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Assessing adaptation – Climate change and indigenous livelihood in the Andes of Bolivia

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Abstract

Based on a case study of Charazani – Bolivia, this article outlines the understanding of adaptive strategies to cope with climate change and its impact on environmental and socioeconomic conditions that are affecting rural livelihoods. Mainly qualitative methods were used to collect and analyze data following the framework for vulnerability assessments of a socio-ecological system. Climate data reveals an increase of precipitation and temperature during the last decades. Furthermore the occurrence of extreme weather events, particularly drought, frost, hailstorms and consequently landslides and fire are increasing. Local testimonies highlight these events as the principle reasons for agricultural losses. This climatic variability and simultaneous social changes were identified as the drivers of vulnerability. Yet, several adaptive measures were identified at household, community and external levels in order to cope with such vulnerability; e.g. traditional techniques in agriculture and risk management. Gradually, farmers complement these activities with contemporary practices in agriculture, like intensification of land use, diversification of irrigation system and use of artificial fertilizers. As part of a recent trend community members are forced to search for new off-farm alternatives beyond agriculture for subsistence. Despite there is a correspondingly large array of possible adaptation measures that families are implementing, local testimonies point out, that farmers often do not have the capacity and neither the economical resources to mitigate the risk in agricultural production. Although several actions are already considered to promote further adaptive capacity, the current target is to improve existing livelihood strategies by reducing vulnerability to hazards induced by climate change.

Keywords: Andes, climate change, adaptation, vulnerability assessment, traditional knowledge

Abbreviations:

ANMI Apolobamba: *Área Natural de Manejo Integrado Apolobamba* (Natural Area of Integrated Management Apolobamba)

INE: *Instituto Nacional de Estadística* (National Institute of Statistics)

NOAA: The National Oceanic and Atmospheric Administration

SENAMHI: *Servicio Nacional de Meteorología e Hidrología* – Bolivia (National Service of Meteorology and Hydrology – Bolivia)

SERNAP: *Servicio Nacional de Áreas Protegidas* (Protected Areas National Service)

TEK: Traditional Ecological knowledge

VMMAyA: *Viceministerio de Medio Ambiente y Agua* (Viceministry of Environment and Water- Bolivia)

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1 Introduction

Adaptation to environmental change is not a new phenomenon (Tompkins *et al.*, 2010). Societies have adapted to their environments to mitigate risks associated with climate variability throughout human history. This interaction is represented in cultural landscapes which constitute a testimony of the past and present-day relationships between society and its environment (Rescia *et al.*, 2008). Indeed, indigenous people and farming communities are a life example of it. They are facing different aspects of climate change depending in where and how they live. People are not only keen observers of climate change, but also actively try to adapt to the changing conditions (Byg & Salick, 2009; Turner & Clifton, 2009). The coherence in this interaction is described by the theory of the co-evolution of ecological and social systems (Gual & Norgaard, 2010; Kallis & Norgaard, 2010), which contributes on the assessment of adaptation strategies.

Indigenous communities from the Andes are well known for their ancient knowledge of the environment and for the development of techniques and technologies that allowed them to survive and adapt to extreme weather conditions and related effects throughout generations, ensuring their basic needs (Davinson-Hunt, 2003; Lhomme & Vacher, 2003; Toledo, 2002; Morton, 2007; Salick & Byg, 2007; Byg & Salick, 2009; Lindner & Pretzsch, 2013). Currently Bolivia contributes only 0.04 % human induced carbon dioxide emission of the world (McDowell & Hess, 2012), yet the effects of anthropogenic climate changes are likely to be of a greater magnitude, and experienced sooner in the Andes, than in other parts of the globe (Bolivia Information Forum, 2009). It will have lasting implications for economic activities, especially for vulnerable rural communities dependent on mountainous ecosystems due to the impact on water availability, and other phenomena like emerging of new pathogens and diseases (Toledo, 2002; Morton, 2007; Wreford *et al.*, 2010; Nath & Behera, 2011; Gentle & Maraseni, 2012). Quality of life in these communities is highly sensitive to climate variability and change, in particular because of the challenges regarding traditional relationships between social and ecological systems (Arana *et al.*, 2007; Howden *et al.*, 2007; VMMAyA, 2010).

Despite uncertainty about reliable predictions of changes in weather patterns and frequency of extreme weather events, climate change is already a fact and has been recognized by local communities in the Andes (Valdivia *et al.*, 2010; McDowell & Hess, 2012). Yet, the diversity of techniques to use and manage the resources developed by the communities allowed a response of adaptive measures to cope with their particular social and ecological exigencies. Examples are the use of agrobiodiversity, management of agriculture in different ecological zones, traditional management of pastures and water as well as traditional social networks (Bellón, 1993; Leff, 2008; Macchi, 2011).

Hence, there is a need to understand the impact of climate change on the socio–ecological system and the capacities and technologies of Andean communities to cope with a changing environment and adapt to it. For that reason, the present study aims to provide information regarding the climate variability and the adaptive measures based on traditional knowledge and new technologies that communities are using to cope with climate change. This research focuses on the case study of Charazani in the National Park and Integrated Area of Management Apolobamba in Bolivia.

2 Materials and methods

2.1 Study area

The study was conducted in the valley of Charazani, located at 272 km northwest of La Paz City within the limits of the ANMI Apolobamba in the Andean region of Bolivia (Fig. 1). This valley harbors an exceptional diversity of ecosystems, including humid montane cloud forests, high Andean wetlands (*bofedales*), peat-bogs (*turberas*), glacial lakes, humid high Andean grasslands (or *tundra*), glaciers and snow-capped mountain peaks (Montes de Oca, 2005). Temperature fluctuation during day on average is 10 °C and 1.8 °C between months (PDM, 2004). Mean temperature in the Andes has increased by approximately 0.1 °C in the last seven decades, and the frequency of extreme weather events is also expected to rise accordingly (Vuille *et al.*, 2008; Valdivia *et al.*, 2010; McDowell & Hess, 2012).

Charazani is well known as the sacred landscapes of the Andes or "*Kallawaya Nation*". It is populated mainly by indigenous communities. About 82.1 % of the total population of 1.800 is Quechua and 14 % is Aymara (INE, 2004). These ancient cultures have developed an intimate knowledge about their environment, guided by an ethic of respect for all forms and expressions of life. Nevertheless about 87 % of population lives in extreme poverty and the main resource of income is subsistence farming. The agriculture practices have been characterized by ancient practices developed

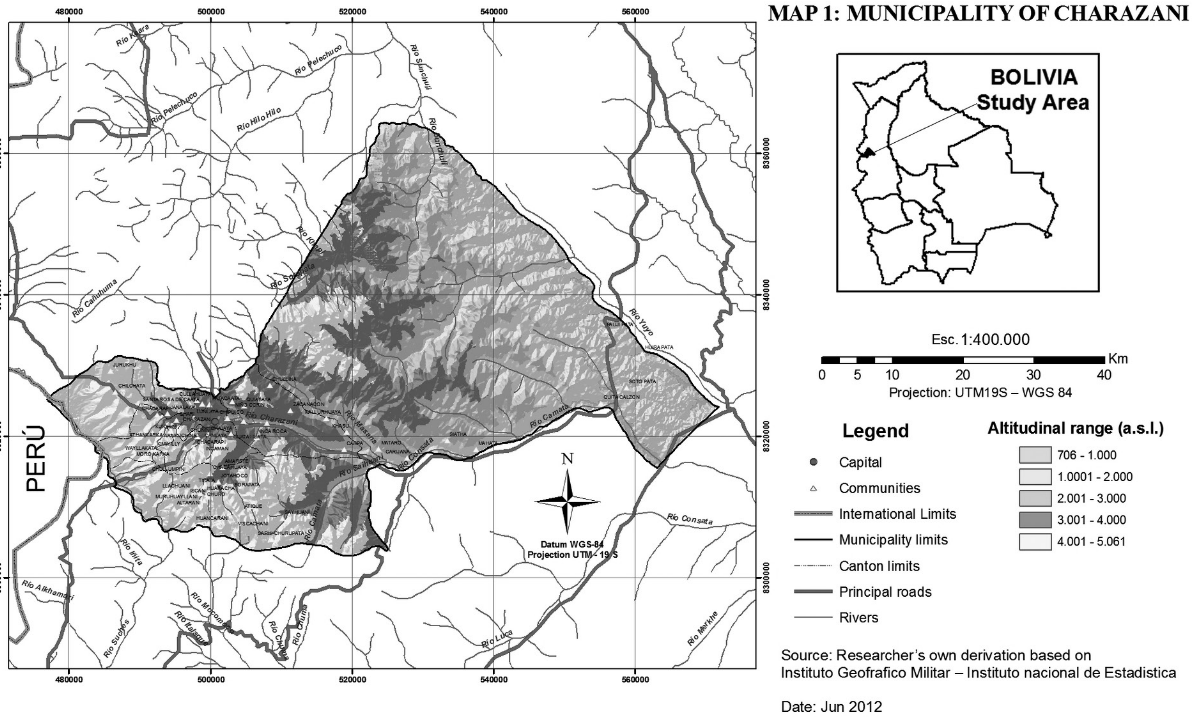

Fig. 1: *Study area (circle) in the municipality of Charazani – ANMI Apolobamba – Bolivia (INE, 2004; modified)*

according to the different altitudinal levels and corresponding microclimates represented in different ecological zones. Therefore there is a large heterogeneity in the landscape and thus in agriculture, which is reflected in high crop diversity (Schulte *et al.*, 1998; Dregne, 2002). Furthermore, agricultural practices have been influenced constantly by additional external factors since the colonization period (Schulte *et al.*, 1998).

2.2 Methodological framework

The theoretical framework set up for this article is the vulnerability assessment of socio-ecological systems based on Adger (2006), Füssel (2007) and Engle (2011) (Fig. 2). This framework is based on the relationship between social and ecological system and considers the impacts driven by bio-physical and social changes in agroecosystems. Furthermore, it explains the vulnerability of the socio-ecological system as a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. The definition of adaptive capacity is the ability of a system (human or natural) to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantages of opportunities, or to cope with the consequences (IPCC, 2001).

This article was mainly based on information collected and systematized from literature review. The main sources of information were: climatic data (SENAMHI, 2012), census data (INE, 2004), NGO reports, ANMI Apolobamba assessment reports, PNB project baseline information, policy reports from SERNAP, and scientific publications. The information was complemented with fieldwork observations in the "Canton de Santa Rosa de Kata" in Charazani.

Primary data was collected at the community and household level during the baseline assessment of the National Program of Biocultura, developed by UME – AUB (PNB, 2011). A total of 30 interviews were conducted in the community of "Santa Rosa de Katta" (this number represents 25 % of a total of 123 families living in the community). The following social and environmental indicators were assessed: change in climatic patterns, social and economic activities based in agriculture and, traditional and contemporary knowledge and technologies applied in agriculture. Furthermore, walks along the community were conducted with the collaboration of local families in order to verify the information given.

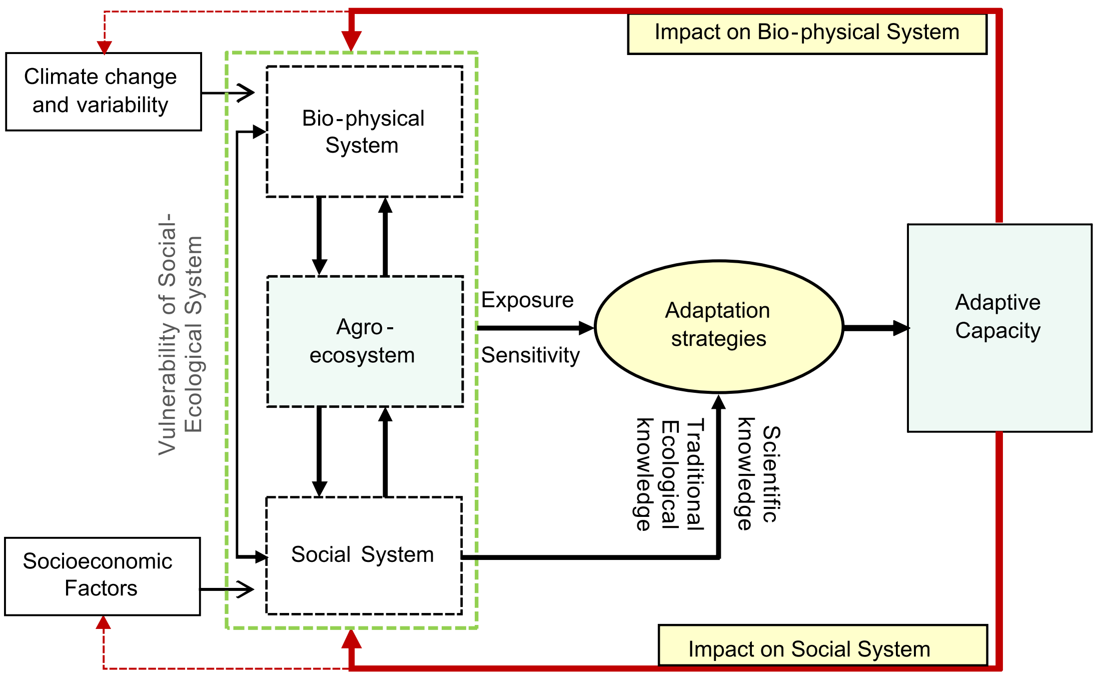

Fig. 2: *Identification of adaptive capacity throughout the vulnerability assessment of socio-ecological systems (based on Adger, 2006; Füssel, 2007; Engle, 2011)*

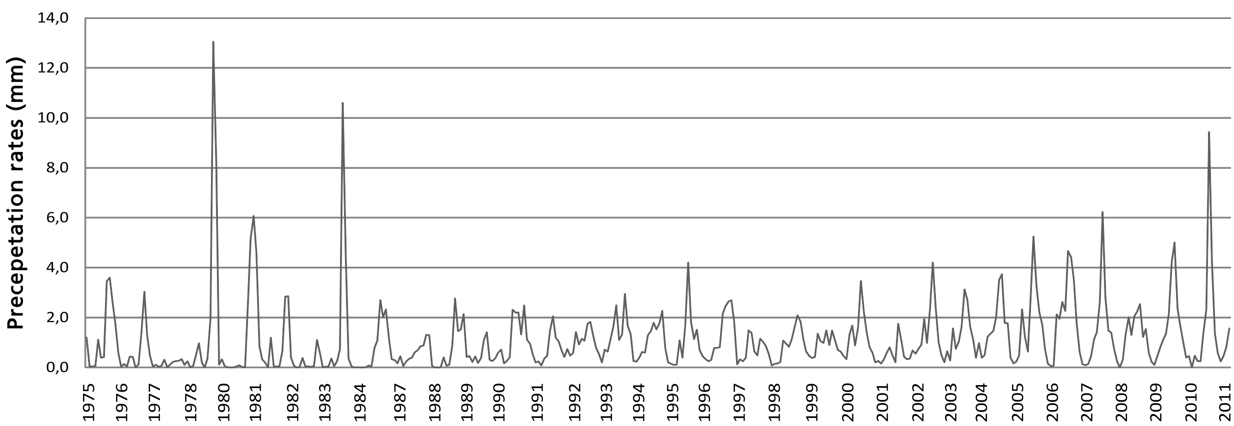

Fig. 3: *Monthly mean precipitation rates in Charazani valley from 1975 to 2011 (SENAMHI, 2012)*

3 Results

3.1 Climatic trends in Charazani valley

Temperature and precipitation show a cycle pattern with distinctive rainy and dry seasons that were highly related to the El Niño phenomenon (SENAMHI, 2012). According to information provided by NOAA (2012) precipitation rate clearly increased during the last decades (Fig. 3). Also the monthly maximum temperature increased by 0.27 °C per decade since 1980.

According to local perception, the frequency of extreme weather events has been increased during the last years. Particularly the older generation was aware of the rapid transformation of weather patterns and the changing climate. It has become very common to hear among local conversations: "… *el tiempo ya no es como antes* …" – the weather is not the same as it used to be. Farmers reported that the frequency and intensity of extreme events was higher than in years before. During wet season, intensive rains were causing landslides and during dry season the periods of drought are prolonged, increasing the chances of fire (natural or man-made). At the same time the frequency of frost was higher (Table 1). Moreover, testimonies from local farmers pointed out the unpredictability of such weather events, what makes it far more difficult to be prepared to avoid losses in production.

3.2 *Assessment of climate vulnerability*

Changes in climatic patterns and the occurrence of extreme weather events, with their respective substantial impacts on agriculture, represent a threat to farmers (Table 2). Most of these impacts have negative effects on the quality of life in the household.

3.2.1 *Adaptive measures to cope with climatic variability*

Base on traditional ecological knowledge (TEK), there were several techniques and technologies that have been developed in order to adapt to climatic changing conditions. One example is the use of natural indicators to predict the climatic patterns. For the study area, a total of 15 climatic indicators have been identified (Table 3). The actual use of these indicators was classified as: in current use and not in use by farmers.

Another example of the use of TEK was observed on the complex terraces system conserved in the area (Figure 4). In addition, specific agricultural techniques developed or adopted by farmers to improve their crop production rate were recorded. These techniques were: use of organic manure, physical works of soil fertilization, pest and disease control, seed selection, food storage and conservation. Farmers from Charazani considered these practices as the foundation of their life style (Schulte *et al.*, 1998).

Moreover, a decrease in yield led the farmers to complement these practices with the implementation of contemporary techniques, including the intensification of land use and with artificial fertilizers and pesticides, purchase of seeds, and import of new varieties appropriate for altered conditions. Local testimonies point out that the use of contemporary practices has been introduced in the area during the last years as a mechanism of defence to yield reduction. The combination of both practices (traditional and contemporary) represents an important strategy to buffer the impacts of climate change (Table 4). Generally farmers indicated the lack of economic incentives responsible for the shortcomings to effectively prevent or mitigate the effects of climatic variability. Hence, farmers referred to the lack of their own economic capacity to implement new technologies.

3.3 *Assessment of social vulnerability*

Through field observations and literature review three main drivers for social vulnerability were identified: (i) access to economic resources, (ii) loss of traditional knowledge and (iii) social organization policies related to the use of natural resources.

Table 1: *Intensity of extreme weather events (1 = normal, 2 = severe and 3 = extremely severe) that occurred from January to December 2010 in Santa Rosa de Katta, Charazani valley. Grey highlighted sections mark the coherence between extreme weather events and related secondary follow-up incidents (rainfall – landslides, drought – fire).*

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Rainfall	3	3	1						1	1	1	2
Landslides	2	2	1									1
Drought					1	2		1		1		1
Fire						1	1	2				
Frost					1	2	2					
Hailstorm	1	1										

Table 2: *Local perspective of climatic variability including extreme weather events and resulting consequences and its impact on agriculture.*

Climate variability, extreme weather events and consequences	*Impact on Agriculture*
Temperature rise	Water availability decrease Does not allow to maintain the soil moisture
Rainfall intensity	Loss of soil fertility (nutrient leaching) Higher susceptibility to pests
Drought	Lack of natural regeneration of vegetation Reducing the vegetation coverage Reducing soil fertility Crop displacement to other areas Loss of seed production Decrease of land available for cultivation
Hailstorm and Frost	Loss of seed production Loss of production
Landslide	Loss of soil fertility Decrease of land available for cultivation
Fire	Loss of grassland

Fig. 4: *Terraces in Charazani, Bolivia*

Table 3: *Local indicators for climatic patterns based on literature review (SERNAP, 2006; Schulte et al., 1998) and confirmed by local testimonies.*

Indicator/Description	*Meaning*	*Actual use*
Zoo – indicators		
Bird reproductive behavior – location of the eggs	According to the location of the eggs, represents dry or wet year	Not in use
Characteristics of sheep excrement	Determines the amount of rain during the year	Not in use
Crying fox	Identifies the place for next plantation	Not in use
Spider webs	Humidity in the soil	Not in use
Ants fly during cloudy day	Announces the rain	Not in use
Phyto – Indicators		
Salvia officinalis (common name: *salvia*)	High concentration of organic material – indicator of soil quality	In current use
Hipochaeris sonchoides (common name: *pilli pilli*)	Grows in moist soil, not good for potato crop (more vulnerable to worm attack) and very difficult to work on it.	In current use
Irifolium sp. (common name: *layo*)	Grows in areas where the soil has very good quality, ideal for potato	In current use
Prunus persica (common name: *duraznero*)	Flowering patterns indicate time of rainy season	No data
Astronomic		
The arrival of the star Qoto (Inca constellation)	Represents the time to start planting	Not in use
Atmospheric and physics		
Red sunset	Indicates humidity	In current use
Yellow moon	Indicates a lot of rain	In current use
White moon	Rain	In current use
Fog and cloud during June and August	Indicates wet year	In current use
Wind from northeast	Brings the rain	In current use

3.3.1 Access to economic resources

According to local testimonies, the main problem of households today is the reduction in food production for self-consumption and for local markets. Thus, subsistence is endangered and the economic income decreases accordingly. As a result financial resources for additional goods and services are scarce or completely absent. Therefore farmers are constantly looking for different sources of income beyond agriculture such as mining, construction and manufacture (INE, 2004) to create opportunity and access to daily goods like food and medicine.

3.3.2 Losses of traditional knowledge

Charazani valley is well known as one of the most traditional areas in Bolivia, most of the agricultural activities are usually initiated with different ritual practices according to the agricultural calendar and the observation of climatic indicators (Tab. 4). Currently, the practice of rituals and use of climatic indicators is diminishing, which fosters the loss of traditional knowledge. According to PNB (2011), 60 % of the families believe in and still practicing rituals as part of their daily activities, although current religious sects in the area prohibited the pagan practices. Moreover, the young generation has lost the ability to “read” the weather and the affiliated skills to understand the climatic patterns to thereby adapt management practises. For some farmers, the compulsory school attendance for children is the main cause for the loss of traditional knowledge: ”*Our kids are all the time in school and they don’t learn how to work the land*”.

Table 4: *Traditional and contemporary risk management practices to cope with extreme weather events according to local perspective and field observations.*

Extreme events and consequences	*Traditional practice*	*Contemporary practice*
Drought	• Principally the performance of traditional rituals • Conservation of traditional practices for storage the water: Qhutanas system • Rehabilitation of traditional irrigation system • Altering amounts and timing of irrigation	• Implementation of new irrigation systems and mechanism of water storage: pipes, channel dug, siphon, wells, ponds and barrels, and tanks • Water distribution by trucks • Diversification of irrigation system according to ecological zones
Hailstorm and Frost	• Bonfires are set near field or straw is laid over crop • Some farmers deal with unexpected hail and frost by gradually planting their fields, exposing only some plants, rather than the whole field	• Use of alternative seed more resistant to different environmental conditions
Landslide	• Use of natural barriers with native species (*Polylepis* sp.) • Reinforcement of the terrace with stones	• Reforestation of the slopes with exotic species (*Pinus* sp. and *Eucalyptus* sp.) • Live barriers and coronation ditches
Fire	• Communal polices based on traditional knowledge • Forest management (pruning and thinning) and fire trenches	• Regulation and policies from National Park

3.3.3 Social organization and policies related to the use of natural resources

Social interactions and networks like *trueque*, *minka* and *aimi*, play an important role in the daily activities of the communities. On one hand *trueque*, nonmonetary interchange of products between different communities, contributes to the conservation of agrobiodiversity, as well as to the reinforcement of the family economy (Schulte *et al.*, 1998; SERNAP, 2006). *Minca* and *aimi* represent a work system of reciprocity, where families collaborate with each other on agriculture practices, whereas payment is whether by work or monetary (Rist & San Martin, 1991). At the same time, traditional social organization plays an important role in the development of the communities. This social structure comprehends a valuable toehold for governance actions and the implementation of projects and programs in the area. Implementation and development of programs and projects need to be analyzed and approved among all actors starting with local councils (*Consejo local*) and in coordination with the municipality. The budget given by the national government is distributed among the communities according to the number of families and their demands, following an annual development plan (*POA – Plan Operativo Anual*, in Spanish). In recent years most of the budget for Charazani has been designated to natural risk prevention, particularly to pasture management and with technical support and infrastructure for the irrigation systems (PDM, 2004).

3.4 Level of action to cope with climate change vulnerability

Social interaction in the communities plays a fundamental role on the development and adoption of techniques and technologies to cope with climate change vulnerability. An assemblage of strategies developed at household level, community level or by external actors represents the potential for the adaptation to climate change (Table 5).

Table 5: *Compilation of strategies developed at different level: household, community and national level that represent the potential for the adaptation to climate change in the case study of Charazani valley -, Bolivia.*

Problems	*Adaptive measures*		
	Household	*Community*	*External – National*
Water stress		• Rituality	• Meteorological data from SENAMHI
Drought *Hailstorm* *Frost* *Landslide* *Fire*	• Risk management	• Reinforcement of traditional system • Development of irrigation system and waterworks	• National budget for Irrigation system and Risk management • External technical support on irrigation system
Changes in biodiversity	• Use of local indicators	• Traditional management of water, soil and biodiversity	• NGO’s working on conservation and natural resources management
Economic system *Access to Market*	• *Trueque* (interchange of products) • Development and adoption of techniques and technologies in agriculture	• Temporary migration • Diversification of economic system beyond agriculture • Mink’a - Aymi	• NGO’s working on agriculture and livestock
Erosion of traditional knowledge	• Ritual practices	• Social organization based on traditions	• National policies: revalorization of traditional knowledge (Ministry of Land) • New curricula scholar incorporating Traditional Knowledge • NGO’s – working on cultural and education programs

4 Discussion

Experiences described by the respondents and supported by meteorological data revealed that there were changes in climate with negative effects on people’s livelihoods in the research area. Intensification of rainfall periods of drought, frequency of hailstorms and frost were identified as the main climatic threat for Charazany. Consequently intensity and speed of climate change is an unprecedented new challenge, particularly for communities like Charazani where lives and livelihoods of the people depend on local resources in different ecosystems.

This article describes some of the adaptation measures adopted by communities based on traditional ecological knowledge and innovative technologies (or contemporary knowledge). In the first case, throughout history, farmers have responded to climate variability and change by using their traditional ecological knowledge (TEK), guided by their culture and the interaction with the environment (Turner & Clifton, 2009). Schulte *et al.* (1998) highlights the importance of the prediction of climate patterns by rural communities all over the Andean Region. These predictions were made by the observation of climate indicators that defines where and when to start the agricultural practices (Chepstow-Lusty *et al.*, 2009; AGRUCO, 2010).

As it was observed, in Charazani most of these climatic indicators are no longer in use. Two main triggers were identified by farmers for the loss of the efficiency of traditional indicators: (i) changing social conditions, altering the transfer mechanisms of TEK; transfer of TEK form elders to young generation is been interrupted and therefore the young generation does not have the ability to use the indicators to predict the weather patterns, (ii) changing environmental conditions, altering the ecology and characteristics and therefore their potential to fulfil the requirements to function as a climatic indicator; therefore, farmers need more time of observation to find out the changing behaviour of the indicators and their implication in the agricultural cycle. Consequently, the understanding of climatic indicators based on scientific evidence could be claimed as a potential source of resilience (Newsham & Thomas, 2011), because it could contribute to the understanding of environmental changes and to the reinforcing cultural values and traditional practices (Macchi *et al.*, 2008).

One of the most important strategies developed in this area is the use of terraces system. Currently there is an ongoing scientific discussion (Schulte *et al.*, 1998; McDowell & Hess, 2012) about the terraced systems in different ecological zones and the complex rotation system known as "*Aynoqa*" (communal land and shared labour for the agricultural system) as key points for adaptation. Those techniques give the opportunity to host a significant number of native crops and the conservation of their respective varieties *in situ*, (Schulte *et al.*, 1998; Manzaneda, 2008; Cuellar & Medina, 2009), and the conservation of soil quality, moisture and fertility (SERNAP, 2006).

During the last decade (1999–2011), 6 % of the terraces in the area have been abandoned (Chapi, 2011) and the time and space for the rotation system has been shortened due to land division (SERNAP, 2006). These facts could be explained by the lack of labour (due to migration) and available land (due to *minifundio*; division of the land into small farms) in the communities. Hence, alterations in social structures prevent the effective use of potential adaptation mechanisms. In this regard social vulnerability in Charazani could be a response of the growing migration rates, in 1992, 83.02 % of the population in Charazani was dependent on agriculture, but in 2001 the percentage was reduced to 44.71 % (SERNAP, 2006; Chapi, 2011).

Even though temporary migration brings new opportunities and access to economic resources, the absence of a family member has a considerable impact on the social structure of the families and their respective role in agricultural activities. In particular the decline in male farming labour had a negative impact on the maintenance of water system and terraces; both require a large labour force. It was observed that many of the traditional irrigation channels have been abandoned because most of the men from the community worked off farm and outside their respective communities.

The intervention of NGO's plays a fundamental role in the development of the area around Charazani. During the last ten years around 13 NGO's implemented projects in different areas of the municipality, whereas projects in highland communities were more related to irrigation systems, pasture and biodiversity management. In lower valley communities the main focus was on technical support, on the production of traditional medicine and agriculture practices (SERNAP, 2006). Nevertheless, not all families benefited to the same extent due to the dependence, of project participation and involvement - but ultimately due to the specific context of the projects.

Furthermore, at national level there is a complex policy framework that aims to reduce yield losses induced by natural risks. On behalf of the National Constitution of Bolivia, the Ministry of Rural Development and Land is promoting by law the revalorization and validation of ancestral knowledge that should be considered in the process of "Risk Management Planning". Additionally the current governmental strategy aims to support and reinforce traditional knowledge as a mechanism for adaptation to climate change. According to the analysis of adaptation on climate change progress (Flores *et al.*, 2011), Bolivia is developing the necessary institutions and the needed capacities to achieve this issue. The National Program on Climate Change is focussing on the implementation of programs on education, human security, research, risk management, mitigation and adaptation, strategy alliance and food security as well as the development of programs and small projects along the Andean region. Although the implementation of adaptive strategies and diffusion of the information was limited, the amount of research has increased enormously in the last years (Espinosa & Becerra, 2008).

Erosion of traditional knowledge is considered by farmers as a threat against adaptation. Hence, it will be important to reinforce the education programs, based on climatic indicators research and traditional practices. Although traditional ecological knowledge systems have been neglected in climate change policy making for quite some time, now it is recognized and valued within the climate change discourse (Salick & Byg, 2007). In accordance to this, consultative and collaborative processes and research methods that respect both academic and indigenous ways of knowing are tremendously important in this regard (Turner & Clifton, 2009).

5 Conclusions

This article describes the challenges that rural Andean families are facing in terms of climate change, particularly due to the occurrence of extreme weather events, like rainfall, droughts, hailstorm and frost in Charazani, and how these events affect directly in the agriculture and life style of people. Yet farmers are facing new challenges to keep their production rates. Currently the combination of traditional ecological knowledge with new practices or "contemporary practices" represents a large array of opportunities of opportunities for adaptation. Nevertheless, due to social stressors and the lack of economic resources the overall capacity to mitigate the impact of climate variability is still low.

In the Andes, the efforts that communities are taking to adapt are focused mainly at agroecosystem level, because agriculture becomes particularly important in providing food security by a sustainable management of the natural resources (Boag *et al.*, 1994). Most of the adaptation measures have their roots in traditional ecological knowledge (TEK) and have been used to survive over long periods of time. They stand up to a variety of environmental and social changes (Schulte *et al.*, 1998), therefore it is important to document this knowledge and encourage future scientific research on this regard, recognizing the value of TEK.

In terms of social vulnerability, the integration of social networks brings new opportunities to the communities to widen the range of options to adapt to climate change. The implementation of policies and projects on adaptation to climate change is growing day by day. Generally, these actions have a new focus: watershed management, territorial planning, restoration of the vegetation, soil erosion reduction, conservation of biodiversity, management of pastures and livestock, among others. The urgency and the magnitude of the expected impact of climate change have given a new perspective of actions and its integration within local communities (Halloy *et al.*, 2010; Campos, 2009).

The understanding of adaptation to climate change and its impact on socio-environmental systems facilitate opportunities to improve the livelihoods in communities of the Andean region of Bolivia. Nevertheless, adaptation cannot proceed without an understanding what climate change means in a particular location (Ensor, 2009). Several strategies have to be taken into account to build adaptive capacities in the communities. Still the current target is to improve existing livelihoods and reducing their vulnerability in the long term and being able to reach this goal in a comparable short amount of time.

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