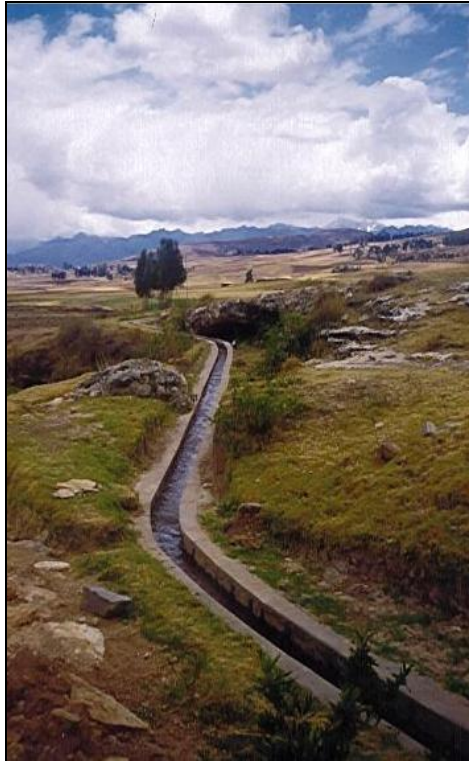


Climate Change and Water Management

A study of perceptions and adaptation in the communities of Taucca and Umasbamba, Peru



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3094812

Master's Thesis

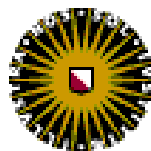
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Executive Summary

The phenomenon of climate change will increasingly alter natural cycles at a global level and affect natural ecosystems and human development in harmful ways. Its effects are manifested in the disruption of the hydrological cycle combined with increasing temperature and precipitations' fluctuations. Numerous studies have proven that climate change is caused by GHG emissions mainly originating in industrialized countries. Unjustly, the harshest effects are experienced by poor people in developing countries that do not substantially contribute to the intensification of climate variability.

The Latin American region is characterized by its biological and climatic diversity; however, it is also characterized for having populations with poor living conditions and few capacities to respond to adverse climate events. Peru is considered one of the most vulnerable countries to this phenomenon due to its high dependence on primary sectors such as agriculture and fishery and for the consequences it may have on poor populations. In the mountain region of Peru, climate change is manifested through decreasing water availability and a number of climatic events that are gravely affecting rural livelihoods.

This study has investigated a population from this region that is highly dependent on the natural resources of their immediate environment. During an internship with the organization of PACC in Cusco, Peru, this research has focused on two communities, Taucca and Umasbamba, to investigate the perceptions peasants have of a changing climate and learn about their adaptation practices. Due to the importance of water in agriculture and human development, this research has focused on the impact of institutional aid on water management to reduce climate vulnerability.

Arariwa and Pronamachcs are two institutions that have given their support to improve water management and soil conservation practices. The construction of infrastructures, and capacity building workshops have been implemented in projects to protect the natural environment and conserve its natural resources. At the same time, this support intended to enhance communities' resilience increasing water availability and efficiency. Despite receiving similar support in similar geographic conditions, the communities' development has been poles apart

This research has found evidence that extreme temperatures are increasing and precipitations are becoming more unpredictable in the analyzed communities. This data is also confirmed by the testimonies of peasants which are increasingly affected by natural disasters; mostly manifested in cold spells, floods, and hail.

As a consequence of climate unpredictability, the majority of peasants have turned to new explanations and left behind traditional knowledge that are becoming less credible. The community members of Taucca show how Evangelism has reduced their belief in indigenous wisdom which is still more present in Umasbamba.

The support of Pronamachcs and Arariwa was focused on agricultural practices to improve the water availability of communities as well as conserving the environment. This happened mainly through water and soil conservation practices such as: infrastructure, terraces, infiltration ditches and capacity building. These contributed to the adaptation for climate change and variability.

Taucca has turned out to be an example for water management and for soil conservation. This has been possible as its peasants have taken advantage of capacity building and because of good coordination and community reliability. Umasbamba has failed to implement water management and soil conservation activities Irrigation technology is not used efficiently to save water and peasants do not repair water installations. Many community members ignored long-term benefits of soil and water conservation practices and opted for short-term rewards in tourism and construction. Inefficient soil and water conservation practices have lead to more erosion of the land.

Arariwa and Pronamachcs have been able to increase peasant's resilience levels when water management practices have been applied and used correctly; these have been in line with most of the perceptions and needs of the communities related to the lack or excess of water. Problems of crop and livestock disease caused by changing temperatures have not been attended by the water management activities analyzed in this study. Elements of the institutional approaches have contributed to paternalism and dependence to economic support. This lead to the discontinuation of water management activities after the institutions withdrew their support in Umasbamba. However, Taucca has been able to organize itself with strict rules, successfully continuing the supported activities and improving their resilience.

In Taucca, evangelism has shown to have had positive impacts on family and community relations. It has helped eliminate problems of alcoholism and promoted organization and cooperation. However, the growth of Evangelism has caused the lost of important traditional knowledge and replaced indigenous culture. In Umasbamba the introduction of Evangelism has caused conflicts between members, weakening the communal organization which is indispensable for successful adaptation and resilience.

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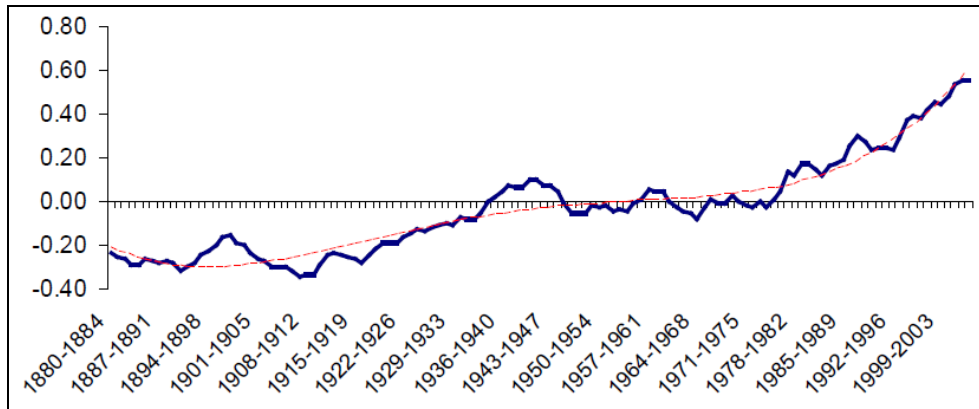
Chapter 1: Understanding Climate Change

The topic of climate change is one that has grown in importance over the last decade and has great consequences in the development discourse as well as on environmental research. Numerous literature and strong evidence points out that this phenomenon is a reality and that if policies do not shift to a more sustainable direction, it is imminent that the world will face scenarios of extreme climatic change with world-wide repercussions. Even if some countries have taken the initiative to reduce factors that alter our climate, the poorest countries are the ones affected the most. The water cycle is expected to be altered in important ways by this phenomenon. The uneven distribution of this resource throughout the year will affect societies in numerous ways, as water is a central resource that supports human activities and ecosystems. The agriculture sector, among others, is extremely vulnerable to climate change due to the constraints it can have on the hydrological cycle and the availability of water. The likelihood that already existing water related problems will worsen are high, therefore the clear next step is to adapt to future conditions.

Poverty is enduring in many aspects, with individuals lacking proper health, food, shelter and education. Although these issues are problems in themselves and require specific responses, global warming and its consequences are invasive and can aggravate different features of poverty. Although this topic has been discussed and dealt with in many levels, especially in international and political agendas, a very different reality is experienced in remote communities. At a global level, goals to react to climate change are clear, where key institutions such as the United Nations Framework for Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) bring countries together to agree on reducing green-house-gasses (GHG) emissions and to find new methods of adaptation. Likewise, NGOs and government institutions are increasingly combining efforts to improve local conditions to resist climate variations (IPCC 2007).

1. Global climate change

Global warming is generally defined as the steady rise in average temperatures of the Earth's atmosphere, caused by the release of greenhouse gasses. Effects of this climate phenomenon are globally manifested in the rise of sea levels and the disruption of the hydrological cycle (mainly in the amount and patterns of precipitation), all of which have other subsequent consequences on ecosystems. Among these, likely effects include the frequent occurrence of extreme weather (heat waves, cold spells), changes in agricultural yields and the deterioration of ecosystems and extinction of species due to shifting temperatures (Vuille, et al. 2008). Graph 1 shows temperature variation since the industrial revolution.



Graph 1. Global temperature variation (*C), the average global temperature rises to 14*C. (Vargas 2009).

2. Climate change in Latin America

The Latin American region is characterized by its biological and climatic diversity, many of which are embedded in the numerous forests that renew the atmospheres' components and the mountain ranges that provide some of the most important sources of fresh water. About 99% of all tropical glaciers from the region are located in the Andes, which provide about 80% of the freshwater supply in the arid and semiarid regions of the tropics and subtropics (Vuille, et al. 2008). Their exposure to increasing atmosphere temperatures caused by global warming is now causing the reduction of glaciers and threatening the reduction of water availability. This has far-reaching consequences for the agriculture sector, hydroelectric plants, natural ecosystems and the general access to fresh water.

3. Climate change in Peru

Peru is a country with a great variety of ecosystems and communities dispersed in its land; many of which are experiencing direct or indirect impacts from climate change. Furthermore, Peru is considered one of the ten most vulnerable countries due to its high dependence on primary sectors such as agriculture and fishing, which are highly exposed to climate change (Vargas 2009). Development programs and projects focusing on vulnerable populations are not new to any region in this country; nevertheless, the Andes region has called special attention due to the concentration of poverty and for its important role on the hydrological system.

According to a UNDP report, Peru has been ranked third globally in terms of risk to climate related disasters, and has ranked in the top thirty in the last three decades. (Rubio 2007). The IPCC has stressed the current and future impacts of climate change in Latin America in terms of vulnerability, something that would greatly affect South America's most water stressed country (Bury en Bryan 2011). While some say that the country has a strategic location for water resources, it will have issues with the balance between water supply and demand due to demographic densification, economic growth and pollution problems due to agriculture and industrial pressures. Peru has 70% of its population living in the coastal region were only 2% of

water resources are found. The Andean region (the mountains), found between the coast and the jungle, has a vital role in providing river runoff. Peru has 71% of the tropical glaciers found in South America and it provides 80% of freshwater for downstream populations and ecosystems. This is possible due to seasonal glacier melt, but the region has already lost 22% of its glacier area since 1970 due to the significant increase of average temperatures (Bury and Bryan 2011). This source of water is seasonally variable and especially important during the dry seasons as it provides a crucial buffer for the coastal lowlands, where most of the cities and population are located. On a side note, runoff water from the Andes is also essential for the country's power supply. Numerous hydro-electric plants are estimated to provide 80% of Peru's electricity requirements (World Bank 2010). The water resource interdependence and the advanced glacier melt that is currently taking place is one of the main reasons for Peru's high vulnerability position.

Nevertheless, there is a frequent misconception when speaking of global warming. Without a doubt there is a danger with the rise of temperatures, but the extreme minimum temperatures are also harming populations and ecosystems. Unexpected temperature changes can result destructive for environments and anything inhabiting them. Peru has recorded minimum temperatures up to -26.5°C and strong ice spells are increasingly frequent in the Andean region (Paredes 2010). This combination of natural events is extremely hard to endure, especially in arid and remote areas such as the ones found in the mountains. Several characteristics of poverty such as poor services, low income and poor health should be taken into account when describing the peasant families that inhabit this region.

4. Impacts of climate change in Peru

The massive amounts of water stored in the mountains of the Andes and their importance for future generations have caused scientists to follow climatic studies to predict their evolution. A study carried out by Vuille in 2008, which has compared data from about 70 years, has recognized steady trends of climate and the reduction of Andean glaciers. His information can be generalized to most glaciers in this region, although with some small differences in humidity, cloud cover, and atmospheric circulation. According to his results, temperature in the Andes has increased by approximately $0.10^{\circ}\text{C}/\text{decade}$. His projections indicate that this warming will continue throughout the 21st century and will do so increasingly at higher elevations. Based on a compilation of 279 weather stations across the mountain region, there has been an overall temperature increase of 0.68°C since 1939. His predictions show that the Andes region may experience a substantial warming of $4.5\text{-}5^{\circ}\text{C}$ by the end of the 21st century. As mentioned before, 22% of its glacier area has already been lost since 1970 due to this significant increase (Bury and Bryan 2011). Based on IPCC scenarios for 2050 and 2080, tropical glacier-models indicate that glaciers will continue to retreat, some disappearing in the next few decades. Such simulations have also pointed out that even if some glaciers do not completely disappear, their

change in seasonal stream flow will significantly affect the water availability due to the reduction of the glacier buffer. Andean and coastal populations will increasingly depend on rainfall and will probably have more extended droughts (Vuille, et al. 2008).

It is important to point out that climate variations in this region are also related to the ENSO phenomenon, which also increase the probabilities of floods, landslides and droughts (IPCC 2007). The IPCC also has related glacier retreat to such events that increase temperatures between 1°C and 2°C above average.

5. Political response

Given the environmental and socio-economic vulnerability of Peruvian society, priority should be given to policies of adaptation to climate variability and change. However, despite the relatively low contribution to GHG emissions, Peru has given a disproportional attention to programs of mitigation (Cancino, Mendoza en Postigo 2011).

A National Strategy for Climate Change (ENCC) was set up in 2001 with the purpose to include climate change issues in policies and regional projects. Later in 2003, the PROCLIM program was approved to strengthen adaptive capacities in public and private institutions. The program's objective includes improving technical capacities of institutions related to climate change and increasing their cooperation and coordination. The National Environmental Council (CONAM) was also established to carry out activities that would strengthen local institutional research capacity to carry out studies on vulnerability and adaptation (Universidad San Martin de Porres 2008). The creation of such institutions and the acquired knowledge on this topic brought together numerous facts in order to heighten the government's and civil society's interest in damages of climate change.

Among the various institutions that have brought together efforts to face climate change, the Program for Adaptation to Climate Change (PACC), is one that has been set up by the Peruvian Ministry of Environment in cooperation with the Swiss Agency for Development and Cooperation. This institution looks to integrate efforts from the national, regional and local levels to coordinate responses to climatic adversities caused by climate change. They aim to learn and inform different stakeholders about climate events and preventive measures in order to reduce their vulnerability. Two Peruvian NGOs they closely work with are 'Libelula' and 'Predes', which develop program evaluations and put pilot experiences for climate adaptation into practice. Their research and results are also used to influence public policies and international negotiations on this subject (PACC Peru 2011). PACC works in Apurimac and Cusco, two departments in the southern mountain region of Peru which are specially affected by climate change. Because of their interest in new research and experience, PACC has allowed students from the University of Utrecht to carry out internships practices. This research was possible thanks to their support throughout my stay in Peru.

6. Research study

Generally speaking, scientific and political agendas seem to be clear on how to tackle the complex issue of climate change by applying mitigation and adaptation measures. Nevertheless, the outcome of such programs and projects are very different from the desired results. For peasants, poverty and survival are more concerning realities than sustainable development and future resources. Such contrasts and the idea to corroborate the implementation of adaptation projects have been behind the motivation for this research. Not only has this allowed me to see the effects of the climate change phenomenon but it has also allowed me to test the effectiveness of development projects.

This study has taken an interest to investigate a population that depends on natural resources and conditions of their immediate environment. The Andean population is one that directly suffers from the climate change phenomenon and that puts the environment and peasant's livelihoods under great pressure. Because the climate is so fundamental to their everyday activities, variations are increasingly being seen as a threat. Focusing on the communities of Taucca and Umasbamba in Cusco, Peru, this thesis has researched the perception peasants have of a changing climate and the effects it has on their lives. Due to the importance of water in agriculture and human development, this research will focus on the relation between climate change and water management.

Local institutions and NGOs are aware of issues of climate change and have tried to combine water management activities to poverty-reduction programs and projects. In this region and context, both mitigation and adaptation practices are possible, however, only the latter will be able to improve peasant's conditions in a near future. This thesis will analyze the projects carried out by institutions, specifically those that deal with water management and then analyze if they are in line with the climate dangers peasants perceive as harmful.

7. Thesis composition

This thesis has been structured in 9 chapters to portray the problems caused by climate change in the world and in Peru, describe local perceptions of this phenomenon, and describe some of the actions that are taking place to reduce its harmful effects. The important concepts surrounding climate change will be dealt with in Chapter 2 to provide the reader with necessary information from relevant literature about this topic. Chapter 3 will elaborate on the research questions and methodology which have been used for this research. This is followed by a descriptive chapter (4) that depicts the region and communities under study and provides necessary background information for further comprehension of this research. Chapter 5, 6 and 7 will describe the research findings. In chapter 5, perceptions and meteorological data on climate variations in the communities and river basin are analyzed. Chapter 6 analyzes the projects institutions have implemented to help communities improve their water management.

Chapter 7 will analyze if the implementation of such projects has allowed communities to build resilience according to their own perceptions. This is followed by Chapter 8 which presents important factors that have determined the project's success or failure. Finally, the conclusions in chapter 9 review the main findings to give the reader the most important lessons from this research.



Picture 1: The Piuray-Ccorimarca river basin with Marco Luna (M. Verkooijen)

Chapter 2: Concepts of Climate Change

The world has been exposed to climate variations since its existence and humans and organisms have been able to react accordingly and successfully. Then why is there so much lobbying for climate change and for development aid related to this phenomenon? In the last decades, much emphasis has been placed on environmental research, focusing on organisms, habitats, and natural disasters, which may have devastating impacts on human livelihoods. This chapter will analyze the concepts surrounding climate change to better understand its meaning and its impacts.

1. Climate change and climate variability

First of all, some clarifications need to be made about the definition of climate change. The atmosphere's balance has been tipped off due to internal and external forces. According to the IPCC, 'climate change' refers to "a change in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer". Such external forcings may vary from increased solar radiation or volcanism to atmospheric change due to the release of toxins (CO₂) caused by human activity, which have mainly started in the industrial revolution (IPCC 2007). On the other hand, internal variability may be characterized by atmospheric processes, such as condensation or evaporation, which may take place instantaneously throughout several years. Further internal components that influence the climate could include the ocean, large ice sheets, or the interactions between them (e.g. El Niño Southern Oscillation), which may bring variability to the atmosphere. It is therefore important to understand the extent to which the observed climate changes are expressions of natural internal climate variability or externally forced climate change caused by human activity. Changes in the means and/or variability are mainly identified as changes in temperature and precipitation. Secondary factors include humidity, atmospheric circulation and cloud cover (Vuille, et al. 2008).

Although many aspects of climate influence characteristics and distributions of physical and biological systems, temperature and precipitation are the most important for measuring the impact of climate change. These two climate parameters are generally chosen because of their practical understanding and for their significant impact on our systems. However, because precipitation has a much larger spatial and temporal variability than temperature, it is harder to calculate its impact. The maximum, minimum and mean temperatures are easily recorded and they show the clearest signals of change in an observed system. Such measurements are also easier to work with when taking the seasonal cycles into account and when making inter-annual comparisons (IPCC 2007) (US Environmental Protection Agency 2011).

2. Mitigation and adaptation

The effects of climate change are unavoidable for numerous generations to come but since they are somewhat predictable, there are some actions humans can now take to face it. The United Nations Framework Convention on Climate Change (UNFCCC) has identified mitigation and adaptation as the two most important reactions. Mitigation to climate change implies reducing greenhouse-gas emissions and enhancing sinks, which remove carbon-dioxide (CO₂) from the atmosphere. Sinks are either natural or artificial reservoirs that accumulate and store this polluting carbon-chemical for an indefinite amount of time. On the other hand, adaptation means adjusting to the impacts of climate change. Most of the industrialized countries have already signed treaties such as the Kyoto Protocol and the UNFCCC to commit themselves to adopt national policies and take some mitigation measures to reduce the overall greenhouse-gas emissions; these efforts have nonetheless been overdue and according to the IPCC, “no mitigation efforts, no matter how rigorous and relentless, will prevent climate change from happening in the next few decades” (IPCC 2007). For this reason, adaptation is a necessary measure, especially for developing countries which have more socio-economic and environmental vulnerability than the industrialized countries.

3. Vulnerability

In this essay, vulnerability will be understood as the characteristics that influence the communities’ abilities to “anticipate, cope, and adapt to climate-related hazards”. These can be socio-economic and environmental factors that affect the exposure to a given hazard as well as the ability to cope or adapt to it. Socio-economic factors such as market conditions, the quantity and quality of livestock, and the variety of crops can be assets which allow households to cope better or worse to climate conditions. Environmental conditions can have adverse impacts on the communities’ abilities to obtain monetary assets and on their general conditions. An example of this could be the high levels of erosion or soil infertility due to strong precipitations or winds that affect crop growth (Sperling 2008). In addition, differences in temperature may bring infectious diseases to plants and animals as well as to humans. Such effects of global warming and climate change can cause permanent damage to land and water ecosystems. Factors that contribute to social vulnerability include rapid population growth, poverty and hunger, low levels of education, gender inequality, poor health, hazardous locations, poor access to resources and services and technological means. This is noteworthy as the world population will increase by some 3 billion over the next 50 years, most of which will take place in developing countries (Sperling 2008).

4. Resilience and adaptive capacity

The most vulnerable individuals are those who have the least assets to absorb “climatic shocks and limited capacity to spread risks and adjust their income sources to changing environmental conditions” (Sperling 2008). Those who are able to adjust their livelihoods to prevalent environmental conditions are characterized as least vulnerable. Hence, the higher the adaptive capacity the less vulnerable one becomes. Generally speaking, resilience and adaptive capacity can be used interchangeably. These terms refer to the capabilities to adapt to internal and external shocks and stresses, which are usually uncertain or undefined. Tangible assets (natural, productive, physical, and livestock and other forms of stock), intangible assets (social capital and non-market institutions allowing access or control of assets or resources, like reciprocity relations in the Andes) and capabilities (human and cultural capital, life cycle characteristics) shape livelihood strategies (Valdivia, et al. 2003). Hence, societies with a high adaptive capacity will be able respond to uncertain or undefined changes with fewer social, financial, and environmental costs and vice versa.

5. Water scarcity

When addressing water scarcity, it is important to know that there are three discourses related to this issue. Water is a vital resource for local as well as national development, however, each discourse has a different policy agenda and to different levels. The water resource management approach usually addresses the problem with large infrastructure supply schemes and demand side management strategies. The climate change approach focuses on the long term climate induced impacts on water scarcity such as floods and droughts and on ways to reduce such effects. Finally, the sustainable development approach focuses on meeting three components which include the social, the environmental and the economic. The first component would focus on the equitable distribution of water, the environmental looks out for the preservation of ecological reserves, and the economic aims towards the economically viable water provision with appropriate pricing structures (Mukheibir 2010). Even if all of these approaches are valuable and complementary for water access, it is generally hard to combine their goals in development practices.

“Combating climate change is vital to the pursuit of sustainable development; equally, the pursuit of sustainable development is integral to lasting climate-change mitigation. And the most pressing challenge is to strengthen the social, economic, and environmental resilience of the poorest and the most vulnerable against climate change and variability” – (Fischer, Shah en Van Velthuisen 2002).

Having access to safe water is something vital that determines livelihood risks and vulnerability. Water scarcity is rooted in power, poverty and inequality, and driven by its combination of depletion and degradation. As this resource is the most significant for reducing poverty and diseases, the UN has aimed at reducing the proportion of people without adequate access to

affordable water by half by 2015 (Mukheibir 2010). “Access to water and water services are also key aspects in water security, but are not always determined by scarcity, although this is often cited as the reason.” What causes water scarcity are generally poor political and economic policies that mismanage water distribution. The ones who suffer the least access are those who are geographically, economically, institutionally and socially marginalized (Mukheibir 2010). Numerous populations in developing countries fail to meet access to water services due to inefficiency, corruption, pricing, and water markets.

6. Water management

In the context of adaptation to climate variability and change, the definition of water management is similar to the one used by PRONAMACHCS, a government institution focused on natural resource management and development.

The terminology describing the human relation to natural resources has evolved through time, shifting from resource ‘use’ to more careful resource ‘management’. The former term implies the utilization of a specific resource but without considering the concepts of preservation, conservation and/or sustainability. For Pronamachcs, natural resource management concerns the combined efforts that take place to give natural resources an appropriate use and allow them to be sustained for future generations (Pronamachcs 2006).

Water management practices are characterized by attending matters of availability, quality and efficient irrigation and management processes. Correct water management will reduce the amount of water that is used per unit for any type of activity and it will favor the preservation or improvement of its quality. In this study, water management includes soil conservation, forestation and irrigation to improve the protection of water sources, water filtration, conservation, distribution and efficiency in its use. Furthermore, it includes the construction or rehabilitation and maintenance of infrastructure and the capacities to manage soil and water in a sustainable and equitable way.

Generally speaking, water management tries to harmonize multiple uses that might affect its supply and usage and at the same time satisfy social, economic and environmental needs. The term that is probably most ingrained in this concept is water efficiency. This refers to any reduction or prevention of loss of water that is beneficiary for society. Water efficiency is intricately related with water conservation, which suggests their goals have social and economic concerns to reach sustainable development goals. This investigation will deal with several technical and organizational capacities that strive for an optimal usage of water.

7. Use of indigenous knowledge in climate variability

According to Valladolid, a cultural legacy of pre-Hispanic cultures had a *cosmo-vision* which oriented indigenous populations in their adaptation to climate variability. This was possible with a highly sophisticated management of infrastructures of soil (terraces) and the capture, preservation and distribution of water. These activities were complemented with the management of *agromegabiodiversity* which combined plants resistant to adverse conditions such as excess water, hails and frosts. Pre-Hispanic cultures also knew how to interpret astronomic and biological signs, related to the behavior of plants, animals, rain patterns, clouds

and frosts, which allowed them to predict climatic events and have a dialogue with their natural environment. This agricultural science was part of their cultural and social organization which was full of religious values and rituals. Among these we find offerings to the Pachamama and pilgrimages, originally used for the exchange of seeds from different ecosystems (Valladolid 2009).

The respect for the indigenous including Andean knowledge is widespread in the society of academics and private or public development organizations which integrate it in their philosophy, views on development and/or practical approaches. This is also the case for Arariwa and PRONAMACHCS, two of the institutions mentioned in this research; however, with different approaches and to different extents. Although the use of indigenous knowledge is hard to preserve, academics such as *Amat* and *Dourojanni* agree that indigenous knowledge can still be useful to adapt to climate variability and climate change (Valladolid 2009) (Earls 2006).

Chapter 3: Problem statement and methodology

1. Problem statement

Local and international NGOs as well as government institutions have been supporting adaptation to climate change in the communities of Taucca and Umasbamba in the Piuray-Ccorimarca river basin of Cusco, Peru.

Climate variations worry peasants in these communities on a daily basis and they respond differently to its damages depending on their level of resilience. Regional and local studies have shown that the overall maximum temperature is rising, water flow from rivers and streams have decreased by 20-30% in the past 10 years, and evaporation of the nearby lake is increasing (Bustinza 2011). On top of this, natural disasters are frequent and their increasing intensity is difficult to be predicted. Among these we find the loss of crops due to intense droughts, icings, floods, and the emergence of new plant and livestock diseases. There are further consequences to these events which include the lack of proper nutrition, the loss of income, and a change in traditional farming. Agriculture and livestock keeping, which are the communities' main livelihoods, are increasingly at risk and the reduction of water as a cause of global warming will only make such matters worse. On top of this, the largest city in the region, Cusco, uses water from the river basin's lake, to supply 75% of the city's water (Pronamachcs 2003). If climate change is not harming these communities' water supply enough, the city is using up a vital resource from peasants without giving them any form of compensation.

Two communities, once similar in socio-economic conditions but now very different have been chosen to be compared in this study. One of the selected communities, Taucca, is now regarded as a milestone in water management in this river basin and in the region, for increasing its resilience to climate change. Peasants in this community are well organized for numerous activities and even receive weekly visits from other communities to talk about their experience and teach farming and irrigation techniques. On the other hand, the community of Umasbamba is one of the poorest in the region and has not been able to improve its production despite having more water resources than Taucca. Although both communities are only a few kilometers away, their progress in the past 10 years has been extremely different.

The area of study is representative of a large part of the Andean region as it shares similar geographical, climatic and socio-economic characteristics. For this reason and because it can prove project's success and possible replication, it is interesting to learn from its experience.

2. Research objective and research questions

Research Objective

The objective of this research is to understand the situation of communities in the Piuray-Ccorimarca river basin responding to the climate change phenomenon, especially on matters of water management that are so important for rural development. It will also investigate the climate change perceptions and manifestations that are common to this region to better understand livelihood struggles. In doing so, it will also look at previous NGO and government water management projects to understand reasons for success and failure, hoping to identify factors that can increase resilience levels.

Research Question

What are the perceptions of climate change in the communities of Taucca and Umasbamba and how are they using water management to increase their resilience?

Sub questions

Perceptions and meteorological data

- How do community members perceive climate change and what is the role of traditional perceptions and practices?
- How is climate change reflected in regional and local meteorological data?

Adaptation practices to climate change

- What is the role of institutions on water management adaptation practices for the communities of Taucca and Umasbamba?

Water management results

- Is institutional support for water management in line with the communities' perceptions and do they improve their resilience to climate change?

3. Research method and techniques

This research has the intention to conduct an in-depth qualitative study interviewing families from the communities of Taucca and Umasbamba within the Piuray-Ccorimarca river basin. This method of study was chosen as it aimed to learn about the different perceptions and responses on climate change and to know the effects of institutional support. The community members interviewed were chosen randomly for reasons of simplicity and to prevent biases. Because peasants were frequently out of their houses, it was better to go around knocking doors rather than making appointments. If peasants were not home, they would sometimes be interviewed in their nearby parcels. The use of a Quechua translator was also needed as some peasants; especially the females were only Quechua speaking.

4. Selection criteria

The reason for the selection of these communities has to do with their involvement in development projects and their importance for the conservation of the Piuray-Ccorimarca river basin. Although they have been equally supported by a number of NGO's and government institutions, their outcomes have differed in various aspects. This will allow an interesting comparison of successful and ineffective factors for their development. Furthermore, two different communities from the same river basin were chosen because they both have rain fed irrigation systems, which can be altered by climate change, and because similar socio-economic conditions can be found.

5. Research population

In total, the community of Taucca has 40 registered families, of which 15 heads of family were interviewed; therefore it can be said that 37.5% of the total population was taken into account. From the results, 66% of the interviewees were male and 34 % were female.

The community of Umasbamba had 68 registered families, of which 19 heads of family were interviewed; therefore the population represented is of 27.9%. The amount of males and females interviewed was also balanced, having 57% of them male and 43% being female.

6. Research operationalization

The communities visited were 1 to 2 hours away from the city of Cusco, depending on the availability of transport. The trips to the field (32) were done to recognize and meet community members and leaders as well as to carry out research. Depending on the time of arrival and on the availability of peasants, interviews could be made. Due to the remote location of the communities, most of the trips first needed transportation by public bus and then with a motorcycle. Interviews were usually done between 7 am and 3 pm, as peasants could be found in their houses for breakfast and lunch. If peasants were found in their parcels, interviews

would also be carried out there. Luckily, the technician that was present through most of the interviews had a motorbike and facilitated transport between houses, crops and communities.

The interviews with technicians took place in the city of Cusco, each being arranged separately and with consultation to PACC. A list of technicians that were involved in projects in this river basin was given by the office of PACC, after which other names were found to be important for the investigation. In many cases the technicians involved had moved to other jobs, which meant meetings usually took place in their offices or in cafes.

All the interviews with peasants and technicians were recorded for further hearing and analysis. This allowed conversations to be more casual and for better discussion. Nevertheless, notes were also taken at all times.

Secondary information was also picked up when interviewing different technicians. Technicians of Pronamachcs were more available as some of them worked as teachers or had jobs in Cusco. This also meant that it was easier to get secondary information from them. The reports collected and used for this research have mostly been obtained through interviews with Arariwa and Pronamachcs technicians and staff of PACC which were very helpful.

7. Questionnaires

The questionnaires were designed having previous knowledge of the presence of different institutions and their objectives in the region. A previous literature review and a few interviews to technicians were carried out to familiarize with information and issues. Having a research objective and sub-questions in mind facilitated the making of the two questionnaires. The questionnaire for peasants was separated in three sections, inquiring about the perceptions, manifestations and adaptation to climate change as well as the projects carried out by Pronamachcs and Arariwa. All questions were relevant to the research; however, some questions have been important to understand the general context and are not necessarily leading to conclusions. In some occasions, questions have lead to discussions which have given a different perspective and added important information to the research. The questions asked to peasants were repeated or explained differently if the interviewees had doubts. The questionnaire for the technicians was created to ask about climate change in the river basin, the institutional involvement and their results. There were also questions that were asked for general comprehension of the river basin management and past and current issues. The research questionnaires to community members and technicians can be found in Annex 1 and 2.

8. Possible research problems

A problem with the interviews could have been that peasants answered differently knowing that I was doing research on previous development projects. Because I asked about the

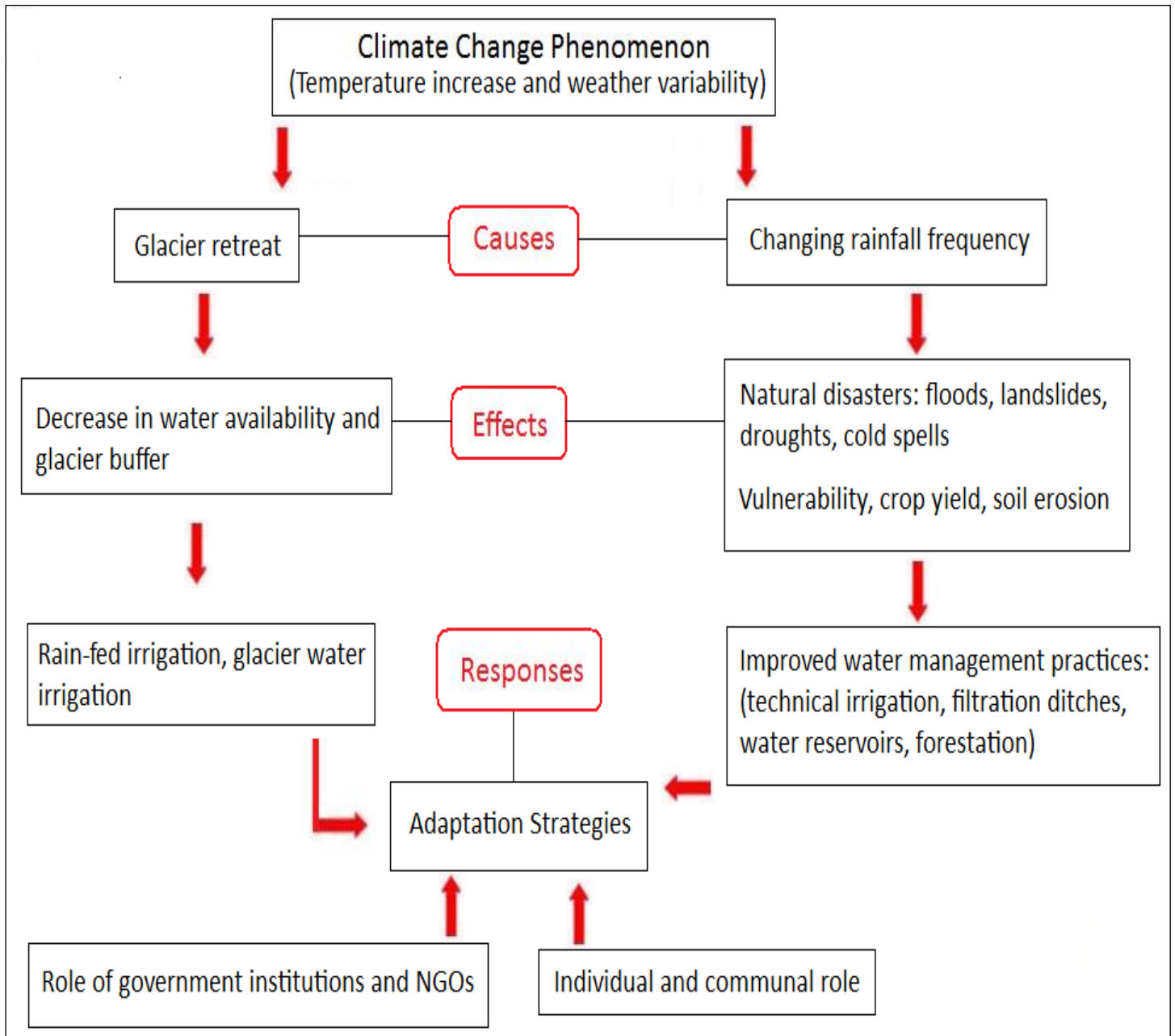
presence of Pronamachcs and Arariwa, some peasants could have undermined the previous support given in order to benefit from more projects. On the other hand, peasants could have answered quickly and without much detail as they were sometimes in a hurry.

The recollection of secondary information has resulted hard for several reasons. First of all, several documents are no longer available. Most of the technicians interviewed have moved on to different jobs or to other cities, which was sometimes an issue to interview them. On top of this, Pronamachcs no longer exists and has merged with other government institutions. At the time of the research, the Pronamachcs archive, which was now in the hands of AgroRural, was transferring from one office to another and the few people attending were busy moving. On the other hand, Arariwa is a closed organization and was reluctant to share reports. Once an agreement between PACC and Arariwa was done to ask for their cooperation, the person in charge of the archives said she had little time to search for reports and that she would send them once she had time; unfortunately this information was not received.



Picture 2: Interviewing peasants in Umasbamba while they worked (M. Verkooijen)

9. Conceptual Model:



Chapter 4: Regional Context

1. Peru's Geography

Peru is located on the western side of South America, with the Pacific Ocean on the West, Ecuador and Colombia on the North, Brazil to the East, and Bolivia and Chile to the South. The total population is 29, 132, 013 people in a total area of 1,285, 216 km² in twenty-four departments and once constitutional province (Eda and Chen 2010).



Figure 1. Map of Peru (Ciudades Virtuales 2010).

Peru has an advantage with its location due to its various sources of water. Its territory includes the Pacific Ocean, the Amazon River, which is the longest river in the world, and 71% of the tropical glaciers in South America. Its basins represent 5% of the world's fresh water supply and 25% of the aquatic ecosystems are found in the Amazon region. If the country's ground, superficial and atmospheric water is taken into account, it makes up 4.6% of the

volume of the world's run-off water (Eda and Chen 2010). However, the distribution of water among the population is not balanced; in fact, the water supply correlation is completely opposite in relation to the amount of people. The highest concentration of people is found in the Pacific slope (60.4%), followed by the Atlantic slope (34.8%), and the Titicaca slope (4.8%). Table 1 shows data related to water resources and their geographic location. It is important to notice that the Pacific slope has much less water supply in spite of its population and high consumption for agriculture, industries, mining, and livestock (Eda and Chen 2010).

Slope	Extension (km ²)	Number of basins	Total of hydric resources (millions m ³)	Superficial water (millions m ³)	Ground Water (millions m ³)	Water supply (% of the total population)	Distributed population (% of the total population)
Total	1,285,216	106	2,045,609	2,042,870	2,739	100	100
Pacific	279,690	53	37,030	34,291	2,739	1.69	60.4
Atlantic	956,751	44	1,998,405	1,998,405	—	97.81	34.8
Titicaca	48,775	9	10,174	10,174	—	0.5	4.8

Table 1. Water supply to the population by slopes (Eda and Chen 2010).

To understand the effects of climate change in Peru and the dangers it might cause, it is important to know the composition and the topography of the country. The Andean mountains are found along the entire territory and it divides the country into the mentioned regions, which can be seen in Figure 2, which portrays the physiographic profile of the country. The Andes are home to a number of tropical glaciers and water reservoirs, all which drain to 53 basins to the Pacific Ocean and 44 basins to the Amazon region. The highlands of Peru, which embodies 30% of the country's surface, are also the bearers of a number of valleys, mountains and glaciers, ranging from 800 to over 6,000 meters above sea level.

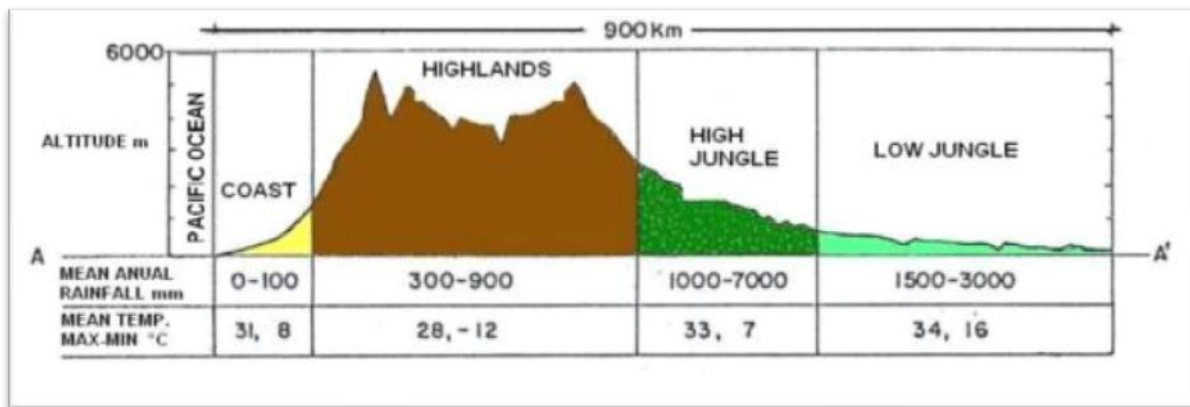


Figure 2. Physiographic profile at latitude 12°S (World Bank 2009).

The seasons in the highlands can be separated in two parts, winter and summer; the former being associated with dryness and low temperatures, and the latter being associated with rain and high temperatures. Because of the large differences in altitude, temperatures are also prone to fluctuations that on average can range from 20°C and 2°C in the course of a day (World Bank 2009). However, extreme temperatures are no exception and they can record as low as -26.5°C. The combination of these altitudes and temperatures make up a variety of ecosystems which also add to the importance of Peru's flora and fauna. However, the Andes' rough landscape is not always ideal for vegetation and agriculture. Figure 3 can show the difference in vegetation between the three regions and indicate how water is necessary for the lower parts of the country. Similarly, Figure 4 can indicate the environmental constraints on each area and the potential levels of production. From these maps, the Andean region can generally be categorized as having steep slopes and mountains with climatic stresses and low soil suitability (World Bank 2009).



Figure 3. Vegetation of land cover (World Bank 2009)

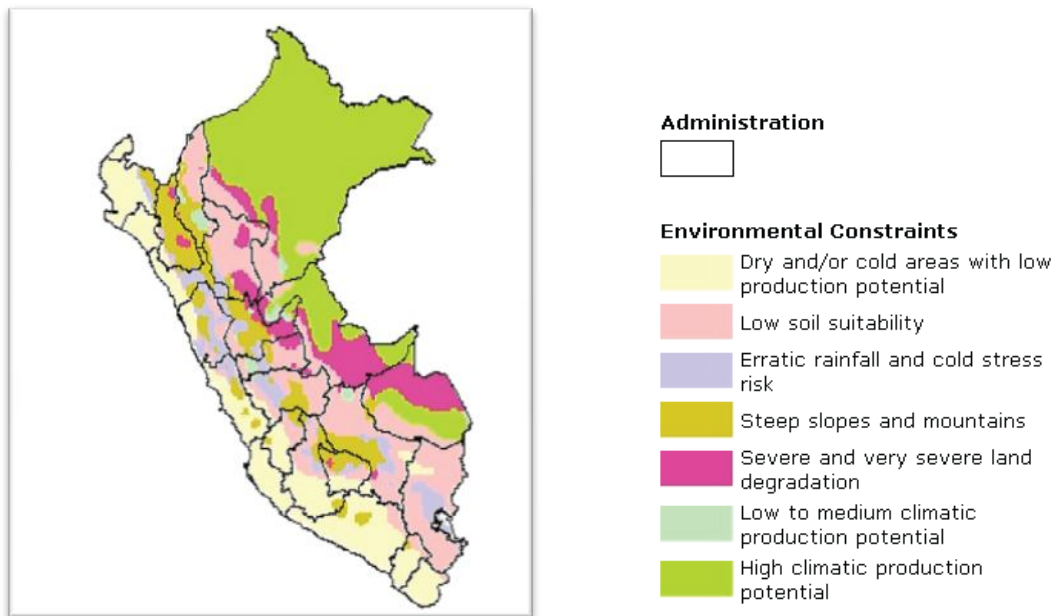


Figure 4. The Major Environmental Constraints related to Agricultural Potential (World Bank 2009)

Such geographic conditions combined with political and social exclusion has made the population in the Andean region one of the poorest in the country. Studies by the World Bank have shown that poverty and extreme poverty are highest in rural areas of the Andes and in both rural and urban areas of the Amazon. Peru has steadily reduced the percentage of population living in poverty, from 48.7% in 2005 down to 39.3% in 2007. Similarly, the level of extreme poverty has fallen from 17.4% in 2005 13.7% in 2007 (Gyorkos, Serene and Casapia 2009)

This reduction may be a cause of several anti-poverty or pro-poor programs such as the *Juntos* program which offers conditional cash transfers, or to the National Compensation and Social Development Fund (Fondo Nacional de Compensacion y Desarrollo, FONCODES) which directs social funds to community groups. Other programs target food assistance like ‘Glass of Milk’ (Vaso de Leche) or community kitchens (comedores populares) to reduce poverty levels. Despite such efforts, Peru has high levels of bottom inequality, were the poorest population lags behind all groups in access to targeted interventions. This means that even though social programs are present, the low quality of services provided will often limit the impact of the programs to improve their outcome and reduce poverty (Gyorkos, Serene and Casapia 2009). Even if development aid and government efforts have targeted distant communities from the rural regions, livelihoods continue to deteriorate and are increasingly alerted by climatic variability.

2. Climate Change, an environmental and socio-economic threat

When analyzing the economic and environmental aspects of Peru in relation to the future prospects of climate change, it is important to point out that 80% of the freshwater that originates in the Pacific side of the mountain region is designated to the arid and semiarid regions, most of which are in the coastal region of the country (Vuille, et al. 2008). This unequal distribution exists because large industries located in this region are given priority by the government for their contribution to the country's economy. 60% of the total population is also living in several developed cities, including the capital, Lima, which has around 1/3rd of the total population (Eda and Chen 2010). This is also why 68% of the country's irrigation infrastructure is found in this region. This leaves most peasant families in the Andes to be dependent on rainfall rather than on the water that comes from their lands. According to a report from the World Bank, 70% of the agriculture that takes place in the Andean region relies on rainfall. Of the total cultivated area, only around 30% is equipped for irrigation, an area which represents 1.7m hectares. From this, only 1.2m hectares are actually irrigated, with 85% done by flood irrigation, 15% by technical irrigation. Agriculture accounts for over 86% of the water usage in the country, yet 65% of this water is lost because inefficient irrigation systems are used. This happens due to leaky distribution systems and the widespread use of unimproved gravity and flooding irrigation methods (World Bank 2009). These facts are worrisome as 38.5% of the total population that is economically active is involved in agriculture (Paredes 2010). Water scarcity will inevitably be an issue if future climate continues to worsen and a proper/integrated water management and distribution system is not installed.

Several authors have studied the economic impact of climate change, especially in agriculture, fishery and the energy sector. According to (Cancino, Mendoza en Postigo 2011) a study by Vargas, projections for 2030 indicate a loss of 6% in GDP by the year 2030 and 20% for 2050 (Vargas 2009). Climate related disasters in countries of the Andean Community (Colombia, Ecuador, Peru, and Bolivia) are likely to affect 4.5% of GNP in 2025. Although losses in mega biodiversity are difficult to quantify, climate change might have serious impacts on biological reserves of these countries, estimated at 30% of its GDP (Amat y León 2008). The socioeconomic threat for people in rural areas is severe, as more than 70% of them live in poverty and whose livelihoods depend on natural resources (Amat y León 2008).

For different reasons, parts of the Andean population have been socially, politically or economically marginalized. Among these we find the lack of proper access to education and health services, access to natural resources and political exclusion. One clear example is the passing of a law in 1992, which opened the purchase of property rights over rivers. The first group to take notice and advantage would be the owners of large industries. In other cases,

indigenous populations living in distant regions would not be informed and therefore lose possession of what had been theirs for generations. Although the government has carried out the privatization of water rights to provide people with a monetary incentive and to coordinate and supervise water usage, this has had increasing social consequences. Situations like these cannot be generalized to the entire region, but a decrease of water availability and the high purchasing power large industries will make indigenous populations struggle to find water resources that are vital to sustain their livelihoods (Trawick 2003).

3. Cusco Region

The department of Cusco is located in the south-eastern part of the Andes region, and according to a study in the year 2000, it is home to 887 registered rural communities. These communities occupy 50,086.14 km², which is 45% of the Andean territory of this department. This is important taking their agricultural activities into account and the extended mountain region and Amazon cover. In the same year, 155 urban centers and 5,123 rural centers were registered. Urbanization levels have greatly increased in the last decades; from representing 25.2% of the regional population in 1940 to 46% in 1993. The reason for such growth has been attributed to the economic and cultural rise and influence of Cusco for other neighboring departments. However, poverty levels have remained high; according to a national household survey in 2001, 75.3% of the population in Cusco lives in a state of poverty, the majority coming from rural centers and communities. Those found in the highest parts of the Andes region, almost 100% of their rural population was lacking the most basic needs and services (Romero, Bautista and Calle 2002).

Although there is a lack of information about the regional GDP, a study in 1995 estimated that the average GDP per capita is \$ 1,345 per year. The main contributors to the regional GDP are the services (46.5%), agriculture (25.4%), manufacturing (10.5%), mining (8.8%), and construction (8.8%). Among the services sector, tourism has been identified as the main contributor and with the most potential for improvement (Romero, Bautista and Calle 2002). Archeological sites, natural sightseeing and cultural offers can provide long-term projects that can add to the generation of jobs and money. Among the activities that tourism has promoted, we find: craftsmanship, construction, services, food, etc. On top of this, national and international investment can improve local as well as regional conditions. A sudden rise in tourism is seen since 1996, as special promotions are created for national travels. Cusco is also internationally recognized with the increased knowledge of the Incan culture and the nomination of Macchu-Picchu as one of the 7 wonders of the world (Romero, Bautista and Calle 2002). Growth in such sectors have had a positive influence on job creation and migration within the region of Cusco.

4. The Piuray-Ccorimarca River Basin

4.1 General characteristics

The Piuray-Ccorimarca river basin is located in the central part of the Cusco department, in the province of Urubamba. It is part of the Vilcanota basin which is composed of two superficial water systems: the Piuray Lake and the Ccorimarca River. The lake is one of the most important water resources of the region as it provides the city of Cusco with 75% of its potable water (Pronamachcs 2003). Four important streams feed this lake: Pacchaoc, Queharhuayqo, Qagahuayco and Qusihuaygo, although superficial runoff and /or rain filtrations are also collected by the Ccorimarca river which separates into numerous more streams. The water from this basin flows to combine with the Vilcanota river which is later joined to the Marañon to then unite with the Amazon river.

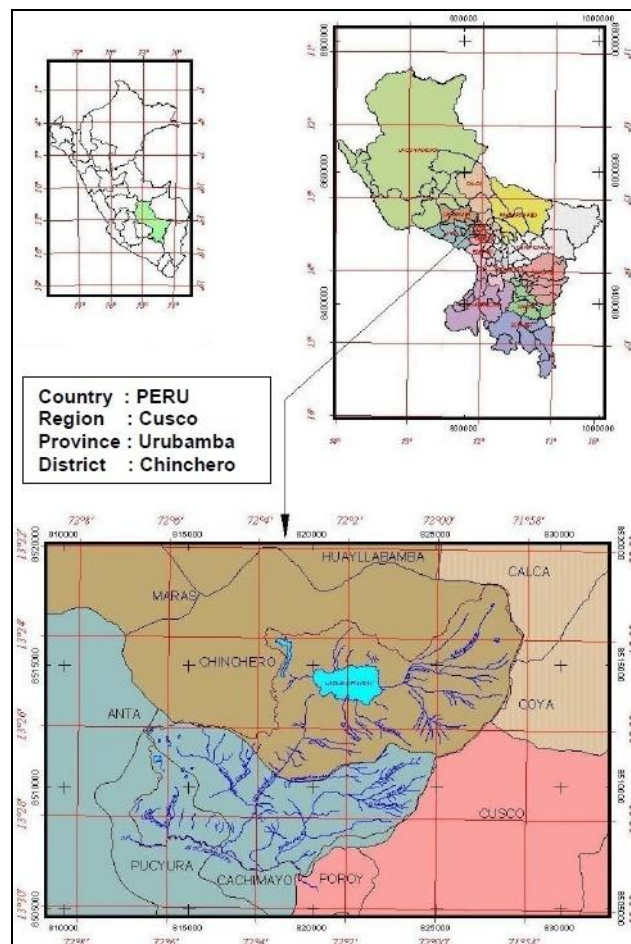


Figure 5. Map of Cusco and the Piuray-Ccorimarca river basin (Montoya 2010).

The total area of the river-basin is 9,603,67 hectares, having an rugged landscape with hills, mountains and plains. The total population is of 6,568 people, organized in 29 rural communities and sectors. The families of this region mainly participate in agricultural production working with Andean crops. They also compliment these activities with services to tourism, commerce, and other temporal/seasonal activities that are required to earn an additional income (Montoya 2010).

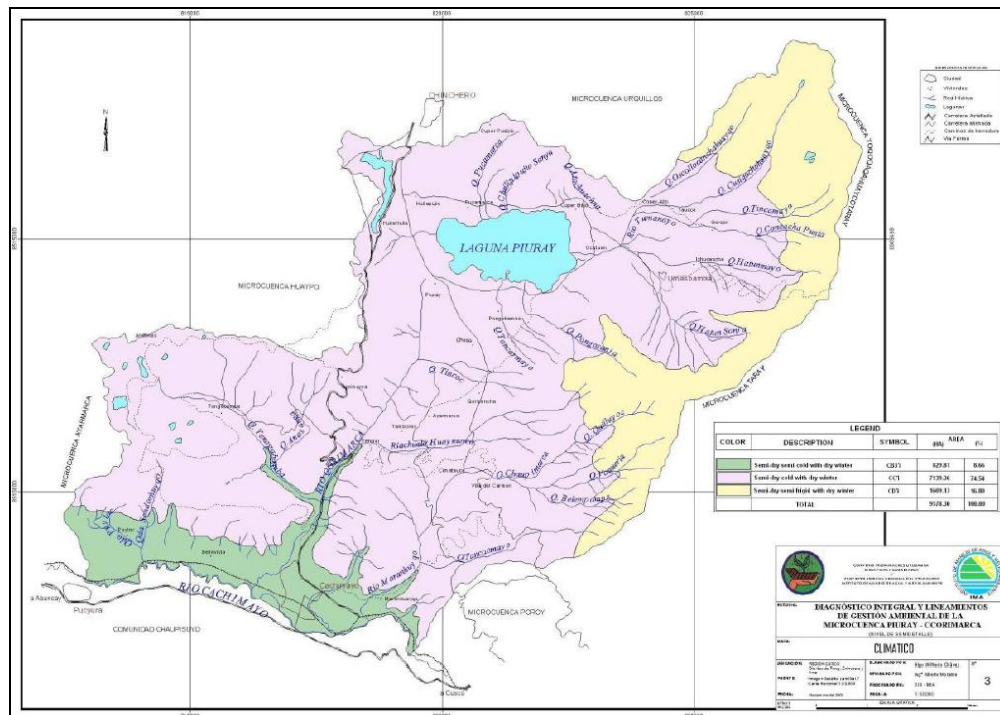


Figure 6. Map of the Piuray-Corimarca river-basin (Montoya 2010).

4.2 Climate

The highest point in the river basin is found at 4,575 meters over sea level and the lowest is located at 3,375 meters over sea level. Such altitudes give this area a frigid climate, being semi dry and semi-cold to cold weather depending on the season. From April through November, the winter is normally dry and cold spells are typical, which prevents some crops to be watered. During the rainy season, December through March, precipitations normally go over the water required by the crops. The temperature range of average annual temperature is calculated at 4°C until 11°C, although this varies greatly with the altitudes found. Two factors that determine the time in which crops should be sowed and harvested are the dry season and cold spells. These are essential as they can damage and kill crops if they are not done in time. They will also determine the type of crops that can be sowed as some are not resistant to temperature fluctuations (Damonte, et al. 2010).

4.3 Crops and livestock

In this basin, the variety of crops and can be distinguished by their zonal gradients, in this case being separated in the high zone “zona alta” and the lower zone “zona baja”. The higher zone is known for having a variety of native tubers like potato, oca and mashua, while the lower zone usually has native and improved potatoes, olluco, oats, barley, wheat and a number of forage crops like alfalfa, rye grass and vegetables. Families of this basin have mentioned that 20 to 30 years ago, there was a larger variety of native crops, especially potatoes, and their reduction is caused by the introduction of new types of seeds, climate variability and a change in eating habits (Damonte, et al. 2010, 204). A similar story is shared with the breeding of livestock, as 50 years ago they consisted of alpacas and llamas, which have been replaced with improved livestock due to the presence of institutions. Livestock now consists mostly of cattle, pigs and horses. There is also breeding of small animals, mainly guinea-pigs, rabbits and chickens.

4.4 Soils and erosion

When looking at aspects of erosion and vulnerability, the higher areas of the river basin are found to be the most vulnerable as geodynamic movements are frequent and can affect activities in the lower regions. In contrast, the lower regions have a regular level of vulnerability as they are less prone to natural movements but they have extensive use by local populations. In any case, habitants of this river basin are exposed to hidric erosion, eolic erosion, and antropic erosion which can be easily tipped off with climate variations. Studies during the 80’s qualified a number of communities with high vulnerability levels, which lead to the intervention of a number of institutions to improve such conditions. Among the projects, soil conservation and water management practices were found, as well as campaigns for reforestation to control runoff and erosion (Damonte, et al. 2010, 358).

4.5 Water Resources

The Piuray-Corimarca river basin counts with several sources of water, both superficial and subterranean although they mostly come from rain. Several rivers are formed to then rest in the Piuray lake, found in the middle of this basin. Furthermore, rain that infiltrates in the mountains and plains is found in sources (*manantes*) that also runoff to the lake. The sources which are permanent retain subterranean water during the rainy season and other temporal sources are only a source during the rainiest days of the year. The permanent sources are the only ones useful for human consumption or crop irrigation and they give their highest potential throughout the months of January through April, when its volume of flow is at its peak. However, it is important to take into account that the availability of water is dependent on the increase and decrease of rain which has fluctuated due to climate change (Arariwa 2003).

The rains are intensive but the dry season is extended, which makes inhabitants of this river basin have problems enduring water availability. This is especially the case for the communities

living in the higher parts of the basin as they do not have access to water from the lake. Inhabitants closer to the lake, who do not always stick to the water laws, are not permitted to use water from this lake as it is exclusive for the use of SEDA Cusco, a private company which provides potable water to the city of Cusco. As the Piuray-Corimarca communities do not have recognized permission to use water from this lake, SEDA is the only beneficiary.

4.6 Resource Conflicts

The high demand for water in this river basin combined with the water extraction for the biggest city in the region and climate unpredictability has initiated a number of resource conflicts. First of all, lower amounts of water coming from river streams and rain is concerning peasants and making them more protective and greedy when sharing common streams. The other main conflict concerns the Piuray Corimarca river basin and SEDA Cusco. Seeing that rain is increasingly unreliable, water from the lake is increasingly being seen as a possible source of water. SEDA Cusco has been using this source since the 1970's, and conflicts mainly started because landslides, caused by the decrease of the lake's level, destroyed numerous crops worth large sums of money. Although such landslides have continued through the 1988's and 1990's, recent discussions deal with the conservation of the water's quality and the compensation communities should be given for the company's use (Damonte, et al. 2010, 379). Despite the increased pressure on the lake due to population growth, the water quality is still optimal for use and SEDA Cusco is not forced to intervene. This, combined with the inactivity of the Piuray-Corimarca Committee to negotiate compensations from SEDA has turned to a deadlock. Although there have been propositions by the company to install proper irrigation and drain system, the disorganization and lack of commitment by the communities have allowed the extraction of this vital source (Antezana 2011).

4.7 Water Distribution

The legal issues surrounding the use of water and land properties lead the communities of the Piuray-Corimarca to organize them to have a representative Board of Directors. With the help of Pronamachcs and Arariwa, the Piuray-Corimarca Committee was created, something that helped the inhabitants represent themselves and organize the management of water sources. Although this river basin contains 21 different towns, this section will only discuss the water distribution between the communities researched.

The water sources of Taucca and Umasbamba are shared with 2 other sectors, Cuper and Ccorcor. Each of them has a committee which is responsible to coordinate and distribute water among the sectors. According to leaders of these committees, this coordination is separated from the Piuray-Ccorimarca Committee as it is better for each party to look out for its own interest. These four parties have been sharing water for decades and there has always been a certain pattern and distribution settled by their ancestors. As water usage has remained

relative to the population size, such rules of allocation have not changed substantially. Any disagreement or imbalance is solved among the committee directives which change every two years. These leaders are also in charge of opening and closing reservoir channels for dry seasons and overnight irrigation. Table 2 will show how water is divided by days and nights (Camero 2011).

Communities	Amount of days of irrigation	Amount of nights of irrigation
Umasbamba	3 days	1 night
Tauca	2 days	1 night
Corccor	2 days	2 nights
Cuper	2 days	1 night

Table 2. Distribution of water for irrigation (F. Titto 2011)

4.8 NGO presence

The involvement of different institutions in the Piuray-Ccorimarca river basin can be separated in two general models they support: commercial and environmental development. For the commercial development, institutions have mostly focused on improving agricultural production and increasing the exchange between peasants and different buyers in the region. This has included a priority for native crops such as potatoes as they are widely consumed among families and sold to nearby towns and cities. As for environmental development, Arariwa and Pronamachcs have launched a number of initiatives, among them a plan to produce and sell a number of native crops with ecological valorization, reforestation measures, and incentives to have a sustainable resource management. Separately, a project from MIMA-Pronamachcs has promoted the growth of forage crops to increase livestock feeding and sale. Other projects have included the promotion of experiential and cultural tourism to diversify incomes and promote the region. This has been done parallel to the provision of some tourism services as the new international airport has high chances of being re-settled in the neighboring town of Chinchero (Damonte, et al. 2010).

4.9 Communities

4.9.1 Taucca

Taucca is one of the 29 communities and sectors of the Piuray-Corimarca river basin, consisting of 40 families (average family size is 5) with about 200 inhabitants. It has a total space of about 622 hectares and is located in the Northern sector of the river basin. The main economic activity is agriculture, livestock and the breeding of small animals.

This community has a special history as a number of events have changed its organization and development. Alcoholism and poverty were widespread until community members decided to come to set up strict rules. One general meeting involving all families, a local governor, the local police chief and a local judge were called together to sign an agreement. Such rules banned the

consumption and sale of alcohol and set up sanctions for uncontrolled grazing and the absence to community meetings and activities. Sanctions were paid as money or as communal work to make up for damages. These rules have had positive impacts on the community's organization and are still widespread (Pronamachcs 2003).

4.9.2 Umasbamba

Umasbamba is a larger community consisting of about 70 families (average size is 5.5), with about 385 people in total. It is located in the North-western part of the river basin and consists of about 567 hectares. Similar to the rest of the communities, its main economic activity is agriculture, livestock keeping and the breeding of small animals. According to peasants and technicians, Umasbamba used to be one of the most developed communities of the river basin but their conditions have changed dramatically due to the persistence of alcoholism and poverty. Much of the farming that takes place is subsistence farming and their income is complemented with work outside of their communities. Migration is common for inhabitants of this community as peasants are not able to get out of their poverty situation. A number of Umasbamba peasants try to find work elsewhere, in some cases going to Cusco or other nearby towns to work at construction sites or with tourism (Damonte, et al. 2010).

A picture from both communities can be seen in Figure 7.

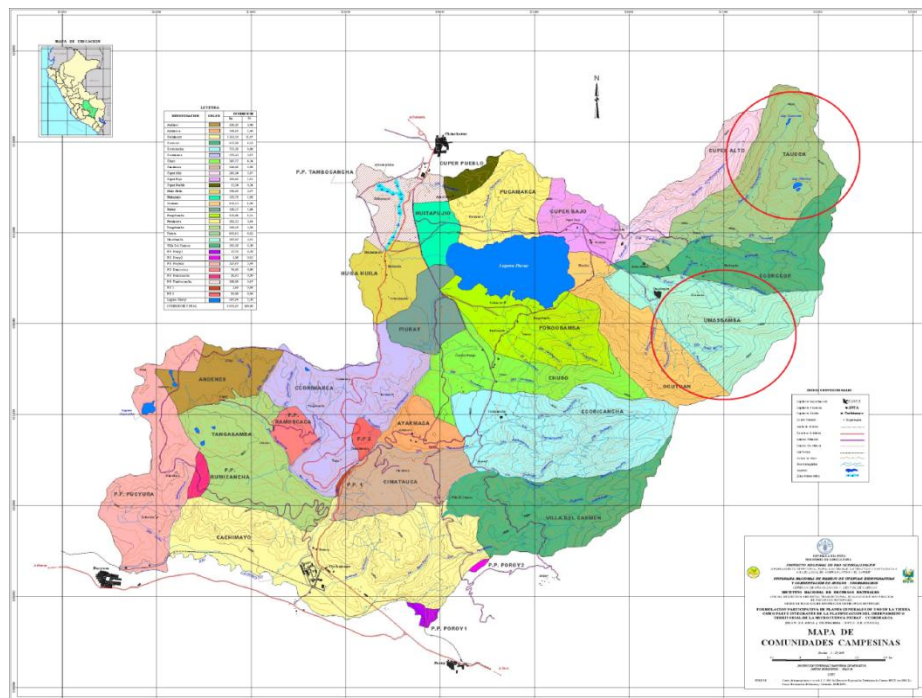


Figure 7. Map indicating both communities (upper: Taucca, lower: Umasbamba) (Camero 2011)

Chapter 5: Perception and manifestation of climate change

1. Perceptions of climate change

As there are many people with different backgrounds and beliefs, climatic variations in this region are susceptible to various interpretations. This section will focus on the ways in which climate change is perceived in the communities of Umasbamba and Taucca. Although climate change can also be perceived with physical damages to crops or to general health, this section will go deeper to understand what communities think about this phenomenon, how it came about and why. Most of the answers come from the field research although secondary literature was also used to compare past and current perceptions and practices. As the communities have different histories, their beliefs will be described and analyzed separately.

1.1 Umasbamba

Traditional perceptions and practices

When talking about the causes of climate variability, a number of community members believe climate has changed throughout time but they do not see a change in pattern or trajectory of climate disasters. Peasants mention that climate catastrophes such as flooding and river overflow are signs that something is not going well with nature. Here in the Andes, Mother Nature or the *Pachamama*, as they call it, is the provider of all food products and the rest of the natural goods that allow them to survive. In this sense, the *Pachamama* is both worshiped and feared. The *Apus*, which are the spirits of the mountains are also important figures in indigenous culture as they are believed to protect or attack livestock. Although these spirits are part of nature, they are worshiped and given offerings separately. People usually give coca leaf rituals, *chicha*, a local drink, and llama fetuses, among others in determined days of the year. These offerings usually take place during the sowing season, weddings, baptisms, trips, etc. Among the main reasons mentioned why such offerings are made, the following are found: 1) to obtain enough food provisions; 2) to protect the health and strength; and 3) to preserve the living space from any harm. Every year, during the month of August, more offerings are made to gratify all these needs (Hernandez 1983). Paying tributes to the *Pachamama* is a tradition which is hard to break and it is still widely practiced. However, many community members of Umasbamba say people have done something wrong to upset mother earth and this is why climate is changing (V. H. Titto 2011).

Climate change has tested indigenous knowledge that has worked for generations in this region, especially those trying to predict climate. Much of this knowledge, which has passed on for generations, has been important to reduce climate uncertainties and administer water and agricultural activities throughout the year. Nevertheless, not all of them are longer accurate due to current climate change. Some of the traditional signs found in this community include: the tilting of the moon, the appearance of certain constellations, the direction of the clouds, and the howling of foxes, among others. For them, everything in nature is interconnected and some environmental clues will take you to more clues that allow interpretations of other climate variations (Damonte, et al. 2010, 322).

Nowadays there are different levels of belief in the *Pachamama* and indigenous knowledge among community members. They are generally separated into two groups, the young and the old, and differences are found depending on their generation. The older generations are thankful and proud of carrying such knowledge and are resistant to other interpretations, values and styles of living. For them, “a lifestyle is more respectable when its origins are more remote” (Damonte, et al. 2010, 323). They also remain distant and critical to other interpretations and models of nature. The middle generation involves individuals that are dubious about some indigenous knowledge but still believes in some indications and traditions. Finally, the more recent generation of younger individuals have not been educated with traditional knowledge and have grown up with different beliefs and lifestyles. They usually consider the eldest generation’s beliefs and values as “prehistoric, ignorant, and delayed” (Damonte, et al. 2010, 323).

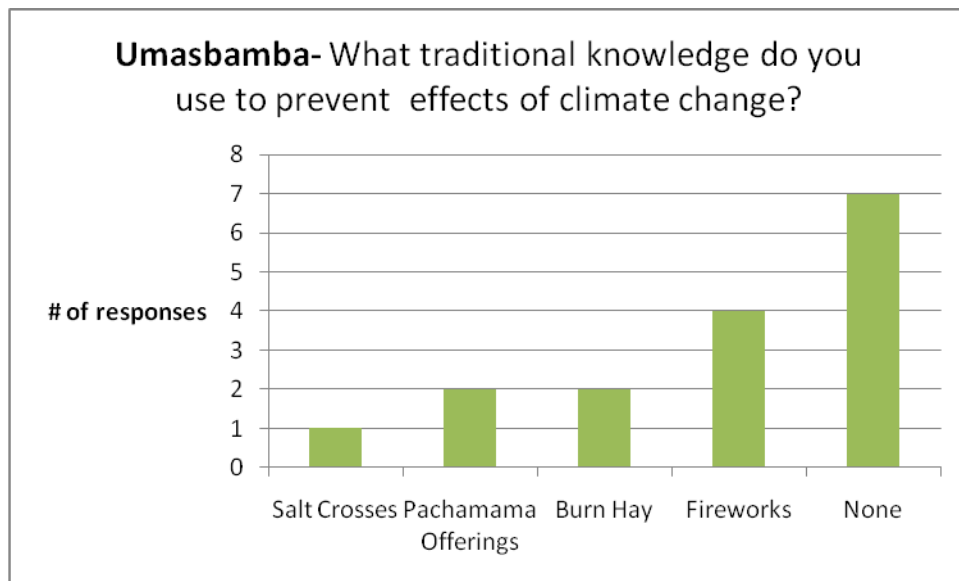
Current perceptions and practices

With an increased pragmatism in this community, especially among the younger individuals, some indigenous knowledge is no longer applied and there are fewer payments to the *Pachamama*. The younger peasants feel they “do not have to invoke the will of a nature” to bring benefits to the people (PREDES CBC, 323). However, some are still in an ambiguous position as they eventually ask elders for advice about climate forecasts. Newer generations have found other references to obtain information and to give reason to climate changes. Among these we find: own interpretations of climate change, information from NGOs or outside sources, and other religions. The most common religions found in this region are the Catholic and the Evangelist. It is important to mention that in many cases the Catholic religion co-exists with the beliefs of the *Pachamama* while the Evangelist does not.

The Catholic religion has had a different way to explain climate change and “interpret the different signs of nature” (Damonte, et al. 2010, 324). For Catholics, the current climate situation is something that has already been predicted in their bible, which offers peasants *hope* and a *positive future* under the current climate. Among the peasants of Umasbamba, the

belief in the *Apus* has slowly faded, but they continue to give ‘offerings’ but as a sign of respect and reverence. On the other hand, the evangelist message reorganizes the peasants’ lives and imaginary meanings and offers an interpretative model of nature that reduces climate concern. According to peasants, they have looked for an abstract and omnipotent God, amid the climate uncertainty and their helplessness against its impacts. Evangelism in Umasbamba is already present for around 10 years but is still far from being a majority. The presence of this religion has caused stress between community members because it has conflicting ideas with local beliefs.

When the interviewees were questioned about the use of traditional knowledge the majority said they no longer use it to predict or prevent climate variations. Several individuals believe that using fireworks during the cold spell season will reduce their frequency and intensity. Fireworks used to be fired at the top of mountains or salt crosses would be drawn near the peaks. Also, some straw was burnt in the fields to reduce the strength of the cold spell and to prevent their crops from dying. Although they spoke about these measures as a last resort, the most frequent was the payment to the *Pachamama*. The younger generations who spoke about such traditions label them as ‘old and used by their grandparents’ (Puma 2011). The results of their use of traditional knowledge can be seen in Graph 2.

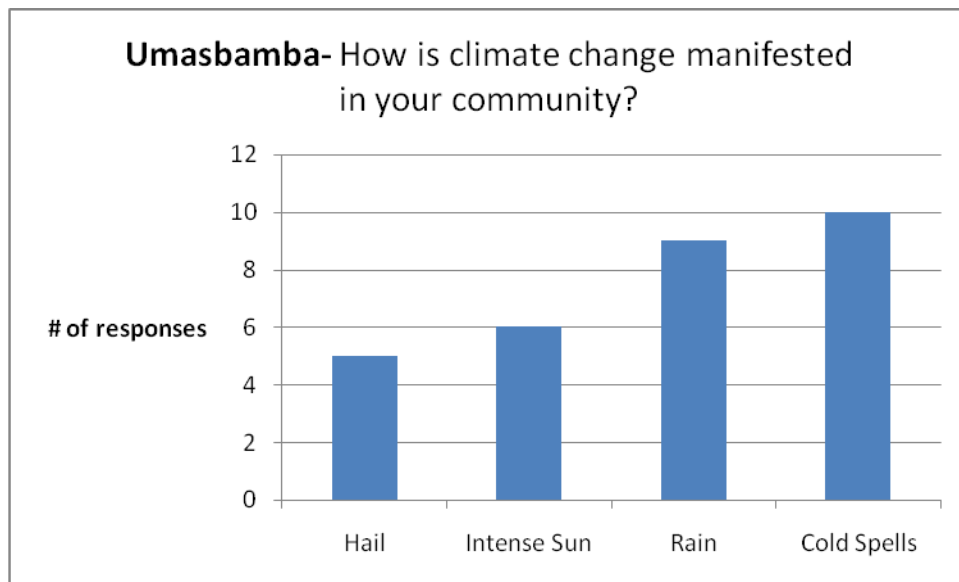


Graph 2. Use of traditional knowledge in Umasbamba (own research).

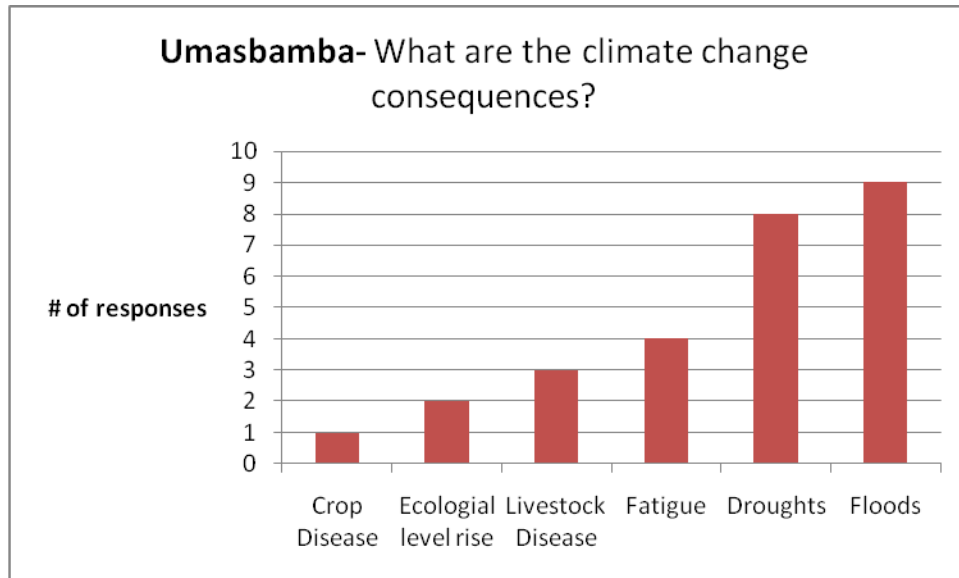
People of Umasbamba are also aware of the glacier retreat happening in the nearby mountain range and there are different opinions as to what is happening. According to peasants, climate change began around 10 years ago, and it has mainly been felt due to temperature changes. They believe glaciers act as regulators of temperatures in this region and glacier retreat has allowed temperatures to elevate. Such happenings have been interpreted as a sign of nature

that something is not going well. However, they are not able to explain the reasons behind this change. A local peasant, explained glacier retreat as a cause of increased temperature and vice-versa. For him, there is no causality between the two processes as they are part of the same system and they are interdependent of each other. He explains, glaciers are important for greater reasons, as keeping the balance of the earth and climate (Damonte, et al. 2010, 345). Other interviewees are not aware of the importance of nearby glaciers as they believe the water runoff does not reach their lands and therefore they do not consider this aspect of climate change as worrying. They believe communities in the “Sacred Valley”, which is in the lower parts of the valley, are the ones that worry the most about glacier retreat as they depend on it for agriculture.

When asking respondents about the manifestations of climate change, interesting answers were given about the changes in temperature and precipitation. As seen in Graph 3, peasants of Umasbamba mentioned cold spells and changes in precipitation as the most common events. Other less common events included the sun intensity and strong hail, which harmed crops and peasants. When respondents of this community were asked about the water availability over the last 10 years, 79% perceived there was a decrease. The consequences of such climatic events can be seen in Graph 4; which shows strong impacts of droughts and floods.



Graph 3. Manifestation of climate change in Umasbamba (own research).



Graph 4. Consequences of climate change in Umasbamba (own research).

1.2 Taucca

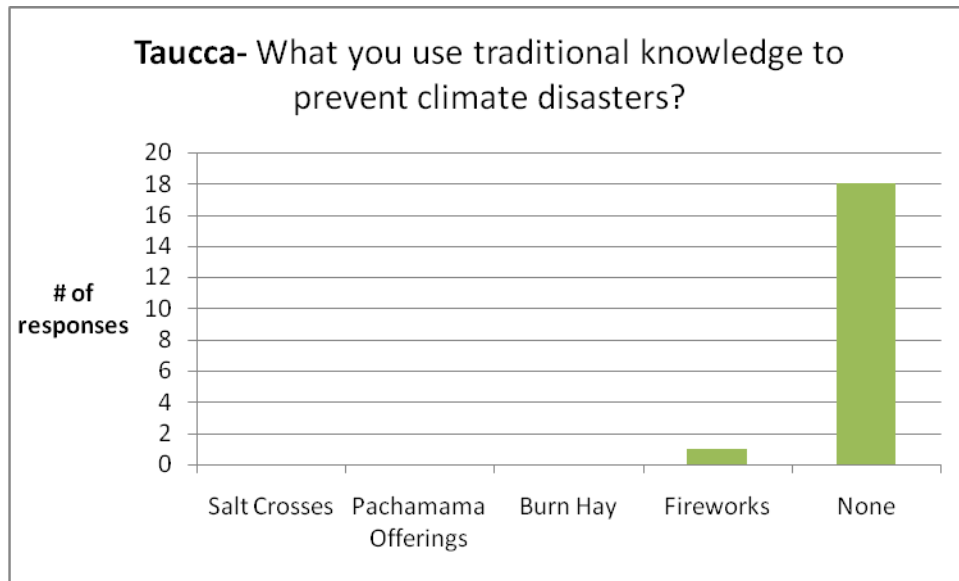
Traditional perceptions and practices

Generally speaking, the perception of climate change was very similar to that of Umasbamba as both communities come from the same background and culture. Taucca has for many years been a traditional community and has also followed indigenous beliefs like those mentioned of the *Pachamama* and the *Apus*. The Evangelist movement that arrived in the late 1980's began to change the way people perceived climate change; this will be explained in the next section.

Current perceptions and practices

A reason why traditional perception of climate change has changed in Taucca is because climate variations make indigenous knowledge less accurate and therefore less credible. Similarly to Umasbamba, people have looked for new explanations to what is happening in their surroundings and in their lives. In the case of Taucca, most people have turned to Evangelism for an explanation. Evangelism has found a different way to explain climate change and its impacts; showing peasants a different relationship between divinity and the way the Andes work. As mentioned before, it has reorganized the peasants' lives and imaginary meanings and offered a different model of nature. The events of glacier retreat and the rise in temperatures has been revealed to people in Taucca as a divine punishment due to human conduct. Because humans have sinned committing adultery and deceit, because they have become atheist and unorganized, climate disasters are taking place. For peasants, "if people used to behave well before, and there wasn't climate change, if there are climatic disasters now it must be because humans are misbehaving" (Damonte, et al. 2010, 351) They believe these are the consequences

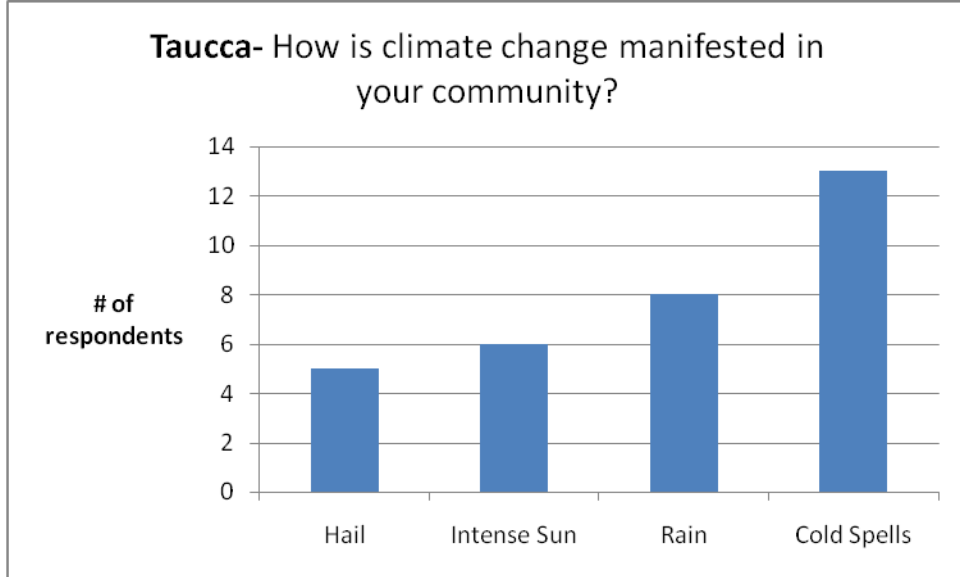
of moral problems of the entire world, including wrong economic and political decisions that disagree with the nature’s way of being. Interviewees mention that the Evangelist bible has already predicted such climatic events and that their “consequences must be endured to receive the Messiah who will redeem the world” (Damonte, et al. 2010, 352). As seen in Graph 5, the introduction of new beliefs has caused the decreased use of traditional knowledge to prevent climate disasters.



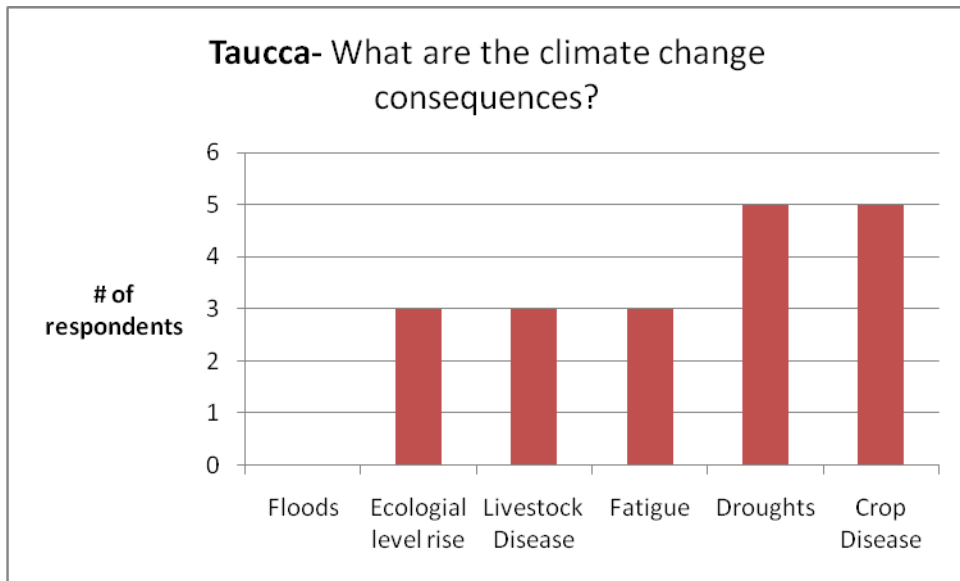
Graph 5. Use of traditional knowledge in Taucca (own research).

For peasants, glacier retreat is a danger for the entire population. As Mario mentioned during an interview, “when the glacier is completely gone it means the world will come to an end as there will be no more life” (Puma 2011). For him, such events have taken place especially due to the incorrect behavior and lifestyles of the newer generations. Such disastrous events are also associated with previous myths that a divine power brings punishment, often destruction, to humanity. A previous myth in the region told that several communities in the region were flooded, which created lake Piuray due to misbehavior of humans (Damonte, et al. 2010, 349)

When asking respondents about the manifestations of climate change, interesting answers were given about the changes in temperature and precipitation. When asked about the manifestation of climate change, peasants mentioned cold spells and changes in precipitation as the most common events (see Graph 6). Other answers included the high intensity of sun and strong hail, which harmed both crops and peasants. When respondents of Taucca were asked about the water availability over the last 10 years, 73% perceived there was a decrease. The consequences of such manifestations can be seen in Graph 7; which shows a strong presence of droughts and crop disease.



Graph 6. Manifestation of climate change in Tauca (own research).



Graph 7. Consequences of climate change in Tauca (own research).

2. Meteorological data at the regional and river-basin level

As the previous section has explained how this climate phenomenon is perceived, this next part will mention the different ways in which climate variations have actually affected the communities of this region. Because Umasbamba and Tauca are located in the same river basin, these events are shared; however, local microclimatic differences may always occur.

In the Piuray-Ccorimarca river basin, climate change is mostly manifested with a change in rain patterns and intensity, as well as with temperature variability. As these are the most practical ways to measure climate change, national and regional institutions have installed weather stations to record the needed data. Information has also been confirmed through interviews with technicians and corroborated with other studies (Sperling 2008).

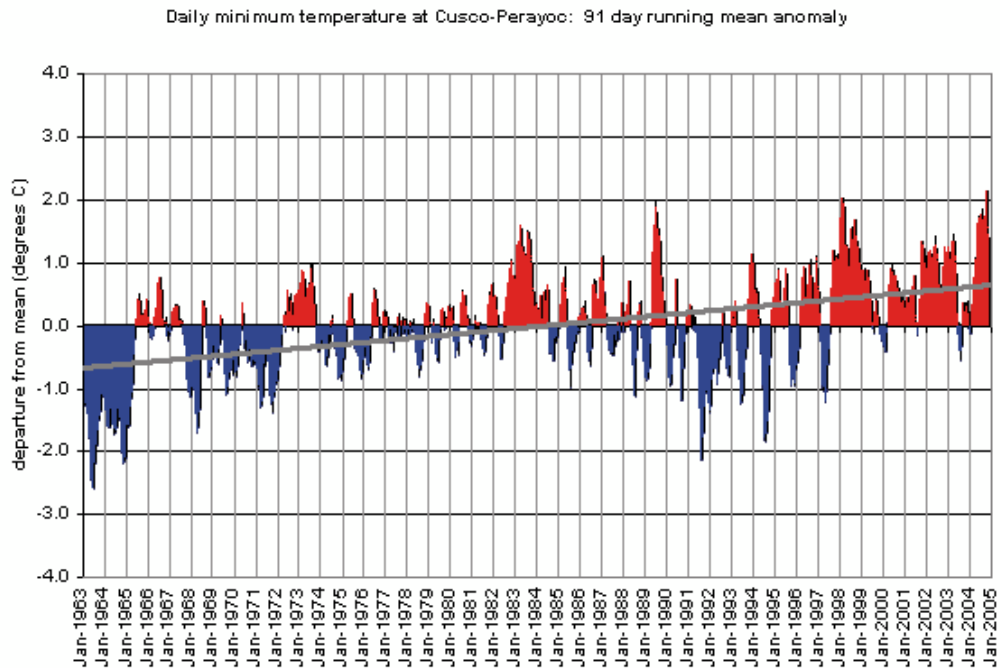
2.1 Regional Level

Temperature and Precipitation: Trends in Cusco

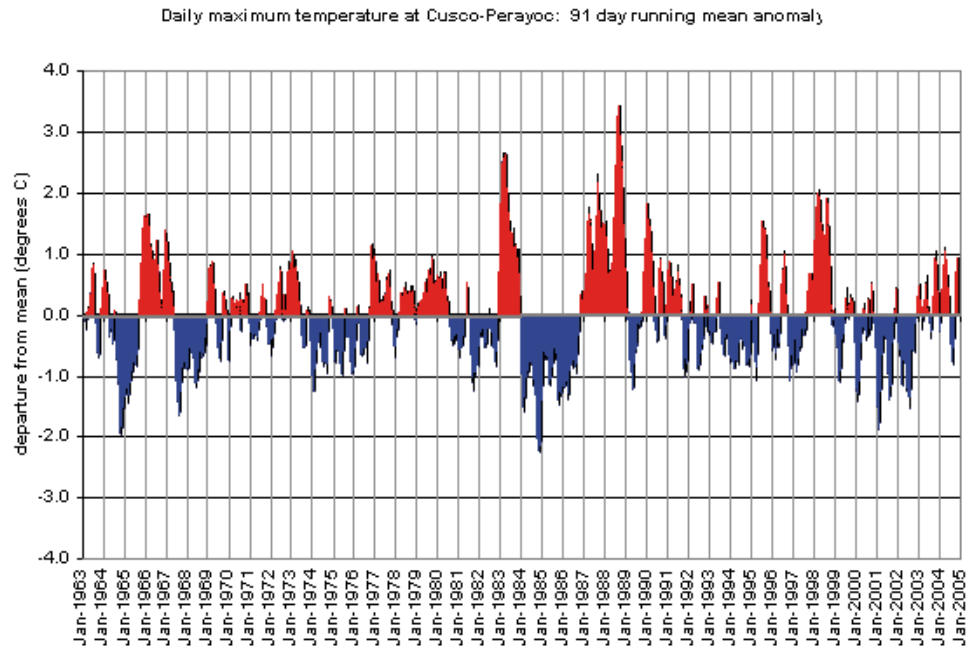
According to studies carried out by Sperling, there has been a significant warming trend in minimum and average temperatures in Cusco over a period of more than 40 years. Maximum temperatures do not show an increasing trend as indicated in Figure 6.

Figure 8. Long-term temperature record for (a) minimum, (b) maximum, and (c) average temperature in Cusco, Peru (Sperling 2008).

(a)



(b)



(c)

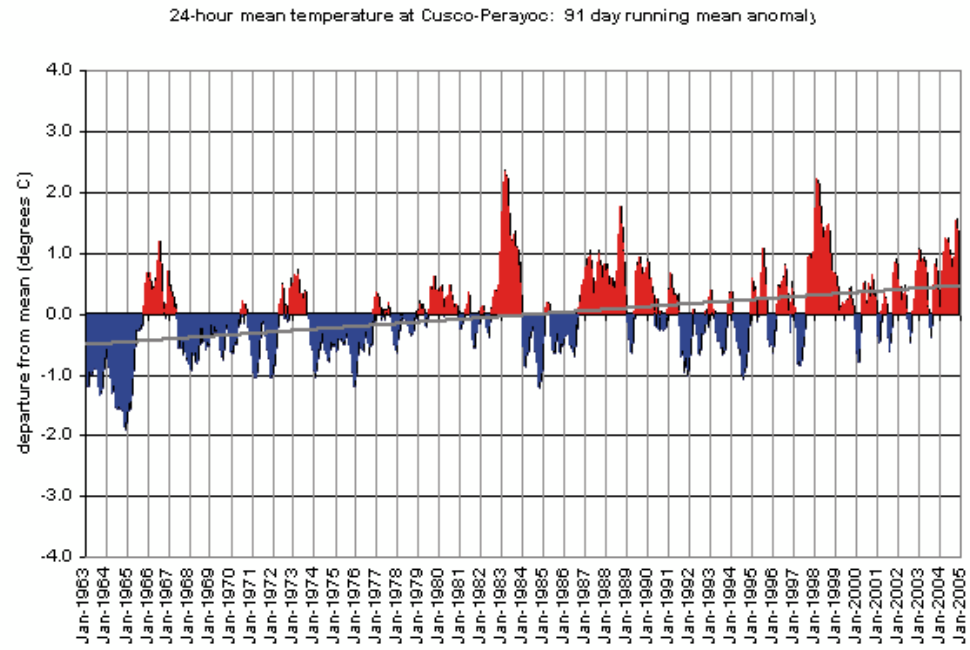


Figure 9 shows the changing precipitation pattern since the year 1904, which in conjunction with changing temperatures and ongoing glacier melt can have considerable implications for agricultural activities in the Altiplano (Sperling 2008).

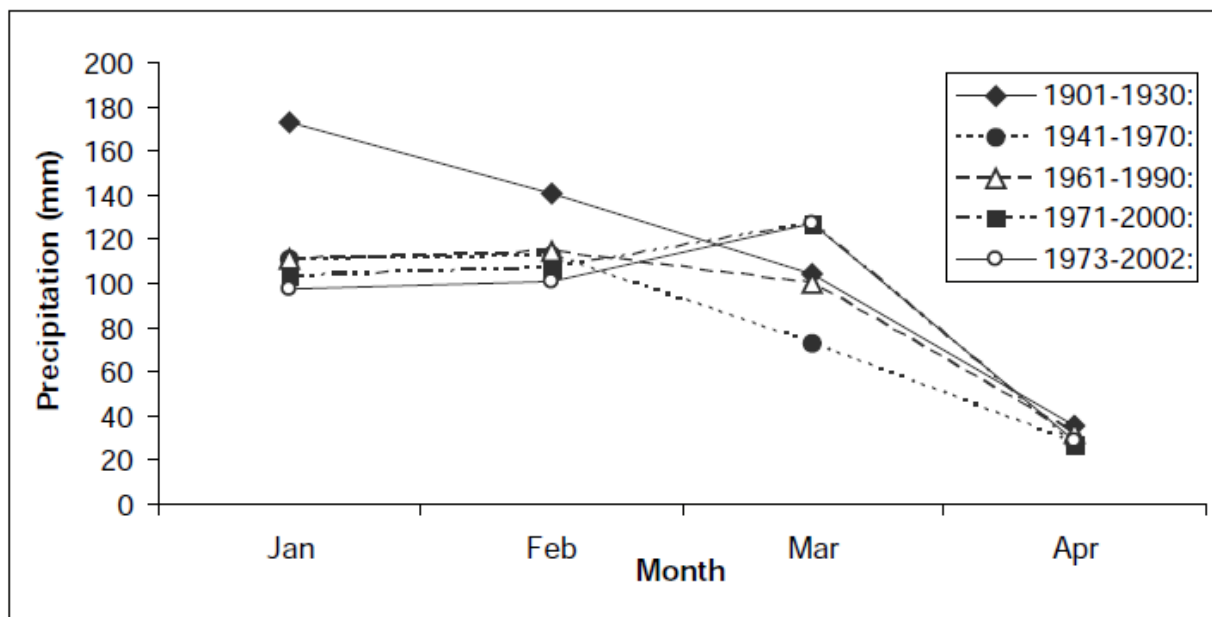


Figure 9. Precipitation averaged over 30 year period for January to April for the Peruvian Altiplano Region (Sperling 2008)

2.2 Piuray-Ccorimarca river basin level

Precipitation

The climate is mainly separated in two seasons, summer and winter, which are also seen as the rainy season and the dry season, respectively. The winter, which takes place during the months of April through November is normally very dry with strong frosts. The rainy season, which lasts from December to March, generally exceeds the water requirements for cultivated crops (Montoya 2010). Nowadays, rain patterns are changing, some rains exceeding previously recorded levels which cause floods, river overflows, landslides, and strong erosion. Depending on the crop location, peasants are in danger of losing partial or entire plantations. Similarly, rain is not always punctual to arrive at the beginning of December and this does not give crops enough time to grow. These are generally crops that take long periods to grow and are some of the few livelihoods peasants have. Peasants from this river basin were used to sow crops when the first rains started, September through October, but this is now pushed to November or December when the humid season is the strongest. This has changed the sowing and harvest timing and hence the intervals between each of them. This means that the pressure on the land

is higher and some lands have less time to recover nutrients and oxygen. If crop yield is low for any of the reasons mentioned above, peasants are forced to borrow money or seeds from other peasants, pressured to work for their neighbors, or even migrate to nearby cities, usually Cusco or Urubamba, to work in constructions or tourism. Another danger that has been expressed by community members is strong hails that can damage crops and livestock. Hail can be destructive for crops as it can cover entire plantations and freeze them to death. If livestock is not protected correctly, these are also vulnerable to diseases (Huarhua 2011).

Extreme temperatures

Changes in temperatures can also be separated in two seasons: summer and winter, which are characterized by high and low temperatures respectively. These generally coincide with the rain and dry seasons of the Andes mentioned before and also have a similar unpredictability. Low temperatures have been recorded to reach -20°C which can cause respiratory diseases to both animals and humans and can freeze entire crops if combined with the slightest humidity. Information collection has revealed that within 24 hours, temperatures at this altitude can fluctuate to such extremes that they exceed the average temperatures of summer and winter (Vargas 2009). Many of the crops found in this region are not resistant to such temperatures and if peasants are not alerted about sudden cold spells, they are likely to lose entire plantations. One example of such crop is the lima bean, which is usually the less resistant type of legume. Climate variations and the danger of having a frost is forcing peasants to change their plantation schedules and sometimes even changing crop variety. Once lima beans are hit by a cold spell they cannot be eaten by humans or animals and are thrown away. Such events are shifting crop schedules and affecting soil capacity and crop yield (Puma 2011).

On the other extreme, warm temperatures can also be harmful to several aspects of peasants' lives. The immediate and most worrying effect is the possibility of having droughts and low levels of crop yield. With higher temperatures, water in the river basin is evaporated more quickly and there's a greater chance of having less water available for drinking and irrigation. At this altitude and with little cloud cover during the dry season, the sun is very harmful both for plants and humans. Crops can be damaged by this exposure and animals can develop infectious diseases. During the interviews, peasants frequently complained about being exposed to the strong sun when working in the field, something that can cause skin problems and fatigue. This forced peasants to stop working in the fields for extended periods and forced them to change their daily activities.

A study by Montoya, shows that a decrease in water availability is due to the increasing water evaporation and transpiration, something that could be attributed to the increase in temperatures (Montoya 2010).

As seen in Figure 10, the combination of temperatures and changes in precipitation has caused a number of natural disasters since 1970, the most common ones being floods, rain and hail.

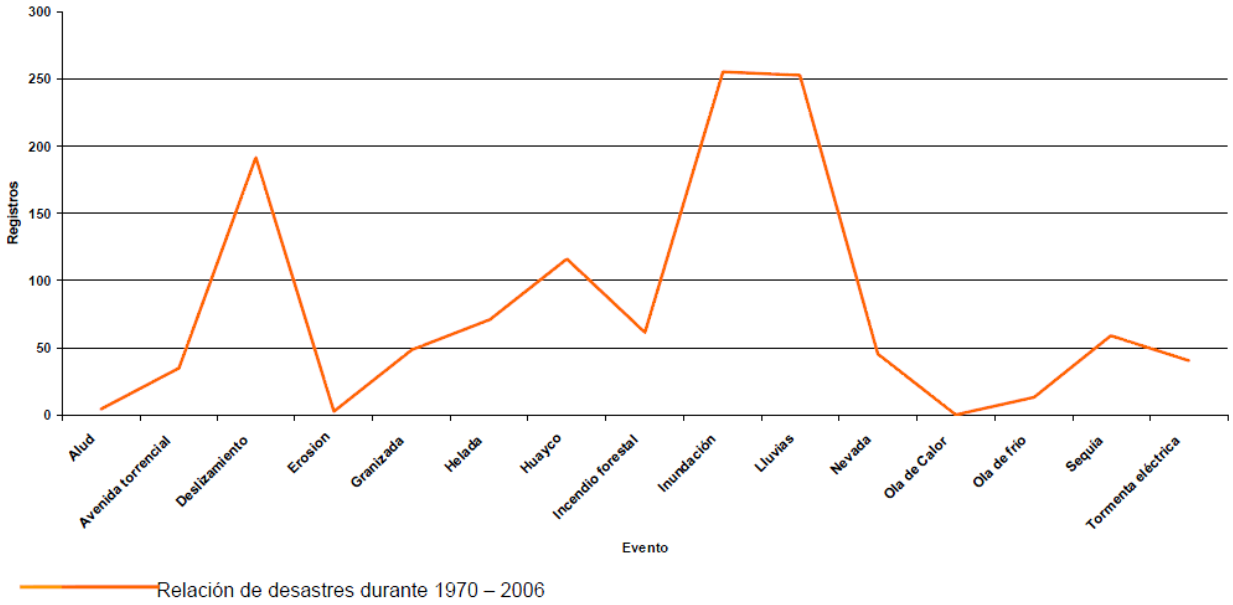


Figure 10. Disaster in relation to time (1970-2006) (Damonte, et al. 2010, 136).

Chapter 6: Role of institutions on water management practices

1. Organizations involved

The institutional involvement has gone into projects of soil conservation and water management. Among the various institutions involved in this river-basin, we find two that have participated and contributed the most to its development: Arariwa and Pronamachcs.

1.1 Arariwa

Arariwa is a non-profit, private institution that promotes sustainable rural development and works closely with the state and civil society to reach their goals. They aim to promote the adequate use of natural resources, advise agricultural development, food security and nutrition and strengthen local and regional institutions. In order to improve rural quality of life, promote their cultural identity and intercultural relationships, Arariwa has focused on the expansion of capacities and the rights of indigenous populations (Arariwa 2011). This institution started working in this river basin in 1982, with projects of soil conservation, forestation and potable water.

According to technicians that worked in the same region, the approach of this institution starts with numerous studies and the promotion of human rights among rural communities. Workshops are the essence of their approach, although numerous studies carried out by this institution contribute to their spread of knowledge. In this river basin, they focused on offering workshops, which are meant to improve rural livelihoods (Ocampo 2011). Although environmental development is one of the goals of this organization, they have also worked on other topics such as gender equality, education and nutrition.

1.2 Pronamachcs

Pronamachcs (Programa Nacional de Manejo de Cuencas Hidrograficas y Conservacion de Suelos) was a project started by in the 1980's by the Peruvian government through the Ministry of Agriculture to improve the conditions of river basins from the Andean region and improve the management of natural resources (Pronamachcs 2011). Since a legislative decree in 2008, Pronamachcs has merged with another 7 projects at a national level to combine similar efforts of rural development, forming AgroRural (Programa de Desarrollo Productivo Agrario Rural) a state run institution (Agrorural 2011). This institution cooperated with local, regional and national partners, focusing on technical assistance for communities in the Andean region. Their aim was the sustainable management of natural resources found in river basins as well as the

interactions with its inhabitants. The Piuray-Ccorimarca river basin was greatly advantaged by their involvement as large amounts of money were spent in workshops with technical assistance, the construction of infrastructure and the strengthening of local institutions.

2. Improving water management

Water management is in the core of farming practices as it is in the conservation of natural environments such as river basins. This section will elaborate on the projects which have focused on matters of water management in the communities of Umasbamba and Taucca. PRONAMACHCS and ARARIWA have worked along the Andean region of Peru to support rural populations affected by natural resource degradation, erosion, deforestation and over grazing, among others. Although these practices have not been directed specifically to respond to climate change, they have helped communities respond to varying levels of water availability. Other organizational and educational aspects have also been essential for their development; including the creation of platforms for discussion and coordination at a river basin level. Seeing that these projects are meant for an efficient and sustainable use of water resources, they can also be considered as an adaptation response to the reduced water availability caused by climate change; added to the fact that they are useful for local communities and for the preservation of the river basin.

2.1 Water management infrastructure and activities

Among the practices for water management, rural infrastructure is probably the one that has the most immediate and direct effects. Because rural communities are generally in distant and sometimes inaccessible locations, infrastructure is difficult to install and can be very costly. Nevertheless, communities in this river basin have received the support of various institutions with large budgets for natural resource management projects. The following have been implemented in both communities throughout the presence of these institutions, although to different levels. The details about the application of water management practices in each community have been elaborated in the following chapter.

2.1.1 Water reservoirs

Water reservoirs are some of the most expensive infrastructure; however, they are essential for irrigation at times of drought and for attending drinking needs. These generally need to be constructed in higher locations for appropriate pressure and need long tubing systems to distribute water to the desired communities. In addition, reservoirs need constant maintenance to fix possible damages and to maintain the water quality. Finally, proper organization is needed to distribute water equally among community members. Depending on the reservoirs, they are used exclusively for water storage for fear that peasants do not receive enough rain water. In different cases, they are used to store drinking water, which would need occasional chlorination to prevent waterborne diseases.



Picture 3: Reservoir found in Taucca used for drinking water (M. Verkooijen)

2.1.2 Channeled tubes

Channeled tubes are used for maximum water take up and distribution either from water reservoirs or straight from water sources (*manantes*) to land parcels. Studies have determined that they have a conduction efficiency of 89.2% (Montoya 2010). Obstructions in the channels are sometimes problems but they are easily identifiable and can be fixed if maintenance is regular. The disadvantage of this infrastructure is that any damage can be costly to repair.

2.1.3 Soil Conservation

Although the following measures might have been implemented with other ends, such as enhancing carbon sinks and preserving microclimates, they have indirectly helped the river basin retain water. Therefore it can be said that by conserving soils, a long term consequence will be a better conservation of water. Soil erosion is a major constraint communities have for agriculture as it can affect soil nutrition, water retention and therefore productivity. When rainfall or irrigation is excessive and the soil infiltration capacity is exceeded, water is lost, seeds and fertilizers can be carried away, and soil erosion starts. While the loss of water, seeds and fertilizers can have immediate effects on production, soil erosion usually has long-term consequences. Once this problem is identified it is probable that further degradation will occur as it accelerates the process and causes structural deterioration.

2.1.4 Filtration ditches

The Piuray Ccorimarca river basin has steep slopes which can enhance the flow of water and therefore the degradation of soil surfaces. Filtration ditches, usually built in the higher or driest areas of the basin, will retain water and force its filtration to the soil. These ditches are easily filled with soil and vegetation which would cancel their purpose. Although these practices do not need a high budget, they require hard labor and constant maintenance.

2.1.5 Bench terraces

Bench terraces consist of numerous platforms built down the slopes at suitable intervals to allow cultivation and water filtration. The platforms are built leveled or at a nearly leveled angle to reduce the amount soil erosion and allow the water to be absorbed at different levels. By decreasing the slope, they also increase plant density on the terraces.



Picture 4: Technical irrigation in Taucuca (M. Verkooijen)

2.1.6 Technical irrigation

The efficient use of water is imperative in a river basin that has decreasing levels of water supply. This is even more important when various communities share the same sources of water and its use is restricted to only certain days or hours. Technical irrigation, separated in sprinkler and drip irrigation, has been the most frequent used practice to manage water due to its great utility, efficiency, low cost and outcome. It has replaced traditional irrigation which is done through crop inundation (also called irrigation by gravity), which is greatly wasteful and unsustainable. In many cases, peasants have been able to decrease the amount of water used and increase their production. According to the Institution of Water Management and Environment, IMA, a change from traditional irrigation to technical irrigation would improve the value of irrigation efficiency from 40% to 70% (Montoya 2010). Such applications have also shown peasants the amount of water the soil needs to be available for plants to absorb.

2.1.7 Forestation

Reforestation has mainly taken place in the middle to upper parts of the mountains to avoid erosion from the upper soils and nutrients and to allow the filtration of water. In some parts of

the basin, forestation has taken place to prevent landslides and crop loss caused by excessive rain. Other opinions point to the fact that forestation improves climate conditions by neutralizing cold spells that occur at night. The concentration of forests may create microclimates to counter extreme temperatures brought by climate change. In the Piuray-Corimarca river basin, 85% of the reforestation which took place during the 90's consisted of Eucaliptus trees. When planted correctly, they can protect crops and provide natural fuels. Nevertheless, peasants' testimonies have pointed out that Eucaliptus trees can be counterproductive due to their excessive water and nutrient absorption. After years, peasants have noticed that these trees should be planted far from the crops otherwise they won't grow (Damonte, et al. 2010, 363).

2.1.8 Water source protection

This technique consists of surrounding the water source with a small construction that will contain the water coming out of it. This can also involve planting trees and vegetation to avoid erosion.

2.1.9 Capacity building

Parallel with the construction of irrigation infrastructure, numerous workshops had to take place to successfully implement projects of water management, carry out of soil and water conservation practices and to organize peasants at the community and river basin level. It is important to mention that the workshops started in 1998 with the contribution of both organizations; however, they started separately and only coordinated efforts since the year 2000. Although several subjects from the workshops can be mentioned, only those pertaining to water management will be elaborated. One of the first themes was the *land use planning*, which taught peasants what types of lands they had and how they needed to be worked. Technicians also provided important information about how peasants can improve their productivity by using fertilizers and different types of crops. Subjects also included the fattening of livestock with better grasses and the breeding of small animals. Other workshops included the education of young leaders, entrepreneurship, organizational skills and conflict resolution (Ocampo 2011) (Camero 2011).

The (P-cubo) or Participative Planification of Pronamachs, was a very important project that looked at improving agriculture at all levels, starting in households to the river-basin level. It gave peasants technical advice on how to have efficient farming, with instructions on how to use technical irrigation, how to plant, how to use biological fertilizers, how to protect their crops, how to harvest them, etc. It also taught peasants the importance of organization with natural resources, dealing with subjects of grazing and water distribution as well as water conservation. At a river basin level it taught communities the value of forestation and soil conservation practices, from how to plant and take care of forests to how to build terraces.

These workshops, also gave peasants the chance to share mistakes they had previously made. (Huaman 2011) (Pronamachcs 2004).

It is important to mention that these two institutions had a great influence, but their approach can be described as both constructive and counterproductive. Arariwa, being the first present in the region, tried to incentivize participation by giving handouts to peasants. These included lunches during workshops or after communal activities. This was also an effective way to bring community members to work together in projects of soil and water conservation such as building infiltration ditches and terraces. A couple of years later, Pronamachcs came in the picture to carry out the same projects but also offered tools to incentivize participation. This initiated a certain competition between the institutions to gain the trust and cooperation of peasants. At this point peasants started demanding payments instead of tools and lunches for their participation, something that the institutions rejected. Only after such issues, the two institutions agreed to discuss and share a common strategy, even combining budgets for similar projects.

2.1.10 Systematization, publications and investigations

Since a number of projects have taken place in this region, a recollection of their objectives and outcomes has been needed to reorganize development aid. Pronamachcs and Arariwa have come up with several documents reporting the advances in infrastructure and soil conservation, as well as in other investigations dealing with climate and socio-economic conditions. This systematization has been important to keep track of poverty levels and the impact of their projects in improving livelihoods.

2.1.11 Management of the Piuray-Ccorimarca river basin

One of the first approaches of these institutions was to incentivize the communities of this region to create the Piuray-Ccorimarca Committee. Its functions started in the year 1999 and had its busiest moments from 2001 until the end of 2002. In 2001-2002, the Piuray-Ccorimarca Committee organized 11 assemblies in 56 hours, having an average of 38 participants of communities, public and private institutions per session. A total of 5,656 dollars were invested in these two years, after which Arariwa and Pronamachcs started retiring their financial support (Pronamachcs 2003).

After attending several workshops and receiving technical help, the two areas around Lake Piuray were able to formalize themselves and be represented by a board. In addition, as the committee would be legit and recognized as such, it would give them more institutional power to negotiate water resources with SEDA. This was seen increasingly important as the dangers of climate change would eventually have communities from this river-basin use water from the lake rather than from runoff and rain. Although the Piuray-Ccorimarca Committee would closely work with the above mentioned institutions, this would give communities more

autonomy about natural resources and their management. Furthermore, members would be able to actively participate in committee meetings to discuss any matters concerning the basin. A similar organization would be found in each community where separate committees would be created to deal with important matters such as water distribution, potable water and pasturing, among others. According to Arariwa and Pronamachcs technicians, this was important to organize the water supply of the region, to do follow ups and evaluations of previous projects and to replicate them in neighboring communities. Such organization has also kept economic, productive and geographical data updated, as well as thematic maps of the region (Estrada 2011).



Picture 5: Interviewing peasant woman in Umasbamba (M. Verkooijen)

Chapter 7: Water management adaptation to climate change

When Arariwa and Pronamachcs got involved in this river-basin, projects planned to improve environmental conditions and the use of natural resources. Although climate change was not yet seen as a future danger, their goals of environmental conservation and efficient resource use proved helpful for present climate change. After less than 10 years of implementing these projects, this research has inquired about their application and effectiveness. After learning about the community's perception of climate change and how they are affected, this section can discuss if institutional support has helped peasants adapt to climate change. Although there have been other projects in this region, this analysis will only focus on those implemented by these institutions on water management, among which a few have resulted crucial to reduce vulnerability to climatic shocks.

When looking at the communities perceptions of climate change, they identify a number of manifestations and various ways in which they affect their lands and activities. Among the most harmful, peasants have mentioned intense sun, cold spells, and rain. While effects of cold spells can be reduced with animal shelters and changes in sowing and/or harvest seasons, responses to sun intensity can include wearing sun caps, reducing exposure and further irrigation of crops. Having mentioned this, it is important to say that the construction of animal shelters is a recent adaptation measure that has been included in regional projects by the government institution AgroRural. The most important and applicable practices have therefore been those of water management, which have helped deal with rain excess and shortage. Rain is perhaps among the most perceived dangers of climate change as it causes more frequent and intense floods and droughts. These problems have direct effects on crops, affecting food security and the most basic source of income for peasants.

Communities of this river basin share a vulnerable position due to their socio-economic conditions. As mentioned before, the capability to adapt to internal or external shocks and stresses will increase a person's resilience with tangible/intangible assets or capabilities. Among the tangible assets provided by the institutions, we find the construction of infrastructure (e.g. reservoirs, channeled tubes, technical irrigation, and terraces); among the intangible we see the creation of the Piuray-Ccorimarca Committee and strengthening of social organization; and among the capabilities we see the capacity building carried out in the water management workshops. Because the results have been different per community, they will be separated accordingly and with testimonies from peasants and technicians.

1. Application and usage of water management practices

1.1 Umasbamba

Communal perspective

According to the research performed, this community has fallen behind using the technologies installed and has not continued with soil and water conservation practices. According to interviews, peasants have either stopped using the infrastructure because of its deterioration, their lack of knowledge or economic resources, and/or because they do not feel they are necessary. First of all, peasants have mentioned that irrigation tubes have broken and that nobody has taken responsibility or initiative to repair them. Because such infrastructure is used by a number of peasants, collective action is needed but there is little coordination. A peasant expressed himself saying: “things belong to everyone and they belong to no one”, referring to the fact that when things benefit peasants, they are present, but when they break nobody takes responsibility (Puma 2011). This means that peasants have continued to use traditional irrigation practices where tubes have been broken and have not learned the importance of water conservation. Other families have stopped using technical irrigation because they do not have the resources to repair such tools. In the majority of cases, peasants do not need such advanced practices as they have subsistence farming and do not need to irrigate large areas.

Peasants of Umasbamba have also pointed out that they indiscriminately use water from a nearby water sources and from reservoirs. Although workshops have tried to differentiate drinkable water from water for irrigation, these community members do not separate their use. This happens because peasants usually do not trust the quality of the potable water and because they have not taken good care of installed infrastructure.

In relation to the practices of soil and water conservation, there has been little or no follow up during the last years. With a simple glance at the surroundings of Umasbamba, it is easy to identify that (re)forestation has not taken place. The surroundings are extremely dry and very few trees have grown since the involvement of Pronamachcs and Arariwa. Some vegetation has remained in the higher areas of the river basin on the side of Umasbamba but much vegetation has been lost due to uncontrolled grazing. This problem has been further aggravated by the lack of maintenance to filtration ditches in the upper mountains of Umasbamba. A number of peasants claim that there are “faenas” or regular community meetings to clean up these ditches from extra vegetation or soil every couple of months. However, another group of peasants have stated that this is not true and that maintenance on filtration ditches is only done once a year or not done at all.



Picture 6: Community of Umasbamba and the little application of forestation. (M. Verkooijen)

Technician's perspective

Technicians have mentioned that at the beginning of their involvement, Umasbamba was one of the most developed communities, having higher socio-economic conditions than other neighbors. Communities “have been given the same number of workshops and tools” to carry out such projects and Umasbamba has had an advantage as they have the most access to water sources. Nevertheless, peasants of this community have not taken advantage of the help they have received and as a technician said: “they are the only responsible for their stagnant development”. They have labeled Umasbamba as “the black sheep” of this river basin as they have not shown the continuity they should have after being involved for several years. Among the reasons for their underdevelopment, technicians identify their lack of responsibility, organization and pro-activeness to be the key issues. Furthermore, they believe peasants of Umasbamba have not taken advantage of workshops and have not learned the importance and value in conserving water. Their lack of interest to save water can be seen in their houses and crops. Such poor attitudes combined with factors of alcoholism, family violence and poverty have been found to be critical for their development (Camero 2011).

1.2 Taucca

Communal perspective

The situation of Taucca has been very different to that of Umasbamba although at some point they have shared various socio-economic and geographic conditions. Taucca has for decades depended on other neighboring communities to receive water from distant sources and has always had low priority to receive this resource. Because of this and diminishing water availability due to climate change, peasants have been forced to use water conservation practices. The initial need to have water then turned to a common practice. Peasants have been able to label water as a commodity for their development, associating water availability with productivity, crop yield, economic input and better socio-economic conditions. As a peasant mentioned, they have “learned to valorize water as an essential resource for development”. Broken irrigation tubes or irregular chlorination was not an option for the population. Even though members of this community still believe they do not receive enough water, their water use efficiency is exemplary for any community in the river basin and the region (F. Titto 2011).

A similar story can be seen with the soil conservation practices that took place in Taucca. Although peasants are aware they did not immediately put into practice knowledge about filtration ditches and terraces, their eventual need to prevent strong erosion caused them to act. Together with this came the increased forestation that would give their land less erosion and better water filtration. They also admitted they only started frequent maintenance when they realized more vegetation around their fields and in higher areas of their community started to grow. This allowed peasants to graze their cattle in different locations and with more frequency, on top of providing them with a new source of food.

In a similar light to that of Umasbamba, the community of Taucca suffered high levels of poverty, alcoholism and family violence. Members have mentioned how this was a recurrent problem to their development until all members were obliged to sign an agreement to improve their behavior. The changes in community rules, commitment and the influence of evangelism have all had positive impacts on their organization and responsibility. When alcoholism was banned from the community, peasants started to attend all meetings and were able to improve their daily activities. This meant better organization at a household and communal level (F. Titto 2011).

In contrast with Umasbamba, Taucca set up better rules for pasturing and organization to divide tasks. This community has developed a number of committees responsible for different tasks, among which we find: irrigation, potable water and livestock. These have been essential for managing water resources and taking care of vegetation and forestation. Once strong rules were set up, members had to pay high fines for uncontrolled grazing, excessive irrigation

and/or absence to community meetings and activities. This kept forestation and soil conservation practices in good conditions as frequent maintenance was done and the community set up a self-controlled system. Their achievements have been so remarkable that their experience has become exemplary for similar development projects. As a way to share their experience and knowledge, Taucca created an “internship committee” to show fellow peasants about agricultural practices. Among the topics dealt with, we see soil conservation, resource management, disaster risk reduction and livestock keeping.



Picture 7: Forestation and terraces in Taucca

Technician’s perspective

Institutions from the region and Peru have held a high respect for Taucca and technicians have not fallen short of words to praise its development. Technicians of Pronamachcs and Arariwa have attributed their exemplary advances to their commitment to the workshops and their application of knowledge learned. In Mr. Camero’s opinion, the entrepreneurial and organizational skills are the most observable results as some community members have developed their innovation capacities to diversify their income with activities of taxi or truck driving, tourism and the introduction of new crops. In other cases, organization is essential for the creation of committees to deal with daily issues and maintenance. Religion has not passed unnoticed for technicians, as they have recognized Taucca as the most evangelist community and as the only different aspect which separates it from the rest (Estrada 2011).

2. Effects of water management practices

Poverty is pervasive and can affect several aspects of rural life, all of which are further affected by climate change. As there are several factors that can contribute to a community's development, it is hard to choose which ones are affected by changes in water management. Among the factors that this research has chosen, we find: economic benefits, access to safe water and the amount of climate related disasters (those avoidable with correct water management practices). These were chosen because information was obtainable from interviews and conversations with peasants and technicians and a clear comparison could be made between the two communities. Conclusions were based on interviews and secondary literature. Most information was obtained for the community of Taucca as its successful experience has led to a follow-up study in 2002. On the other hand, Umasbamba had poor results and little information on its progress. This section concludes by analyzing the communities' resilience.

2.1 Economic benefits

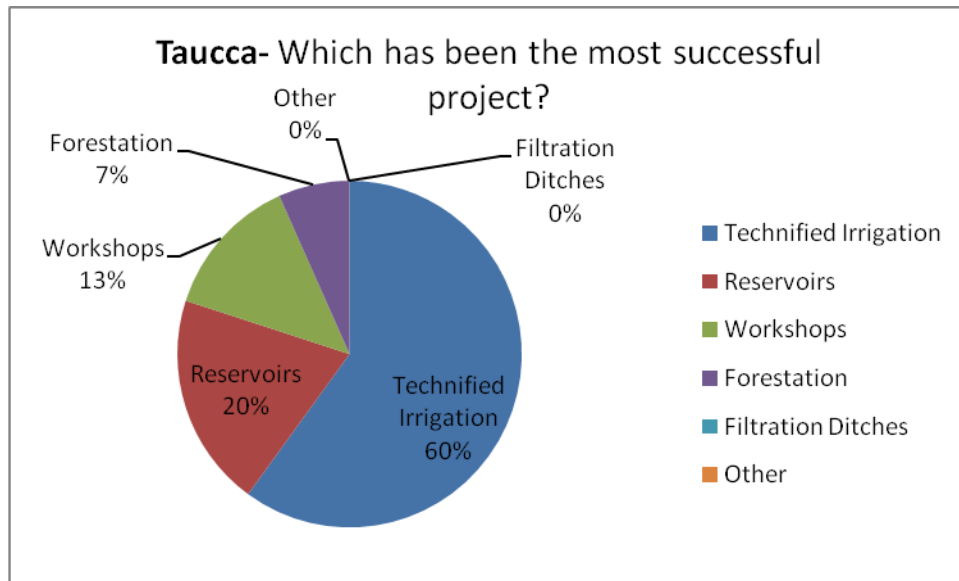
The efficient use of water leads to an increased irrigation capacity; which can lead to a higher crop output. Similarly, the growth and preservation of grasses can improve livestock fattening. In the interviews, peasants were asked about their agricultural sources of income and how they improved their economic conditions. Because there has been no previous records on the production or productivity levels of Taucca and Umasbamba, their improvements in crop output can only be based on the information collected in interviews and their general opinions on their sense of improvement.

Taucca

Communal perspective

Some peasants in Taucca only practice subsistence farming while most of them produce for the market. Peasants of this community are proud to mention that improved water management has been contributing to increase the production of a variety of products, which has been able to give them more economic resources. They are able to sell what they produce to the nearby town of Chinchero or to the city of Cusco, something that was less common before the institution's involvement. According to the interviews, the implementation of technical irrigation such as sprinklers and drip irrigation has made the most impact on their levels of productivity. As seen in Chart 8, 60% of the peasants interviewed have labeled this water management practice as the most successful project, while reservoirs and workshops have been secondary. Furthermore, all of the peasants interviewed in Taucca used technical irrigation. Peasants have attributed this improvement to the fact that Taucca has little water resources and they are compelled to use it efficiently. Because many of them also have livestock, they are greatly benefited by growing different grasses. Of the peasants interviewed,

a majority had large livestock to fatten and small animals. Families usually had up to 6 large livestock (cows, bulls) to feed and sell for a higher price. Also, peasants with livestock have also had great improvements with irrigation on new types of grasses as they are able to better feed their animals. They mentioned livestock was taken to the fields for grazing but grasses were not nutritious and animals had little weight when sold. The improved amount and nutritious value of grasses has had great impacts on peasant's economy.



Graph 8. Opinion of most successful project in Taucca (own research).

Technician's perspective

According to technicians, peasants from this community have considerably improved their economic situation due to the correct application of soil and water management practices. According to Walter Antezana from Pronamachcs, their general progress can be seen as many of their houses are well built, livestock are common, crops are ample and some families can afford the university for their children.

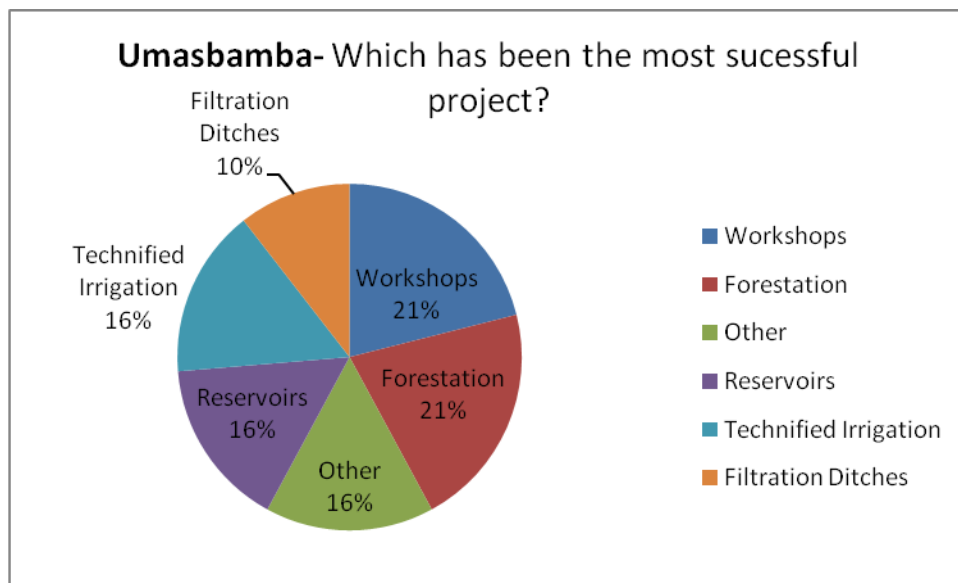
Information retrieved from a follow-up study in Taucca, revealed that before 1998, this community had traditional irrigation practices which irrigated a total of 3 hectares with a stream that provided 6 liter per second. An average of 3 liters per second was able to reach the crops and the rest was wasted in between. In 2002, by the end of the involvement of Arariwa and Pronamachcs, each family in Taucca had at least two irrigation tools (sprinklers) and one 100 meter hose. The systems of technical irrigation gave Taucca an irrigable area of 26 hectares with 0.57 liters/second/hectare. Opinions showed that 94% of the population thought technical irrigation (sprinklers or drip irrigation), was good or very good for their development (Pronamachcs 2003).

This study also pointed out that 39 hectares of land with technical irrigation is dedicated to grass growing, which is fed to livestock for fattening. This has allowed peasants to feed livestock for 3-4 months to then sell to the markets in Chinchero and/or Cusco. This has caused many peasants to choose livestock keeping over agriculture as they consider it a sure profit (Pronamachcs 2003).

Umasbamba

Communal perspective

For this community, different results are found because many peasants are not interested in making a great profit from their crops. For many peasants, livestock and small animal keeping are the main sources of income. In Umasbamba, crops are mainly harvested for own consumption, however, when asked about their different incomes, several peasants mention construction and tourism as important sources. Of the 19 family individuals interviewed, 9 answered they have subsistence farming. They very rarely sell products outside their community and trade products within their community instead. Efficient irrigation is not seen as important as in Tauccha as they have large fields but less cultivated crops. According to the interviews carried out, only about half of the peasants in Umasbamba use technical irrigation while the rest use traditional irrigation. Furthermore, as seen in Chart 9, they placed more importance on projects such as workshops and forestation rather than technical irrigation.



Graph 9. Opinion of most successful project in Umasbamba (own research).

Technician's perspective

Technicians attribute this lack of interest in technical irrigation to weak organization and their involvement in non agricultural jobs outside the community, as mentioned in Section 3.1.

2.2 Access to safe water

Projects in this river basin have also looked at giving peasants access to safe water. If water is managed correctly, then it should be accessible and in good conditions. Projects by Arariwa and Pronamachcs have included plans to increase water availability by building reservoirs, channeled tubes, and technical irrigation systems. Although they have been implemented both in Taucca and Umasbamba, their development has been different.

Taucca

Peasants of Taucca have emphasized their efforts on projects mostly in matters of water administration. When asked about their sources of water, they mentioned different reservoirs or ground water for irrigation and for drinking. Of the 15 interviewees, only 1 peasant mentioned he uses the same water for both purposes. This can be explained as rules in Taucca keep the reservoirs well chlorinated; families put more value on water as they know it is in good conditions for consumption. Similarly, because they have strict rules about when they can use water (2 times/1night every 8 days) efficiency is very important for their crops.

Umasbamba

On the other hand, Umasbamba has shown less responsibility and coordination when taking care of reservoirs and channeled tubes, and this is reflected in their access to safe water. First of all, because peasants have not shown ownership of the installed infrastructure; they are often damaged and water is wasted. When asked about their sources of water for irrigation and for drinking, only half of them use different sources; the other half use it indiscriminately. According to several respondents, this happens because the water that comes from the reservoir for drinking is not treated correctly and/or regularly with chlorine. Although certain rules and assignments have been made to regularly apply chlorine, peasants have stopped trusting water from this source because in several occasions children have gotten sick from waterborne diseases.



Pictures 8 and 9: The difference of water conservation in Taucca (left) and Umasbamba (right) (M. Verkooijen)

2.3 Avoidable climate related disasters

Projects carried out by Arariwa and Pronamachcs have dealt with water and soil conservation practices, and some of their results can be measured by the amount of climate related disasters. The work of reforestation, filtration ditches and terraces are mainly built to avoid erosion and to conserve water. If these have been successful, then a reduction in erosion and floods is possible.

Taucca

In Taucca, although changes in precipitations have been mentioned as a common manifestation of climate change, none peasants have mentioned floods as a common climate risk. This can mean that soil and water conservation practices around the community have been successful to prevent erosion.

According to a study carried out in 2002 by Pronamachcs, Taucca carried out water and soil conservation practices in 73.50 hectares, distributed in the following way: 50 hectares were forested, 13.65 hectares of filtration ditches, 7 hectares of terraces and 3.08 hectares of agro forestry.

Umasbamba

In contrast, this community has mentioned floods as the most common climate risk (9). This is consistent with the information that heavy rain was the second most common manifestation of climate change, after cold spells. As stated before, peasants have not taken good care of filtration ditches and terraces as they do not have regular maintenance. Technicians have mentioned that if these structures are not given proper maintenance, their effects will be counterproductive. The combination of heavy rains and inefficient soil and water conservation practices may have caused an increase in floods.

3. Water management practices and vulnerability

3.1 Community's resilience

Looking back, water management practices have resulted useful for economic benefits, water access and efficiency, which are important factors that determine vulnerability and resilience for both communities. When applied correctly and kept in good conditions, water management systems have shown to reduce some dangers of climate change; however, peasants continue to see climate change as detrimental for water resources, crops and livestock. Taucca and Umasbamba have given different priorities to different practices and this can be seen in the level of application and maintenance in water management systems, which result in different resilience levels. This following section will distinguish the community's perceived needs against climate change and the way in which institutions may have helped reduce their environmental risks.

3.1.1 Taucca

This community has proven that water management practices have developed the efficient use of water and has been able to respond mainly to the reduction of water and the increase of droughts. This has been seen as a result of the use of technical irrigation, the separation between potable and irrigating water, and the soil and water conservation practices that have reduced floods. These are all factors that have increased Taucca's resilience.

Taucca community members, despite having less water resources than Umasbamba, have been able to create and diversify their income. The results are clear when Taucca peasants mention their water management expertise and its effects on their market involvement. They have participated in workshops with technical assistance provided by institutions and have continued applying learned techniques to improve their environmental conditions. On top of this they mention improvement in crop output and the increased feeding and selling of livestock, which are also measures of increased resilience to climate change.

Water management projects have not been able to resolve other problems caused by climate change, some of which peasants have described as harmful for their health and crops.

Nevertheless, such events are not directly related to water management and need other projects to be present. Among these we find crop disease, which is mainly caused by excessive heat. Perhaps crops are not resistant to high temperatures or they need to be planted during a different time of the year. A similar story is seen with cold spells which are frequent in the region. This type of climate related disasters may however be prevented with early warning systems that allow peasants to protect their livestock and take other necessary methods to protect their crops.

3.1.2 Umasbamba

Floods and droughts have been indicated by this community as the most serious consequences of climate change. These problems are directly related to the soil and water infrastructure and management. Furthermore, as many peasants do not separate potable and irrigation water, this source becomes scarcer during droughts, increasing their environmental vulnerability. Given the little interest in improving agriculture, economic benefits have stagnated and vulnerability increased. Water management activities have been in line with the needs to reduce floods and droughts. However, water management projects are not enough to protect these communities from other climate risks such as cold spells and intense sun, which are harmful for their health and crops. As mentioned before, a response to these events have not been included in projects of Arariwa and Pronamachcs. Early warning systems and animal shelters have been mentioned as the most likely adaptation measures, however, only the latter have been recently implemented through another government institution, AgroRural. Resilience does not seem to be improving, mainly because the community lacks interest to improve its irrigation and to maintain its soil and water infrastructure.

In the opinion of another technician W. Antezana, climate change is not the main factor contributing to decreased water availability, but the lack of coordinated soil and water conservation strategies at the river-basin level (Antezana 2011).

Chapter 8. Possible causes for success or failure of projects

1. Institutional approach and conflict

The support of ARARIWA and PRONAMACHCS has reached numerous communities to improve social, economic and environmental aspects and although they have had similar objectives, they had different approaches. Both institutions had projects involving capacity building, infrastructure and activities, however, their focus and methods were different. Arariwa focused more on aiding communities through workshops and promoted this by offering lunches and monetary rewards. On the other hand, Pronamachcs also tried to encourage participation by providing tools and monetary rewards. As institutions had to work closely with community members to gain their trust, set up regular meetings, and organize communal activities, their efforts resulted counter-productive.

The involvement of both institutions in the same communities and at the same time caused a duality in activities and an unnecessary waste of time. Institutions forced community members to attend activities from each organization (e.g. workshops, assemblies, activities), which reduced their time for working hours. This was even a bigger dilemma for peasants as both institutions would offer compensations for assistance. More problems arose when Arariwa and Pronamachcs demanded communities to have separate committees for each organization (e.g. irrigation committee). Nevertheless, in the year 2000-2001, after such conflicting programs started to undermine development work in the region, an inter-institutional consensus was reached. This was requested by community leaders to have a better institutional division of work, have more integrative projects, and have more innovative ideas. This would result in larger space for discussion and innovation, larger budgets, more information, and more benefits for all participants (Pronamachcs 2003)

Projects related to water management needed to be implemented at a river basin level in order to have better results and to collectively conserve water supplies. This has been important as numerous communities are found in the region and several of them share the same sources of water. Arariwa and Pronamachcs intended to gain support and attendance from communities of the river-basin but it resulted in competition and deficient coordination. Only when peasants started demanding cash in turn of labor that would be needed in their region (ex: filtration ditches, terraces), the institutions agreed on a common strategy. This allowed both institutions to combine and designate money to specific tasks.

However, this outcome was also detrimental as the long-lasting support created a dependence on development aid, mostly seen in Umasbamba. As many technicians mentioned, the institutional approach introduced a certain “paternalism” where communities would not participate if they did not get any reward for their work. Furthermore, many peasants opted for working with tourism or constructions nearby as it would give better pay and the reward would be immediate. In a similar line, some peasants demanded institutions to repair any infrastructure that was damaged because they had put it there in the first place.

In the years that institutions were involved in the region, they were not able to leave a solid organization of independent and active communities. Although the Piuray-Ccorimarca committee was created, they did not have enough resources and convening power to call meetings once Arariwa and Pronamachcs withdrew their support. This was especially important when engaging in meetings with SEDA Cusco, which have tried to negotiate a form of payment to the river basin for using water from its lake. Because communities are affected differently by SEDA’s use of the lake’s water (those that do not border the lake are not concerned), the attendance was limited and therefore no collective decisions could be made. In one occasion, SEDA offered to install a complete irrigation system for potable water around the river-basin but communities demanded cash instead. In 1999, this lack of organization and a lack of commitment from the different communities resulted in the suspension of all communication between SEDA and the Piuray-Ccorimarca river basin. Since then, SEDA has not made any contributions to the region and has not made any payments for the water they use from Lake Piuray (Estrada 2011).

2. Tourism and construction

The rise of tourism in the region due to the importance of the Macchu Picchu ruins and the Inca culture have brought new job opportunities for people of this river basin. Many tourist agencies are hiring peasants for hard labor such as carrying backpacks and equipment for adventure tours. These jobs usually last a couple of days to a couple of weeks as they are extensive treks, many times doing the Inca Trail. According to peasants, this type of jobs usually gives low pay and they have awful conditions; nevertheless, they still choose to partake as pay is immediate and usually during the dry season. Construction work has a similar effect on people of these communities as this river basin is not very far away from populated towns. Both activities can affect community relationships as peasants are no longer working in crops or helping in communal activities. This means less people attend communal meetings and/or work less to maintain their environment.

Such events have happened with more frequency in Umasbamba than in Taucca. This may happen because Taucca has high levels of production and therefore they do not need supplementary jobs to diversify their incomes. Migratory work possibly undermines water and

soil conservation strategies and it may also be a cause for their decreasing levels of agricultural production.

3. Religion

The factor of religion has come as a surprise to this research as it seems to have influenced water management and development in several ways. Evangelism has steadily expanded throughout this region and especially in the community of Taucuca. All of the 15 family members interviewed belonged to this religion. On the other hand, in Umasbamba nearly 50% (9 out of 19 interviewed) were evangelist. Although there is no evidence of a causal relationship between religion and development, both community members and technicians have labeled it as a significant factor for their improvement.

For evangelist peasants, their religion has remodeled several aspects of their lives which bring “joy and pride in what they do” (Huarhua 2011). Their life values have changed and so have their priorities and ambitions, which are reflected in their everyday lives. This has had implications for family relationships as well as for community ties. The evangelist religion prohibits its followers to drink alcoholic beverages, something that has reduced alcoholism and alcohol related problems in a vast number of families. This has allowed families to focus more on other aspects of life such as family and work. On one hand it has improved family relations as there is less household violence; on the other, money that was spent on alcohol could be used for other domestic needs. In many cases, interviewees highlighted the increased interest for the children’s future. Evangelist peasants were more concerned about the future education their children could receive, many of them wanting to send their children to nearby towns and cities to study. The reduction of alcoholism has also resulted in more efficient working hours and more economic benefits. Peasants were aware that alcohol could reduce their working capacity and hence their ability to earn money. This has also had an impact in community cooperation as peasants are punctual to meetings and are reliable for work. Peasants of Taucuca mentioned that communal meetings took place once a month or whenever necessary and absence was not an option.

Differences in religious practices have also had an effect in community relationships as discrepancies sometimes resulted in envy, distrust and exclusion. This was mostly the case in Umasbamba, where evangelists were the minority, although their numbers are said to be growing. Some Evangelist families have labeled Evangelists as untrustworthy because they have “different views and have abandoned previous beliefs, such as those mentioned of the Apus and the Pachamama”. Because Evangelists no longer take part in traditional offerings, they are left out of community meetings and festivities. In some cases this has led to the exclusion of Evangelists from water related meetings, in some cases not letting them use enough water for their crops (V. H. Titto 2011). On the other hand, Evangelists call Catholic community members

envious of what they have and what they have accomplished. Such differences may have affected community relations and coordination for better water management.

4. Population Size

It is important to analyze the possibility that the population size in the communities has an impact on its organization and internal decision making processes. On one hand we see that the community of Tauccha has a smaller population than that of Umasbamba. With people living closer to each other, it is easier to have communal meetings and notice who is missing. This also has an impact on the control system communities may have; once rules are set for grazing, chlorinating water, and distributing water, it is easy to point out who is responsible. A smaller community also requires less water and it needs to be distributed around a smaller area. With fewer infrastructures, damages are also less likely to occur and they can be easier to find and fix.

Similarly, a larger population can have several implications on the environmental conditions, especially with a higher demand for water and an increased pressure on arable land. As many of the peasants of this river basin also have a number of livestock, land would be further deteriorated, which can also have negative impacts on soil conservation practices; if the vegetation is lost then there could be a loss in infiltration. Another consequence of this might involve higher pollution to the lake which could bring problems to neighboring communities and with SEDA Cusco.

Chapter 9: Conclusions

1. Climate change is present in the Piuray-Ccorimarca river basin. Records give evidence that extreme temperatures are increasing and precipitations are becoming more unpredictable. This data is also confirmed by the testimonies of peasants which are increasingly affected by natural disasters; mostly manifested in cold spells, floods, and hail.
2. As a consequence of climate unpredictability, the majority of peasants have turned to new explanations and left behind traditional knowledge that are becoming less credible. Those that still use traditional practices to predict and/or prevent climate variability are usually the older generations, although these are slowly fading as they are not continued by newer generations who are becoming more skeptical. The community members of Taucca show how Evangelism has reduced their belief in indigenous wisdom which is still more present in Umasbamba.
3. Pronamachcs and Arariwa have been the most involved institutions, focusing their efforts in implementing projects to improve water management in the Piuray-Ccorimarca river basin. Their efforts focused on agricultural practices to improve the water availability of communities as well as conserving the environment. This happened mainly through water and soil conservation practices such as: infrastructure, terraces, infiltration ditches and capacity building. These contributed to the adaptation for climate change and variability.
4. Despite their long involvement, both communities did not benefit to the same level; Taucca being the one that assimilated such practices the most and Umasbamba being the community that absorbed the least. Taucca has turned out to be an example for water management and for soil conservation. This has been proven through the successful use of technical irrigation, the implementation of soil conservation practices, and the maintenance of soil and water infrastructure. This has been possible as they have taken advantage of the workshops given. A regular maintenance has been possible because of good coordination and community reliability. Taucca has organized itself by creating different committees to handle everyday issues such as irrigation, grazing, and maintenance, among others.

5. Umasbamba has failed to implement water management and soil conservation activities. Irrigation technology is not used efficiently to save water and peasants do not repair installation or continue with practices. Peasants participated in such activities for monetary rewards and when institutions withdrew their support, they had no more interest in continuing the supported activities. Many community members ignored long-term benefits of soil and water conservation practices and opted for short-term rewards in tourism and construction. Inefficient soil and water conservation practices have led to more erosion of the land. This has had further consequences on water absorption capacity and has deteriorated the quality of the land. Peasants of this community are more vulnerable to climate variability, especially excessive precipitations.
6. Arariwa and Pronamachcs have been able to increase peasant's resilience levels when water management practices have been applied and used correctly; these have been in line with most of the perceptions and needs of the communities related to the lack or excess of water. Peasants of Taucca have been able to efficiently use their scarce water resources and are less vulnerable to weather changes, especially droughts. Peasants of Umasbamba are more prone to natural disasters, mainly droughts and floods which can be attributed to deficient water management practices. Problems of crop and livestock disease caused by changing temperatures have not been attended by the water management activities analyzed in this study.
7. Elements of the institutional approaches have contributed to paternalism and dependence to economic support. This led to the discontinuation of water management activities after the institutions withdrew their support in Umasbamba. However, Taucca has been able to organize itself with strict rules, successfully continuing the supported activities and improving their resilience.
8. In Taucca, evangelism has shown to have had positive impacts on family and community relations. It has helped eliminate problems of alcoholism and promoted organization and cooperation. However, the growth of Evangelism has caused the loss of important traditional knowledge and replaced indigenous culture. In Umasbamba the introduction of Evangelism has caused conflicts between members, weakening the communal organization which is indispensable for successful adaptation and resilience.

Annexes

Annex 1:

Questionnaire for Communities

Name interviewee:

of family members:

Community:

Sex:

Date:

Informative

1. How many sources of income do you have? Which ones?
2. What religion do you have?
 - a. How does it influence your organization?
 - b. How does it influence your family/comunal relations?
3. What is your source of drinking water?
4. ? What is your source of irrigation water?

Climate change perception and manifestation

5. How is climate change manifested in your community?
6. What have been the most damaging climatic events for your community in the last 10 years?
7. Have you noticed there is less, more, or the same amount of water than 10 years ago?
8. What do you do to prevent damages of climate change?
9. Do you use traditional knowledge to prevent effects of climate change? Do you use any technology?

Water Management

10. Do you have problems with water management? Either for drinking or irrigating?
11. How has institutional support improved your water management and preventing climate damages?
12. Is there a committee for water resource management? Do you participate in their meetings?
13. Do you participate in communal activities to prevent climate dangers?

14. Have you received any type of capacity building workshop? From which institution?

Results

15. What has been the most successful project? How could it have been better?

16. How has institutional support improved production and economic benefits?

17. In your opinion, what factors have influenced the success or failure of these projects?

18. What have been the successes and failures of the committee for water resource management? What would you do to improve it?

Annex 2:

Questionnaire for Technicians

Name of Technician:

Institution:

Current position:

(previous position):

Place:

Date:

Climate Change

1. Do you consider climate change is present in the Piuray-Ccorimarca river basin? How is it manifested?
2. How is the climate of this river basin different now compared to 10 years ago?
3. Do the communities of this river basin give importance to the climate change phenomenon?
4. Do the communities ask for institutional help for climate change adaptation?
5. Which are the areas and activities most affected by climate change?
6. Is there a reduction in water availability in this river basin? What are the factors that influence this availability?

Institutional Intervention

1. Since when is your institution involved in this river basin? Have they worked with Umasbamba and Taucca?
2. Is climate change adaptation part of your program? If yes, how?
3. Which policies, strategies, and or projects were successful for climate change adaptation? Which ones were not?
4. What are the problems of water management in Taucca and Umasbamba?
5. What politics, strategies and or programs have been implemented to improve water management?
6. Which ones have been successful and why?
7. Which ones were not successful and why?
8. Were new technologies and/or indigenous knowledge implemented to improve water management? If yes, which ones and do you think they were implemented correctly?
9. How do you compare economic conditions and livelihoods of these communities before and after institutional intervention?
10. Which ones can still improve?
11. What have been the success and limitations of the water resources management committee?
12. What have been the successes and limitations of the Piuray-Ccorimarca Committee?

Bibliography

- Agrorural. *Ministerio de Agricultura*. 2011. <http://www.agrorural.gob.pe/> (accessed May 31, 2011).
- Amat y León, Carlos. *El Cambio Climático no tiene fronteras*. Lima: Comunidad Andina, 2008.
- Amat y Leon, Carlos. *El Peru nuestro de cada dia*. Lima: Universidad del Pacifico, 2006.
- Antezana, Walter, interview by Mauricio Verkooijen. *Technician Interview* (May 2011).
- Arariwa. *Asociacion Arariwa*. 2011. <http://arariwa.org.pe/main.html> (accessed May 30, 2011).
- . *Nuestra Laguna de Piuray*. Cusco: Arariwa, Agro Accion Alemana, 2003.
- Bury, Jeffrey T., and Mark G. Bryan. "Glacier recession and human vulnerability in the Yanamarey watershed of the Cordillera Blanca, Peru." *Climate Change*, 2011: 105:179-206.
- Bustinza, Victor, interview by Mauricio Verkooijen. *Technician Interview* (April 2011).
- Camero, Robert, interview by Mauricio Verkooijen. *Technician Interview* (April 2011).
- Cancino, Ignacio, Armando Mendoza, and Julio C. Postigo. *Políticas frente al cambio climático*. Report, Lima: CEPES-CIES, 2011.
- Ciudades Virtuales. *Redperuana*. 2010. <http://www.redperuana.com/mapas/> (accessed August 3, 2011).
- Damonte, Gerardo, Adhemir Flores Moreno, Fiorella Minan Bartra, Gilberto Romero Zeballos, Karin Kancha Sucno, and Milton Gamarra Montanez. *Impactos de la variabilidad y cambio climático en los sistemas productivos rurales y en las condiciones de vida y desarrollo campesinos- Una vision desde la poblacion rural de Cusco y Apurimac*. Cusco: PACC-Peru, PREDES, CBC, 2010.
- Dourojeanni, Axel C. "Gestion por cuencas y cambio climático." *Foro Nacional "Agua: Políticas, conflictos y consensos"*. Lima: IPROGA, 2009.
- Earls, John. *Topoclimatología de alta montana*. Lima: Consejo Nacional de Ciencia y Tecnología CONCYTEC, 2006.
- Eda, Laura E. Higa, and Weiqi Chen. "Integrated Water Resource Management in Peru." *Procedia Environmental Sciences* 2, 2010: 340-348.
- Encalada, Gabriela, and Ernesto Guhl Nannetri. *El agua de los Andes*. Lima: Comunidad Andina, 2010.
- Estrada, Andres, interview by Mauricio Verkooijen. *Technician Interview* (April 2011).
- Fischer, Gunther, Mahendra Shah, and Harrij Van Velthuizen. *Climate Change and Agricultural Vulnerability*. Report, Vienna: IIASA, 2002.

Gyorkos, Theresa W., Joseph A. Serene, and Martin Casapia. "Progress towards the Millenium Development Goals in a community of extreme poverty: local vs. national disparities in Peru." *Tropical Medicine and International Health*, 2009: 645-652.

Hernandez, Jesus Contreras. "Subsistencia y ritual en Chinchero (Peru)." *Boletin Americanista*, 1983: 195-222.

Huaman, Guido, interview by Mauricio Verkooijen. *Technician Interview* (April 2011).

Huarhua, Bonifacia Sayo, interview by Mauricio Verkooijen. *Interview Community* (March 2011).

IPCC. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Report, Cambridge: Cambridge University Press, 2007.

IPCC. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Report, Cambridge: Cambridge University Press, 2007.

IPCC. *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Report, Cambridge: Cambridge University Press, 2007.

Llosa, Jaime, and Erick Pajares. "Estado de situacion de las politicas publicas adapatacion al cambio climatico y gestion del agua en los paises de la subregions Andina." In *Cambio climatico, crisis del agua y adaptacion en las montanas andinas*, by Jaime Llosa, Erick Pajares and Oscar Toro, 23-91. Lima: Desco, 2009.

Monge, Carlos, León Portocarrero, Claudia Viale, and Rocío García. "Recursos naturales y conflictos sociales en el Perú del siglo xxi." In *Peru hoy: del hortelano su perro: sin espacio ni tiempo historico*, by Monica Pradel. Lima: Desco, 2009.

Montoya, Nilton. *The effects of climate change on water supply in the Piuray Ccorimarca Catchment-Cusco- Peru*. Thesis Report, Zurich: Swiss Federal Institute of Technology Zurich, 2010.

Mukheibir, Pierre. "Water Acess, Water Scarcity, and Climate Change." *Environmental Management*, 2010: 1027-1039.

Ocampo, Ruben, interview by Mauricio Verkooijen. *Technician Interview* (April 2011).

Ortega Duenas, Ramiro. "El agua en la agricultura prehispanica y la problematica actual asociada con el cambio climático. La Región Cusco." In *Cambio climático, crisis del agua y adaptación en las montanas andinas*, by Jaime Llosa Larrebure, Erick Pajares Garay and Oscar Toro Quinto, 253-284. Lima: DESCO/Red Ambiental Peruana, 2009.

PACC Peru. *Programa de Adaptacion al Cambio Climatico*. 2011. <http://www.paccperu.org.pe/> (accessed June 14, 2011).

Paredes, Jorge. "¿Como afecta el cambio climatico a las diferentes zonas del Peru?" *El Comercio - Planeta*, September 20, 2010.

Pronamachcs. *Gestion Participativa de los Recursos Naturales para el Desarrollo Rural Sostenible*. Cusco: Pronamachcs-SNV, 2004.

—. *Ministerio de Agricultura*. June 13, 2011. <http://www.pronamachcs.gob.pe/pnmpublicaciones.asp> (accessed May 31, 2011).

—. "Ministerio de Agricultura." *Programa Nacional de Manejo de Cuencas Hidrograficas y Conservacion de Suelos*. June 10, 2006. http://www.infoandina.org/sites/default/files/recursos/bases_conceptuales.pdf (accessed August 1, 2011).

—. *Tauca; La Gestion y el Manejo de sus Recursos Naturales*. Lima: Ministerio de Agricultura, 2003.

Puma, Mario Hanco, interview by Mauricio Verkooijen. *Interview Community* (March 2011).

Romero, Fernando, Martha Bautista, and Jaime Maxi Calle. "Plan Estrategico de Desarrollo Regional Concertado." *Cusco al 2012*. December 2002.

http://www.mesadeconcertacion.org.pe/documentos/regional/Cusco/r08_00555.pdf (accessed August 23, 2011).

Rubio, Erika Trigoso. *Climate Change Impacts and Adaptation in Peru: The Case of Puno and Piura*. Occasional Paper, Washington: UNDP, 2007.

Sperling, Frank. *Transitioning to Climate resilient Development*. Washington: World Bank, 2008.

Titto, Florencio, interview by Mauricio Verkooijen. *Community Interview* (March 2011).

Titto, Vicente Hanco, interview by Mauricio Verkooijen. *Interview Community* (April 2011).

Trawick, Paul. "Against the Privatization of Water: An Indigenous Model for Improving Existing Laws and Successfully Governing the Commons." *World Development*, 2003: 977-996.

Universidad San Martin de Porres. *Instituto del Peru: La gestion del cambio climatico*. February 26, 2008. http://institutodelperu.org.pe/index.php?option=com_content&task=view&id=451&Itemid=117 (accessed June 20, 2011).

US Environmental Protection Agency. *Climate Change- Science*. April 14, 2011. <http://www.epa.gov/climatechange/science/recenttc.html> (accessed June 10, 2011).

Valdivia, Corinne, Jere Gilles, Christian Jette, Roberto Quiroz, and Rigoberto Espejo. "Coping and adapting to climate variability: the role of assets, networks, knowledge, and institutions." *In Insights and Tools for Adaptation: Learning from Climate Variability*, 2003: 189-199.

Valladolid, Julio Rivera. "Cosmovision andino-amazonica. Conocimientos tradicionales y cambio climatico en el Peru." In *Cambio climático, crisis del agua y adaptación en las montañas andinas*, by Jaime Llosa Larrebure, Erick Pajares Garay and Oscar Toro Quinto, 285-307. Lima: DESCO/Red Ambiental Peruana, 2009.

Vargas, Paola. *El Cambio Climatico y sus Efectos en el Peru*. Working Papers, Washington: World Bank, 2009.

Vuille, Mathias, et al. "Climate change and tropical Andean glaciers: Past, present and future." *Earth Science Reviews*, 2008: 79-96.

World Bank. *Peru: Country Note on Climate Change Aspects in Agriculture*. Country Note, Washington: World Bank, 2009.

World Bank. *Peru: Overcoming the Barriers to Hydropower*. Report, Washington: The World Bank, 2010.