COPING AND ADAPTING TO CLIMATE VARIABILITY: THE ROLE OF ASSETS, NETWORKS, KNOWLEDGE AND INSTITUTIONS

Corinne Valdivia, University of Missouri Columbia
Jere L. Gilles, University of Missouri Columbia
Christian Jetté, United Nations Development Program Bolivia
Roberto Quiroz, International Potato Center, Peru
Rigoberto Espejo, Bolivia

Assessments of climate change show that developing countries in the Tropics are worse off than developed countries under different scenarios of global climate change, especially because they lack resources to invest in adaptation strategies (Kayser). Their populations are poorer, more vulnerable to the stresses and shocks brought about by climate variability and climate change (expressed in warmer climates), and increased droughts and floods (Kayser). Markets and political conditions also are important sources of stress and shock. Some households successfully cope with these events, and exhibit livelihood systems that are able to adapt. The populations of the Andes of Bolivia and Peru have persisted in agriculture for centuries, coping with climate variability, and with political, social and economic changes (Mayer; Orlove et al). Diversification has been a distinguishing characteristic of rural livelihoods in Africa and the Americas (Cotlear; Ellis). This trait is the opposite of specialization, believed to be an engine of growth in Tempreate regions. In the case of the Tropics, diversification is consistent with the need to manage climatic risk (Sakurai and Reardon), maximize use of resources (Mayer; Ellis; Valdivia et al), and achieve multiple goals (Valdivia and Gilles).

Research funded by NOAA in the Andes of Peru and Bolivia studied the livelihood strategies of rural families in agropastoral systems, in highland environments above 3,700 m above sea level. The purpose was to understand how families cope and adapt to climate variability and what role does information on climate play in their production and consumption decisions. We looked at assets, demographic characteristics, sources of information for decisions, and networks that household participate in, the integration to markets and what role they play in coping and adapting, and the capacity to generate forecast information in the Andes, both local and scientific capabilities.

The research evaluated the factors that affect livelihood strategies, and their relationship to diversification (a risk management strategy) and income generation. Changes in the strategies through time in Bolivian households of an Andean community were identified with data from three household surveys applied in 1993 (after an el Niño), 1995 (drought) and 1999 (a year of floods after El Niño). Livelihood strategies of household in the Peruvian Altiplano in 1999-2000 were also idenfied through household surveys, as were the networks to access forecasts, both in Peru and Bolivia.

Livelihood Strategies

The sustainable livelihoods framework guided the study, cluster and canonical correlation analysis were undertaken to understand the diverse set of livelihood strategies pursued (Valdivia et al 2000; Valdivia and Quiroz, 2003; Valdivia and Jetté, 1997, nd; Materer,

2001). The changing strategies and the coping dynamics provide lessons for long term adaptation to climate variability. To understand the relation between the capacity to cope and adapt to climate change or other external forces, we study how assets, capitals, and capabilities (Bebbington; Ellis; Valdivia and Gilles) relate to income generation and to a diverse set of activities expressed in the household portfolio. To identify the objectives and strategies of households and individuals in this context we use a household economic portfolio approach (Valdivia et al; Valdivia and Gilles), which is defined through political economics and peasant household economics perspectives (Ellis; Valdivia and Jetté; Bebbington; Valdivia and Gilles; Winters et al.). The purpose is to explain which factors shape strategies that contribute to both income and diversification of the economic portfolio in Andean rural communities.

To understand the capabilities of households to deal with variability of climates we studied the current access to forecasts, their use and local knowledge. Unlike previous ENSO events, information relating to the 1997 El Niño was available months in advance. Although this information was widely published and became common knowledge in developed countries, studies have shown that in Southern Africa and North East Brasil farmers did not respond to the information (Blench; Finan). The lack of utilization of the forecast information in these regions suggests that: a) a gap exists between the information needed and delivered (Blench); b) there is lack of trust or miscommunication between users and providers (Finan); or c) that even if the information is available the ability to respond by changing practices is limited or non existent (Finan; Broad); d) that capacity is not available at a local scale to address agriculture's needs (Espejo et al, 2003).

Assets

Resilience of peoples' livelihoods depends on their capabilities to adapt to internal and external shocks and stresses (Chambers and Conway). Tangible assets (natural, productive, physical, and livestock and other forms of stock), intangible assets (social capital and non-market institutions allowing access or control of assets or resources), and capabilities (human and cultural capital, and life cycle characteristics) shape livelihood strategies (Conway and Chambers; Bebbington; Adatto and Meinzen-Dick; Valdivia et al.; Valdivia and Gilles). Livelihood strategies are expressed in the set of activities that a family pursues. A diversity of economic activities is characteristic of a setting where production and consumption decisions are joint (Ellis; Valdivia et al a.), capitals are fungible (Chen and Dunn; Winters et al), and many factor and product markets are incomplete, or households are partially integrated to markets. In this setting, individuals in the household pursue many objectives – those maximizing income, managing risk, and activities of a social reproductive nature. Many assets and strategies contribute to the capacity to withstand shocks (droughts, market failure, strikes) in fragile environments like the Andes.

Factors that contribute to resilience are control of assets, the capability for collective action for negotiating with markets (Valdivia and Gilles), and including non-covariant activities. Asset composition is important in determining investments in the various activities, and that these decisions are gender dependent. Assets are resources in

production, and at the same time can be invested or divested, accumulated or depleted, from one year to the next. Examples often observed are divestment in natural capital by shortening the fallow fields and not replenishing the soil, or by pulling out children from school to work in the field, or reducing food intake, especially in years of shocks.

Livelihood strategies vary (Ellis; Cotlear; Valdivia et al), influenced by linkages inside and outside agriculture (Bebbington), and family life cycle characteristics such as age, education, and the number of family members. The degree of diversification of the household portfolio of activities is determined by these characteristics and by the household's and individual's objectives, such as risk management practices, consumer preferences, and/or strategies available to cope with shocks. If the diversification occurs only among crops, the portfolio will be more vulnerable to climate than if it takes place between crops and livestock; it would be less vulnerable if non agricultural activities are incorporated. The choices of the household are constrained by the combination of assets (productive, natural, human, cultural, public and social) that can be accessed (Bebbington; Chambers and Conway; Valdivia and Gilles; Winters et al). Households with assets are able to cope with adverse events.

Access to Information – Local Knowledge and Networks

What are current sources of information in the community? In peasant communities the relationship between agriculture and climate is much more intricate than in western cultures, and farmers are able to identify, with the aid of many indicators, specific and important weather patterns. Farmers base their crop and other production decisions on local knowledge systems, developed from years of observations, experiences, and experiments (Hatch; Bharara and Seeland; Osunade). Local knowledge forecasts provide more than just information about the forecast. They provide a set of behavioral rules that households and communities follow when certain indicators are or are not observed. Predicting climate is an important cultural component for farmers, as it is common to discuss indicators on the street, markets and with family members (Hatch). While Bharara and Seeland conclude knowledge systems will never be replaced with scientific knowledge, because these provide farmers the ability to make informed production decisions and prepare themselves psychologically, Bebbington (1991) defines local knowledge as a changing system, where western knowledge has a place.

In some areas, even with skillful probabilistic forecasts, producers may not be able to modify strategies to reduce vulnerability due to economic or other structural constraints (Muchna and Iglesias; Finan). Local knowledge may adapt to change as their livelihood strategies do (Markowitz and Valdivia).

Institutions: Markets

Households with access to markets can introduce new activities like the sale of labor, which does not depend on agricultural production. This contributes to liquid capital that can be used to deal with an idiosyncratic shock. Markets for commodities like milk can provide collateral to borrow in times of loss. Secured prices also work as an insurance, as is the case with dairy production in the Altiplano. On the other hand markets can create

incentives to specialize in production that is sensitive to climate, like potato production in the Andes.

Overall, improved cattle, in-kind and cash food crops, off-farm income, and forages seem to be the most important elements of strategies used by the households in SJL. Analysis was able to identify strategies that maximize income. In-kind and cash food crops was the variable associated the most with this goal of the household. Off-farm income and improved cattle contributed also contribute to this purpose both in Bolivia and Peru. In Bolivia only takes place in 1995, while in Peru it is an activity of families that are constraint by agricultural assets (land and animals). Improved cattle and forages are components of households with high income and diversity. The elderly in the Bolivian community seem more vulnerable that in the Peruvian communities. In Bolivia age was a determinant factor in relation to diversity and income.

Finding on Coping and Adapting

Our study of canonical correlations was significant (Valdivia and Quiroz; Barreda et al). What do these results mean in terms of coping and adapting to variability? In Bolivia, 1993, a year of average rainfall, the first canonical correlation indicates that households having high values of food crops, improved cattle and off farm employment will score high in response variable 1, which has a large contribution in income and is negligible on diversity. So for a year characterized by average rainfall, all these activities contribute to income. At the same time, the second canonical correlation indicates that households that have a combination of food crops, old age, and are low in labor and forages, may have a positive income but a negative effect on diversity, which may increase vulnerability. A decrease in diversity may result in increased vulnerability if families can only rely on crops, which is convariant with climate. It may not increase vulnerability if the income sources are off farm employment or if the elderly receive remittances. In San José Llanga the elderly are bequeathing their assets and relying more on family networks because of their loss of labor availability.

In 1995, a year of drought, it is interesting to note that off-farm employment is the only factor that scores high with a response variable 1 that is high in income, and negligible in diversity. This is consistent with the fact that off-farm employment becomes a buffer with climate stress. The second canonical correlation in this year is a bit more complex to explain. Households having a high amount of forages and improved cattle but low off-farm employment and food crops will attain a high strategy 2 value. For the responses, high values of diversity and low in income will score high on response 2. This highlights that an important mechanism to maintain diversity is based in building buffers such as livestock and forages, and is especially useful during drought periods like 1995. The low value in income in response 2 is consistent with low productivity of food crops in that year.

In contrast, 1999, also an average year of rainfall following el Niño, shows that households with a strategy based on food crop production correspond to a response 1 that is high on income and negative on diversity. On the other hand, households high in

improved cattle and with young household members correlated with a response variable high on diversity and negligible on income. The results seem to indicate a tradeoff based on access to resources or assets. Household that mainly have access to land for food crops, may benefit in good years, and lose during bad years. This has an impact, as income will be variable. Only if accumulation takes place in the good years, buffers can be built for the bad years. In the Andes chuño is an example of this possibility, both for home consumption and for market. For consumption as this freeze dried potato can be stored for many years, and it also is a value added product that commands higher market prices. Potato production for markets has increased through the years since 1992. It has become a strategy for a group of families that link to markets, and can provide an opportunity for accumulation, though prices were decreasing in 1999-2000. Households that are more diverse and rely on livestock activities appear to have a consistent income in years of stress and average years, and smooth income from year to year.

The experiences of strategies and their impact on diversification and income indicate that households relying mostly on food crop production will attain high income in years of average rainfall, but will not be able to achieve this during droughts, which is obvious. It also highlights the fact that in the case of Bolivia off-farm income seems to be mostly an activity that becomes important during stress – 1995. Elderly households seem to be less capable of diversifying, and only in 1993 seemed to have a positive relationship to income, but consistently negative with respect to diversity. Finally activities like forage and dairy seem to contribute to a diversified portfolio in agriculture, because of their nature as a buffer (feed) and cash source through milk sales.

In times of stress, such as the drought of 1995, households with improved cattle and forages, as well as linkages to the outside coped by generating income off the farm. There was less need to liquidate livestock assets, and as a consequence the growth of the herd suffered less. Diversity in 1995 fell slightly and more than recovered in 1999 for those with higher numbers of improved cattle. The elderly and the extensive/potato have seen a continued loss of diversity. More vulnerability, and a decrease of sheep through sales, with high labor demand in the household to invest in potato production is resulting in a loss of diversity (although not necessarily potato diversity (Materer 2001)) that may result in less access to protein in the diet.

Lessons from short term variability and adaptation

The study of livelihood strategies over the span of seven years using three data points underscores the dynamics of household activities that turn on and off according to events. Food crop production has been an effective activity in generating cash and in-kind income for the households, but it does have drawbacks when droughts or floods occur. The effect of markets has shifted the weight of production for consumption to production for markets, but the households pursuing this strategy are less diversified and more exposed to climate variability. The frequency of the climate events will have an impact on the ability to produce seed, and therefore on the ability to increase production in a following good year of rains. In terms of the resilience of the livelihood strategy, it appears that building buffers and support systems as was the case of dairy production in the Altiplano, allows for activities that adapt better to variability. Some have positive

externalities, as the introduction of forages not only allowed for dairy but also for improved sheep, a woman income domain (Valdivia and Gilles). It may have also displaced sheep as women have to manage both sheep and cattle. Linkages to markets, through employment, and sales of dairy products and value added crops have buffered some families from climate variability, allowing them to cope with events during this period, and may in the long run contribute to adaptation. This will depend on the ability of rural families to continue to develop their capacity to negotiate. Overall, the livelihood strategies of this community speak to flexibility, opportunistic behavior, and testing of new activities, qualities that are consistent with adaptation. Concerns remain about the elderly and poor families that are depleting rather than accumulating assets, even during average rainfall years (Materer). These groups require targeted policies that can foster their ability to conserve rather than deplete resources in times of stress or shock.

Institutions: Lessons on Networks

Our analysis of local knowledge and mechanisms to access information about climate found that farmers don't incorporate scientific forecasts in their decisions because of a preference for locally based forecasts. Previous work in more developed countries has suggested that a barrier to forecast use has been lack of understanding of probabilistic forecasts. Considerable effort has been placed on educating users on how to interpret these.

Understanding probabilities does not seem to be the main barrier in the Altiplano. The local, traditional forecasters that producers rely upon, use techniques that include an intuitive approach to probabilities. Local forecasters are potentially the conduit by which forecasts could reach producers. If local experts believed in the accuracy of scientific forecasts, this information would be incorporated into their predictions. In the case of Altiplano producers, the widespread belief that forecasts are only valid for the location in which they are generated – i.e. a forecast produced by an office in Lima or La Paz is only valid (at best) for Lima and La Paz.– is the major barrier to forecast use. Improvements in the communication of forecasts will not lead to increased use of forecasts, unless there is a way to overcome this belief. These results emphasize the importance of working with local experts and with validating down-scaled forecasts.

The current research suggests that we should modify some of our beliefs about indigenous knowledge. It has long been noted by anthropologists and folklorists that traditional knowledge disappears with modernization and the incorporation of indigenous peoples into global and national economic systems. Traditional knowledge becomes confined to the elderly and is lost when they die. The situation found in the three communities examined in this study suggests that these ideas need to be modified. Although local climate experts are elderly, the knowledge of traditional forecast indicators is not limited to this cohort of individuals. Knowledge of traditional indicators remains widely distributed across age and economic groups. The ability to manage multiple, sometimes contradictory, indicators is being lost however. Almost all of the local experts were nearly full time farmers who spent nearly all of their time in their villages working on their farms. People with off-farm or non-farm activities did not spend sufficient time in the field to develop accurate forecasts and people who were

primarily livestock producers were not as interested in forecast information. In short one of the techniques that farmers use to deal with risk, income diversification, is undermining their abilities to forecast climate risk. Because traditional knowledge is still widespread and because it uses some indicators that have a scientific basis, the best way to improve and to communicate forecast information is probably through a partnership with local experts.

Acknowledgment

The Office of Global Programs, National Oceanic and Atmospheric Administration provided partial funding for this research through grant NA96GP0239. We are grateful for their support. We also would like to acknowledge the SR-CRSP, USAID Grant no. 138-G-00-0046-00, which funded research on Sustainable Agropastoralist Systems in the Andes, through which the 1995 data was collected. We are especially grateful to the people of San José Llanga, to Ramiro Carrillo for his outstanding work in the field and who we miss.

References

Adato, M and R Meinzen-Dick. 2002. Studying the impact of agricultural research on poverty using the sustainable livelihoods approach. Prepared for International Conference on Impact of Agricultural Research and Development. San José Costa Rica. February.
Bebbington, A. Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty. World Development. 27(1999, 12): 2021-2044.
Chambers, R. and G. R. Conway. 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. Discussion Paper 296. IDS, London.
Chen A and E Dunn. Household Economic Portfolios. AIMS Project Report, USAID/G/EG/MD. Management Systems International. Washington DC
Easter, C. 2002. Effects of Transaction Costs and Household Participation. Market Integration Within the Southern Highland Region of Peru. Unpublished MSc Thesis Agricultural Economics University of Missouri Columbia.
Ellis, F. Household Strategies and Rural Livelihood Diversification. The Journal of Development Studies. 35(1): 1-38. 1998.
Espejo, R., J. L. Gilles, C. Valdivia and C. Jetté. 2003. Poster: "Using network analysis to improve forecast use among vulnerable farmers: The Case of Bolivia." Open Meeting of the Human Dimensions of Global Environmental Change Research Community. 16-18 October, Montréal, Canada.
Jovel, R., A. Tapia and I. Thompson. Bolivia: Evaluación de los Daños Originados por el Fenómeno de El Niño en 1997-1998. CAF. La Paz, Bolivia. 1998.
Kayser, H. Assessing Research on the Impacts of Climate Change on Agriculture. Ch 7 in Frisvold, G and Kuhn, B (eds) Global Environmental Change and Agriculture. 1998.
Markowitz L and C Valdivia. 2001. Patterns of technology adoption at San José Llanga: Lessons in agricultural change. Chapter 7 in Coppock D L and C Valdivia (eds) Sustaining Agropastoralism on the Bolivian Altiplano: The Case of San José Llanga. Department of Rangeland Resources, Utah State University, Logan Utah. 292 pp.

Materer, S. 2001. The Role of Potato Production in Diversified Household Economic Portfolios: Study of San José Llanga, Bolivia. Unpublished MSc Thesis. Agricultural Economics University of Missouri Columbia.
Mayer, E. 2000. The Articulated Peasant. Household Economies in the Andes. Westview Press. Oxford.
Morduch, J. 1995. Income Smoothing and Consumption Smoothing. Journal of Economic Perspectives. 9 (Summer 1995): 103-114.
Orlove, B, J. C. Chiang, and M. A. Cane. 2000. Forecasting Andean rainfall and crops yield from the influence of El Niño on Pleiades Visibility. Nature 403: 68-71.
Pratt, D.J., and J. D. Shilling. 2002. High Time for Mountains. A Program for Sustaining Mountain Resources and Livelihoods. World Development Report: Background Paper.
Reardon T, C Delgado, and P Matlon. 1992. Determinants and Effects of Income Diversification Amongst Farm Households in Burkina Faso. J of Dev Studies. 28(2).
Ribot A, Magalhäes R and S Panagides. Climate Variability Climate Change and Social Vulnerability in the Semi-arid Tropics. Cambridge University Press, Cambridge. 1997.
Sakurai, T and T Reardon. Potential Demand for Drought Insurance in Burkina Faso and Its Determinants. Amer. J of Agricultural Economics 79 (November 1997): 1193-1207.
Townsend , R. Consumption Insurance: An Evaluation of Risk Bearing Systems in Low Income Economies. *The Journal of Economic Perspectives* 9 (Summer): 83-102.
Valdivia, C. Household socioeconomic diversity and coping response to a drought year at San José Llanga. Chapter 6 in Coppock D L and C Valdivia (eds) Sustaining Agropastoralism on the Bolivian Altiplano: The Case of San José Llanga. Department of Rangeland Resources, Utah State University, Logan Utah. 292 pp. 2001
Valdivia, C., E. Dunn and C. Jetté. Diversification as a Risk Management Strategy in an Andean Agropastoral Community. AJAE. 78(5) (1996 December): 1329-1334.
Valdivia, C., C. Jetté, R. Quiroz, J. Gilles, and S. Materer. 2000. Peasant Household Strategies in the Andes and Potential Users of Climate Forecasts: El Niño of 1997-1998. American Ag Economics Association Selected Paper. July 30- August 2. Tampa, FL.
Valdivia, C. and J. L. Gilles. 2003. "Coping and adapting to climate variability in the Andes: strategies and local knowledge." Open Meeting of the Human Dimensions of Global Environmental Change Research Community. 16-18 October. Montréal, Canada.
Valdivia, C. and R. Quiroz. 2003. Coping and Adapting to Increased Climate Variability in the Andes. Selected Paper American Agricultural Economics Association. July 27-30, Montréal Canada. http://agecon.lib.umn.edu/cgi-bin/pdf_view.pl?paperid=9073&ftype=.pdf
Valdivia, C. and J. L. Gilles. 2001. Gender and resource management: Households and groups, strategies and transitions. Agriculture and Human Values. 18 (2001 1): 5-9.
Valdivia C. and C. Jetté. 1997. Peasant Household Strategies, Technologies and Diversification in Andean Fragile Lands. Agricultural Economics Working Paper. AEWP-1997. University of Missouri Columbia MO.
Winters P, B Davis, L Corral. 2002. Assets, activities and income generation in rural Mexico: factoring in social and public capital. Agricultural Economics 27 : 139-156.