EXTREME METEOROLOGICAL EVENTS AND RISK MANAGEMENT IN THE ANDES OF PERU

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ABSTRACT

This contribution presents findings from the ongoing project MAREMEX-Mantaro risk reduction and adaptation to climate change in the Peruvian Central Andes in which the physical and socio economical aspects of extreme meteorological phenomena, such as drought, intense rainfall and frosts, and their impacts are studied at the sub basin level, with emphasis on the most vulnerable population (i.e. those with less access to economic, social and information resources).

The main objectives of the project are to strengthen the capabilities for risk management associated with these meteorological events by: researching the physical aspects; developing an integrated risk management and adaptation strategy in collaboration with the local and regional authorities, population, and other institutions; disseminating the results of the study in the population and involving local researchers, students, and research institutes in the development of the study.

Research in the physical aspects is aimed at increasing the knowledge of atmospheric mechanisms associated with the extreme events to improve the capability of prediction and mitigation of these events. Also, the general analysis includes the identification of the key players and stakeholders, and the identification and analysis of past events and their impacts on the population.

Keywords: Risk management; Extreme meteorological events, Andes

INTRODUCTION

The Andean region is particularly vulnerable to natural phenomena and Peru is especially vulnerable to extreme meteorological events. This situation is likely to worsen due to increasing population pressures and climate change. Although in Peru the population and its authorities are sensibilized to the impacts of meteorological phenomena, limitations in scientific and technical knowledge precludes the implementation of effective actions to prevent them.

The Mantaro Valley is located in the Peruvian Central Andes, important agricultural zone of the country, where crops such as potato, maize, kiwicha, etc. are cultivated. The valley population is approximately 500,000 inhabitants, of which 70% are located in the cities of Huancayo, Jauja and Concepción. Nevertheless, this percent fluctuates, due to a migrant population that mobilizes between rural and urban areas, largely associated with the agricultural seasonality.

Table 1 Meteorological extreme events and their main negative impacts identified in the Mantaro Valley

Scope	*Meteorological extreme events*		
	Intense rain	*Droughts*	*Frosts*
Urban	Damages in transport (bridges, roads, etc.), housing and drinking water infrastructure; loss of human beings.	Cuts in drinking water service; decrease in the generation of hydroelectric energy	Bronco-pulmonary diseases, especially in children and the elderly
Rural	Loss of agricultural land, seeds, etc.; loss of agricultural infrastructure (canals, rural roads, etc.); erosion	Water conflicts; decrease in the crop yields; increase in pests and plant diseases.	Bronco-pulmonary diseases, especially in children and the elderly; impacts in agriculture as decrease in crop yields; low yield of milk and meat in cattle and sheep (*)

(*)Life testimonies of farmers in the Mantaro valley (Conveagro, 2007)

Urban and rural populations are vulnerable to extreme meteorological events that can turn into disasters. The events that have a larger impact on the population were identified using different sources of information: meteorological data, local newspapers, surveys and interviews and these are: intense rainfall, droughts and frosts (IGP, 2005; Martinez, 2007). Table 1 presents a summary of the main negative impacts of these events.

The negative impacts are well differentiated between the rural and urban areas, those who are aggravated due to these events frequently occur simultaneously. Among these impacts are: human deaths, damages in urban and rural infrastructure, loss of men/labor hours, children/study hours, food shortage, potable water service cuts, etc., but not always are easily quantifiable.

This situation is compounded by the threat of the negative consequences of climate change. Future climate scenarios for the year 2050 developed for the central Mantaro river basin, where the Mantaro valley is located, (IGP, 2005b), indicate:

- Increase of 1.3°C in air temperature.
- Decrease of 19% of rainfall during the months of December to February.
- Decrease of 6% in relative humidity.

These results are alarming. They will add to the retreat of the Huaytapallana glacier (Zubieta and Lagos, 2010), affecting the supply of drinking water and water for agriculture, and increasing conflicts by water that have begun to emerge in recent years (IGP 2005c). In addition, the increase in air temperature will likely increase the presence of pests and diseases in agriculture; and the decrease in relative humidity could mean frost more frequent and intense (IGP 2005c). Also have to be taken into account numerous socio-economic factors, such as the population increase, which in turn would increase the pressure on resources.

It is in this context that in February 2009 started the project "Disaster Risk Management to extreme meteorological events (drought, frost, and intense rains) as a measure of adaptation to climate change in the Mantaro valley", (MAREMEX-Mantaro).This project is being executed by the Geophysical Institute of Peru with funding from the International Development Research Center (IDRC) of Canada, and has a duration of 36 months. The main objective is to strengthen the capacity of risk management to extreme meteorological events by the population and the institutions that are in charge of the natural resources management, in order to reduce the vulnerability of the urban and rural population in the Mantaro valley. It´s expected that the knowledge generated will serve as input into the preparation of local plans for adaptation.

STUDY ZONE

The study includes the sub basins of Achamayo, Shullcas and Cunas, which are distributed between the provinces of Concepción, Huancayo and Chupaca. The urban areas prioritized are the homonymous capital cities of each of these provinces. In addition, districts in rural areas were identified: 9 de Julio, Acopalca, and San Juan de Jarpa, which correspond to the sub basins of Achamayo, Shullcas and Cunas, respectively. In Figure 1 can be seen a map of the areas described.

These study areas were chosen taking into account various factors: representativeness of ecosystems, vulnerability to the occurrence of the meteorological extreme events identified, accessibility, existence of important urban areas, interest and intention to participate, etc.

The differences between the urban and rural scopes are large, and are associated with housing characteristics, level of education, health, access to basic services, access to communications, etc. For example, the availability of public lighting in the urban sector is around 90 %, while in the rural sector this percentage is barely 42%; the percentage of drinking water supplied by river, ditch or spring is 12% in the urban environment, and 65% in rural areas; and the use of firewood for cooking is 32% in the urban scope, and 83% in rural areas (INEI- ENAHO, 2008).

However, despite these differences, both scopes coexist around complementary economic activities, primarily related to the agricultural sector. The urban environment has rural components and the rural environment in turn have urban components, and the borders between the two scopes are - in many cases, diffuse, and the links very strong (De la Cadena, 1988).

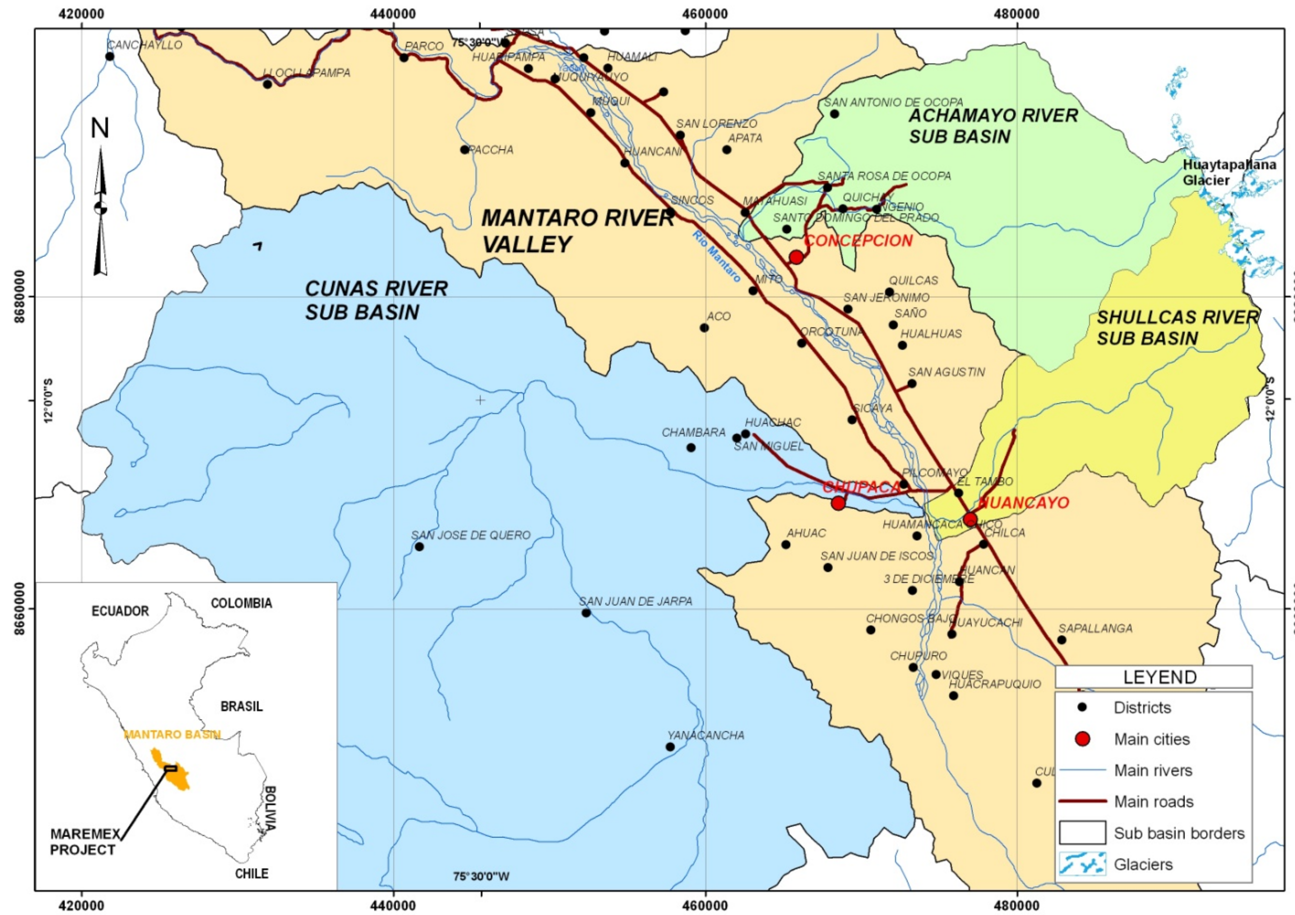

Figure 1: Study zone map of MAREMEX-Mantaro project.

OBJECTIVES AND RESEARCH ORGANIZATION

The specific objectives of the project are: to strengthen and deepen the studies on the causes, occurrence and impacts of frost, drought and intense rain the valley; to identify key stakeholders involved and assess the current capacity of the Mantaro valley residents in the disaster risk management due to meteorological extreme events; to develop an integrated plan for risk management and adaptation strategies against frost, drought and intense rains in the Mantaro valley, with the participation of local authorities, regional governments, communities, NGOS and other relevant actors, and to promote institutional strengthening and the dissemination of the project results to the population, institutions and scientists through the creation or strengthening of research capabilities of entities and local researchers on issues related to climate change adaptation. To achieve these objectives, the research was organized as shown in Figure 2.

The project focused on the main extreme meteorological events: droughts, frosts and intense rain. The analysis included their physical characterization, impacts characterization, analysis of population and decision making responses, and finally the identification of local adaptation strategies.

The physical characterization was prioritized, since there is a large lack of information about the physical processes that controls the occurrence of the extreme events. The meteorological information has been obtained from the ServicioNacional de Meteorología e Hidrología (SENAMHI), among others institutions. The Geophysical Institute of Peru operates the Observatory of Huancayo, near Chupaca, with has one of the longest meteorological data series in the Central Andes (1922-present). This information have been used to calculate trends in mean climate and extreme events and to determine the correlations between extreme events and their impacts.

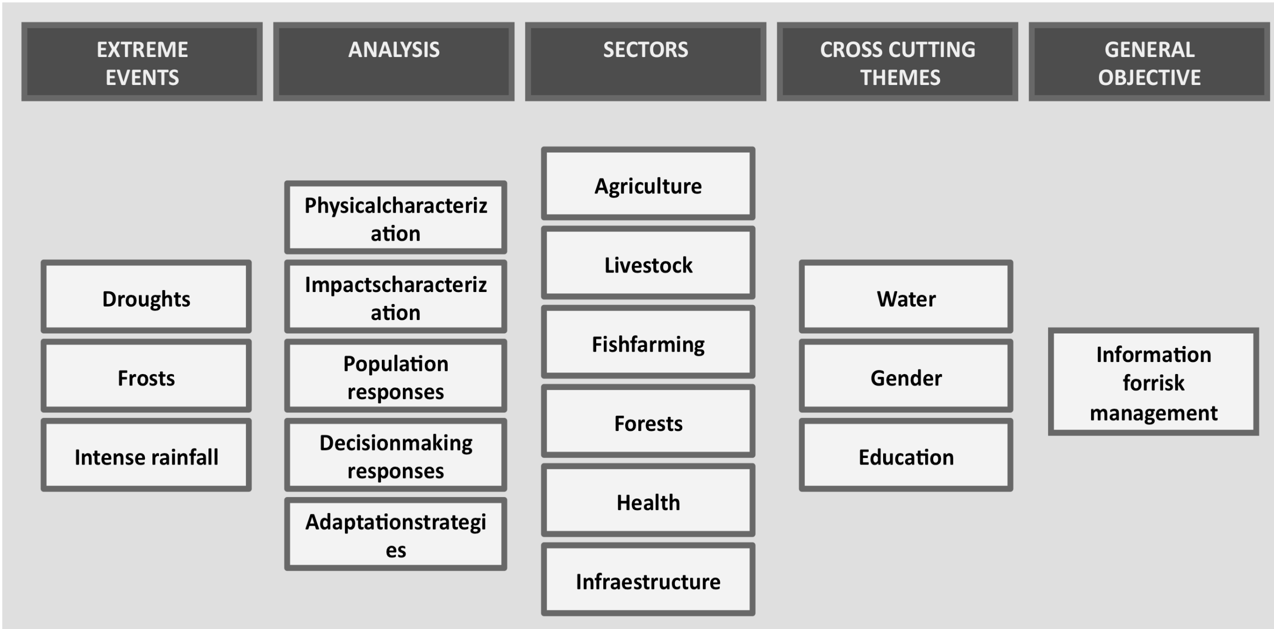

Figure 2: Research organization of MAREMEX-Mantaro project.

The analysis of vulnerability in the economic sectors was originally focused on agriculture and livestock but, as the project developed the sectors of Fish farming (aquaculture) and Forestry were added, as additional researchers and institutions joined the project. In addition, we considered the analysis of impacts on health and infrastructure (related to the physical vulnerability of urban and rural town centers), which, although they are not economic sectors, are basic sectors for the welfare and development of the populations under study.

The analysis of vulnerability by sectors was done using participatory tools such as: chronologies of meteorological extreme events, vulnerabilities arrays, mapping of threats, etc., that have been complemented through participatory workshops, surveys and interviews.

In addition, multiple databases with historical information of impacts have been used. One of them is DESINVENTAR (www.desinventar.org), which is a database of news about disasters; as well as the SINPAD (www.indeci.gob.pe), which is the database of emergencies operated by the National Institute of Civil Defense. Additionally a database was implemented within the project based on local newspaper reports of incidents related to hydrometeorological events(www.met.igp.gob.pe/proyectos/maremex/BasedeDatos). The information in these databases allowed identification of extreme events and their impacts, the action of authorities, etc., and these information was compared with data from meteorological stations and surveys information.

The ultimate goal is that the information generated in the project can be used for risk management, including the preparation of local plans of adaptation. In reference to risk management as an adaptation strategy, it must pointed out that risk management has to be treated with actions at two different levels: one at the family and community level, and another at the “formal” level of local and regional decision-makers, and this needs to be done through capacity building at all levels, where the integrated management of water and soil resources must be a priority.

PERCEPTIONSOF CLIMATE CHANGE

An important aspect to be considered in the assessment of the capacity of the population for risk management is the perception that the population has of the extreme meteorological events. This information was collected through participative workshops, surveys and interviews. Among the main changes that the population has noticed are changes in the rainfall regime, mainly in its temporality. The collected information suggests that beginning of rain season has been delayed from September to October, November or even December (IGP, 2005c), which has been confirmed through the analysis of meteorological data from the Huayao Observatory. This has very serious implications to productive sectors as agriculture and livestock raising.

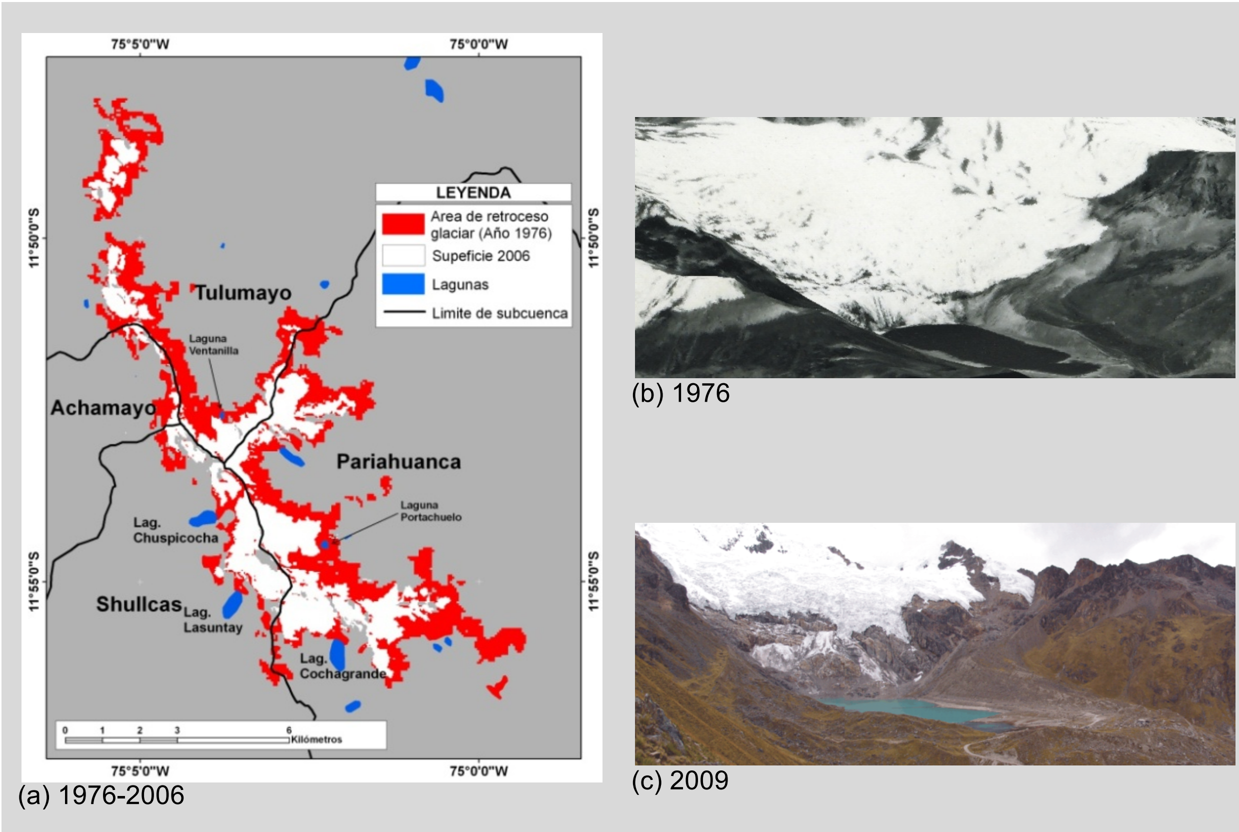

Figure 3 (a) Map of Huaytapallana Glacier and its loss of ice mass between 1976 and 2006. (b) View of Huatapallana Glacier en 1976. (c) View of Huaytapallana Glacier in 2009.

These sectors are also affected by frosts, which are perceived more intense and frequent. This is consistent with meteorological data in the Central Andes (IGP, 2005c; Trasmonte, 2008). Respiratory diseases are apparently associated with drops in temperature (Enciso, 2010), mainly among children and elderly.

According to the surveys, the clearest indication of climate change for the population of the area is the melting of the Huaytapallana Glacier. Tropical glaciers are excellent indicators of the evolution of the climate by its extreme sensitivity to variations in the meteorological parameters such as temperature, radiation, and precipitation, etc. (Pouyaud et al., 1995). In the study zone, especially the inhabitants of the Shullcas river sub basin (Figure 3) indicated their concern, a situation of which are clearly aware since the Huaytapallana Glacier has an access and it is very near the city of Huancayo (35 Km), which makes it a popular destination for weekend visits.

This perception is corroborated by the analysis of LandSat images, which indicates that between the years 1976 and 2006 the glacier area was reduced from 35.6 to 14.5 km2, i.e. a reduction of 59.4 % (Zubieta and Lagos, 2010).

LOCAL PRACTICES AND BELIEFS

Although there are abundant local/traditional practices and beliefs related to climate in the Andes of Peru,, which in several cases have been used for hundreds of years research on these has been focused mainly on the compilation of techniques or indicators used in agriculture (e.g. Project In Situ, PRATEC, Magazine MINKA, etc.).There are very few instances of attempts to systematize these and determine the extent or fits current usage. Fewer still are the efforts of scientifically determining the utility of this knowledge (e.g. Orlove et al., 2002).

In this project, information on these local/traditional practices and beliefs in the area has been collected through surveys and a classification into three large groups has been proposed based on the kind of application: a) climate prediction (seasonal time-scales); b) forecasts of extreme events (hours to days in advance);and c) preventing the occurrence or the impacts of such extreme events.

The climate prediction is understood as the prognosis of whether a year will be "good" (i.e. with a normal onset of the rainy season) or "bad" (i.e. with a delayed onset of rainfall).The importance of the date of the onset of rainfall is mainly agricultural, and is due to the importance of the first rainfalls to humidify the ground sufficiently to allow the breaking upof the soil and to start the agricultural cycle.

Indicators for climate forecast can be subdivided into three groups (Fig. 4).The first are astronomical, such as the Pleiades appearance (Orlove et al., 2002), or the moon position. A second type are biological, which can be the related to the behavior of the local fauna (howling of the fox, etc.) and with the state of local flora (presence of some kinds of seaweeds like *cushuro*, etc.). The third type are hydrometeorological, e.g. related to the direction of the winds, the color of the sky, state of rivers and lagoons, etc., which are more local in nature.

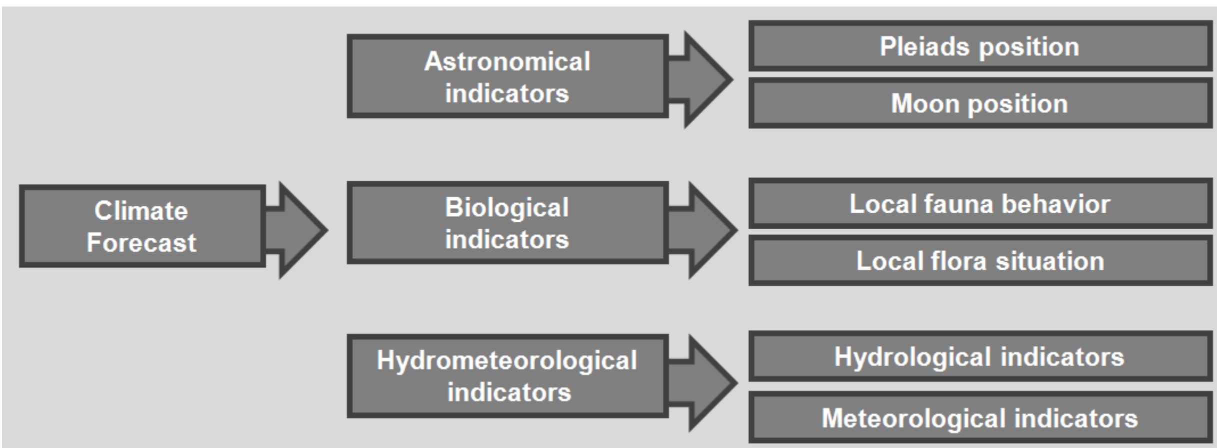

Figure 4 Local knowledge on climate forecast of “good year” in the Mantaro Valley

For the forecast of extreme events, two types of indicators have been identified: biological and meteorological events, with similar characteristics described above. An indicator that stands out because of its consistent mention in surveys in the three sub-basins is the observation of clear and starry skies as a predictor of frosts. This technique appears to have a physical basis, as clouds reduce the energy loss of the ground by infrarred radiation and preliminary measurements at the Observatory of Huancayo indicate that the absence of clouds can determine the occurrence of frost.

Finally, on the knowledge on how to prevent such extreme events or their impacts, various actions have been identified with respect to hail storms, lightning, frost, and “veranillos” (similar to "Indian summers"). More than 80% of these actions are related to local cultural traditions that appear unlikely to be effective from a physical perspective, e.g. collection of water in earthen vessels to prevent veranillos from occuring; wearing black against hailstorms; to burn ram's horns against lightning, etc.

Nevertheless, a common practice in the three sub basins that is used worldwide and has been used in the Andes at least since the time of the Incas (Garcilaso de la Vega, 1608) is to produce a smoke cloud over the crops by burning different kinds of material (dry grass, dung, etc.) to prevent the onset of the frost.

Although almost no scientific research can be found regarding the effectiveness of this method, in principle smoke particles could act as natural water clouds to prevent radiation loss from the ground. The interviewed elderly indicated that until a few decades ago this was an usual practice used by the peasant community, and that however is used less and less, in part due to the weakening of the role of the community as an coordinating institution.

RELATIONS BETWEEN SCIENTIFIC RESEARCH AND SENSIBILIZATION OF THE LOCAL POPULATION

There are two major tasks in the framework of MAREMEX project: The study of the physical aspects of meteorological events, and to improve risk management capacity to face these events. A strategy that was developed within this project to develop both aspects at once is the implementation of a basic meteorological network with high spatial density based on communities in the area of interest, which would improve the spatial characterization of extreme events and would allow the members of the communities to have a better knowledge of their environment and consequently, to improve their management capacity.

A key aspect of the strategy is the use of simple low-cost instruments (pluviometers and thermometers) that were donated to the communities under the sole condition of maintaining the measurements. This was complemented with training of as many people as could be gathered in the communities. The low cost and simplicity of the instruments allowed to make installations without technical problems, ante its number increases the probability of obtain useful information.

About 40 rain gauges were installed in the 3 sub basins of study at the beginning of the 2010-2011 rainy season, with the support of NGO that have been working in the zone, and the concurrence of the peasant communities.

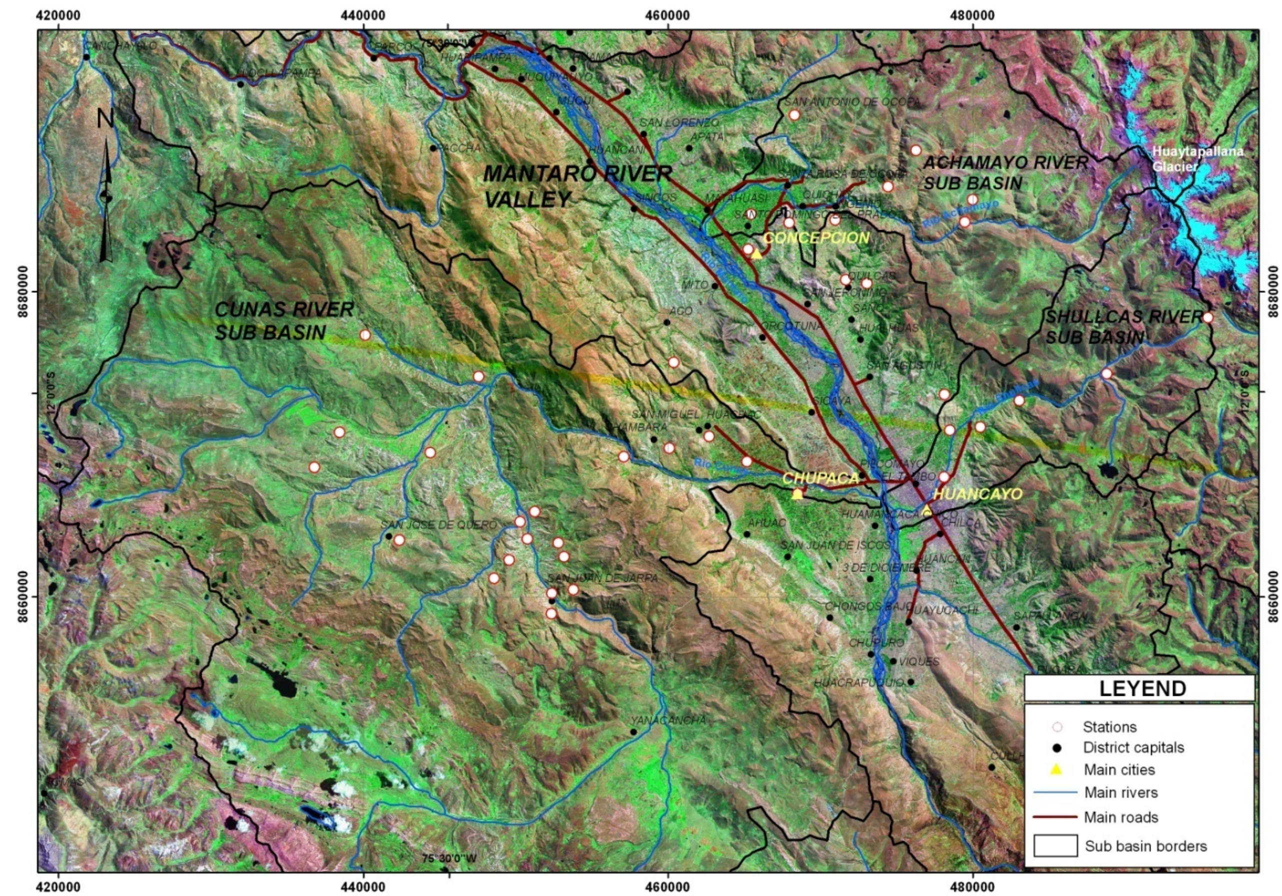

Figure 5 Map with the rain gauges stations in Mantaro Valley.

The measurements are made daily at 7 am, using especially prepared spreadsheets to facilitate the data capture and minimize errors. The observers were trained both in a theoretical way - explaining the importance of the measurements-, as in a practical way with real cases and using the instrumental installed.

It should be noted that the conditions of each installation were quite different in each case with regard to the places and potential observers, providing a wealth of experience from the perspective awareness and study of risk management. The installations were made in such different places as community centers, schools, backyards and cultivation land (Figure 6), a 10% of stations had to be relocated later to your installation as the observers indicated that did not have enough time to carry out the measurements. Only one of the gauges (2.5 %) was lost without being able to recover it.

Men, women and children were trained in the collection of data, but initially it was mainly men that took on the role of weather observers. Later, due to the necessity of continuous data collection, many of the observers trained their children, wives and other relatives, so instead of having observers, in many cases there were "families of observers".

(a) (b)

Figure 6 (a) Training in the use of the rain gauge in San Juan de Jarpa, Cunas sub basin. (b) The rain gauge has been reproduced in the spreadsheets to facilitate the data capture.

The staff of the project visits the stations every1-2 months to collect the rain measurements, reinforce training in data collection, control the data quality, as well as to collect the comments of the observers. Toward the end of the rainy season 2010-2011, more than 30 stations were still operational, surpassing initial expectations and the data were in general were of good quality. Four of the remaining stations are located in isolated communities that are difficult to reach during the rainy season, so the records have not yet been collected.

During this rainy season, several impacts associated with rains were presented in the Mantaro valley. The Institute for Civil Defense (INDECI) has registered more than 60 emergencies in the area, mainly associated with floods. The data of rain gauges suggest, however, that these emergencies were not associated with exceptionally rainy specific days, but with the persistence of the rains.

One of the objectives of this experience was for the communities to discover applications for the data. An example of the utility of the information was that the community of Ranra, in the Achamayo sub-basin cited measurements of rain as supporting evidence for a demand for aid to INDECI, illustrating how local access to information increases the risk management capacity of the populations.

INTER-INSTITUTIONAL AND MULTI-DISCIPLINARY WORK

One of the most important experiences during the development of the project was the implementation of an strategic alliance formed by decision-makers (Regional Government of Junín, and Provincial Government of Concepción); NGOs (Yanapai Group, CARE and REDES); research groups and institutions (Faculty of Veterinary Medicine at Universidad Nacional Mayor de San Marcos and Forst-, Geo- und Hydrowissenschaften Technische Universität Dresden); national institutions (National Institute of Civil Defense INDECI); and beneficiary communities (Peasant Communities of 9 de Julio, San Juan Jarpa and Acopalca).

This strategic alliance has made possible to strengthen the research and sensibilization activities. In this sense has been extremely useful to permit an "open participation" (Martínez, 2008), where researchers and institutions have been able to freely join the investigation even during advanced stages of the project. While this has meant adjust activities and the forming of new links between the different activities already planned, has benefit the study with the opening of complementary subjects that have nourished and enriched the project.

The formalization of the strategic alliance among their member institutions through agreements and letters of intent has been critical, since these legal instruments have protected the continuity of their participation, even with the changes of authorities (in the case of Regional and Provincial governments). It should be noted that in several cases this formalization has been a long and complicated task, but has proved been worthwhile.

Another important strategy used has been the study of specific research topics through the development of university students' thesis projects. This has proved to be extremely positive for the project, since it has allowed the development of skills in young students in topics related to the physical, socio-economic and cultural aspects of climate change; it has allowed to fill information gaps that otherwise would had to be developed by consultancies; and has proved to have a relatively low cost.

The thesis studies had a wide range of themes, and the students had various different backgrounds (physics, fluid mechanics, geography, systems engineering, etc.).Various detect some gaps in the university current system: the lack of habit of writing technical reports, lack of facilities (funding) for the collection of data in the field, extremely cumbersome administrative formalities, etc.

Precisely because the necessary interaction between specialists and students from different disciplines, and taking the experience of how difficult this process can be (Martínez, 2008), periodic meetings of "information and activities integration" were performed almost from the start of the project. These bi-monthly meetings were a space for exchange and homogenization of terminologies, concepts, and methodologies, where each member of the technical team briefly presented their main findings, problems and future activities. These meetings had the additional benefit to allow better planning of field work, surveys and workshops, as well as the formation of strongly cohesive project team.

Figure 7 Some of the dissemination products of the project

OUTREACH ACTIVITIES

In order to disseminate the results of the project at the level of authorities, decision-makers, other institutions, and the general public, - in addition to the presentations in workshops, seminars and national meetings-, several publications are in production: semi-annual newsletters; two volumes with the results of the project, and a couple of publications in specific issues.

The purpose of the newsletters has been - rather than to just publicize the project - to present advances in research, which has proved to be a good strategy to draw attention to the work being carried out. On the other hand, the 2 volumes are not only sets of articles on the various research topics, on the contrary it is planning prepare them as sequential issues, submit both scientific findings, as well as the methodology used, strengths and weaknesses, etc.

The dissemination of the information to the beneficiaries peasant communities has been considered as well. In a way to "give back" the information collected some specific products will be distributed: maps of susceptibility to landslides and floods, pasture and livestock maps, posters with relevant information for the communities, etc. It has been coordinated with the beneficiaries themselves, to prepare this information in large formats (posters), framed and placed in the community house, schools, municipalities, etc. of the communities that are participating in the project.

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