MASTER's THESIS – Natural Resources Management and Development

Cologne University of Applied Science - Institute for Technology and Resources Management in the Tropics and Subtropics
and
Pontifical Catholic University of Peru

MOUNTAIN COMMUNITIES' PERCEPTION OF CLIMATE CHANGE ADAPTATION, DISASTER RISK REDUCTION AND ECOSYSTEM-BASED SOLUTIONS IN THE CHICÓN WATERSHED, PERU

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2017

Natural Resources Management and Development

Cologne University of Applied Science
Pontifical Catholic University of Peru
ITT - Institute for Technology and Resources Management
in the Tropics and Subtropics

“Mountain communities’ perception of Climate Change Adaptation, Disaster Risk Reduction and Ecosystem-Based Solutions in the Chicón Watershed, Peru”

Thesis to Obtain the Degree of
MASTER OF SCIENCE
NATURAL RESOURCES MANAGEMENT AND DEVELOPMENT
DEGREE AWARDED BY COLOGNE UNIVERSITY OF APPLIED SCIENCES

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ACKNOWLEDGEMENTS

I am very grateful to god for giving me the strength during this process and guiding my path. I dedicate this work to my husband, my sister and my parents. Special thanks to my husband for being always there for me during the hard times, you are my biggest inspiration. I couldn't be happier for your friendship and love. YOF

I also would like to thank:

- The German Academic Exchange Service (DAAD) for the wonderful scholarship programme and the opportunity to do my field research in Peru.
- PD Dr. Udo Nehren for all the advises, patience, time and reliable supervision of my thesis.
- Pontifical Catholic University of Peru for the partnership programme.
- Corazones para Peru for their support during my stay in Urubamba.
- CARE Peru for all the wonderful support and sponsoring my workshop. Special thanks to Karen Price, Walter Choquevilka and Liw Canales.
- The Urubamba municipality for the interviews and shared information.
- PREDES for sharing with me their studies.
- Thanks to Ursula Cockburn for hosting me in her country and all the help in the workshop.
- Thanks to my friends in Nicaragua for being there for me.
- Thanks to my ITT friends and to my sister from Myanmar.
- Finally, this work could not have been done without the participation of the people from the four communities and support of their leaders. Special thanks to Willbert Mañaccasa, Eloy Umeres, Celia Texce, Olga Alencastre and Fermin Alencastre.

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ABREVIATIONS

CC	Climate Change
CCA	Climate Change adaptation
CVCA	Climate Vulnerability and Capacity Analysis
DRR	Disaster Risk Reduction
EbA	Ecosystem-based Adaptation
Eco-DRR	Ecosystem-based Disaster Risk Reduction
Eco-DRR/CCA	Ecosystem-based Disaster Risk Reduction and Climate Change Adaptation
EWS	Early Warning System
GEF	Global Environmental Facility
GLOF	Glaciar Lake Outburs Flood
INDECI	Instituto Nacional de Defensa Civil (National Institute of Civil Defense)
INEI	Instituto Nacional de Estadística e Informática (National Institute of Statistics and Informatics)
IPCC	Intergovernmental Panel on Climate Change
JASS	Juntas Administradoras de Servicios de Saneamiento (Sanitation Services Management Boards)
MINAM	Ministerio del Medio Ambiente
MINSA	Ministerio de Salud
NAPAs	National Adaptation Programmes of Action
NGO	Nongovernmental organization
PACC	Proyecto de Adaptación al Cambio Climático (Adaptation to Climate Change Project)
PRAA	Proyecto Regional de Adaptación al Impacto del Retroceso Acelerado de Glaciares en los Andes Tropicales (Regional Project for the Adaptation to the Impact of Accelerated Retreat of Glaciers in the Tropical Andes)
SERNANP	Servicio Nacional de Areas Naturales Protegidas (National Service for Protected Natural Areas)
SENAMHI	Servicio Nacional de Meteorología e Hidrología del Perú (Peruvian National Service of Meteorology and Hydrology)
SINPAD	Sistema Nacional de Información para la Prevención y Atención de Desastres (National System of Information for the Prevention and Attention of Disasters)
UNISDR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change

GLOSSARY

Adaptation
"The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (UNISDR, 2009).

Alluvium (Glacier lake outburst flood)
It is a term used in Spanish geology that refers to the "detachment of large masses of snow and rocks from the summit of great mountains. They travel with high speed through ravines or sloping valleys, due to the rupture of natural and/or artificial dikes, sudden discharges of lagoons or intense precipitations in the high parts of valleys and ravines" (INDECI, 2006).

Awareness
"Knowledge or perception of a situation or fact. Concern about and well-informed interest in a particular situation or development" (Oxford Dictionaries, 2017a).

Coping capacity
"The ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters" (UNISDR, 2009).

Climate Change
"A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2007).

Disaster
"A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (UNISDR, 2009).

Disaster Risk Reduction
"The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events" (UNISDR, 2009).

Early warning system
"The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss" (UNISDR, 2009).

Ecosystem-based Adaptation (EbA)

Ecosystem based Adaptation (EbA) is conceptualized by the Convention on Biological Diversity as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies" (CBD 2009:41 as cited by Renaud et al., 2016). Incorporates biodiversity and ecosystem services into an overall adaptation strategy to help people to adapt to the adverse effects of climate change (Convention on Biological Diversity-CBD 2009)

Ecosystem-based Disaster Risk Reduction (Eco-DRR)

Ecosystem based Disaster Risk Reduction (Eco-DRR) is a more recent concept defined as the "sustainable management, conservation, and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development. People derive indispensable benefits from nature, also known as ecosystem services, which can be harnessed for hazard mitigation, disaster recovery, climate change mitigation and adaptation, livelihoods development and poverty reduction. Eco-DRR provides multiple benefits for human well-being regardless of a disaster event, and involves relatively low cost construction and maintenance where ecosystems are healthy and well managed" (Estrella & Saalismaa, 2013).

Eco-DRR/CCA

"Is the sustainable management, conservation, and restoration of ecosystems to reduce disaster risk and adapt to the consequences of climate change, with the aim of achieving sustainable and resilient development" (Renaud et al., 2016).

Ecosystem Services

"Ecosystem services are the direct and indirect benefits that people obtain from nature". These services are classified as provisioning services, regulating services, cultural services and supporting services (Millennium Ecosystem Assessment, 2005 as cited by (Renaud, Sudmeier- Rieux, & Estrella, 2013).

Glacial lake outburst flood

Glacial lake outburst flood (GLOF) starts with the formation of new glacial lakes and the enlargement of existing ones due to the accumulation of melt water. These unstable lakes are subject to sudden torrent of water discharges that carry out debris on their way becoming into potential sources of danger to people and property in the valleys below them (ICIMOD, 2011).

Hazard
"Is a dangerous phenomenon of environmental origin that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hazards may be natural, anthropogenic or socionatural origin" (UNISDR, 2009 as cited by Renaud, Sudmeier-Rieux, & Estrella, 2013).

Huayco (mud/debris flow)
Huayco is a Peruvian word derived from quechua that etymologically means brook or quebrada in Spanish (Moreno and Percy, 2006). The term refers to the phenomenon caused by heavy rains in high areas that remove and detach deposits of the soil from the slopes, carried by water from the slope to the valleys with a great destructive power, when falling in the rivers causes their overflow, enormous burials and destroys everything that finds on its way: houses, crops, roads, animals, people, etc. (Milla Vergara, 2000). Based on this definition, the appropriate quechua term is "lloclla" that means mud/debris flow and in geology is technically called alluvium (INDECI, 2006).

Landslide
"Sudden drop of a portion of soil, rock, or non-consolidated material, due to the loss of shear strength and gravity, without presenting a sliding plane. The landslide is usually conditioned to the presence of discontinuities or cracks in the soil with absence of non-phreatic water filtration. Generally, they occur on steep slopes" (INDECI, 2010).

Perception
"The way in which something is regarded, understood, or interpreted" (Oxford Dictionaries, 2017b).

Resilience
"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2009).

Vulnerability
"The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Moreover, there are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors" (UNISDR, 2009).

ABSTRACT

Located in the Urubamba mountain range, the Chicón glacier is the third highest tropical glacier of this area and the source of water for the Chicón watershed. Moreover, from this watershed four communities obtain water for human consumption and agriculture, which is their main economic activity. In the last years glacier retreat is evident in the area and threatens the livelihoods of the people because it affects the availability of fresh water.

The general objective of this research is to analyse the perception of people living in this watershed to climate change, disaster risk, and ecosystem-based solutions. The specific objectives are to identify natural hazards and climate change effects in the community, to recognise potential ecosystem services suitable for Ecosystem-based Adaptation (EbA) and Ecosystem-based Disaster Risk Reduction (Eco-DRR), and to assess to which climate change effects and disasters the communities are vulnerable based on their own perception. The methodological steps are based on literature review, expert interviews, questionnaires to the community, a workshop and field observations.

The results show that people perceive changes in the climate such as increase in temperature, less precipitation and shifts of the rainy and the dry season. The climate-related disasters that were identified are Glacier Lake Outburst Flood (GLOF), droughts, frosts and hailstorms. However, GLOFs are not frequent in the area and drought is the hazard that people consider will be more frequent. Additionally, pests were identified as biological hazards. Several ecosystems services can be obtained for EbA and Eco-DRR from forests, especially if native trees such as Qiwiña (*Polylepis spp.*), Chachacoma (*Escallonia resinosa*) and Aliso (*Alnus jorullensis*) are used in ecosystem management. Finally, the hypothesis was partially accepted since people in the study area are to some extent aware of climate change impacts, but only partially understand causes and effects. Further, they recognize most of the ecosystem services that forests provide. Therefore they are starting to implement ecosystem-based solutions in the watershed with the support of external institutions.

Keywords: Climate Change, Disaster Risk Reduction, Ecosystem-based solutions Perception of communities, Chicón watershed.

RESUMEN

Ubicado en la cordillera de Urubamba, el Nevado Chicón es el tercer glaciar tropical más alto de esta cordillera y la fuente de agua para la cuenca de Chicón. Así mismo, de esta cuenca cuatro comunidades obtienen agua para el consumo humano y la agricultura, la cual es su principal actividad económica. En los últimos años, el retroceso de los glaciares en esta zona es evidente; afectando la disponibilidad de agua y amenazando los medios de vida de la población.

El objetivo general de esta investigación es analizar la percepción de las personas que viven en la cuenca ante el cambio climático, el riesgo de desastres y las soluciones basadas en ecosistemas. Los objetivos específicos son identificar los riesgos naturales y los efectos del cambio climático en la comunidad, reconocer los posibles servicios ecosistémicos adecuados para la Adaptación basada en los Ecosistemas (EbA), la Reducción del Riesgo de Desastres basado en los Ecosistemas (Eco-DRR) y evaluar a cuáles efectos del cambio climático y desastres, son vulnerables las comunidades basado en su percepción. La metodología consistió en revisión bibliográfica, entrevistas a expertos, cuestionarios a la comunidad, un taller y observaciones de campo.

Los resultados muestran que las personas perciben cambios en el clima como el aumento de la temperatura, reducción en la precipitación y cambios en la estación lluviosa y seca. Los desastres relacionados con el clima que se identificaron son aluviones, sequías, heladas y granizadas. Sin embargo, los aluviones no son frecuentes en la zona y la sequía es el peligro que la gente considera que será más frecuente. Igualmente, las plagas fueron identificadas como peligros biológicos. Los bosques ofrecen varios servicios ecosistémicos para la Adaptación basada en los Ecosistemas y la Reducción del Riesgo de Desastres basado en los Ecosistemas, especialmente si se utilizan árboles nativos como Qiwiña (*Polylepis spp.*), Chachacoma (*Escallonia resinosa*) y Aliso (*Alnus jorullensis*) en la gestión de ecosistemas. Finalmente, se aprobó parcialmente la hipótesis ya que las personas en el área de estudio están en cierta medida conscientes de los impactos del cambio climático, pero no comprenden las causas y los efectos en su totalidad. Además, reconocen la mayoría de los servicios ecosistémicos que proporcionan los bosques. Por lo tanto, se han empezado a implementar soluciones basadas en los ecosistemas en la cuenca con el apoyo de instituciones externas.

Palabras clave: Cambio Climático, Reducción del Riesgo de Desastres, Soluciones basadas en ecosistemas, Percepción de comunidades, Cuenca Chicón.

1. INTRODUCTION

Peru contains 71% of the tropical glaciers in South America, which are distributed across 19 mountain ranges. The Chicón glacier is one of the 117 glaciers located in the Urubamba mountain range in Cusco, Peru (ANA, 2014). With an altitude of about 5,530 m.a.s.l., Chicón is the third highest mountain in the region and has one of the biggest portions of tropical glaciers of the country. The site is located in a subtropical highland climate zone with two defined seasons. The dry season lasts from May to November while the rainy or wet season begins in December and ends in April, with an average temperature range from 11 to 16° Celsius (INDECI, 2005). The complex combination of topography, altitude, the Humboldt current, El Niño Southern Oscillation (ENSO), and the Intertropical Convergence Zone (ITCZ) creates different micro climates in the tropical Andes, allowing for a high degree of biodiversity and different ecosystem services (Drenkhan, 2016).

The water coming from this glacier flows through the Chicón river and four rural communities make use of it. The main economic activities of these communities are agriculture (primarily corn and vegetables) and livestock rearing. Most of the population speaks both Quechua and Spanish. According to the last population census of Peru, in 2007 the Urubamba district had a total of 17,787 inhabitants of which 34% live in rural areas (INEI, 2007). The settlements are surrounded by pine (*Pinus sp.*) and eucalyptus (*Eucalyptus sp.)* plantations. Due to the closeness of the communities to the Chicón glacier they are vulnerable to the effects of glacier retreat (Proyecto INDECI-PNUD, 2005).

Climate change is increasing the risks of climate-related disasters that harm people's livelihoods, assets, economies and safety (Munang et al., 2013). At the same time, climate change accelerates glacier retreat in the tropical Andes. Glaciers are important water sources for the communities, especially nowadays, as the water demand in these watersheds are rising due to irrigated agriculture expansion and population growth (Drenkhan, 2016).

Many studies refer to the key role of ecosystems in climate change adaptation and disaster risk reduction, since ecosystems provide many ecosystem services, including: natural protection against hazards, climate and water regulation, carbon sequestration, and pest regulation. In addition to this, management of ecosystems increases the resilience of the ecosystems and communities to climate change and disasters (Munang et al., 2013).

In order to understand the interactions between climate change, disasters, and ecosystems, and to plan effective solutions at the community level, participatory tools are good options as they allow combining local knowledge with scientific information. It also allows a better understanding of the perception of communities that are often the most vulnerable to climate change and disasters as they have limited access to those resources that would facilitate their resilience (CARE International, 2009).

1.1. Problem Analysis

In terms of climate change, Peru faces trends such as increasing temperatures, extreme temperature fluctuations, changing rainfall patterns, sea level rise, and a rising rate of glacier melt in the Andes. The country is strongly vulnerable to these changes, as the majority of inhabitants live in water-sensitive areas, work in resource-dependent sectors such as agriculture or fishing, or live in or on the margins of poverty (USAID, 2011).

The Chicón watershed is highly degraded and affected by climate change. The rapid glacier coverage decline represents a big issue since glaciers are the main source of fresh water in Peru. From 1970 to 2009 the glaciers in the Urubamba mountain range had reduced by 61,61% (25,59 km^2) based on the 41,48 km^2 glacier coverage partially inventoried in 1970 (ANA, 2014). Moreover, in 2010 the abrupt ice melting of the Chicón glacier led to the formation of two new lagoons; the Ritticocha and Wiñajcocha as well as the falling of ice blocks over Urubamba city, destroying roads, agricultural fields, houses, schools and health centres (PREDES, 2010).

According to the Environmental Ministry of Peru, glaciers below 5,000 m.a.s.l. will disappear by 2025 due to climate change. Glacier retreat has different effects ranging from the quality and volume of water, its effects on health, agriculture, impact in hydropower generation, losses infrastructure, ecosystems and services environmental deterioration and loss of diversity biological; all these impacts translate into decrease of GDP and thus a drop of the Peruvian economic status; at the same time, it directly affects levels of development and welfare of the affected population (Gil Mora, n.d). Glacier melting also rises the risk and exposure of several poor and vulnerable communities to disasters, such as landslides, mudslides and GLOFs that most of the time end in material and human losses (Fontenla et al., n.d.).

1.2. Research Gaps

The following research gaps were found in the study area and are going to be addressed in this investigation:

- Climate change studies are done only in a regional scale in Peru.
- Perception of the people to climate change, disaster risk reduction and ecosystem based solutions in the Chicón watershed is not documented.
- So far, no vulnerability assessment has been conducted in the Chicón watershed.
- There are only few studies about EbA and Eco-DRR for tropical glaciers in Peru.

1.3. Research Questions

- How is climate change impacting the Chicón watershed?
- How do people in the Chicón watershed perceive climate change and disaster risk and are they aware of ecosystem-based solutions?
- To which climate change effects and disasters are the communities vulnerable in the Chicón watershed?
- What are the potential ecosystem services that can be used for EbA and Eco-DRR in the Chicón watershed?

1.4. Objectives

In accordance with the problem analysis and research questions the following objectives were formulated:

1.4.1. General Objective:

- Analyse the perception of people to climate change, disaster risk and ecosystem based solutions in the Chicón watershed.

1.4.2. Specific Objectives:

- Identify climate change effects and natural hazards in the study area.
- Asses to which climate change effects and disasters the communities are vulnerable based on their own perception.
- Recognise potential ecosystem services suitable for EbA and Eco-DRR

1.5. Hypothesis

The following hypothesis was developed and tested in the Chicón watershed:

Climate change increases disasters such as droughts and GLOFs in the Chicón watershed. People in the study area are aware of climate change impacts, but they only partially understand causes and effects. Ecosystem services for climate change adaptation and disaster risk reduction are also not fully understood and therefore ecosystem-based measures remain untapped.

The prediction of this hypothesis would be:

If the close interrelations between climate change impacts, disaster risk and protective ecosystem services are fully understood among the inhabitants in the Chicón watershed, Eco-DRR and EBA projects can be easier accepted and implemented by the communities.

2. STATE OF THE ART

This chapter provides an overview of the latest international agreements that recognized the role of ecosystem services that, for instance, land, wetlands and biodiversity provide. These agreements also promote the use of ecosystem-based solutions for Climate Change Adaptation and Disaster Risk Reduction. Although is not an agreement, Eco-DRR has also been supported by the IPCC Special Report on Extreme Events where experts recommend investing in ecosystems, sustainable land management and ecosystem restoration and management (IPCC 2012; Lo, 2016). Likewise, projects and initiatives that use Eco-DRR and EbA approaches in Andean countries are shown. Finally, the status of implementation of these concepts and inclusion of communities' perception in Peru is also reviewed.

2.1. Recent International Agreements linked to Ecosystem-based solutions for Climate Change Adaptation and Disaster Risk Reduction

2.1.1. Sendai Framework for Disaster Risk Reduction (SFDRR)

According to the UNISDR, the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) is the first major agreement of the post-2015 development agenda, with seven targets and four priorities for action. It is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters. The framework is a 15-year voluntary, non-binding agreement, which recognizes that the state has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. The goal of this framework is to reduce disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries (UNISDR, 2015).

2.1.2. Sustainable Development Goals

The 17 Sustainable Development Goals were adopted by the UN General Assembly in September 2015 and came into effect in January of 2016. It is also a 15-year agenda that aims to protect the planet and ensure prosperity for all. Some of these goals refer to the role of ecosystems services for climate change adaptation and disaster risk reduction (UNDP, 2016).

2.1.3. COP 21 Paris Agreement- UNFCCC

The Paris agreement was adopted in 2015 and brought together all nations to fight climate change and adapt to its effects. Its objective is to "strengthen global respond to climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius". All parties have to reduce their emissions and present

their nationally determined contributions (NDCs) every five years in order to achieve the common goal. (UNFCCC, 2015).

2.1.4. Ramsar Convention on Wetlands of International Importance

The Ramsar Convention offers the structure for international cooperation and national action for the conservation and prudent use of wetlands and their resources. In June 2015, this convention gave important emphasis on the integration of CCA and DRR in wetlands management (Estrella et al., 2016).

2.1.5. United Nations Convention to Combat Desertification - UNCCD

This convention deals with the issue of land degradation and desertification and calls for measures on sustainable land management. At the 12th COP in 2015, it was established that parties will focus their action programmes in achieving land degradation neutrality (LDN) by the sustainable use, conservation and restoration of ecosystems and biodiversity in the context of reducing the risk of desertification and drought (Estrella et al., 2016).

2.1.6. Convention on Biological Diversity

This convention, defined the concept of EbA in 2009 and on its 12th COP in 2014, promotes a stronger role for biodiversity conservation and implementation of ecosystem-based approaches to climate change mitigation and adaptation, so as disaster risk reduction in local and national strategies as well as in National Adaptation Plans (NAPs) (Estrella et al., 2016).

2.2. Strategies and Research on EbA and Eco-DRR in Andean Countries

2.2.1. Ecosystem-based approaches to Adaptation: Restoring Paramos in Highland Ecuador (PRAA Project)

The *Regional Adaptation Project to the Impact of Accelerated Glaciers Retreat in the Tropical Andes (PRAA)* pursues to increase adaptive capacities in communities impacted by rapid glacier retreat in the high Andes in Bolivia, Peru and Ecuador. It was executed from 2008 to 2012 and included pilot projects that were carried out by CARE in priority watersheds of the tree countries to strengthen ecosystem resilience and local economies to the impact of glacier retreat in the tropical Andes (Fontenla et al., n.d.). The study case from Ecuador is directly linked to the use of ecosystems for climate change adaptation and a summary of it is presented below.

The pilot area is located in the micro watershed Papallacta, close to the Antisana glacier, and supplies 30% of drinking water to Quito, the capital city of Ecuador. The community has 500 families that work primary in private and public water, energy and oil companies. The secondary sources of income are tourism and dairy farming. Moreover, they have low social organization levels and depend on external markets for their food provision

(Fontenla et al., n.d.). Hence, CARE Ecuador developed adaptation measures that included: 1) Implementation of home gardening techniques to enhance the resilience of subsistence farming 2) Implementation of agroforestry plantations for protection ecosystems and water sources. 3) Participatory water monitoring. 4) Implementation of a Wildfire Prevention Plan for the Paramo (high mountain wetlands). In long run the sustainable management of the Paramo will benefit the Papallacta community and the downstream urban water users in Quito (Girot, 2013).

2.2.2. "Living with floods" Strategies - Ecuador

This kind of projects use the natural storage and recharge properties of critical forest and wetlands by including them in solutions to reduce floods, rock fall, avalanches and landslides by incorporating forest protected areas and riparian corridors. The main goal is to reduce disasters by ecosystem-based solutions (McBreen, 2016).

2.2.3. Biological Corridors in a Changing World - Ecuador

This bank-funded project in the highly threatened Choco Andean system in Ecuador, has increased the connectivity of forest patches and strengthened biological corridors through funding for private reserves and innovative conservation models bringing together states, municipalities, NGOs, and academic institutions (The World Bank, 2009).

2.2.4. Climate Change Adaptation Project (PACC) - Ecuador

Implemented by the Ministry of Environment and UNDP, this project is focused on 36 community level projects in Azuay, Loja, Manabí and Morona Santiago provinces. Through recovery of ancient knowledge and practices, agroecology and forest management enough water resources will be ensured for the present and the future reducing climate change vulnerability (McBreen, 2016).

2.2.5. Addressing Food Security: traditional knowledge for adapting productive systems to climate change - Ecuador

This project was applied by ECOPAR in the Paramos of Chimborazo / Chorrera Mirador and Pulinguí San Pablo. It strengthened capacities of local stakeholders for the planning and application of climate change adaptation measures, promoted policies to conserve and manage Paramus. Ecosystem-based approaches included pastures improvements for sustainable livestock production, and incorporation of windbreaks to reduce vulnerability of pastures to frost and strong winds (McBreen, 2016).

2.2.6. Adaptation measures and conservation of ecosystem services in the El Ángel watershed - Ecuador

Corporación Grupo Randi Randi led the project with focus on inclusive and sustainable watershed management for climate change adaptation. It promoted sustainable livelihoods management, protection of riverbanks and wetlands, and reduction of natural

hazards such as floods and drought, by using a participatory approach that involved communities, public sector, civil society and non-governmental organizations to support food security and build resilience to disasters and climate change (McBreen, 2016).

2.2.7. PRAA Project - Bolivia

In Bolivia, the PRAA incorporated the impact of rapid glacier retreat into integrated watershed management, creating an integrated pilot catchment management plan for watersheds, and mainstreaming adaptive river defenses (The World Bank, 2009). The pilot areas included 3 Sub-basins: Cullucachi in the Batallas municipality, Amachuma Grande and Tapacaya in the Palca municipality. In this mountain areas, the aim was to have more resilient crops to climate-related disasters and improve the water supply (Fontenla et al., n.d.).

2.2.8. Traditional knowledge for adapting productive systems to climate change - Bolivia

Implemented by the Ministry of Environment and Water of Bolivia (MMAyA) in the Mamoré River Basin, Beni department to avoid disasters such as floods and drought, traditional knowledge on cultivation and irrigation (Waru Waru) was used to capture water when there are droughts and when there is too much rain allowing crops to be effectively irrigated all year round and acts as an important buffer to ecosystems and communities in times of flash flooding; improved income opportunities for communities by promoting crop production in periods of flood and drought, and also promotes CCA and DRR to floods and drought in communities (McBreen, 2016).

Amazonia Services in the Santa Ana del Yacuma Municipality, Beni department, executed a similar project. It also promoted the ancient soil management system Waru Waru to improve food security, carbon sequestration and to protect against soil erosion of the Amazon plain and gallery forests (McBreen, 2016).

2.2.9. Building awareness and strengthen DRR capacities - Bolivia

The project was founded by the Swiss Cooperation and took place in six departments: La Paz, Oruro, Cochabamba, Chuquisaca, Potosí and Tarija. One of the components focused on reducing climate risks in agriculture by the application of agroecology practices in mountain ecosystems for prevention, mitigation and adaptation (McBreen, 2016).

2.2.10. Biological Corridors in a Changing World - Colombia

The Global Environmental Facility (GEF) project in the Andes is committed to building ecological corridors through degraded cloud forests and Paramo habitats of the mountain chain. The project has recognized new areas for conservation through private reserves and at the moment is working with farmers to raise awareness of the need to establish biological corridors that will also help to adapt to climate change (The World Bank, 2009).

2.2.11. Payments for Environmental Services to Protect Biodiversity and Carbon in Agricultural Landscapes - Colombia

By using payment for ecosystem services, the GEF-financed project, *Regional Integrated Silvopastoral Approaches to Ecosystem Management* was implemented, among other countries, in Colombia from 2002-2008. The idea was to demonstrate and measure the effects of payment incentives to farmers for environmental services. The project demonstrated that silvopastoral practices generate substantial benefits in terms of biodiversity conservation, carbon sequestration and water services, and that PES can induce, in a positive way, significant land use changes. Based on these results, a larger scale project is being prepared to scale up and adopt biodiversity-friendly silvopastoral production systems (The World Bank, 2009).

2.2.12. National Adaptation Plan (NAP) framework - Colombia

It was developed by the government in 2011 to address climate change, defining guidelines for different sector and territories to reduce vulnerability and include climate change and climate variability in their planning methods. In total 11 territorial climate change adaptions have been formulated. The EbA and Eco-DRR measures currently implemented include: rehabilitation of wetlands to reduce flooding risk and drought related to climate change and variability, and adaptation measures to mitigate climate change on the water yield and hydrological regulation capacity of wetlands and high mountain ecosystem. Other key ecosystems they considered are Moors (Paramo, Andean woodlands), high Andean forest, cloud forest and tropical forest (Lo, 2016).

2.2.13. Restoration of highly degraded dry forests - Colombia

It was implemented by the Alexander von Humboldt Research Institute of Biological Resources, along with other institutions in the Ituango Municipality, Department of Antioquia. The restoration activities will be achieved through three pilot projects to compensate environmental harm caused by the construction of a reservoir, and to contribute to the conservation of the fragile dry forest ecosystem of the area. The project will work as a reference for compensation (McBreen, 2016).

2.2.14. Management Plan for the Arroyo Carolina micro-watershed - Colombia

The management plan of the watershed was developed by the Fundación Humedales and included watershed uses, vulnerability analysis and management plan oriented to climate change adaptation. Each land use was identified and mitigation measures were associated with the restoration and recovery of the ecosystems existing in the watershed (McBreen, 2016).

2.2.15. Vulnerability Assessment and adaptation strategy of the Lagunas de Fúquene Cucunubá and Palacio - Colombia

It was established by the Fundación Humedales and its aim was to create a management plan using ecosystems services derived from the lagoons and wetland complex to adapt to climate change in the highlands on the Eastern Cordillera of the Colombian Andes. (McBreen, 2016).

2.3. Implementation of Solutions in Peru

To adapt to climate change Peru has developed a National Strategy for Climate Change that was last updated in 2014 and contains the guidelines to promote national actions on climate change until 2021. Moreover, its vision is to adapt to the adverse effects and take advantage of the opportunities that imposes climate change by setting the basis for a low carbon sustainable development. This strategy is implemented through institutionalism and governance, public awareness and empowerment of capabilities, scientific knowledge, technology and financing. It presents synergies with biological diversity, water resources, desertification, energy, cities, etc. (Ministerio del Ambiente, 2015).

Peru has 11 framework instruments related to environmental management where climate change adaptation and disaster risk reduction are tackled. Those instruments are: National agreement, General Environmental Law, Organic Law of Regional Governments 2002-Law 27867 and its modification, Multi-annual Macroeconomic framework, National Environment Policy, National Plan of Environmental Action 2011-2021, Bicentennial Plan: Peru towards 2021, Framework Law of the National Environmental Management System, Creation Law of the National Disaster Risk Management, National Agenda for Environmental Action 2013 - 2014, National Policy for the Modernization of Public Administration 2021. From these instruments it is important to mention that the National Plan for Disaster Risk Reduction remarks that ecosystem protection is relevant for DRR.

Regarding the management of climate change Peru has 8 specific documents: First National Communication on Climate Change 2001, National Strategy of Climate Change, Second Communication on Climate Change, Action Plan for Adaptation and Mitigation to Climate Change - PAAMCC, Risk Management and Adaptation Plan to Climate Change in the Agrarian Sector 2012 – 2021, Regional Climate Change Strategies on the basis of the Regional Governments Organic Law, Report of the Multi-sector Commission created by Resolution No. 189- 2012-PCM, and Third National Communication on Climate Change.

Peru hosted the COP20 of the United Nations Framework Convention on Climate Change (UNFCCC) in 2014. These instruments and the COP 20, show that the country is engaged with climate change mitigation and adaptation in an international level.

When it comes to implementation of measures some examples with focus on ecosystem-based solution were found.

The Mountain EbA Project: Climate Change Adaptation in the Peruvian Andes: Implementing no regret measures in the Nor Yauyos- Cochas Landscape is a pilot project run by the Ministry of Environment of Peru (MINAM) and is implemented in the Nor Yauyos-Cochas Landscape Reserve (NYCLR), with support from the National Service for Protected Natural Areas (SERNANP, in Spanish). Its objective is to reduce the vulnerability of Peru to climate change impacts through piloting EbA options with particular emphasis on mountain ecosystems in the Nor Yauyos-Cochas Landscape Reserve. This project is a good example of implementation of ecosystem-based solutions and community participation.

Participatory Management of Protected Areas, in Peru is a project that has been supported by GEF since 2005. The Salinas and Aguada Blanca National Reserve is one of the protected areas supported under the project. The study area is located north of Arequipa city, at an altitude between 3,600 and 6,000 meters. With 3 volcanoes and 2 lagoons it is the habitat of 169 animal species (of which 23 mammals and 138 birds) and protects a large source of water that supplies the city of Arequipa as well as other smaller towns. The natural ecosystems are threatened by deforestation by the 14 local communities. Therefore several sub-projects have supported water conservation and management activities that at the same time had a positive impact on biodiversity conservation. Some of the solutions are water retention terracing to collect water during the raining season and to improve infiltration and conservation, including traditional knowledge (The World Bank, 2009).

Another project was implemented in the native Awajun community called Shampuyacu in the San Martin region in the Peruvian Amazon, under the REDD+ mechanism. The objective of the project was to increase the riparian vegetation cover and to protect the crops from river bank erosion and floods (McBreen, 2016).

The Regional Adaptation Project to the Impact of Accelerated Glaciers Retreat in the Tropical Andes (PRAA) was also implemented in Peru from 2008 to 2012. The objective of the project was to improve the water storage infrastructures and water use practices in the agricultural and livestock sectors (CARE Peru, n.d.). It included activities such as reforestation, infiltration, ditches, terraces and others. CARE Peru was in charge of the implementation of the following pilot projects:

- Promoting the integrated and participatory management of water resources in the Shullcas River sub-basin.
- Promoting the integrated and participatory management of water resources in the Santa Teresa micro basins (Ahobamba, Sacsara and Salkantay, Chaupimayo and Vilcanota).

After reviewing this project it can be stated that ecosystem-based solutions are being implemented in the country but also in the Andes mountain range. Although, there are not so many pilot projects, they can be used as example of the benefits that Eco-DRR/CCA gives.

3. THEORETICAL FRAMEWORK

3.1. Climate change

For long times in the Holocene, the climate in the earth persisted only with slight changes. However, 200 years ago changes began. Population started to grow and fossil fuel became the energy source that enabled rapid industrialization. However, its consumption has increased the concentrations of carbon dioxide in the atmosphere keeping the planet warm (Hardy, 2003). Moreover, climate change has been defined by the Intergovernmental Panel on Climate Change (IPCC) as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2007).

Several scientists have shown evidence of the influence of climate change in the fast retreating of glaciers above 5000 m elevation (Hastenrath and Ames, 1995; Kaser and Georges, 1999; Francou et al., 2003; Bradley et al., 2006). For instance, the model in figure 1 shows that temperatures will increase the higher the mountains are. Therefore the Andean glaciers are predicted to have the highest temperature increases. Studies also indicate that temperatures have increased 0.11 °C/decade in the Andes mountain range, a rate much higher than the global average of 0.06 °C/decade, during the period between 1939 and 1998. The warmest years were recorded at the beginning of 1980 (M. Vuille et al. 2003; Bradley et al., 2006).

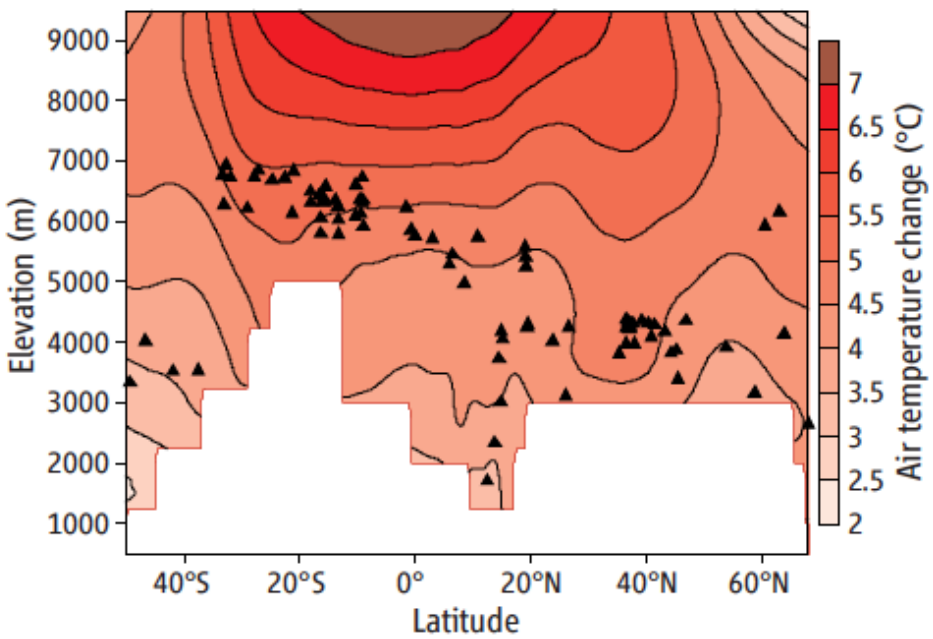

Figure 1. Global warming in the American Mountain range

Projected changes in mean annual free-air temperatures between (1990 to 1999) and (2090 to 2099) along a transect from Alaska (68°N) to southern Chile (50°S), following the axis of the American Cordillera mountain chain. Results are the mean of eight different general circulation

models used in the 4th assessment of the Intergovernmental Panel on Climate Change (IPCC), using CO2 levels from scenario A2 in the Special Report on Emissions Scenarios. Black triangles denote the highest mountains at each latitude; areas blocked in white have no data (surface or below in the models). **Source:** (Bradley et al., 2006)

The convergence of several factors contribute to the changes in glacier mass. According to several studies variability of precipitation in Andean countries is related to the El Niño–Southern Oscillation (ENSO) concluding that El Niño years (warm phase of ENSO) tend to be warm and dry, while La Niña years (ENSO cold phase) are associated with cold and wet conditions on the Altiplano. Deficit in precipitation and cloudiness explains low values of albedo and the high melt rates (Favier et al., 2004a, Rabatel et al., 2013). Opposite to this, the cold ENSO phase brings colder temperatures, higher snowfall amounts and increased cloudiness, preventing albedo drops and decreases available energy for melt (see figure 2 below). Though, the changes in glacier mass are complex, temperature is a good indicator as most of the observed changes are linked to rise in temperature (Francou et al, 2003; Bradley et al., 2006)

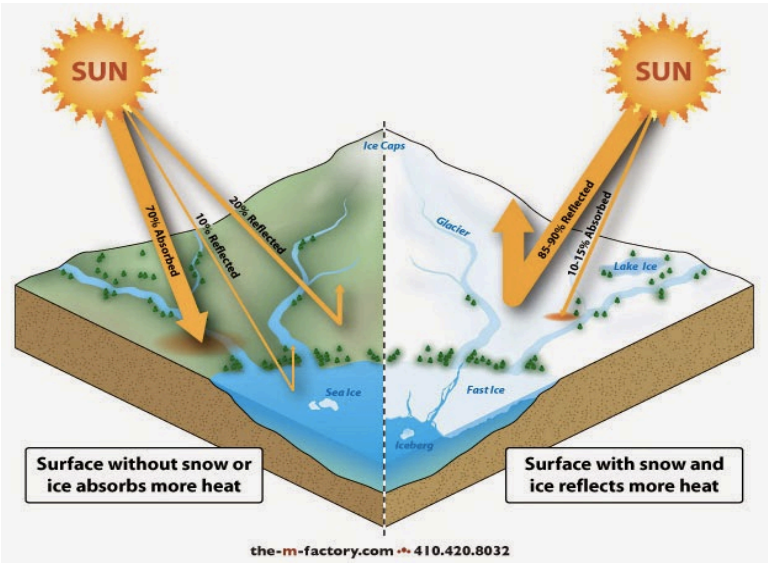

Figure 2. Albedo effect and energy reflected by glaciers
Source: https://goo.gl/images/fe6kzq

3.2. Natural Hazards and Disasters

Many people around the world live and work in dangerous places, for instance near volcanoes or in floodplains as these areas provide productive soil for agriculture, the land is cheap or just because the resources they need are closer. Besides, the reason for this can be cultural, economic (poverty) or lack of knowledge. People build houses in dangerous areas and when a natural hazard occurs it can cause serious physical damage and even cause the death of people (Hyndman and Hyndman, 2016).

The type of damage that natural hazards cause depends on the economic development of the area. In developing countries the majority of losses are human, while in developing countries the losses are usually economic. Additionally, climate change is leading to more

extreme weather events that trigger landslides, floods, hurricanes and wildfires (Hyndman and Hyndman, 2016).

There are several concepts of hazards but the following definition is used in this research. A hazards "a dangerous phenomenon of environmental origin that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hazards may be natural, anthropogenic or socio natural origin" (UNISDR, 2009 as cited by Renaud, Sudmeier-Rieux, & Estrella, 2013). Whereas, disaster is "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (UNISDR, 2009).

Based on this definition hazards can derived from technical and human activity. The hazards originated from the earth are classified as Geotectonic hazards and Hydrometeorological hazards (Ranke, 2015).

- *Geotectonic hazards:* Natural processes that have their origin in Earth's crust and mantle resulting in convectional movements that cause lithospheric plates to be permanently in motion; this motion lets mountain ranges build up, oceanic plates subduct under continental plates, or oceanic ridges develop. These movements are the triggering elements for earthquakes, volcanic eruptions, mass movements, or the uplifting or subsidence of land.

- Hydrometeorological hazards: Natural processes that have their origin in the Earth's atmosphere. They are responsible for climate variations that create flash floods, droughts, storms, and/or extreme weather.

The figure 3 shows the hazard classification proposed by CRED and Munich Re.

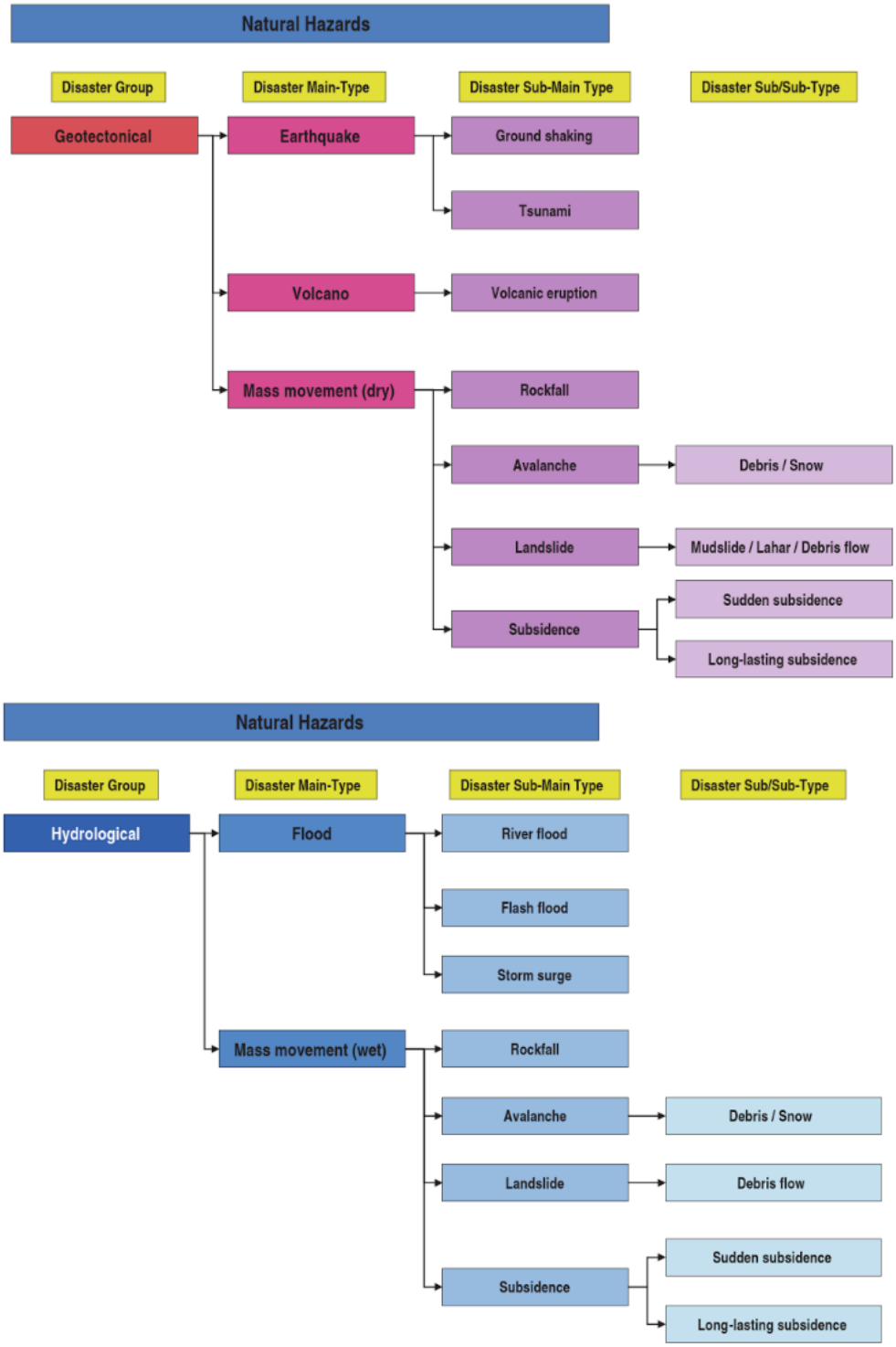

Figure 3. Disaster type classification proposed by CRED and Munich Re
Source: (Ranke, 2015)

As mentioned before, a hazard becomes a disaster when it poses a threat to human beings (Ranke, 2015). Due to the increase of disasters new measures are being implemented to reduce them, one of those is Eco-DRR. The disaster management cycle includes preparation, response, recovery and mitigation (see figure 4).

Figure 4. Disaster management cycle
Source: (Lo, 2016)

3.3. Opportunities of Ecosystem based approaches in CCA and DRR

The concept of ecosystem services gained more attention after the Millennium Assessment defined it as: the benefits people obtain from ecosystems and divides ecosystem services into supporting, regulating, provisioning and cultural services (MEA 2005; Estrella and Saalismaa, 2013). Ecosystems provide a range of services that are fundamental to human well-being, health, livelihoods and survival (Constanza et al., 1997; MEA, 2005; TEEB Foundations, 2010; TEEB Synthesis, 2100; Ninan, 2014).

As shown in figure 5, ecosystems services derived from the natural capital, which contributes to achieve human well-being by interacting with built capital (financial and manufactured capitals), social capital, human capital and natural capital (Ninan, 2014). However, human well-being, livelihoods, and ecosystems around the world are being threatened by climate change and climate-related disasters (Lo, 2016).

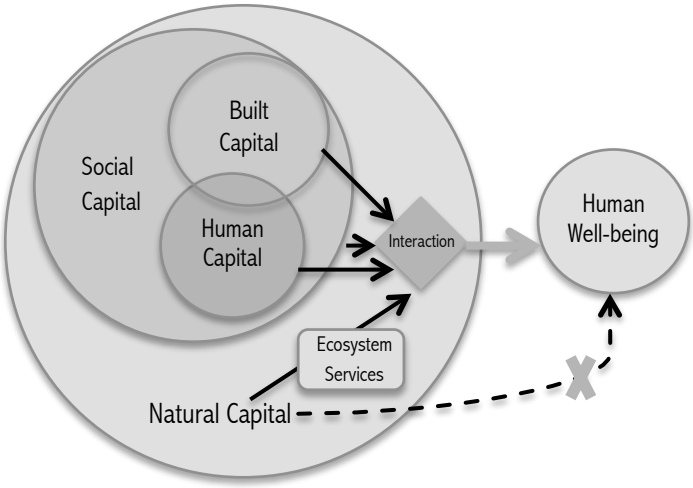

Figure 5. Capital forms and Ecosystem Services
Source: Ninan, 2014

The management, conservation and restoration of ecosystems has been recognized by several experts as a key component for climate change adaptation and disaster risk reduction (Estrella and Saalismaa, 2013). From this idea the concepts of Ecosystem-based Disaster Risk Reduction (Eco-DRR) and Ecosystem-based Adaptation (EbA) have emerged.

Ecosystem-based Disaster Risk Reduction (Eco-DRR) is defined as the "sustainable management, conservation, and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development" (Estrella and Saalismaa 2013; Renaud et al., 2016).

On the other hand, Ecosystem-based Adaptation (EbA) was defined few years before as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies" (CBD 2009; Renaud et al., 2016).

Based on their concepts the main difference between them is that each approach addresses an specific issue, DRR and CCA (Renaud et al., 2016). Yet, as seen in figure 6 they have more similarities than differences and overlap as they focus on ecosystems (Lo, 2016).

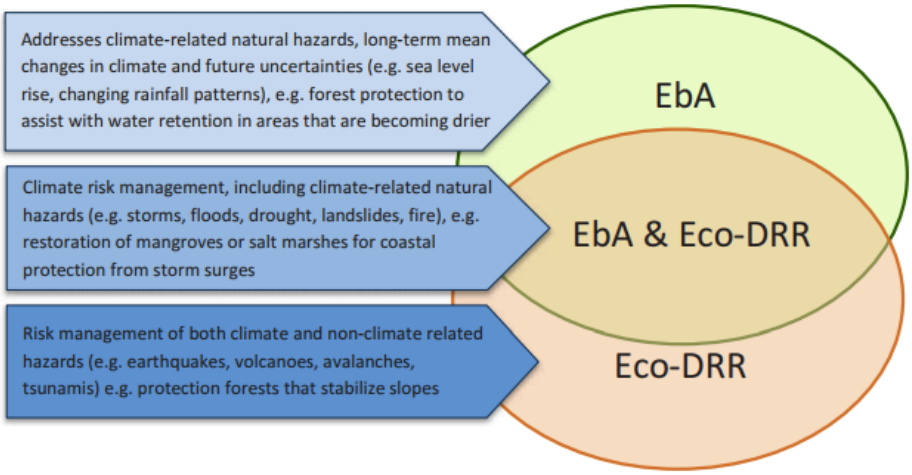

Figure 6. Overlap between ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR)
Source: (Mitchell and Van Aslst, 2008; Lo, 2016)

After finding many converging points between these two approaches, another concept has arisen to emphasize the benefits that ecosystem-based approaches provide to achieve both DRR and CCA. Eco-DRR/CCA is described as "the sustainable management, conservation, and restoration of ecosystems to reduce disaster risk and adapt to the consequences of climate change, with the aim of achieving sustainable and resilient development" (Renaud et al., 2016). Finally, Eco-DRR/CCA complement other disaster risk reduction and climate change adaptation measures. Additionally, ecosystems provide other co-benefits to societies such as carbon storage and sequestration, water and soil protection, contribution to sustainable livelihoods and so on (see figure 7) (Lo, 2016).

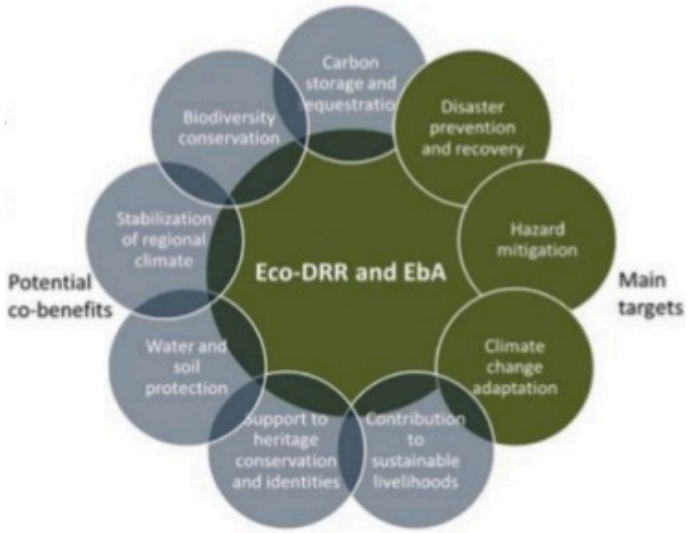

Figure 7. Examples of multiple benefits for Eco-DRR and EbA
Source: (UNEP and CUAS, 2015; Lo, 2016)

3.4. Perception and Awareness

As explained before ecosystem-based approaches represent several opportunities to achieve human well-being. However, for their implementation it is important to understand whether or not communities are actually interested in Eco-DRR/CCA. The perception of communities is needed to know if it is the best option available for all (Estrella et al., 2016).

Perception and awareness of communities can be collected by a participatory research, which is valuable for gathering information and understanding a variety of perceptions at a local level, and for planning interventions that may help hundreds of people (CARE International, 2009). Participatory tools allow the use of guiding questions to identify more specific information, asses vulnerabilities, impacts, hazards and risk, and can be valuable for influencing national policies and practices, such as agricultural research and development priorities, or standards for water utilization (CARE International, 2009).

Knowledge of the communities is valuable as they interact with landscapes and extract natural resources such as firewood. Moreover, their perspective is important to be considered when designing policies and solutions for CCA and DRR (Young and Lipton, 2006). The level of awareness of communities can be used for building up capacities and designing educational campaigns for adaptation to climate change and reduction of disasters (van Aalst et al., 2008) .

4. METHODOLOGY

4.1. Study area

The Chicón watershed is located in the Urubamba province, Peru. This watershed has an area of 37.38 km^2 with an elongated shape and is surrounded by the Sayhua and Tantanmarca hills. Its main river is known as Chicón or Tullumayo and originates from the thawing of the Chicón glacier. The average slope of the channel is 16% but in some areas the slope can be 70%. The Chicón river is a second order tributary with a base flow of 4.0 m^3/sec during the dry period before its volume is captured for irrigation and water supply. The river has a length of 10.17 km that crosses the city of Urubamba by a channeled section of 700 meters length converging at the end in the Vilcanota river (Proyecto INDECI-PNUD, 2005).

On top of the watershed the Chicón glacier can be found, which is one of the 117 glaciers located in the Urubamba mountain range. With a peak of 5,300 m.a.s.l., Chicón is the third highest mountain in the region (INDECI, 2005).

Bellow the glacier in the upper, middle and lower part of the watershed four rural settlements or communities make use of the glacier water: San Isidro de Chicón, Yanaconas, Chichubamba and Ccatan Pino. Urubamba city is located in the river mouth,

on alluvial and fluvial deposits (Tecsi and Tupa, 2017). The following map shows the location of the watershed and the Urubamba province.

Figure 8. Location map of the Urubamba province and the Chicón watershed
Source: Own elaboration

4.1.1. Mountain communities

The above mentioned communities are structured into community assemblies integrated by a president, a secretary and a treasurer that are democratically elected every 2 years. They also have other committees and boards that discuss specific interests. In an inter-communal scale, the Irrigation Committee of the Chicón watershed represents the highest authority. The budget for public works, depends directly on the Urubamba district. The four communities are connected to the drinking water system and drainage facilities, so as electric service (PRODER Cusco, 2013).

All communities have an irrigation committee that discusses and manages the activities related to water for irrigation, particularly for the dry season. According to the community president of San Isidro de Chicón, this is the only committee that is democratically elected every 4 years. Moreover, the Sanitation Service Administrative Boards (JASS) are community organizations with legal status that administrate, operate, and maintain water and sanitation systems. The JASS committee is elected every 2 years.

The “Glass of Milk” Programme is a social feed or nutrition plan that aims to improve the nutrition of the most vulnerable groups such as children up to 6 years old, pregnant women and women during breastfeeding period that do not have enough resources to meet their nutrition needs (Municipalidad Provincial de Ferreñafe, 2017). This programme

includes committees that represent each community and that are integrated by women. Likewise, Women with Identity Committees are formed to watch for women's rights and perform activities for their development.

The following figure summarizes the committees that each community has.

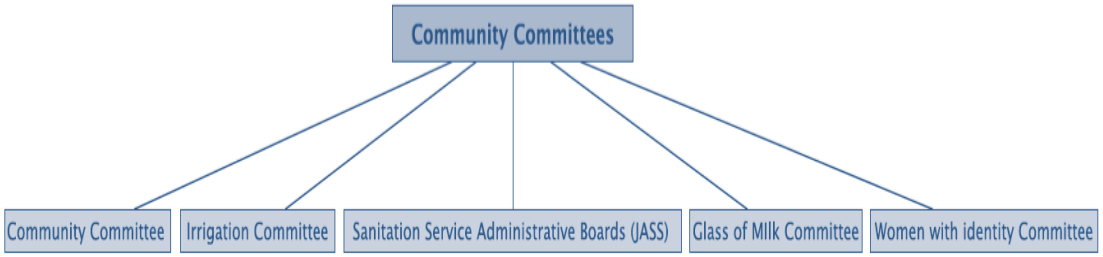

Figure 9. Community Committees in the Chicón watershed

The dominant religion is Catholic with the presence of protestant religions that are fading traditional rituals. Regarding the language they speak Spanish and Quechua (PRODER Cusco, 2013).

- ***San Isidro de Chicón***

This community is located in the upper part of the watershed, 6 kilometers from the Urubamba district and can be accessed by a dirt road (PRODER Cusco, 2013). It is located at an altitude of 3100 m.a.s.l. and according to the president of the community there are 170 families registered. It has an initial school called Ikarus - School of hope (Escuela de La Esperanza) and a Home for children called Munaychay, both created by the NGO Corazones para Peru.

The land ownership is based on community lands where the resources are shared by the community and their land cannot be sold or transferred to people that do not belong to the community. It was recognized in 1980 and the property title was given in 1981. The land is georeferenced (Ministerio de Cultura, n.d.).

- ***Yanaconas***

This community is located in the middle part of the watershed at 5 km away from the Urubamba city, at an altitude of 3000 m.a.s.l.. It shares similar social, political and economic characteristics with San Isidro de Chicón (PRODER Cusco, 2013). It has an initial school called Wawa Sonqo from the NGO Corazones para Peru. Additionally, 169 families belong to the irrigation committee.

People work the land mechanically in accessible areas or with plows pulled by animals. Thus, agricultural customs such as ayni[1] and minka[2] are being lost. The daily wage has been prioritized, although they are trying to keep the ayni, as an ancestral inheritance. The land ownership is dominated by minifundio (small holdings) with property titles but there are still communal lands that are managed by the community itself (PRODER Cusco, 2013).

- ***Chichubamba***

Is located at the valley level at 2 kilometers away from the Urubamba city and can be accessed by a dirt road. It is located at an altitude of 2868 m.a.s.l. (PRODER Cusco, 2013). It has 204 families officially registered in the irrigation committee and is the most populated community. The community has one educational institution at the initial level and another at the primary level. The community has all communication services.

In agriculture, its main crop is white corn, fruit growing, vegetables and flower cultivation. The cows are settled in temporal rotational lands in which natural pastures grow and potatoes of different varieties are planted. This community is not directly exposed to the Chicón river. In Yanaconas the water is deviated from the river to a reservoir, which is connected to irrigation channels that bring water to the croplands. The community is rich in flora and fauna since they have the Wachaq lagoon that also belongs to the Yucay district (PRODER Cusco, 2013).

- ***Ccatan Pino***

According to the interviews with the people in the study area, this community is integrated by the sectors of Cctan and Pino. As they cover a relative small area in comparison to the other communities they got together and formed a political figure to deal with issues related to agriculture, water sanitation, nutrition and so on. They have the same committees as the other communities and 85 families are registered in the irrigation committee.

This community or sector is next to the Urubamba city at 2900 m.a.s.l. and is under process of urbanization. They are water users of the Chicón watershed for irrigation purposes while drinking water supply is also obtained from the neighbor watershed known as Pumahuanca. Similar to Chichubamba, they bring water to their croplands through irrigation channels that are connected to the Chicón river in Yanaconas.

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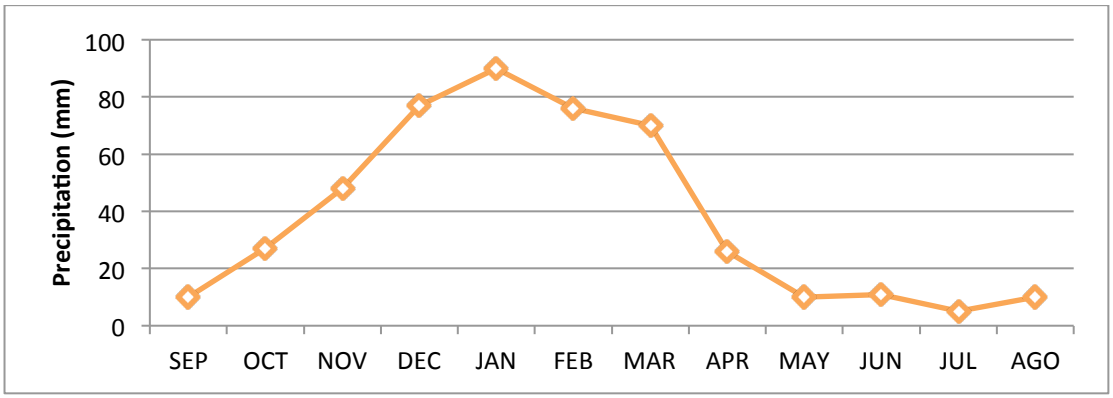
[1] Ayni was a working system of mutual reciprocity between the members of the ayllus (peasant communities, families), destined to agricultural works and to the constructions of houses. The ayni consisted in helping with the works that made a group of people with the condition that they would correspond equally when they needed it (Altamirano and Bueno, 2011).

[2] Minka is the work that was carried out in for the benefit of the ayllu as a whole. A kind of free communal work that consisted in the construction of premises, irrigation chanels, temples and so on (Altamirano and Bueno, 2011)

4.1.2. Climate

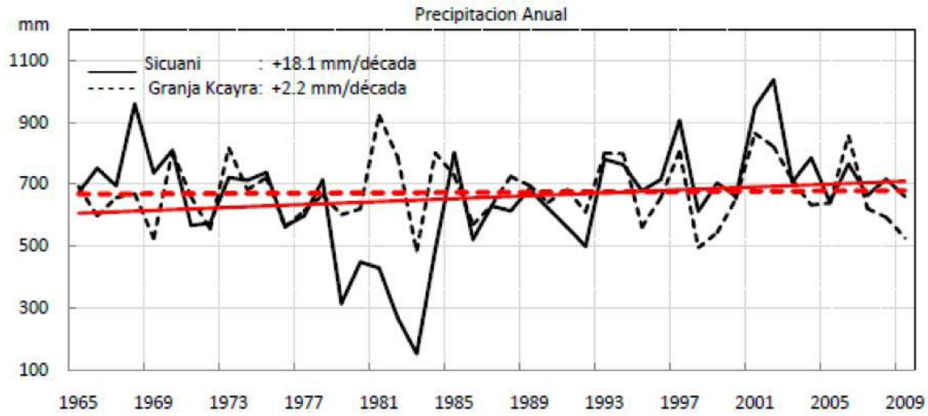
The watershed area presents a subtropical highland climate with two defined seasons and significant difference in temperature between day and night. As seen in figure 2, the dry season last from May to November while the rainy or wet season begins in December and ends in April. Precipitation peaks are common in January with values up to 90 mm/month while July is the driest month with values of 5 mm/month (Proyecto INDECI-PNUD, 2005).

There are four main big scale systems that influence the precipitation patterns in Peru. These are "la Alta Bolivia" (AB), South Atlantic Convergence Zone (SACZ), Intertropical Convergence Zone (ICZ), South Pacific Anticyclone (SPA) and South Atlantic Anticyclone (SAA). The coupling joint from the first three mentioned systems generates a convective activity in the region during the summer, whereas the SPA can be able to block or facilitate the entrance of frontal systems in the winter, which will generate rain events. SAA can enhance the advection of warm and humid air coming from the Amazons and when it clashes with the Andes they ascend because of the orographic effect. This ascension produces a fast cooling of the air and results into strong precipitation that covers the east regions of the Andes (Avalos, 2005).



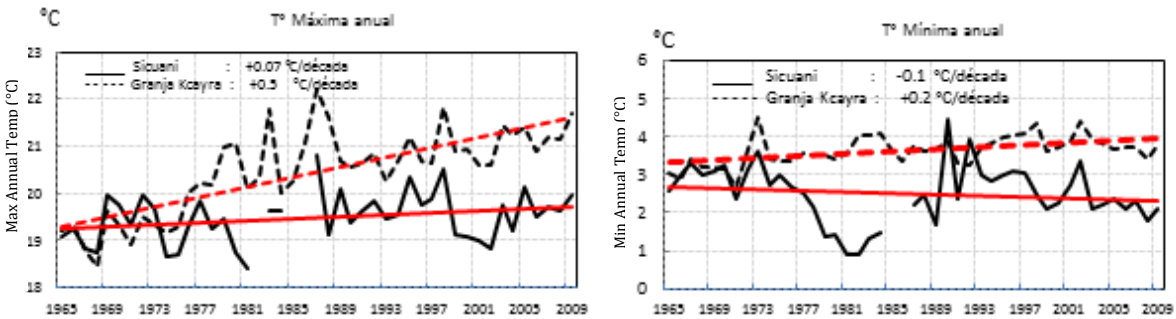
Graph 1. Mean monthly precipitation (mm) in the weather station of Urubamba
Source: SENAMHI, 2007

When it comes to precipitation trend in the last 50 years, a specific increase or decrease cannot be identified, due to the complex spatial distribution of precipitation in the Andes Mountain generated by the big scale systems mentioned above (SENAMHI, 2012). Except for a very dry period in 1976 and 1984 the precipitation has kept constant. Nevertheless, in the last decade big changes of precipitation have not been registered, giving a possible sign of drier conditions for the future.



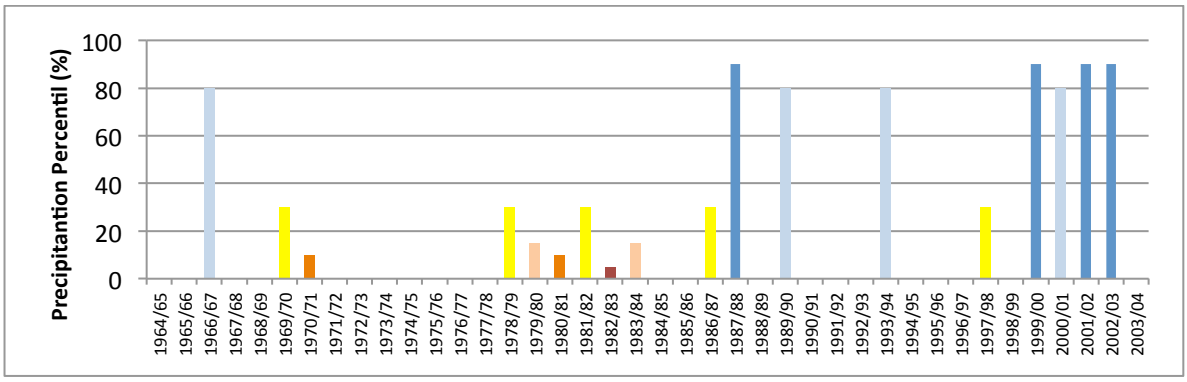
Graph 2. Annual precipitation in the Urubamba watershed
Source: SENAMHI, 2012

The annual average temperature is between 11 to 16 °C. The graph below contains the information about the maximum and minimum annual temperature at two different levels of the Urubamba watershed. Granja Kcayra (uncontinuous line) represents a town from the upper part of the Urubamba watershed and Sicuani (continuous line) of the lower part of the watershed. The Chicón watershed is located nearer to the Granja Kcayra weather station and therefore used as reference for the climate conditions in the study area for the last 50 years. The maximum annual temperature (in the left side) shows a change equivalent to an increase of +0.5°C per decade. According to SENAMHI this tendency corresponds to warmer days and nights, so as a decrease of the "heladas"/ frosts in some locations of the watershed, namely 0.33 day less per year. On the other hand the change of the minimum annual temperature increased by 0.2°C (SEMAMHI, 2012).



Graph 3. Maximum (left) and minimum (right) annual temperature at two different levels in the Urubamba watershed
Source: SEMAMHI, 2012

Drought seasons in Urubamba we determinated by SENAMHI, using the percentile methodology. Lack of precipitation relative to the local mean precipitation will derive in a higher magnitude of drought. If the percentile is 30% (yellow) is considered a "Deficiency", if it is below 15% (beige) will be a "Moderate drought", below 10% (orange) a "Severe drought" and if it reaches only 5% (red) is categorized as an "Extreme drought". The same methodology was used for wet periods, where the yield of the farmers was affected due to intensive and/or prolonged rainy periods. The percentile of 90% (dark blue) represents an "Extreme excess" and if it is 80% (light blue), it is a "Moderate excess" (SENAMHI, 2007).



Graph 4. Determination of drought seasons in Urubamba using the percentile methodology
Source: SEMAMHI, 2007

4.1.3. Land use cover

The study area presents different land uses. As shown in figure 10 the areas where the communities are settled are used for irrigated crops and agroforestry. There are also rainfed crop areas with agroforestry and some portions of pasturelands that are used for animal raising. Furthermore, the Eucalyptus forest is located in the upper part of the San Isidro de Chicón community while the Qiwiña forest mainly covers the steep areas close to the glacier. The surrounding areas of the Chicón glacier from an altitude of 5,000 m.a.s.l. are rocky.

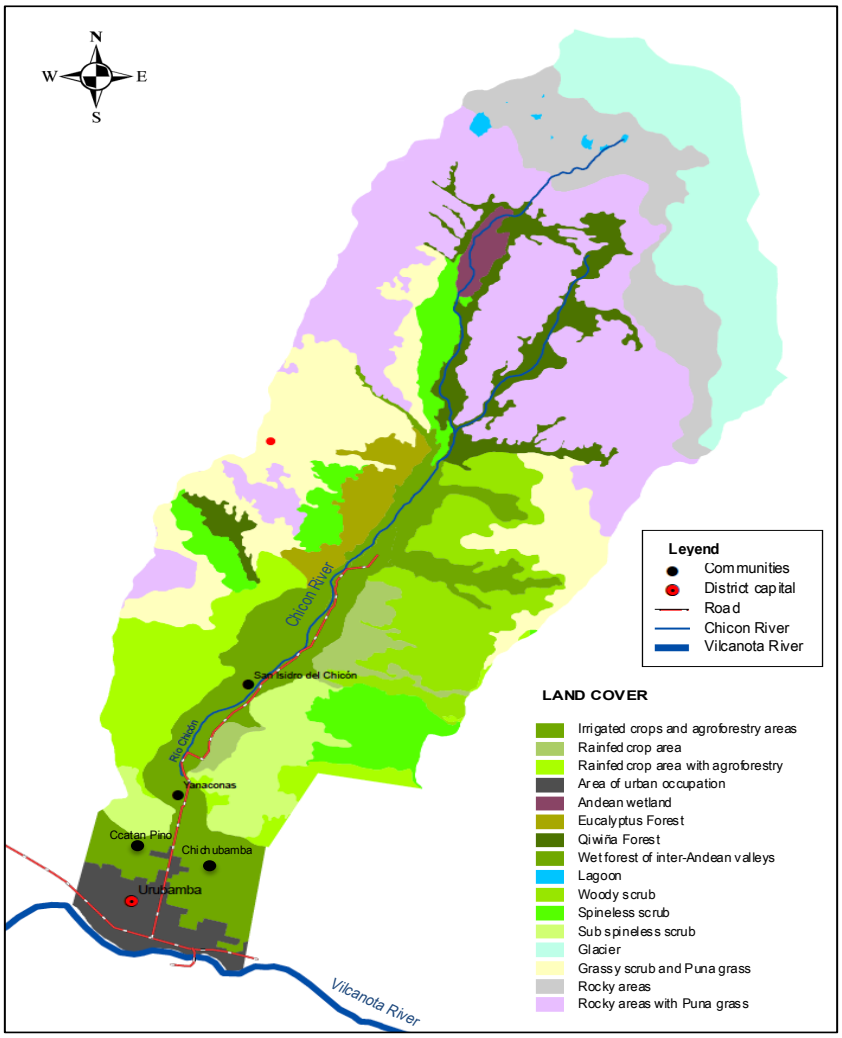


Figure 10. Land cover of the Chicón watershed
Source: Urubamba Provincial Municipality, 2014

According to the Dr. L. R. Holdrige classification the watershed is established between the altitudinal floors in the following life zones (Proyecto INDECI-PNUD, 2005).

- Humid, Montane Tropical Forest (bh-MT).
- Very humid, Sub-Alpine Tropical Paramo[3] (Pmh-sat).
- Pluvial, Sub-Alpine Tropical Paramo (Pp-Sat)

4.1.4. Economic activities

As mentioned before, the economic activities are intensive agriculture and animal husbandry, especially cattle. The main crops produced are corn, potatoes, improved pastures, lima beans, quinoa, oat, alfalfa, barley and other vegetables, that are marketed locally, regionally and nationally. Animal feeding is done with natural pastures found in the upper part of the watershed and stored cornhusk. Moreover, San Isidro de Chicón and Yanaconas have Eucalyptus and Pine plantations that are used as firewood.

[3] Andean Moor

4.1.5. Glacier retreat

Located at 5,300 m.a.s.l, the Chicón glacier belongs to the Urubamba mountain range that drains to the Atlantic Ocean. In 1970, the glacial surface of this mountain range was 41,48 km^2 while in 2009 the area was found to be 15,89 km^2. In other words, this mountain range presents a reduction of 61,61% (25,59 km^2). It is important to mention that in the last inventory it was found other glaciers that were not inventoried in 1970 (ANA, 2014).

The Chicón glacier is in process of deglaciation. It is around 5 km length in NW-SE direction and has an average width less than 1 km. The following figure shows in red the lost area of the Chicón glacier, whereas the light blue spots are the remaining.

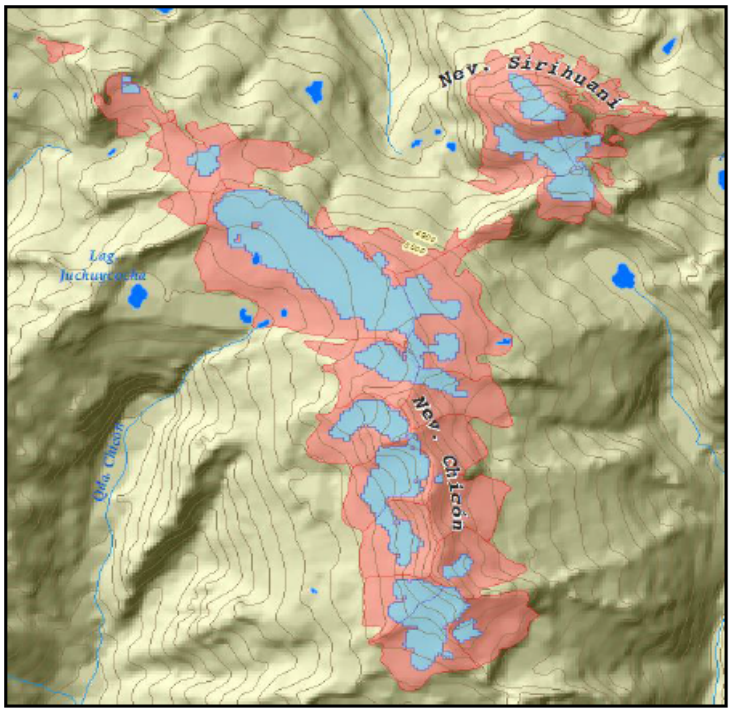


Figure 11. Glacier retreat of Chicón
Soure: (ANA, 2014)

4.1.6. Climate Change projections

- <u>2030 Projection</u>

For the next figures, the projection of the precipitation change until 2030 is exhibited for the Urubamba watershed in different seasons of the year. The Chicón watershed is located very near to Urubamba city (marked with a blue star). The most prominent change happens during winter time (JJA) with a decrease up to 45%. For the rest of the year the precipitation varies from -15% to +15%.

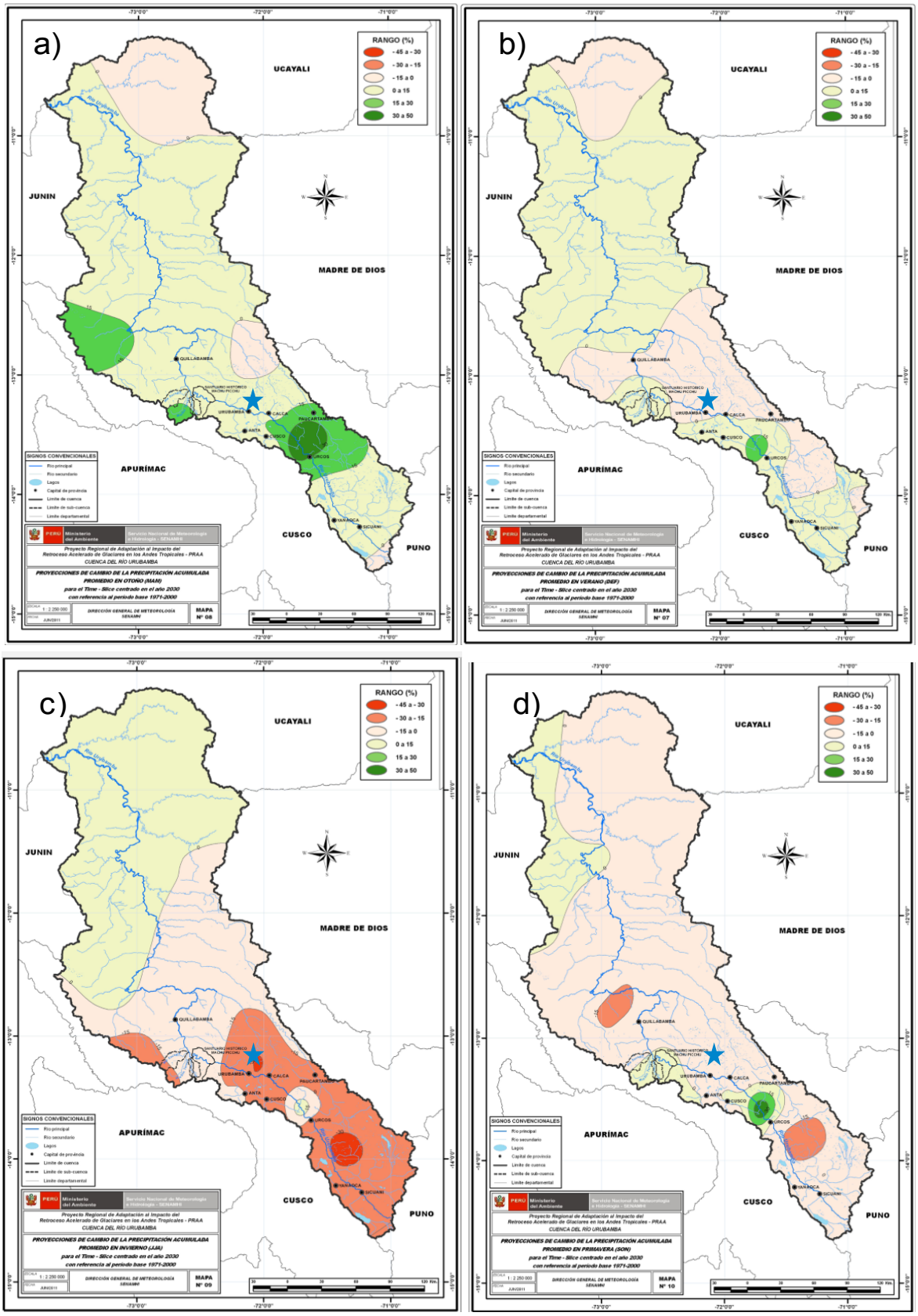


Figure 12. Relative change of precipitation projected for 2030 during different seasons of the year: a) Summer (DJF); b) Autumn (MAM); c) Winter (JJA) and d) Spring (SON). Chicón watershed marked with a blue star. Reddish colors represent a decrease in the precipitation patterns, whereas greenish colors show an increase.
Source: SEMAMHI, 2012

Looking at the outcome of simulation of maximum daily temperature behavior for 2030 in Urubamba an expected increase of about 1°C is expected all over the year. In the graph below the change can be observed in the different seasons. The minimum daily temperature behaves similar to the maximum one. A warming up of 1°C was simulated for the different season of the year.

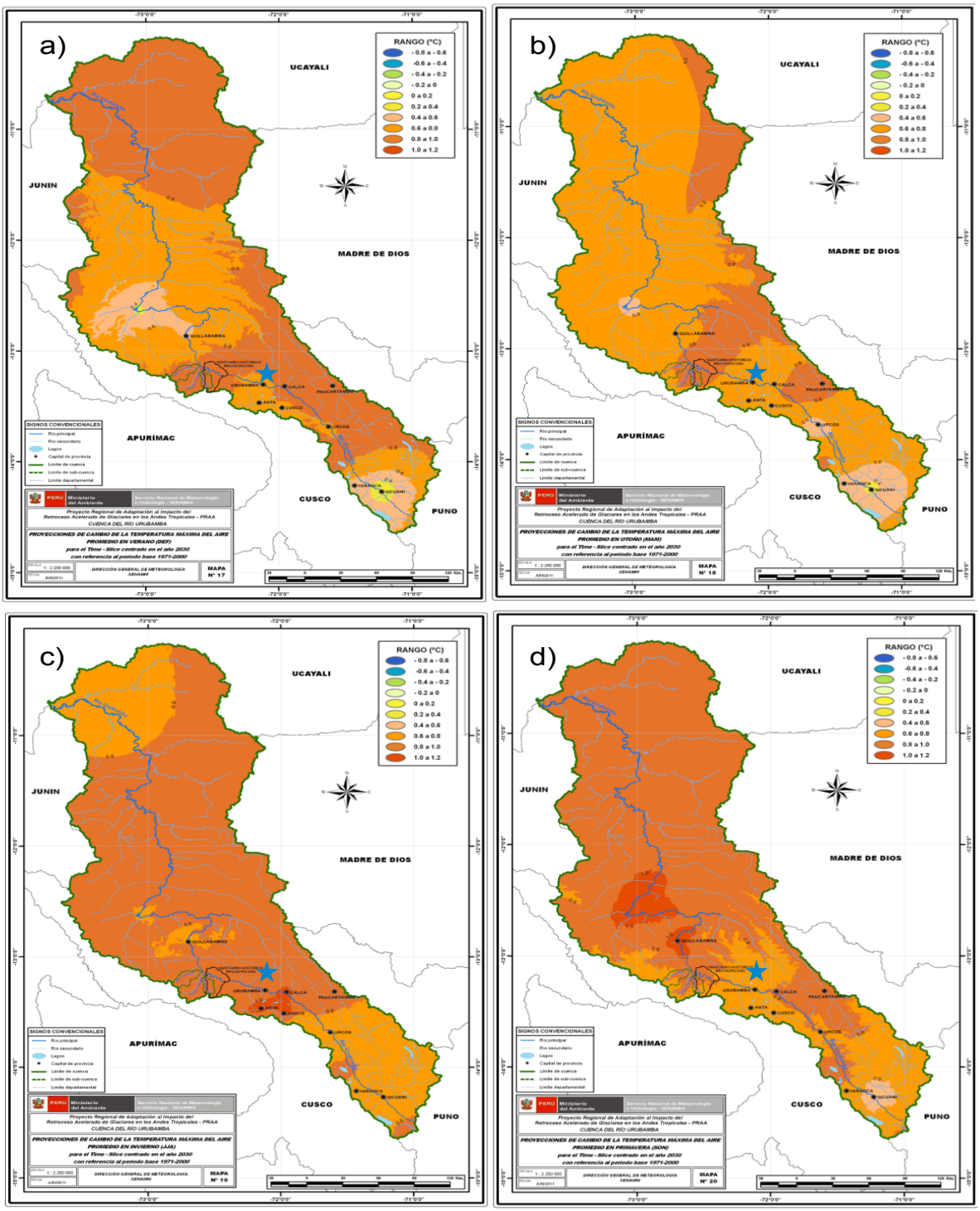
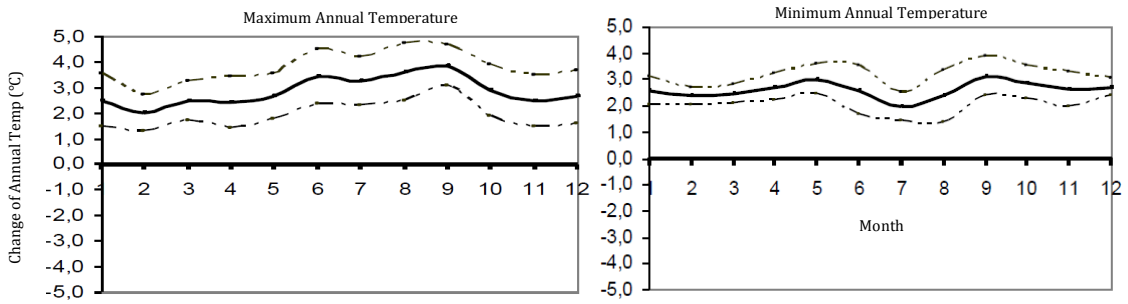


Figure 13. Change of the maximum annual temperature during different seasons of the year: a) Summer (DJF); b) Autumn (MAM); c) Winter (JJA) and d) Spring (SON). Chicón Catchment marked with a blue star. Reddish colors represent an increase in the temperature patterns, whereas greenish and bluish colors show a decrease.

Source: SEMAMHI, 2012

- <u>2100 Projection</u>

SEMAMHI (2007) worked on a projection of the maximum and minimum temperature for 2100. The maximum and minimum annual temperatures are expected to increase between 2 and 3 °C along the year, using the A1B scenario of the IPCC.



Graph 5. Projection of maximum and minimum temperature in Urubamba for 2100**.**

4.1.7. Disasters in the Chicón watershed

The first sign of GLOFs in this watershed dates back in 1679. Experts have found field evidences of this event, for instance alluvial material covering gypsum rocks of the Yahuarmaqui hill landslide (Proyecto INDECI-PNUD, 2005).

In 1942, another GLOF was registered as product of an avalanche that overflowed a lagoon. The debris flow traveled through the Chicón river until the Tantamarca hill where it divided into two parts, a larger part headed towards the agricultural sector of the Chichubamba community affecting a large part of the crops and another part with less energy continued its course towards the east of the city. From the current cemetery, the debris flow dragged blocks of rocks and fine material that reached the Mariscal Castilla Avenue in the Urubamba city. Because of this GLOF preventive measures were taken, such as the extension of Mariscal Castilla Avenue, as well as the river channeling from the cemetery to the Vilcanota river (Proyecto INDECI-PNUD, 2005).

In October 2010, another GLOF occurred in this watershed due to the detachment of a glacier portion that overflowed sequently the Ritticocha lagoon and later the Pucacocha lagoon (See figure 14). This event was classified as medium impact (PREDES, 2010).

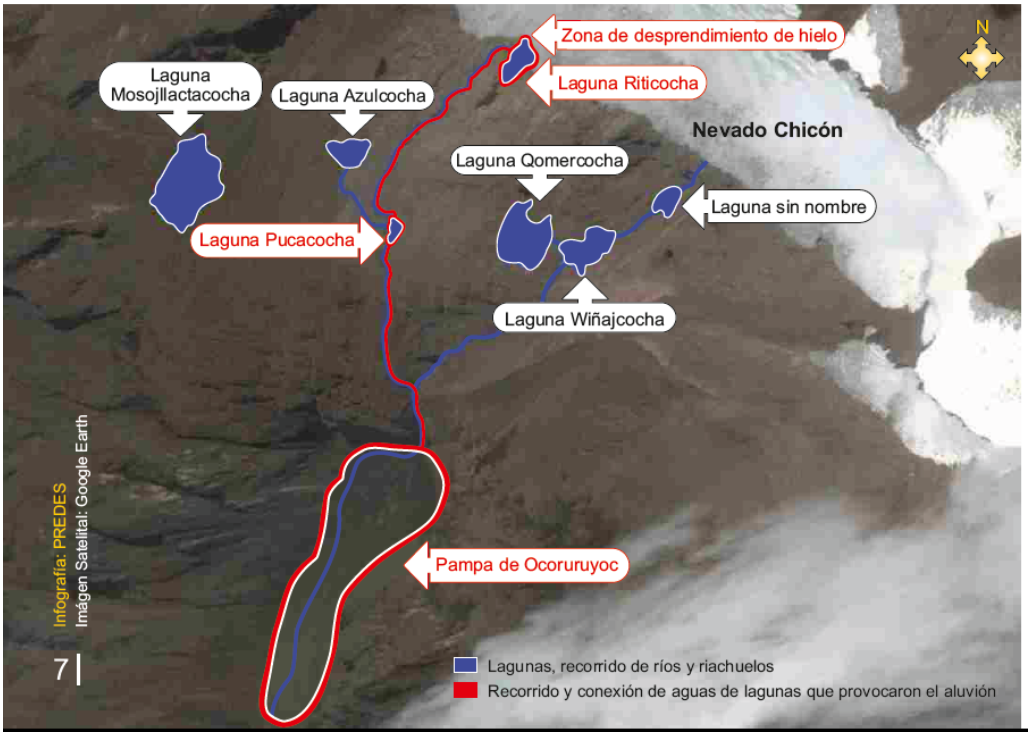


Figure 14. GLOF in 2010, Chicón watershed
Source: (PREDES, 2010)

As appreciated in the following photos, the debris flow carried big rocks and mud that affected 581 people in San Isidro de Chicón, Yanaconas, Chichubamba and the Urubamba city (PREDES, 2010). Note that Ccatan Pino is not in the influence area in case of GLOFs.

Photo 1. Glacier detachment in Chicón (right), Impact of the GLOF in the San Isidro de Chicón community (middle), Mud dragged to the Chichubamba croplands (left).
Source: (PREDES, 2010)

According to a report from PREDES in February 2011 there was another GLOF and during the same year in October the Chicón river was flooded. Luckily in these two events were light and did not affect many people (PREDES, 2011).

Other geodynamic hazards that have been observed along the middle and lower part of the watershed are old landslides, some of which are can be reactivated, gullies, alluvial fan, landslides, and local erosion in the margins of the Chicón river (Proyecto INDECI-PNUD, 2005).

4.1.8. Disaster Prevention in the sectors of San Isidro de Chicón, Yanaconas, Chichubamba and Urubamba city.

In 2015, the municipality executed the installation of the protection service in the Chicón watershed. The project included: enabling of accesses, drainage of the Ritticocha lagoon, an extreme flow dissipation system (retention wall) in Ocoruruyoc, construction of channeling structures and hydraulic dissipaters (channeling of the Chicón river), early warning system, meteorological stations, organization and training of stakeholders, environmental management plan, archaeological monitoring plan (Consorcio Presas y Canales Chicón, 2013).

Within this framework, the Early Warning System (SAT) was designed. It consists of a set of integrated mechanisms for observation and information gathering on a continuous basis of dangerous events and the rapid transmission of data that allow the activation of alarm mechanisms and the mobilization of a previously sensitized population on hazards that could harm them, and that are trained to react according to Evacuation and Emergency Plan.

The early warning system (EWS) was installed by the Urubamba municipality with the support of the project "Strengthening Capacities of Risk Management Sub-National Systems, and Developing Resilience of Vulnerable Communities to Disasters", which was funded by the European Commission Office of Humanitarian Aid and Civil Protection. The EWS project was executed by Welthungerhilfe, Diakonie, Soluciones Practicas, and the Study Center and Disasters Prevention - PREDES. The objective the project is to save the life of inhabitants living close to the Chicón micro-watershed including the San Isidro de Chicón community (PROYECTO DIPECHO, 2014). The EWS consists of 4 components: Monitoring and Surveillance System, Communications System, Alarm and Warning System, and Evacuation System. Civil defense is the coordinator of the EWS with support of the police, fire fighters, MINSA, Serenazgo[4], EsSalud[5].

The component that is still missing in this system is the sensitization of people. According to the environmental manager of the Urubamba city, this will be the last step to achieve a full functionality of the system. This phase will be worked together with CARE Peru as part of the partnership they started last year for the Glacier Project (Proyecto Glaciares).

4.1.9. Key Stakeholders

- Corazones para Peru

This non-profit association was established since 1998, in order to fight hunger, illiteracy, lack of medical care and inaccessibility to clean water, improve the sustainably and the living conditions of the indigenous population, especially children, in the Peruvian Andes (Herzen für eine neue Welt e.V., n.d.). Corazones para Peru has broad experience working with the communities from the Chicón watershed.

[4] In charge of social security. Works and supports the police.
[5] Social helath insurance of Peru.

- PREDES

It worked actively in the Chicón watershed after the 2010 GLOF. Is a non-governmental organization created in 1983 to help to reduce the vulnerability and risk of disasters in the country. It promotes prevention as a permanent approach to all kind of risks.

- Soluciones Practicas

It was part of the institution consortium that worked in the Evacuation routes. Its objectives are to contribute to sustainable rural development by improving capacities for the planning, prioritization and implementation of local government investments, allowing the overcoming of poverty and strengthening the capacities of local authorities and civil society actors for integration of disaster risk management in sustainable development planning.

- Caritas del Peru.

It provides assistance in humanitarian aid in the most affected areas and where the response of the state is weak or nonexistent. It considers that the disaster risk management starts with emergency care, and promotes the participation of the population as active actors implementing mechanisms and strategies to manage their risks.

- CARE Peru

Is a Non-Governmental Organizations dedicated to eradicate poverty with presence in more than 90 countries. CARE began its work in Peru 45 years ago, following the emergency that occurred in Callejón de Huaylas, in Ancash. Since then, they have successfully fought poverty, supported communities with comprehensive programs and advocacy efforts; generating sustainable impact in a strategic and transparent way, through its different programs. They are in charge of the execution of many projects founded by the Swiss Agency for Development and Cooperation. They are currently working in Urubamba with the Glacier Project (Proyecto Glaciares).

4.2. Methodological approach

The perception to climate change, disaster risk reduction and ecosystem-based solutions was assessed through a qualitative research that included the collection of data using secondary and primary sources. The data was collected from literature review, expert interviews, household questionnaires and a workshop.

4.2.1. Secondary data sources

Secondary data sources gathering is a preceding step of primary research activities and it helps to get a better understanding of the problem under investigation (FAO, 1997).

For this research data was collected from literature review of relevant documents and publications that could support the investigation and give a better overview of the study area, research gaps and questions. Besides, this data allowed the preparation of the questionnaire, workshop and provided the information that could be later compared with the collected primary data results.

The main sources of secondary data were handbooks, reports, institutional websites, papers and electronic books. Local NGOs also provided reports that were used in this research.

4.2.2. Primary data sources

Primary data was obtained during the field research trough expert interviews, household questionnaires and a workshop. The structure and content of each of them was formulated previously, aiming to obtain information related to the research questions.

- Expert interviews

The expert interviews were done to different professionals that work either in the regional government or in nongovernmental organizations and that are active in the study area. Since each expert was working in specific topics, unstructured interviews were executed. Unstructured interviews are free-flowing discussions without the sequence of questions that were defined in advance and its main objective is to identify the key functions in which the experts are engaged (Cooke, 1999 as cited by Naikar, 2013).

Table 1 shows the experts that were interviewed and the transcripts can be found in the annex 1.

Table 1. Expert interviews and their objectives

Interviewees	Location	Objective of interview
Mrs.Karen Price Rios National Coordinator of the GLACIARES Project CARE Peru	CARE Peru Lima	To collect information about the role of the NGO in CCA and DRR, to know the areas where they work and implementation of Eco-DRR/EbA
Mr. Walter Choquevilka Project coordinator, CARE Peru	CARE Peru Cusco	To know if measures for DRR and CC have been taken in the Chicón watershed, current projects they are implementing, more details about their CVCA methodology for vulnerability to climate change and hazard assessment
Camilo Ortiz De Orue Carrion Civil defense coordinator	Urubamba municipality, Civil Defense office	To know if they have risk or hazard maps, the role of civil defense in disaster respond, census of the last disasters.
Susan Romina Bustos Pezo Environmental Management office	Urubamba municipality, Environmental management office	To get more information about disasters in the Chicón watershed, implemented solutions in the watershed
Karin Kancha Sucno Project coordinator PREDES	PREDES, Cusco	To know the role of the NGO in the disaster management cycle, to get data on people affected in the last GLOF

- Household questionnaires

A questionnaire was designed with several questions to know how people from the four communities that make use of water from the Chicón watershed perceive climate change/climate variability and their opinion towards the role of ecosystems, namely forests, and its potential to help the adaptation process and disasters reduction. The questionnaires were conducted between April and May 2017 in four communities: San Isidro de Chicón, Yanaconas, Chichubamba and Ccatan Pino. These communities were also selected based on their location, upper and lower part of the watershed, to identify if there are differences in household perception and their concerns.

The questionnaire included structured questions to obtain a better understanding of people's perception. It was designed in five chapters or sections, which were: personal data, migration, climate change, disasters and natural resources. The questionnaire layout is attached in Annex 6.

The communities' leaders suggested the best days and time to visit their communities, since there are market days when they are out in the city selling their products. Moreover, the research was done with the special support of the San Isidro de Chicón community committee and the president of the Chichubamba irrigation committee.

Data collection was done by visiting the communities and searching for people willing to participate in the survey. To have a representative sample of each community it was decided to interview at least 10% of the adult population of each area. However, an average of 9% (113 householders) answered the questionnaire.

There was no clear data about the total population of each community. The literature was not consistent and the municipality did not have the data. Therefore each community leader was asked to give the number of people registered in the Irrigation committee and JASS. As shown in table 2, the irrigation committee is the one with more number of members and this data was used to calculate the number of respondents.

Table 2. Number of members in the Irrigation committee and JASS

Committee / number of members	Communities			
	San Isidro de Chicón	Yanaconas	Ccatan Pino	Chichubamba
Irrigation committee	170	169	85	204
JASS	150	136	70	170

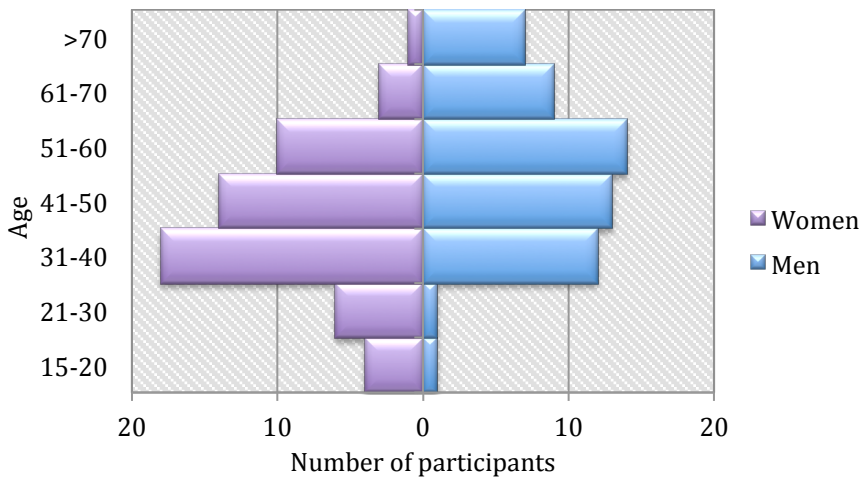
Then the number of these members was multiplied by 2, and the result it was assumed to be the total adult households. All together 113 individual households were interviewed out of a total of 1256.

Table 3. Number of adults in each community and percentage of respondents

	Communities				Total
	San Isidro de Chicón	Yanaconas	Ccatan Pino	Chichubamba	
Households	340	338	170	408	1256
Respondents	30	29	15	39	113
Respondents %	8.82%	8.58%	8.82%	9.56%	9%

- *General Information about the respondents.*

From the total number of respondents women represented 50.44% while 49.56% were men. In the following figure, the age distribution by gender can be observed. The maximum age of the respondents was 71 years old and the minimum age was 16 years old. The majority of people that participated were between 31 to 60 years old. Additionally, 61% of the families have between 4 to 6 members, 17% have between 1 to 3 members, 15% have 7 to 9 members and only 7% have between 10 to 12 members. This means that families are smaller than before, which corresponds with the decrease in the population growth rate of Peru from the last 50 years (INEI, 2014).



Graph 6. Age and gender structure of the participants

- Women Workshop

As part of this investigation a workshop was carried out with a focus on vulnerability to climate change and adaptive capacity at the Chicón watershed level, located in the district and province of Urubamba. It included only women from the San Isidro de Chicón and Chichubamba community as well as the sectors of Ccatan Pino and San Jose.

The activity was organized and executed by the researcher, and founded by CARE Peru within the framework of the *Glaciers Project (Proyecto Glaciares) for Climate Change Adaptation and Risk Reduction of Disasters caused by glacier retreat in the Andes mountain range*. The information collected was systematized and given to the NGO so they could use it in their project for decision-making and to complement the material they already have.

This workshop focused only on women for several reasons; women are particularly vulnerable to the effects to climate change and disasters and therefore their perception needs to be considered in decision making (CARE International, 2009). Furthermore, it was suggested by the leaders of the communities, because most of the time women remain in silence during community meetings, men are normally in charge of representing the family interests and women have limited access to information, resources and services. Finally, CARE Peru performed the same workshop last year with women and men from the San Isidro de Chicón community. The outcome of the women workshop can be compared with the perception of mixed gender groups and additionally it brings more information because it considers all communities from the Chicón watershed.

The analysis was carried out using the methodology developed by CARE, from experiences of other participatory workshops, to collect information for Climate Change projects. This methodology is called *Climate Vulnerability and Capacity Analysis (CVCA)* and it allows the active participation of women who manage natural resources in the watershed and that are often the most vulnerable to the effects of climate change and disaster risk related to glacier retreat.

Prior to the workshop, several meetings were held with the presidents of the Women's committees of San Isidro de Chicón and Yanaconas, so as the presidents of the Nutrition Committees (Milk Glass Committees) of Chichubamba, Ccatan Pino and San José, to clarify them the content of the CVCA workshop and coordinate and ensure their participation.

The workshop was held under the title *"Integrated Adaptation and Disaster Risk Reduction due to Glacier Retreat Analysis using the CVCA methodology in the Chicón watershed"* on April 29, 2017 in the community center of San Isidro de Chicón with the participation of women and social organizations from the watershed. In total 16 women attended to the workshop from which 11 belong to San Isidro de Chicón, 3 to San Jose, 1 to Chichubamba and 1 to Ccatan Pino. As event opening, an introductory presentation was done to explain some of the key terms and definitions of Climate Change, Hazards, Disasters, Vulnerability and Ecosystem Services. Moreover, the watershed problems were stated and two videos were presented; one created by the Glacier Project[6] about glacier retreat in the Andes mountain range and the second one focused on the 2010 GLOF, produced by PREDES[7]. Additionally, a scale model of the San Isidro de Chicón micro-watershed was exposed to facilitate the hazard mapping.

Subsequently, the CVCA process was followed according to the field guides from the CARE Handbook. Each field guide has an objective, which is presented in the next table for a better understanding of the participatory tool.

[6] The video can be found at: https://www.youtube.com/watch?v=59rebIFXbu4
[7] The video can be found at: https://www.youtube.com/watch?v=TQbgUx-6Fwc

Table 4. Participatory tools and their objectives for the Climate Vulnerability and Capacity Analysis

	Field Guide	Purpose
1	Facilitation Tips	• To guide planning and preparation for community visits • To provide general guidance on effective facilitation
2	Hazard Mapping	• To become familiar with the community, and to see how the place is perceived by different groups within the community • To identify important livelihoods resources in the community, and who has access and control over them • To identify areas and resources at risk from climate hazards • To analyze changes in hazards and planning for risk reduction
3	Seasonal Calendars	• To identify periods of stress, hazards, diseases, hunger, debt, vulnerability, etc. • To understand livelihoods and coping strategies • To analyze changes in seasonal activities • To evaluate use of climate information for planning
4	Historical Timeline	• To get an insight into past hazards, changes in their nature, intensity and behavior • To make people aware of trends and changes over time • To evaluate extent of risk analysis, planning and investment for the future
5	Vulnerability Matrix	• To determine the hazards that have the most serious impact on important livelihoods resources • To determine which livelihoods resources are most vulnerable • To identify coping strategies currently used to address the hazards identified
6	Venn Diagram	• To understand which institutions are most important to communities • To analyze engagement of different groups in local planning processes • To evaluate access to services and availability of social safety nets

Source: CARE International, 2009

These participatory tools offer opportunities to link community knowledge to existing scientific information on climate change and disaster risk reduction. It also balances learning and collection of information. Therefore, they were used to understand the perception of the people at a local level (CARE International, 2009).

For the Hazard Mapping all the women worked together in a single group in order to have more inputs to draw the entire Chicón watershed and identify the main resources of all the communities. Afterwards two groups were formed; one with 8 women from San Isidro de Chicón and another mixed group to elaborate the Seasonal Calendar and Historical Timeline. Additionally, the Vulnerability Matrix and the Venn diagram were performed again in a single group due to time constraints. Finally, a small discussion was done to hear from the participants some recommendations and ideas to adapt to climate change and reduce disasters.

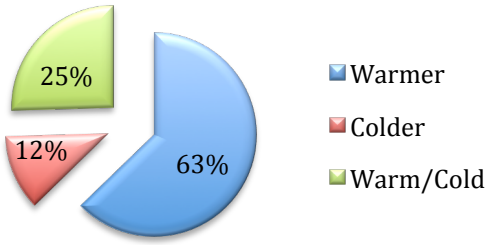
Once the information collected was processed, a third meeting was held for the return of systematized information to the women who attended to the workshop.

5. RESULTS

5.1. Climate Change

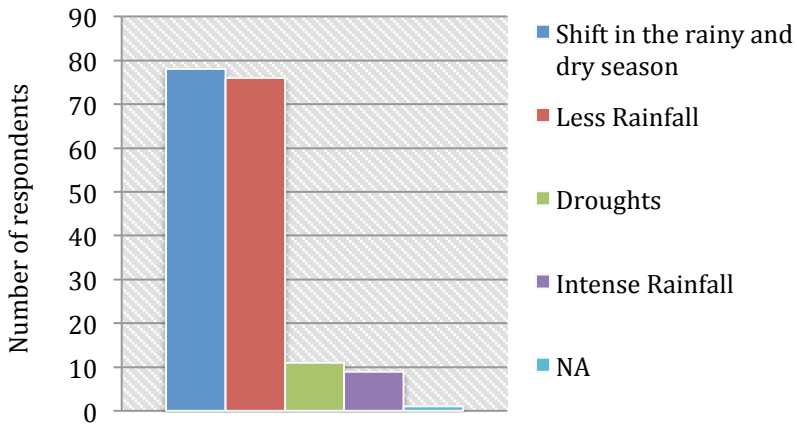
5.1.1. Perception to Climate Change

When it comes to climate change 99% of the participants perceive changes in the climate. As observed in graph 7, one of those changes is the temperature; 63% of the people perceive warmer temperatures than before, 25% of the people think that the temperatures are more extreme; warmer during the day and colder at night. In addition, 12% notice colder temperatures.



Graph 7. Perception to temperature changes

Regarding changes in the rainfall regime, shifts in the rainy and dry season are evident so as less rainfall during the wet season. Only few people think that rainfall is more intense (See graph 8).

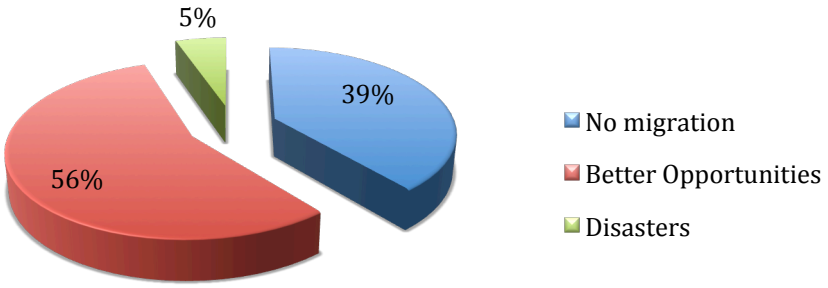


Graph 8. Perception to changes in the rainfall regime
NA: Not applicable

These changes in temperature and rainfall regime are mostly distinguished by 72% of the participants since 10 years to the present. Only few people notice changes more than 11 to 30 years ago.

5.1.2. Migration

In this question, people were asked about migration in their communities in order to know if it is related to climate change and climate related-disasters. As a result, 39% of the participants said that there is no migration in the area, while 61% said that people migrate to other areas to find better opportunities such as new jobs or, in the case of the young people, to continue with higher education in universities. As seen in graph 9, there were only few people saying that migration is driven by disasters in the Chicón watershed.



Graph 9. Drivers of Migration in the Chicón watershed

5.1.3. Seasonal Calendars

The seasonal calendars were done in two groups and despite the women were from different sectors, the most important events were identified almost for the same periods, as well as stress periods, threats and illness. Both results were joined in one table and discussed with the women to make sure that the dates and events were matching.

The most critical months are May, June, July, August and September, i.e. during the dry season as there is water shortage and people must queue early in the morning to have access to water for irrigation. Additionally, there are also cold waves during these months that affect both children and elderly health, they cause losses in crops that are sensitive to low temperatures and as a consequence the price of food increases.

It was observed that the land is currently cultivated all year and that the fallow period is no longer being respected. To achieve good harvests, there has been an increase in the use of fertilizers and pesticides.

Table 5. Seasonal Calendar of the Chicón Watershed

Events	J	F	M	A	M	J	J	A	S	O	N	D
Rainy Season	X	X	X	+								X
Dry Season					X	X	X	X	X	X		
Irrigation shifts							X	X	X			
Frosts / Cold waves					X	X	X					
Landslides / rock fall	X	X										
Corn sowing							X	X	X			
Corn harvesting	X	X		X	X							
Green corn harvesting		X										
Potatoes sowing						X	X	X	X			
Potatoes harvesting	X	X	X									X
Vegetables sowing and harvesting	X	X	X	X	X	X	X	X	X	X	X	X
Land preparation*	X	X	X	X	X	X	X	X	X	X	X	X
Expensive food						X	X	+				
Firewood collection				X	X	X	X					
Houses construction						X	X	X	X			
Respiratory diseases					X	X	X	+				
Academic year			X	X	X	X	X	X	X	X	X	X
Easter week			X	X								
Festivities		X			X	X	X			X	X	X

Source: Women Workshop: Integrated Adaptation and Disaster Risk Reduction due to Glacier Retreat Analysis using the CVCA methodology in the Chicón Watershed, 2017

*: The land is being prepared all year as it is now intensively cultivated

+: Non-traditional / variable dates

5.1.4. Historical Timeline of the Chicón watershed

During this step, two groups identified the most important events in the last 10 years. However, some older important events that the women still remember and know from their relatives were also included. The documentation of events was done from the most recent to the old ones, as events in recent memory are more likely to be reminded (CARE International, 2009). Additionally, the results were merged into one timeline to have a clearer idea of the main events that took place in the four communities.

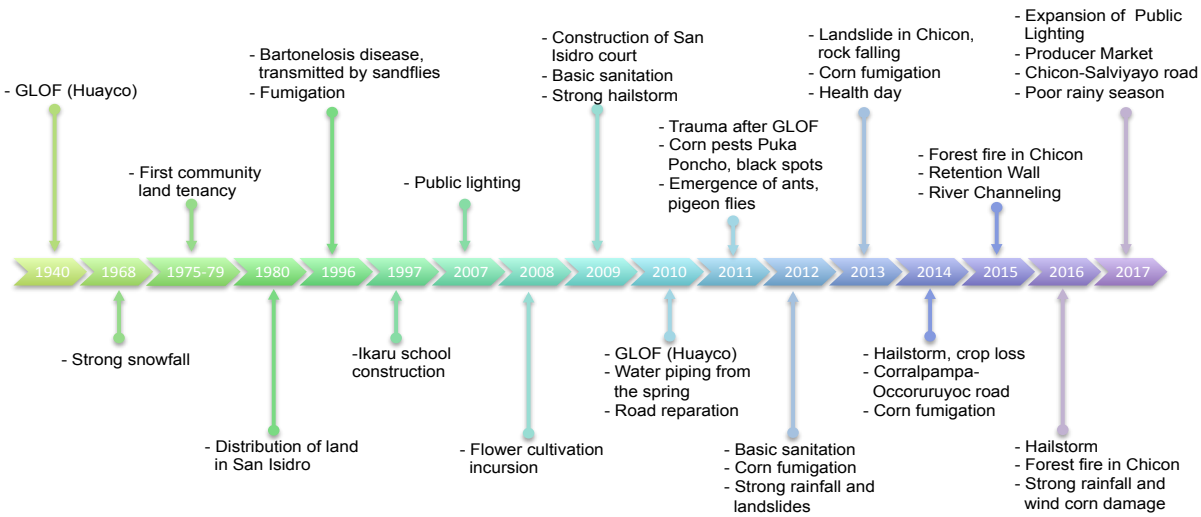


Figure 15. Historical timeline of the Chicón Watershed

As seen in figure 15, during the current year different infrastructures have been built. These infrastructures promote the economic development of the region, for instance the road that connects Chicón with the Salviayoc hill and the producers' market. Moreover, women in the basin said that this rainy season brought little rain.

In 2015 and 2016 forest fires occurred in the upper part of the basin, losing several trees in the forest. Additionally, the channeling of the Chicón river in the community areas of San Isidro de Chicón and Yanaconas was done, so as the construction of the retention wall that was built in the area known as Occoruruyoc to prevent and reduce the risk of GLOF. According to interviewees the installation of an early warning system was done. However, the information about it has not yet been fully diffused to the population.

From 2010 to 2014 there were crop losses due to intense rains and hailstorms and there were also several days of fumigation in corn plantations to fight pests such as Puka Poncho[8] that stunts the growth of corn. Nevertheless, the most notable event in this period was the 2010 Huayco/GLOF in which many crops were lost and many houses located on the banks of the Chicón river were seriously affected. Many people were traumatized, some decided to migrate to other towns and cities and others sold their lands as their value decreased due to the disaster. After the GLOF the local government made basic sanitation in the most affected areas, repaired streets, bridges and reservoirs for drinking water were built.

In 2008, there was the incursion of flower cultivation[9] in Chichubamba. The changes in the climate allowed this year to start growing flowers in higher areas.

Between 1975 and 1980 land was equitable distributed in San Isidro de Chicón, Yanaconas and Chichubamba, among small farmers organized in cooperatives and agricultural societies, as part of the agrarian reform. This reform came into force with the 17716 Law, published in 1969. Its objective was to “substitute the latifundio (large privately own lands) and minifundio (small holdings) regimes for a fair system of ownership, land tenure and exploration that contributes to the social and economic development of the nation and that guarantees social justice in the field and increases the production and productivity of the agricultural sector by raising and ensuring the income of the peasants” (Gobierno de Peru, 1969).

Women also mentioned that in 1940 there was another Huayco/GLOF that generated large losses in the watershed and in the Urubamba city. However, according to the literature this GLOF occurred in 1942 and mainly impacted the farmlands of Chichubamba (Proyecto INDECI-PNUD, 2005).

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[8] Puka poncho is a corn disease caused by two pathogens: Spiroplasma kunkelii and Phytoplasma. It is transmitted by cicadaids of the Dalbulus genre (INIA, 2012).

[9] According to the farmers flower cultivation in San Isidro de Chicón started in 2013.

5.2. Identification of Natural Hazards and Disasters

The identification of Natural Hazards through a participatory mapping was done during the women workshop held on April 29, 2017 at the Community Center of the San Isidro de Chicón Community. Moreover, perception to disasters was assessed within the questionnaire. Some of the aspects covered are the frequency of disasters in the Chicón watershed, affected areas, measures implemented, awareness of the EWS and preparedness to disasters.

5.2.1. Hazard Mapping

Using the hazard mapping field guide from CARE International, it was possible to make a participatory map of the watershed and also the identification of natural, physical, financial, human and social resources (See Table 6 and Figure 16).

Among the most important natural resources that can be mentioned are the glacial lagoons Azulccocha, Pukaccocha or Quelloccocha, Yanacocha or Rit'iccocha, forests of eucalyptus and pine that are used for the extraction of firewood, so as the native forest. Another vital natural resource is the Chicón river from which people obtain the drinking water and irrigation water. Moreover, the areas for cultivation or farms were identified between the settlements and mountains.

Among the physical resources the only reservoir for crop irrigation, that supplies water to the lower part of the watershed: Ccatan Pino and Chichubamba during the months of water shortage, was placed on the map.

As a main financial resource, the income from agricultural sales was identified while ancestral agricultural knowledge was recognized within human resources. Finally, as social resources the committees of the communities or sectors were mentioned.

Table 6. Main livelihoods of the Chicón Watershed

Natural Resources	Physical Resources	Financial Resources	Human Resources	Social Resources
• River and lagoons/lakes • Cropland (Chakras) • Eucalyptus and Pines forest in San Isidro de Chicón • Native forest • Animals • Plants and crops	• Households • Bridges and roads • Irrigation channels • Drinking water reservoirs • Irrigation water reservoir • Churches • Schools, Pronoei	• Income from sale of potatoes, corn, cereals, vegetables and flowers • Work in local government • Works in educational centers	• Traditional agricultural knowledge • Experience in organic production • Organizational capacity	• The community • Community committee • Women with Identity Committee • Irrigation Committee • Sanitation Service Administrative Boards (JASS) • Child Nutrition Committee (Milk Glass Committee) • Children's home

Likewise, the following hazards and areas of the basin that are more affected by them were acknowledged:

• Huaycos / GLOF: People from the community is more related to this hazard under the name Huayco or alluvium although they have different definitions as explained in the previous chapters, the actual hazard is GLOF. Women identified this during the workshop as the main hazard. Based on past events, it mainly affects the upper basin: San Isidro de Chicón and Yanaconas since they have less time to react or escape. Likewise, the infrastructures such as households and roads, and all the inhabitants living on the banks of the Chicón river could be probably affected.

• Drought: women referred to the water shortage that exists in the dry season of the year and that covers the months of June to October. However, in the last years the water availability in these months is reducing and as a result water conflicts are increasing. The effects of droughts happen in all sectors of the watershed, however those who would have less access to water are Chichubamba and Ccatan Pino since they are in the lower part of the basin.

• Pests in crops: In recent years, the use of strong pesticides has increased due to the presence of pests that attack the crops in the area and that are more resistant to them.

• Frosts or cold waves: Although they are not visible on the hazard map, frosts were identified in the discussion as other extreme event that lead to the loss of crops and which in many cases generate large income losses for the population. They affect mainly the community of San Isidro de Chicón due to the altitude.

As discussed during the workshop, one of the hazards that most concern the population is drought, since water is getting scarcer. Additionally, the Chicón glacier, which is the main source of water in the basin, is retreating at a very fast rate and it is estimated that in the coming years it will completely disappear (Choquevilca, 2017).

The shortage of water represents more challenges in agriculture and livestock grazing, which are the main sources of income for the population living in the watershed and it also threatens their food security.

In recent years, crops that could be only cultivated in lower altitudes are now planted in higher areas due to increase in temperature. One example is the cultivation of flowers that previously did not occur in the Chicón watershed but which is now feasible because of its price and changes in temperature.

According to the participants there is also an overuse of fertilizers, pesticides and chemicals that are not good for health and contaminate water sources. Finally, it is noted the delay of the rainy season, which has a negative impact to the crops.

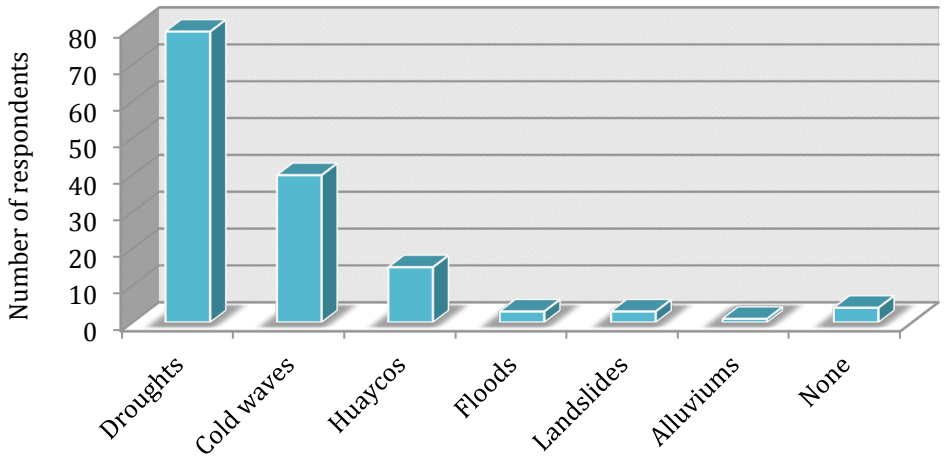
Figure 16. Participatory Hazard Mapping of the Chicón Watershed
Source: Women Workshop: Integrated Adaptation and Disaster Risk Reduction due to Glacier Retreat Analysis using the CVCA methodology in the Chicón Watershed, 2017.

5.2.2. Perception to disasters

As a consequence of climate change, the frequency of disasters has globally increased and so it is in Peru, which is also known for being one of the countries hardly affected by the ENSO (Glave et al., 2008). Because of this fact, the following aspects were investigated; frequency of disasters in the Chicón watershed, affected areas, measures implemented, awareness of the EWS and if they feel prepare to respond to disasters.

- Frequency of disasters

Only 40% of the people reported that disasters have increased in the study area and from those disasters droughts was the most common answer. Other people also mentioned Frosts/Cold waves and Huaycos[10].



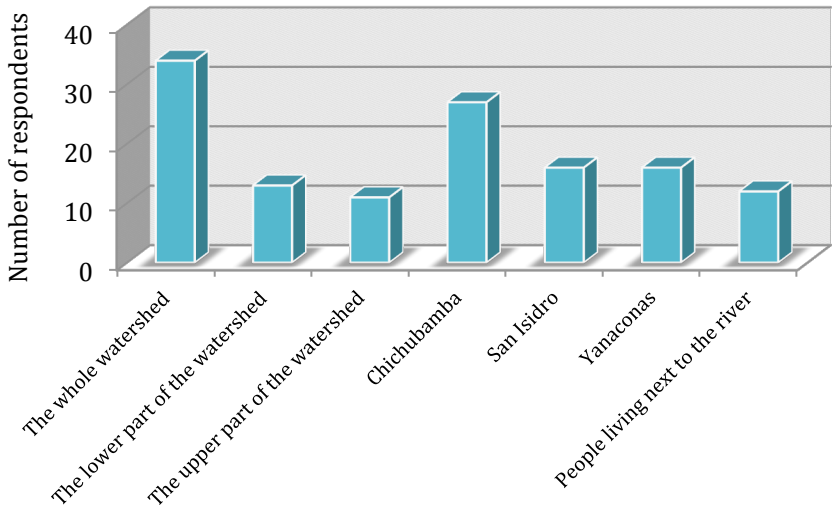
Graph 10. Perception to increase in disaster frequency

- Affected areas by disasters

From the disasters that have already taken place in the watershed most of the people said that all communities are affected by them. The second frequent answer was the Chichubamba community, since GLOFs can reach the farmlands and damage their crops. Chichubamba is also highly affected by droughts as they are located at the bottom of the watershed and have the highest number of farmers that make use of water for irrigation.

On the other hand, San Isidro de Chicón and Yanaconas were mentioned as prone communities to GLOFs and frosts/cold waves as they are located in the upper part of the watershed and closer to the glacier. On top of that, these two communities have a representative number of people leaving on the riverbanks and consequently are more exposed.

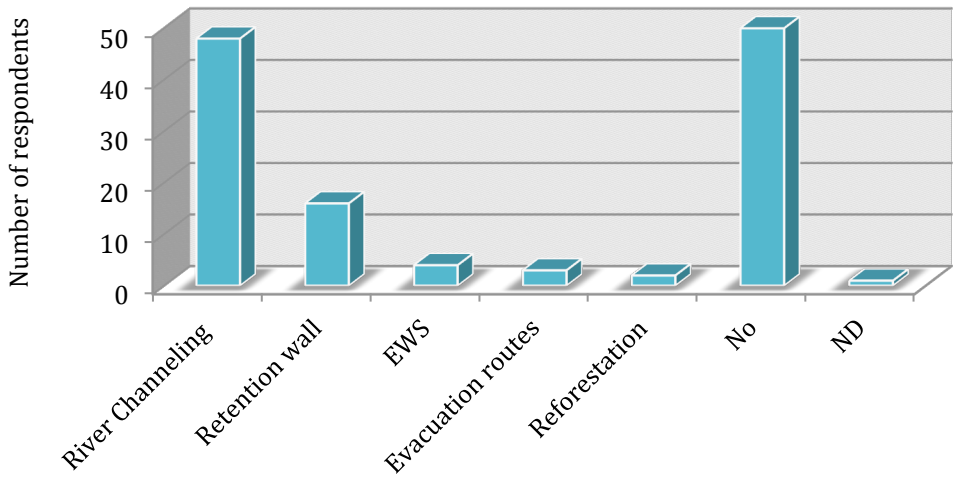
[10] People are related to the term Huayco but actually they refer to the GLOF concept.



Graph 11. Perception to affected areas by disasters

- Awareness of implemented measures in the Chicón Watershed

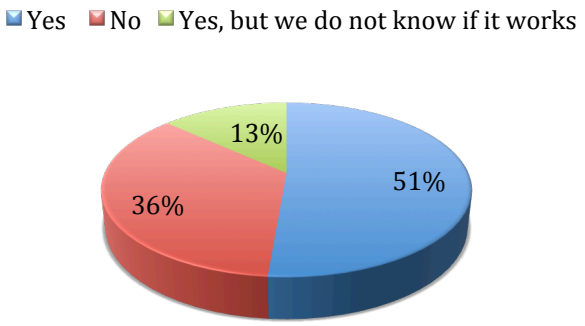
Another feature that was asked are the implemented measures they know. Most of the people who stated that there are implemented measures referred predominantly to the channeling of the Chicón river. A smaller portion mentioned the retention wall, the early warning system, evacuation routes and the reforestation that took place last year in the high part of the watershed. Almost half of the participants have any knowledge of these measures.



Graph 12. Awareness of implemented measures
ND: No data

Subsequently, people were asked directly about the existing EWS that was installed in the watershed few years ago to reduce disasters. After explaining in a simple way what this system is about, 51% of the respondents said that they know the system and recognized the monitoring antennas that are close to their houses. Other 13% also know the EWS but

they do not know if it is working. Finally, 36% have not heard and are not aware of this system. (See graph 13)



Graph 13. Awareness of the existing Chicón's Early Warning System

- Preparedness to disasters

Lastly, when it comes to response to disasters and traditional knowledge 79% of the people said that in case of Huaycos/GLOF they must run to the hills and follow the escape routes. None of them mentioned ways to respond in case of droughts or other disasters.

5.3. Vulnerability to Climate Change and Disasters

5.3.1. Vulnerability Matrix

The main identified hazards were huaycos/GLOF, frost or cold waves, droughts and hailstorms. The hazard that affects most of the people's resources is the GLOF, which has a high negative impact in almost all the resources. However, people do not believe that more GLOFs can occur in the future, because the glacier is retreating and according to them humans through an explosion in the glacier induced the last one. Those who did it were looking for minerals beneath it.

On the other hand, the participants consider droughts as the hazard that will be more frequent and more intense in the next years affecting their livelihoods. Taking place in the same months as droughts, cold waves and hailstorms hugely threaten animals, food and crops, which are their main sources of income in the Chicón watershed.

Furthermore, the most vulnerable resources no matter the hazard are: animals, food and crops, which are the base for their economic activities.

Table 7. Vulnerability Matrix of the Chicón watershed

RESOURCES	HAZARDS			
	Huaycos/GLOF	Frost/Cold waves	Droughts	Hailstorms
Animals	3	3	3	2
Water	3	0	3	1
Food	3	3	3	3
Forest	2	0	1	0
Health	3	2	0	1
Crops/Cropland	3	3	3	3
Schools	3	2	0	0
Households	3	0	0	1

Note: The scoring system for the hazards against the livelihoods resources is classified as a significant, medium, low, or no hazard. The scoring system was as follows:

3 = significant impact on the resource
2 = medium impact on the resource
1 = low impact on the resource
0 = no impact on resource

5.3.2. Venn Diagram

As seen in the figure 17, the most important institutions for the community are CARE Peru, Corazones para Perú, the National Water Authority (ANA), the Municipality or local government and its Environment and Sanitation office. PREDES is another important organization, which worked and trained the population on the emergency routes in case of GLOF.

Both MINSA and Pro Peru are two entities that have worked with the population but should do it more and improve their service.

The institutions, which do not work with the community but are very important for Climate Change Adaptation and Disaster Risk Reduction; are Civil Defense, the Institute of Mountains, National Association of Ecological Producers (ANPE) and Regional Directorate of Agriculture (DRA) and National Institute of Agrarian Innovation (INIA).

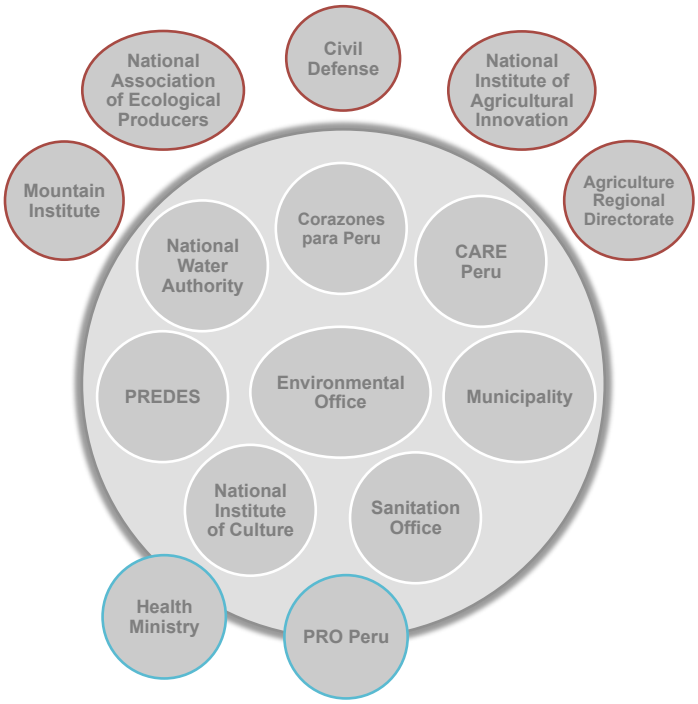
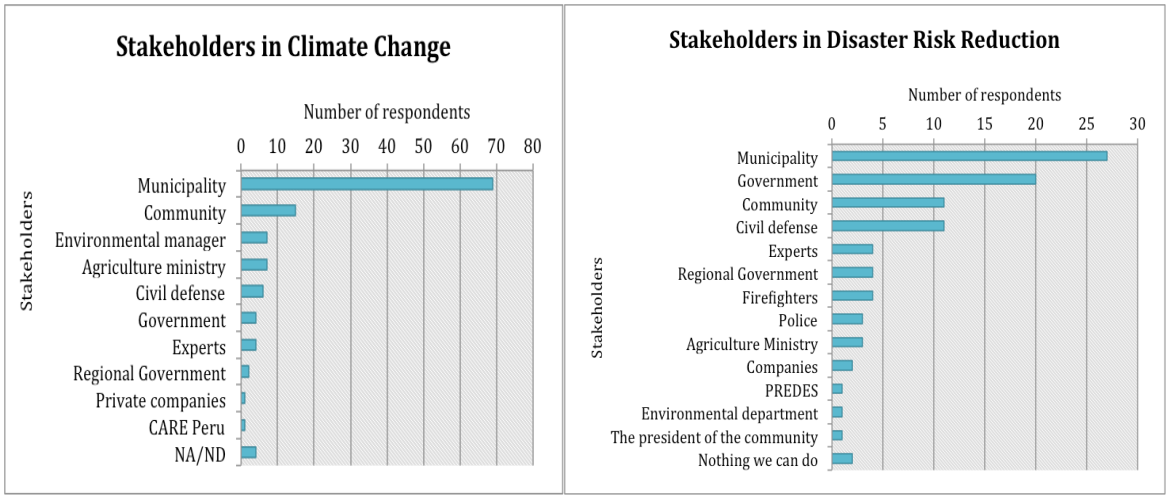


Figure 17. Venn Diagram of the Chicón watershed

5.3.3. Stakeholders in Climate Change and Disaster Risk Reduction

Another important aspect is to know which stakeholders should be involved in Climate change mitigation and adaptation as well as disaster risk reduction. When people were asked about who they think should give solutions to these problems most of them mentioned the local government as the main stakeholder. In the second place they positioned the community and its committee as key part of mitigation and adaptation to climate change. On the other hand, the key stakeholders for disaster risk reduction are the local and national government, so as the community and civil defense.



Graph 14. Stakeholders in Climate Change (left) and Disaster Risk Reduction (right) in the Chicón watershed

5.4. Ecosystem services suitable for EbA and Eco-DRR

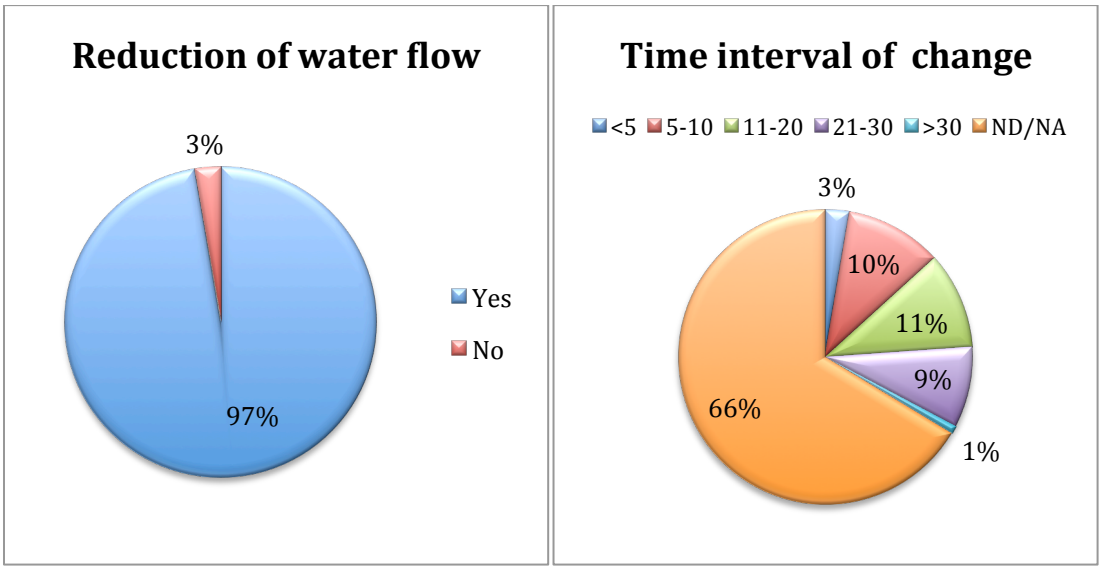
To evaluate which ecosystem services that can be used for EbA and Eco-DRR, the degradation of ecosystems from the Chicón watershed have to be identified. Subsequent the perception and acceptance degree of people to ecosystem-based solutions was investigated.

5.4.1. State of ecosystems

People also gave their perspective concerning the changes and state of the natural resources in the Chicón watershed. The included resources were: Chicón river, the forest, the glacier and land.

- Chicón river

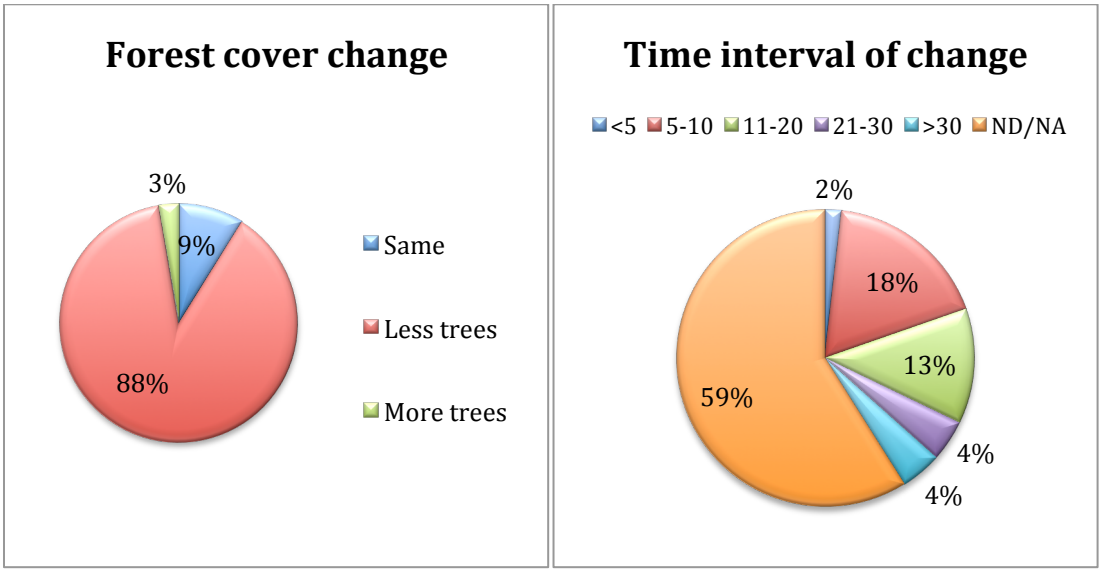
From the total of participants, a 97% notice a reduction in the water flow of the Chicón river versus 3% that do not perceive any changes. Regarding the time when these changes began, more than half of the people said that they do not have any idea when it started, whereas 30% said that the changes started between 5 to 30 years ago. People do not clearly know when this decrease in the water flow started.



Graph 15. Perception to reduction of water flow (right) and time interval of change (left) in the Chicón watershed
NA: Not applicable. ND: No data

- Forest cover change

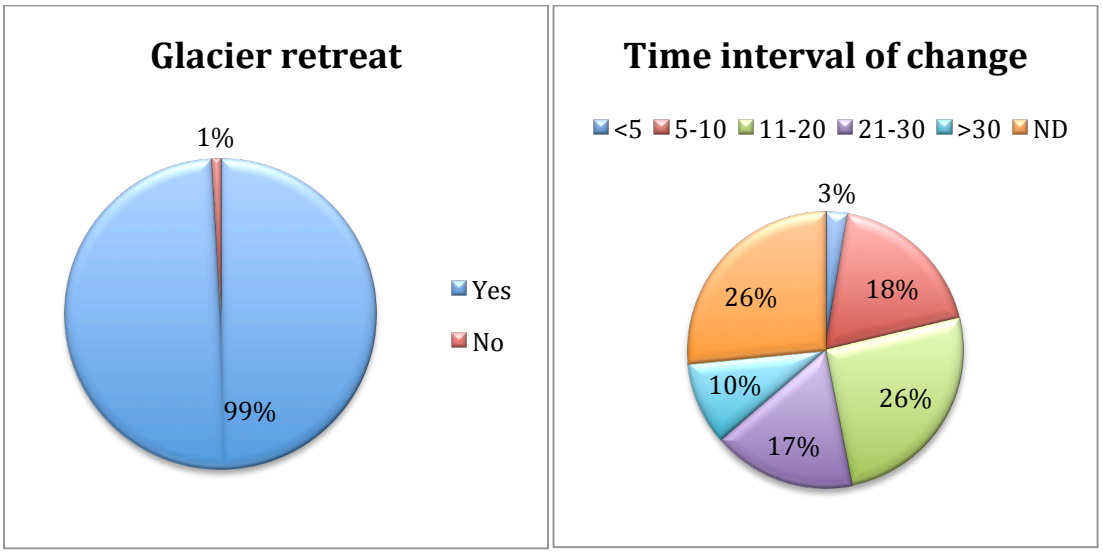
As seen in the graph 16, 88% of the people observe a decrease in the forest cover while 9% do not see any changes at all and 3% think that there are more trees after the reforestation that took place last year. Moreover, 59% of the participants said that they could not recall the year when the forest cover was extensive. Other 31% said that changes range between 5 to 20 years ago.



Graph 16. Perceptions to Forest cover change (left) and Time interval of change (right) in the Chicón watershed
NA: Not applicable. ND: No data

- Changes in the Chicón glacier

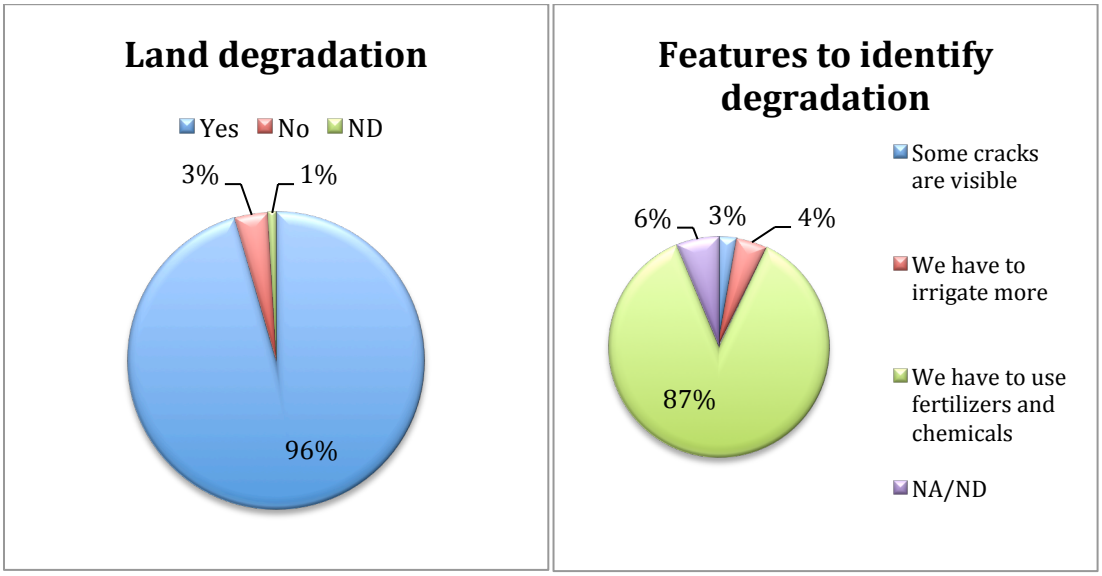
In this case 99% of the people said that a decrease in the size of the glacier is evident. The period when the glacier started to retreat is also not clear, however 26% think it started between 11 to 20 years ago, 17% in the 80s while another 18% think it was between 5 to 10 years after the 2010 GLOF.



Graph 17. Perception to Glacier retreat (left) and Time interval of change (right) in the Chicón watershed
NA: Not applicable. ND: No data

- Land degradation

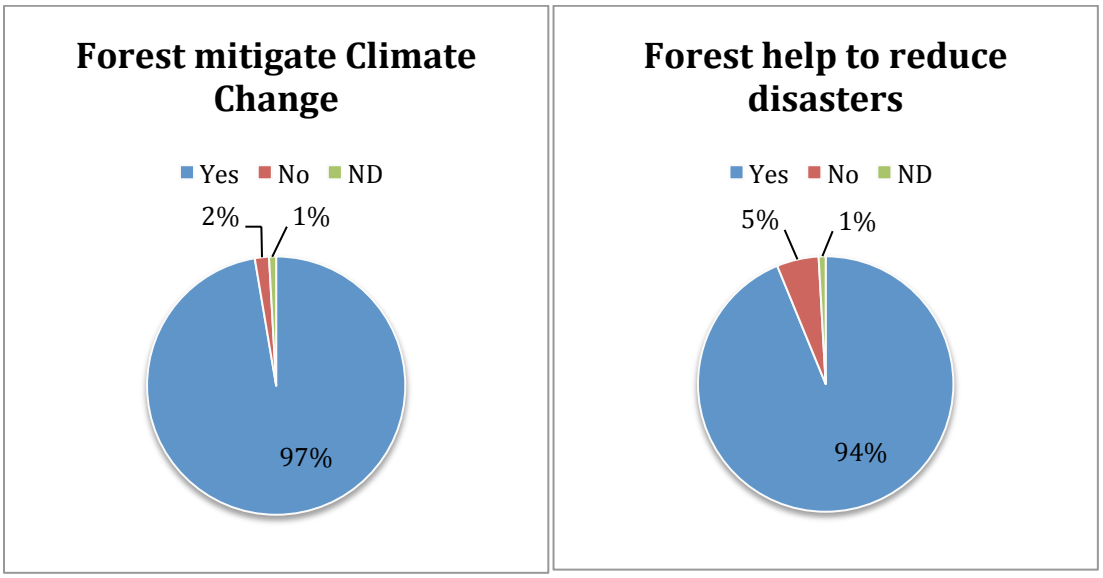
This feature was included to know if this can be a relevant factor that increases the risk of disasters such as landslides, GLOF and huaycos. Since land degradation is not a familiar term for the people living in the study area, they were asked about fertility and visible cracks in the soil. Using fertility instead 96% of the respondents said that land is less fertile than before. This is feasible because before their parents used only manure in land preparation and now they have to use a lot of fertilizers and chemical to have a good harvest. Other explanations they gave, but in a smaller percentage, were that they have to irrigate more and that some cracks are visible in the hills.



Graph 18. Perception to land degradation (left) and features to identify degradation (right) in the Chicón watershed.
NA: Not applicable. ND: No data

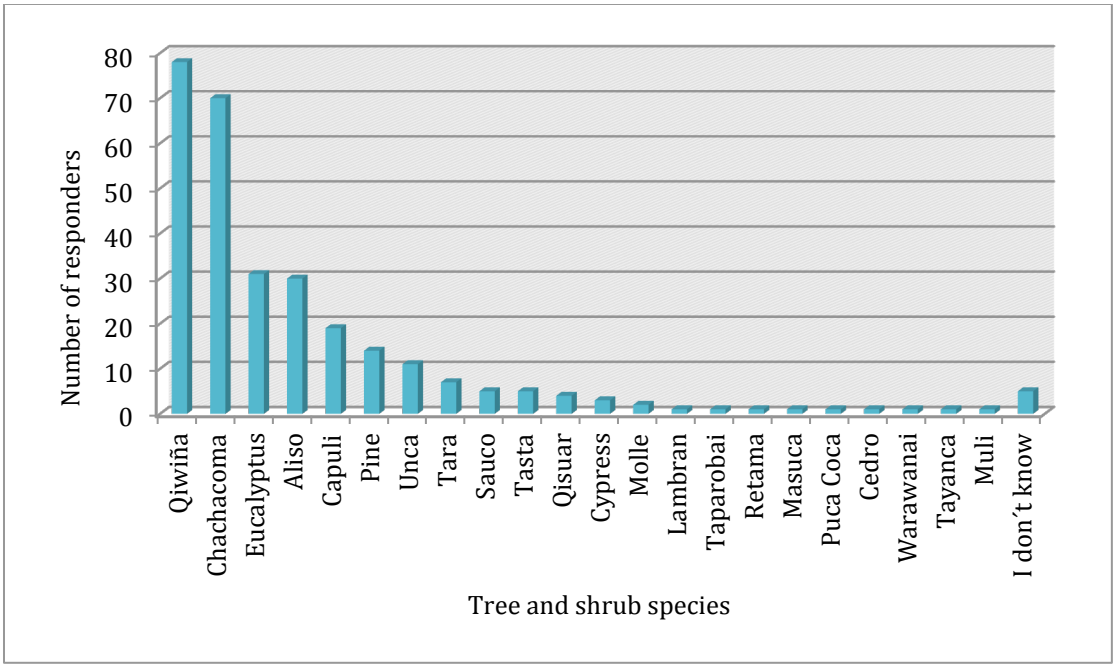
5.4.2. Acceptance degree of ecosystem-based solutions

Perception of ecosystem-based approaches is also included in this research since acceptance of the communities is a key factor for implementation of this type of solutions. Based on the literature review and expert interviews it was found that native forest can help to mitigate and adapt to climate change and at the same time prevent disasters in the future, because of that the participants were asked about it. As a result, 97% and 94% are positive with the role of forest in this regard.



Graph 19. Perceptions to the role of forest in Climate Change mitigation (left) and Disaster Risk Reduction (right) in the Chicón watershed.
ND: No data

Besides, they declared that best tree and shrubs species for reforestation are the native species especially Qiwiña (*Polylepis spp.*) and Chachacoma (*Escallonia resinosa*). They also mentioned Aliso (*Alnus jorullensis*), Capuli (*Prunus serotina*), Pine (*Pinus*), Unca (*Myrciantes mirtilloides*), Tara (*Caesalpinia spinosa*), Sauco (*Sambucus peruviana*), Tast'a (*Escallonia mirtylloides*) and Quisuar (*Buddleja incana*). In general people is aware of the importance of forest in the protection of the glacier and the water. Nonetheless, 27% of the respondents think that eucalyptus (*Eucalyptus sp.*) is a good option to keep the watershed in good condition.



Graph 20. Tree and shrub species recommended by the community for the watershed protection

6. DISCUSSION

This chapter presents a comparison between the results obtained in the literature review, the household questionnaire and women workshop. Perception and awareness of the issues, namely climate change and disasters, stakeholders involved in the study area, condition of ecosystems and implemented solutions in the Chicón watershed.

6.1. Perception to Climate Change

The respondents are aware of variability and changes in the climate. However, some of them confused at first climate change with seasonality and the question had to be asked again in a different way. All of them perceive changes in temperature, for instance 63% perceive higher temperatures than before and another 25% think that temperatures are more extreme: warmer during the day and colder at night. Climate studies prepared by SENAMHI, show that between 1965 and 2010 the maximum annual temperature has increased +0.5 °C in the Urubamba watershed while the minimum annual temperature has increased +0.2 °C (SENAMHI, 2012). This fact supports the theory of warmer days but not colder nights.

People also note changes in the rainfall patterns and variability in the weather. The main changes refer to a drop in rainfall during the rainy season and shifting seasonality. This was also confirmed in the workshop in the seasonal calendar, during the discussion of this exercise they alleged that in the last years the rainy season has ended in April instead of March having negative implications in agriculture such as lost in corn harvesting since it cannot be dry outside when is raining.

During the dry season, the situation is even more critical than before. Water demand has increased hand in hand with population growth and expansion of irrigated agriculture. Hence, the water available in the dry season is not enough to cover the demand so they have implemented since 1980 irrigation shifts, in which they have to get tickets according to the land they own to have access to water in July, August and September. At the same time frost/cold waves and hailstorms hit the watershed in the same period putting in danger their health and livelihoods.

Climate variability and change perception in the Chicón watershed is drawn from the experiences they have gone through, including increased climate-related disasters, the retreat of the glacier and their main concern, water availability. The changes are mainly perceived since 10 years and many said that after the GLOF in 2010 the changes were very marked.

It was presumed that participants in this study are aware of climate change impacts, but they only partially understand causes and effects. However, their perception on changes in temperature, and rainfall agrees partly with the literature.

Climate change and disasters are often discussed among academics as drivers of migration. The risk to people of being displaced owing to disasters is 60 % higher now in

comparison to 40 years ago. This is also linked to climate change since it contributes to extreme weather events and to the loss of people's life support inducing migration to other places (Greenpeace Germany, 2017).

Based on the household questionnaire results there is not enough evidence to state that disasters or climate change cause migration of the people from the Chicón watershed to other regions as only 5% of the respondents associated migration to disasters. These 6 participants said that people they know moved from their communities after the disaster of 2010 destroyed their houses or croplands and because the land could decrease its value if another GLOF occurred.

Reports from the local government on how many people were displaced after the disaster could not be got. However, according to a disaster report from PREDES 40 houses were destroyed and 80 were partially affected in the communities of Yanaconas, San Isidro de Chicón, Chichubamba and the Mariscal Castilla Avenue of the Urubamba city (PREDES, 2010).

Women mentioned during the workshop that after this disaster the population was very scared. They thought that another event like that could repeat at any time and it took them time to recover psychologically from it and feel secure living in this area. Perhaps this could have been another motivation to migrate from the area.

On the other hand, climate change is not leading to migration of people in the watershed as nobody from the community declared it. Nonetheless, as water conflicts in the study place are increasing and so water available for irrigation, it can influence migration in the near future if mitigation strategies are not implemented. Finally, further research on this topic is recommended since this investigation only considered 10% of the adult people from the communities and because environmental migration flows are frequently undocumented (Greenpeace, 2017).

6.2. Perception to Disasters and Implemented Measures

It was evident that the perception they have on disasters is based on events from the past. Only few people perceive increment in the frequency of disasters. Participants of the questionnaire and workshop agreed that the most frequent hazards are droughts and frosts/cold waves. Droughts affect all the communities as they depend on agriculture. Both, Chichubamba and Ccatan Pino receive less water from river, as they are located in the bottom of the watershed.

The research revealed that many people from the watershed believe that the 2010 GLOF was provoked to extract minerals and they involved people from the community with the previous major Benicio Rios and the JERGO Company. Few people link the GLOF to climate change (Tecsi and Tupa, 2017). Because of this, they do not consider that another disaster like this will not occur any time soon. Though, the women stated that GLOFs are the most dangerous hazards since they affect many physical resources such as roads, houses, cropland, bridges, and water supply among others. The high-risk areas for them

are San Isidro de Chicón and Yanaconas, while in the questionnaire results Chichubamba was also mentioned. This can be because the impact in this community was mainly in the croplands and not to animals and houses. Overlapping with the literature, the Hazard Map of the Urubamba city study reveals that the communities with very high risk to Alluvium (GLOF) are the ones located in the upper part of the watershed (San Isidro de Chicón and Yanaconas) as well as in Chichubamba (Proyecto INDECI-PNUD, 2005). Lastly, they are also aware and have in their memories knowledge of the two GLOF from 1942 and 2010.

The women also identified pests in the crops during the hazard mapping as well as in the Historical timeline. In 2011, Puka poncho affected corn plantations and hence in 2012, 2013, 2014 fumigations were executed to prevent the pest.

The awareness of implemented measures to reduce disasters in the Chicón watershed was also included in this category. The findings show that not everybody is aware of the measures. The river channelling was most mentioned, perhaps because the working area was the closest to where people live. The retention wall was built in the area called Ocoruruyoc Pampa at approximately 4 km from the San Isidro de Chicón community. This can be the reason why not everybody has seen it.

The early warning system is another executed solution that is not well known by the participants. According to the Environmental Manager from the local government, the next component of this system that they are working on is the social. They are planning to train people and make awareness campaigns together with CARE Peru to spread its functionality (See expert interview Annex 4).

Finally, one of the traditional knowledge they have is how to respond to GLOF. Most of them expressed that they have to run to the hills following the logic. While others respond the same but based on the scape routes that are also in high areas. As mentioned before, the escape routes were developed by the consortium of institutions that included: PREDES, Welthungerhilfe, European Comission, Soluciones Practicas, Diakonie Katastrophenhilfe and the Urubamba Municipality.

6.3. Historical Timeline of the Chicón watershed

In this regard, it was determined that the communities have gone through some changes and trends in crop cultivation. In 2007, they started with plantation of vegetables such as lettuce due to their productivity, they required less labour, can be harvested all year and very fast. However, this has negative implications in the soil because there is intensive agriculture and fallow period is no longer respected. Another change is the cultivation of flowers that started in Chichubamba in 2008 and was followed by San Isidro de Chicón in 2013. All these changes are related to the increase in temperature.

Expansion of agriculture is feasible in the area as in the last years two roads were created by the local government. The first one connects the Corral Pampa sector with Occoruruyoc, and the most recent connects the Salviayoc hill with the San Isidro de Chicón community.

The stress periods cover May, June, July, August and September as there is water shortage, cold waves, hailstorms, losses of crops, food tends to get more expensive when the harvests are lost, and health of the people is threatened.

6.4. Vulnerability

Vulnerability is often determinate by scientific methods. Though, communities offer crucial perspective on the problem that can be valuable for policy makers in the creation of adaptation measures (Haque et al., 2012).

With this premise, Vulnerability in the Chicón watershed was evaluated using a Vulnerability Matrix but also with complementary interrogations in the questionnaire. The main hazards for them are GLOF, droughts, frosts and hailstorm and the vulnerable livelihoods are crops, land, animals and food.

All the communities are vulnerable to droughts, climate variability and change. Water flows from the river to the lower communities through irrigation channels that distribute it among the crop fields. During the dry season, the most vulnerable in terms of agricultural vulnerability are Ccatan Pino and Chichubamba.

In case of GLOF people living in the riverbanks are especially vulnerable because of their exposure. Chichubamba is also vulnerable as the debris flow can reach the crop fields through the irrigation channels. If this is compared with the results of physical vulnerability estimated by PREDES, vulnerable areas turn out to be the same in the upper part of the watershed. First, San Isidro de Chicón and Yanaconas are located as many rural settlements next to the rivers. Also, the physical vulnerability of houses in the river banks is high since they are made of adobe, are not well structured and therefore cannot resist violent flows (PREDES, 2011).

Frost and hailstorms also affect the watershed in general, but due to the altitude of the communities in the upper part the impact on crops and animals is stronger. This vulnerability is also attributed to location.

Overall the communities in the Chicón watershed are vulnerable in different ways. Its population is poor, expose to risk areas, steep slopes, and weak work of local institutions like civil defence and agriculture office.

The stakeholders that the communities consider important include government institutions and NGOs. As expected, they visualize the national and local government as the main body that should give solutions to both climate change adaptation and disaster risk reduction. They also recognize the role of civil defence in case of disasters and the responsibility that the community has as they are the mains affected.

In the questionnaire, they also mentioned, with less frequency, other entities like the Agriculture Ministry, CARE Peru, Fire fighters, Police, PREDES, Environmental office and

private companies. While in the workshop the women included more specific stakeholders and the institutions that should be more engage and supportive. They included as active institutions the local government, the Sanitation office, National Institute of Culture, Environmental office, PREDES, CARE Peru, National Water Authority and Corazones para Peru. PRO Peru and the health ministry are partially working with them and are considered important for their development. Besides, Civil Defence, The Mountain Institute, National Association of Ecological Producers, National Institute of Agricultural Innovation and Agriculture Regional Directorate are five essential institutions that are barely or never assisting them.

From a general point of view the participants of this study have a good understanding of the institutions involved in these two topics, but it does not mean that all the communities inhabitants know all these institutions. These stakeholders represent potential allies in addressing vulnerability at the community level (CARE International, 2009).

When it comes to the four communities, it was seen that San Isidro de Chicón is actively working with institutions and were the most cooperative community with this research. It is important to highlight that all communities belong to the Irrigation Committee of the Chicón watershed representing the main authority that integrates all efforts in this regard (Tecsi and Tupa, 2017).

6.5. Ecosystem Services suitable for EbA and Eco-DRR

6.5.1. Degradation of ecosystems

Chicón river

The results of this study indicate that people perceive a decrease in the water quantity of the river in comparison to the past. The participants do not have clear the time when the decrease in water started, as the answers were very mixed. As mentioned above, studies indicate that glaciers are retreating and this also means loss in water resources as they are sources of water during the dry season(ANA, 2014).

Forest cover

Land use change and population growth have negative repercussions in forest cover. The people perceive these changes, as most of the respondents said that there are fewer trees in the forest. They could not also recall when the changes started.

Chicón glacier

This is one of the most evident changes for the people. The glacier does not have the same extension as before. Climate change is accepted by the people as main cause but also to the disaster of 2010. This result goes with findings in the literature, indicating that the glacier cover has been reduced 20 to 25 meters by 2000.

Land degradation

Land degradation was analysed from the fertility point of view so the people could explain their thoughts. Almost all of them perceive less fertility in their land and now they must use

many fertilizers and chemicals. Deforestation of native species has taken place in the hillsides, as they are used for crop cultivation or animal husbandry.

6.5.2. Ecosystem-based solutions

Ecosystem-based solutions were thought of not being implemented in the study area as it is not mentioned in the literature. Nevertheless, after the NGO CARE Peru did a workshop last year with people from the San Isidro de Chicón community using the CVCA methodology, the participants suggested as adaptation measure the reforestation of surrounding areas of the glacier using native species. At the beginning of this year the people from the four communities got together and began applying this solution. Despite of being a small-scale measure, for adaptation to climate change and protection of the watershed, it promotes the idea of ecosystem management to achieve better results. Especially now that the agricultural in the area is expanding to the Salviayoc hill it can be done by managing ecosystems in a sustainable way.

People are aware that ecosystem-based solutions, such as reforesting with native species, are good options for climate change adaptation and disaster risk reduction. Native species from the Andean region help to stabilize slopes, protect crops from cold and strong winds, generate a microclimate inside the system, provide shade to protect from solar radiation, they improve conditions and recycling of soil nutrients, fix carbon and protect watersheds. Most of the native species have the advantage that they do not require too much water for their growth. For instance Aliso (*Alnus jorullensis*) is important species for soil recovery in the Andes mountain range, Qiwiña (*Polylepis spp.*) grows in poor soils, tolerates high stoniness and requires few water, and Chachacoma (*Escallonia resinosa*) responds well to poor and degraded soils, and tolerates droughts (Arica, n.d.).

7. CONCLUSIONS

Perception of people to climate change, disaster risk reduction and ecosystem-based solutions in the Chicón watershed was analysed in this research. People are aware to climate change effects, especially about the increase in temperature, drop in precipitation, shift in the rainy and dry season that are perceive since 10 years.

The perception to climate-related disasters is based on events from the past, they recognize GLOF as the hazard that threads the most their livelihoods but they do not think that another event like this will happen in any time soon as the most popular explanation among the communities is that the last one was provoked by humans that were looking for minerals beneath the glacier. Moreover, droughts and frosts are the most frequent disasters and they affect all communities as they depend on agriculture. Both, Chichubamba and Ccatan Pino receive less water from the river, as they are in the lower region of the watershed, while San Isidro de Chicón has a higher risk to frost since they are located in a greater altitude. These findings overlap with scientific studies on hazard risk.

The potential ecosystems services that can be obtained from the native forest are supporting services, regulating services, cultural services and provisioning services. The main species mentioned by the locals were: Qiwiña (*Polylepis spp.*), Chachacoma (*Escallonia resinosa*) and Aliso (*Alnus jorullensis*). These species are often used for soil recovery in the Andes, to protect water and regulate microclimate. Results show that people are aware of the benefits that native forest bring and show willingness to reforest the surroundings of the Chicón glacier, as they already did one reforestation campaign this year and because it was one of the women recommendation to adapt to climate change and reduce disaster risk.

Women assessed vulnerability in a workshop using the CVCA methodology from CARE International. The outcome shows that all their livelihoods (crops, farms, animals and food) are vulnerable to GLOF, droughts, frosts and hailstorms. People from San Isidro de Chicón and Yanaconas living in the riverbanks are especially vulnerable because of their exposure to GLOFs. Chichubamba is also vulnerable but in a lower level as the debris flow can reach the crop fields through the irrigation channels. Results on physical vulnerability estimated by PREDES, support these findings. Vulnerability is exacerbated by physical vulnerability of houses since they are made of adobe and are not well structured, poverty levels, steep slopes and poor work of local institutions.

Finally, after testing the hypothesis it can only be partially approved. It was found out that climate change increases disasters such as droughts and GLOFs in the Chicón watershed. People in the study area are aware of climate change impacts, but they only partially understand causes and effects. However, the asseveration that ecosystem services for climate change adaptation and disaster risk reduction are also not fully understood and therefore ecosystem-based measures remain untapped is false, as people have reforested the upper part of the watershed. Moreover, the results from the questionnaire and workshop show that the communities are willing to implement Eco-DRR and EbA projects.

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9. ANNEXES

Annex 1. Expert Interview

Time and Date: 15:00, 30.03.2017
Place: CARE Peru, Lima.
Mrs. Karen Price Rios
National Coordinator of the GLACIARES Project
Climate Change Programme
Av. General Santa Cruz 659. Jesús María. Lima www.care.org.pe
Of: (+51) 4171153 |Cel: (+51) 995 301 561
E-mail: kprice@care.org.pe

- How is CARE Peru involved in Climate Change Adaptation and Disaster Risk Reduction?
CARE Peru is identifying vulnerabilities to climate change with local leaders using two different methodologies: CRISTAL tool (Community Based Risk Screening Tool Adaptation and Livelihoods) and CVCA (Climate Vulnerability and Capacity Analysis).

- Do you have Projects in Cusco?
Yes, we have an office in Cusco and we are working in Urubamba. We have organized leadership workshops and we have found out that people is worried about water quality and supply and not that much about risk.

We have also implemented these methodologies in Chicón. The people had done a participatory mapping and had identified the best measures to solve their problems.

You can also used our methodology and do a replication of the workshop with a gender focus on woman this time.

- Do you know if there are researches and implementation of solutions in the Chicón watershed in order to reduce risk and adapt to climate change?
There is an infrastructure (Retention wall) that was built to reduce the flow of the river in case of another GLOF. However, people complain that it was not properly built and that the money invested could have been used more efficiently.

On the other hand, the NGO PREDES was also working with the municipality and they helped with the implementation of an Early Warning System. Besides, USA and the Zurich University have done an ethnographic research in this area.

You can also search the risk map for GLOF or alluviums, as they are called in Peru, as well hydrologic studies.

Last year, there was a reforestation campaign in the upper part of Chicón watershed for protection and to maintain the water recharge.

- Do you think that people are aware of glacier retreat and risk?
Yes, people is conscious about glacier retreat because is evident and they know they have to adapt to those changes. Despite of this, the risk of another GLOF is not high and the main concern and challenge, as I told you, is water supply.

- Is this area very touristic?
No, there is not much tourism in Urubamba and the Chicón watershed. The people have a need of higher sources of income, especially in the short term, which is their priority.

- Do you know if ecosystems are being used for climate adaptation and for disaster risk reduction in Peru?
Yes, the iconic project is PACC (Climate Change Adaptation Programme), which was created to solve problems related to climate change. It is cooperation between the Environmental Ministry and the Swiss Agency for Development and Cooperation (COSUDE). The regional governments of Apurimac and Cusco have implemented it while the Helvetas Swiss Intercooperation, Libélula and PREDES are the facilitators.

The project is based on the communities and the GLACIARES Project so as the Zurich University are the technical members. The mission is to take people out of poverty and the vision is to change the attitude of people and to empower them. It is a mix between scientific and social knowledge.

When you work in this kind of projects is also important the economic aspect, so people can have a direct return and keep the initiatives.

- What do you think is needed to promote EbA and Eco-DRR?
In Peru the public investments for projects are sectored or categorized into one use and that is a barrier because multi-use projects are generally not accepted. There are multi-use projects but mainly in the pacific and in big scales.

Annex 2. Expert Interview

Time and Date: 17:00, 31.03.2017
Place: CARE Peru, Cusco.
Mr. Walter Choquevilca
Project coordinator, CARE Peru in Cusco
Los Kantus C18, Urb. La Florida, Distrito de Wanchaq, Cusco. www.care.org.pe
Cel: (+51) 949 655 854
E-mail: wchoquevilca@care.org.pe

- Which measures have been taken in the Chicón watershed?
There is an Early warning system that was installed by the municipality. It includes four components: Monitoring and surveillance, Communication Network, Warning and Alarm, and an Evacuation Plan.

The university of Zurich has worked in a risk map for the watershed and also in a leadership plan.

We also helped the San Isidro de Chicón community to build a model of their community and resources. It was exposed in the municipality recently and now the president of the community has it. Finally, last year we did a workshop using the CVCA tool in order to identify vulnerabilities from the community point of view. The cold waves and hailstorms are the hazards they think are more dangerous. The leaders of the community proposed adaptation projects. One initiative was the reforestation using native trees and not Eucalyptus.

Furthermore, students of psychology and anthropology from the Cusco University had research about the perception of people to climate change. Maybe you can talk to them.

- What are the topics that you work with the communities?
We focus on 4 modules: Climate change adaptation, Disaster risk community management, Diagnosis of Integrated water resources management in watersheds and Community development planning.

- Do you think that I can use your methodology and do a workshop with the community?
Yes, it is a good idea. You can do it only with women from the watershed and not only San Isidro de Chicón so we can have more information and complement the existing one.

- Can you give me more information about the steps for this workshop?
You have to use the CVCA and according to this methodology you have to do an informative meeting with the representatives of each community. You have to explain them why are you doing this, how it works and the benefits for them.

After you talked to the representatives and you set the date and time, you will do the workshop. The women will work in teams for about 5 hours. They have to identify and prioritize vulnerabilities.

The third step is to give back the information to the community. In this meeting they will validate the results and you should improve the report in case they suggest something.

I recommend you to inform the people in one of their committee meetings so their attendance is mandatory. You should also decide with them where to do it and who is going to cook the lunch.

- What other recommendations do you have?
You should make an introduction before you start with the workshop. You should talk about the glacier retreat and ask them what is going to happen once the glacier disappears, let's say in 10 years.

You have to know and consider some facts about the study area. For example, in Cusco and the sacred valley the young people leave rural areas and go to big cities to find better opportunities. The government uses an economic development model that does not locate environmental conservation as a priority. Additionally, there is no good capacity to manage water resources.

The uses and costumes are being lost and they are not included in the legal framework creating a conflict between them. In practice, this issue worsens water management. Moreover, the legal framework is focused on the coast and is not realistic and applicable to the mountain range.

Due to climate variability and climate change there is more lost of water through evaporation and there is no storage or harvesting of the rainfall. The ENSO phenomenon is increasing droughts in the mountain range while in the coast there is a lot of rainfall. According to some studies 85% of the small glaciers (below 5000 m a.s.l) in Peru will disappear very soon.

Annex 3. Expert Interview

Time and Date: 10:00, 05.04.2017
Place: Urubamba municipality.
Camilo Ortiz De Orue Carrion
Civil Defense
Cel: (+51) 959 768 506
Email: fortaleza.2008@hotmail.com

- Is there a risk map for GLOFs?

Unfortunately we do not have a risk map for GLOFs but there is a geological study for this area that was done by INDECI and UNDP. I am also doing a postgraduate and I am evaluating the economical, environmental and social risk to disasters in the Chicón watershed.

- What is Civil defense doing to respond to disasters?

We are working together with CARE Peru and we are having trainings in order to improve our work. Besides, we work under the Provincial adaptation plan.

- How often are the disasters in this area?

The last disaster that we had was the one in 2010. We do not have records of other disasters.

- Do you have a census of the people that was affected in that disaster?

No, we do not have the exact numbers.

- Do you know how many people live in the communities from the watershed?

We also do not have a census but you can get that information from the INEI (National Institute of Statistic and Informatics).

Annex 4. Expert Interview
Time and Date: 10:30, 05.04.2017
Place: Urubamba municipality.
Susan Romina Bustos Pezo
Environmental Management Office
Plaza de Armas s/n - Urubamba
Telf. (+51) 084 201 077

- How often are disasters in this watershed?
There have been two GLOFs in this watershed. The first one was in 1940 and the last one in 2010. Both reached until Mariscal Castilla, the urban area of Urubamba.

- Do you have a policy or a climate change action plan here in Urubamba?
We have a four years valid climate change agreement with CARE Peru. We started last year with the formation of leaders.

The municipality works with micro watersheds that are Chicón, Pumahuanca and Yanahuara.

At a local level we work with the Concerted Development Plan, we also have a Regional Concerted Development Plan and finally a national one called Bicentennial plan.

- Have you implemented solutions in the Chicón micro watershed?
We installed an Early warning system, which is one of the components of a project between the municipality, FONCODES, JERGO and FONCOMUN.

This EWS includes dissipaters, channeling of the river, a retention wall, cameras, meteorological stations, substation in the monitoring lagoons, motion sensors. This EWS is connected to the firefighters, Police, MINSA (Health Ministry) and the Municipality. The system is working but not fully. We have to train the people in order to improve the social component of the system; we are planning to do that together with CARE Peru.

- Can I have access to the EWS file?
Yes, you should write a letter to the major (Ing. Humberto Huaman Aouccapuma) and ask for a digital copy of the technical file “Installation of the protection service in the Chicón watershed, Urubamba district, Urubamba province, Cusco”.

Annex 5. Expert Interview
Time and Date: 10:30, 10.04.2017
Place: PREDES Cusco.
Karin Kancha Sucno
Project Coordinator
Urb. Magisterio primera etapa calle trinidad Enríquez B-3
Tel. (+51) 084 201 077

- Which actions did you take after the disaster of 2010?
First of all we are an NGO that works with disaster risk management. After a disaster occurs we try to be involved in the emergency.

In the Chicón micro watershed we were part of a consortium of institutions that was financed by the European commission. Initially, we worked with IGEMET and did a study to evaluate the risk. In 2011-2012 we did a simulation of GLOF using the flow of the disaster of 1942 and the result was that in 15 to 16 minutes the flow could reach the main avenue.

The EWS of the Chicón watershed was designed using the guidelines of the Civil Defense National System (SINADECI). However, this guideline was valid until the beginning of 2012. Afterwards the National System of Disaster Risk Management (SINAGERD) was created and the municipality asked for a report due to the change in the policies.

With money from the Promotion Fund for Regional and Local Public Investment (FONIPREL) the Urubamba municipality implemented the project in order to reduce disasters.

In 2011 PREDES also promoted a contest called “Saving food for hard times” so the people could store, transport food and not depend only from one crop. In 2012 we also did a campaign called “Safe and healthy housing” that included simulacrums so the people could know the escape routes. I will send you a file with the project information that we have.

- Are you still working with this watershed?
No, we work with places that are in emergency state and that is why we are frequently changing locations. Right now we are working in Calca with a project called “Adaptation of Andean Communities to Climate Change”.

- Do you know if someone else is supporting the municipality with adaptation to climate change and the reduction of disaster risk?
Well, I know that there are some studies that can be useful for your research. You can try to find a report called “Sustainable cities- Urubamba Hazards Map”. It was done by the INDECI and the United Nations.

For climate change you can search models in Cusco and information from the Regional Andean Project for Climate Change Adaptation (PRAA). Additionally, you can also use information from the PACC project since they have been working in Cusco since 9 years.

- Do you know where can I get a population census for the communities in the watershed?
The last census was done in 2007. I think there is no updated data. You can use that value and estimate the actual population by using the population growth rate.

Annex 6. Household questionnaire

ENVIRONMENTAL AND SOCIAL RESEARCH: CHICÓN WATERSHED, PERU

Field Research for Master's Thesis
Cologne University of Applied Sciences (TH Köln)
Institute for Technology & Resources Management in Tropics and Subtropics (ITT)
Email: yaremi_rivera@yahoo.es

QUESTIONNAIRE: COMMUNITY SURVEY

Objective: The main objective of this questionnaire is to know the perception of the community to disasters and climate change, as well as their traditional knowledge to reduce them and to adapt.

--Thanks for your help

Date: **Community**:

1. PERSONAL DATA:

1.1 Gender: __ Male; __Female
1.2 Age:
1.3 How many members does your family have? (number)

2. MIGRATION

2.1. Do you think people migrate to other places? No__ ; Yes__
2.2. If yes, please indicate why?
Disasters; __Climate change; __Better opportunities; __Deforestation; __Others

3. CLIMATE CHANGE

3.1. Have you perceived changes in the climate in the last years?

3.2. If yes, what are the visible changes for you?
__Shift in the rainy and dry season; __Droughts; __Intense rainfall; __Less rainfall
3.3. Is the temperature the same? Is it warmer or colder?

3.4. Do you know if there are measures implemented to adapt to climate change?

3.5. Who should take decisions and implement solutions for climate change?

4. DISASTERS

4.1. Do you think that disasters have increased in the last years?

4.2. What disaster are more frequent for you:
__Droughts; __Floods; __Landslides; __Alluviums; __Huaycos; __Cold waves
4.3. Which areas of the Watershed are more affected by disasters?

4.4. Do you know if there are measures implemented to reduce disasters in the area?

4.5. Is there a traditional knowledge to respond to disasters?

4.6. Who should take decisions and implement solutions to reduce disasters?

4.7. Do you know the early warning system in the community?

5. ECOSYSTEMS/NATURAL RESOURCES

5.1. Do you think that the forest help to adapt or mitigate climate change?

5.2. Do you think that the forest can help to reduce disasters?

5.3. Are the water resources reduced in the last years?

5.4. Is the forest cover the same in comparison to 10/20/30 years ago?

5.5. Which are the more important tree species for you?

5.6. Do you think that the Chicón glacier is smaller than before?

5.7. Do you think that the soil has been degraded in the last years?

Declaration in lieu of oath
By

"Yaremi Karina Cruz Rivera"

This is to confirm my Master's Thesis was independently composed/authored by myself, using solely the referred sources and support.

I additionally assert that this Thesis has not been part of another examination process.

Cologne, August 26th 2017

Place and Date | Signature