**Session title:** Does Gender Matter in Climate Change Adaptation: Evidence from Africa, Latin America and Asia

## Climate change, global drivers and local decision makers in rural communities: the role of translational research, and adaptation strategies that contribute to resilience[1]

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### Abstract

People in rural communities negotiate the effects of a changing climate, of markets and other events that affect their livelihoods. These contexts are often uncertain and risky, and the decision makers are vulnerable. This presentation shares experiences with rural communities in the Andes, and in Kenya, using a similar framework, to create information that is relevant to local decision makers, through a process that builds trust, by connecting local and scientific knowledge. One experience focuses on translational research for information on innovations, while the second focuses on community processes to understand sources of vulnerability and potential practices that contribute to adaptation and resilience. Participatory research approaches aim to build human, social and political capitals while producing salient information for local decision makers. These cases used techniques that acknowledge potential gender, ethnicity, life cycle, and vulnerability status. The cases are set up to compare outcomes across landscapes shaped by agroecological conditions, markets, and policies.

[1] This paper is based on three experiences, one from the Andes on Bolivia on climate change, a second from Peru's Altiplano, and the third from Kenya on translational research process. Do not cite this manuscript. The first is captured in *Adapting to Change: Institutions and Processes in Linking Knowledge Systems for Action*, a paper presented at the *2nd UNITAR-Yale Conference on Environmental Governance and Democracy: Strengthening Institutions to Address Climate Change and Advance a Green Economy*. Panel "Governance of Climate Change Adaptation", Sept 17-19, 2010, Yale University, New Haven Connecticut. The second is from an article Valdivia, C., J. Gilles, and C. Turin. 2013. Andean Pastoral Women in a Changing World: Challenges and Opportunities. *Rangelands.* 35(6): 75-81.The second is an earlier version of a paper recently published, *Using translational research to enhance farmers' voice: a case study of the potential introduction of GM cassava in Kenya's coast***,** by Corinne Valdivia, Kengo Danda, Dekha Sheikh, Harvey James, Violet Gathaara, Festus Mureithi, and William Folk published in Ag and Human Values. **PLEASE email Valdiviac@missouri.edu for latest version in order to cite.**

## Introduction

Negotiating climate, markets and the interactions of human action and the environment are all key to adapting to change in rural communities, such as the Andes of Bolivia and Peru, or those in the Coast and Eastern in Kenya. Often innovations and/or institutions and policies are at the center of strategies developed to improve the ability of decision makers to adapt and thrive in these changing contexts. Eleven rural communities in Bolivia and Peru have worked with researchers to understand these changes, and their effect on livelihoods and their landscapes. A framework of multiple scales, governance and institutions, informed the process. Interdisciplinary research and participatory approaches to link knowledge systems -local and new- for action were undertaken through two distinct forms of collaboration. Many farmers from rural communities in the Coast and Eastern province in Kenya shared with researchers their experiences with shock events, the impacts on their livelihoods and production systems, and their knowledge of innovations in cassava varieties, in order to figure out in which ways genetically modified technologies could contribute to their adaptation. All these experiences have in common placing decision makers at the center of the construction of knowledge, and scientists and other decision makers as collaborators, in a process to identify knowledge and institutions that contribute to building sustainable livelihoods. Lessons are learned in terms of developing meaningful knowledge and the institutions and networks that can support adapting to new contexts and sustainability. We find that approaches have inherent biases that must be taken into account when building knowledge linkages. The implications of these experiences for institution building for adaptation are discussed.

## Climate Change and Vulnerability

Globalization, climate variability and climate change are increasing food insecurity in Tropical regions (Lobell et at, 2008), where agriculture often does not have functioning institutions to protect against risk—especially in rainfed production systems. Climate change is a driver, as are other global changes that impact the livelihoods of rural populations that depend on agriculture for their livelihoods and food security in developing countries.  To understand how adaptation to climate change takes place, it is necessary to learn how risk, uncertainty, vulnerability, institutions and path dependency interact with the changing climate context and what this means for the decision maker. Changes in climate include changes in mean temperatures and precipitation, shifts in rainfall patterns, increases in extreme events, and environmental conditions that affect pests and diseases, access to water. As farmers strive to participate in the larger economy and seek to increase their wellbeing, factors affecting decisions in rural regions of developing countries include concerns with food security and market signals.

Sustainable Livelihoods (Conway and Chambers, 1992), sustainable development in the 21$^{st}$ century, proposed a framework that has contributed to interdisciplinary research focused on wellbeing of people and the environment.  Peasant household economics and intra-household economics nuanced decision making by introducing multiple goals, multiple decision makers, bargaining power, and provided tradeoffs analysis opportunities, for example between markets and consumption, production and health, and trade and nutrition.  This directly contributed to how we conceptualize sustainable livelihoods as households with assets (tangible and intangible) that can be accessed to invest in activities that define the household portfolio, and to look at outcomes as wellbeing and vulnerability, informed by consumption smoothing, income smoothing, and asset smoothing. Social capital becomes an intangible asset in coping as well as accessing markets and technologies. Transaction costs, fixed and proportional, inform of what facilitates access, introducing new capitals in the analysis of market participation. Access to this information another important factor (Valdivia et al 2003).  The types of networks, the nature of social capital, may act as a bridge to new possibilities or limit access to information.

Institutions matter (North, 1993) in access and control.  These institutions are a factor in the costs of transacting.  Path dependence shaped by culture, history, geography, and policies (Ruttan and Hayami, North) -the diversity of contexts in which farming decisions are made- shape them. At larger scales, global, regional and watershed models have been developed to understand the effect of changes and tradeoffs. From decision-making models to complex socio-ecological systems there is need to understand the thresholds (Liu et al 2007), feedback loops (Ostrom), as these will differ and matter at the local level.

*Adaptation* to climate means adjusting practices or processes by using capitals in response to current or future climate change (Howden et al, 2007). This can be facilitated by participatory research to study options that may help agricultural decision makers understand the advantages of taking action now (Valdivia et al 2010; Valdivia Gilles and Garcia 2010). Adaptation will be required in all sectors including marketing and supply (Antle and Capalbo 2010). The adaptation and mitigation framework proposed by Jarvis et al (2011) is multipronged, including management of risk in the short term, climate risk management that can lead to long term adaptation, exploit mitigation policies that contribute to adaptation while not compromising food security or economic development, and assess benefits and tradeoffs between likely adaptation and mitigation actions, evaluating interventions holistically. They, as many in the climate community, call for more effective communication with end users for adaptive capacity, using global models, coupled with effective communication strategies. Another call is for better verification tools in mitigation actions that contribute to adaptation. Others question the effort placed on verification on one end and not on measuring how the vulnerable are benefiting (Jeneck and Olsson). There is need for support of smallholder farmers who may not be able to affront the upfront costs of project development; a call for improvement in interactions between scientists and decision makers at all levels of society as other have in recent articles about knowledge to action (Reid et al.; Kristjanson et al; Valdivia, Gilles and Garcia); and a call for communication and exchange with local or traditional knowledge. There is need to place decision makers at the center; a focus on understanding the information needs of stakeholders, actionable knowledge. Four constraints to behavioral change in the context of climate change adaptation: *uncertainty of outcomes of different decisions; cognitive problems and* *differing perceptions of vulnerability or risk; lack of compelling motive or incentives; and lack of capacity*.

**Uncertainty and decision making**

Studies on risk and uncertainty informed by psychology, seek to explain the difference between the optimal and the observed. Uncertainty is a central issue as the projections of extreme events in climate change show shifts in the probability density functions. Two forms of knowledge are experiential and rules based (Slovic and Weber 2002). Distinguishing this is critical because in situations of lack of control or high feelings of dread, decision makers are more likely to resort to their experiential learning. Two-way communication facilitated by participatory processes, and networks of access are elements of a strategy to develop adaptive capacities in vulnerable regions, such as Africa and Mountain regions like the Andes.

The severity and diversity of potential impacts of climate change calls for a focus on strengthening local capacities. Institutional policies that strengthen local capacities and facilitate access to information and provide safety nets considered no regret short -term actions in support of adaptation (Jarvis et al 2011). While crop insurance has been a mechanism to protect farmers in developed economies where the share of the agricultural sector in the economy is small, it is still being studied in vulnerable regions of developing countries. Certainly experiments continue in this area as a mechanism to avoid loss during extremes conditions (Garrett et al, 2012). Jarvis et al (2011, p. 190) maintain that “food systems naturally evolve and adapt…” however, “accelerated adaptation requires larger, structural changes.” While no-regret strategies are key in the context of food insecure farmers, some argue that … ‘The unprecedented speed and extremity of predicted changes will require tough *decision-making, preparatory policies and enabling incentives — employed in an environment of uncertainty and trade-offs.*’ (Jarvis et al, 2011, p. 186 cited in Garrett et al 2012).

The insights into the human dimension of IPM modeling in the uncertainty of climate change, which highlight the need to involve decision makers, transdisciplinary and translational research will play key roles in making any model successful (Valdivia et al, 2010). Translational research addresses the social and human dimensions of laboratory science developments to take the developments of science to appropriate individuals and groups (Woolf 2008).

Behavioral models of decision-making at the farm level for the context of fragile environments are not yet well developed (Hertel and Rosch, 2010). The study of risk assessment, perceptions, communication, and management, developed in response to challenges presented by increasingly technologically-oriented societies (Covello, 1983; Kates and Kasperson, 1983; Slovic, 1987), has provided insight into how people make decisions under risk and uncertainty. Risk perception rather than actual risk is relevant to decision-making (Garrett et al., 2012; Gent et al., 2011; McRoberts et al., 2011; Slovic and Weber, 2002). Farmers base their crop and livestock decisions on local knowledge systems, resulting from years of observations, experiences, and experiments (Bharara and Seeland, 1994; Gilles and Valdivia, 2009; Marx et al., 2007). For example, in Argentina, farmers faced with uncertainty and risk of La Niña were able to handle at most one adaptation decision (Hansen et al., 2004).

There is great diversity in the presentation of events at the local level, and often not enough information available. For example, there is spatial and temporal correlation resulting from potential pest and disease spread means that decisions made by some parties will influence pest and disease problems experienced by other parties.

The degree of dread, fearfulness or gut feeling of angst in response to hazards such as pests and diseases (Valdivia Jimenez and Romero 2007) is an important factor in terms of decisions and outcomes (Garrett et al 2012). Because people assess risks using rules based systems and association/experiential based systems (Marx et al., 2007; Slovic and Weber, 2002; Valdivia et al 2010), when the results of both conflict, people will tend to rely on the associational since past experiences are often more memorable and dominant (Slovic et al., 2002). This is specially the case when the dread of an event is high. Marx et al. (2007) discuss how decision makers use different types of information. There is a tendency to weight recent experience. If rare events have not occurred recently, they are given less weight; on the other hand people may overreact to recent rare events. This response may be adaptive if the system is changing in a directed manner. People tend to respond to vivid events rather than to statistical information; and they also tend to assume that the future will be similar to what they have experienced so far. Several years ago Mumford and Norton (1984) called for obtaining information early on about farmers' perceptions, the constraints they face and their objectives, especially for the development of pest control research and extension. These recommendations are relevant to all research conducted with farmers in a climate change adaptation context (Garrett et al 2012; Kristjanson et al, 2009; Reid et al 2009; Valdivia et al 2010).

Participatory approaches are especially effective when the degree of vulnerability of the decision maker is high, which is often the case when market fail and there are no safety nets. Strategies that build knowledge to anticipate and plan, as well as strengthen the capacity of rural communities to effect change, are key in building resilience and adaptive capacity, at local and larger scales (Valdivia et al 2010; O'Brien et al 2008).

Research on the type of information trusted by decision makers in rural regions of the developing world has shown that it must be relevant (salient), in the language of the decision maker, in their decision context and from a trusted source. Efforts should include: 1.targeted measures to increase resilience; 2) institutional policies to support adaptation strategies and practice; 3) insurance mechanisms or institutional change that insures against risks; 4) innovations in agriculture that increase resilience/reduce existing losses; and 5) building the capacity to learn, educate and advise through multiple forms of institutions.

**Institutions Scales and Local Context**

Many people equate the term institutions with organizations. Institutions are broader than organizations, and essentially define the 'rules of the game'. Institutions include formal organizations and contracts as well as informal social and cultural norms and conventions that operate within and between organizations (North 1990; Ostrom 2005).

Can information improve adaptive capacity? Researchers have found institutional, economic, and political constraints to the use of climate forecasts (Agrawala et al 2002; Eakin 2000). Better forecast information alone may not address vulnerability. Often those who benefit are those best placed to take advantage of knowledge, and not necessarily the most vulnerable (Adger 2006). Information with alternatives provided to vulnerable farmers allows them to adjust (Valdivia et al 2003; Patt Suarez and Gwata 2005). Meinke et al (2006) caution about the risk of over reliance on quantitative approaches that lead to focusing inquiry on easy to measure factors is especially relevant in this context. Reality is simplified with computer models decisions (Bergez et al. 2010), calling for participatory approaches to analyze findings with decision makers. The climate is changing and managers need to adapt (Howden et al. 2007). While climate change is a problem that no single nation can address on its own (Lemos and Agrawal 2006; Ostrom 2009), local efforts are often problematic due in part to its framing as a global issue (Ostrom 2009). Climate change, socially framed as a global environmental pollution problem, historically has had a top down approach in adaptation and mitigation (van Aalst et al. 2008). This framing places responsibility on regional, national and international leaders to act, but in turn removes authority and emphasis from the local level (Ostrom 2009). However, the most effective approach may start at the most local level (Lemos and Agrawal 2006; Ostrom 2009a), with an approach where government and citizens from local upward view the problem as legitimate (Ostrom 2009a). Ostrom argues for the need to act at multiple scales and where local is key. She reminds us that there are no optimal solutions. Central to collective action: trust and reciprocity. A polycentric approach encourages experimental efforts at multiple levels. A socioecological systems framework frames the scales that are relevant, allowing to understand how drivers interact at different scales (Valdivia et al. 2007), and identify the stakeholders.

The research experiences reported here are part of multi and inter disciplinary research projects framed by the conceptual models developed in Valdivia et al., (2007) and Valdivia et al (2014). To deal with climate and market changes or adopt innovations a multi-scale and governance levels (Ostrom, 2007) approach was developed, from the field to the watershed and regional scale, and from household to community decision-making levels. This paper emphasizes agency, which we define as the ability to act - the hinge articulating livelihoods with structures (de Haan, 2000; Valdivia and Gilles, 2001; Valdivia 2004). It examines different approaches to capacity development - participatory research, research interest groups, socializacion and advocacy coalition, and translational research processes - to strengthen local social and human capitals. Processes such as sharing knowledge about markets and climate through protocols that require participants to identify what needs to be done to address barriers, in themselves lead to a change in attitudes (Sperling et al, 2008). Monitoring of these activities allowed us to gather data to understand which institutions are more effective in development and adoption of new knowledge, and which are those that are more effective in developing adaptive capacity. Our activities included collaborative approaches in themes that concern climate change and adaptation in rural areas with our research partners, policymakers, and development practitioners (soils, pests, crops, markets), and innovations to address agricultural constraints.

Flora et al introduced the concept of advocacy coalitions as a purposeful process to develop the social and political capitals of rural communities. Reid et al. (2009) introduced the new model of boundary spanning across level and scale --- philosophy and practice of *boundary spanning* at nested individual (agent), team, and organizational levels to create strong back and forth connection among scientist policy makers and communities. Kristjanson et al. (2009) consider boundary spanning, access and trust, and brokering that spans the boundaries between partners, and the importance of the role of boundary spanning individuals. Their cases pointed to the need to use *rigorous processes, tried and tested tools, expertise in facilitating stakeholder engagement, building teams and establishing ways to measure and* *communicate impacts and outcomes* (p.5050). Others have used stakeholder platforms, organized strategically to ensure that connections are built between rural communities and decision makers at higher political scales in order to create pathways for information flow that enable local decision makers to act.

Committing to co-learning and co-producing hybrid knowledge (also referred by others as linking scientific and indigenous or local knowledge). Other elements include improving stakeholder engagement, and manage power asymmetries (for example the scientists) by including local indigenous knowledge. We argue that there is a basic need to do this, not just to address power, but because in the context of climate change this is necessary to build local adaptive capacity. How best to build capacity in different systems? By selection of multiple strategic sites to ensure the knowledge can be shared more broadly; and by translational research processes that build this local capacity.

**The Case of the Andes and Strengthening Institutions (Valdivia Gilles and García; Valdivia et al 2010)**

Efforts emphasize the use of science and information to support adaptation around the world. We argue that science is a necessary condition, but in order for knowledge to lead to action by decision makers, there is also need for institutions and processes designed for vulnerable contexts. We further find that interdisciplinary approaches that engage local decision makers in problem definition and the research process, and include relevant stakeholders at multiple scales facilitate the knowledge and action of vulnerable populations facing climate change. Our discipline plays a key role in problem definition, understanding the factors that facilitate or preclude market participation and negotiation, the feedback loops across multiple scales of socio-ecological systems that result from global/international and national drivers. The drivers include markets and transaction costs, and how institutions may facilitate or preclude adaptation in a changing context driven by climate and global changes.

Strengthening institutions to address climate change entails an understanding the institutional structures, decision-making processes, and the context in which the interplay takes place. Strengthening institutions for decision-making assumes that the knowledge to address climate change exists. There are two types of governance issues, the first is the creation of meaningful knowledge, and the second is in creating the capacity to act. The focus on governance assumes that the process of creating useable knowledge has already been resolved. But this is not the case in mountain regions, where geographic variability means that the scale of the information matters; where data is scarce due to the lack of weather stations; where the institutions are diverse; and where reliable knowledge does not exist. Therefore, the focus of this article is on strengthening the institutions to create this knowledge in order to act.

The Andean region of South America is very diverse, spanning multiple countries, cultures, and governments. It is in the mountains that climate change is felt more. While glacier melting is the most visible, the warming trends experienced in the recent decades have significant impacts on the ecosystems and livelihoods of rural communities, who depend on farming for their food security. Systems that are resilient can either absorb shocks, or contain the elements to reorganize in order to adapt to change without undermining their survival in the long run (Forbes et al, 2001). Vulnerable human and biological systems either lack or are losing the ability to handle these shocks. This case study takes into account the complexity of the Andes. Three regions of the Altiplano, the north and central of Bolivia, and the south of Peru are the focus of this case study. An approach to link knowledge systems and develop adaptive capacity was implemented from 2006 to 2009.

Climate patterns and the high elevation of the Andes (Vuille, 1999; Garreaud and Aceituno, 2001) have always made agriculture in the region vulnerable to frosts, hail, droughts and floods (García et al, 2007). Even in “normal” years (50% dependable precipitation) there is large probability that crops will suffer from dry spells (García et al., 2007). Existing climate models predict that in the future there will be longer dry seasons and more frequent storm events (Robledo et al, 2004). Recent studies of climate variability and change point to significant increases in temperature, change in the rainfall patterns, and changes in the occurrence of extreme events (Seth et al, 2010; Thibeault et al, 2010). Farmers in the region have also observed these changes (PNCC, 2005; Valdivia et al 2010). Along with climate, migration and the growth of a market economy have made it more difficult to maintain traditional practices that buffered against the climate stresses and shocks (Zimmerer,1993). This included rotation and long periods of fallow, as well as the use of organic fertilizers, and labor-intensive cultural practices to protect crops like potatoes. Agro-ecosystems are becoming less diverse and more vulnerable to shocks. The number of crops grown has declined as well as the number of varieties grown within farming communities, while losses due to drought, frost, disease and pests have increased.

Networks that communicate forecast information in the Altiplano are local and do not utilize scientific forecasts (Valdivia et al 2003; Gilles and Valdivia 2009), while the networks that communicate scientific forecasts do not include farmers (Sperling et al 2008; Gilles and Valdivia 2009; Valdivia et al 2010). There is lack of capacity to use scientific knowledge to develop plans, so the work in the Andes focuses on both, developing knowledge together, and assessing the types of institutional setups that were more inclusive of vulnerable decision makers, creating the capacity to act.

The case study revolves around the understanding of vulnerability to climate, farmers' perceptions, and the process of linking knowledge systems. In our conclusions we speculate about the other steps in linking knowledge to action create the political capital for action.

**Climate Change Soils and Institutions in Adaptation in the Andes** Adapting to change in the Andes was the focus of a collaborative group of researchers, farmers, and practitioners from many organizations in the Andes and the US. Farmers in the Andes rely on local knowledge and institutions to address uncertainty and risks, which have proven to work for centuries (Gilles and Valdivia, 2009, Valdivia et al 2003; Orlove et al.). Altiplano landscapes are characterized by a high degree of variation, which makes negotiating uncertainty at local level a key issue for adaptation. The impacts of climate variability on farming systems in the Altiplano are well documented (Sperling et al 2008; Valdivia, 2004; Valdivia et al 2003; Coppock and Valdivia 2001). Farmers face recurrent droughts, floods and frosts, but climate change is presenting new challenges that reduce crop production such as increased pressure from pests and plant disease and shifts in the onset and intensity of rains (Valdivia et al 2010). The premise of the research case presented here is that participatory processes that link local and scientific knowledge systems are critical to building the capacity to adapt to change in the Andes. Selection of the 11 sites in this SANREM project, represented various agroecological sites and market integration state. The climate and risk findings are derived from a synthesis article by Valdivia, Thibeault, Gilles, Garcia, and Seth. Results on institutions and participatory research presented here are part of a manuscript by Valdivia Gilles and Garcia (2010).

Negotiating climate, markets and the interactions of human action and the environment are all key to adapting to change in rural communities of the Andes. Eight rural communities in Bolivia have worked with researchers to understand these changes, and their effect on livelihoods and their landscapes. A framework of multiple scales, governance and institutions, informed the process. Interdisciplinary research and participatory approaches to link knowledge systems -local and new- for action were undertaken through two distinct forms of collaboration. The efforts described here are designed to enhance the ability of low income producers to act to adapt to changing conditions. This capacity to act (agency) requires that first that a problem can be identified and in a way that there are meaningful solutions. Our approach is one that focuses on the linking of scientific and local knowledge systems. Following Kloppenberg (1991) and Fortmann (2008), we start with the assumption that local/practitioner knowledge and scientific knowledge systems are distinct but complementary ways of understanding reality. While both are empirically based, the former is contextualized knowledge while the latter attempts to ignore (control for) the influence of context. We see our job as to build bridges between scientific and local knowledge systems. Our primary tool for doing this is participatory research. By building bridges between the two systems we can enhance the adaptive capacity of farmers. The research includes a self assessment of the two experiences of participatory research using different institutions—in one case indigenous communities and in the other case producer organizations. Each approach has inherent biases that must be taken into account when building knowledge linkages. The implications of this experience for institution building for adaptation were also part of the research process.

**Soil Moisture Projections for the Altiplano with** A2 scenario (Thibeault, 2010), showed that soil moisture starts to decrease throughout the annual cycle by 2020-2049, though some models project an increase during the rainy season. By the end of the century, 2070-2099, there is good agreement among the models that soil moisture reductions will increase throughout the annual cycle, even in the peak rainy season. Multi-model time series of seasonal soil moisture show reductions in spring (OND) throughout the 21st century, consistent with projections for lower rainfall and higher temperatures (Seth et al., 2010; Thibeault et al., 2010). Lower summertime (JFM) soil moisture is expected from mid-century onward. Higher precipitation intensity is likely to lead to an increased runoff ratio as rainfall rates exceed the infiltration capacity of the soil. Increased evapotranspiration from higher temperatures will further reduce Altiplano soil moisture. With the exception of frost days, projected trends in climate extremes share the same sign as observed trends at Patacamaya and La Paz/El Alto. The combination of higher temperatures, changes in precipitation timing and intensity, and soil moisture reductions are likely to increase the climate-related risks to rural agriculture in the Altiplano as greenhouse warming progresses.

**Perceptions of risks and shocks** To understand the relationship of the production systems, geography and climate impacts on the livelihoods of farmers, a household survey was conducted. Data about the impacts of climate on farming and about hazard threat perceptions in 2006 covered a 200 km transect, and included five landscapes, three in a watershed in the North Altiplano region, and two in the Central Altiplano region. The watershed lowlands in the North are on the shores of Lake Titicaca at 3,815masl; the mid elevation landscape is 12km up the watershed; and the high elevation landscape, more pastoral than cropping, is 20km from the Lake. The Central Altiplano landscapes are in two different agroecological zones, the flat low lands where dairy production has developed, and the highlands where cropping takes place mostly with animal plow. Analysis of the data using cluster analysis identified groups at different stages in the life cycle (p-value < .05), with differences in income levels and importance of farming and non farming activities between and within regions. Education levels are higher among those in the early stages of the life cycle, and income is highest in the productive groups. The Central Altiplano region has higher income levels, and the share from farming is higher.

The perceived risks – the threat each hazard presents to their livelihood- and the impacts of hazards on crops and animals differed in intensity by landscape and region. In most landscapes hazards were a very strong threat. Perceived frost, floods and hail hazards were high in the Central Altiplano. Hail hazards were mostly felt in the higher elevation landscape of this region. Concerns in the North were especially high about the changing climate, loss of soil fertility, and becoming unemployed, consistent with the overall low income, and greater importance of off-farm income (migration). Production shocks related to pests were particularly prevalent and perceived as a high threat in both regions, consistent with increased warming trends. Perceptions of flood hazards were high in the low lands of the North Altiplano, near Lake Titicaca. In the mid and high elevations perceptions of environmental (soils) and social threats were high, localities with less income, education, and land. High perceptions of risk coupled with low levels of income mean that farmers weigh the present more than the future in their livelihood decisions.

**Uncertainty and decisions** Altiplano farmers will likely rely on traditional knowledge when it conflicts with probabilistic forecasts (Valdivia et al., 2010) due to the context of uncertainty they face, which suggest that two-way participatory communication may enhance local knowledge by providing salient knowledge to the decision-makers (Slovic and Weber 2002). This process is more likely to create common expectations and language that can be used to discuss alternative strategies. Farmers can listen to the forecasters, make their own observations and derive lessons beyond the conclusions made by researchers. The participatory research is a mechanism for linking knowledge systems, identifying barriers and courses of action. In order to enhance adaptation to climate change in the Altiplano the knowledge systems of meteorologists and those of indigenous farmers need to be linked.

The forecast community must meet many challenges in order to bring this to pass. The first challenge is the farmer's lack access to useful meteorological data that has both technical and socio-economic dimensions. As indicated before the Altiplano is characterized by a myriad of microclimates. Where such cases, the production of locally useful meteorological forecasts requires a high density of weather stations. However, the Altiplano region is characterized by a low density of stations, exacerbated by the fact that few stations have the quality of data needed to identify trends. There were only 14 stations in the Altiplano with 35 years or more of quality data and only two stations with data to model extreme events in a region with an area of approximately 240,000 square kilometers (Valdivia et al., 2010). Downscaling of the global models is also a challenge in this context. The scale of existing models is too large to be translatable to the local level. In addition projections from climate models focus on average changes in temperature and precipitation, and changes in extreme event frequencies. Farmer decisions must be based on estimates of rainfall distribution and extreme events within the cropping year. There is a lack of knowledge about climate trends that inhibits the creation of adaptation strategies. In addition, farmers do not trust forecasts generated outside of their immediate area (Gilles and Valdivia, 2009; Valdivia et al 2003). Second, demographic changes are reducing the adaptive capacity of traditional production systems. Increased population has led to the division of land into ever smaller farms and shorter fallow periods (Valdivia et al 2007). Traditionally Altiplano farmers minimized weather related risks by planting crops in a variety of micro-environments, no longer possible with present farm sizes. Population pressures have led farmers to migrate seasonally creating labor shortages that restrict the number of adaptive alternatives as well.

**A participatory strategy for linking knowledge systems** Because of the challenges described above, neither scientific forecasts nor local knowledge can by themselves guide smallholder adaptation to climate change. However, a participatory process involving forecasters and producers could do so. Identifying adaptive strategies is a lengthy process, so the first step is to secure the commitment of participating communities. Once that is obtained, a series of meetings between the team and producers are carried out where producers can express their concerns about climate change and risk, and discuss how they deal with these concerns. At the same time, forecasters present their estimates of change and their observation of trends to the communities in order to help producers begin to think about adaptation strategies**.** During this process, care is taken to involve men and women of all ages and resource levels, because viability of adaptive strategies depend on the characteristics and resource endowments of producers as well physical and biological constraints. Following this step, efforts are made to correlate forecast data from national weather services by installing weather stations in communities to help farmers in specific micro-climates. In addition, discussions about adaptation strategies continues and local experiments with possible adaptive strategies are carried out together. The process facilitates a common language, as well as knowledge of each other addressing issues of trust. The two-way process builds the knowledge networks (which may be social and political) that enable agency or ability to act. These knowledge networks include government agencies and non-governmental organizations that can provide technical assistance and resources to assist in adaptation. This process is farmer driven but expert assisted, in order to provide the flexibility needed to find appropriate strategies for different microclimates and resource endowments.

The Altiplano is diverse in social and ecological conditions. Changes in climate trends along with climate change projections underscore the need for approaches that can develop capacities and knowledge for adaptation. The most vulnerable families also express the highest concerns with climate and other hazards, because of the difficulties to cope with the consequences of the hazards. Two knowledge gaps inhibit the development of adaptive capacity in the Altiplano. Filling these gaps should be a priority. The first is that current adaptive strategies have not been evaluated scientifically, and there is a need to monitor these long-term with farmers. The second is the lack of a link between farmers and national weather services. Participatory research and collaboration between farmers and the climate community can contribute to build the human, social and political capitals to support a network that focuses on the process of developing knowledge for adaptation. Adaptive capacity in this context will entail connecting institutions, building networks, and negotiating local and new knowledge to deal with uncertainty and inform on strategies that build capacity to adapt. It will also entail addressing asymmetries in market negotiation and access to public institutions. For example, the research on soils resulted in identifying amendment practices that contribute to carbon sequestration and capture humidity, but barriers to adoption are access to labor in families where adult members migrate seasonally (often the most vulnerable) and access to inputs (Valdivia Gilles and Garcia 2010). The carbon sequestration services provided could benefit from mitigation programs like payments for environmental services, but this is not yet possible in these communities. Market access institutions created to address market constraints have still high transaction costs for vulnerable farmers, who don't participate in the participatory markets chain platforms (Figueroa and Valdivia).

While local perceptions of the climate trends were similar to observed trends in the last fifty years (Seth et al., 2010), there were also key differences. Perceptions of the reasons for decrease in rainfall were actually related to faster evapotranspiration due to increased temperatures as well as shifts in the timing of rainfall, and not reduction in total rainfall as farmers believed. Farmers in fragile environments where there is spatial and temporal variability, such as mountainous regions, may have little confidence in forecast information generated outside of their community or neighborhood (Gilles and Valdivia, 2009; Valdivia et al 2003).

**Development of Adaptive Capacities** is essential to enable local communities to adapt to change due to the magnitude of the issue and to the fact that context matters. Collaborative research that is interdisciplinary and engages relevant decision makers, at multiple scales, such as farmers, communities, practitioners in government and NGOs, scientists and students, and policy makers and private sector relevant to the inputs outputs or outcomes – boundary spanning organizations. Knowledge to Action under Uncertainty requires – climate change scenarios highlight shifts in the probability distributions of events, and therefore what we know may not be enough or may lead to wrong decisions. Understanding the decision making process and its effects on outcomes that can inform ex-ante, and building the trust, and knowledge that is relevant, in the context and language of the decision maker will contribute to increasing the likelihood of use for decisions. This entails linking existing local knowledge with new through processes that address power asymmetries.

Several factors were considered in the selection of Altiplano ecosystem sites. The first set included physical characteristics such as altitude, rainfall, and temperature. The second dealt with relationship to markets to capture differences in the role of markets and policies in shaping livelihood strategies. All sites chosen shared the same culture and ethnicity.

Comparisons included access to and participation in markets, effects of climate trends in short-term strategies, and approaches to collaborative research between communities and organizations with differing principles of collaboration. Collaboration revolved around volunteer farmer groups in the Central Altiplano of Bolivia and community organizations in the Northern Altiplano of Bolivia and Southern Altiplano of Peru. While groups in Bolivia contributed to new research activities in soils, pests, biodiversity, and climate, in Peru the focus was on approaches that increase social and political capitals. Peru introduced knowledge already developed through co-learning and coalition building approaches.

***Process: Linking Knowledge Systems and Institutions*** Can information improve adaptive capacity**?** Researchers have found institutional, economic, and political constraints to the use of climate forecasts (Agrawala et al 2002; Eakin 2000). Better forecast information alone may not address vulnerability. Often those who benefit are those best placed to take advantage of knowledge, and not necessarily the most vulnerable (Adger 2006). Information with alternatives provided to vulnerable farmers allows them to adjust (Valdivia et al 2003; Patt Suarez and Gwata 2005). In this case participatory approaches that incorporate the knowledge of trends, projections of climate change with implications for the Altiplano agriculture, and the local knowledge of forecasts, and the participatory research activities are all element in developing adaptive capacity, introducing a process that anticipates events, an early warning system through participatory process improve the ability to prepare for these events.

Linking knowledge in this problem driven research took place at various scales, and various knowledge systems, from the disciplinary, interdisciplinary research and local knowledge through participatory processes. Knowledge, to be useful, needs to be in the context of the decision maker, which meant that the project included the effects of climate on the production system, and other factors affecting it, the interactions. In the next paragraphs, examples of how we proceeded with climate, its effects on production (crops, pests and soils), and on livelihoods, and in turn the role of markets on livelihoods and what these mean for climate resilience are presented.

Participation as a process seeks to empower those who powerless to make decisions (Hayward 2004). Contradictory results are often a consequence of not differentiating between passive participation (when the purpose is consultation) and active participation (a collaboration or partnership) (Hayward et al., 2004). Organizational structures, cultures and differing goals are often constraints in participatory research. Scientists often operate with the assumption that if they generate the knowledge it will be useful. This implies a research paradigm with a hierarchical relationship between the knowledge of scientists that of end-users (Gurung and Menter, 2003), which may lead to a relationship the repeats the power relations participation tries to address. These power relations need to be addressed to ensure that priorities and needs in community-based participatory planning processes include all (McCullum et al., 2004; Valdivia and Gilles, 2001). Gender power relations are also a key concern in agriculture, as women heads of household are often the most vulnerable (Gurung and Menter 2003; Valdivia and Gilles, 2001).

Another key reason for participatory research, specifically related to the context of climate change is the degree of uncertainty of the context in which knowledge may be used, and the degree of vulnerability of the decision-maker (Valdivia et al, 2010). Two-way participatory communication can enhance trust between knowledge systems (Wilkins, 2001) when information is probabilistic in nature. People assess risks using rules based systems and association based systems (Slovic and Weber, 2002), so when there is conflict between the findings in these two knowledge systems people are more likely to use their own knowledge; in the Altiplano this may mean that farmers will use the traditional assessment model –unless expert forecasts can be incorporated into local knowledge systems (Slovic and Weber 2002).

If the unevenness in power is addressed, and a two-way process can be developed, participation is seen as key to strengthening social and human capitals to foster alliances. Elements of advocacy coalitions, developed as a tool in policy analysis (Sabatier, 1988), informs development of capacities, and building networks for political action. The Advocacy Coalitions Framework seeks to reverse a process of capitals loss (Emery & Flora, 2006), and improve interactions among market, state and civil society that are conducive to practices that increasingly "socially just, environmentally benign and economically viable" (Campana, Bravo and Fernandez-Baca). Processes that build knowledge that aims at understanding vulnerabilities, change, and identifying opportunities are best-bets in adaptive capacity (Sperling et al, 2008; Yana et al., 2008). The participatory processes implemented sought to facilitate integration or linking of knowledge systems to build human, social and political capitals to strengthen adaptive capacities (Valdivia et al., 2010; Hayward Simpson and Wood, 2004). The protocols in conducting participatory research included developing between farmers and researchers of a common set of expectations and language to discuss alternative strategies (Valdivia et al., 2010).

*Linking in Climate*

Altiplano climate conditions and trends over the past 30 years and decision makers' knowledge and perceptions of these climate trends at the household and community-watershed scales were studied, and then compared wit through participatory processes. Perceptions were captured through community participatory assessments and household surveys. Climate trends and current conditions were compared with climate change projections for the Altiplano. The study of current trends and projections to middle (30 to 50 years) and late 21$^{st}$ century informed social and agricultural alternatives for adaptation. Research on local knowledge forecast indicators and their link to trends and projections was developed through a participatory research process that builds local knowledge systems (cultural and human capital) and fosters a common understanding and trust. Participatory assessments and mapping of climate hazards were carried out with community participants to evaluate climate forecast products in terms of effect on current production systems and identify adaptation strategies (ability to act).

A coalition building approach—advocacy coalitions—informed the process of building the social and political capitals necessary to identify adaptation strategies and partners. The projections were evaluated with stakeholders in the climate change community, where we aim to develop a climate change working group. Results were shared with stakeholders at the local, regional, and national levels, seeking also to inform government and international policies for adaptation. Landscape research at the watershed level, especially imagery analysis and participatory mapping of change at the watershed/community scale, were developed and were inputs in a dialog about vulnerabilities and planning for adaptation.

**Biophysical Research** Although this paper concentrates on climate related research, adaptation to climate and market changes requires agronomic research be conducted. We focused our efforts on pests and diseases, soils, and biodiversity. Pests and diseases were emphasized because they are a major risk factor for farmers (Table 2) and we know that pest and disease dynamics are influenced by changes in climate and production systems.  Soils, because declining fertility was also a problem and increasing soil organic content can buffer temperature changes, and bio-diversity because plant bio-diversity is another way to reduce risk.  These areas were the major focus on participatory research efforts in our communities because they directly involved farmers and addressed major problems of the farmers themselves.  Climate change was one of the motivating factors of this research rather than being the focus of the research itself.

***Livelihoods and markets***  The focus of the social and economic research was on decision makers at the household and community levels, and on how they link and negotiate with markets in each region. It identified the interaction between markets and climate shaping livelihood strategies. Differences in access and control of capitals had an effect on the livelihood strategies as well as on perceptions of risks (Table 1 and Table 2). The purpose was to compare livelihood strategies and farming practices across communities and ecosystems to discern the effect of geography and markets. This contributed to understanding how the capitals, resources, and the capabilities of individuals, households, and community engender agency and adaptation. Assessments of practices, such as soil amendments and management of pests considered input and output markets, to determine viability from the point of view of the farmer. Community participatory assessments with a gender perspective identified differences in the perceived benefits and constraints of the practices. Economic portfolio research informed on market integration (or lack thereof) and the economic activities that were important in each region, as well at to food security (Valdivia et al, 2007). Diversification of crops and potato varieties, accumulation of assets such as land, education, and animals,  are indicators of economic and social wellbeing. These and indicators of environmental wellbeing (natural capital) —soils, crop diversity, and fallow length— were studied to understand the tension between investments in the natural capital and wellbeing (Valdivia et al 2007; Valdivia et al, 2010). Risk perceptions were studied in the context of livelihoods and capitals. The data of a cross section of Altiplano families to link livelihoods with perceptions of risk, types of capital, and ability to cope with risk events —agency was gathered through household surveys. This and research on perceptions of change elicited through community participatory evaluations and mapping, were key elements in the knowledge sharing process aimed at developing new knowledge about adaptation options to climate and market changes, and how this information is shared with others.

**The Process Methods**

Participation was central to the development of the research and its implementation. In identifying which were the key problems that a collaborative group could address, consultations were conducted with several communities in all the regions. This entailed participatory workshops to identify key issues that a team could address. While the problem is demand driven, we needed to acknowledge that the program funding this research was a given, the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP). The focus was on adapting to change and improving wellbeing in the Andes.

To develop new knowledge that integrated local knowledge with that of the researchers we used a 3-pronged methodology. The first consisted of workshops using an established protocol to identify perceived risks, land use pattern changes, and participants' perceptions of the drivers of change. The second was a set of participatory research methodologies to conduct on-farm research. The third was knowledge sharing, or *socialización*, aimed at linking disciplinary and interdisciplinary findings with local knowledge, shared through workshops with defined protocols to identify what next. Collaborative methods to compile local climate (soils, pests) knowledge to study trends, and establish relationships in the area of climate were undertaken. In terms of climate knowledge sharing consisted of comparing observations with farmers' perceptions, and introducing the projections from global circulation models along with government products to educate on climate change, to discuss with groups what this meant to them, and what could be done. Figure 2 summarizes the process, which began with an assessment of existing practices, perceptions of what is happening, and learning about the local knowledge.

The project established contracts (memorandums of understanding (MOU) of collaboration in participatory research) with the collaborators, both organizations and rural communities. The contracts with communities were developed differently in the northern and central regions of Bolivia.  The university leading activities in the Northern Altiplano established a Memorandum of Understanding with the officials of each rural community.  The Non Governmental Organization (NGO) in the Central Altiplano established MOUs with farmer groups, who had been created through past extension projects this organization had undertaken in the region.

Collaborative research groups were established in the communities to conduct research, and training in various areas identified with the farmers.  Examples included Integrated Pest Management (IPM) in response to the high degree of fear about the lack of control of pests in both regions (Valdivia et al 2007), and experiments with new varieties of crops.

Figure 2: Process Design to Develop Adaptive Capacities

**Research of three participatory research types of farmer groups to determine how knowledge in rural communities informs decisions**


***Knowledge as Information***

1. Trusted source
2. Language
3. Relevant

***Ability to Act***

**Strengthen social & political capitals**
**Information & Networks & Coalitions**
**for Adaptation**

Participation in “events” (project participatory activities) was monitored both to track who is participating, and identify problems with the process. For example women were not participating as much at the beginning in the Central region because the meetings were at time they could not attend. This was modified. The objective was to study who were the participants, who were those not participating, in order to learn why. Producer groups were interested farmer groups who had collaborated with the NGO in the Central region. The Community approach, consisted of research groups established through the official channels of the peasant communities, recognized governance institutions that also were responsible for ensuring participation and land for experiments. Knowledge sharing (*socialización*) was the process of integrating knowledge (local and new) and generating information products for decision-making in the communities. This incorporated what was learnt about the roles of markets and climate as drivers, along with findings on soils or other theme, in the context of the

decision-maker, in order to build from existing local knowledge. The first two years of the project focused on understanding dynamics of change through participatory assessment and research on climate, soils, pests and biodiversity. Studying ¨process institutions¨ to support adaptive capacity entailed monitoring the implementation of the approach and its effects on participation in each community. Knowledge sharing of findings - socializacion- was in the context of climate and market information.
While the methods (protocols) employed did not vary by community or region, the project itself worked with different local institutions in the Central Altiplano and Lake regions of Bolivia. In the Central Altiplano, the project worked with farmer producer organizations and in the Lake region, it was through the community and its authorities. This difference had an impact on the scheduling of meetings and the attendance at program activities. In the case of the producer groups in the Central Altiplano, the scheduling of activities was made in collaboration with the leaders of producer organizations. No attempt was made to exclude farmers from these organizations and community members were invited to attend program activities, but the program was an activity of the producer organizations. In the case of the Lake region, the research projects were done in collaboration with the communities themselves. Activities were organized in conjunction with community leaders and most research activities took place in the form of community meetings called by the leaders. As we will see later in this paper, the choice of local institutional collaborators has an impact on project activities.

**Initial workshops and mapping exercises** The purpose of the initial workshops - community participatory assessments- to discuss with participants their production systems, soils, and land use patterns at the community level, along with their perceptions of change, and their food security and sources of vulnerability in their landscape. A protocol was developed for the project, and implemented in the same way with all participating rural communities to ensure that the approach implemented was the same at all sites. The protocol included a mapping exercise, to discuss land use patterns and changes and what drove these, and vulnerability to climate events. It also included an exercise to identify and rank what were the events that had greater impact on their livelihoods. The workshops were undertaken in Aymara and Spanish, in order to ensure that all participants could share their knowledge, especially women and the elderly.

**Baseline surveys** The baseline survey elicited information about the farming practices, off-farm activities, land use practices, the different types of capitals, and their perceptions of the risks they faced and the control they had over them. On the one hand the surveys informed about their present livelihood strategies; on the other it was the baseline information to compare the characteristics of those who participated more often in project activities. The baseline provides information on the migration patterns of the household, who is the head of the household, and their education and income levels, as information to understand if these are barriers to participation. Surveys were conducted at the beginning of the project (2006) and the end of the project (2009). A total of 330 households were interviewed in the first Bolivian survey, and 315 in the second. A community that decided not to participate in the project after the first survey did not participate in the second survey. Summary statistics of capitals, income, and perceptions of risks from the 2006 survey are presented in Tables 1 and 2.

**Participatory research** Research on soil quality and amendments, agrobiodiversity (potatoes, quinoa, and oca), dynamics of pests, biodiversity, and climate were conducted in the communities, some times on community fields, and others on farmers fields. This depended on the types of contracts or agreements developed with the rural community. In the central Altiplano agreements were established with farmer producer groups, while in the northern Altiplano this was established with the comunidad campesina, the smallest unit officially recognized form of governance of a population group. In the first type the land was provided by a member of the producer group, in the second depending on availability, the land was communal, or there were also agreements to work in collaboration with individual farmers to test with them specific soil amendment practices, or different varieties of crops. Participatory research in the establishment, monitoring, and evaluation phases was accompanied by training in areas that farmers identified as needs. For example, integrated pest management was one, as well as learning about new varieties of quinoa.

In order to assess change as a result of the process, local knowledge, perceptions, attitudes, and practices were recorded, and the research products shared in the context of the initial knowledge and perceptions of the farmers. Farmers from the different communities met through field days to share their work. The results from the disciplinary research, such as the effect of soil amendments, and dynamics of the Andean weevil, and the climate trends and change, were shared with farmers basing the new information on their own knowledge and perceptions, through workshops.

**Landscapes and livelihoods near the Lake (North Altiplano)** Four rural communities in a watershed of Ancoraimes municipality agreed to participate in the research program. This watershed is located 135km north of La Paz, capital city of Bolivia, in the province of Omasuyos, Department of La Paz. Mean rainfall in the region is 480.9mm (sub-humid environment), and mean temperature of 8C. Across the highlands temperature contrasts take place between night and day, so means are not a statistic that describes well climate. The rural communities are located at various altitudes and distance from Lake Titicaca (from 3km through 20km), and represent a diverse set of livelihoods. In the lower elevation (3,856m. above sea level) the production system includes rainfed potato production along with irrigated-intensive onion production, and livestock production. In the middle of the watershed (4,089-4,095m a.s.l, and 12 and 9 to 14km from the Lake), two small communities produce a combination of potatoes, peas, quinoa, and livestock, especially small ruminants, and off farm employment is a key income generating activity. These communities have access to water for irrigation in some of their plots. In the higher level of the watershed (4,313m.a.s.l., and 20.5Km from the Lake) the production system is quite different, with alpacas, llamas and few sheep, and bitter potato, oca, and more recently sweet varieties of potatoes and turnips. Markets for this region include nearby local weekly fairs, large rural markets like Achacachi, and the La Paz markets, like Faro Murillo and Chijini. Participation in these markets depends on the type of product, size of the supply, and labor availability. Since off-farm employment by migrating plays a key role in income generation, labor is a constraint in production and marketing. Another important constraint in this region, explaining the importance of off-farm employment is the high degree of land fragmentation. Table 1 presents the characteristics of the households in terms of their capitals –human, social, financial, and natural-, and income levels. Table 2 presents perceptions of how climate hazards and change are a threat to each community.

**Landscapes and livelihoods in the Central Region** Four rural communities in the Central Altiplano agreed to participate in the project. This region is known as a dairy shed for the Department of La Paz. Located in the Province of Aroma, 90km south of the city of La Paz, it has two different landscapes, the low and flat and the hilly (3,757m.a.s.l.) and higher elevation rural communities in the hillsides (4,071 m.a.s.l.). The average rainfall patter fluctuates around 300 and 400mm, a semi-arid environment. In the low lands livestock production, especially dairy cattle, are a key economic activity, along with potato production and other grains like quinoa and barley. In the higher elevation the main production is potatoes, along with further processing into chuño. The region is known for their potato production, and Patacamaya is the main regional market, close to the communities. Most of the production is sold in this market. Milk is collected through an established system that has been operating for almost 20 years in the low lands. There are contrasts in terms of the role of off-farm employment, as well as the level of income in the two landscapes. The highest income levels are in the low lands. Off-farm migration is an important income strategy in the high lands of this region. Irrigation is mostly to establish alfalfa in the lower elevation. Otherwise dry-land farming predominates, with potatoes as an important cash crop in the high elevations when measured as a share of total income. As before the perceptions about climate hazards are summarized in table 2.

**Diversity of settings and institutional linkages** The regions selected represent a diversity of settings, in terms of the environmental context, the climate conditions and changes. While in the central Altiplano rainfed crops are grown, livestock production has become a main economic activity in the low elevations. Incomes rely mostly on farming (Table 1), with a high level of potato diversity through out. There is a dominant participation in the local market with the sales of potatoes, chuño, and livestock, as well as sales of milk. Communities in the higher elevations rely mostly on potatoes, and off-farm employment as main economic activities. On the other hand, in the Northern Altiplano, communities have a more rural strategy, meaning a significant share of income from non farming activities, combining seasonal migration with crop farming, in small plots of land. The region in average earns a fourth of the income of the Central region. It links to markets in many ways, such as selling for subsistence in local markets, selling as an enterprise (onions for example) to large markets, mainly in La Paz, and through the use of family networks in urban centers.

The climates are contrasting, and this is captured in the perceptions of climate hazards. So are the ways in which households link to markets. In terms of outside actors there are also differences. In the Central Altiplano there has been a non governmental organization that has supported potato production technologies (Markowitz and Valdivia, 2001; Figueroa, 2009). Others in the past supported management practices to protect the natural resources, and others like DANIDA worked to promote dairy production in the 1980s (Coppock and Valdivia, 2001. In the Northern Altiplano rural communities have had less experience with NGOs, though a couple have contributed knowledge on natural resource management and organization. In the case of the project, a new organization (and institution) became an actor in the North region, a public university. Collaboration approaches varied depending on the local organization. In the central region an NGO was a key actor in the research process, while the university was the main presence in the northern region.

**Results - Case Study in the Andes**

**Climate efforts** Meetings were held with farmers to get their initial estimates of climate change and also to assess perceived climate risks. There was a general feeling that climate was changing and was becoming more difficult to manage. Farmers argued that rains had diminished, that winters were not as cold and that in the Northern Altiplano that frosts had increased. The greatest perceived weather related risks were flooding and frost. Pest infestations had also increased, probably in part due to warmer winter temperatures. At the same time, daily meteorological data was gathered from the few weather stations in the region that had 30 or more years of data in order to observe trends in weather. This analysis revealed that contrary to the belief of farmers that there were no changes in precipitation. It did however support their observation of increases in temperatures, and an increased incidence of frost in the Lake region. The results of the workshops were taken back to the communities for comment. The difference between the meteorological observations and farmer's views is probably due to the fact that there has been an increase in evapo-transpiration due to higher temperatures. When farmers were asked how they knew there was less rain, they explained that soils were drier and the rains were not sufficient to completely water crops. Increased evapo-transpiration would also explain the increased incidence of frost in the more humid lake region. Since soils are drier than in the past, farmers attributed this to less rain.

Sharing information gathered in the report with farmers led to several conclusions. Frosts were of greatest concern in most communities and floods were in communities that had lowland areas. Lowland areas are the most productive lands in normal and dry years but are subject to flooding and water logging in wet years or when there are extreme storm events. When adaptation methods were discussed, there were few strategies that could deal with flooding after a flood-prone area was planted. Better longer term forecasts could, however affect planting decisions. Farmers saw more opportunities to deal with frost. Farmers could recall a time in the past, when fires were lit to reduce frost damage and when people planted more frost resistant varieties of potatoes. When villages practiced collective rotation systems similar to medieval open field systems of production, the person in charge of supervising the rotations and managing communal lands was also in charge of organizing frost responses. Since communal rotations have been replaced by individual plot management, this position and the knowledge that went with it have disappeared.

The decision was made to redevelop these systems but to do so, there needed to be a local level forecasting and early warning system to do this. It was decided that the best way to do this was to revive traditional forecasting and weather management techniques and combine them with scientific research methods. Contact was made with SEHNAMI, the national weather service, and weather stations were installed in participating communities. Participatory research was initiated on the indicators themselves and we have completed two years of study of them. This season will begin experiments to reduce frost damage.

**Participatory research on Soil Amendments** The loss of practices that contributed to the resilience of the ecosystem, led us to test if community awareness of the mitigating effects of soil organic matter on increasing temperature and decreased rainfall can be raised through workshops, demonstrations, and focus groups, and if it would lead to adoption. As part of the collaborative agreements with the communities, projects were discussed and set up with farmer groups, cops planted and monitored, with assessment carried out throughout the farming period. Farmers evaluated the plants, at flowering and at harvest, assessed productivity, and taste, and assessed the costs of the practice. The field trials were established so they could observe the effects of increased soil organic matter on increased temperature and decreased rainfall. Table 3 shows participation in the research for 2007 and 2008. Participatory research on soils and organic amendments findings indicated that some of the practices were highly rated by farmers, as successful in terms of expenses and the effect on soils and the crop. One of the barriers to adoption identified by the farmer groups in both regions is the labor requirements to implement the practice; more so in the North due to the outmigration for work. Some of the new possible actions will require outside sources of funding, and therefore an approach that strengthen the networks and negotiation skills, along with the knowledge, will contribute to adaptive capacity at a greater rate than producer groups. As more emphasis is placed on adaptation in the Andes, these are approaches that should continue to be monitored.

**Socialización – Knowledge sharing** Knowledge sharing protocols were developed, which included the format of the information as well as the workshops to discuss these. A team was trained and each organization was in charge of organizing the knowledge sharing in each region. Project research findings about climate trends, climate change, and the markets households engage with were shared with each community. Table 3 presents the participation levels for 2008 when sharing about market findings took place, and levels in 2009 when sharing about climate and markets were combined with findings on soil amendments and pest dynamics. The organization in the North was able to share and conduct workshops in all communities, while the organization in the Central region only succeeded with one rural community, in the higher elevation, who was very committed to their work on improving technologies for potato production (Figueroa, 2009). The other community in this landscape was going through difficulties, and later divided in two. The *Socialización* protocol included a discussion about the findings, what were the contraints and opportunities, and what are next actions as a group (Sperling et al., 2008).

**Differences in the approaches** While the methods used for developing linkages between knowledge systems did not vary by community or region. The institutional focus of the project was different in the Central Altiplano and Lake regions of Bolivia. In the Central Altiplano, the project with farmer producer organizations and in the Lake region, it was through the community and its authorities. This difference had an impact on the scheduling of meetings and the attendance at program activities. In the case of the producer groups in the Central Altiplano, although initially all producers had the opportunity to join the groups some self-selection took place. In addition the scheduling of project activities was made in collaboration with the leaders of producer organizations. No attempt was made to exclude farmers from these organizations and community members were invited to attend program activities, but the program was an activity of the producer organizations. In the case of the Lake region, the research projects were done in collaboration with the communities themselves. Activities were organized in conjunction with community leaders and most activities took place in the form of community meetings called by the leaders. As we will see the choice of local institutional collaborators has an impact on project activities.

**Effectiveness in terms of involvement and continuity** Table 3 shows the level of involvement in the two regions in two activities—the participatory research itself and the process of sharing the results of the research (*socialización*). In both the case of participatory research and the sharing of results, participation of households was higher in the case of Ancoraimes (Lake region) where the community-based approach was used. However the differences were smaller in the case of the research itself than they were in the case of workshops to share results (*socialización*). In the second year of research there was no difference between *municipios* for involvement in the research itself, but there were differences in large differences in attendance in the workshops, which shared the results of the research. For example in 2008, 17% of the households participated in both regions the research itself, but attendance at the events in 2009 where the results of the 2008 research was presented had a marked difference, 30% of the households in the Central region and 66% in the Northern (Lake) region. Involvement in the participatory research itself also differed by income and gender—especially in the case of participatory research. If we look at income quintiles, presented in Table 4, the community oriented approach used in the Northern (Lake) region, had a much higher participation of lower income and higher income households (48% in 2007 and 65% in 2008) than did the Central region (31% and 32% respectively). Research participants represented the "middle class" where the research was carried out through producer organizations, and the extremes where community approaches were used. Differences in gender were not as striking as those by income, but women in the North where a community based approach was used were more likely to participate than men, while in the Central region men were more likely to participate. Women participated more in the higher elevation communities of this region. Developing adaptive capacities benefits from larger participation and more diverse participation, especially as the communities need to strengthen the networks – bridging capitals – as they build new knowledge - human capital.

**Conclusion** The adaptation to the challenges of climate change requires the creation or recreation of new institutional arrangements. In this paper we are examining the institutional changes that must take place to ensure the generation of information that can inform adaptation to climate change. This requires the creation of local forecast systems that must necessarily combine elements of traditional and modern systems. Although current practices in participatory research emphasize the creation of farmer research groups, because it requires less effort to organize research, the community approach to participatory research seems to have the best potential. First because cooperation with government agencies such as SENAMHI is needed to maintain and these institutions find it easier to work with local governments than with producer organizations. In addition, there needs to be commitment to protect and manage weather stations and this seems to be easier to do when there is a community buy-in rather than just individual buy-in. Peasant communities are officially recognized governance institutions, and are there for the long run. Currently these communities have more say in the distribution and use of budgets in each region. This is also the case in Peru. Group formation for collaborative research through these organizations has also the advantage of involving the more vulnerable households, and those headed by women, so human and social capitals are strengthen at a higher rate. In addition, when communities are stakeholders in the process participation in field days and other events highlighting research activities are higher.

The efforts described here were designed to enhance the ability of low income producers to act to adapt to changing conditions (Valdivia, Gilles and García, 2010). This capacity to act (agency) requires that first that a problem can be identified and in a way that there are meaningful solutions. Our approach focuses on the linking of scientific and local knowledge systems. Following Kloppenberg (1991) and Fortmann (2008), we start with the assumption that local/practitioner knowledge and scientific knowledge systems are distinct but complementary ways of understanding reality. While both are empirically based, the former is contextualized knowledge while the latter attempts to ignore (control for) the influence of context. We see our job as to build bridges between scientific and local knowledge systems. Our primary tool for doing this is participatory research. By building bridges between the two systems we can enhance the adaptive capacity of farmers.

Translational research for knowledge that is used in practice (leads to action) is framed with the decision makers, links science and local or indigenous knowledge, and includes the stakeholders that are key to the issue. Key areas of research are the participatory processes, and the institutions to support adaptive capacity building, and the process to link scenario models with decision makers incorporating the uncertainties of climate change, and shape and deliver the information in the context of the relevant decision makers.

**Agricultural Innovations: The Case of GM Cassava in Kenya (Valdivia et al 2014)**

This paper focused on the ability of smallholder farmers in developing countries to communicate effectively their wants and needs and to influence the direction new technology development takes, particularly regarding the genetic modification of crops. That is, it is a question of whether and to what extent farmers have a voice. Do smallholder farmers have a voice in the debate and a place at the table when it comes to the development of new agricultural technologies, especially genetically modified (GM) crops? If not, then what processes can be implemented to improve the voice of smallholder farmers? We provided insight to these questions from workshops we held with a group of smallholder farmers in Kenya that focused on the potential introduction of GM cassava in the country. Cassava is currently being modified to be resistant to two viruses, cassava mosaic virus and cassava brown streak disease through field trials but

GM cassava has not yet been commercialized in Kenya. We undertook a study to examine the benefits, risks and potential unintended consequences of introducing GM cassava in Kenya (James Valdivia and Folk, 2010). We found that while diseases plague cassava that affect overall productivity, the larger question of food insecurity is about lack of market opportunities, access to resources, and a vulnerability context that challenges the ability of smallholder farmers to accumulate assets (James et al. 2014). Because we wanted to know what the main concerns are of smallholder farmers in Kenya, we used a translational research approach to listen to many farmers' voices, as this can help scientists and policymakers frame the problem and identify solutions that respond to unique farmer contexts. Kenya's Coastal region was the focus, a place where cassava plays an important food security role in the livelihoods of people. Our translational research approach had three stages. The first was a participatory assessment with farmers to learn about their concerns with food insecurity, the role of cassava in their livelihood strategies, their access to information and technologies through their connections to institutions, and their knowledge of GM crops. The second stage was to share the farmers' knowledge about their livelihoods, practices, technology, and cassava with scientists so that they can respond to the needs of smallholders in ways that reflect the unique circumstances of different farmers in difficult contexts. The third stage was the feedback process with farmers to share what we learned from them, to ask if we captured what they shared with us, and to present information that responds to their concerns, as well as continue the conversation about GM modified crops.

Farmers will ultimately decide what crops to grow and how to do so, and farmers are in charge of negotiating within their unique circumstances in their pursuit of livelihoods and wellbeing, reason why it is key to listen to their voices and engage them to share their priorities and needs, to inform scientists on the critical concerns farmers face in addressing food security. Here we summarize some of the findings of how translational research processes can facilitate and enhance the capacity of farmers to have a voice.

**The Vision of the Govt. of Kenya is a** *"A vibrant cassava sub-sector contributing significantly to improve livelihoods, food security and industrialization"* (Ministry of Agriculture 2011, p. 2). Cassava is an important food security crop in Western Kenya, the Coastal regions, and parts of Eastern Kenya, grown in very difficult climate conditions. KARI's (now KALRO) mandate is to conduct and oversee all agricultural research in Kenya through several research programs, including the study of food crops, such as variety development, improvement, husbandry, and post-harvest analysis, and socioeconomics and applied statistics (SEAS). Importantly, the SEAS mission is to better understand farmer needs so research programs can effectively meet those needs. Unfortunately, barriers have prevented an effective communication channel between KARI and smallholder farmers, especially in regions with a high degree of food insecurity.

**Some barriers to farmers' voice,** include the considerable fragmentation among farmers within Kenya. Fragmentation among farmers makes it difficult for KARI and government extension agents to reach a large number of smallholder farmers, especially in rural areas. However, recently many farmers have begun to form into groups, a policy objective in agricultural extension dating to the 1990s, as a strategy to cost-effective reach more farmers with the limited resources. Another problem is that farmers in rural areas have been poorly represented, related to an administrative structure that was a top-down system where the chief and village elders took orders from the District Commissioners and District Officers, so that keeping relations with senior officials good meant ensuring that success stories were reported even if not the case. Some examples include experience with famine/food shortage or need for relief seed that were understated for fear of tarnishing the effectiveness of the chief. Governance structures did not facilitate transparency and information-sharing that was consistent with the situation and needs of the farmers. Information related to problems does not flow up the chain of command, because it would have meant that the situation was perceived to not be under control. This also reflected inherent power asymmetry, as local chiefs feared victimization by officers up the chain of command. Farmers' voice requires a process of governance takes into account and acknowledges that there are vulnerable regions, and where the expectation is to learn and address vulnerability. Fortunately, there appears to be two factors that are changing this – the farmer group approach that is given them voice and the changes in county government format that removes the disincentives for effective communication. Another constraint is that informing farmers about technologies is not sufficient for adoption when contexts are uncertain. For example, reporting climate data to farmers will not lead to its use (Ziervogel and Downing 2004; Patt and Schroter 2008). For farmers to have a voice, information presented to them by scientists and other stakeholders has to fit the farmer's context and be relevant and delivered in their language by a trusted source (Valdivia et al. 2003; Valdivia et al. 2010). An important context is how farmers feel as a result of risk and uncertainty, such as resulting from climate change. Therefore, the riskiness and uncertainty surrounding the decision-making context, as well as the capacity of farmers to take risks, matter a great deal when communicating information to them. However, even when risk and uncertainty are taken into account, there may be other barriers that impede use of the new information. Fourth, smallholder farmers and scientists utilize different knowledge systems. Thus, a failure to bridge these systems will create a barrier to farmers' voice. Translational research addresses the social and human dimensions of laboratory science developments to take the developments of science to appropriate individuals and groups (Woolf 2008).

**Translational research and farmers' voice**

We argue that a translational research effort can help overcome these barriers. It does so by bringing smallholder farmers together and by enhancing a two-way communication and participatory process where farmers and researchers work together to bridge differences in knowledge systems, to build social and political capital, and to strengthen the capacity of smallholder farmers to act in contexts where there is uncertainty. An effective form of participatory research is where farmers present their knowledge to scientists and they in turn provide farmers the results of their existing knowledge (Valdivia et al. 2010).

Our translational research approach began by understanding the vulnerability context and degree of insecurity, learning about the livelihood strategies and the role cassava plays, how well connected farmers are to sources of information, whom they trust for that information, and what experiences they have with technologies. We engaged women and men farmers as well as groups of farmers who are more and less food secure in order to learn from their unique experiences and perspectives. We then shared these with crop scientists so that they would be better able to develop knowledge that reflects the experiences, needs and preferences of smallholder farmers. To this end we held two workshops. In the first workshop we learned from the farmers about the various roles of cassava in their livelihoods, and the context in which they have to make decisions. We shared this information with the scientists and helped them develop contextualized information for the farmers, and presented in a second feedback workshop. In the second workshop, which included participation by KARI scientists, we focused the dialogue on what we learned and what scientists and stakeholders had to share in response to the needs and concerns of smallholder farmers. In short, we aimed to enhance the voice of smallholder farmers.

**The case study design, protocol and process** As part of our broader project to understand the risks and benefits of introducing GM cassava in Kenya, we expected that gender and degree of vulnerability are important factors affecting the type of livelihood activities farmers undertake. Because of gender and vulnerability differences, we also expected that the technology preferences, concerns, and access potential would differ (see James et al. 2014). Therefore, we designed the protocol to gather farmer responses by identifying groups of smallholder farmers that differ by their degree of vulnerability; we also separated men from women in some group discussions in order to capture gender differences. The case study design was single case of a well-connected farmer group, and multiple embedded of subgroups formed according to food security and gender. In this context, “well-connected” means access to trusted sources of information, such as having regular interactions with KARI and Ministry of Agriculture extension agents.

In our first workshop, we developed specific activities around several overarching questions about farmer livelihood strategies. The first group activity was a food security profiling exercise to define what food is, and what the characteristics are of those who are secure and those who are vulnerable. Color-coded cards were used to capture responses by women and men, and to self-identify into a group. The second group activity was the development of a timeline of shocks and other events that have impacted their community and families in the past fifteen years. The third and fourth activities were based on sub-group, formed by food secure and food insecure, and by gender. In the third activity we asked about livelihood activities, the farming system, and the role of cassava and who makes decisions on consumption production value added activities and marketing, and preferred varieties of cassava according to their uses. In the fourth activity, we identified sources of trusted information and how it was used. The final group activity brought everyone together. Discussion helped farmers recall experiences with technologies and their knowledge of GM crops.

A team of nine people was trained to facilitate the workshop and process the data. The protocol was pilot tested by the team with 18 farmers (16 women and 2 men) in a similar community in Kilifi, in the Coast province of Kenya. Team building was critical because it helped engender confidence among smallholder farmers participating in our group discussions. One evidence of confidence created by the team is that farmer participants voluntarily categorized themselves into food secure and food insecure groups and also identified themselves as vulnerable or non-vulnerable.

The farmer group that is the focus on this case study is *Basi Mwangaza* (meaning “Seen the Light”). It is located in Tezo, Bahari Division, Kilifi county, in the Coast Province of Kenya. The group was formed in 2001 as a maize group that changed to cassava in 2005 because maize was not profitable. The group is considered well connected to extension services, KARI, the University of Nairobi, the National Council for Science and

Technology, and a German NGO. *Basi Mwangaza* produces ethanol with cassava and is the parent organization for six other community-based organizations, each with 33 members. They also carry out milling of maize and cassava, and sell cassava cuttings. There were 42 women and 9 men from *Basi-Mwangaza* who participated in our study.

**General findings from the workshops**

The first workshop was conducted in November, 2012. The meeting lasted five hours. Discussions were conducted according to the protocol explained above. The data was recorded and translated into English and analyzed by each team facilitating the activity. Additional information from the cards was used to complement the flipcharts, notes, and recordings from the group activities. The first activity with smallholder farmers included discussions with all group members. Both women and men identified maize, cassava, cowpeas, and green grams as the crops grown in this region. While maize was grown by 30 percent of the food secure participants, cassava was grown by 80 percent. Cassava is mostly farmed in an intercropping system. Farmers can use leaves for green manure and the tubers as a feed for livestock. Cassava was also viewed as a commercial crop for ethanol production and for other value-added production activities, such as dried chips and flour. Some farmers marketed cassava cuttings. Challenges to cassava production include the mosaic and brown streak diseases, theft of tubers, pests such as white flies and green mites, poor access to markets for inputs, and leaves that wilt when there is drought. Some consumption problems include bitterness and high cyanide levels, fibrous tubers, and perishability. Many farmers lack equipment for drying and chipping, which can be a problem during long rain seasons, while some farmers don't possess skills for processing. Markets are insecure and are especially poor for bitter varieties.

Basic needs for these smallholder farmers are varieties of cassava that are sweet, equipment for drying and chipping, and better access to markets. The most preferred varieties of cassava include Kibandameno, Kaleso, Tajirika, Shibe, and Karembo. Several of these were sourced by other farmers, although KARI has also provided cuttings to farmers.  According to the men in the group, to be food secure means that people have access to meals at all times, have healthy children, and can rely on their own harvest for food security. They are able to invest and pursue development projects, have full time employment, and are well behaved and moral. While women listed these same indicators, they added living a happy life, having a family that is well-clothed, and being able to meet all school expenses. Food insecurity indicators included the need to purchase food, children that could not attend school, children that are malnourished, and being dependent on work off the farm for income. Food insecure people are poorly clothed and cannot save, and they depend on others for assistance. Women added that food insecure people are always under stress, have to stint on meals, cannot afford good shelter, depend on assistance, have poor health, and may opt to steal.

We found important differences in the information networks of food secure and food insecure farmers and in their experiences with new technologies. For example, men in the food secure group considered the Ministry of Agriculture as their primary source for crop husbandry. They are also connected with KARI for crop varieties, the University of Nairobi for new crop varieties for ethanol extraction, and the East African Agricultural Productivity Project, the Equator Kenya and Afrigoken for production and marketing of chili pepper, and the Kenya Dairy Development Project for savings and credit. Women in the food secure group were connected to organizations that facilitated access to technologies. The most trusted source for them was the Ministry of Agriculture for planning seed access, pest management, diseases, crop husbandry and post-harvest management. Ranked second was KARI, which provided seeds, capacity building, disease control, and value addition. The women listed the University of Nairobi as third, related to cassava and cowpea seeds and value addition of leafy vegetables.

In contrast, while men in the food insecure group indicated a connection to several organizations, they noted that a lot of the information they receive is not particularly helpful because they do not have the resources needed to implement any knowledge they learn from them. For example, the National Accelerated Agricultural Inputs Program (NAAIP) provided information on fertilizers, but farmers were not able to use it because they cannot afford to purchase the needed farm inputs. Similarly, USAID provided knowledge on sweet potatoes seeds, green grams and cowpeas but farmers do not have the resources to buy them. Organizations they felt most helpful are those that provided resources rather than information. For example, the University of Nairobi provided new varieties of cassava that they are testing, while Equator Kenya and Frigoken provided seeds for chili production. Similarly, KARI provided access to three cassava varieties Karembo, Tajirika, and Shibe, although this group preferred primarily Tajirika.

The food insecure women indicated the fewest connections to sources of information. They tended to trust the Ministry of Agriculture for information on cassava value addition, as well as village elders for issues related to health, and the village level farmer groups for issues related to welfare. This group of women indicated that they use the information from the four sources listed.

The *Basi Mwangaza* group has had experiences with new technologies. They indicated benefiting from new varieties for consumption, processing and marketing. The key challenge of the new cassava varieties is that these are bitter, but are acceptable when processed into flour. These varieties tend to attract wild animals, which destroy the crops, and their market prices are not favorable. They seek varieties that have high yields, are early maturing, have large tubers, and produce better marketing opportunities. Importantly, when asked about their awareness or knowledge of GM crops, only one participant in our well-connected group of smallholder farmers mentioned having heard about GM maize on the radio from a story originating in South Africa.

The second workshop, held in January, 2014, included participation by farmers and KARI scientists. In this workshop, the results of the participatory assessments were presented and discussion followed to determine if the presentation had captured their issues. This was followed by presentations and booths providing information on farmer identified issues. Sessions included cassava agronomy and dealing with pests and the best bet production practices. A second session focused on post-harvest handling and value addition, with particular focus on cassava. A third focused on marketing, in particular how to deal with increased production, consumer preferences, and product diversification. The fourth session focused on GM crops, particularly GM cassava, in order to enhance awareness of on-going research, benefits and find out about concerns or fears.

During the evaluation of the event farmers validated the knowledge presented as reflecting discussions in the participatory assessment. Participants commented approvingly of the approach taken, focusing on two-way communication and interaction. Farmers completed a short assessment form of the feedback workshop, singling out the process as a new approach in building a partnership of farmers with research and extension. The most liked presentations were value addition and marketing, which is consistent with the concerns expressed at the participatory assessment workshop. Areas for improvement listed included providing more advisory technical presentations and punctuality. They also expressed an interest in more information about GMOs, which farmers understood would allow them to escape the challenges of pests and diseases, but feared the short and long-run consequences of consuming GM crops. Farmer representatives were chosen to participate in a stakeholder conference where their own experiences will be shared.

**Discussion** Although there are many ways to think about translational research, it is primarily about engaging in a participatory process in a systematic way that addresses power relationships and focuses on the decision makers voice. Our argument here is that translational processes can help bridge the gap and overcome barriers that inhibits the ability of farmers voices to be heard. Our case study, of workshops held in Kenya with smallholder farmers, illustrates how translational research processes can help.

The participatory activities in the translational research process use various techniques to bring farmers together and to encourage them to express their voices, especially those of women, the elderly and the vulnerable. The process itself aims to strengthen the social networks within the group. It also aims to build more bridging social capital by creating a two-way communication process with other stakeholders, such as the scientists, extension officers, others in the value chain. This is important, because for farmers to be willing to express themselves they need to trust each other as well as other stakeholders and sources of knowledge.

Another barrier we identified was that farmers in rural areas tend to be poorly represented in government – at both the local and national levels. One manifestation of this is that the governance structures between the village and district commission do not facilitate the flow of information that reflects the issues of the farmer groups, especially during shock events. Moreover, as indicated above, previous research has demonstrated that merely informing farmers about technologies is often not sufficient for adoption in contexts of uncertainty. The feedback workshops, integral to the translational approach, provided an opportunity for the farmers, including the vulnerable, and women, to express their own knowledge during the presentation of KARI scientists so that scientists could better understand the contexts within which decisions and adaptation strategies are made, the nature of events they face, and therefore the barriers are that exist in adopting new technologies. For example, the groups of men and women and of secure and less secure farmers identified post-harvest and marketing as key constraints, and also the nature of preferences farmers are looking for that are not yet available. The two-way process not only contributed to strengthening the trust and communication, key in uncertain and risky contexts, but also facilitated information to the scientists about the key traits farmers are looking for so that they understand what to focus on. Overcoming other key barriers to improved livelihoods by smallholders, such as poor markets and limited processing abilities, are central to adoption, and farmers had the opportunity to learn from other stakeholders who are working to facilitate access to markets.

The translational approach as conceived and implemented in this project aimed to strengthen the human, social and political capitals of smallholder farmers as they engage with researchers and other actors to define their concerns, needs, opportunities and aspirations. This particular case focused on enabling a conversation about what farmers need and about what new technologies can offer, especially regarding the potential introduction of GM cassava in Kenya. The process aimed to share knowledge, strengthen the networks, and building the connections to participate in the conversation. Farmers actually have little information about GM, they are certainly in a vulnerability context, and the networks of information are mostly one-way communication, so this type of process can effectively increase their voice in decisions about innovations that target them.

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**Table 1. Livelihood Capitals Buffers and Income in Central and Northern Altiplano of Bolivia in (2006)**

| Variables | Ancoraimes Municipality – Northern | Umala Municipality - Central |
|---|---|---|

| Communities (n = 330 HHs) | Chin (57) | Coha (27) | Cala(23) | Choj(27) | SanJo (96) | SanJu (31) | ViCo(29) |
|---|---|---|---|---|---|---|---|
| *Human Capital* | | | | | | | |
| Education HH (yrs) | 7.1 | 3.4 | 4.8 | 4.5 | 7.1 | 5.3 | 4.4 |
| Labor Availability (A.E.) | 3.5 | 3.1 | 4.4 | 2.9 | 3.9 | 3.3 | 3.8 |
| *Natural Capital* | | | | | | | |
| Plowed for Crops (Has) | 0.390 | 0.091 | 0.171 | 0.286 | 1.835 | 2.550 | 0.853 |
| Fallow land (Has) | 1.636 | 0.222 | 0.391 | 0.703 | 3.955 | 7.370 | 3.960 |
| Alfalfa (Has) | 0.182 | 0.002 | 0.106 | 0 | 2.105 | 2.112 | 0.796 |
| *Social Capital* | | | | | | | |
| Access to credit (% HHs) * | 16 | 26 | 17 | 30 | 29/ 21 | 16 /0 | 24 |
| Information, radio % | 35 | 15 | 35 | 7 | 7 | 0 | 7 |
| *Cultural Capital* Knowledge | | | | | | | |
| LK Biophysical Indicators % | 32 | 63 | 65 | 56 | 60 | 52 | 35 |
| *Economic Capital* | | | | | | | |
| Cattle (heads) | 3.7 | 1.3 | 2.0 | 3.5 | 8.2 | 8.7 | 3.7 |
| Sheep (heads) | 14.7 | 11.2 | 19.4 | 42.8 | 34.1 | 35.2 | 27.2 |
| *Coping Strategies Crop Failure* | | | | | | | |
| Buffer - Chuño (*arroba* =11kg) | 5.04 | 1.88 | 2.89 | 4.72 | 23.90 | 19.81 | 15.42 |
| Livestock sale %HH | 82 | 63 | 74 | 73 | 9 | 0 | 4 |
| Borrow from friends % HHs | 21 | 37 | 26 | 19 | 17 | 11 | 20 |
| *Income Sources* | | | | | | | |
| Income –cash & in kind Bs | 10,171 | 2,416 | 6,768 | 5,910 | 24,029 | 22,880 | 10,582 |
| Income Ag Cash Bs | 6,770 | 497 | 2,248 | 2,649 | 12,020 | 11,742 | 2,978 |
| Income from migrant labor Bs | 4,016 | 1,633 | 3,517 | 1,692 | 3,372 | 4,645 | 4,447 |

Source: Household Survey 2006. Head of household (HH). Exchange rate: US$1 = 6.95 Bs. *: /n is percentage of credit from friends.

**Table 2. Perceptions of Risks to Household Wellbeing in the Central and Northern Altiplano of Bolivia** (2006)

| Type of Threat | Northern Altiplano | | | | Central Altiplano | | | | P |
|---|---|---|---|---|---|---|---|---|---|
| Communities & n of HHs | Chin 56 | Coha 27 | Cala 23 | Choj 27 | SanJo 94 | SanJu 31 | VinCo 29 | Kell 25 | |
| Hail impact on crops & livestock | 3.51 | 3.96 | 4.09 | 3.56 | 3.88 | 3.77 | 4.24 | 4.32 | *** |
| Impact of Floods | 3.96 | 3.89 | 3.91 | 3.85 | 4.48 | 4.23 | 3.76 | 4.28 | *** |
| Impact of Drought | 2.41 | 2.96 | 3.00 | 2.67 | 2.98 | 2.90 | 3.00 | 3.00 | *** |
| Impact of Frost on agriculture | 3.89 | 3.93 | 4.26 | 3.59 | 4.29 | 4.52 | 4.66 | 4.32 | *** |
| Impact of Changing Climate | 3.79 | 4.26 | 4.22 | 4.11 | 3.90 | 3.81 | 3.29 | 3.80 | ** |
| Impact of Pests | 3.68 | 4.04 | 4.17 | 3.78 | 3.16 | 3.06 | 3.48 | 3.88 | *** |

Source: Household Survey 2006. *** P<0.000 ** P<0.02

Scale: 1 =it is not a threat; 2= it is a minimal threat; 3 = it is a moderate threat; 4 = it is a very strong threat; 5 = it is an extreme threat

**Table 3. Participation in Participatory Research and *Socialización* Activities 2007-2009**

| Communities | Participatory Research 2007 | | Participatory Research 2008 | | | *Socialización* 2008 | | *Socialización* 2009 | |
|---|---|---|---|---|---|---|---|---|---|
| (n) | Total # | % | # | Total % | Female % | # | % | # | % |
| Umala (181) | 38 | 20 | 31 | 17 | | 22 | 12 | 61 | 30 |
| SanJo (96) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SanJu (31) | 9 | 29 | 12 | 39 | 0 | 0 | 0 | 29 | 0 |
| VinCo (29) | 15 | 52 | 11 | 38 | 43 | 22 | 76 | 24 | 83 |
| Kellh (25) | 14 | 56 | 8 | 32 | 0 | 0 | 0 | 8 | 32 |
| Ancoraimes (134) | 39 | 30 | 23 | 17 | 38 | 74 | 56 | 89 | 66 |
| Chin (57) | 14 | 25 | 16 | 28 | 35 | 31 | 54 | 36 | 54 |
| Coha (23) | 12 | 44 | 7 | 26 | 46 | 18 | 67 | 16 | 48 |
| Cala (27) | 1 | 4 | 0 | 0 | 44 | 12 | 52 | 15 | 52 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Choj (27) | 12 | 44 | 0 | 0 | 29 | 13 | 48 | 22 | 67 |
| Total (315) | 77 | | | | | 96 | | | 50 |

Fuente: Data Base on Participation; Jimenez et al, 2009. Analisis de Evaluaciones Participativas y Socialización en Comunidades de Ancoraimes y Umala. La Paz Bolivia.

**Table 4. Income Distribution (quintiles) and Participation In the North and Central Region 2007 and 2008** (% households)

| Region | North | | | | Central | | | |
|---|---|---|---|---|---|---|---|---|
| Income Quintile | 2007 | | 2008 | | 2007 | | 2008 | |
| | P. | N. P. | P. | N. P. | P. | N. P. | P. | N. P. |
| 1 | 28 | 16 | 35 | 21 | 21 | 20 | 16 | 37 |
| 2 | 18 | 21 | 22 | 15 | 21 | 20 | 26 | 18.5 |
| 3 | 21 | 20 | 4 | 15 | 24 | 20 | 23 | 15 |
| 4 | 13 | 23 | 9 | 21 | 24 | 19 | 19 | 18.5 |
| 5 | 20 | 20 | 30 | 28 | 10 | 21 | 16 | 11 |

Source: Contreras et al 2009. P: Participated. N.P.: Did not participate.

**Table 5. Participation by Gender in the North and Central Region (2009)**

| Region | | North | | Central | | Total |
|---|---|---|---|---|---|---|
| Gender | Participation | # | % | # | % | # |
| Female | Yes | 37 | 76 | 22 | 52 | 59 |
| | No | 12 | 24 | 20 | 48 | 32 |
| | Total | 49 | 100 | 42 | 100 | 91 |
| Male | Yes | 78 | 72 | 68 | 58 | 146 |
| | No | 30 | 28 | 49 | 42 | 79 |
| | Total | 108 | 100 | 117 | 100 | 225 |

Source: Data Base Survey 2009. Gender of household head female or male.

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