?	More heavy rain?	More extreme weather events?
Yes, a lot more	35	33	38	38
Yes, more	15	7	30	28
Same as before	6	4	7	11
No, less than before	10	9	0	4
Never happening before	13	27	6	0
No Response	21	20	19	19
Total (%)	100	100	100	100

Source: adapted from Milan and Ruano, 2014: 64.

Table 7 shows that the most commonly perceived climatic change in the 1992-2011 period is the increase in rain and extreme weather events. As noted in the limitation section, the results could be biased by heavy rains which characterized the year prior to the research, destroying local harvests. Survey respondents and participants to PRA sessions also emphasized that rainfall is increasingly variable. Perceived changes in rainfall in the last twenty years relate mostly to its changing seasonality and unpredictability. Survey respondents also mentioned increased intensity and decreased frequency of rain events[18].

Figure 4 - Annual rainfall (mm) in study area (1977-2011)



Source: Milan and Ruano, 2014: 65.

The overall amount of annual rainfall is perceived to be more or less unchanged. However, figure 4 shows that the 1977-2011 period is characterized by a first decreasing stage from 1977 to 1993, followed by an increasing trend from 1994 to 1998, a new decrease from 1999 to 2003, and

[18] The authors could only access daily data from Labor Ovalle for the 1996-2010 period which is not enough to study long-term trends. In contrast to local perceptions, data show an increasing trend regarding the number of rainy days per year (which can be taken as a proxy for frequency of rain events) as well as a slight decrease in the average amount of rain per rainy day (proxy for intensity of rain events).

another increase from 2004 to date. The area received the highest amounts of rainfall in 2010 and 2011, right before fieldwork.

3.4.3 Rainfall impacts

Survey respondents were asked whether changes in rainfall had affected their food production: 68% answered "yes, a lot", 29% "yes, but only a little" while 1% stated that rainfall does not affect their food production (and 2% did not answer).

These results are consistent with the outcomes of PRA sessions on rainfall patterns and impacts. PRA participants added that rainfall-induced decreases in food production trigger several further problems: lack of money to buy food, lack of job opportunities, increase in costs of agricultural inputs, reduction in the amount of food consumed, decrease of animal productivity and reduction in opportunities related to livestock production and selling. Furthermore, they remarked the impact of droughts which affect water availability for human consumption as well as crops during their growing process. For the former, with the support of an NGO, many households are installing water reservoirs to collect rain during the rainy season. For the latter, farmers have been adapting by planting crop varieties which are more tolerant to drought, such as some local corn and bean germplasms.

3.4.4 Food insecurity

Food insecurity constitutes a problem for most households in the research site: 78% of survey respondents indicated having suffered food scarcity at least once in the last 10 years while only 16% have not (and 6% did not know). Given the prevalence of rain-fed subsistence agriculture in the area and the strong dependence of local market dynamics on local production which emerged during the PRA session on livelihood risks, the relationship between rainfall and food security is mostly related to food production. Nevertheless, local experts highlighted that nutrition-related problems in the area are often exacerbated by issues related to access to food (few products are available in the local market) and consumption habits (people tend to over consume corn).

In fact, the rate of malnourishment among children in Cabricán is considerably high (69.8% compared with the Guatemalan average of 45.6%). In San Carlos Sija, a neighboring municipality where food consumption is much more diversified and wheat, potatoes, local vegetables, eggs, milk and meat are widely consumed, the rate of child malnutrition is 41.7% (MINEDUC & SESAN, 2009).

Participants to PRA sessions on food security also emphasized that the highest food insecurity period is from May to November, the latter being when corn fields are harvested. Survey results also show that when households did not have enough food (or money to buy food) in the last 10 years, 46% of them modified food production to increase output, 20% sold assets (mostly livestock, the first option is poultry, and then pigs), 18% reduced food consumption, 12% reduced their expenditures, 10% diversified their activities while other coping strategies were mentioned by very few respondents[19]. PRA participants added that in conditions of food scarcity, families with relatives who work in the United States, Quetzaltenango or Guatemala City ask them for a remittance; moreover, men often sell their labor within their community or in a neighboring one and/or they ask for an "informal" loan from a relative, friend or neighbor (in this order).

Local women highlighted that the governmental programs "*Mi Familia Progresa*" (My Family Progresses) and "*Bolsa Solidaria" (*Solidarity Budget) are important sources of support. *Mi Familia Progresa* provides cash payments to poor mothers upon the condition that they send their children to school and health checks. *Bolsa Solidaria* distributes monthly food rations to the neediest families. Unfortunately, no data on the percentage of households receiving them were collected during the study.

3.4.5 Local livelihood diversification

Agricultural diversification

Information collected during the rapid rural appraisal showed that farmers have developed an agricultural diversification strategy that has two main

[19] Multiple responses were possible.

objectives: producing the highest quantity of different foods in a limited piece of land and coping with climate variations, in particular rainfall variability and frost.

Agricultural diversification in the study area is not limited to the production of several crops, but is also implemented through the production of more than one genotype of each crop. For example, four varieties of maize are sowed: white, yellow, red and black. Black, white and red beans are grown and three varieties of *piloy* (yellow, red and black) are also common. Moreover, there are two varieties of lima beans (small and large) and three kinds of *ayote*. Farmers combine different varieties of each crop which yield the highest level of production under different climatic patterns. For instance, during a "normal" rainy year, white and yellow corn would yield the highest level of production while in a year with low rainfall, black corn would yield better. Black corn is also the most resistant to frost, and the one that better grows in soils with low fertility, even though it has less yield potential. In a year with excess of moisture, red corn would have the best performance. The same strategy applies to other crops; *piloy,* for example, yields less than beans but it is more resistant to excess moisture. Among the three bean genotypes, black is the one with the highest yield potential but it has less tolerance to heavy rainfall and frost. Broad beans and *ayote* follow a similar pattern, with each genotype responding differently to different rainfall and temperature patterns (Ruano and Juarez, 2008).

These adaptive strategies have a positive impact on local livelihoods. However, according to participants to several PRA sessions, even in times of good rainfall, yields are not satisfactory because of the lack of good quality seeds and their insufficient number: households consume as much as possible of their potential seeds.

In all households where this is economically feasible, livestock is produced as a diversification strategy. In fact, all survey respondents mentioned owning livestock, but only one mentioned the selling of livestock as the most important activity for his household. While the quality of the survey data on livestock is not good enough to offer results on it, PRA outcomes show that the production of poultry (hens, chickens, turkeys and ducks) is very common. Pigs and sheep are also common, although not among the

poorest households. Large livestock is produced to a lesser degree and is common among the few families that have more resources in terms of capital or land. Common species include cattle, which are also the primary means of transportation, and pack animals such as horses, mules and donkeys.

Non-agricultural diversification

Up to the late 1980s and early 1990s, employment in limestone caves was the main source of non-agricultural diversification for local households. According to the local forestry office, back in 1989, Cabricán had sixty-eight lime stock ovens. At present, only ten limestone ovens are left and survey data show that weaving rapidly replaced work in the ovens as the main non-agricultural diversification activity.

The local forestry officer and participants to PRA sessions stated that for several decades one of the most important centers for weaving in Guatemala was Salcajá, situated near Quetzaltenango. However, in the early 1990s, most of its inhabitants began migrating to the United States and local entrepreneurs had to almost completely stop the weaving business because of the lack of local labor supply. In response to the crisis, one of the largest textile traders from Salcajá started looking for alternative labor sources to keep up with textile production. In Cabricán, he found a population that demanded opportunities for diversifying their economic activity and he moved his production there.

Households who work on textiles in Cabricán do it under an oral contract, working for a "*patrón*" (owner) who usually lives in Salcajá (about 60 km away from Cabricán). The *patrón* provides them with equipment, tools and materials. In exchange, he (usually a man) buys the final product for a set price. Local experts suggested that the payment that households receive corresponds to approximately 10% of the final selling price in the market. PRA participants stated that there has been an increase in the number of households who want to work in this sector which led to a significant decrease in earnings for those working in this sector. They estimated that

few years ago, owners demanded between four and five *cortes*[20] per week while at present they tend to request only one or two, and for a lower price.

PRA analysis shows that when agricultural diversification does not work and resources cannot be generated from textiles, the first option in most households for earning money is to sell small or large livestock. Depending on the need, the first option is poultry followed by pigs. When this is not an option for the household, men try to sell their labor within the community or in a neighboring town. Alternatively, members of a household will try to obtain an "informal" loan from a relative, friend or neighbor (in this order). Families with relatives who work in the United States, Quetzaltenango or Guatemala City will ask for remittances. When none of these strategies work, individuals will resort to eating wild herbs collected from the forest. Another last resort strategy adopted by the population is to reduce food intake or (very seldom) to decrease the number of meals from three to two per day. In extreme situations, individuals mill *olote* and mix it with water or some *atol*.

3.4.6 Migration patterns

In line with national data, survey data show that migration patterns in Cabricán are mostly related to people leaving the community: the place of birth of 99% of individuals from the Rainfalls database is within the research area, with only of 1% immigrants (mostly women who moved in because they married a local man). The primary reason for the very low rate of immigration is that environmental, economic and social conditions and opportunities are not favorable for attracting outsiders.

Survey data show that 25% of the households have one or more migrants (22% international and 3% internal) who still depend on (students)/contribute to (labor migrants) the financial resources of the household. These data are likely to be an underestimation since (as

[20] A *corte* is a one meter wide and seven meters long tissue. The tissue is then used as raw material for making garments, such as shirts, skirts, curtains, carpets or wall decorations. *Cortes* can be found in several colors (blue, red, green, yellow, orange, purple, black, white) and their designs is related to the Mayan view of the world.

mentioned in 2.2.5) people tended to deny having a household member living abroad.

Migrants are 23 years old on average and three-quarters of them are men. Moreover, 78% of them are married or under consensual union. The schooling level of migrants is nearly two years above the average of the population. All except one surveyed migrant declared to have moved primarily for economic reasons.

However, outcomes of PRA sessions show that even migration decisions which seem to be mainly caused by economic considerations related to opportunities in areas of destination are usually influenced by rain-fed agricultural production. PRA sessions also revealed that, in the past and for several decades, seasonal migration to work on the cotton fields in the Southern Coastline of Guatemala was very common. Migration to the midlands above the coastline was also frequent for those who wanted to work in the coffee farms.

Survey data show that 78% of migrants from households currently based in Cabricán have moved to the United States, while the rest of them are mostly seasonal workers going to the coastline (10%) or Guatemala City (10%). Outcomes of the PRA sessions on migration confirm these results.

Participants remarked that most migrants to the United States have plans to come back once they have saved enough money to renovate their house and possibly ensure a better future for their households. People migrating to Guatemala City usually move there to work as construction workers or in textile factories, but they have less saving capacity and possibilities to send money back home. However, they also aim at returning to Cabricán.

PRA participants also perceive that after the 2001 terroristic attack to the Twin Towers, migration flows to the United States have decreased significantly, one of the main reasons being the price to be paid to a travel assistant called "*coyote*". As of 2011, the cost of the trip fluctuated between 45,000 and 50,000 Quetzals (approximately US$ 6,000 at the time of research), which is an extremely high price for locals. High risk in terms of personal security while travelling through Mexico was also perceived to play an important role in this reduction. Moreover, communities perceive that there is a significant reduction of work opportunities in the United

States related to the economic downturn. However, this is in contrast with national data which show that migration to the United States seems to keep increasing exponentially while the only effect of the more rigid immigration laws seems to be an increase in the number of Guatemalans which are forced to return from the US to Guatemala. No data could be found for migration to Mexico.

The population expressed its strong attachment to the communities and its willingness to stay there; as a consequence, households as a whole only tend to only migrate as a risk management strategy when *in situ* options are not profitable. In contrast, migration of just one (or several) household members is a common risk management strategy decided upon at the household level, usually in combination with other non-migratory strategies.

3.5 Discussion

The results of this case study allow drawing some conclusions from the case study in Cabricán on the main research question for this chapter: "Under which circumstances can people in marginal mountainous environments of Latin America migrate as a livelihood risk management strategy in the context of high rainfall variability and food insecurity"

In the long-term, the most common *in situ* risk management strategies relate to agricultural (associating different crops, in combination with planting different varieties of the same crops) and non-agricultural diversification (mostly weaving). In addition, one or more household members of at least one-fourth of the households has migrated in recent years (mostly to the US) as an economic diversification and risk management strategy. It is often the case that only one or more household members move while the rest of the household stays in the community and it diversifies its sources of livelihood there.

Households clearly expressed their preference for livelihood diversification and risk management strategies which allow them to stay in their community of origin; as a result, the whole household only migrates when local diversification options are not profitable. Besides their preferences, at present, none of the current long-term livelihood diversification and risk

management strategy in relation to increasing rainfall variability and food insecurity seems to be sustainable for the communities. On the one hand, income from weaving, the main *in situ* non-agricultural diversification activity, is decreasing. On the other hand, migration to the US is perceived to be increasingly dangerous and expensive, limiting the potential for migration.

These trends might expose local populations, particularly households who do not currently receive remittances from the US, to the risk of becoming trapped in the near future in a place where they are extremely vulnerable to economic and environmental shocks.

3.6 Conclusion

Physical and economic isolation, land steepness and fragmentation, exposure to low temperatures and problematic access to markets are all factors that determine livelihood conditions in Cabricán. These factors are common to other mountain areas worldwide and future research should investigate their interaction with mobility patterns.

In relatively marginal and isolated mountain communities such as those described in this chapter, where livelihoods are based on subsistence rain-fed agriculture, populations are highly vulnerable to environmental and climatic conditions and threats even if they have tried to adapt to these changing conditions. As a consequence, even when migration seems to be mainly caused by economic considerations and food insecurity, the root cause can be climatic. In this context, climate change and increasing rainfall variability are likely to exacerbate these problems, particularly for households who might be unable to move away from places where they are extremely vulnerable to environmental stressors as well as natural hazards. Future empirical research in mountain areas could also shed light on this issue.

At the local level, individuals with entrepreneurial vision and ambition have expressed their willingness and motivation to become entrepreneurs and to produce for one or more export markets. Several years ago, there was an attempt to export textiles to Europe and the United States. However, payments from trade intermediaries were delayed so much that

communities were not satisfied with the process which was not repeated. Thus, policies promoting effective access to international markets for locally produced textiles could offer interesting opportunities for local development and economic empowerment.

Additionally, Cabricán is suitable for the development of many products, such as already existing fruit trees, vegetables and medicinal plants. Intensive agriculture aimed at selling vegetables on the market could also be pursued. Intensive production could be performed in very small areas using so-called macro- and micro-tunnels, which are relatively cheap. This could be combined with higher technical assistance from the government as well as better access to credit and markets.

The development of a timber industry aimed at producing items such as doorframes, window frames and toys is another option for new economic opportunities in the region which has already been successfully pursued in similar contexts in Guatemala. Such an industry, under sustainable forest management plans, could have a positive effect both in terms of economic development and increasing the forested area while reducing the negative consequences of timber mining, such as landslides and soil erosion.

4. LIVELIHOOD AND MIGRATION PATTERNS AT DIFFERENT ALTITUDES IN THE CENTRAL HIGHLANDS OF PERU[21]

4.1 Introduction

This chapter extends the analysis of chapter 3 by studying livelihoods and migration patterns in three rural mountainous communities in the Province of Huancayo (Peru) which lie within few kilometers from the commercial city of Huancayo. Unlike the relatively isolated communities in Cabricán, these communities can access one of the largest markets of Peru in the nearby city of Huancayo (Haller & Borsdorf, 2013; Stolmaker, 1979).

In particular, this chapter will look at how households located at different altitudes and with different access to the opportunities offered by the nearby city of Huancayo combine rural and urban activities and the role played by human mobility in their livelihoods. The following analysis aims at answering the following research question: Under which circumstances do people located at different altitudes and with different levels of access to urban opportunities migrate as a livelihood risk management strategy in the context of high rainfall variability and food insecurity?

4.2 The Peruvian context

Peru is located in western and inter-tropical South America, bounded to the north by Ecuador and Colombia, to the east by Brazil, to the southeast by Bolivia, to the south by Chile and to the west by the Pacific Ocean. The country claims 200 nautical miles of the Pacific along its coast as part of its dominions, according to international law.

The Peruvian territory is crossed from south to north by the Andes range, a chain of high mountains that divides the country into three very distinct regions: the coast, with desert climate from sea level to an altitude of 800 meters above sea level; the sierra, with peaks in excess of 6000 meters; and

[21] This chapter is based on: Milan, A. and Ho, R. (2014). Livelihood and migration patterns at different altitudes in the Central Highlands of Peru, *Climate and Development*, 6, 69–76; Ho, R. and Milan, A. (2012). "Where the Rain Falls" project. Case study: Peru. Results from Huancayo Province, Junín Region. *UNU-EHS Report No. 5*. Bonn, Germany: UNU-EHS.

the Amazon jungle in the east. A fourth region is formed by the Andean high plateau (3800 meters) that drains into Lake Titicaca, the highest navigable lake in the world. Thanks to the presence of this mountain range, the country presents 28 of the 34 climates in the world (Cigarán et al., 2008), from the Pacific coast desert to the humid Amazon jungle. Temperature and precipitation depend on the altitude, resulting in a mega-diversity of ecosystems, species and microclimates.

The major cities are mainly located in the coastal strip which shows the best industrial and commercial development of the country. The coastal valleys are small oases formed by rivers that originate in the peaks of the mountain range and discharge into the Pacific Ocean. The sierra is formed by the Andes range. In general, the northern Andes are characterized by lower altitude and they are more humid. The central Andes, where the research area is located, are the highest and steepest. The southern Andes are wider than the northern and central Andes. In the mountains there are numerous inter-Andean valleys that allow, mainly under rain-fed agriculture, a variety of food crops typical of the Andean region such as native potato and other Andean tubers (maca, oca, olluco). The higher and colder areas are devoted to grazing livestock (cattle, sheep and South American camelids).

4.2.1 Socioeconomic condition

In 2011, Peru ranked eightieth worldwide in the Human Development Index, with a score of 0.755 (high human development) which is slightly higher than the average for Latin American countries (0.731) (UNDP, 2011).

In economic terms, Peru is an emerging country, but in 2010 31.3% of its population was still below the poverty line and 9.8% was still below the extreme poverty line, which is a substantial decrease from 2001 data (54.7% and 24.4% respectively) yet it suggests a high inequality index. In fact, according to ECLAC, the Gini coefficient for Peru went down from 0.525 in 2001 to 0.458 in 2010[22]. It is interesting to note that in 2001 the Gini coefficient was substantially higher in urban areas than in rural areas (a

[22] However, comparing the 2001 and 2010 poverty and Gini values in absolute terms is only indicative due to a change in the methodology from 2004 onwards.

difference of 0.38)[23]. However, the coefficient in urban and rural areas was almost equal in 2010 (0.05 higher in urban areas), mostly due to a decrease in the index in urban areas. In 2010, the prevalence of poverty and extreme poverty was higher in rural areas than in urban areas (54.2% versus 19.1% and 23.3% versus 2.5%) (ECLAC, 2011).

Between 1981 and 2007, the contribution of the secondary sector to the Peruvian Gross Domestic Product (GDP) has been stable (always between 14% and 15%) while the contribution of the primary sector has decreased from 38.2% in 1981 to 25%, in 2007 and the percentage for the tertiary sector has increased from 39% to the current 56.8% (IOM, 2009: 58).

4.2.2 Glacial melt

As reported in the chapter on Latin America of the IPCC Working Group 2 for its Fourth Assessment Report (IPCC AR4 WG II), glacial melt is a very important issue in Latin America (Parry et al., 2007). As a consequence of the temperature increase, the trend in glacier retreat already reported in the previous IPCC reports is accelerating and inter-tropical glaciers are very likely to disappear over the next decades, affecting water availability both in rural and urban areas. Within Latin America, Peru is one of the most affected countries, especially because of its heavy reliance on the glaciers in the peaks of the Andes (Parry et al., 2007: 584–585). Peru contains about 70% of the world's tropical glaciers, which are distributed in 18 mountain ranges (Vuille et al., 2008), and their water reserves are used for agriculture, generation of energy, mining and human consumption (Leavell, 2008).

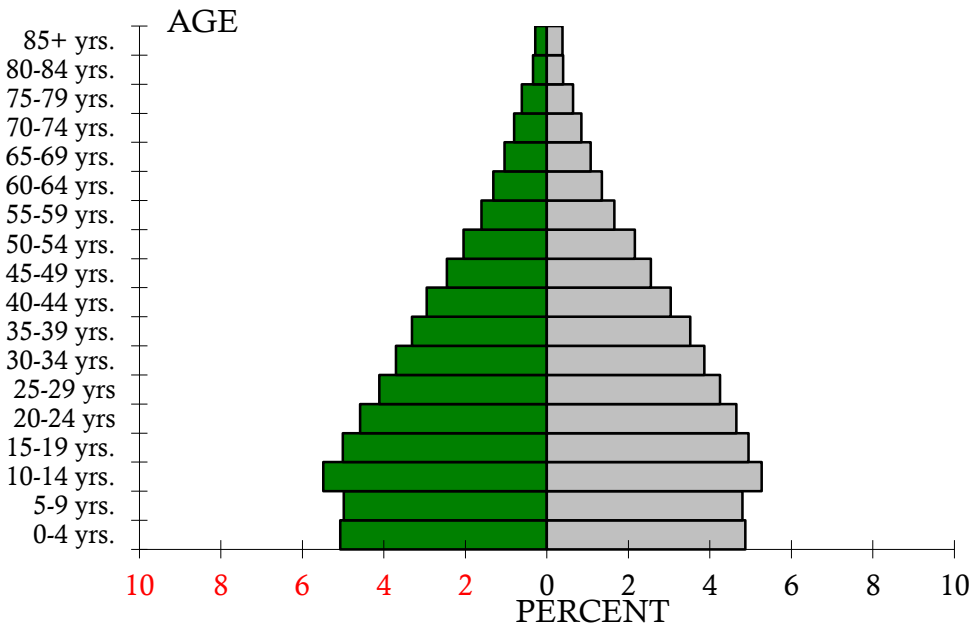
Glaciers play a strategic role in regulating the availability of water in rivers and lakes by melting slowly and allowing the rivers to maintain a base flow during the non-rainy period. The retreat of glaciers in Peru has been accelerating for approximately three decades. For example, in an inventory performed in 1997 on 18 mountain ranges with glaciers in Peru, Morales Arnao (2000) found that there was a 21.8% reduction in the cumulative area of these peaks, compared to the base year of 1970. In the case of the

[23] Urban area or urban population center are areas that have at least 100 homes grouped together. Urban areas also include all district capitals population centers, even when they do not meet the specified condition (INEI, 1993).

Huaytapallana peak in the central Andes, the reduction affected 36.4% of the area.

4.2.3 Population

Figure 5 - Population pyramid of Peru in 2007



Source: Data from INEI (2010b). Men are on the left and women on the right.

With a population of 28,220,764 inhabitants (2011 estimate), Peru is the fifth most populous country in South America. The 2007 population pyramid (figure 5) shows evidence for fertility decline in the last ten years (the number of 10-14 years old is higher than 0-4 and 5-9 years old) (INEI, 2010b). In fact, the Peruvian annual population growth rate between 1993 and 2007 was 1.6%, down from previous inter census rates which were always higher than 2%. Most of the population increase takes place in

urban areas: between 1940 and 2007, Peru has had a tenfold increase of its urban population and only a 65% increase in the number of rural inhabitants (see table 8). Nevertheless, the Latin American country had more rural inhabitants in 2007 than total inhabitants in 1940.

Table 8 - Evolution of Peruvian population 1940-2007 (total, urban, rural), in thousands

	Total	Urban	Rural
1940	6.208	2.197	4.011
1961	9.907	4.658	5.209
1972	13.538	8.058	5.480
1981	17.005	11.092	5.913
1993	22.048	15.459	6.590
2007	27.412	20.810	6.602

Source: Data from IOM (2012).

In 2007, 54.6% of Peruvians lived along the coast, 32% in the sierra and 13.4% in the jungle region (INEI, 2008). This is a marked change from the past: until the 1960s, the majority of Peruvians lived in the sierra (IOM, 2012). In 2010, urban dwellers constituted 74% of Peru's total population, while 26% of Peruvian people lived in rural areas. However, the agricultural sector is still one of the main sources of employment in the country as in the same year it employed 16.6% of Peruvian workers, compared with 31.1% for the entire industrial sector and 52.3% for services (ECLAC, 2011).

Peru is a multi-ethnic nation formed over five centuries by many ethnic groups; a relative *mestizo* majority can be observed today. The ethnic composition of Peru has changed at various stages during its history, showing a steady decline in the Amerindian proportion as the result of multiple socio-economic and political factors. There are currently more than 5,600 indigenous communities, two-thirds of which are of Andean

origin (Quechua and Aymara cultures), and the remaining third of Amazonian origin (distributed in 40 ethno-linguistic groups).

4.2.4 Migration

According to the 2007 census, 4.5% of the Peruvian population moved from one province to another within their departments of residence between 2002 and 2007, whereas 5.8% moved from one department to another. It is interesting to note that after decades of increase in the percentage of internal migrants with respect to the total population (from 8.9% in 1940 to 20% in 1981 and 20.6% in 1993), the 1993-2007 period was marked for the first time by a 1.6% decrease in this percentage which in 2007 was 19% (IOM, 2010b).

Table 9 - Peruvian migrants and remittances by country of destination

Country of destination	**Peruvian migrants (%)***	**Remittances (%)****
United States	31.5	33.5
Spain	16	15.9
Argentina	14.4	NA
Italy	10.1	8.2
Chile	8.8	6
Japan	3.7	9.2
Venezuela	3.1	NA
Bolivia	2.7	NA
Brazil	2	NA
Other	7.7	27.2
Total	**100**	**100**

Source: Data from * INEI et al. (2013) and ** IOM (2013).

Peruvian emigration was limited to few thousand migrants per year until the 1980s when it started growing due to a severe economic and political crisis which manifested itself in armed conflict and hyper-inflation.

In 2010, it was estimated that 3.5 million Peruvian were living abroad (see table 9) and 704,746 households have at least one member living abroad. Moreover, 91.6% of international migrants come from urban areas (46.5% from Lima/Callao) and only 8.4% from rural areas (INEI and IOM, 2009).

The country has seen a rapid increase in remittances received: from US$0.93 billion in 2001 to US$2.7 billion in 2011, 93.3% of which goes to urban areas (table 9 shows remittances per country of destination of migrants). The average of remittances sent by Peruvian migrants to their households is US$198.00 per month (IOM, 2013). The region of Junìn sends 3.5% of international Peruvian migrants (84.9% of which come from its urban areas), but it only receives 2.1% of migrant remittances.

Table 10 - Percentage of immigrants to Peru by country of origin

Country of origin	**Immigrants in Peru (%)**	**Country of origin**	**Immigrants in Peru (%)**
United States	12.4	Italy	3.9
China	8.7	Mexico	3.3
Argentina	7.2	Ecuador	3
Bolivia	6.3	French	2.7
Spain	6.1	Japan	2.6
Chile	5	Korea	2.1
Colombia	4.7	Canada	2.1
Germany	4.5	Venezuela	2
Brazil	4	Other	19.4
Total	**100**	**Total**	**100**

Source: Data from IOM (2013).

In recent years, Peru has also seen an increase in the number of immigrants which in 2007 reached 64,303 (0.2% of the total population of the country), only 39.8% of which are women. Table 10 above shows the main countries of origin of immigrants in Peru. In 2007, 95.1% of immigrants in Peru had acquired Peruvian nationality. In this context, the region of Junín hosts 3.4% of the Peruvian population but only 0.8% of migrants (INEI, 2010b).

The 2007 census only identified 33,501 Peruvian returnees, defined as people who were residing abroad as of 22 October 2002 and returned by the time of the census. Table 11 shows the Peruvian returnees by country of migration. Only 1.6% of returnees went to Junìn (INEI and IOM, 2009).

Table 11 - Peruvian returnees by country of origin

Country of origin	Returnees in Peru (%)	Country of origin	Returnees in Peru (%)
Chile	34.3	Ecuador	3.6
United States	18.2	Venezuela	3.4
Argentina	10.5	Colombia	2.2
Spain	8.1	Japan	2
Bolivia	6.1	Other	11.6
Total	**100**	**Total**	**100**

Source: Data from IOM (2013)

In the Andes, recent literature shows that populations move from dispersed to more concentrated settlements; these are not migrations in the strict sense, but human movements or mobility which operate within a more or less wide local context as the result of marriage, job opportunities or the search for more and better services for family welfare (Altamirano 2012). In line with Altamirano's findings, the results of this case study show the high prevalence of commuting/short-term mobility.

4.3 Research area

Figure 6 - Location of the research area in Peru

Map prepared by Milan and Rossow

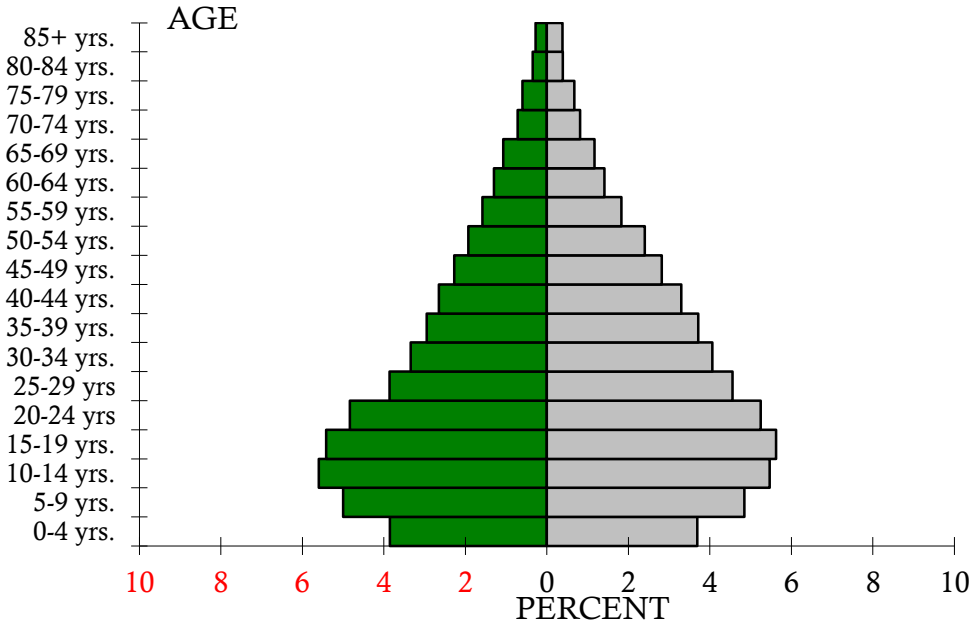
The case study was conducted in the Shullcas river sub-basin (and its surroundings), which is located in the central part of the Mantaro River basin. With an approximate length of 36 km, the Shullcas River gives rise to a narrow valley that runs from the foothills of the Huaytapallana peak in the area of highest elevation, until the Mantaro River in the lowest area, on the east side of the city of Huancayo.

The flow of the Mantaro River depends on rainfall throughout the basin, the level of Lake Junín and the lagoons located at the foot of the snow-capped peaks of the western mountain range and of the Huaytapallana glacial peak. The Mantaro River basin is of great importance as the

generator of about 35% of the country's electric power. Agricultural production in the Mantaro valley also provides food to Lima, and its population exceeds 700,000 inhabitants (CONAM, 2005).

The Shullcas sub-basin is located in the Huancayo province, department of Junín. According to the 2007 census, the population in the Huancayo province was 466,346 inhabitants. The rate of inter-Census (1993–2007) population growth was 1.29%, slightly lower than the national average (1.6%). As for the urban and rural population, 78.4% of the population of the province is concentrated in urban areas (national average: 75.9%) and 21.6% in rural areas (national average: 24.1%). Huancayo remains a province of negative net migration: between 2002 and 2007, it received 47,461 immigrants while 52,881 people left the province (INEI, 2009).

Figure 7 - Population pyramid of Huancayo in 2007 (urban areas)

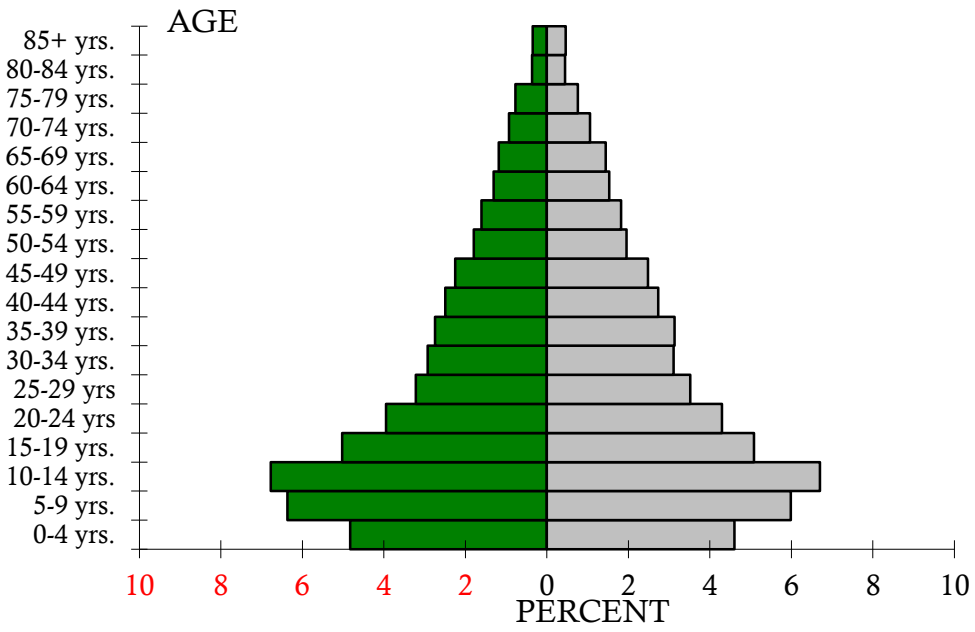


Source: Data from INEI (2010b). Men are on the left and women on the right

In line with the rest of Peru, the population pyramids of both rural and urban areas of Huancayo show a clear fertility decline. Past population pyramids show that the fertility decline had just started in 1981 and it increased in 1993; unfortunately, data from the 1981 and 1993 were not disaggregated by rural/urban areas (INEI, 1981; 1993).

Both the population pyramid of urban areas (figure 7) and of rural areas (figure 8) also show a clear sign of outmigration of young men. Those from rural areas tend to go to the nearby city of Huancayo, and an even higher number of young men leaving Huancayo tend to go to Lima and abroad.

Figure 8 - Population pyramid of Huancayo in 2007 (rural areas)



Source: Data from INEI (2010b). Men are on the left and women on the right

Table 12 on urban and rural sex ratios in the province of Huancayo quantifies the decline in the sex ratio between the 0-14 age groups which is

higher than 1 (indicating more men than women in those age groups) and 15+ years old age groups which have a lower than 1 sex ratio (more women than men). The decrease is mainly caused by the prevalence of outmigration of young men, as documented later in this chapter.

Table 12 - Urban and Rural sex ratios (male to female) in the province of Huancayo

Age group/Sex Ratios	Urban Sex Ratio	Rural Sex Ratio
0-4 years.	1.04	1.05
5-9 years	1.03	1.06
10-14 years	1.02	1.01
15-19 years	0.96	0.99
20-24 years	0.92	0.92
25-29 years	0.85	0.91
30-34 years	0.82	0.94
35-39 years	0.79	0.87
40-44 years	0.80	0.91
45-49 years	0.81	0.91
50-54 years	0.80	0.92
55-59 years	0.86	0.88
60-64 years	0.91	0.85
65-69 years	0.91	0.82
70-74 years	0.88	0.87
75-79 years	0.89	1.01
80-84 years	0.87	0.81
85+ years	0.72	0.75
Total	0.91	0.96

Source: Data from INEI (2010b).

Fieldwork took place in October and November 2011 in three communities located within the Shullcas sub-basin and its surroundings (Hullahoyo sub-basin), two of them belonging to the Huancayo district and the last one to the El Tambo district:

1. **Paccha**

Paccha, located at 3,260 meters above sea level in the Hullahoyo sub-basin (which is on the border of the Shullcas sub-basin), was chosen as the main community for this study. From an administrative point of view, Paccha is located in the district of El Tambo. Paccha village consists of about 300 households. The rural community (*comunidad campesina*) is formed by 140 communal families, less than half of the population of the village, and many of them live scattered in the hills and highlands outside the village, where their grazing land is located. This land is mostly above 3,800 meters, and it reaches an altitude of 4,400 meters in an area called Suytucancha.

Paccha has two distinct ecological zones. In the valley floor households produce a variety of food crops such as potatoes, corn, oca, olluco, broad beans, peas and a range of vegetables. Most of the production is for self-consumption, and a smaller proportion is sold in the market of Huancayo. Locals supplement their farm incomes with the craft activities of embroidery, weaving and the production of "engraved gourds". In the high ecological floor (Puna), the main activity is the breeding of sheep, cattle and some South American camelids (llamas and alpacas) that leverage the extensive rangelands of communal lands in Suytucancha. Cattle ranches (*estancias*), grazing lands that are assigned temporarily by the rural community organization to its members in lots of 100 to 200 hectares, are located in this area.

2. **Acopalca**

Acopalca is located above 3,900 meters in the Shullcas River sub-basin, near the foothills of the Huaytapallana snow peak, and it consists of 162 households. Acopalca is located in the district of Huancayo. The entire production area of this community is on the Puna ecological floor, where households benefit from extensive natural pastures for livestock farming of

sheep, cattle and camelids. In the very small plots in the warm folds of the land households grow some native tubers typical of the Andes such as oca and mashua, and native potatoes used for family consumption.

3. Chamisería

Chamisería (administratively part of the Acopalca community) is located at 3,583 meters in the central part of the Shullcas River sub-basin and it is inhabited by 40 households. Because of its location on the valley floor, it has a favorable climate for growing potatoes, corn, broad beans, peas and a diversity of vegetables in smallholdings of less than half a hectare, on a narrow river shore. Households own lands on the slopes of the valley that allow them to keep small flocks of sheep (30 to 50 according to PRA participants). The relationship with the urban area, which is relatively close, allows its inhabitants to travel frequently to the city in search of jobs to help them supplement their incomes.

4.3.1 Socioeconomic conditions

The Gross Domestic Product (GDP) of Huancayo province has been growing at 0.5% per year between 1993 and 2007; in 2010, 6.4% of the population still lived in extreme poverty and 22% in relative poverty, a lower percentage than the national averages of 9.8% and 31.3% respectively (ECLAC, 2011; INEI, 2010a: 82). In 2012, the unemployment rate of the province (2.4%) was lower than the national average of 3.7% (MTPE, 2013). The agricultural economic sector employs 14.5% of the population (Peru: 16.6%).

Traditional rain-fed agriculture is the most important economic activity in most rural areas of the province of Huancayo. While at higher altitudes (above 3,900 meters) non-agricultural diversification is limited, at relatively lower altitudes (up to 3,600 meters) non-agricultural diversification is widespread and survey data show that for most households income from non-agricultural activities exceeds agricultural income. At higher altitudes, climatic conditions only allow households to produce potatoes (100% of household using land for agricultural purposes), often in combination with

one or more other Andean tubers (mashua, oca and olluco). At relatively lower altitudes, potatoes are still the most common crop but household also grow corn (77% of household using land for agricultural purposes) and lima beans (27% of them). Embroidery/handicraft is the most common second main economic activity.

4.3.2 Patterns of human mobility

Most studies on livelihood and migration patterns in the Central Highlands of Peru until the 1980s focused on the impact of the development of the mining sector on local livelihoods from the early twentieth century. Mallon conducted a very comprehensive study of the evolution of rural communities in the Peruvian Central Highlands from 1780 (and particularly from 1860) to 1940. Her book shows that migration, particularly seasonal migration, has always been a common livelihood diversification and risk management strategy in the area (Mallon, 1983). Long and Roberts studied the complexity of the rural society in the Mantaro Valley between the late nineteenth century and the 1970s (Long & Roberts, 1978; Long & Roberts, 1984). They show that rural livelihoods have always been characterized by complex inter- and intra-household social and economic interconnections (Long & Roberts, 1984). The peasant economy could not be distinguished from the capitalist economy (Laite, 1984: 109); in fact, migration was "not from a peasant economy to a capitalist one, but …part of capitalist development" (Laite, 1984: 138).

Migration in the 1980s and 1990s was mainly driven by the government's conflict with the terrorist group *Sendero Luminoso*. Intermediate cities such as Huancayo received tens of thousands of migrants from the rural communities from higher altitudes. However, Huancayo also suffered from terrorist attacks which triggered migration to Lima (Haller & Borsdorf, 2013: 557). Overall, outmigration from the province of Huancayo has always prevailed over immigration. Between 1988 and 1993, the province of Huancayo had 55,194 immigrants and 61,005 out-migrants. Between 2002 and 2007, 47,461 people arrived and 52,881 left. Of these 52,881 migrants, 51% of went to Lima/Callao and 21% went to other provinces within the Department of Junìn. In the same period, 35.4% of immigrants in

Huancayo came from other provinces within Junìn and 18% from Lima/Callao (INEI & IOM, 2009).

With respect to international migration, data from 2007 show that 10.7% of urban households have one or more members living abroad. In rural areas, 5.6% of households have one or more international migrants: 3.8% have one/two members abroad, 1,1% have three/four members abroad and the remaining 0.7% have five or more (INEI, 2010b).

PRA participants highlighted that the most common current form of mobility for rural households in the Shullcas sub-basin is commuting (from lower altitude) and circular/short-term migration (from higher altitude) to the city of Huancayo[24]. Patterns of human mobility in rural areas of the province of Huancayo are determined primarily by the economic situation in the communities of origin of potential migrants as well as in the city of Huancayo. Moreover, employment opportunities in other areas of Peru and abroad influence longer term migration patterns (INEI, 2009).

Accordingly, survey data from this case study show that the three most important reasons determining migration decisions in the research site are economic: better job opportunities in the city; not enough income in the community of origin; and unemployment in the community of origin (in descending order). Moreover, more than 70% of the migrants from households located both on lower and higher altitudes on the Shullcas sub-basin leave during the wettest months of the year (January, February and March). These months are characterized by the high demand for agricultural workers in the Peruvian "*ceja de selva*" (the outer edge of the Peruvian jungle – above 800 meters).

4.4 Results of the case study

4.4.1 Recent changes in rainfall: perception versus rainfall data

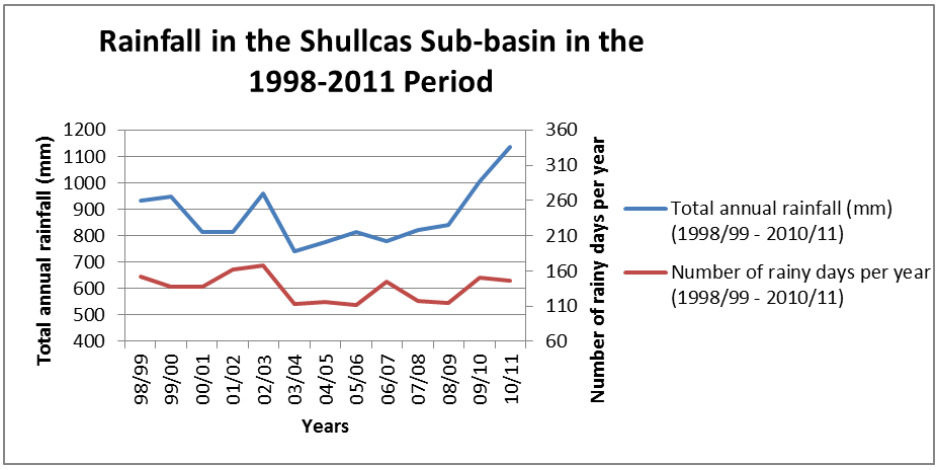
The meteorological station nearest to the three research communities (Shullcas) is located in the Shullcas sub-basin (El Tambo district, province

[24] The household survey did not capture this mobility because it only recorded movements from one province to another.

of Huancayo) at 3,750 meters, between what is defined in this chapter as relatively lower land (up to 3,600 meters) and highland (above 3,900 meters). Daily precipitation data are only available since October 1997 hence this sub-chapter focuses on the great variability in rainfall between 2009 and 2011 with respect to the preceding eleven years rather than on long-term trends.

The average annual rainfall in Shullcas from 1998/99 to 2010/2011 (875mm/year) is higher than in the other meteorological stations located on lowland in the Mantaro Valley (IGP, 2012: 55). The decreasing trend in annual rainfall until 2008/2009 is in line with data from the Huayao Station, located on lowland in the Mantaro Valley (Silva et al., 2007).

Figure 9 - Total rainfall and number of rainy days per year

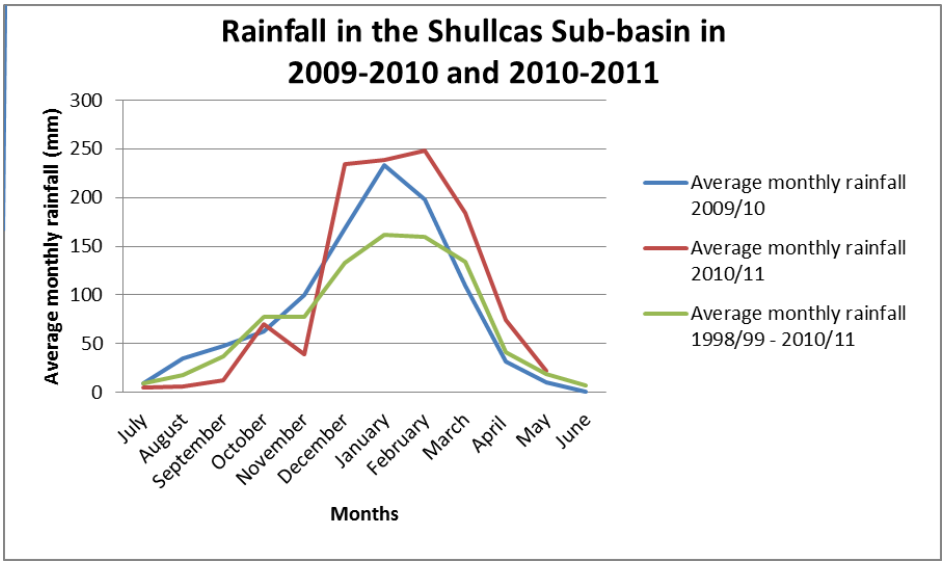


Source: Milan and Ho, 2014: 72. Rain years are calculated from 1st July to the following 30th June.

The Mantaro river basin is characterized by high unpredictability of rainfall (IGP, 2010: 32). Survey data show that 85% of respondents observed changes in rainfall over the last 10-20 years. The two most perceived changes in rainfall were more rain in unexpected moments and longer dry spells. More rain in "unexpected" moments cannot be checked against

rainfall data. However, it is worth noting that fieldwork was conducted right after the wettest August and September of the whole sample, with more than 70mm of rain per month (the 1998-2011 average for these months is 21.8mm and 39.5mm respectively). Data from the Shullcas meteorological station does not seem to match people's perception on longer dry spells[25].

Figure 10 - Average monthly rainfall of the 2009/10 and 2010/11 seasons



Source: Milan and Ho, 2014: 72.

During PRA sessions, participants noted that the previous two years (2009-10 and 2010-11) had been characterized by heavy rains and great variability in rainfall patterns. This perception seems to match rainfall data: these rain years were characterized by a very high amount of total annual rainfall

[25] Dry spells (mentioned by 43% of survey respondents as longer and by 17% as more at unexpected moments) are defined by the Geophysical Institute of Peru (IGP) as 7 or more days with less than 0,3mm of average daily rainfall, in the period between the 1st of January and the 31st of March. (IGP, 2012: 206)

(third highest and highest in the 1998-2011 period respectively) but they also show sharp differences in rainfall patterns.

In fact, figure 10 shows that almost two-thirds of annual rain in 2010-11 was concentrated in three months, which were also the three wettest months of the whole sample. On the contrary, in 2009-2010, all months from July to February (except October) had higher than average rainfall. The last two years were also characterized by great differences in rainfall patterns during the first months of the rainy season. In the 2009-2010 season, August and September were very wet while 2010-11 had the latest onset of the entire 1998-2011 period. In contrast with the previous year, 2011-2012 showed the earliest onset of the whole period[26].

4.4.2 Livelihood and migration patterns at different altitudes

The rural population on which this study is focused is clearly divided into two types of rural community.

First, the high Andean communities of Acopalca and the upper part of Paccha (Suytucancha), whose main occupation is the farming of sheep, cattle and South American camelids (llamas and alpacas), are located in the Puna ecological floor above 4,000 meters. The climate is cold, its average annual rainfall is about 800 mm (CONAM, 2005) and frosts and hailstorms are frequent. *Comuneros* (members of the farmers' community) are organized into estancias or pasturage zones assigned individually by the communal authority for raising cattle. The communal authority keeps another part of the land under communal administration, depending on the extent of land available. Acopalca owns approximately 24,000 hectares and Paccha (Suytucancha) 7,000 hectares of communal land.

Puna grasslands are low-yielding agricultural areas. PRA participants stated that a typical family herd consists of 50–100 sheep, six cows and 10–20 llamas and alpacas, which require approximately 130–210 hectares of native pasture. The population living in Puna sells meat, wool and some livestock in the cattle fairs of the neighboring villages, usually from May or

[26] The onset was defined by the days in which annual precipitation reached 50mm and 100mm (CONAM, 2005: 43)

June when the animals are in their best condition. They complement their activities with work in Huancayo, and around 20% of the men (according to the seasonal calendar PRA session in Acopalca) get hired as shepherds for periods of three years in the US at least once in their lives.

Second, the rural communities of Paccha and Chamisería are located at altitudes of between 3,200 and 3,600 meters in the valley floor (Quechua ecological zone). These communities enjoy better access to the urban area of Huancayo. Households mostly perform family farming on small plots of land. The climate is warmer and allows the cultivation of food crops (potato, corn, broad beans, peas and a variety of vegetables). In these Quechua areas, plots of land have become, over time, smallholdings as the result of inheritance customs. Crafts such as embroidery and engraving gourds are on the rise, with the support of some governmental programs that promote the formation of associations of craftsmen, and they allow for non-agricultural diversification. Family farmers tend to expect the creation of jobs locally with more government support so they will not have to migrate as often. People also complement their activities with occasional employment in the urban area of Huancayo and other cities (for example, Jauja and La Merced in the Junín district). Proximity and ease of access to urban areas and transport facilities allow people to combine their agricultural activities with employment outside of their farms (particularly in the coffee harvest season or in construction).

Local experts estimate that there has been a 50% cent increase in the urban area of Huancayo in the last twenty to thirty years. In the same period, means of communications between Huancayo and the surrounding communities have improved substantially.

Table 13 -Livelihood and mobility patterns by altitude[27]

Lowland (3200 to 3600 meters)	Highland (above 3900 meters)
An agricultural[28] economic activity is the most important for 23% and second most important for 27% of households	An agricultural economic activity is the most important for 54% and second most important for 62% of households
Agricultural production in small land holdings (less than 1 ha) – individual land	Cattle herding in pasturages (more than 50 ha) - communal land
Most of the population concentrated is in a small geographical area	Population scattered and often isolated from the central part of the community
Huancayo can be reached in 20/30 minutes	Huancayo can be reached in more than one hour (access to the city depends on the location of the household)
Minority of households facing food shortages at least once in the last 5 years (36%)	Slight majority (53%) of households facing food shortages at least once in the last 5 years
Very low percentage of households migrating as a coping strategy in times of food scarcity (9%)	Almost one-third of households migrating as a coping strategy in times of food scarcity (30%)
Three main responses at the household level when food/money to buy food is insufficient (in descending order): 1. Diversify activities to increase alternative income 2. Reduce expenditure 3. Rely on external help	Three main responses at the household level when food/money to buy food is insufficient (in descending order): 1. Diversify activities to increase alternative income 2. Migration of household member(s) 3. Reduce food consumption
Main places of migration destination: Lima, Peruvian central jungle	Main places of migration destination: Lima, US (men), Argentina (women)
Expectation of youth for the future: staying in the place of origin	Expectation of youth for the future: settling in the big city

Source: Milan and Ho, 2014: 73.

[27] Percentages refer to answers to the household survey.

[28] "Agricultural" meaning any activity related to farming, cattle herding and fishing

Differences in altitude and levels of access to urban opportunities can influence the geographical distribution of household members. Household members from lowland tend to live together, with one or more of them commuting to Huancayo daily. On highland, it is common to have one or more members of the household taking care of the animals in the communal land on the highland while the rest of the household stays in Huancayo and takes urban economic and educational opportunities.

4.4.3 Land tenure

A key land-related issue in the Shullcas sub-basin is the process of fragmentation of land ownership in the case of the villages located in the lower valley floor around Huancayo, resulting from inheritance practices as land is divided equally between children when inherited from their parents. This process of shifting towards smallholdings hinders asset accumulation for young households. Rural households aim to achieve the maximum productivity from family labor and it is profitable for them to supplement their incomes with non-farming activities, as small farms are unable to fully absorb their labor. This situation increasingly boosts mobility to Huancayo and seasonal migration to intermediate cities in the central jungle, usually by the head of household. As this occurs, the rest of the family often remains in the village or town of origin.

A different case occurs in the highland communities where cattle pasturages are not inheritable but revert to the community that holds the ownership of land. However, in recent decades, communal institutions and social cohesion for collective entrepreneurship are being weakened in the context of the increasing tension between collective initiatives and individual interests. The dissolution of community action brings disadvantages for the most vulnerable (elderly, single women and widows, or the poorest in the community), who largely depend on solidarity and mutual support mechanisms.

Unlike farmers from the lower villages, cattle herders in the Puna often live alone in the pasturage, suffering inclement weather and lack of basic services. They usually leave their families in the nearest town, preferably in the city of Huancayo where the children can study and have a better

standard of living. In other words, the family migrates to the city but the head of the family remains in the pasturage. In few cases, livestock care is left to the wife while the husband migrates for short periods or seasonally to undertake other trades (commerce, transportation, construction labor and so on). This situation is common in families with babies or children below school age. When it is time for children to go to school, the opposite occurs, as described above.

4.4.4 Gender issues

The economic role of women in the Shullcas sub-basin relates mostly to resource management, income generation at home and responsibility for household chores. Women, who often do not have gas or electricity to cook with, have to collect wood and carry water for food preparation from remote areas. They are involved in various activities including farming, producing cheese and butter, cloth embroidery, weaving sheep or llama wool. Moreover, they often carry on the business of convenience stores − spaces that have become suppliers of staple foods for many families in the community. Through their daily movement to the city of Huancayo, women also market their agricultural products, bringing products from the city for their own supply and/or selling in the community. Likewise, they are in charge of strengthening the ties of kinship with the family that is in the city of Huancayo.

Within the household, women mainly decide on the resources for family consumption, such as livestock, horticultural crops or income that they can generate by selling crafts. Culturally, gender inequality is still a prevailing issue and women have most commitments related to the domestic sphere of the household. In contrast, men are engaged in work outside the house, relationships with other communities and work outside their communities. Generally, the decision on which crops or livestock are to be sold in the market is made by the head of household, which is usually a man.

Another gender-related issue is the scarce participation of women in decision-making in the community, in which they still do not have a defining role despite their knowledge and economic participation in the productive and domestic activities of their households. It is a tradition that

men represent the household in the local assembly, with little representation of women.

4.4.5 Migration

According to participants in all migration-related PRA sessions, international migration is profitable as long as people migrate legally. Remittances are intended for the education of children, feeding the family, home improvements or repairs, and sometimes the expansion of family businesses – such as opening a small shop or buying a car. Remittances are perceived to be a substantial contribution to those households who receive them. Unfortunately, the rainfalls database does not offer more detailed data on remittances than what has been presented in section 4.2.4.

The Venn diagram PRA session on migration in Paccha indicated that family, friends and neighbors are the most important sources of support in the migration decision and process:

1. Family was mentioned as the source of the most important support for potential migrants, to which they turn most frequently;
2. Friends and neighbors, like family, are easily accessible and can be trusted. It was even mentioned that, in some cases, this group of people provide migrants with better support than the family;
3. Money lenders were named as the third source of support. They are unable to provide a large amount of money (above 1,000 nuevos soles/360 US$) but they can lend money quickly, even within a day. However, PRA participants stated that lenders charge high interest rates (10 to 20%), so they are only considered when money is required unexpectedly or in the case of emergencies;
4. The last source to be mentioned was the bank, which, unlike the money lenders, is able to lend "large" sums of money, for example 5,000 nuevos soles (1,800US$). However, access to such a loan is very complicated and cumbersome, as there are many requirements and banks give preference to those receiving remittances. Even when the loan is approved, the bank takes time to deliver. Therefore, it is highly unlikely that potential migrants will resort to the bank for loans.

The participant responses for Chamisería to the same Venn diagram added that they also receive credit from a non-governmental organization (NGO) called PRISMA.

Women reported during migration-related PRA sessions that, when their husbands migrate, children are saddened, the man's contribution is missed and their home is less secure. Despite these problems, the economic contribution of the person working outside the community, especially if in the United States, often ensures better living conditions for all members of the household. The living conditions in the pasturage are harsh because shepherds do not even get basic amenities (they live in very rustic homes with no special protection against the cold, no potable water, electricity and sanitation) and live in very isolated conditions in remote sites. Therefore, the family generally resides in the nearest population center or stays in Huancayo where their children study.

The rest of sub-section 4.4.5 discusses the main similarities and differences between migration patterns at higher and (relatively) lower altitudes. Most of the information comes from PRA sessions rather than the survey. In fact, given the relatively small survey size (150) and the lack of information on migration to Huancayo[29], I will not present data on the relative number of migrants heading to different destinations.

Migration around Paccha and Chamisería (relatively lower altitude)

In Paccha and Chamisería, most people who work outside the village commute daily to the city of Huancayo, taking advantage of everyday transportation facilities both for education and for any type of job such as masonry or commercial activities. Bus tickets to Huancayo are relatively cheap – in 2011, a bus ticket from Chamisería to Huancayo costed 1 nuevo sol (0.36 US$). People also go to neighboring municipalities such as Quilca, Racracaya and Tiso (located on higher ecological floors), where they frequently share livestock pasturages, exchange corn for Andean tubers or participate in fairs and traditional celebrations in the villages.

[29] Migration was defined as a movement of at least one month outside the province of Huancayo.

People commuting daily to Huancayo often combine rural and urban life rather than abandoning their rain-fed farming activities in the communities of origin. Even those who settle in the city keep their agricultural plots for rain-fed agriculture and cattle herding (or both). They rely on members of their extended family to maintain farming work while they are away, at least in the first few years following their move.

Participants in migration-related PRA sessions also highlighted that a second type of mobility, which is typical of Chamiserìa and Paccha, is seasonal migration to intermediate cities in the central jungle region (La Merced, Satipo and San Martin de Pangoa) to work on the coffee harvest (between March and August), or on the pineapple and ginger harvests. Moreover, in the school vacation period (January to February), some young people go to Lima to work and return when classes begin.

A third type of mobility, long-term/permanent migration, typically occurs towards the capital city, Lima, where many young people go to seek new horizons.

Finally, there are less frequent cases of migration abroad. Some families have a relative or acquaintance that has migrated abroad. The most common destinations are (from most to least common) the United States, Argentina and Italy:

- *United States.* People migrate mainly to the states of California, Oregon and Colorado to work as shepherds. The standard time spent in those places is three years – after that, migrants either stay for three more years or they return. The cost of the one-way fare is, in many cases, paid for in advance by the party in charge of organizing the work contracts. In other cases, families sell their cattle, raising approximately 10,000 nuevos soles (3600 US$) to pay for all the administrative processes at the embassy. In some cases, they obtain bank loans or raise the money from their family.

- *Argentina.* Migrants go to work in commerce, establishing themselves in the labor market in Buenos Aires. Mainly young, single women migrate to Argentina to work as domestic servants and in garment factories.

- *Italy.* Migration to Italy is less common than migration to the United States and Argentina. Mostly young women migrate to Italy to serve as caregivers for the elderly and children in addition to house cleaning.

Migration around Acopalca and Suytucancha (higher altitude)
In the mainly pastoral, higher altitude areas of Acopalca and Suytucancha (part of the Paccha village located 3,800 meters), people more often migrate temporarily or permanently rather than commuting to Huancayo on a daily/short-term basis.

The most common form of international migration from Acopalca is by far to the United States to work as shepherds under contracts that generally last for three years. PRA participants stressed that the end of this period, most of them return to the community while few of them stay for three additional years. It is not common for people to settle in the United States because working conditions there are perceived to be very hard. Few women go to Argentina, mostly to work as domestic servants and in garment factories.

Most internal migrants from the highland go to Lima; according to PRA participants, the numbers of migrants to Lima is similar to the number of migrants to the United States. Unlike the communities in the lowlands, villagers did not mention seasonal migration to intermediate cities in the central jungle.

4.5 Discussion
In spite of the work opportunities in the urban area of Huancayo, this chapter shows that households from Paccha, Chamiserìa and Acopalca combine rural and urban activities rather than leaving their communities. This result is in line with existing literature on migration in the area: already in the 1980s, research was showing the interconnections between the cities of Lima and Huancayo and the rural villages of the Mantaro Valley as well as the combination of rural and urban activities in the area (Laite, 1981; Smith, 1984).

This chapter highlights that households located at relatively lower altitude have different migratory habits with regards to those on highland. In addition, they are more affected by rainfall variability, possibly because agriculture is the most common main economic activity on lowland while at higher altitudes cattle herding is the prevailing form of rural livelihood.

In the words of Laite, in the first eighty years of the twentieth century, migration in the Central Highlands of Peru was not "a flight from the land by the landless but rather a means of maintaining work alternatives across a number of economic sectors" (1981: 120). This chapter shows that daily mobility is now the most common means of maintaining work alternatives across a number of economic sectors for households based on relatively lower altitudes. The urban area of Huancayo can be accessed by commuting daily from the surrounding communities such as Paccha and Chamiserìa. Household based on relatively higher altitudes maintain these alternatives through circular migration and they do not abandon their pasture land.

It is always difficult for researchers dealing with migration to generalize empirical results obtained at the local level. However, this chapter highlights the importance of altitude and ease of access to urban economic opportunities in shaping livelihoods and mobility patterns from mountain areas. These factors should be taken into account for future research on migration patterns and their development outcomes in other mountain areas worldwide.

4.6 Conclusion

Different levels of access to centers of economic wealth and political power, high sensitivity to climate change, fragility, marginality and high climatic variability within short horizontal distances often characterize mountain areas. These factors proved to be very important in explaining livelihood and mobility patterns in the research area.

While this case study was conducted in a rural-urban context, the effects of climate and environmental stressors on human mobility tend to be more severe in rural mountainous areas where people rely on rain-fed agriculture for their livelihoods (see for example Gentle & Maraseni, 2012,

Nawrotzki et al., 2015a). Future empirical studies on rainfall variability, livelihoods and migration in vulnerable environments in mountain areas would enhance understanding on the relationship between rainfall variability, food and livelihood security and migration.

An earlier study from de La Cadena (1988) on migration from rural mountain communities to the city of Huancayo concluded that migration dynamics and outcomes for the migrants were influenced by altitude and livelihood characteristics of their community of origin. On the one hand, rural households from relatively lower altitudes were able to generate agricultural surpluses which allowed them to invest in Huancayo and successfully integrate in a relatively short time. On the other hand, poorer migrants from the higher areas migrated in order to supplement their scarce agricultural income with urban work. Agricultural income remained important for them, given the scarcity and insecurity of urban income. Almost thirty years later, it would be interesting to conduct a study on rural immigrants to Huancayo by interviewing the migrants themselves in their destination.

Coordinating promotion of the Shullcas sub-basin as a touristic area is fundamental for recent and current local efforts to promote the area of Huancayo and the Huaytapallana glacier as a destination for national and international tourists. The already existing structure for hosting tourists in Acopalca is not being used and it currently cannot deliver the expected benefits because the area lacks a broader touristic infrastructure. At the end of fieldwork (November 2011), the president of the community of Paccha was working with a local NGO on the creation of a park for tourists in the Bosque Dorado (Golden Forest) area (on highland). The park could only bring tourists and new employment opportunities to the surrounding communities if part of a broader plan for the area to become attractive for tourists.

Deglaciation of the Huaytapallana is attracting increasing attention among international scientists. Unfortunately, measuring the glacial retreat is complicated; it is also very costly to intervene and preserve it. Considering the limited budget available locally, I believe priority should be given to the protection of the most vulnerable communities and households within communities, especially since the farming communities who used to

provide support to the most vulnerable within each community are now in crisis.

5. AGENT-BASED MODEL OF HUMAN MIGRATION IN THE CONTEXT OF ENVIRONMENTAL CHANGE IN THE PERUVIAN ANDES [30]

5.1 Introduction

This chapter extends the analysis of chapter 4 by looking at the relationship between climatic stressors, livelihood resilience and human mobility under different rainfall scenarios from 2015 until 2050. In particular, building on the analysis of past and present migration patterns in the rural mountainous community presented in the preceding chapter, it aims at shedding light on whether migration dynamics in the Peruvian research area are likely to remain stable in the upcoming decades, or whether the area may expect depopulation.

The model presented in this chapter simulates possible future migration under different rainfall scenarios and its relationship with household resilience in its sociological meaning (Brand & Jax, 2007), defined as the ability of households "to cope with external stresses and disturbances as a result of social, political and environmental change" (Adger, 2000). Rainfall is the main independent variable because it was the most common climatic factor affecting livelihoods and migration patterns across many earlier case studies on environmental change and migration (Warner 2011a; 2011b). Given the complexity and interconnectedness of determinants of future migration, I decided to simulate future scenarios through agent-based modelling (ABM), a computational social simulation that enables the user to model the behavior of individual decision-making entities (such as individuals and/or households), as well as their interactions with each other and the environment. Such a model is made up of numerous heterogeneous units (agents) which are capable of making autonomous, potentially goal-oriented decisions and may have the capacity to learn, adapt and modify their behavior based on perceived changes in their environment (Bonabeau,

[30] This chapter is based on Milan, A., Smith, C., Kniveton, D. and Warner, K. (under review): Agent-Based Model of human migration in the context of environmental change in the Peruvian Andes. *Regional Environmental Change*, special issue on Andean communities in the face of global change. For replication purposes the model will be available at this link as soon as this paper is formally accepted for publication: https://www.openabm.org/model/4846/version/3/view.

2002; Janssen & Ostrom, 2006; Kniveton et al., 2012). One of the key advantages of agent-based models is their potential to simulate emergent outcomes. Such emergence would be unattainable from a conventional 'sum of the parts' analysis and can result from the complex and non-linear interactions that occur in social systems.

The use of an ABM accounts for the stochastic nature of future rainfall variability as captured by the aforementioned Monte Carlo simulation and for the heterogeneity of agents (Schlüter et al., 2013). The approach adopted here thus seeks to capture the decision-making processes of heterogeneous agents by accounting for processes and non-linearities that are specific to the region in question. An integrated approach such as that described by Sietz (2014) is proposed to have the potential to reveal system-specific factors and reveal the underlying conditions of vulnerability that are important to facilitate vulnerability reduction. This approach was chosen over an equation-based modelling (EBM) alternative, such as System Dynamics (Ginnetti, 2015), because (unlike ABM) EBM focuses on entire systems rather than on agents within systems and does not take into account the interaction between individuals. In fact, migration in cannot be understood without looking at inter- and intra-household processes and interactions (Wrathall, 2012: 585). Moreover, ABM permits a comparison of the encoded behavior of agents in the model with the observed behavior of real agents while also capturing space in relation to interactions, thereby allowing the potential for greater accuracy (Sietz et al., 2006).

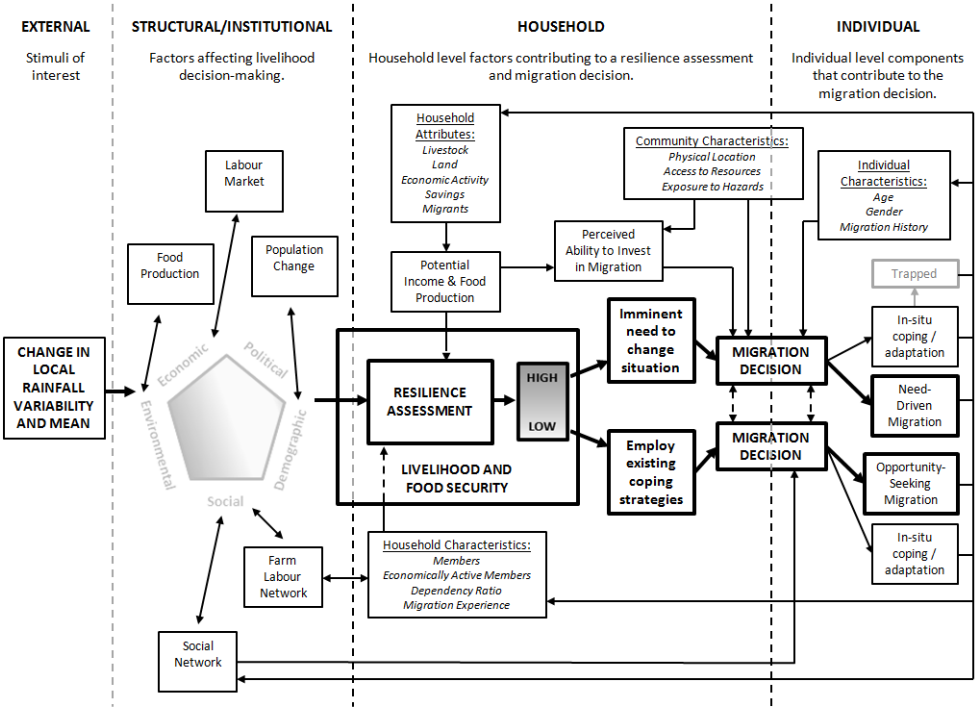
The Agent-Based Model (ABM) designed to simulate migration scenarios in the research area builds on the results of the case study conducted in October and November 2011 presented in the previous chapter of this thesis. The case study explored the past and present relationships between rainfall variability, livelihoods and migration patterns in the area (Ho & Milan, 2012; Milan & Ho, 2014). Daily mobility and circular short-term migration are the most common means for households to diversify their livelihoods. The urban area of Huancayo can be accessed by commuting daily from the surrounding communities at relatively lower altitude such as Paccha and Chamiserìa. Households based in the highlands (Acopalca and Suytucancha, the higher part of Paccha) diversify their livelihoods through circular (usually short-term) migration and they tend not to leave their agricultural land. Households in the three communities under study combine rural

activities at different altitudes ("vertical livelihoods") and they rely on complex inter- and intra-household activities and connections ("confederations of households") between rural and urban areas (Murra, 1972; Skeldon, 1985; Smith, 1984). These livelihoods entail complex mobility patterns in terms of short-term mobility as well as long-term (often long distance) migration that play a key role in determining household resilience.

5.2 Methodology

5.2.1 Conceptual Design of the Rainfalls Agent-Based Migration Model (RABMM)

Figure 11 - Rainfalls Agent-Based Migration Model (RABBM) Conceptual Framework



Source: Smith, 2014: 79.

The conceptual basis behind all Rainfalls Agent-Based Migration Models (RABBM), including the model for Peru presented in this chapter (RABBM-P), relies upon the notion that human capacity to anticipate changes to an existing migration dynamic as a result of a change in rainfall are contingent upon the way in which such a change affects the existing drivers of migration (Ajzen, 1991; Foresight, 2011). While the technical model development and testing is described in detail by Smith (2014), I will outline some of its key features below.

The conceptual framework displayed in figure 11 sets out the range of components included at each of the four levels of analysis identified: external, structural/institutional, household and individual. At the household level, the foremost component is the 'resilience assessment', from which a household determines its resilience at time t. Within the conceptual framework, migration decision-making is undertaken as an individual decision mediated by the household to which the individual belongs. While an individual's migration decision is therefore affected by his/her household's ability to invest in migration (itself affected by income and community characteristics such as physical location, access to resources and exposure to hazards), the propensity of each individual towards migration is derived from their own characteristics (age, gender and migration experience) and the influence of their social network.

Although it may be argued that gradual changes in rainfall also have the potential to influence political, demographic and social drivers of migration, this model is based on the assumption that the clearest and most replicable changes will be manifest through environmental and economic channels. Within Figure 11, arrows indicate the primary direction of influence of one component over another. Bold elements highlight the most important components of the resilience assessment and migration decision-making processes being modelled. Non-bold items indicate secondary factors seen to contribute to these processes.

The Rainfalls data collection focused on the temporal evolution of rainfall variability and change rather than on shock events. Sudden and short-term forms of migration are thus beyond the scope of the analysis of chapter 4 and

of this model. As a consequence, and considering the low prevalence of seasonal migration in the Rainfalls Peru dataset (less than one third of total migration and diminishing over time), the model only simulates long-term migration (minimum six months) outside the province of Huancayo and with one month as the temporal unit of analysis within the model.

5.2.2 Assumptions of the model

Based on the analysis of the Rainfalls Peru survey and participatory research data, the model was built with the following assumptions:

- Households assess their livelihood and food security on the basis of the income and agricultural production achieved within their household;
- A household is deemed resilient if its surplus income and food production following subsistence allows it to comfortably endure the rainfall conditions affecting the household at a point in time. On the contrary, the household is deemed non-resilient if the conditions cannot be comfortably endured;
- Resilient households may choose to send one or more migrants as a form of aspirational action that has the potential to further boost household income and therefore resilience;
- Non-resilient households may also choose to send one or more migrants due to the need to both increase household income and reduce consumption requirements at home;
- Because of the likely greater degree of planning, increased ability to invest in migration and draw upon social networks, migration from resilient households is proposed to be, on average, more expensive than need-driven migration from non-resilient households;
- In identifying the value of migration to a household the decisions made by the relevant decision-makers within the household will be affected by the equivalent actions of their social network.

5.2.3 Primary data collection and parameterization of the model

Primary data on rainfall variability, food and livelihood security, and human mobility in the three communities were collected as part of the Rainfalls case

study in Peru (see sub-chapter 2.2). A one-to-one mapping of survey respondents to model agents was used so the model is populated by 150 households, for a total of 755 individuals.

Within the 2011 Rainfalls study in Peru, I only collected data on the first and last migration[31] of each individual belonging to the households sampled during their entire life. As a consequence, in addition to the *ex-ante* input validation in the development of the model, the RABBM-P was validated through an *ex-post* "descriptive validation" approach which means comparing simulation outputs generated by the model with historical data collected on the phenomenon of interest (Bianchi et al. 2007: 247). The *ex-post* validation was done through a second round of data collection which took place in October/November 2013, when I sought the full migration histories from 1998 to 2011 of the 150 households surveyed in 2011 (15 of them could not be found so I collected a total of 135 household migration histories). The 1998-2011 validation period was chosen because historical rainfall data collected from the Shullcas meteorological station only covers these years.

For the purposes of this research a non-scaled normal probability function (normal distribution) has been adopted as a means to test the likely shape of influence of rainfall upon agricultural yield (Smith 2014: 81-83). A non-scaled normal probability function is derived from the relevant historical mean (μ) and variance (σ^2) of rainfall values recorded in the meteorological station nearest to the three research communities (Shullcas, located directly in the Shullcas sub-basin). Using these values, a non-scaled normally distributed multiplier function value (n) represents the scale of change in a variable such as agricultural yield under known rainfall conditions (R):

$$n = \exp\left(-\frac{-(R-\mu)^2}{2\sigma^2}\right)$$

Using this approach to multiplier function generation, the benefit to agricultural yield gained from an increase in relevant rainfall will increase up to a point at which maximum yield is attained before further increases in

[31] Movement of at least one month outside of the province of previous residence, excluding holidays/family visits.

rainfall begin to have a negative influence and start to decrease yield (Smith, 2014).

Table 14 - Relative values assigned to household livelihood and food production contributory variables in RABMM-P

Attribute:		**Relative Value:**
Crop yield per acre of land:		4 per year
Livestock:	1 x Cow	1 per year
	1 x Horse	1.1 per year
	1 x Pig	0.35 per year
	1 x Goat	0.14 per year
	1 x Chicken	0.03 per year
Individual resilience threshold:		0.143 per month
Household resilience threshold (average no. of household members = 5)		0.72 per month
Return for daily non-farm wage:		0.71 per day
Average cost of resilient migration:		0.73 per migration
Average cost of non-resilient migration:		0.1 per migration
Max Return on Migrant Labour:		1.43 per month

Source: Calculated by the authors on the basis of Rainfalls Peru dataset and FAOSTAT (2011).

In addition to primary data collected within the Rainfalls project, variables used within RABMM-P that contribute to the livelihood and food production systems of a household require quantification from sources other than the limited income and yield data offered by survey respondents. Table 14 displays the relative values sourced for RABMM-P.

Table 15 - Variables that contribute significantly to the prediction of migration, income, and non-farm work[32]

	Variable	Univariate Binomial Logistic Regression	Multivariate (ALL) Binomial Logistic Regression
Variables that contribute to the prediction of migration	family size	0.074*	0.011**
	dependency ratio	0.011** (-)	0.014** (-)
	altitude of dwelling	0.041** (-)	0.022** (-)
	household income	0.043**	0.494
	participation in farming	0.058* (-)	0.268 (-)
Variables that contribute to the prediction of the income	dependency ratio	0.005*** (-)	0.023** (-)
	education	0.001***	0.027**
	land ownership	0.064* (-)	0.282 (-)
	land size	0.046**	0.123
	participation in farming	0.030** (-)	0.256 (-)
	participation in non-farm work	0.021** (-)	0.020** (-)
Variables that contribute to prediction of the rate of employment in non-farm work	family size	0.000*** (-)	0.000*** (-)
	dependency ratio	0.015** (-)	0.199 (-)
	livestock ownership	0.046**	0.569
	livestock yield	0.001** (-)	0.016** (-)
	participation in farming	0.004*** (-)	0.367
	per capita income	0.031**	0.358 (-)

Source: Rainfalls Survey data (Ho and Milan, 2012). *** = P>99% ** = P>95% * = P>90% (-) = inverse relationship.

[32] ***** = P>99% ** = P>95% * = P>90% (-) = inverse relationship.**

From a comprehensive analysis of Peruvian survey data (key univariate and multivariate binomial logistic regressions are reported in table 15), a number of variables are deemed to be significant contributors to the determination of the likelihood that a household will send one or more of its members as a migrant:

- Demographic Factors: family size, dependency ratio
- Economic Assets: land ownership, land size, livestock ownership
- Economic Activities: participation in farming, participation in non-farm work and household income, livestock yield
- Other factors: altitude of the dwelling, level of education

RABMM-P uses a livelihood resilience oriented approach to simulating the number of migrants originating from modelled households each month. All RABMM-P simulation results represent the average values generated from ten model runs. For clarity, results presented as time plots are five-year moving averaged rather than yearly changes so that smoother transitions between simulated changes can be observed.

Within each monthly run of the model, demographic and economic data are assumed to be fairly constant while changes in rainfall affect household incomes and food production systems. An important characteristic of the model is that it simulates variations in household resilience classifications over time: the post-subsistence resilience score calculation that determines whether a household is considered resilient or not is repeated for every simulated month. In other words, households can move from one resilience category to the other every month.

5.2.4 Rainfall scenarios

RABMM-P was tested using a projected reduction in mean annual rainfall of 19% in Central Peru by the year 2050 (World Bank 2009: 1) with respect to

1998-2011 data (Milan & Ho 2014: 72). The rainfall scenarios used within the RABMM-P are provided by Monte Carlo simulations that represent the stochastic probability-distributed nature of the variation in future rainfall around the longer-term trend.

While the constant drying scenario distributes the anticipated reduction in rainfall evenly across the simulated period, thereby generating a consistent decrease in precipitation, the varied drying option allows the anticipated change to be manifest in a stochastic manner through different year-to-year variations in rainfall around a decreasing mean.

5.2.5 Model limitations

Although the data used for RABBM-P offered comprehensive information relating to the circumstances of surveyed households in 2011, it lacked information relating to the nature of temporal changes to household attributes over time. Further, a binary approach to household resilience classification was needed for modelling purposes but it limits the capacity of the model to replicate the complexity seen in a real world livelihood decision-making process.

The external validation approach used also has its limitations. With the potential window for validation limited to 13 years of observed migration data populated using a retrospective approach to data collection, the challenge of appropriately validating RABMM-P was considerable. It is clear from the validation results presented in sub-chapter 5.4 that modelled migration exceeds that observed throughout the majority of the validation period with the difference between the two flows tapering towards 2011, likely as a result of the retrospective nature of the observed data. This however might also be anticipated because of the necessity of initializing the model at zero migrants in 1998, a state that is then built upon throughout the simulation. The unknown nature of many past attributes of model agents (each of which represents a surveyed individual), and the need for such attributes to adjust on an unknown scale, make the validation process as much about the replication of past demographic change of the communities in question as it is about migration. However, this is not in itself an issue as

the effective running of the demographic structures of RABMM-P is also paramount in producing appropriate future oriented simulations.

5.3 Model Results

5.3.1 Total Migration

Figure 12 - Simulated total migration[33]

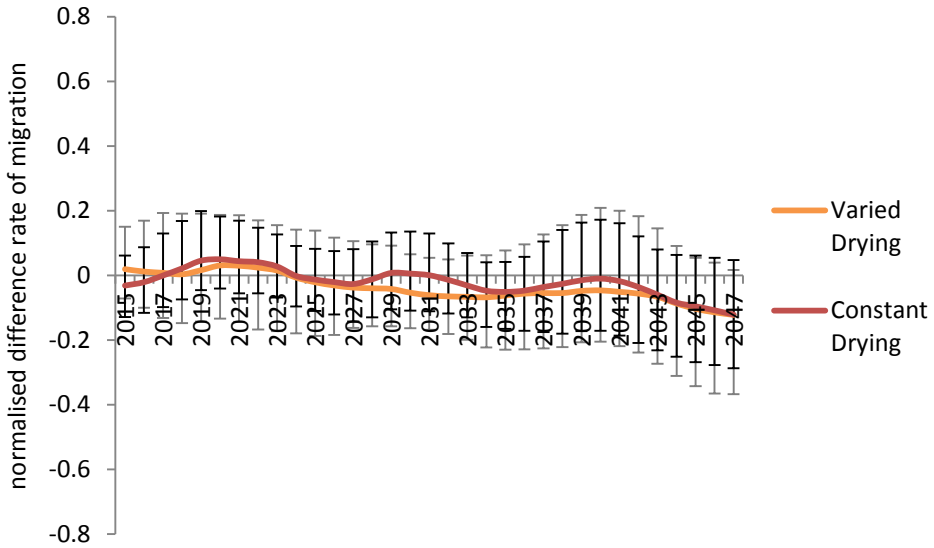


Figure 12 displays normalized results (outcomes from scenario of interest subtracted from outcomes from the base scenario that represents consistently average rainfall conditions) to reveal simulated trends under varied and constant drying scenarios compared to the base scenario. The RABMM-P modelled impact of drying scenarios upon total migration is

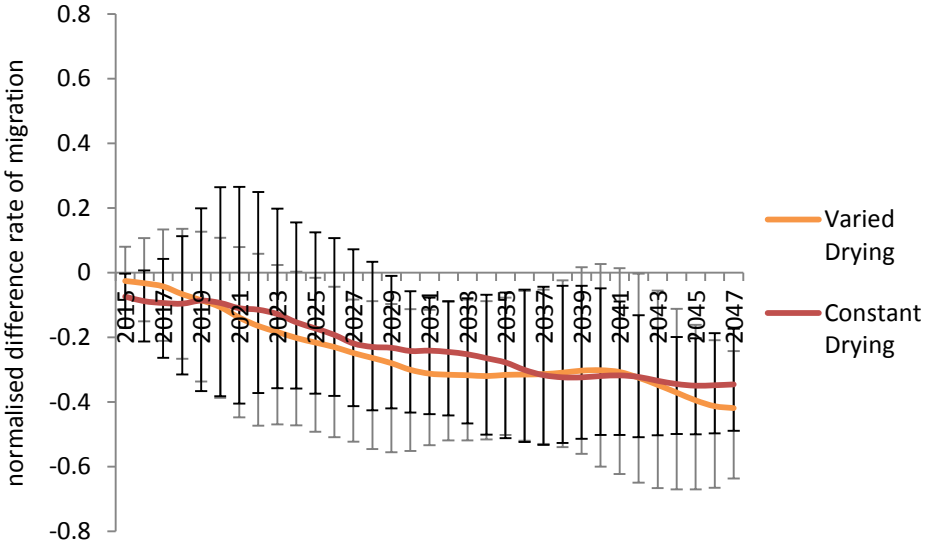
[33] Error bars indicate the envelope of changes modelled under ten member ensembles.

overall small but, on average, negative with both scenarios simulating overall reductions in total migration compared to the base scenario.

Although only a small negative change in total migration is simulated, the model also simulates a decrease in the number of resilient households with respect to the average base scenario both under the varied and constant drying scenarios. As a consequence, further analysis is needed to determine whether the simulated reduction in migration flows was equally distributed within the two household categories (resilient and non-resilient) or whether different patterns emerged.

5.3.2 Migration from Resilient Households

Figure 13 - Simulated migration from Resilient Households



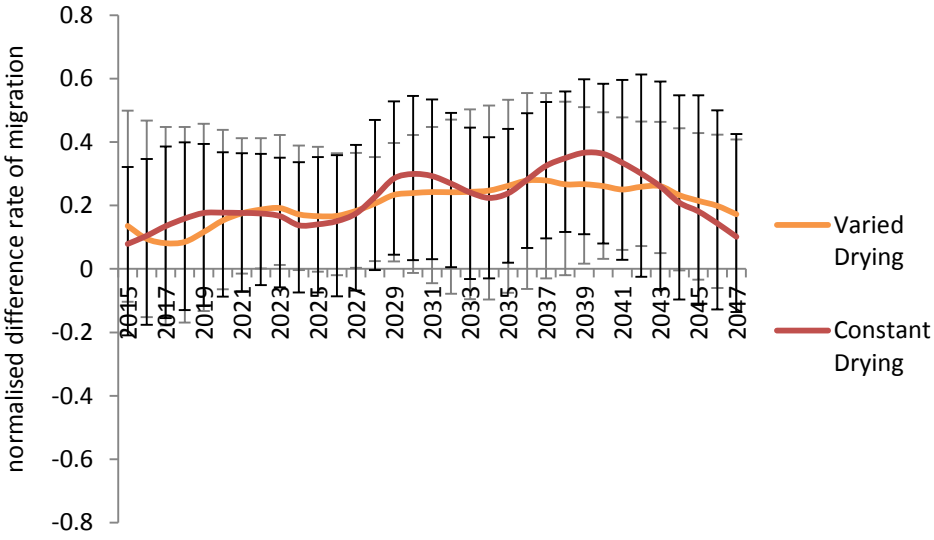
The varied and constant drying rainfall scenarios generate similar mean changes in the number of migrants originating from resilient households with reductions of 25% and 23% respectively compared to the base scenario. When compared to the reduction in the number of resilient households over

time, it becomes evident that most of the decrease in migration is due to a reduction in the number of households simulated as resilient.

However, the simulated negative change in migration from resilient households is greater than the simulated reduction in the number of resilient households, suggesting that resilient household will be less likely to migrate over the upcoming decades.

5.3.3 Migration from Non-Resilient Households

Figure 14 - Simulated migration from Non-Resilient Households



In contrast to the trend in migration from resilient households, migration from non-resilient households is simulated to increase over the base scenario under both the varied and constant drying rainfall scenarios tested by RABMM-P (figure 14).

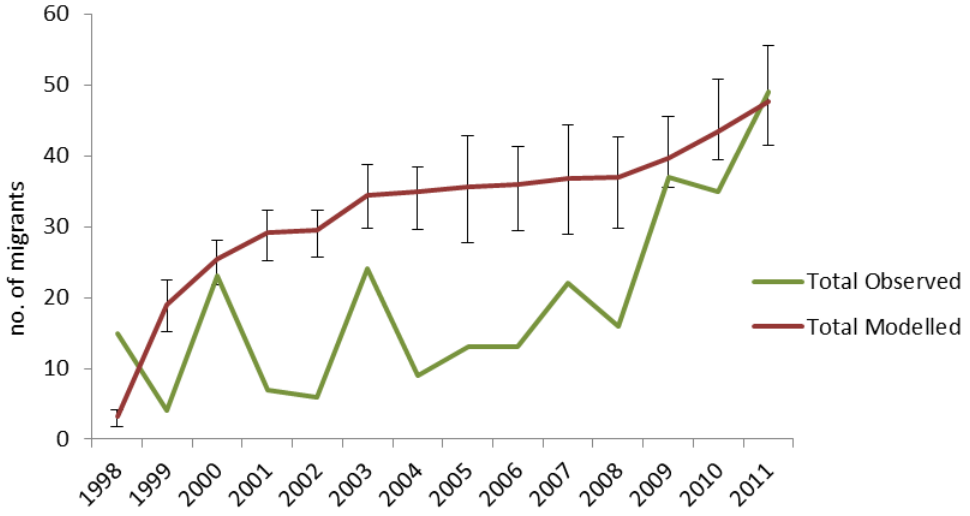
Although lesser than the negative change simulated for resilient migration, the positive trend in non-resilient migration is seen to be consistent both

throughout the simulation period and within the envelope of changes simulated by ten member ensembles.

Interestingly, while the change in resilient migration was seen to decrease steadily over time, the increase in non-resilient migration is seen to be less steady, peaking around 2040 under both scenarios. Both the varied and constant drying scenarios generate modelled non-resilient migration flows that are slightly greater than those simulated under the base scenario.

5.4 Validation of the model

Figure 15 - Observed and RABMM-P modelled total migration between 1998 and 2011[34]



The version of RABMM-P used for external validation was adapted from its future-oriented design to look at the 1998-2011 period. The starting

[34] Correlation coefficient = 0.57 (95% significance). RMSE = 52.2%. Modelled flows represent the average of ten ensemble runs with error bars displaying the complete envelope of changes simulated

population of the model was reduced to only those individuals that had already been born at the start of the validation period. The similarities between the observed and modelled flows of migrants are highlighted by the 95% significance of the correlation coefficient for the two sets of data (0.57).

However, it is clear from Figure 15 that, despite the broad rate of change seen in the observed data being replicated by RABMM-P, the capacity of the model to replicate the year-to-year changes in migration observed in the short retrospective record is limited. The disparity between the two flows in this regard is highlighted by the root-mean-square error (RMSE) of 52.2%. In addition to effectively replicating the broad rate of change in migration observed between 1998 and 2011, the migrant flows simulated by RABMM-P also align well with some of the peaks seen in the observed data. Specifically, in the years 2000 and 2003 the observed data shows two clear peaks. Although not visible as peaks in the simulated data, the modelled flow is seen to increase sharply at both these points.

5.5 Discussion

Livelihoods in Acopalca, Chamisería and Paccha are characterized by "confederations of households", complex inter- and intra-household connections between individuals based in neighboring rural and urban areas (Smith, 1984). As a consequence, the region's complex human mobility patterns are a key determinant of household resilience in the context of environmental change. Increases in rainfall variability can act as a multiplier for already existing environmental stressors which are interrelated with other demographic, economic, political and social factors and they determine livelihood and migration patterns in the area (Milan & Ho, 2014).

The analysis presented above reveals the simulated relationships between a drying rainfall trend and changes to both household resilience classifications and migration flows. When combined, the overall influence of the drying scenarios upon total migration results in a marginal decrease in the number of migrants compared to the base scenario. These findings reflect the point made in recent literature on migration and global environmental change that while environmental changes will have an increasing impact on migratory

flows, this will not necessarily imply an increase in the number of migrants (Foresight, 2011), especially when households can rely upon extended social networks that can allow them to adapt locally (Nawrotzki et al., 2015b). In line with Gray (2009) and Jokisch (2002) but contrary to a prevailing discourse, this article shows that mountain areas characterized by high prevalence of migration should not necessarily expect depopulation and agricultural abandonment. In this context, it would be interesting for future research to study in more depth the role played by place attachment in migration decision making (Adams, 2015; Mellander et al., 2011).

The model only simulates long-term migration (minimum six months) outside the province of Huancayo. Recent and past work in rural communities of the Mantaro Valley has shown that households in the area combine the scarce income from agricultural production with urban income rather than abandoning the farming land because of work opportunities in the city of Huancayo (Haller & Borsdorf, 2013; Long & Roberts, 1978; 1984; Milan & Ho, 2014). In fact, these opportunities can be accessed through daily commuting/short-term migration to the nearby city of Huancayo which might be substitutes for longer term migration and it does not count as migratory movement within the model as commuters/short-term migrants remain within the same province.

In this context, it is worth analyzing census data to see if rural areas of the Andean regions of Peru are facing a decrease or increase in population (table 16) and also to look at the evolution of migratory patterns (table 17).

Unfortunately, the distinction between rural and urban area at the provincial level is only available for the 2007 census; as a consequence, table 16 looks at rural areas by department (Huancayo belongs to the department of Junín) rather than by province.

Census data seem to be in line with the ABM's finding that rural communities in Junín should not necessarily expect depopulation: in fact, Junín has the second highest rate of rural population growth between 1993 and 2007 (after Pasco) and the third highest rate between 1940 and 2007 after Huánuco and Cajamarca. While the rural population of Junín seems to keep growing at a high pace, the 1993-2007 rural population growth for Peru (0.2%) was lower than the overall population growth rate (1.6%) and several

Andean departments have seen a substantial decrease in their rural population (for example, Apurimac 11.9%, Ancash 6.5%).

Table 16 - Evolution of rural population by Andean department

	1940	1961	1972	1981	1993	2007	1993-2007
Peru (total)	4,010,834	5,208,568	5,479,713	5,913,287	6,589,757	6,601,869	0.2%
Junín	**200,726**	**265,458**	**281,890**	**341,576**	**357,590**	**400,211**	**11.9%**
Ancash	329,794	391,636	385,457	386,802	406,995	380,505	-6.5%
Apurimac	221,158	231,107	233,525	239,924	248,048	218,519	-11.9%
Ayacucho	273,390	306,872	306,904	319,704	255,733	257,105	0.5%
Cajamarca	416,383	624,081	746,020	815,274	948,673	933,832	-1.6%
Cuzco	364,040	413,631	452,415	484,108	557,038	526,719	-5.4%
Huancavelica	206,752	245,081	252,001	261,022	284,723	310,775	9.1%
Huanuco	187,055	254,894	303,115	329,450	401,711	438,288	9.1%
Pasco	61,667	91,313	73,640	90,116	92,912	106,856	15%
Puno	477,292	562,113	590,013	607,036	656,596	638,550	-2.7%

Source: Data from INEI's 1940, 1961, 1972, 1981, 1993 and 2007 census

Table 17 - Net internal migration flows by department

	1940	1961	1972	1981	1993	2007
Junín	**- 13,792**	**- 19 440**	**- 33 513**	**- 65 968**	**- 160 703**	**- 212 938**
Ancash	- 48,131	- 76 087	- 137 701	- 172 889	- 247 104	- 273 865
Apurimac	- 11,570	- 67 454	- 115 164	- 144 787	- 173 451	- 193 987
Ayacucho	- 27,604	- 97 227	- 158 216	- 186 103	- 279 385	- 253 040
Cajamarca	- 48,620	- 106 481	- 211 202	- 311 168	- 405 436	- 531 984
Cuzco	1,702	- 20 844	- 72 848	- 89 488	- 132 128	- 181 793
Huancavelica	- 12,972	- 59 816	- 100 875	- 128 796	- 200 240	- 229 906
Huanuco	- 6,223	- 22 093	- 48 212	- 57 936	- 83 193	- 186 266
Pasco	NA	- 5 088	- 19 848	- 34 119	- 76 209	- 92 785
Puno	- 28,131	- 81 223	- 138 707	- 187 483	- 261 463	- 289 046

Source: Data from INEI's 1940, 1961, 1972, 1981, 1993 and 2007 census

Disaggregated census data on migration is only available for internal migration and at the department level rather than provincial level, and without distinction between rural and urban areas. However, it is very interesting to see from table 17 that all Andean departments have substantial net outmigration flows, which implies that population growth prevents them from depopulating. Almost all internal migrants go to the department of Lima-Callao which in 2007 had a net migration inflow of 2,606,409 Peruvians.

5.6 Conclusion

This chapter contributes to the thesis by presenting a case study-based agent-based model of migration patterns under different rainfall scenarios. In spite of its limitations, the RABBM-P allows for a nuanced understanding of how the relationship between changing rainfall patterns, household resilience and human migration in the Andean communities under study might evolve in the decades to come.

This modelling exercise is also a first step towards a next generation of models that allow for deeper understanding of possible future impacts of climatic and environmental stressors on different types of households. The simulation shows that under likely scenarios of future rainfall, more households might become what the model defines as non-resilient. It would be interesting for future models to move from a binary definition of resilient/non-resilient households to a more sophisticated definition of households by resilience level.

In order to advance the field of agent-based social simulation of migration decision-making under changing rainfall regimes, greater spatio-temporal data are required that, in combination with historical rainfall data, can be used to effectively parameterize the nature of the interactions that exist between such components over time.

Agent-based models would also benefit greatly from the inclusion of local economic and demographic scenarios. I tried to include them in the RABBM-P in order to answer the research question but for different reasons this was not possible. Regarding economic scenarios, I could only include crop price scenarios at the local level but they were not a good proxy for local socio-

economic scenarios. Demographic scenarios were also excluded from the analysis because there was no basis for the creation of new households within the model. Thus, households would have just gotten bigger over time which would have been unrealistic.

Previous research by Warner and Afifi has highlighted that, while migration tends to be beneficial for resilient households, if often worsens the long-term situation of non-resilient households (2014a: 11). In line with the Rainfalls results presented by Warner and Afifi, an important policy implication of this article is therefore that promoting and supporting resilience at the household level might not only prevent households sliding towards vulnerability but also allow them to stay in their communities of origin and possibly benefit from short-term/circular migration opportunities.

Households in Acopalca, Chamisería and Paccha implement sophisticated livelihood diversification and risk management strategies through extensive inter- and intra-household networks. These strategies are closely interlinked to their human mobility patterns which are simulated in this chapter to remain relatively unchanged in the decades to come. Future research on the potential of migration as an entry point of transformational change in Andean communities would contribute greatly to our understanding on what shapes their resilience to regional and global change. Building on such research, migration policies that maximize benefits and minimize risks related to human mobility could foster sustainable development in the area.

6. MIGRATION AND GLOBAL ENVIRONMENTAL CHANGE: METHODOLOGICAL LESSONS FROM MOUNTAIN AREAS OF THE GLOBAL SOUTH[35]

6.1 Introduction

Within resource-dependent areas of the global South, mountains are particularly vulnerable to the adverse effects of climate change because of their high sensitivity to climatic changes and high prevalence of (often rain-fed) family farming in marginal and harsh areas (Beniston, 2003; IPCC, 2013b, 2014; Jodha, 1992; Messerli et al., 2004).

Mountain areas comprise approximately 20% of the earth's surface, they are home to roughly 10% of the world's population, and they supply about half of the world's population with major natural resources including water, energy, minerals, forest and agricultural products. Moreover, they are key storehouses of biological diversity, natural habitat to endangered species, and an indispensable part of the ecosystem of the world (Godde et al., 2000; Smethurst, 2000; Viviroli et al., 2007).

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) points out major adverse impacts of climate change on mountain areas worldwide and particularly on precipitation, glaciers, snowfall, permafrost, and ice cover (IPCC, 2014). Rising global temperatures contribute to changes in species distribution (Pounds et al., 1999); rainfall variability and extreme rainfall events (Dore, 2005); and snow cap melting (Hock, 2003). Glacial melting and high rainfall can in turn lead to intensive floods and landslides (Evans & Clague, 1994); higher amount of debris flows and avalanches (Beniston, 1994); and other potential hazards which impose major threats to the ecosystem and great damages to the infrastructures, communication networks, farm productivity and local economy (Beniston, 1994).

The interaction of climatic and environmental changes with other drivers of livelihood change in mountain areas (such as population dynamics and

[35] This chapter is based on: Milan, A., Gioli, G. & Afifi, T. (2015a). Migration and global environmental change: methodological lessons from mountain areas of the global South. *Earth System Dynamics 6*: 375–388.

economic globalization) is of greatest importance yet relatively understudied (Jodha, 1992; Messerli et al., 2004). In particular, the relationship between migration and environmental and climatic changes is a crucial driver of livelihood dynamics which has barely been studied in a systematic way (Kollmair & Banerjee, 2011; Skeldon, 1985).

This chapter extends the analysis beyond the two case studies already presented in chapters 3 and 4 by looking at similar studies in other mountain areas of the Global South. Among others, this chapter focuses on a third Rainfalls case study conducted in the Kilimanjaro area in Tanzania (6.5) as well as a case study from the Hindu-Kush-Himalaya in Pakistan (6.6) which took a similar methodological approach to Rainfalls.

In the context of my thesis, this chapter aims at answering the following research question: How can the next generation of empirical research move beyond understanding of single case studies to draw general lessons on the relationship between household vulnerability and migration in mountain areas of the global South?

6.2 Past empirical approaches to study migration and environmental change in mountain areas of the global South

6.2.1 Quantitative studies

From an empirical point of view, most quantitative studies on migration in the context of environmental change in mountain areas have taken two approaches: either using existing population and environmental data from different sources or designing a new survey to collect them through a case study approach (Bilsborrow & Henry, 2012).

A good application of the first approach is offered by the Chitwan Valley Family Study (CVFS) in the Terai belt of Nepal (situated at the foothill of the Himalaya). The CVFS database spans over 108 months (between 1997 and 2006) and includes a total of 1583 household surveys, 5271 individual interviews (with life histories), land use measurement for each neighborhood, and a monthly registry of demographic events. The database has been analyzed applying descriptive and inferential statistical tools as

well as modelling migration through discrete time event history methods (Bhandari, 2004; Massey et al., 2010).

However, already existing survey data can only be used when a comprehensive database with information on demographic, migratory and environmental issues is available. Given the remoteness and isolation of mountain areas and the lack of reliable data, the chances of successfully replicating this method are presently limited. As a consequence, researchers have more often designed a new survey to answer specific research questions (Ezra, 2003; Gray, 2009; Gray & Bilsborrow, 2013; 2014). While individual sample surveys can be tailored very well to specific contexts (Piguet, 2010), they have rarely been used to look at migration in mountain regions of more than one country.

The Rainfalls case studies in mountain areas of Guatemala, Peru and Tanzania (the latter to be presented later in 6.5) are an exception. Similarly, the case study of Pakistan presented in section 6.6 has followed an approach developed by the International Centre for Integrated Mountain Development (ICIMOD) in the project entitled "Too much water, too little water – Adaptation strategies to climate induced water stress and hazards in the greater Himalayan region" (2008–2011) which looked at the role of labor migration in communities affected by the impacts of too much (flash and other floods) and too little (drought and water shortage) water in four countries of the Hindu-Kush-Himalaya (HKH) region (China, India, Nepal and Pakistan) (Banerjee et al., 2011, 2013).

6.2.2 Mixed methods

The relationship between population dynamics and the environment in mountain areas of the global South is complex and cannot be easily captured by quantitative surveys alone. While empirical studies relying exclusively on qualitative methods are rare (for example Kaenzig, 2014), most researchers use a mix of quantitative methods (especially survey data) and qualitative data (especially ethnographic methods).

There are two most common combinations of quantitative and qualitative data. Firstly, household surveys are often complemented by in-depth individual interviews (Goodall, 2004). Secondly, as shown in the case studies

presented in chapters 3 and 4 as well as later in this chapter, survey data can be combined with key informant interviews as well as Participatory Rural Appraisal (PRA) tools (Banerjee et al., 2013).

6.3 Contribution of this chapter

This chapter shows that household profiles linking household vulnerability with human mobility patterns can help understand the role of migration in household attempts to manage risks in areas where they are highly vulnerable to environmental and climatic stressors. In particular, these profiles bring insights into households which migrate to enhance their resilience; those for which migration is an erosive and undesirable action indicating constraints or limits to adaptive capacity *in situ*; and those who cannot move, even if they "would like to" (Gioli et al., 2014: 263; Warner & Afifi, 2014a: 11).

While these household profiles, built as an *ex-post* exercise, provide important insights and lessons learned for the future, the authors suggest in the discussion that transdisciplinary teams should aim at linking household vulnerability measured through a correlation-sensitive multidimensional index with human mobility patterns from the onset of their research. Such link should be used as a lens through which researchers study the relationship between household vulnerability and different forms of mobility both within and across different case studies, especially in the case of rural mountain areas of the global South which are highly sensitive to climate change and where isolation, lack of demographic data and scant distribution of meteorological stations open up a specific set of challenges.

6.4 Theoretical background of the case studies

The theoretical foundation for all the Rainfalls case studies as well as the Pakistani case study presented in section 6.6 (which was not part of the Rainfalls project) is the New Economics of Labor Migration (NELM) (Stark & Levhari, 1982; Stark & Bloom, 1985). Migration is hence understood as a risk management strategy adopted at the household level, and the main question addressed by the case studies presented in chapters 3 and 4 as well as in sections 6.5 and 6.6 is "under what circumstances can people migrate

as a livelihood risk management strategy when facing rainfall variability (Guatemala, Peru and Tanzania), environmental shocks (Pakistan) and food insecurity (all)?".

As discussed in 2.1, such a question calls for a deeper understanding of the livelihood and environmental context, and this is why the NELM theory was supplemented by the Sustainable Livelihood Approach (SLA) which allows to explore the asset base of households, divided into natural, physical, financial, human and social assets that are complementary to each other (Banerjee et al., 2013; Carney, 1998; Kollmair & Gamper, 2002; Kniveton et al., 2008).

6.5 The Rainfalls Tanzania case study[36]

6.5.1 Methodological approach

Like the rest of the Rainfalls case studies, a mixed-methods approach combining expert interviews with 165 household surveys and PRA tools was applied in Tanzania.

The expert interviews included national and local government officials, NGO representatives and academics in the fields of migration and climate change, geographers and meteorologists. Due to the availability of information about household wealth data, it was relatively simple to apply stratified random sampling on households that were classified as poor, medium and wealthy. The three research villages were classified according to their altitudes: Ruvu Mferejini (lowland – 655 meters above sea level) Bangalala (midland – 900 meters) and Vudee (highland – 1,950 meters) are all located in the Same district, Kilimanjaro, north-east of Tanzania, on the borders with Kenya (Afifi et al., 2014).

6.5.2 From methods to results

The methods were applied smoothly in the three villages with a few challenges and limitations associated with the field work. These challenges

[36] For a more detailed analysis of the Rainfalls Tanzania case study, please refer to Liwenga et al., 2012; Afifi et al., 2014.

did not vary significantly across the three villages; the researchers almost faced the same challenges regarding the availability of the interviewed households for the entire duration of the interviews as well as the conflicts of interests among the PRA participants. The lack of local data linking weather changes to migration flows in the three villages were – to the extent possible – compensated for by information gathered from the household survey, PRA sessions and expert interviews.

Meteorological experts, survey respondents and PRA participants agreed that the total amount of annual rainfall has not decreased significantly throughout the past three decades. Nevertheless, large amounts of rain fall in only a limited number of days throughout the year, resulting in crop failure. Hence, it is the intensity and distribution of the rain over time that affects the livelihoods. PRA outcomes show that rainfall variability (increase in drought incidences, seasonal shifts and prolonged dry spells) and water shortage are the most important threats to livelihood, and hence, they influence the migration decision.

Elevation also plays a role in determining the migration patterns across the three villages; Vudee (highland) is the village with the least migration records. The reason for that could be the higher precipitation level (successful subsistence agriculture) and the fewer landholdings of its inhabitants (least means for migration) as compared to the rest of the villages. In addition, Vudee has the highest average years of schooling and the most teachers (no need to send the children to schools outside the village). The immobility can also be attributed to Vudee's highest number of elderly.

The extreme opposite is represented in the lowland village Ruvu Mferejini with the most landholdings and the lowest precipitation. Not only would its inhabitants be relatively mobile due to these two factors (more resources and means to out-migrate and stronger reasons to seek water resources elsewhere, respectively) but also to its closeness to urban areas. This creates pull factors for inhabitants seeking new jobs. Moreover, this is the village with the highest ratio of pastoral communities (highest percentage of people dependent on livestock activities out of the three villages) that are more sensitive to water availability. It is worth mentioning that the high number of landholdings of this village could be an outcome of the remittances that

in turn support young people in the communities to seek education elsewhere.

Bangalala, the midland village, lies in between the two other villages regarding all the factors mentioned above.

6.5.3 Questions remaining open

There are a few open questions remaining after the field research and the analysis of its outcomes: it is not clear how the communities will deal with climatic problems in the future, especially since these seem to have intensified throughout the past few decades. This might not be an issue in the highlands where the precipitation is relatively high and the infrastructure allows the communities to survive without needing to move to other areas. However, in the lowlands, it is important to consider the migration patterns more closely and to find out whether short-term and seasonal migration would turn into long-term or even permanent migration, given the increasing frequency of droughts and dry spells. Permanent out-migration, especially among the youth, would imply less labor in the areas of origin and would hence lead to neglecting agricultural activities with all the negative effects on vegetal cover and soil.

Another question the research was not able to answer is to what extent villages with different altitudes interact in terms of human mobility and whether there are migration flows between these villages with all the implications on labor and landholdings. For example, it is not clear that Vudee (highland) has the lowest records of out-migration, but the researchers did not know whether it received migrants from mid- and lowland villages, such as Bangalala or Ruvu Mferejini, who might want to benefit from the high precipitation and improved education, instead of moving downwards to urban areas. This might be an option for Vudee, given that the number of elderly is the highest among the three villages and "pumping" new labor into it would be beneficial for the village in general.

6.5.4 Lessons learned for the future

Since the field research period consisted of a total of three weeks in one particular season, the researchers sensed the need of visiting the same research site more than once and staying longer in each visit, in order to capture more detailed and nuanced insights into its dynamics, especially that the most important variable they were looking at was rainfall variability. Therefore, future research should consider the number of visits and its duration.

Since polygamy is widespread in the research site, it was often a challenge to find out which household representative to interview in the case of the absence of the household head. It might be useful to design the questionnaires in the future, such that this factor is considered and where a set of questionnaires could accommodate more than one household in the case of polygamy. It might also be useful to compare between villages on the same altitude but in different areas/regions rather than comparing between villages of different altitudes in the same area/region. This might help the villages that are under similar circumstances to learn from each other, especially when it comes to coping strategies in response to rainfall variability.

6.6 The Pakistan case study[37]

6.6.1 Methodological approach

In line with the Rainfalls project, the case study presented in this section employed a mixed-methods approach combining expert interviews with 210 household surveys and Participatory Research Approach (PRA) tools (including 31 interviews with key informants at the community and national levels, and six gender-disaggregated focus group discussions with eight to ten people). The fieldwork was carried out in the Gilgit-Baltistan Province of Pakistan, covering six villages of the West Karakoram (altitudes ranging between 1,800 and 2,760 meters) in the Hunza and Yasin Valleys. Both valleys have an arid climate, where agriculture depends on indigenous

[37] For a more detailed analysis of the results of this case study, please refer to Gioli et al., 2013; 2014.

irrigation systems channeling meltwater directly from glaciers to the bottom of the mountain slopes. The two valleys have faced similar challenges and they followed the same model of development (implemented by the Aga Khan Rural Support Program)[38]. Nonetheless, their level of development diverges, as suggested by various socioeconomic indicators such as literacy and the average per capita income which is US$160 in Yasin and US$340 in Hunza (Gioli et al., 2014: 259).

The study area lies in the upper Indus Basin (UIB), where the observed climatic trends are anomalous: as opposed to the climate change signal experienced in the Himalaya, the UIB has experienced cooling trends in the summer season for decades, non-statistically significant trends of annual temperature, and increasing or stable precipitation throughout the year (Archer & Fowler, 2004; Fowler & Archer, 2006; Khattak et al., 2011; Bocchiola & Diolauiti, 2013), accompanied by mass gains in the glaciers of the region (Bolch et al., 2012; Hasson et al., 2014). The survey considered two major environmental shocks: the 2010 flood (Yasin) and the massive 2010 landslide, which blocked the Hunza River and created Attabad Lake. The lake submerged houses, agricultural land, and infrastructure, including part of the vital Karakoram Highway. While the two events considered are not a direct result of climate change, they are assumed to be a proxy for future more severe natural hazards resulting from climate change.

The household survey aimed at collecting data on (1) the local perceptions of changes in climate patterns and natural shocks, (2) the impacts of climate change and variability on households' productivity, livelihood security and main adaptation strategies, and (3) the role of migration in the context of environmental change and its gendered impacts. The households were randomly selected in each village by random walks, and the sample consisted of approximately 12% of the estimated number of households per village.

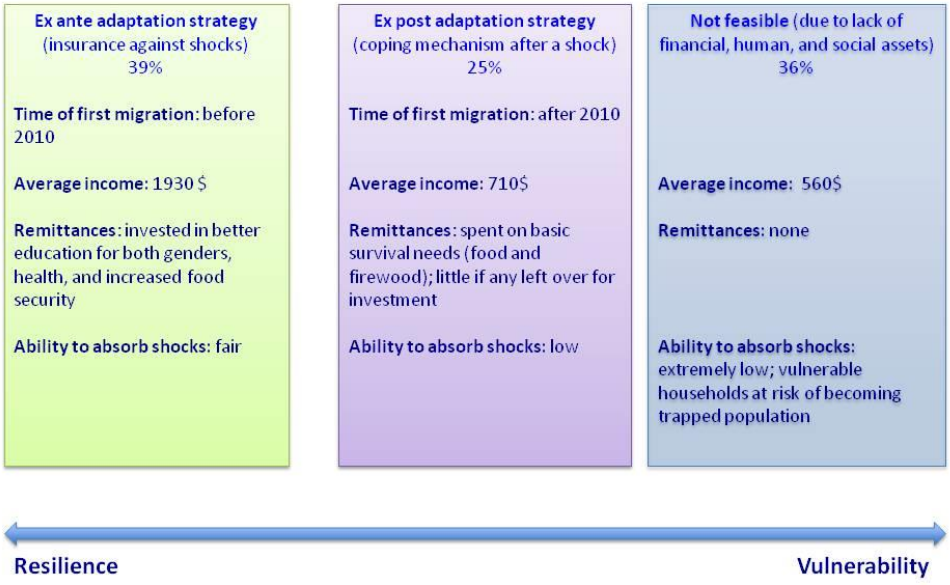
[38] The Aga Khan Rural Support Program (AKRSP) is a branch of the Aga Khan Development Network (AKDN) that has pioneered rural development in Gilgit–Baltistan. Since the 1980s AKRSP has introduced cash crops such as potatoes and developed orchards (e.g. of almonds, apricots, and grapes), which have become a major source of income for local people.

6.6.2 From methods to results

The study has found a high degree of convergence between climatic data and the local narratives of change collected in the survey (Gioli et al., 2013). Over the last 10 years, climate change and variability are perceived to have negatively affected non-agricultural productivity by over 85% of the surveyed households, and "Low temperatures", "Erratic rainfall", "Flood", and "Landslide" are indicated as the top causes. As for the responses to climate change and variability, the study highlighted that most households resorted to coping mechanisms to ward off immediate risks rather than proactive adaptive strategies. In the sample, labor migration emerges as an important means of livelihood and is undertaken by 76% of the surveyed households. Migration occurs predominantly at provincial (50%) and national scales (97%), from rural to urban areas, and is predominantly seasonal and circular, towards trade hubs in the region or to major cities within the country (especially to Karachi). Migration peaked in 2010 – the year in which the two considered environmental shocks took place – with 34% of all the migrants' first migration occurring during 2010–2012 over a period spanning from 1985 to 2012.

Some interesting patterns emerged from the analysis of the migratory behavior of a sub-set of households (17%) constituted by those who lost all or most of their land as a result of the 2010 environmental shocks. This group is made of extremely poor and vulnerable households whose average income is about half of the mean value for the whole sample, and it was lower than the average income already 10 years ago.

Figure 16 - Household profiles linking vulnerability and migration in the context of the 2010 floods



Source: Gioli et al., 2014: 263.

The analysis of the survey data pertaining to this subsample (and substantiated by PRA) generated three distinct household profiles in relation to their migratory response to the 2010 environmental shocks (see figure 16):

- Households unable to move (36%), due mostly to the lack of financial resources, employable skills, human capital as well as to family obligations and illnesses. The 2012 income of these households was found to be about 60% less than that of those who lost land but were able to resort to labor migration (the second and third groups below). Interestingly, 10 years ago the incomes were homogenously distributed in the subsample. The inability to

migrate is hence positively correlated to the possibility of falling into the poverty trap;

- Households who undertook migration *ex-post* (25%) in 2010 to cope with losses and damages in the wake of environmental shocks (Warner & van der Geest, 2013). In 2012, this group earned 30% more than those who did not migrate. However *ex-post* migration might prove detrimental in the medium or longer term, as it erodes important assets and decreases the household's overall resilience
- Households (39%) whose first migration took place before 2010 (mostly in the 2000s). This group has increased substantially its income which is now more similar to the average of the whole sample showing that migration as *ex-ante* risk mitigation strategy is more successful than migration as an *ex-post* strategy.

6.6.3 Questions remaining open

The observed changes of the hydro-climatology of the surveyed area over the last few decades present peculiar features as compared to the rest of the HKH region. The scientific reasons behind such anomalous behaviors are still being debated and it also remains unclear whether such anomalies will persist in the near future. Until now, besides diversifying livelihoods, local people have resorted to several coping measures and in the sample, the shift of the agricultural calendar in response to cooler summers, reduced river flow, and erratic precipitation was the most commonly adopted measure (Gioli et al., 2013).

Pakistan has the highest urbanization rates of any country in South Asia, and future demographic scenarios are paramount for policy and highly uncertain (the last national census was held in 1998). Improved education for both genders is triggering rural-to-urban movements, and Gilgit–Baltistan fares slightly better than the national average at almost every level of education in terms of female school enrolment (USAID, 2011). The surveyed communities, especially Hunza, fare particularly well within the region and the increase in highly educated men and women in the region presents both a challenge and an opportunity. It is not clear to what extent *in situ* opportunities will arise for taking advantage of the human capital and start a virtuous cycle of development and gender-positive transformation.

Another aspect of uncertainty is the institutional status of the target area. The region is remote and institutionally marginalized within Pakistan[39]. The proper integration of the region within the state of Pakistan would indeed contribute to reducing its volatility and to sustaining mid- and long-term plans for adaptation and climate-smart rural development.

6.6.4 Lessons learned for the future

The desk review of relevant local literature and expert interviews took place in Islamabad and Lahore over a period of two months. However, the lack of available socioeconomic, geographical and geophysical data (due to its special constitutional status, the province is not included in official statistics) have limited the quality of the design of the survey, as well as the ability to interpret the obtained data. Future research should integrate surveys on migration with information on land cover and its changes obtained through satellites to enhance understanding, for instance, how changes in agriculture affect migration and vice versa. The research team could fully appreciate the benefit of such an interaction, as an extensive investigation of seasonal snow cover in the study area (Hasson et al., 2014) was motivated by both the meteorological observation and the local perceptions collected in the present study. The integration of advanced Remote Sensing (RS) and Geographical Information System (GIS) techniques with mixed methods and micro-scale approaches to livelihoods and communities' perceptions would significantly help in better understanding the vulnerabilities, quantifying the risks, and mapping the capabilities of the local communities, and could greatly enhance understanding of mobility in the context of global environmental change.

Due to the remoteness and security challenges, as well as to lack of resources, the actual fieldwork in Gilgit-Baltistan was completed in 18 days (in June 2012), and the area of Astore (initially in the plan) had to be dropped. The surveyed communities are very cohesive and ethnically homogenous. It would have been extremely important to survey at least one community

[39] In August 2009, the region gained self-rule and was granted the locally elected Gilgit–Baltistan Legislative Assembly, obtaining a de facto but not constitutional province-level status within the country.

within a province facing similar environmental challenges, but characterized by a different social composition and economic indicators.

In the future, more attention shall be devoted to the selection of control groups in order to better assess the role played by several socio-economic variables in determining the availability and the success of migration as a livelihood diversification strategy in the context of environmental change.

6.7 Comparative results and discussion

6.7.1 Household profiles

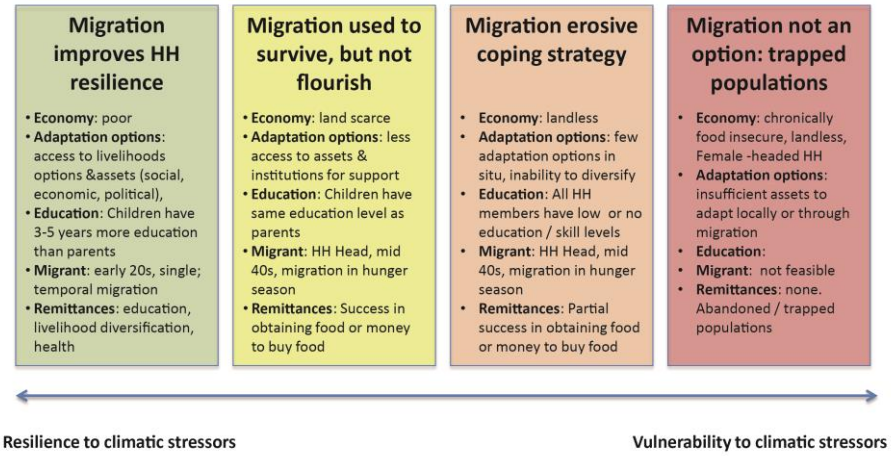
Lessons learned from the case studies

Beyond its single case studies, the Rainfalls project offered interesting insights into how to move methodologically from case study-specific results to cross-country results through profiling of households in terms of their socio-economic characteristics and migratory dynamics (figure 17). It would be interesting to conduct a similar exercise for several studies in different mountain ranges worldwide.

The profiles have been shown in this chapter to link human mobility patterns to both long-term processes, such as rainfall variability (Guatemala, Peru and Tanzania, figure 17), and short-term shocks, such as floods and landslides (Pakistan, figure 16).

The households' typology helped identify two main processes of positive feedback in both studies. On the resilient side of the spectrum, more assets allow for more livelihood diversification (including migration), which in turn produces more assets and increases the resilience of the household. On the vulnerable side, a positive feedback process is found again, but one leading to a "poverty trap": the most vulnerable households enter a self-reinforcing mechanism which causes poverty to persist.

Figure 17 - Household profiles linking vulnerability and human mobility



Source: Warner and Afifi, 2014a: 11

6.7.2 Future research: linking a multidimensional vulnerability index to human mobility patterns

The profiles in the case studies presented in this chapter were derived from an *ex-post* data analysis; however, for the next generation of research on migration and global environmental change they could be built by linking human mobility patterns to a multidimensional household vulnerability index derived from household survey data. Researchers from different academic disciplines should work closely with practitioners in order to build a solid vulnerability index, based on the most appropriate dimensions, indicators and thresholds.

While the use of multidimensional indices in the poverty (Alkire & Foster, 2011) and livelihoods (Hahn et al., 2009) literature is widespread, its possible use in relation to human migration is promising yet understudied

(Loschmann & Siegel, 2014; Milan et al., 2015b; Siegel & Waidler, 2012), and no attempt has been made to link a multidimensional vulnerability index to human mobility patterns in mountain areas of the global South.

On one hand, such an index would build on the lessons learned from the poverty and livelihoods literature, both from a theoretical perspective (which dimensions of vulnerability should be considered) and an empirical point of view (which indicators and thresholds allow researchers to build effective profiles that can be conducive for case study-specific in-depth understanding and for comparability).

On the other hand, the index should take into account the specificities of local livelihoods in resource-dependent mountain areas, such as the importance of livelihood diversification, preventive measures against climatic and environmental hazards and housing conditions.

Based on the literature presented above, I propose the dimensions and indicators shown in table 18 for a multidimensional household vulnerability index that could be built into future household survey.

I believe that the dimensions could be standardized; however, the indicators and thresholds should be adapted to the local context. Moreover, I would suggest calculating a Correlation-Sensitive Vulnerability Index (CSVI), based on Rippin's Correlation-Sensitive Poverty Index (CSPI) (Milan et al., 2015b; Rippin, 2011; 2012) rather than the more commonly used Alkire-Foster method (Alkire &Foster, 2011).

Alkire and Foster (2011) advocated for the introduction of a dual cutoff method as a practical tool to draw clear conclusions on a dataset. Proponents of this method argue that the use of a double cutoff, one to determine the deprivation for each dimension and a second to determine the total household deprivation, reduces the arbitrariness of such a method. Nevertheless, the threshold they suggest (1/3) is arbitrary and it is not necessarily the most appropriate in each context.

In contrast, within the CSPI the cutoff depends entirely on the data on which it is based. In addition, a unique additional benefit of CSPI is its decomposability in incidence, intensity and inequality of vulnerability which allows for a clear and unbiased understanding of the vulnerability of

any given sample. The correlation-sensitive index also eliminates the assumption that the dimensions perfectly substitute each other below an arbitrary threshold and they perfectly complement each other above it (Dotter & Klasen, 2014).

Table 18- Proposed dimensions and indicators for a household-level multidimensional livelihood vulnerability index

Dimensions	**Indicators**
Economic	1. Less than two sources of income
	2. Dependency Ratio is below the sample mean
	3. Household Head is unemployed or inactive
	4. Household owns neither house nor land
	5. Household owns less than 2 assets
Education	1. Household Head is illiterate
	2. At least one child in school age not attending school
Health & Nutrition	1. Household has no access to health care
	2. Household has a permanently sick or injured member
	3. Household has no access to drinking water at least once a day
	4. Household does not have enough food for three meals a day
Housing & Environment	1. Household has taken no measures against future hazards
	2. Household has no access to electricity
	3. Dwelling's Walls & Roof are not made from resilient materials
	4. Household exposed to environmental hazards in past 10 years
Social Capital	1. Household is not a member of an organization
	2. Household has no access to a Mobile Phone
	3. Household cannot count on somebody for help
	4. Household has no access to formal credit
Social Inclusion	1. Household has had security issues in the last year
	2. Household has experienced discrimination
	3. Household has no access to informal credit

Source: Milan et al. (2015b): 3

Linking such an index to human mobility would contribute to the academic debate on migration and environmental change in several ways.

Firstly, it would help overcome the inherent tension between much needed site-specific research digging deeply into a situated reality (with a combination of quantitative methods and ethnographic and PRA methods) and generalizations conducive to comparability and general lessons for policy makers.

Secondly, drawing on the economics of poverty, linking this multidimensional index to human mobility patterns could help integrating migration (usually neglected in the microeconomics of poverty or understood as negative) in studies of micro-dynamics of adaptation to climatic and environmental changes at the household/community level.

Thirdly, the index could act as a bridge for better integrating migration research with community-based adaptation methodologies. For instance, the role of gender and ethnicity in shaping the differentiated and interdependent adaptive options available to men and women has been increasingly acknowledged (Adger et al., 2009; Nightingale, 2009; Onta & Resurreccion, 2011; Verma et al., 2011). Whereas the wider adaptation scholarship recognizes the role of entrenched inequalities at the intersection of gender, class, ethnicity, religious affiliation, caste in shaping adaptive responses, the literature on migration and global environmental change is still lacking a proper integration of these elements, with the notable exception of the work of Baldwin (2013; 2016). In the case of mountain areas, the case study of Pakistan has explicitly looked into gender dynamics and Massey et al. (2010) in their CVSF study show that the effects of environmental change vary by gender and ethnicity, with women being more affected by changes in the time required to gather fodder and men by changes in the time gathering firewood, and high caste Hindus generally being less affected than others by environmental change.

6.7.3 Way forward: further methods for transdisciplinary research on migration and global environmental change

The Pakistani case study has highlighted the potential of integrating remote sensing in the research design. For example, Brandt et al. (2014) that

investigated interactions between changes in temperature, rainfall patterns and vegetation trends by combining Geographic Information Systems (GIS) with in-depth field work at the local. The combination of macro-scale top-down approaches (GIS and remote sensing) and bottom-up mixed methods to develop and complement a multidimensional index could greatly enhance understanding of migration in the context of climatic and environmental changes, in particular if such approaches are not just merely juxtaposed but co-designed since the outset of the research.

Regarding methodologies to simulate possible future migration patterns under different climatic and environmental scenarios, agent-based modelling seems to be the most promising approach, as discussed in chapter 5 (see also Kniveton et al., 2011; McLeman, 2012; Piguet, 2010; Smith et al., 2008).

A further methodological addition could be made by complementing monitoring of monthly migratory movements with a demographic database and with genealogical charts which offer very interesting insights into long-term migratory dynamics (Umezaki & Ohtsuka, 2002).

Last but not least, a comprehensive framework of analysis enabling the overcoming of a reductionist and "naturalized" understanding of the socio-economic drivers of vulnerability is still missing in the migration and global environmental change scholarship. In recent years, academics have tried to overcome the disciplinary isolation and reductionism of the climate change and migration scholarship through interdisciplinary approaches (McAdam, 2010). Nevertheless, knowledge on the field of migration, environmental change and migration is still uncertain and the concrete nature of the problem is disputed (Bettini, 2013; Bettini & Andersson, 2014; Bettini & Gioli, 2015; Nicholson, 2014), a context which calls for a truly transdisciplinary approach rather than just interdisciplinary approaches (Klein et al., 2001; Hirsch Hadorn et al., 2008).

In particular, the case studies presented in this article confirm that survey data should always be combined with PRA tools, a cornerstone of transdisciplinary research, understood as an approach based on collaboration with local people that takes in account their rich knowledge and their perceptions of the problem.

6.8 Conclusion

Over the last few years, the theoretical debate on migration and global environmental change has moved forward substantially (Black et al., 2011a). The literature would also benefit from more systematic transdisciplinary empirical approaches, and a widespread use of mixed quantitative and qualitative methods (Obokata et al., 2014; Piguet, 2010; Warner, 2011a, b).

There are three main reasons why transdisciplinary approaches and linking human mobility patterns to a multidimensional vulnerability index have a great potential for the advancement of the literature on migration patterns in the context of environmental change both in mountain areas and elsewhere.

Firstly, in an increasingly mobile world, accounting for the timing, conditions, and costs of migration across different socio-economic types of households is a crucial step for a comprehensive livelihoods assessment. This can also be the first step to assess through time-series analysis under which circumstances migration can be considered as a positive process contributing to livelihood resilience rather than a detrimental process.

Secondly, studying rural livelihoods through the systematic use of a multidimensional index would allow for drawing general lessons based on relative considerations. It would be interesting to understand whether households which are in similar relative conditions within their socio-economic and environmental context in different areas of the world tend to also follow similar migration patterns.

Thirdly, building household profiles with a trans-disciplinary approach could help embed wider developmental concerns and indicators in research on population/environment interactions, in particular on how socio-economic differences shape the migration process itself and the relationship between mobility and immobility (who is able to move, where to, and at what price) in different contexts.

7. DISCUSSION AND CONCLUSION

7.1 Summary of the thesis

After introduction (chapter 1) and presentation of the case study methodology (2), this thesis has presented four main chapters that aim to enhance scientific understanding of migration in vulnerable environments in mountain areas of Latin America.

Firstly, the chapter on Guatemala (3) provides insights on migration in a marginal mountainous environment with a rapidly growing population. Among other things, chapter 3 sheds light on the first two of the four specificities of mountain areas mentioned in section 1.2 and their relationship with human mobility patterns: inaccessibility (which implies isolation and limited human mobility options) and fragility due to high altitude and steep slopes.

In fact, the chapter shows that the food production in Cabricán is worsening (fragility) and it is associated with a perceived decrease in the profitability of both *in situ* diversification options and migration opportunities (partially because of complicated access to main communication routes and economic markets). These trends expose local populations to the risk of becoming trapped in the near future in a place where they are extremely vulnerable to climate change. No long-term risk-management and livelihood diversification strategy, including *ex situ* strategies, seems to be sustainable for people in Cabricán.

Building on chapter 3, the contribution of the fourth chapter on Peru is to provide empirical evidence on the importance of location and access to urban opportunities in determining livelihood and migration patterns in rural mountain areas. The case study also shows the diversity/heterogeneity of livelihoods within very short horizontal distances (third of the mountain specificities presented in section 1.2) and it highlights differences in livelihood and human mobility patterns between households located at different altitudes.

The results of the chapter show that at relatively lower altitude, one or more members of most households commute daily to work in the city of Huancayo. At higher altitude households (or some of its members) often

move to Huancayo and resettle there. In both cases, circular migration patterns (including daily mobility) can be identified and households combine the scarce income from urban employment with rural income rather than abandoning the farming land.

Building on the analysis of chapter 4 on present and past mobility patterns, the fifth chapter simulates the evolution of human mobility patterns in response to rainfall changes in the same three rural Andean communities from 2015 until 2050 through an agent-based model of migration. Past approaches to examining the influence of climatic changes upon migration have tended to ignore the non-linear interactions between the drivers of change, the livelihoods they are affecting, and the resulting migration patterns. The use of an agent-based model not only allows the inclusion of interacting heterogeneous agents and contexts in non-linear systems, but also permits the inclusion of changing subjective norms on attitudes towards migration.

The results of the simulation based on expected rainfall scenarios towards 2050 show a slight decrease in total outmigration: on the one hand, migration from non-resilient households is simulated to increase as more households become non-resilient and more non-resilient households identify need-driven migration as a valid livelihood strategy; on the other hand, the simulated decrease in migration from resilient households is even stronger, more than cancelling out the increase in non-resilient migration. The simulated overall reduction in outmigration from the rural communities can be explained by the opportunities for daily and short-term employment in the nearby city of Huancayo that allow people to live in their communities while commuting to the urban area. In fact, migration is defined in the model as a movement outside the province of Huancayo. As a consequence, short-distance mobility from the rural communities to the urban area of Huancayo does not count as outmigration.

The sixth chapter aims at drawing lessons learned from the two case studies presented in chapters 3 and 4 as well as from the broader literature on migration in vulnerable environments in mountain areas of the Global South in order for future empirical research on the topic to move beyond understanding of single case studies and draw general lessons.

In particular, the chapter suggests that the systematic use of transdisciplinary approaches, with a combination of quantitative and qualitative empirical methods, is the key to understanding global migration patterns in rural mountain areas of the global South. In the future, survey data should be triangulated with PRA results as well as secondary data in order to link household vulnerability (calculated through a correlation-sensitive multidimensional index) with human mobility patterns. Such a link can be conducive to better understand the feedback processes between livelihoods and mobility patterns both within each case study and across case studies, helping researchers to draw general lessons.

Chapter 6 has been important for me to link the results of this thesis as well as the four key points that emerged from my literature review (see end of section 1.1) to my planning for further work on this topic beyond this dissertation.

Key point 1: Environmental change will have an increasing impact on migration in the future through its interrelationship with other demographic, economic, political and social drivers of migration and in the context of rising national inequalities.

Beyond its contribution to studies on mountain areas, this thesis aims at encouraging a paradigm shift in the debate on migration and environmental change: from "environmental migration" and all its implications, especially the simplistic causal relationships between migration and the environment as well as its isolation from mainstream migration studies, to the study of specificities of migration in vulnerable environments. Building among others on the work of Foresight (2011) and Piguet (2013), I believe researchers currently associated with the "environmental migration" literature would offer a better contribution to the literature by focusing on context-specific and time-relevant studies on migration in vulnerable environments, rather than trying to explain global migration patterns worldwide, including areas where climatic and environmental factors play a very limited role in people´s livelihoods. Rural mountainous areas of the Global South are just one example where such vulnerable environments can be identified: they include areas which are often affected by natural disasters, sea level rise, droughts and other environmental and climatic stressors.

Much can be done to further integrate the "environmental migration" literature into broader empirical work on migration in the near future. I discussed in chapter 5 how agent-based modelling of future migration patterns would benefit greatly from a deeper analysis of the impact of interrelated changes in demographic, economic, environmental, political and social drivers of migration. I have also discussed in chapter 6 why I believe that migration patterns in vulnerable environments should be linked to household vulnerability in the broader sense rather than trying to directly connect climatic and environmental stressors to human mobility. In this context, taking a human-centered livelihoods approach rather than just looking at the interaction between migration and development processes (or migration and processes of adaptation to climate change) seems to be the best way to account for the complexity of migration decision-making, particularly in areas characterized by a subsistence economy.

The study of the relationship between rising national inequalities and migration in vulnerable environments is beyond the scope of this thesis. The topic has been relatively understudied; however, McLeman et al. (2016) have just published a book that collects several empirical investigations as well as methodological and policy reflections on "environmental migration" and social inequalities. While the book is a good first contribution to the topic, I believe that a new generation of empirical research is needed to move our understanding forward. In particular, building on the idea of linking household vulnerability and human mobility patterns presented in chapter 6, future studies should aim at enhancing understanding on the conditions under which migration is beneficial for the migrants themselves, their households as well as communities of origin, transit and destination. In this context, they should also look at whether migration acts as a multiplier of existing (often rising) social inequalities, particularly through remittances that only reach some households, or whether it has the potential to lead to a decrease in social inequalities.

Key point 2: Most migration in the context of environmental change is and will be internal and relatively short distance rather than international, with the notable exception of border areas (including mountains) and small states (particularly small island developing states).

An interesting case with some specificities in common with mountain areas (especially inaccessibility) is that of Small Island Developing States (SIDS).

Building on the work in Guatemala and Peru presented in this thesis, in 2015 I led the research component of the Pacific Climate Change and Migration (PCCM) project (PCCM results will be published shortly) which studies the factors which contribute to current migration flows from three SIDS: Kiribati, Nauru and Tuvalu. The PCCM study looks not only at household socio-economic characteristics, but also at attitudes and subjective norms towards human mobility, and how they interact with migration decision making[40].

Among other things, in line with the methodological ideas presented in chapter 6, the PCCM project includes an Agent-Based Model which builds on the ABM presented in chapter 5 but it has an even stronger focus on subjectivity and personal opinions on migration. In particular, the PCCM ABM was built through by using an additional method drawn from social psychology, the Q method, to include more efficiently people´s opinions and attitudes towards migration in the model (Brown, 1980).

Key point 3: While migration is often understood and framed as a failure to adapt to environmental and climatic changes, it can also be part of successful livelihood risk management strategies.

Building on lessons learned from Guatemala and Peru and particularly from chapter 6 of this thesis, I have co-designed the research methodology (and in particular I led the drafting process of its household survey) for the Migration, Environment and Climate Change: Evidence for Policy (MECLEP) Project. Within the project, I have also led the research for the case study in Haiti (see Milan et al., 2015b for preliminary results, the full survey report will be published shortly).

The MECLEP Project aims at studying how migration, displacement and planned relocation interact with household vulnerability in vulnerable environments in six countries worldwide (Dominican Republic, Haiti,

[40] For more information on the PCCM project, please visit the project website: http://www.unescap.org/subregional-office/pacific/pacific-climate-change-and-migration-project.

Kenya, Mauritius, Papua New Guinea and Vietnam)[41]. The project links directly to key point 3 because its main idea is to enhance scientific understanding on when migration is successful and when is it detrimental for the individuals and households involved in the process.

From an empirical point of view, the MECLEP Haiti research studies the relationship between a correlation-sensitive multidimensional household vulnerability index and the prevailing human mobility patterns at the household level. The aim of this approach is to determine which forms of human mobility are associated with higher and lower levels of vulnerability.

Key point 4: In the upcoming decades, millions of people who would like to move might be unable to leave locations in which they are vulnerable to environmental change.

One of the lessons I learned from my case study in Guatemala is that it is extremely difficult to define who can be considered "trapped". In order to enhance understanding on who might be defined forced to be immobile, the PCCM research includes a component on place attachment as well as on attitudes of people towards mobility in the broader sense.

In particular, besides the Q method mentioned above, the household survey includes a section on times when household members wanted to migrate by they could not, and the reasons (both financial and non-financial) why they could not migrate. Moreover, I have conducted several PRA sessions which touched upon migration decision-making processes, and reasons why people would migrate or not.

7.2 Reflections for further research

The issue of migration in vulnerable environments touches upon several other research areas where more research is needed in the years to come.

Firstly, there is an increasing recognition of the fact that natural disasters and climate change are likely to displace an increasing number of people,

[41] For more information on the MECLEP project, please visit the project website: https://www.iom.int/cms/meclep.

and these are likely to face individual legal protection gaps. The legal debate about the potential extension of the international refugee discipline mentioned in chapter 1.1 seems to be closed now, with a wide academic agreement on the fact that "climate refugee" is an inappropriate term, at least from an international law perspective. Nevertheless, a dissenting voice came recently from Gemenne (2015) who thinks that the term, although incorrect under the current international definition of refugee, should be used because migration in the context of climate change is not just an environmental problem but also a political one. In fact, Gemenne stresses that the use of the term "refugee" would bring a much-needed re-poli*t*icization of the debate.

In the case of people displaced who cross a national border, the Nansen Initiative on cross-border disasters-related displacement was launched in October 2012 in order to draft (through a bottom-up approach) a protection agenda to bridge the legal protection gaps faced by those who are forced to cross an international border because of disasters or the adverse impacts of climate change yet cannot apply for refugee status. After a series of inter-governmental regional consultations and civil society meetings which took place between 2012 and early 2015 in the Pacific (Cook Islands and Fiji), Central America (Costa Rica and Guatemala), the Horn of Africa (Kenya), South-East Asia (Philippines and Thailand) and South Asia (Bangladesh and Nepal), in October 2015 the Nansen Initiative produced a protection agenda[42] which has been approved by more than 110 States. This agenda is neither a binding legal agreement nor a soft-law instrument but it could be the basis for more effective policies addressing protection gaps of persons displaced internationally by natural disasters and long-term climatic issues (Kälin, 2012).

In particular, the agenda:

1. Conceptualizes a comprehensive approach to disaster displacement to deal effectively with cross-border disaster-displaced persons;

[42] The Nansen Protection Agenda can be downloaded on http://www.nanseninitiative.org/global-consultations/.

2. Compiles a broad set of best practices to ensure effective future responses to cross-border disaster-displacement;
3. Highlights the need for enhanced collaboration between relevant actors in order to bring together and link multiple policies and action areas to address cross-border disaster-displacement (and its root causes);
4. Identifies three priority areas for action to address existing gaps: data collection, effective use of existing humanitarian protection measures and disaster displacement risk reduction in areas of origin.

In the case of internal displacement, the adoption (for those countries who have not adopted them yet) and effective implementation of the United Nations Guiding Principles on Internal Displacement (which include natural and human-made disasters among possible factors leading to internal displacement) would be the most important step for the effective protection of internally displaced persons in the context of natural disasters (United Nations, 1998).

In the longer term, States should aim at harmonizing the legal protection frameworks of people displaced by climate change and natural disasters internally and internationally (Kälin & Schrepfer, 2012; Martin, 2011). While most scholars focus on international and national level policies, few authors have stressed the importance of regional approaches - for example, Mayer (2013) for Asia and the Pacific and Wood (2015) for Africa. More research is needed on the best scale of intervention to bridge these legal protection and policy gaps.

Within this legal and political debate, a further interesting case is that of low-lying island states such as Kiribati, the Maldives, the Marshall Islands, Tokelau and Tuvalu for which access to global market is even more difficult than it is for marginal mountainous areas. If current sea-level projections prove to be correct, these islands risk disappearing by the end of the century. In their case, beyond the individual protection of those who are displaced, a political solution has to be found for states which might

become entirely uninhabitable, with obvious consequences in terms of cultural losses (Kelley, 2011; Kelman, 2008; Park, 2011).

Secondly, as impacts of climate change begin to be felt more strongly, academics, international institutions and policymakers begin to discuss openly the possibility that an increasing number of people in vulnerable environments might have to be relocated in the near future from areas that become uninhabitable, particularly in the case of natural disasters or irreversible climatic phenomena such as sea-level rise (Bronen & Stuart Chapin III, 2013; De Sherbinin et al., 2011; Ferris, 2012; Leckie, 2012; McAdam, 2015; McNamara & Des Combes, 2015; Tan et al., 2013; Wilmsen & Webber, 2015).

Thirdly, recent studies have opened a very interesting debate on the relationship between human mobility, immobility and limits to adaptation to climatic and environmental changes in vulnerable environments. This debate has strong policy implications for international negotiations on climate change, and particularly over loss and damage related to climate change. Scholars are discussing the costs and benefits of local adaptation versus adaptation strategies that include migration of either one or more household members or the entire household (Barnett & Webber, 2010; Dow et al., 2013; Warner, 2012; Warner & van der Geest, 2013; Warner & Afifi, 2014b; Warner et al., 2015). However, the language used in the academic debate does not yet match the politically agreed language on "loss and damage associated with climate change impacts in developing countries particularly vulnerable to the adverse effects of climate change" used by the United Nations Framework Convention on Climate Change (UNFCCC), hindering the science-policy dialogue on the topic.

Fourthly, the academic community would benefit from stronger links between work that has been done in the "environmental migration" and "disaster risk reduction" literature, particularly regarding the role that migration can play as part of risk management and early warning systems (Birkmann et al., 2013; Black et al., 2013; Collins, 2013). The same holds for the link with studies on the role of other demographic factors in determining population size and distribution in vulnerable environments, a prerequisite for a comprehensive view on the population-environment

nexus in the broader sense (De Sherbinin et al., 2008; Hugo, 2011; Hummel et al., 2013; Hunter & O´Neill, 2014).

Fifthly, more innovative methodologies such as experimental approaches in migration studies (McKenzie & Yang, 2012) as well as the use of cell-phone data to track population mobility (Bengtsson et al., 2011; Lu et al., 2016; Wesolowski et al., 2013) are very promising and should be pursued further.

Last but not least, a gender perspective is almost completely missing in the debate on migration in vulnerable environments. I believe that the future of this literature lies in human-rights based, gender-sensitive and forward-looking approaches to migration.

8. BIBLIOGRAPHY

- Acosta, P., Calderon, C., Fajnzylber, P., & Lopez, H. (2008). What is the impact of international remittances on poverty and inequality in Latin America? *World Development*, *36*(1), 89-114.
- Adamo, S. B., & Izazola, H. (2010). Human migration and the environment. *Population and Environment*, *32*(2-3), 105-108.
- Adams, H. (2015). Why populations persist: mobility, place attachment and climate change. *Population and Environment* (ahead of print).
- Adams R. (2004). Remittances and poverty in Guatemala. *World Bank Policy Research Working Paper, 3418*.
- Adams, R. (2006). Remittances, poverty and investment in Guatemala. In International migration, remittances, and the brain drain (pp. 53-80). Washington DC, USA: World Bank.
- Adams, R., & Page, J. (2005). Do international migration and remittances reduce poverty in developing countries? *World Development*, *33*(10), 1645-1669.
- Adger, W. N. (2000). Social and ecological resilience: are they related? *Progress in Human Geography*, *24*(3), 347-364.
- Adger, W. N., Benjaminsen, T. A., Brown, K., & Svarstad, H. (2001). Advancing a political ecology of global environmental discourses. *Development and change*, *32*(4), 681-715.
- Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., ... & Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change*, *93*(3-4), 335-354.
- Afifi, T. (2011). Economic or environmental migration? The push factors in Niger. *International Migration*, *49*(s1), e95-e124.
- Afifi, T., & Warner, K. (2008). The impact of environmental degradation on migration flows across countries. *UNU-EHS Working Paper, 5*. Bonn (Germany): UNU-EHS.
- Afifi, T., Liwenga, E., & Kwezi, L. (2014). Rainfall-induced crop failure, food insecurity and out-migration in Same-Kilimanjaro, Tanzania. *Climate and Development*, *6*(1), 53-60.
- Afifi, T., Milan, A., Etzold, B., Schraven, B., Rademacher-Schulz, C., Sakdapolrak, P., ... & Warner, K. (2015). Human mobility in

response to rainfall variability: opportunities for migration as a successful adaptation strategy in eight case studies. *Migration and Development*, (ahead-of-print), 1-21.
- Aguilar-Støen, M., Taylor, M., & Castellanos, E. (2016). Agriculture, Land Tenure and International Migration in Rural Guatemala. *Journal of Agrarian Change*, *16*(1), 123-144.
- Aide, T., & Grau, H. (2004). Globalization, migration, and Latin American ecosystems. *Science, 305*(5692), 1915–1916.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211.
- Alkire, S., & Foster, J. (2011). Counting and multidimensional poverty measurement. *Journal of public economics*, *95*(7), 476-487.
- Arango, J. (2000). Explaining migration: a critical view. *International Social Science Journal*, *52*(165), 283-296.
- Altamirano, T. (2012*). Refugiados Ambientales: Cambio climático y Desplazamiento Humano*. Lima, Peru: Fondo Editorial de La Pontificia Universidad Católica del Perú.
- Archer, D. R., & Fowler, H. J. (2004). Spatial and temporal variations in precipitation in the Upper Indus Basin, global teleconnections and hydrological implications. *Hydrology and Earth System Sciences Discussions*, *8*(1), 47-61.
- Baldwin, A. (2013). Racialisation and the figure of the climate change migrant. *Environment and Planning A*, *45*(6), 1474-1490.
- Baldwin, A. (2016). Premediation and white affect: climate change and migration in critical perspective. *Transactions of the Institute of British Geographers 41*(1), 78-90.
- Banerjee, S., Gerlitz, J. Y., & Hoermann, B. (2011). Labour migration as a response strategy to water hazards in the Hindu Kush-Himalayas. Kathmandu, Nepal: International centre for integrated mountain development (ICIMOD).
- Banerjee, S., Gerlitz, J. Y., & Kniveton, D. (2013). A methodology for assessing patterns of labour migration in mountain communities exposed to water hazards. In Disentangling Migration and Climate Change (pp. 81-100), Springer Netherlands..
- Banerjee, S., Black, R., Kniveton, D., & Kollmair, M. (2014). The Changing Hindu Kush Himalayas: Environmental Change and

Migration. In *People on the Move in a Changing Climate* (pp. 205-227). Springer Netherlands.
- Bardsley, D. K., & Hugo, G. J. (2010). Migration and climate change: Examining thresholds of change to guide effective adaptation decision-making. *Population and Environment*, *32*(2-3), 238-262.
- Barnett, J., & Adger, W. N. (2007). Climate change, human security and violent conflict. *Political geography*, *26*(6), 639-655.
- Barnett, J., & Webber, M. (2010). Migration as adaptation: Opportunities and limits. In Climate change and displacement: Multidisciplinary perspectives (pp. 37–56). Oxford, UK: Hart Publishing.
- Bates, D. C. (2002). Environmental refugees? Classifying human migrations caused by environmental change. *Population and Environment*, *23*(5), 465-477.
- Bebbington, A. (1999). Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty. *World development*, *27*(12), 2021-2044.
- Bengtsson, L., Lu, X., Thorson, A., Garfield, R., & Von Schreeb, J. (2011). Improved response to disasters and outbreaks by tracking population movements with mobile phone network data: a post-earthquake geospatial study in Haiti. *PLoS medicine*, *8*(8), 1128.
- Beniston, M. (Ed.). (2002). *Mountain environments in changing climates*. New York, USA: Routledge.
- Beniston, M. (2003). Climatic change in mountain regions: a review of possible impacts. In *Climate Variability and Change in High Elevation Regions: Past, Present & Future* (pp. 5-31). Springer Netherlands.
- Beristain, C. (1998). Guatemala Nunca Más. *Revista Migraciones Forzadas*, *3*, 23-26.
- Bettini, G. (2013). Climate barbarians at the gate? A critique of apocalyptic narratives on 'climate refugees'. *Geoforum*, *45*, 63-72.
- Bettini, G., & Andersson, E. (2014). Sand waves and human tides: Exploring environmental myths on desertification and climate-induced migration. *The Journal of Environment & Development*, *23*(1), 160-185.

- Bettini, G., & Gioli, G. (2015). Waltz with development: insights on the developmentalization of climate-induced migration. *Migration and Development*, ahead of print.
- Bianchi, C., Cirillo, P., Gallegati, M., & Vagliasindi, P. A. (2007). Validating and calibrating agent-based models: a case study. *Computational Economics*, *30*(3), 245-264.
- Bhandari, P. (2004). Relative deprivation and migration in an agricultural setting of Nepal. *Population and Environment*, *25*(5), 475-499.
- Biermann, F., & Boas, I. (2008). Protecting climate refugees: the case for a global protocol. *Environment: Science and Policy for Sustainable Development*, *50*(6), 8-17.
- Bilsborrow, R. E. (1992). *Rural poverty, migration, and the environment in developing countries: three case studies*. Washington DC, USA: World Bank.
- Bilsborrow, R. E., & Henry, S. J. (2012). The use of survey data to study migration–environment relationships in developing countries: alternative approaches to data collection. *Population and environment*, *34*(1), 113-141
- Birkmann, J., Seng, D. C., & Setiadi, N. (2013). Enhancing early warning in the light of migration and environmental shocks. *Environmental Science & Policy*, *27*, S76-S88.
- Black, R. (2001). *Environmental refugees: myth or reality?* (Vol. 34, p. 13). UNHCR.
- Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global Environmental Change*, *21*, S3-S11.
- Black, R., Bennett, S. R., Thomas, S. M., & Beddington, J. R. (2011). Climate change: Migration as adaptation. *Nature*, *478*(7370), 447-449.
- Black, R., Arnell, N. W., Adger, W. N., Thomas, D., & Geddes, A. (2013). Migration, immobility and displacement outcomes following extreme events. *Environmental Science & Policy*, *27*, S32-S43.
- Black, R., & Collyer, M. (2014). Populations' trapped' at times of crisis. *Forced Migration Review, 45,* 52-56.
- Bocchiola, D., & Diolaiuti, G. (2013). Recent (1980–2009) evidence of climate change in the upper Karakoram, Pakistan. *Theoretical and applied climatology*, *113*(3-4), 611-641.

- Bolch, T., Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, J. G., ... & Bajracharya, S. (2012). The state and fate of Himalayan glaciers. *Science*, *336*(6079), 310-314.
- Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. *Proceedings of the National Academy of Sciences*, *99*(suppl 3), 7280-7287.
- Brand, F. S., & Jax, K. (2007). Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and Society*, *12*(1), 23.
- Brandt, M., Romankiewicz, C., Spiekermann, R., & Samimi, C. (2014). Environmental change in time series–An interdisciplinary study in the Sahel of Mali and Senegal. *Journal of Arid Environments*, *105*, 52-63.
- Bronen, R., & Chapin, F. S. (2013). Adaptive governance and institutional strategies for climate-induced community relocations in Alaska. *Proceedings of the National Academy of Sciences*, *110*(23), 9320-9325.
- Brown, S. R. (1980). *Political subjectivity: Applications of Q methodology in political science*. New Haven, USA: Yale University Press.
- Burrows, K., & Kinney, P. L. (2016). Exploring the Climate Change, Migration and Conflict Nexus. *International Journal of Environmental Research and Public Health*, *13*(4), 443.
- Cascone, N., Milan, A., & Pena del Valle, A. (2016). Local Adaptation in the community of Las Palomas (Mexico): what role for migration? In Migration, risk management, and climate change - Evidence and policy responses. *Global Migration Issues book series*, upcoming.
- Cigarán, M. P., Bambarén, S., Amat y León, C., Macera, L., Seminario, B., Vásquez, D., & Cigarán, M. T. (2008). *El cambio climático no tiene fronteras: Impacto del cambio climático en la Comunidad Andina*. Lima, Peru: Comunidad Andina.
- CARE (2011). Informe Biofísico del Municipio de Cabricán, Departamento de Quetzaltenango.
- Carney, D. (1998). *Sustainable rural livelihoods: what contribution can we make?* London, UK: Department for International Development (DFID).

- Castellanos, E., & Guerra, A. (2009). *Cambio Climático y sus Efectos Sobre el Desarrollo Humano en Guatemala*. New York, USA: United Nations Development Programme.
- Castles, S., de Haas, H. & Miller, M. (2014). *The Age of Migration: International Population Movements in the Modern World*, 5th Edition, Basingstoke, UK: Palgrave.
- Chambers, R., & Blackburn, J. (1996). The power of participation: PRA and policy. Policy Briefing, 7. Brighton, UK: Institute of Development Studies.
- CIA (2015). Sex Ratio - Country Comparison to the world. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/fields/2018.html .
- Collins, A. E. (2013). Applications of the disaster risk reduction approach to migration influenced by environmental change. *Environmental Science & Policy*, *27*, S112-S125.
- CONAM (Comision Nacional del Ambiente). (2005). Vulnerabilidad Actual y Futura ante el Cambio Climatico y Medidas de Adaptacion en la Cuenca del Rıo Mantaro (Vol. III). Lima, Peru: Comision Nacional del Ambiente (CONAM) and Instituto Geofısico del Peru´ (IGP).
- Crutzen, P. J. (2002). Geology of mankind. *Nature*, *415*(6867), 23.
- Crutzen, P. J. & Stoermer, E. F. (2000): The 'Anthropocene'. *Global Change Newsletter*, *41*, 17–18.
- Davis, J., & Lopez-Carr, D. (2010). The effects of migrant remittances on population–environment dynamics in migrant origin areas: international migration, fertility, and consumption in highland Guatemala. *Population and Environment*, *32*(2-3), 216-237.
- De Haas, H. (2010). Migration and development: a theoretical perspective1. *International migration review*, *44*(1), 227-264.
- De Haas, H. (2011). Mediterranean migration futures: Patterns, drivers and scenarios. *Global Environmental Change*, *21*, S59-S69.
- De Haas, H. (2014a). What drives Human Migration? In Migration: A COMPAS Anthology. Oxford, UK: International Migration Institute.
- De Haas, H. (2014b). Migration theory: Quo vadis. *Working Paper 100.* Oxford, UK: International Migration Institute.

- De la Cadena, M. (1988). Comuneros de Huancayo: Migracion campesina en ciudades serranas. *Documento de trabajo del Instituto de Estudios Peruanos (IEP), 26*. Lima, Peru: Instituto de Estudios Peruanos (IEP).
- De Sherbinin, A., VanWey, L. K., McSweeney, K., Aggarwal, R., Barbieri, A., Henry, S., ... & Walker, R. (2008). Rural household demographics, livelihoods and the environment. *Global Environmental Change*, *18*(1), 38-53.
- De Sherbinin, A., Castro, M., Gemenne, F., Cernea, M. M., Adamo, S., Fearnside, P. M., ... & Scudder, T. (2011). Preparing for resettlement associated with climate change. *Science*, *334*(6055), 456-457.
- Docherty, B., & Giannini, T. (2009). Confronting a rising tide: a proposal for a convention on climate change refugees. *Harvard Environmental Law Review*, *33*, 349-403.
- Döös, B. R. (1997). Can large-scale environmental migrations be predicted? *Global Environmental Change*, *7*(1), 41-61.
- Dore, M. H. (2005). Climate change and changes in global precipitation patterns: what do we know? *Environment international*, *31*(8), 1167-1181.
- Dotter, C., & Klasen, S. (2014). The Multidimensional Poverty Index: Achievements, Conceptual and Empirical Issues. Human Development Report Office Occasional Paper.
- Dow, K., Berkhout, F., Preston, B. L., Klein, R. J., Midgley, G., & Shaw, M. R. (2013). Limits to adaptation. *Nature Climate Change*, *3*(4), 305-307.
- Eakin, H., Tucker, C., & Castellanos, E. (2006). Responding to the coffee crisis: a pilot study of farmers' adaptations in Mexico, Guatemala and Honduras. *The Geographical Journal*, *172*(2), 156-171
- ECLAC (Economic Commission for Latin America) (2010). Guatemala - efectos del cambio climatico sobre la agricultura.
- ECLAC (Economic Commission for Latin America) (2011). Anuario Estadístico 2011. Santiago de Chile, Chile: ECLAC.
- El-Hinnawi, E. (1985). *Environmental Refugees*. New York, USA: United Nations Development Programme.
- Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford, UK: Oxford University Press.

- Entzinger, H., Jäger, J., & Gemenne, F. (2010). Le projet EACH-FOR, *Hommes et migrations, 1284*, 10-15.
- Etzold, B., Ahmed, A. U., Hassan, S. R., & Neelormi, S. (2014). Clouds gather in the sky, but no rain falls. Vulnerability to rainfall variability and food insecurity in Northern Bangladesh and its effects on migration. *Climate and Development*, *6*(1), 18-27.
- Etzold, B., Ahmed, A. U., Hassan, S. R., Neelormi, S., & Afifi, T. (2016). Rainfall Variability, Hunger, and Social Inequality, and Their Relative Influences on Migration: Evidence from Bangladesh. In *Environmental Migration and Social Inequality* (pp. 27-41). Springer International Publishing.
- Evans, S. G., & Clague, J. J. (1994). Recent climatic change and catastrophic geomorphic processes in mountain environments. *Geomorphology*, *10*(1), 107-128.
- Ezra, M. (2003). Environmental vulnerability, rural poverty, and migration in Ethiopia: a contextual analysis. *Genus*, 63-91.
- FAO (Food and Agriculture Organization of the United Nations) (2003). Estado de la Diversidad Biológica de los Árboles de los Bosques de Guatemala. Retrieved from ftp://ftp.fao.org/docrep/fao/007/j0605s/j0605s00.pdf.
- FAO (Food and Agriculture Organization of the United Nations) (2009). Crop Prospects and Food Situation, no. 4 (November). Retrieved from http://www.fao.org/docrep/012/ak340e/ak340e05b.htm.
- FAO (2011). FAOSTAT. Available from http://faostat.fao.org/DesktopDefault.aspx?PageID=703&lang=en#ancor.
- Ferris, E. (2012). Protection and planned relocations in the context of climate change, *PPLA/2012/04*, Geneva: UNHCR.
- Findlay, A. M. (2011). Migrant destinations in an era of environmental change. *Global Environmental Change*, *21*, S50-S58.
- Findley, S. E. (1994). Does drought increase migration? A study of migration from rural Mali during the 1983-1985 drought. *International Migration Review*, *28*(3), 539-553.
- Foresight (2011). *Migration and Global Environmental Change*, Final Project Report, London, UK: The Government Office for Science.

- Fowler, H. J., & Archer, D. R. (2006). Conflicting signals of climatic change in the Upper Indus Basin. *Journal of Climate*, *19*(17), 4276-4293.
- Gemenne, F. (2011). Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes. *Global Environmental Change*, *21*, S41-S49.
- Gemenne, F. (2015). One good reason to speak of 'climate refugees'. *Forced Migration Review*, *49*, 70-71.
- Gentle, P. & Maraseni, T. N. (2012). Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environmental Science & Policy*, *21*, 24-34.
- Ginnetti, J. (2015). Modelling displacement. *Forced Migration Review*, *49*, 10.
- Gioli, G., Khan, T., & Scheffran, J. (2013). Climatic and environmental change in the Karakoram: making sense of community perceptions and adaptation strategies. *Regional environmental change*, *14*(3), 1151-1162.
- Gioli, G., Khan, T., Bisht, S., & Scheffran, J. (2014). Migration as an adaptation strategy and its gendered implications: a case study from the Upper Indus Basin. *Mountain Research and Development*, *34*(3), 255-265.
- Godde, P. (2000). *Tourism and development in mountain regions*. Wallingford, UK: CABI.
- Goodall, S. K. (2004). Rural-to-urban migration and urbanization in Leh, Ladakh: A case study of three nomadic pastoral communities. *Mountain research and development*, *24*(3), 220-227.
- Grau, H. R., & Aide, T. M. (2007). Are rural-urban migration and sustainable development compatible in mountain systems? *Mountain Research and Development*, *27*(2), 119-123.
- Gray, C. L. (2009). Environment, land, and rural out-migration in the southern Ecuadorian Andes. *World Development*, *37*(2), 457-468.
- Gray, C., & Bilsborrow, R. (2013). Environmental influences on human migration in rural Ecuador. *Demography*, *50*(4), 1217-1241.
- Gray, C. L., & Bilsborrow, R. E. (2014). Consequences of out-migration for land use in rural Ecuador. *Land use policy*, *36*, 182-191.
- Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from

climate variability and change—A case study in Mozambique. *Global Environmental Change*, *19*(1), 74-88.
- Haller, A., & Borsdorf, A. (2013). Huancayo metropolitano. *Cities*, *31*, 553-562.
- Harmeling, S. (2011). *Global Climate Risk Index 2012*. Bonn, Germany: Germanwatch e.V. Retreived from http://germanwatch.org/klima/cri.pdf.
- Hartmann, B. (2010). Rethinking climate refugees and climate conflict: rhetoric, reality and the politics of policy discourse. *Journal of International Development*, *22*(2), 233-246
- Hasson, S., Lucarini, V., Khan, M. R., Petitta, M., Bolch, T., & Gioli, G. (2014). Early 21st century snow cover state over the western river basins of the Indus River system. *Hydrology and Earth System Sciences*, *18*, 4077-4100.
- Ho, R. & Milan, A. (2012). "Where the Rain Falls" project. Case study: Peru. Results from Huancayo Province, Junín Region. *UNU-EHS Report, 5*. Bonn, Germany: UNU-EHS.
- Hock, R. (2003). Temperature index melt modelling in mountain areas. *Journal of Hydrology*, *282*(1), 104-115.
- Hodgkinson, D., Burton, T., Young, L., & Anderson, H. (2009). Copenhagen, Climate Change 'Refugees' and the Need for a Global Agreement. *Public Policy*, *4*(2), 155.
- Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (Eds.). (2008). *Handbook of transdisciplinary research*. Zurich, Switzerland: Springer.
- Holdridge, L. R. (1967). *Life Zone Ecology*. San José, Costa Rica: Tropical Science Center.
- Homeland Security (2011). *Yearbook of Immigration Statistics*. Washington DC, USA: Homeland Security.
- Homer-Dixon, T. F. (1999). *Environment, scarcity, and violence*. Princeton, USA: Princeton University Press.
- Hugo, G. (1996). Environmental concerns and international migration. *International migration review*, *30*(1), 105-131.

- Hugo, G. (2011). Future demographic change and its interactions with migration and climate change. *Global Environmental Change*, *21*, S21-S33.
- Hulme, M. (2008). Climate refugees: Cause for a new agreement? *Environment*, 6, 50-51.
- Hummel, D., Adamo, S., de Sherbinin, A., Murphy, L., Aggarwal, R., Zulu, L., ... & Knight, K. (2013). Inter-and transdisciplinary approaches to population–environment research for sustainability aims: a review and appraisal. *Population and Environment*, *34*(4), 481-509.
- Hunter, L. M., & O'Neill, B. C. (2014). Enhancing engagement between the population, environment, and climate research communities: the shared socio-economic pathway process. *Population and environment*, *35*(3), 231-242.
- Huntington, E. (1907). *The pulse of Asia: A journey in Central Asia illustrating the geographic basis of history*. Boston, USA: Houghton Mifflin.
- Huntington, E. (1922). *Civilization and climate*. New Haven, USA: Yale University Press.
- IARNA (Instituto de Agricultura, Ambiente y Recursos Naturales) (2005). *Amenazas al Ambiente y Vulnerabilidad Social en Guatemala*. Documento técnico del Perfil Ambiental de Guatemala. Guatemala City, Guatemala: Universidad Rafael Landivar.
- IARNA (Instituto de Agricultura, Ambiente y Recursos Naturales) (2008). *Establecimiento de prioridades de inversión en infraestructura vial para la promoción del crecimiento agrícola en el altiplano de Guatemala*. Documento técnico del Perfil Ambiental de Guatemala. Guatemala City, Guatemala: Universidad Rafael Landivar.
- IARNA (Instituto de Agricultura, Ambiente y Recursos Naturales) (2009). *Perfil Ambiental de Guatemala 2008-2009: las señales ambientales críticas y su relación con el desarrollo*. Documento técnico del Perfil Ambiental de Guatemala. Guatemala City, Guatemala: Universidad Rafael Landívar.
- IGP (Instituto Geofısico del Peru) (2010). *Cambio climatico en la cuenca del Mantaro. Balance de 7 anos de estudios*. Lima, Peru: IGP.

- IGP (Instituto Geofısico del Peru) (2012). *Eventos meteorologicos extremos (sequıas, heladas y lluvias intensas) en el valle del Mantaro. Lima*, Lima, Peru: IGP..
- INE (Instituto Nacional de Estadística) (1996). *X Censo Nacional de Población y V de Habitación*. Guatemala City, Guatemala: INE.
- INE (Instituto Nacional de Estadística) (2002). *XI Censo Nacional de Población y V de Habitación*. Guatemala City, Guatemala: INE.
- INE (Instituto Nacional de Estadística) (2011a). *Encuesta Nacional de Condiciones de Vida - ENCOVI 2011.* Guatemala City, Guatemala: INE.
- INE (Instituto Nacional de Estadística) (2011b). *Guatemala's population data.* Guatemala City, Guatemala: INE.
- INEI (Instituto Nacional de Estadıstica e Informatica) (1981). *Censos Nacionales 1981 - VIII de Población y III de Vivienda*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica) (1993). *Censos Nacionales 1993: IX de Población y IV de Vivienda*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica)) (2008). *Perfil sociodemográfico del Perú*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica) (2009) *Peru: Migraciones Internas 1993–2007*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica) (2010a). *Mapa de Pobreza Provincial y Distrital 2009. El enfoque de la pobreza monetaria*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica) (2010b). *Censos Nacionales 2007: XI de Poblacion y VI de Vivienda – Perfil Sociodemografico de la Provincia de Huancayo*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica) & IOM (International Organization for Migration) (2009*). Migración internacional en las familias peruanas y perfil del peruano retornante*. Lima, Peru: INEI.
- INEI (Instituto Nacional de Estadıstica e Informatica), IOM (International Organization for Migration) & DIGEMIN (2013). *Perú: Estadísticas de la Emigración Internacional de Peruanos e Inmigración de Extranjeros 1990 - 2011*. Lima, Peru: INEI.
- IOM (International Organization for Migration) (2007): Migration and the Environment, *IOM Discussion Note*, MC/INF/288.

- IOM (International Organization for Migration) (2008). Survey on Remittance 2008 and Environment. *Migration Workbooks, 26.*
- IOM (International Organization for Migration) (2010). *Encuesta sobre remesas 2010, protección de la niñez y de la adolescencia*, Guatemala City, Guatemala: IOM.
- IOM (International Organization for Migration) (2012). *Perfil migratorio del Peru 2012*. Lima, Peru: IOM.
- IOM (International Organization for Migration) (2013). *Perfil migratorio de Guatemala 2012.* Guatemala City, Guatemala: IOM.
- INSIVUMEH (Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología) (2010). *Información Climática.* Guatemala City, Guatemala: INSIVUMEH.
- IPCC (Intergovernmental Panel on Climate Change) (2013). Climate change 2013: the physical science basis. Contribution of working group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- IPCC (Intergovernmental Panel on Climate Change) (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part A: Global and Sectoral Aspects. Contribution of Working Group II 5 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- Jäger, J., Frühmann, J., Günberger, S., & Vag, A. (2009). Environmental change and forced migration scenarios: project synthesis report.
- Jakobeit, C., & Methmann, C. (2012). 'Climate refugees' as dawning catastrophe? A critique of the dominant quest for numbers. In *Climate Change, Human Security and Violent Conflict* (pp. 301-314). Springer Berlin Heidelberg.
- Janssen, M. A., & Ostrom, E. (2006). Empirically based, agent-based models.*Ecology and Society*, *11*(2), 37.
- Jodha, N. S. (1992). Mountain perspective and sustainability: A framework for development strategies. In Sustainable Mountain Agriculture (pp. 41-82), New Delhi, Inida: Oxford and IBH Publishing Co.
- Jokisch, B. D. (2002). Migration and agricultural change: The case of smallholder agriculture in highland Ecuador. *Human Ecology*, *30*(4), 523-550.

- Jónsson, G. (2010). The environmental factor in migration dynamics: a review of African case studies. *Working paper 21,* Oxford, UK: International Migration Institute.
- Juarroz, E. (2004). Diagnóstico y Pronóstico Socioeconómico del Municipio de Cabricán, Quetzaltenango. Informe de EPS, Guatemala City, Guatemala: Universidad de San Carlos de Guatemala.
- Kaenzig, R. (2015). Can glacial retreat lead to migration? A critical discussion of the impact of glacier shrinkage upon population mobility in the Bolivian Andes. *Population and Environment*, *36*(4), 480-496.
- Kaenzig, R., & Piguet, E. (2014). Migration and Climate Change in Latin America and the Caribbean. In People on the Move in a Changing Climate. The Regional Impact of Environmental Change on Migration (pp. 155-176). Springer Netherlands.
- Kälin, W. (2012). From the Nansen principles to the Nansen initiative. *Forced Migration Review*, *41*, 48-49.
- Kälin, W., & Schrepfer, N. (2012). Protecting people crossing borders in the context of climate change: Normative gaps and possible approaches. UNHCR Legal and protection policy research series, Geneva (Switzerland): UNHCR.
- Kelley, J. (2011). Climate Change and Small Island States: Adrift in a Raising Sea of Legal Uncertainty. *Sustainable Development Law & Policy*, *11*, 56-57; 94-95.
- Kelman, I. (2008). Island evacuation. *Forced Migration Review*, *31*, 20-21.
- Khattak, M. S., Babel, M. S., & Sharif, M. (2011). Hydro-meteorological trends in the upper Indus River basin in Pakistan. *Climate Research*, *46*(2), 103.
- Klein, J. T., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R. W., & Welti, M. (Eds.). (2012). *Transdisciplinarity: joint problem solving among science, technology, and society: an effective way for managing complexity*. Birkhäuser.
- Kniveton, D., Schmidt-Verkerk, K., Smith, C., & Black, R. (2008). Climate change and migration: improving methodologies to estimate flows. *IOM Migration Research Series, 33*. Geneva, Switzerland: International Organization for Migration

- Kniveton, D., Smith, C., & Wood, S. (2011). Agent-based model simulations of future changes in migration flows for Burkina Faso. *Global Environmental Change*, *21*, S34-S40.
- Kniveton, D. R., Smith, C. D., & Black, R. (2012). Emerging migration flows in a changing climate in dryland Africa. *Nature Climate Change*, *2*(6), 444-447.
- Kollmair, M., & Banerjee, S. (2011). Drivers of migration in mountainous regions of the developing world: A review. Foresight: Migration and global environmental change driver review no. 9.
- Kollmair, M. & Gamper, S. (2002). The Sustainable Livelihood Approach: Training Input. Zurich, Switzerland: Development Study Group Zurich (DSGZ).
- Koser, K. (2009). Why migration matters. *Current History*, *108*(717), 147-153.
- Kropotkin, P. (2012). *Mutual aid: A factor of evolution*. London, UK: William Heinemann.
- Kumar, S. (2002). *Methods for Community Participation: A Complete Guide for Practitioners*. London, UK: ITDG Publishing.
- Laczko, F., & Aghazarm, C. (Eds.). (2009). *Migration, environment and climate change: Assessing the evidence*. Geneva, Switzerland and New York, USA: IOM, UNU-EHS, CCEMA, Rockefeller Foundation.
- Laite, J. (1981). *Industrial development and migrant labour in Latin America*. Manchester, UK: Manchester University Press.
- Leavell, D.N. (2008). *The consequences of climate change for the water resources of Perú*. Proceedings of the XIII World Water Congress, International Water Resources Association.
- Leckie, S. (2012). The management of climate displacement. *Forced Migration Review*, *41*, 17-18.
- Lewis, S. L., & Maslin, M. A. (2015). Defining the Anthropocene. *Nature*, *519* (7542), 171-180.
- Liwenga, E. T., Kwezi, L. & Afifi, T. (2012). "Where the Rain Falls" project. Case study Tanzania. Results from the Same District, Kilimangiaro Region. *UNU-EHS Report, 6*. Bonn, Germany: UNU-EHS.

- Lonergan, S. (1998). The role of environmental degradation in population displacement. Environmental change and security project report, 4(6).
- Long, N., & Roberts, B. (Eds.). (1978). *Peasant cooperation and capitalist expansion in Central Peru*. Austin, USA: University of Texas Press.
- Long, N., & Roberts, B. (Eds.). (1984). *Miners, peasants and entrepreneurs: Regional development in the Central Highlands of Peru.* Cambridge, UK: Cambridge University Press.
- Loschmann, C., & Siegel, M. (2014). The influence of vulnerability on migration intentions in Afghanistan. *Migration and Development*, *3*(1), 142-162
- Lu, X., Wrathall, D. J., Sundsøy, P. R., Nadiruzzaman, M., Wetter, E., Iqbal, A., ... & Bengtsson, L. (2016). Unveiling hidden migration and mobility patterns in climate stressed regions: A longitudinal study of six million anonymous mobile phone users in Bangladesh. *Global Environmental Change*, *38*, 1-7.
- Lucas, R. E., & Stark, O. (1985). Motivations to remit: Evidence from Botswana. *The Journal of Political Economy*, 901-918.
- Luján Muñoz, J. (1993). *Historia General de Guatemala. 6 tomos.* Asociación de Amigos del País, Fundación para la Cultura y el Desarrollo, Guatemala.
- Mallon, F.A. (1983). *The defense of community in Peru's Central Highlands: Peasant struggle and capitalist transition, 1860–1940*. Princeton, USA: Princeton University Press.
- Maplecroft (2010). Climate Change Risk Atlas 2011. Bath, UK: Maplecroft.
- MARN (Ministerio de Ambiente y Recursos Naturales) (2001). *Primera Comunicación Nacional Sobre Cambio Climático.* Guatemala City, Guatemala: MARN.
- Martin, S. F.: Review of legal and political framework which affects migration, including institutional architecture and capacity, and how it is affected by future environmental change. Foresight: Migration and global environmental change driver review.
- Martin, S. F. (2014). *International Migration: Evolving Trends from the Early 20th Century to the Present*. New York, USA and Cambridge, UK: Cambridge University Press

- Massey, D. S., Arango, J., Hugo, G., Kouaouci, A., Pellegrino, A., & Taylor, J. E. (1993). Theories of international migration: A review and appraisal. *Population and development review*, 431-466.
- Massey, D. S., & Parrado, E. A. (1998). International migration and business formation in Mexico. *Social Science Quarterly*, 1-20.
- Massey, D. S., Axinn, W. G., & Ghimire, D. J. (2010). Environmental change and out-migration: Evidence from Nepal. *Population and Environment*, *32*(2-3), 109-136.
- Matthews, B. and Ross, L. (2010*). Research methods: A practical guide for the social sciences*. Harlow, UK: Longman.
- Mayer, B. (2013). Environmental Migration in the Asia-Pacific Region: Could We Hang Out Sometime? *Asian Journal of International Law*, *3*(1), 101.
- Mayer, B. (2014). 'Environmental Migration' as Advocacy: Is it Going to Work? *Refuge, 29* (2), 27-41.
- McAdam, J. (Ed.) (2010). *Climate Change and Displacement: Multidisciplinary Perspectives*, Oxford, UK: Bloomsbury Publishing,
- McAdam, J. (2011). Swimming against the tide: Why a climate change displacement treaty is not the answer. *International Journal of Refugee Law*, eeq045.
- McAdam, J. (2015). Lessons from planned relocation and resettlement in the past. *Forced Migration Review*, *(49)*, 30.
- McDowell, C., & De Haan, A. (1997). Migration and sustainable livelihoods: A critical review of the literature. Sussex, UK: Institute for Development Studies.
- McGregor, J. (1994). Climate change and involuntary migration: implications for food security. *Food Policy*, *19*(2), 120-132.
- McKenzie, D. and Yang, D. (2012). Experimental approaches in migration studies. In Handbook of research methods in migration (pp. 249-272), Northampton (UK): Edward Elgar Publishing.
- McLeman, R. (2013). Developments in modelling of climate change-related migration. *Climatic Change*, *117*(3), 599-611.
- McLeman, R., & Smit, B. (2006). Migration as an adaptation to climate change. *Climatic change*, *76*(1-2), 31-53.
- McLeman, R., Schade, J., & Faist, T. (2016). *Environmental Migration and Social Inequality*. Advances in Global Change Research 61, Springer International Publishing.

- McNamara, K. E. (2007). Conceptualizing discourses on environmental refugees at the United Nations. *Population and Environment*, *29*(1), 12-24.
- McNamara, K. E. (2008). Pragmatic discourses and alternative resistance: Responses to climate change in the Pacific. *Graduate Journal of Asia-Pacific Studies*, *6*(2), 33-54.
- McNamara, K. E., & Des Combes, H. J. (2015). Planning for Community Relocations Due to Climate Change in Fiji. *International Journal of Disaster Risk Science*, *6*(3), 315-319.
- Mellander, C., Florida, R., & Stolarick, K. (2011). Here to stay - The effects of community satisfaction on the decision to stay. *Spatial Economic Analysis*, *6*(1), 5–24.
- Messerli, B., Viviroli, D., & Weingartner, R. (2004). Mountains of the world: vulnerable water towers for the 21st century. *Ambio*, 29-34.
- Milan, A., Areikat, S. & Afifi, T. (2011). Environmentally Induced Migration and Sustainable Development. Paper presented at the 18th Annual Conference of the European Association of Environmental and Resource Economists.
- Milan, A., & Ho, R. (2014). Livelihood and migration patterns at different altitudes in the Central Highlands of Peru. *Climate and Development*, *6*(1), 69-76.
- Milan, A., & Ruano, S. (2014). Rainfall variability, food insecurity and migration in Cabricán, Guatemala. *Climate and Development*, *6*(1), 61-68.
- Milan, A., Gioli, G., & Afifi, T. (2015a). Migration and global environmental change: methodological lessons from mountain areas of the global South. *Earth System Dynamics*, *6*(1).
- Milan, A., Melde, S., Cascone, C., Schindler, M. & Warner, K. (2015b). When do households benefit from migration? Insights from vulnerable environments in Haiti. *MECLEP Policy Brief Series 8* (1). Geneva, Switzerland: IOM.
- Milan, A., Smith, C., Kniveton, D. & Warner, K. (under review): Agent-Based Model of human migration in the context of environmental change in the Peruvian Andes. *Regional Environmental Change*, special issue on Andean communities in the face of global change.

- Milan, A., Schraven, B. & Warner, K. (eds.) (forthcoming). *Migration, risk management, and climate change - Evidence and policy responses*. Global Migration Issues book series.
- MINEDUC (Ministerio de Educación) & SESAN (Secretaría de Seguridad Alimentaria y Nutricional) (2009). *Tercer Censo Nacional de Talla en Escolares*.
- Morales, A.G. N. (2007). *The Peruvian migration phenomenon.* Gender and Development Program, Centro de Asesoría Laboral del Perú. Retrieved from http://www.caritas-europa.org/module/FileLib/Naranjopanel1.pdf
- Morales Arnao, B. (2000). Los eternos nevados en el Perú están retrocediendo en forma cada vez más acelerada. In El Medio Ambiente en el Perú. Lima, Peru: Instituto Cuánto.
- Moran-Taylor, M. J., & Taylor, M. J. (2010). Land and leña: linking transnational migration, natural resources, and the environment in Guatemala. *Population and Environment*, *32*(2-3), 198-215.
- Morrissey, J. (2009). Environmental Change and Forced Migration, a State of the Art Review. Refugee Studies Centre Background Paper.
- Morrissey, J. (2012). Rethinking the debate on environmental refugees': from 'maximalists and minimalists' to' proponents and critics'. *Journal of Political Ecology*, *19*, 36-49.
- Mortreux, C., & Barnett, J. (2009). Climate change, migration and adaptation in Funafuti, Tuvalu. *Global Environmental Change, 19*(1), 105-112.
- MTPE (Ministerio del Trabajo y Promocion del Empleo) (2013). *Informe Anual del Empleo en el Perù 2012*.
- Murali, J., & Afifi, T. (2014). Rainfall variability, food security and human mobility in the Janjgir-Champa district of Chhattisgarh state, India. *Climate and Development*, *6*(1), 28-37.
- Murphy, D. W. (2015). Theorizing climate change, (im) mobility and socio-ecological systems resilience in low-elevation coastal zones. *Climate and Development*, 7(4), 380-397.
- Murra, J. V. (1972). El Control vertical de un maximo de pisos ecológicos en la economia de las sociedades andinas. In Visita de la Provincia de León de Huánuco en 1562 (2) (pp. 427-476), Huánuco (Peru): Universidad nacional Hermilio Valdizan, Facultad de letras y educación.

- Myers, N. (1993). Environmental refugees in a globally warmed world. *Bioscience 43*(11), 752-761.
- Myers, N. (1997). Environmental refugees. *Population and Environment*, *19*(2), 167-182.
- Myers, N. (2002). Environmental refugees: a growing phenomenon of the 21st century. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *357*(1420), 609-613.
- Narayanasamy, N. (2009). *Participatory Rural Appraisal: Principles, Methods and Application*. New Delhi, India: Sage.
- Nawrotzki, R. J., Hunter, L. M., Runfola, D. M., & Riosmena, F. (2015a). Climate change as a migration driver from rural and urban Mexico.*Environmental Research Letters*, *10*(11), 114023.
- Nawrotzki, R. J., Riosmena, F., Hunter, L. M., & Runfola, D. M. (2015b). Amplification or suppression: Social networks and the climate change—migration association in rural Mexico. *Global Environmental Change*, *35*, 463-474.
- Nicholson, C. (2014). Climate change and the politics of causal reasoning: the case of climate change and migration. *The Geographical Journal*, *180*(2), 151-160.
- Nightingale, A. (2009). Warming up the climate change debate: A challenge to policy based on adaptation. *Journal of Forest and Livelihood*, *8*(1), 84-89.
- Obokata, R., Veronis, L., & McLeman, R. (2014). Empirical research on international environmental migration: a systematic review. *Population and environment*, *36*(1), 111-135.
- Onta, N., & Resurreccion, B. P. (2011). The role of gender and caste in climate adaptation strategies in Nepal: emerging change and persistent inequalities in the far-western region. *Mountain Research and Development*, *31*(4), 351-356.
- Park, S. (2011). Climate change and the risk of statelessness: The situation of low-lying island states. *UNHCR Legal and Protection Policy Research Series, 4*. Geneva, Switzerland: UNHCR.
- Parry, M. L. (Ed.). (2007). *Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (Vol. 4). Cambridge, UK: Cambridge University Press.

- Perch-Nielsen, S. L., Bättig, M. B., & Imboden, D. (2008). Exploring the link between climate change and migration. *Climatic Change*, *91*(3-4), 375-393.
- Piguet, E. (2010). Linking climate change, environmental degradation, and migration: a methodological overview. *Climate Change*, *1*(4), 517-524.
- Piguet, E. (2012). Migration: The drivers of human migration. *Nature Climate Change*, *2*(6), 400-401.
- Piguet, E. (2013). From "primitive migration" to "climate refugees": The curious fate of the natural environment in migration studies. *Annals of the Association of American Geographers*, *103*(1), 148-162.
- Pounds, J. A., Fogden, M. P., & Campbell, J. H. (1999). Biological response to climate change on a tropical mountain. *Nature*, *398*(6728), 611-615.
- Rademacher-Schulz, C., Afifi, T., Warner, K., Rosenfeld, T., Milan, A., Etzold, B., & Sakdapolrak, P. (2012): Rainfall Variability, Food Security and Human Mobility: An Approach for Generating Empirical Evidence. *Intersections, 10.* Bonn, Germany: UNU-EHS.
- Rademacher-Schulz, C., Schraven, B., & Mahama, E. S. (2014). Time matters: shifting seasonal migration in Northern Ghana in response to rainfall variability and food insecurity. *Climate and Development*, *6*(1), 46-52.
- Ramlogan, R. (1996). Environmental refugees: a review. *Environmental conservation*, *23*(1), 81-88.
- Ratzel, F. (1882). *Anthropogeographie.* Stuttgart, Germany: J. Engelhorn.
- Ratzel, F. (1903). *Politische geographie*. Munich, Germany: Oldenbourg.
- Ravenstein, E. G. (1889). The laws of migration. *Journal of the Royal Statistical Society* 52(2): 241–305.
- Ravenstein, E. G. (1891). Lands of the globe still available for European settlement. *Proceedings of the Royal Geographic Society 13*: 27–35.
- Renaud, F. G., Dun, O., Warner, K., & Bogardi, J. (2011). A decision framework for environmentally induced migration. *International Migration*, *49*(s1), e5-e29.

- Reuveny, R. (2007). Climate change-induced migration and violent conflict. *Political Geography*, *26*(6), 656-673.
- Reuveny, R. (2008). Ecomigration and violent conflict: Case studies and public policy implications. *Human Ecology*, *36*(1), 1-13.
- Rippin, N. (2011). A Response to the Weaknesses of the Multidimensional Poverty Index (MPI): The Correlation Sensitive Poverty Index (CSPI). German Development Institute Briefing Paper, 19.
- Rippin, N. (2012). What is poverty? The Correlation Sensitive Poverty Index (CSPI). In: German Development Institute Annual Report 2011-2012: building bridges between research and practice (pp. 24-27).
- Ruano, S., & Juarez, H. (2008). *Estudio Sobre la Situación Actual del Sistema Milpa en el Departamento de Sololá*. Guatemala City, Guatemala: Japan International Cooperation Agency (JICA).
- Ruano, S. & Milan, A. (2014). Climate change, rainfall patterns, livelihoods and migration in Cabricán, Guatemala. *UNU-EHS Report, 14.* Bonn, Germany: UNU-EHS.
- Sakdapolrak, P., Promburom, P., & Reif, A. (2014). Why successful in situ adaptation with environmental stress does not prevent people from migrating? Empirical evidence from Northern Thailand. *Climate and Development*, *6*(1), 38-45.
- Schlüter, M., Müller, B., & Frank, K. (2013). How to use models to improve analysis and governance of social-ecological systems - the reference frame MORE. Social Science Research Network (SSRN) Scholarly Paper ID 2037723. Rochester, USA: SSRN.
- Schraven, B., & Rademacher-Schulz, C. (2016). Shifting Rainfalls, Shifting Livelihoods: Seasonal Migration, Food Security and Social Inequality in Northern Ghana. In *Environmental Migration and Social Inequality* (pp. 43-56). Springer International Publishing.
- Semple, E. C. (1911). *Influences of geographic environment*. New York, USA: Holt.
- Siegel, M., & Waidler, J. (2012). *Migration and multi-dimensional poverty in Moldovan communities*. UNU-MERIT Working Paper
- Sietz, D. (2014). Regionalisation of global insights into dryland vulnerability: Better reflecting smallholders' vulnerability in Northeast Brazil. *Global Environmental Change*, *25*, 173-185.

- Sietz, D., Untied, B., Walkenhorst, O., Lüdeke, M. K. B., Mertins, G., Petschel-Held, G., & Schellnhuber, H. J. (2006). Smallholder agriculture in Northeast Brazil: assessing heterogeneous human-environmental dynamics. *Regional Environmental Change*, *6*(3), 132-146.
- Silva, Y., Trasmonte, G., & Giraldez, L. (2007). Variabilidad de las precipitaciones en el valle del Mantaro. Memoria del sub proyecto. In Pronostico estacional de lluvias y temperature del aire en la Cuenca del rio Mantaro para su aplicacion en la agricultura (2007–2010) (pp. 54–58). Lima, Peru: IGP.
- Skeldon, R. (1985). Population pressure, mobility, and socio-economic change in mountainous environments: regions of refuge in comparative perspective. *Mountain Research and Development 5*(3), 233-250.
- Skeldon, R. (1990). *Population mobility in developing countries*. London, UK: Belhaven Press.
- Smethurst, D. (2000). Mountain geography. *Geographical Review*, *90*(1), 35-56.
- Smith, C. D. (2014). Modelling migration futures: development and testing of the Rainfalls Agent-Based Migration Model–Tanzania. *Climate and Development*, *6*(1), 77-91.
- Smith, C. D., Kniveton, D., Wood, S. & Black, R. (2008): Predictive modelling, *Forced Migration Review, 31*, 58–59.
- Smith, G.A. (1984). Confederations of households: Extended domestic enterprises in city and country. In Miners, peasants and entrepreneurs: regional development in the central highlands of Peru (pp. 217–234). Cambridge, UK: Cambridge University Press.
- Stark, O. (1980). On the Role of Urban-to-Rural Remittances in Rural Development.
- Stark, O., & Bloom, D. E. (1985). The new economics of labor migration. *The American Economic Review 75*(2), 173-178.
- Stark, O., & Levhari, D. (1982). On migration and risk in LDCs. *Economic development and cultural change 31*(1), 191-196.
- Stark, O., & Yitzhaki, S. (1988). Labour migration as a response to relative deprivation. *Journal of Population Economics*, *1*(1), 57-70.
- Stark, O., & Taylor, J. E. (1989). Relative deprivation and international migration. *Demography*, *26*(1), 1-14.

- Stern, N. H. (2006). *Stern Review: The economics of climate change*. London, UK: HM treasury.
- Stolmaker, C. (1979). The Sunday Fair at Huancayo: A Market's Contribution to the Regional Economy. *Journal of Anthropological Research*, *3*(4), 459-476.
- Suhrke, A. (1994). Environmental degradation and population flows. *Journal of International Affairs*, *47*(2), 473.
- Tacoli, C. (2009). Crisis or adaptation? Migration and climate change in a context of high mobility. *Environment and Urbanization*, *21*(2), 513-525.
- Tan, Y., Zuo, A., & Hugo, G. (2013). Environment-related resettlement in China: a case study of the Ganzi Tibetan Autonomous Prefecture in Sichuan Province. *Asian and Pacific Migration Journal*, *22*(1), 77-107.
- Taylor, E. J. (1999). The new economics of labour migration and the role of remittances in the migration process. *International migration*, *37*(1), 63-88.
- Trejo, J. (2012). Agro en Cifras 2011. Guatemala City, Guatemala: Ministerio de Agricultura, Ganadería y Alimentación (MAGA).
- Tucker, C. M., Eakin, H., & Castellanos, E. J. (2010). Perceptions of risk and adaptation: coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change*, *20*(1), 23-32.
- Umezaki, M., & Ohtsuka, R. (2002). Changing migration patterns of the Huli in the Papua New Guinea Highlands: A genealogical demographic analysis. *Mountain Research and Development*, *22*(3), 256-262.
- UNDP (United Nations Development Programme) (2011a). Human Development Report - Sustainability and Equity: A Better Future for All.
- UNDP (United Nations Development Programme) (2011b). Quetzaltenango – Cifras para el desarrollo humano.
- UNHCR (2002): The Environment - A Critical Time. *Refugees,* 127.
- United Nations (1998): *Guiding Principles on Internal Displacement.*
- UNICEF (2011). *State of the World's Children 2011.*
- United States Department of State (2012). *Background Note: Peru*. Retrieved from http://www.state.gov/r/pa/ei/bgn/35762.htm.

- UNPD (United Nations Population Division) (2015). *2015 Revision of World Population Prospects.*
- USAID (United States Agency for International Development) (2009). Guatemala Gender Assessment. Retrieved from http://www.usaid.gov/our_work/cross-cutting_programs/wid/pubs/Guatemala_Gender_Assessment.pdf.
- USAID (United States Agency for International Development) (2011). Pakistan Education Statistics. Islamabad, Pakistan: Academy of Educational Planning and Management. Retrieved from: http://www.aepam.edu.pk/Files/EducationStatistics/PakistanEducationStatistics2010-11.pdf.
- Van Der Geest, K. (2011). North-South migration in Ghana: what role for the environment? *International Migration, 49*(s1), e69-e94.
- Van der Geest, K., Khoa, N. V., & Thao, N. C. (2014). Internal migration in the Upper Mekong Delta, Viet Nam: What is the role of climate related stressors? *Asia-Pacific Population Journal*, *29*(2).
- Verma, R., Nellemann, C., & Hislop, L. (2011). *Women at the Frontline of Climate Change: Gender Risks and Hopes.* Arendal, Norway: United Nations Environment Programme, GRID-Arendal.
- Viviroli, D., Dürr, H. H., Messerli, B., Meybeck, M., & Weingartner, R. (2007). Mountains of the world, water towers for humanity: Typology, mapping, and global significance. *Water resources research*, *43*(7).
- 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), 79-96.
- Warner, K. (2011a). Environmental change and migration: methodological considerations from ground-breaking global survey. *Population and environment*, *33*(1), 3-27.
- Warner, K. (2011b). Interdisciplinary approaches to researching environmental change and migration: methodological considerations and field experiences from the EACH-FOR project. In Handbook of Research Methods in Migration (pp. 366–395), Cheltenham (UK): Edward Elgar Publishing.
- Warner, K. (2012). Human migration and displacement in the context of adaptation to climate change: the Cancun Adaptation

Framework and potential for future action. *Environment and Planning C: Government and Policy*, *30*(6), 1061-1077.
- Warner, K., & Afifi, T. (2014a). Where the rain falls: Evidence from 8 countries on how vulnerable households use migration to manage the risk of rainfall variability and food insecurity. *Climate and Development*, *6*(1), 1-17.
- Warner, K., & Afifi, T. (2014b). Enhancing Adaptation Options and Managing Human Mobility: The United Nations Framework Convention on Climate Change. *Social Research: An International Quarterly*, *81*(2), 299-326.
- Warner, K., Ehrhart, C., de Sherbinin, A., Adamo, S. B., & Onn, T. C. (2009). *In search of shelter: Mapping the effects of climate change on human migration and displacement*. Bonn, Germany: UNU-EHS, CARE, and CIESIN Columbia University.
- Warner, K., & van der Geest, K. (2013). Loss and damage from climate change: local-level evidence from nine vulnerable countries. *International Journal of Global Warming*, *5*(4), 367-386.
- Warner, K., Hoffmaister, J. & Milan, A. (2015). Human Mobility and Adaptation: Reducing Susceptibility to Climate Stressors and Mainstreaming. In Environmental Change, Adaptation and Migration Bringing in the Region (pp. 41-58). Springer.
- Wesolowski, A., Eagle, N., Noor, A. M., Snow, R. W., & Buckee, C. O. (2013). The impact of biases in mobile phone ownership on estimates of human mobility. *Journal of the Royal Society Interface*, *10*(81), 1-6.
- Westing, A. H. (1992). Environmental refugees: a growing category of displaced persons. *Environmental Conservation*, *19*(3), 201-207.
- Westing, A. H. (1994). Population, desertification, and migration. *Environmental Conservation*, *21*(2), 110-114.
- Wilmsen, B., & Webber, M. (2015). What can we learn from the practice of development-forced displacement and resettlement for organised resettlements in response to climate change? *Geoforum*, *58*, 76-85.
- Wood, T. (2015). Developing temporary protection in Africa. *Forced Migration Review*, (49), 23.

- WHO/PAHO (2008). *Malnutrition in Infants and Young Children in Latin America and the Caribbean: Achieving the Millennium Development Goals.*
- WMO (World Meteorological Organization) (2013). A summary of current climate change findings and Figures, *WMO Information Note*. Retrieved at http://www.wmo.int/pages/mediacentre/factsheet/documents/Climate-Change-Info-Sheet-136_fr.pdf.
- World Bank (2009). *Peru: country note on climate change aspects in agriculture*, December 2009. Retrieved from http://www.worldbank.org/lacagccnotes.
- World Bank (2015). *Fertility Rates, total (per woman)*. Retrieved from http://data.worldbank.org/indicator/SP.DYN.TFRT.IN/countries?order=wbapi_data_value_2012+wbapi_data_value+wbapi_data_value-last&sort=desc.
- World Economic Outlook (2005). *Globalization and External Imbalances*. Washington DC, USA: International Monetary Fund.
- Wrathall, D. J. (2012). Migration amidst social-ecological regime shift: The search for stability in Garifuna villages of northern Honduras. *Human Ecology*, *40*(4), 583-596.
- Yang, D., & Choi, H. (2007). Are remittances insurance? Evidence from rainfall shocks in the Philippines. *The World Bank Economic Review*, *21*(2), 219-248.
- Yin, R. K. (2013). *Case study research: Design and methods*. New York, USA: Sage publications.

Summary of the thesis

This PhD dissertation on "Rural livelihoods, location and vulnerable environments: Approaches to migration in mountain areas of Latin America" builds on four key points which emerge from the recent literature and the case studies presented in this manuscript:

1. In the context of climate change, environmental change is expected to have an increasing impact on migration in the future through its interrelationship with other demographic, economic, political and social drivers of migration and in the context of rising national inequalities;
2. Most migration in the context of environmental change is and will be internal and relatively short distance rather than international, with the notable exception of border areas (including mountains) and small states (particularly small island developing states);
3. While migration is often understood and framed as a failure to adapt to environmental and climatic changes, it can also be part of successful livelihood risk management strategies;
4. In the upcoming decades, millions of people who would like to move might be unable to leave locations in which they are vulnerable to environmental change.

In this context, the rationale behind the geographical focus on mountain areas of Latin America is that the interaction of environmental changes with other drivers of livelihood change in mountain areas (such as population dynamics and economic globalization) is of great importance yet relatively understudied. In particular, the relationship between migration and environmental changes is a crucial determinant of rural livelihoods which has barely been studied in a systematic way.

Mountains often constitute politically contested border areas and they are prized for their potential for tourism. Physically and economically, they have several specificities related to their natural resources and livelihoods that have often been studied in geography and economics but not in migration studies:

1. Inaccessibility due to slope, altitude and recurrent hazards (landslides, snow, and so on) which can imply isolation, poor communication and limited human mobility;
2. Fragility due to altitude and steep slopes;
3. Diversity/heterogeneity within very short horizontal distances;
4. Comparative advantage for specific products such as plants that only grow beyond certain altitudes.

This dissertation aims at bridging this gap on migration in mountain areas, particularly from an empirical point of view.

After an introduction (chapter one) and presentation of the case study methodology (two), this thesis presents four main chapters that aim to enhance scientific understanding of migration in vulnerable environments in mountain areas of Latin America.

Firstly, the chapter on Guatemala (three) provides insights on migration in a marginal mountainous environment with a rapidly growing population. Among other things, chapter three sheds light on the first two specificities of mountain areas and their relationship with human mobility patterns: inaccessibility (which implies isolation and limited human mobility options) and fragility due to high altitude and steep slopes.

The chapter shows that the food production in the Guatemalan municipality under study (Cabricán, in the Western Highlands of Guatemala) is worsening and it is associated with a perceived decrease in the profitability of both *in situ* diversification options and migration opportunities (partially because of complicated access to the main communication routes and economic markets). These trends expose local populations to the risk of becoming trapped in the near future in a place where they are extremely vulnerable to the adverse impacts of climate change. No long-term risk-management and livelihood diversification strategy, including *ex situ* strategies, seems to be sustainable for people in Cabricán.

Building on the previous chapter, the contribution of the fourth chapter (based on a study conducted in three communities in the Province of Huancayo, Central Highlands of Peru) is to provide empirical evidence on the importance of location and access to urban opportunities in determining livelihood and migration patterns in rural mountain areas. The case study

also shows the diversity/heterogeneity of livelihoods within very short horizontal distances (third of the mountain specificities) and it highlights differences in livelihood and human mobility patterns between households located at different altitudes.

The results of the chapter show that at relatively lower altitude, one or more members of most households commute daily to work in the nearby city of Huancayo. At higher altitude, households (or some of its members) often move to Huancayo and resettle there. In both cases, circular migration patterns (including daily mobility) can be identified and households combine the scarce income from urban employment with rural income rather than abandoning the farming land.

Building on the analysis of chapter four on present and past mobility patterns, the fifth chapter simulates the evolution of human mobility patterns in response to rainfall changes in the same three rural Peruvian communities from 2015 until 2050 through an agent-based model of migration. Past approaches to examining the influence of climatic changes upon migration have tended to ignore the non-linear interactions between the drivers of change, the livelihoods they are affecting, and the resulting migration patterns. The use of an agent-based model not only allows the inclusion of interacting heterogeneous agents and contexts in non-linear systems, but also permits the inclusion of changing subjective norms on attitudes towards migration.

The results of the simulation based on expected rainfall scenarios towards 2050 show a slight decrease in total outmigration: on the one hand, migration from non-resilient households is simulated to increase as more households become non-resilient and more non-resilient households identify need-driven migration as a valid livelihood strategy; on the other hand, the simulated decrease in migration from resilient households is even stronger, more than cancelling out the increase in non-resilient migration. The simulated overall reduction in outmigration from the rural communities can be explained by the opportunities for daily and short-term employment in the nearby city of Huancayo that allow people to live in their communities while commuting to the urban area. In fact, migration is defined in the model as a movement outside the province of Huancayo. As a consequence, short-

distance mobility from the rural communities to the urban area of Huancayo does not count as outmigration.

The sixth chapter aims at drawing lessons learned from the two case studies presented in chapters three and four as well as from the broader literature on migration in vulnerable environments in mountain areas of the Global South in order for future empirical research on the topic to move beyond understanding of single case studies and draw general lessons.

In particular, the chapter suggests that the systematic use of transdisciplinary approaches, with a combination of quantitative and qualitative empirical methods, is the key to understanding global migration patterns in rural mountain areas of the global South. In the future, survey data should be triangulated with PRA results as well as secondary data in order to link household vulnerability (calculated through a correlation-sensitive multidimensional index) with human mobility patterns. Such a link can be conducive to better understand the feedback processes between livelihoods and mobility patterns both within each case study and across case studies, helping researchers to draw general lessons.

Chapter seven presents the conclusions of the dissertation. After a summary of the thesis, the chapter links the results of this thesis as well as the four key points that emerged from my literature review (see end of section 1.1) to the broader literature and suggests avenues for future research.

Addendum on valorization to the dissertation

This addendum highlights the non-academic value created by this thesis through my commitment to making its knowledge suitable and available for non-academic audiences.

This addendum is organized in three sections: relevance of research results for non-academic audiences; activities/products related to the thesis; and schedule and implementation of its valorization.

Relevance of research results for non-academic audiences

This thesis builds on four and a half years of research at the United Nations University Institute for Environment and Human Security (UNU-EHS), an institute which aims to bridge the existing gaps between scientific knowledge and evidence-based policymaking (particularly on climate change) as well as between science and practice on the field.

This research has been developed in cooperation with several policymakers and practitioners on the field. In the case of the Rainfalls case study in Peru, for example, the results of my research have been used to develop a community-based adaptation program developed by our partners of CARE Peru, a non-governmental organization (NGO).

As mentioned in the text, mountain areas are a relatively blank spot in terms of empirical analysis on migration. However, several international organizations, NGOs and policy networks interested in migration in mountain areas find this dissertation interesting for their policy work and projects on the field.

In particular, the Mountain Partnership, a United Nations voluntary alliance of more than 250 governments, intergovernmental organizations, major groups (e.g. civil society, NGOs and the private sector) and subnational authorities, has followed my work with great interest. Several of its members have contacted me to receive a copy of this dissertation as soon as it is published because they believe it constitutes an important knowledge base

for programs and projects on migration in mountain areas of the Global South.

Moreover, in these years I have contributed to and benefited from exchange with several members of the Global Knowledge Partnership on Migration and Development (KNOMAD), a global hub of knowledge and policy expertise on migration and development issues hosted by the World Bank.[43]

Last but not least, I believe the results of my research are relevant to the work of the United Nations Framework Convention on Climate Change (UNFCCC) on human mobility, particularly after the December 2015 Paris Agreement has established a task force to "develop recommendations for integrated approaches to avert, minimize and address displacement related to the adverse impacts of climate change".

Activities/products related to the thesis

In the context of my PhD research, I have produced the following academic and policy-oriented publications:

- Milan, A., Schraven, B. and Warner, K. (eds.) (2016). Migration, risk management, and climate change - Evidence and policy responses. Global Migration Issues, vol.6 (forthcoming).
- Cascone, N., Pena del Valle, A. and Milan, A. (forthcoming). Local adaptation in the community of Las Palomas (Mexico): what role for migration? In Milan, A., Schraven, B. and Warner, K. (eds.) (2016). Migration, risk management, and climate change - Evidence and policy responses. Global Migration Issues, vol.6 (forthcoming).
- Milan, A., Melde, S., Cascone, N., Schindler, M. and Warner, K. (2015). When do households benefit from migration? Insights from vulnerable environments in Haiti. Migration, Environment and

[43] My co-supervisor Dr. Koko Warner is the Vice-Chair of the Thematic Working Group on Environmental Change and Migration.

Climate Change: Policy Brief Series 8:1. Geneva, Switzerland: International Organization for Migration (IOM).

- Milan, A., Gioli, G., and Afifi, T. (2015). Migration and global environmental change: methodological lessons from mountain areas of the global South, *Earth System Dynamics*, 6, 375–388.

- Afifi, T., Milan, A., Etzold, B., Schraven, B, Rademacher-Schulz, C., Sakdapoldrak, P., Reif, A., van der Geest, K., Warner, K. (2015). Human mobility in response to rainfall variability: opportunities for migration as a successful adaptation strategy in eight case studies. *Migration and Development*, ahead-of-print (2015): 1-21.

- Milan, A. and Ruano, S. (2014). Rainfall variability, food insecurity and migration in Cabricán, Guatemala, *Climate and Development*, 6:1, 61-68.

- Milan, A. and Ho, R. (2014). Livelihood and migration patterns at different altitudes in the Central Highlands of Peru, *Climate and Development*, 6:1, 69-76.

- Ruano, S. and Milan, A. (2014). Climate change, rainfall patterns, livelihoods and migration in Cabricán, Guatemala. Report No. 14. Bonn, Germany: United Nations University Institute for Environment and Human Security (UNU-EHS).

- Rademacher-Schulz, C., Afifi, T., Warner, K., Rosenfeld, T., Milan, A., Etzold, B. and Sakdapolrak, P. (2012). Rainfall variability, food security and human mobility. An approach for generating empirical evidence. Intersections No. 10. Bonn, Germany: United Nations University Institute for Environment and Human Security (UNU-EHS).

- Ho, R. and Milan, A. (2012). "Where the Rain Falls" project. Case study: Peru. Results from Huancayo Province, Junín Region. Report No. 5. Bonn, Germany: United Nations University Institute for Environment and Human Security (UNU-EHS).

I have held presentations in international workshops and conferences in Fiji, Germany, Guatemala, Italy, the Netherlands, Portugal and the United Kingdom. Moreover, I have held trainings for researchers and policymakers in Bangladesh, Germany, Guatemala, Haiti, Italy, Kiribati, Nauru, Peru and Tuvalu.

Schedule and implementation of the valorization

One of the lessons learned from my PhD is that the impacts of migration on vulnerable environment are understudied. In 2014 and 2015 I have led the design of the quantitative methodology for the Migration, Environment and Climate Change: Evidence for Policy (MECLEP) Project which aims at bridging this gap by studying how migration, displacement and planned relocation interact with household vulnerability in vulnerable environments in six countries worldwide (Dominican Republic, Haiti, Kenya, Mauritius, Papua New Guinea and Vietnam)[44]. I have also led the MECLEP research in Haiti and produced (as lead author) a policy brief and a case study report on my work in Haiti[45].

The MECLEP project has also allowed me to contribute to the development of the first national migration policy in Haiti. In fact, as research leader for the case study in Haiti, I have contributed to the work of the inter-ministerial task force on migration and the environment and to the development of the migration policy from the first draft to its finalization[46].

While the Rainfalls project was an important first step to enhance understanding on the attitudes of people towards migration in vulnerable environments, I learned through my thesis that more work is needed to include local people´s views into empirical research. In 2014 and 2015, I led the development of the research methodology for the Pacific Climate Change

[44] For more information on the MECLEP project, please visit the project website: https://www.iom.int/cms/meclep.

[45] The case study report is ready for publication; however, its publication is subject to approval by the Haitian government which has been delayed due to the current political crisis in the country.

[46] The final approval of the migration policy by the Haitian government has been delayed due to the current political crisis in the country.

and Migration (PCCM) project. The research component of the PCCM project is an important step in this direction as it studies the factors which contribute to current migration flows from Kiribati, Nauru and Tuvalu, including not only household socio-economic characteristics, but also attitudes and subjective norms towards human mobility, and how they interact with migration decision making[47].

From a methodological point of view, both projects build on the ideas presented in the sixth chapter of this thesis and their surveys allow for the construction of a multidimensional livelihood vulnerability index that helps understand the interactions between vulnerability and migration patterns at the household level.

The PCCM project is also an opportunity to build on the Agent-Based Modelling (ABM) work done during and after the Rainfalls project (see chapter 5) and move towards a next generation of ABM which has an even stronger focus on subjectivity and personal opinions on migration. This is currently the work of Dr. Robert Oakes who is using an additional method drawn from social psychology, the Q method, to include more efficiently people´s opinions and attitudes towards migration in the ABM developed within the PCCM project (Brown, 1980).

Building on the research I have conducted for my PhD, in 2015 I have also edited a book on "Migration, risk management, and climate change - Evidence and policy responses"[48]. In fact, one of the ideas that I stressed in my thesis (particularly in chapter 6) is the importance of gaining more knowledge about under which circumstances migration can be a positive risk management strategy and how this positive potential could be fostered. The book aims at bridging this academic and policy gap by bringing together several case studies analyzing time- and context-specific patterns of

[47] For more information on the PCCM project, please visit the project website: http://www.unescap.org/subregional-office/pacific/pacific-climate-change-and-migration-project. The case study reports from the three countries (Kiribati, Nauru and Tuvalu) will be published in the second half of 2016.

[48] The book is co-edited by Dr. Benjamin Schraven, Dr. Koko Warner and Ms. Noemi Cascone and it is currently with the publishing house and it will be printed in the second half of 2016.

migration as a risk management strategy vis-à-vis global environmental change.

The book includes eleven chapters focusing on several regions of the world. In particular, the first part of the book focuses on mountain areas and it includes four chapters on Bolivia, Mexico, Nepal and Pakistan respectively. On top of my coordinating role as editor, I have contributed (as co-author) a chapter on migration in the mountainous community of Las Palomas (Mexico). The chapter shows that emerging opportunities for locals to participate in circular migration programs are allowing them to increase their income and reduce risks related to migrating outside regular migration channels.

Curriculum Vitae

Andrea Milan was born on 29 July 1986, in Caltanissetta, Italy. Prior to university (1999-2004), he earned a high school diploma in modern languages (English, French and Spanish) from Liceo Ginnasio Ruggero Settimo (Caltanissetta, Italy). Andrea holds a Bachelor Degree in "Economy of the Public Administrations and of the International Institutions" and a master's Degree in "Applied Economy and Economic Policies" from University of Ferrara (Italy). During his Bachelor studies, Andrea was an Erasmus Scholarship-funded exchange student at University of Birmingham (UK). During his Masters, he was an Atlante Scholarship-funded Exchange student at Middlebury College (USA).

In 2009-2010, Andrea was an intern at the United Nations Office for ECOSOC Support and Coordination (UNDESA-OESC) as well as the United Nations Division for Sustainable Development (UNDESA-DSD). Between February 2011 and November 2015, he worked for the United Nations University Institute for Environment and Human Security (UNU-EHS) in Bonn, Germany which is the institute in which research for this thesis was carried out. At UNU-EHS, Andrea has conducted trainings and empirical research in Bangladesh, Guatemala, Haiti, Kiribati, Mexico, Nauru, Peru and Tuvalu. In June 2013, Andrea was a European Commission-funded (COST Action IS1101) visiting scientist at Sussex University (UK). Between 2013 and 2015 he has also lectured students and policymakers in Germany, Guatemala, Italy and the Netherlands.

From November 2015, Andrea is a Programme Analyst with the Economic Empowerment Section (Policy Division) of UN Women where he focuses on the migration portfolio of the section. His work at UN Women focuses mostly on the contribution of the Agency to the Global Migration Group (GMG) (UN Women holds the GMG Chair in 2016) as well as on a project on human and labor rights of women migrant workers from Mexico, Moldova and the Philippines.