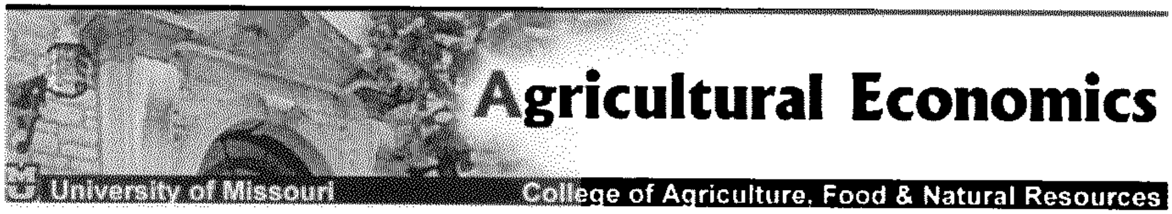

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Department of Agricultural Economics Working Paper No. AEWP 2001-4

February 25, 2002

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AEWP-2001-04

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Keywords: Climatic variability, El Niño, Coping Strategies, Rural Livelihoods, Climate Forecasts

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Acknowledgments

The Office of Global Programs, National Oceanic and Atmospheric Administration provided partial funding for this research through grant NA96GP0239. We would like to acknowledge the SR-CRSP for funding a project that provided the data for 1995. We also are grateful for the hard work of Ramiro Carrillo, Edgar Cala and Justina Condori in the application of the survey in 1999, and to Mariana Cruz from the International Potato Center, for development of the data base. We are especially indebted to the families of San José Llanga, who contributed their time to both answering our questions, and improving the way we develop these.

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Abstract

Production strategies pursued by households and individuals in a peasant community of the Bolivian Altiplano are shaped by access to resources, social networks and institutions, wealth, and the ability to develop urban rural linkages. In times of climatic stress such as the low rainfall of 1995, the household economic portfolio shifts to activities less vulnerable to climate. The ability to shift is conditioned by access to resources, social capital, stage in the life cycle and wealth. A typology developed to understand how strategies take shape during a drought is used to evaluate access to information during el Niño (1997-8) and impacts on potato production in 1998-99. The relationship between diversification and use of climate forecasts (local and modern) is evaluated. The study proposes that diversification and use of forecasts may go hand in hand, and should be considered in the profile of potential users.

Introduction

Droughts, frosts, and ENSO events have an important impact in the Bolivian Altiplano. El Niño's impact of 1997-98 was significant in Bolivia, with the highlands' drought contributing 53% of the total $527 million damage suffered (Jovel). Production of food crops fell in 1998-1999 according to the Bolivian Agriculture Ministry. Among these, potato and quinoa, two important traditional food crops grown in the Andes. The decrease in potato production especially affected the poor, and seed production (Jovel, 1998).

Household producers in highland semiarid production systems of the Andes face climatic variability, characterized by droughts and El Niño Southern Oscillation (ENSO) events. These climatic events as well as economic, social, cultural and biotic factors, shape the mix of activities in and outside of the farm (Valdivia and Jetté; Valdivia et al.; Bebbington, 1999). Many argue that with improvements in forecast skill such as ENSO's, these negative impacts could be reduced by improving disaster preparedness, or informing production decisions of small holder farmers.

To unveil distinct household livelihood strategies and their use of climate information, a peasant household production approach is developed. In light of the strategies identified, current access to sources of climate information for potato production decisions are analyzed, as this crop is an important but vulnerable food grown in the highlands of Bolivia. Three research questions are answered: 1) What are successful household strategies developed to cope with climatic perturbations in the Andean region; 2) What sources of information are accessed, local or modern, to make production and consumption decisions; and 3) Are there differences among identified groups of farmers in current or potential use of climate forecasts. Some authors hypothesize that the greater the degree of diversification and the higher the importance of livestock in relation to crops, the less will farmers respond to these forecasts (Blench). This research aims to shed light on this hypothesis.

Profiles of Forecast Users

Forecasts are useful if they are skillful, timely and relevant to potential users (Stern and Easterling). Forecast information must address current needs, be expressed in the language of the users, and be trusted by the potential users (Price; Stricherz; Blench; Stern and Easterling; Finan). Even if these conditions take place, these forecasts will probably be useful only to certain types of producers (Blench), as not all farmers can equally access nor use the information (Finan;

Broad). Blench proposes that these forecasts are only relevant to producers that conform to the following profile: large and specialized operations, high in human capital safety nets and information, and dependent on rainfall. These types of producers will gain by accessing forecast information, because they can bear the risks of the outcome, having more cash to protect themselves from inaccurate forecasts. However, some studies show (Ellis; Cotlear; Valdivia et al.) that wealth and diversification may go hand, which implies that not only specialized rich farmers may benefit from forecasts. To identify different rural livelihood strategies the study uses a peasant household framework, because it recognizes the simultaneity of production and consumption decisions, and the interaction between agriculture and nonagricultural activities. It also allows incorporation of non-market access to resources, and life cycle effects.

Access to forecasts, use of forecasts, and local predictions.

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).

What are current sources of information in the community? Are there differences according to the identified groups? Can the information provided by the forecast agencies replace the information generated from the local knowledge systems? Do probabilistic forecasts convey more information than the local knowledge systems convey?

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). Users' 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 weather 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 forecasts, producers may not be able to modify strategies to reduce vulnerability due to economic or other structural constraints (Muchna and Iglesias; Finan). In other cases communication is a hindrance. Local forecasts , as knowledge, are embedded and may adapt to change as their livelihood strategies do (Markowitz and Valdivia).

Rural Livelihood Strategies, Climate, and Forecasts

Rural livelihood strategies are shaped by several factors. In the Andean region climate is important in production and consumption decisions. Other factors affecting rural household decisions are access and control of human, natural, productive, cultural and social capital (Bebbington, 1999), markets, institutions, and the political environment. These strategies are diverse (Ellis), a function of linkages in and outside agriculture. Age, education and stage in the life cycle also affect these strategies (Valdivia and Jetté).

Stage in the life cycle, household's access to resources, and risk and loss management strategies to cope with a shock, affect the degree of diversification. In areas of greater risk household strategies are expected to be more diversified as a mechanism to minimize possible shocks from negative climate events, especially when loss management strategies are limited. Households with portfolios of economic activities that are diversified and have less covariant activities, will be able to cope better with climatic risk (Reardon et al.). As income grows moving families away from food insecurity, some expect that households will specialize, and use insurance markets instead of diversification to deal with risk (von Braun et al.).

Stage in the life cycle affects the degree of diversification. Households in their initial stages start to accumulate and their ability to expand or diversify their portfolio is limited. As accumulation grows, diversification in agriculture and in non agricultural activities can take place. As families become old and resources are bequeathed households become less diversified (Kusterer).

Diversification, is also a strategy to maximize use of resources (Ellis), and may persist with greater levels of wealth in environments such as the Andean region (Cotlear). In these environment type of resources - natural, human, social and productive- accessed determines how households diversify.

When climatic perturbations or any idiosyncratic risk take place, households may access resources through networks of families and friends. These are ex-post, consumption smoothing management strategies. Besides accessing networks, other strategies may include liquidation of assets, and temporal migration (Dunn et al.; Valdivia et al.;Ellis; Bebbington). All these are pursued in the Andes.

This case study of San Jose Llanga illustrates two issues. The first is that rural livelihood strategies in the Andes are diverse, and that decisions on when and how much to produce depend on both local knowledge systems and resources constraints. The next section provides information about the setting, followed by an analysis of the livelihood strategies using only local knowledge systems, during an average rainfall year and a drought.

Location and Methods

Climate, El Niño, and the Altiplano

The region of study, Aroma Province in the Department of La Paz, has an average rainfall of 404 mm., with a coefficient of variation of 30%. During the1983 and 1980 El Niño events total rainfall were 197.6 mm, and 231 mm respectively. The differences in total rainfall during El Niño years provide a measure of unpredictability. Even if producers know there is a El Niño year, the range in outcome is large. Added to this is the fact that rainfall is also erratic during non El Niño years. For example, in 1992-1993 annual rainfall was 388.5mm, and while it was only 241.9 mm in 1994-1995. Besides the variation from year to year, farmers also have to deal with the uncertainty of the onset of the rains, and variation in rainfall throughout the growing season. From July to April the uncertainty is especially important, since this period is crucial for crops.

For example in 1998-99 precipitation was 422 mm with 78 days of rainfall, while during the Niño event of the previous year (97-98) was 359 mm in 57 days. Major rainfall deficit months were December and January of 60% and 30% respectively, while October November and March were months of 50% surplus in 1998-99 (Bolivia-MAGDR, 1999).

Frost events are another risk faced by many crops. Potato and quinoa are vulnerable to both (Le Tacon et al.). The probability that potato growth will be affected by frost is 30%. The probability of 90 days of production free of frost in Patacamaya is 62%, while for 120 days is 45% (Le Tacon et al.). Spatial variation, with several plots of different soil types geographically dispersed, staggered planting, and several potato varieties are managed to deal with variability (Le Tacon et al.).

San José Llanga is an agropastoral community, 116 Km south of La Paz, Bolivia's capital. Located in the central Altiplano, at 3,786mts above sea level. Mean annual precipitation between 1943 and 1990 was 402 mm, with a coefficient of variation of 31%. Periodic droughts and ENSO events affect this area (Washington-Allen). This community exhibits diverse production strategies, growing traditional food crops such as potatoes and quinoa, as well as raising animals, cattle and sheep. The community controls 7,200 has of land, with six settlements or neighborhoods. (Valdivia and Jetté). Fallow agricultural land and crop residues are important in the integration of cropping and livestock production.

Rural livelihood strategies

In order to unveil distinct household strategies, a household/peasant economic portfolio approach is used to develop a characterization. The need for climatic information may vary according to the diverse strategies identified. A survey was applied to 45 families (50% of the population) in San José Llanga, in 1995, to identify the types of production strategies pursued by households during a drought year. In 1999 a second survey is applied.

Nine variables are identified and cluster analysis is applied to the 1995 data set (Valdivia and Jetté). The variables chosen capture stage in the life cycle, types of technologies used, either intensive or extensive, the incorporation of commercial activities, the ability to invest in technologies less vulnerable to drought and frost, the level of investment, and the capacity to generate income outside of agriculture. The set of variables corresponds to a household peasant economics framework. The operational variables chosen are the following: labor available to the household measured in adult equivalents (Valdivia and Jetté), age of the head of the household, number of criollo/local sheep, number of improved sheep, criollo cattle, improved cattle, forage area, assets for investment (cattle numbers that can be liquidated), wages received, and consumption (estimated from in-kind production and cash expenditures).

The variables reflect assets or set activities that are distinct (Bebbington, 1999). Age and access to labor capture life cycle effects on rural livelihood strategies. Irrigated land, captured by forage area, represents resources owned less vulnerable to droughts. Criollo sheep and criollo cattle represent access to livestock that is less sensitive to drought and feed availability. Improved sheep measures availability of feed resources, while improved cattle reflect market integration, production of a cash crop, in this case dairy. Wages/off-farm income aims to capture a non agricultural activity to diversify income sources, and consumption (in-kind and cash production for consumption) measures the ability of the household to satisfy a safety first condition, food security. Net income from cattle measures the ability to capitalize and invest in new opportunities, as well as migrate through pull effects to other areas. A diversity index measures the level of diversification of each group. The inverse Simpson (Valdivia et al.) is used to calculate the number of activities and their share on the income being generated.

By analyzing the household strategies a pattern is revealed as to how families produce in a climatic variable zone. The meaning of these activities is explored to understand households' response to 1995's climate event, a year of 'delays and lower rainfall'. Changes in production strategies are consistent and reveal important insights into adaptation and security. In September of 1999 a household survey was applied to gather information about El Niño and La Niña years. The information on local knowledge systems and impact of ElNiño on production in 1998-99 is evaluated based on the strategies identified in 1995.

Results

What are successful strategies developed to cope with climatic variation

The analysis of the 1995 survey provides information about the livelihood strategies pursued by households, with household decisions informed by local knowledge systems about forecast of the production year. Table 1 presents the characteristics of each distinct strategy, in a year characterized by delayed rains and low rainfall levels.

Livelihood Strategies in 1995

Cluster analysis applied to the data identified livelihood strategies defined groups first by the stage in the life cycle. Two major groups reflecting distinct strategies are identified as the productive and the elderly. The productive group is divided in two subgroups, those generating significant off farm income (rural strategy), and those that rely mostly on agricultural production (agricultural strategy). Table 1 presents these groups. The productive rural strategy is younger, and depends on off-farm employment to complement farming activities. Their farming operation consists of dairy production as well as sheep and food crops, with off-farm income being very important. The productive agricultural strategy relies basically on farming with low income from off farm opportunities. Those with greater access to labor generate in the agricultural strategy have larger income for consumption.

Two risk reducing activities were incorporated to manage risk in 1995, off farm employment and increase in livestock/forage production. The first is growth of off-farm income in the rural group (Table 1). Those depending mostly on agriculture are investing more in forages. Producers with limited capacity to invest in dairy are increasing the area planted to potatoes. This area grew to be similar to that of the wealthier farmers pursuing the rural strategy.

Diversification

Diversification, as mentioned before, allows families to reduce the vulnerability caused by climatic variability, and maximize use of resources. An Inverse Sympson Index (Valdivia et al) is calculated for each household in 1995. The greater the index, the larger the number of activities and the evenness in the share of income from each activity. Table 1 shows that the differences between the elderly and the productive in the degree of diversification. As expected (Kusterer) older households are less diversified than younger households. Differences in diversity index also existed between those with off farm interactions, and those relying mostly on agriculture. Diversity and income move together, indicating that diversity and wealth behave as in other rural areas of the developing world (Ellis; Cotlear).

Diversification is not only a risk reducing strategy, but also maximizes use of resources. The group pursuing off farm activities has more income, suggesting that their linkages to markets allow them access to information and other income improving opportunities.

Analysis of income sources in 1998-99 (La Niña year) indicate that farmers revert to agricultural activities. This was a year considered to benefit potato production, and farmers were able to rely on their own resources in agriculture.

How do farmers currently use information from forecasts and local sources to make production and consumption decisions

Regardless of the degree of wealth and the stage in the life cycle, all families in San José Llanga grow potatoes as their basic staple food. Several varieties are planted, some are native varieties while others are introduced. Native bitter varieties, tolerant to frosts and droughts, are planted by few families. Introduced varieties are mostly produced for the market. Table 2 shows the mean area planted to potatoes in 1993, 1997-8 and 1998-1999 by each group. The area planted to potatoes has grown, especially for the group that relies mostly on agriculture (Valdivia et al., 2000).

Vulnerability to drought

The change in potato production between 97-98 and 98-99 is significant. Table 3 shows the growth in potato production by group strategy. The groups experiencing the greater percentage change are the extensive producers and the elderly, indicating these were more vulnerable to El Niño. These groups proportionally were less aware of El Niño, and those that were did not change production decisions (Table 4). The levels of production between the rural and agricultural strategies, in absolute terms differ, with the first achieving higher production both in 1997 and 1998.

Constraints to potato production in 1998

Even though the data shows that potato production increased between both years, this increase is limited by lack of seed our cash outlays to cope with El Niño in the previous year. Reasons affecting producers ability to increase production further in 1998 are presented in table 5. The lack of seed resulting from the El Niño year had equal impact across groups in planting for 1998-99. Proportionally more households in the agricultural group had monetary constraints to purchase seed and pesticide. Fertilizer purchase constraints was similar in all three groups. The proportion of households where access to more land for planting was a constraint was proportionally greater for the elderly first and second for the rural groups. Overall economic constraints had similar importance in all groups. Very few households, all in the agricultural group believed that 1998-99 would be bad for potato production. Households that did believe the year would not be favorable, did not rely on neighbors nor outside sources for their beliefs about climate and the year. These households were concentrated in the agricultural group.

Use of information about el Niño: differences among farmers in the actual or potential use of climate forecasts

For the most part, farmer's knowledge of climate came from natural indicators and traditional knowledge (Table 6), which can be defined as local knowledge systems. Nearly all farmers, regardless of group (98%) used natural indicators such as the wind direction in early August, and biological indicators such as the flowering of T'ola and the behavior of birds and other animals. Traditional knowledge of weather patterns obtained from elders was also important for the agricultural households. Only 4% total used mass media to obtain information, and 20% of the rural relied on neighbors, as opposed to the elderly that were only 10 percent. None used the technical knowledge produced by governmental or non-governmental organizations and institutions. In terms of indicators mentioned in focus group interviews the agriculturalists in Incamaya provided more detail of the indicators. But all coincided in trusting the behavior of the winds to determine if there would be a drought. While farmers still relied on local knowledge to predict the production year, there was a concern about the ability to predict in recent years.

Local knowledge was the source of virtually all of the farmer's ideas about climate. A large proportion of households, 75%, had been aware of the 1997-1998 El Niño event, as publicized, but the timing of access to the information for most farmers may have been too late. The elderly appeared ignorant of the phenomenon. This information raises two interesting possibilities: 1) that awareness of the El Niño phenomena does reach farmers but not in time for decisions to be taken and 2) that knowledge of El Niño comes indirectly through personal networks and not from forecasts or official sources, as sources of information (table 6) indicates.

At the individual farm level, only the farmers who reacted to climate forecasts were those in the rural strategies group. These farmers can include the probability of a wetter or drier year into their production decisions even though the information by itself has limited predictive value for producers. The richer farmers (rural strategy) and diversified farmer who has the opportunity to invest in off farm activities can benefit from this information. Knowing that there is an increased likelihood of drought or floods may help them decide how to allocate labor during the year. Larger farmers who do not have large sources of off-farm income do not have alternative uses for their labor. These farmers were more vulnerable to El Niño because the amount, but had a great ability to recover in a year of good rainfall. This group has also other activities, and can shift resources to these when a drought is anticipated. As compared to the rural group, the other groups did not react nor change practices with knowledge of El Niño. This also may be because some of these farmers obtained this information too late. A current study will unveil the timing of the information question.

The ability to expand production further after a dry year is limited by access to cash in almost all instances. Their ability to buy seed and fertilizer and to rent tractors is influenced by the conditions of the previous year. In other words, these farmers are unable to expand production rapidly after a drought because their cash reserves are depleted. Expansion will not occur even with information that the next year will be better. The elderly are unlikely to benefit from forecasts. They are limited by their income and perhaps their available labor. They plant as much as possible every year but are limited by their ability to access seed and land.

The group of farmers who are most likely to change farming practices in response to weather forecasts are those farmers who are diversified, have livestock and have significant amounts of off farm income. This finding is contrary to what is expected by Blench's profile of users: High risk farmers would find forecast information more useful than more diversified farmers. Since diversification is a strategy to reduce risk, diversified farmers are less vulnerable to climatic conditions and consequently would not value forecasts as much as more specialized producers whose livelihoods were more exposed to the elements. Our findings, belie these assumptions, those who changed their planting practices had significant off farm sources of income that made them less vulnerable to the vicissitudes of weather. We propose that it may be that these groups use forecasts to maximize income rather than to reduce risk. They can shift labor to non-farm activities if they feel that yields will be lower. Farmers who are most dependent upon agricultural production lack the means to change production strategies significantly. They lack the outside resources needed to shift strategies drastically in order to respond to possible weather shifts.

Basically under present conditions, the portion of the population whose well-being is most affected by weather conditions is least likely to alter behavior based on forecast information. This situation will not change unless there are institutional changes that facilitate producers relying mostly on agriculture to develop alternative strategies to respond to forecasts.

Conclusions

The approach proposed unveiled household strategies and the ability of different groups to access and take advantage of forecast information. This approach showed that wealthy diversified households have a use for improved forecasts and the flexibility to change activities in their economic portfolios. Overall strategies in 1995 show there is a move towards livestock production strategies, which is an activity less vulnerable to weather fluctuations, and to off farm income activities.

The study showed that local knowledge systems are the basis for the forecasts in all groups of households. The few that accessed information from outside the community were in the rural group, while those who accessed information from community networks were in the productive group. The greater proportion of households who knew of El Niño was in the rural group, and shifted their production activities. Access to off-farm income provides flexibility and the ability to take advantage of improved forecasts. Access to less vulnerable activities in the farm could allow farmers to invest more in those activities in years of anticipated high probability of drought.

Although focus groups indicated that farmers are observing their indicators to be less reliable than in the past, these are still essential sources of information for households, explaining the evolution of complex risk reduction strategies.

Two points should be kept in mind in observing the use of forecast information within the community of San José Llanga. The first is that although the El Niño event of 1997-1998 was strongest than the 1983 event, it did not impact the Altiplano nor San José as dramatically. The second is that periodic droughts are common during non El Niño year, and the ability to predict these events is more difficult. For example in 1995 San José and other areas of the Altiplano experienced a severe drought, affecting crops and livestock production. Total reliance on modern forecast information will not be a strategy employed by farmers in the Altiplano. If the forecasts are to be incorporated, these will be combined with local knowledge systems, providing farmers with a back up strategy and decision making processes.

Currently in Bolivia information about El Niño in 1997 and La Niña in 1998 was provided through the National Early Warning System and Food Security (SINSAAT Sistema Nacional de Seguimiento de la Seguridad Alimentaria y Alerta Temprana), and was used mostly to assess the impact at the regional level, not to provide information at the micro level. A next step should be an assessment of a potential forecast system for the user in agriculture, as there is the possibility that some producers in this region may benefit from access to this information.

Table 1. Identified Groups of Household and their Characteristics in 1993 and 1995 in San José Llanga, La Paz, Bolivia

	Rural livelihood Strategies in 1995			
	Productive Rural	Productive Agricultural Resource Access	Productive Agricultural Strategy Less Resources	Elderly
Age (years)	41.9	49	47.7	67
Labor (adult eqv.)	2.9	2.8	3.9	1.4
Criollo Sheep (head)	4.7	16	19.1	1.2
Criollo Cattle (head)	1.3	4.4	0.4	0.6
Improved Sheep (head)	42.3	12.4	10.1	6.2
Improved Cattle (Head)	5.8	5.3	5.2	0.6
Forages (has)	4.1	4.2	7.3	1.6
Consumption Bolivianos	9,703	4,253	5,837	1,944
Off-farm Income Bolivianos	4,809	333	952	301
Diversity Index*	3.3	2.95	2.97	2.64

Sources: Surveys of rural households in San José Llanga in 1995

*Valdivia et al.

Table 2. Income Sources in 1998, by strategy, in San José Llanga.(Bolivianos)

Income Source	1995			1999		
Strategy	1	2	3	1	2	3
Food Crops	1,784	1,475	802	5,630	5,301	1,450
Sheep	2,081	1,477	489	1,059	776	97
Cattle	2,431	3,886	683	7,850	2,929	118
Milk Sales	932	1,179	58	2,678+	4,090+	371+
Wages	4,809	681	301	275	200	123
Other Income	104	352	284	0	0	172
Welfare	9,703	5,045	1,944	9,642	10,367	2,213
Expense						

Exchange rate: $1=4.5 in 1995; $1 = 6Bs in 1999. + Estimated, not actual.

Table 3. Mean Amount of Potato Harvested (quintals) by Group and Growth between 1997 and 1998

Cluster	Harvest 97-98			Harvest 98-99			Growth
	Qty	Ha	Yld	Qty	Ha	Yld	
Rural	5,590	1.6	3,494	7,235	1.5	4,823	38%
Agricultural	4,989	1.4	3,564	9,700	1.7	5,706	60%
Elderly	2,351	0.8	2,938	6,830	1.2	5,691	93%

Source: Survey of 1999 with 42 observations; 1997-8 with 45 observations. Excluding highest quantity/outliers, group two: from 3,850 to 6,095Kg, and group three from 3,910 to 6,003Kg.

Table 4. Knowledge of El Niño Event, and Change in Planting Area by Group in 1997.

Group	Knowledge	Change Area	Did Not Change	Total
Rural	No	0	0	0
	Yes	4	6	10
Agricultural	No	0	3	3
	Yes	4	15	19
Elderly	No	0	6	6
	Yes	1	3	4
Total	No	0	9	9
	Yes	9	24	33

Source: Survey of 1999.

Table5. Percent of households and reasons for not planting more introduced potato varieties in 1998-1999 by groups.

Reasons for not planting more	Groups (%)		
	1	2	3
R1: Did not have more seed	70	73	50
R2: Did not have more land available	30	18	40
R3: No more money to purchase seed	50	59	40
R4: There was no seed available in market	10	5	20
R5: Could not purchase more fertilizer	20	18	10
R6: Did not have cash to purchase pesticide	10	5	10
R7: Did not want to grow more of the type	0	0	0
R8: Feared the climate would not be good	0	9	0
R9: Feared the year would not be good	0	14	0
R10: Did not have more prepared land	40	27	40
R11: The variety is not marketed	0	5	0

Source: Survey 1999. Group 1: rural. Group 2: agriculture. Group 3: the elderly.

Table 6. How do you know if the climate will be good or bad: Sources of Information in San José Llanga (% responding they use the source).

Factors that contribute to knowledge about climate Cluster	Respondents Yes % 1 / 2 / 3*
1. Knowledge from our grandparents	56 50 73 20
2. Information from radio or TV	4 10 5 0
3. Neighbors in the community	16 20 18 10
4. Neighbors from other communities	0
5. Technical personnel from Organizations or Institutions	0
6. The Bristol Calendar (Farmers Almanac Bristol)	4 0 4 0
7. Natural Indicators (Three days in August, winds from north or south)	98
8. Biological Indicators (flowering of bushes, birds, other animals)	98
9. Other: Dreams, God's disposition	29 10 32 40

Survey of 45 households in 1999.
*Second line shows the percent distribution per group. 1: rural; 2: agricultural; 3: elderly.

References

Agrawal, A. 1995. Dismantling the Divide Between Indigenous and Scientific Knowledge. Development and Change 26: 413-439.

Bharara, L.P. and K. Seeland. 1994. Indigenous Knowledge and Drought in the Arid Zone of Rajasthan: Weather prediction as a means to cope with a hazardous climate. Internationales Asienforum. 25:53-71.

Bebbington, A. 1991. Indigenous Agricultural Knowledge Systems, Human Interests, and Critical Analysis: Reflections on Farmer Organizations in Ecuador. Agriculture and Human Values. 8: 14-24.

Bebbington, A. 1999. Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty. World Development. 27(12):2021-2044.

Blench, R. 1999. Seasonal Climate Forecasting: Who can use it and how it should be disseminated? Natural Resource Perspectives. No 47, November 25. Overseas Development Institute. UK. 4Pp. Available: http://www.oneworld.org/odi/nrp/47.html

Bolivia- MAGDR. 1999. Bolivia Ministry of Agriculture, Livestock, and Rural Development. Evaluación de la Producción Agrícola 1998-1999. La Paz, Bolivia: May.

Broad, K. 1999. Climate Information and Conflicting Goals: El Niño 1997-98 and the Peruvian Fishery. Workshop Proceedings from Public Philosophy, Environment, and Social Justice. October 21-22. Carnegie Council on Ethics and International Affairs. New York, USA.

Céspedes, J.and L. Rodriguez. Evaluación y Pronóstico de la Producción de Vista del Productor Campesino. Not published. Mimmeograph Report.

Coppock, L. and C. Valdivia (eds). Forthcoming. Sustaining Agropastoralism on the Bolivian Altiplano: The Case of San José Llanga. Published by the Global Livestock CRSP and International Livestock Research Institute.

Cotlear, D. 1989. Desarrollo campesino en los Andes. IEP Instituto de Estudios Peruanos. Lima.

Dunn, E., N. Kalaitzandonakes, and C. Valdivia. 1996. Risk and the impacts of micro-enterprise services. Assessing the Impacts of Microenterprise Services (AIMS). MSI. Washington DC.

Ellis, F. 1993. Peasant Economics: Farm households and agrarian development. Second Edition.

1993. Cambridge University Press.

Ellis, F. 1998. Household Strategies and Rural Livelihood Diversification. The Journal of Development Studies. 35(1): 1-38.

Finan, T. 1999. Drought and Demagoguery: A Political Ecology of Climate Variability in Northeast Brazil. Workshop Proceedings from Public Philosophy, Environment, and Social Justice. October 21-22 1999. Carnegie Council on Ethics and International Affairs. New York, USA.

Hatch, J. 1983. Our Knowledge: Traditional Farming Practices in Rural Bolivia Vol:1 Altiplano Region Edited and Illustrated by John K Hatch.

Jovel, R., A. Tapia and I. Thomson. 1998. Bolivia: Evaluación de los Daños Originados por el Fenómeno de El Niño en 1997-1998. Corporación Andina de Fomento. La Paz, Bolivia. December.

Kusterer, K. 1989. Small farmer attitudes and aspirations. USAID Program Evaluation Discussion Paper No. 26. USAID, Washington, DC.

Le Tacon, Ph., J. Vacher, M. Eldin, and E. Imaña. 1991. Los Riesgos de Helada en el Altiplano Boliviano. D. Morales and J. Vacher (eds) Actas del VII Congreso Internacional sobre Cultivos Andinos. La Paz, Bolivia, Febrero. Pp. 287-291.

Markowitz, L. and C. Valdivia. (Forthcoming). Patterns of technology adoption at San José de 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 Jose de Llanga. Global Livestock Collaborative Research Support Program and International Livestock Research Institute.

Morduch, J. 1995. Income Smoothing and Consumption Smoothing. *Journal of Economic Perspectives.* 9 (Summer): 103-114.

Muchna, P and A. Iglesias. 1992. Vulnerability of Maize Yields to Climate Change in Different Farming Sectors in Zimbabwe. Chapter 11 in Peterson G., D. Kral and M. Viney (eds) Climate Change and Agriculture: Analysis of Potential International Impacts. American Society of Agronomy.

Osunade, M.A. Adewole. 1994. Indigenous Climate Knowledge and Agricultural practices in

Southwestern Nigeria. Malaysian Journal of Tropical Geography.1 : 21-28.

Pepin, N. 1996. Indigenous knowledge concerning weather: The example of Lesotho. Weather 51: 242-248.

Price, M. F. 1995 . Climate change in mountain regions: a marginal issue? The Environmentalist 15: 272-280.

Stern, P. and W. Easterling (eds). 1999. Making Climate Forecasts Matter: Panel on the Human Dimensions of Seasonal-to-Interannual Climate Variability. Committee on the Human Dimensions of Global Change. Commission of Behavioral and Social Sciences and Education. National Research Council. National Academy Press. Washington D.C.

Stricherz,V. 1999. Long-Term Forecasting Cold Give Nations Tools to Survive Climate Change. January 23. Online Internet. November 11, 1999. Available http://www.eurakalert.org/releases/uw-lfn011999.html.

Reardon, T., C. Delgado, and P. Matlon. 1992. Determinants and effects of income diversification amongst farm households in Burkina Faso. The Journal of Development Studies. 28 (2) : 264-296.

Rosenzweig, M. R. and H. P. Binswanger. 1993. Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments. *The Economic Journal* 102 (January): 56-78

Valdivia, C., E. Dunn, and C. Jetté. 1996. Diversification, a risk management strategy in an Andean agropastoral community. American Journal of Agricultural Economics. 78(5) (December): 1329-1334.

Valdivia, C. and C. Jetté. 1997. Peasant Household Strategies Technologies and Diversification in Andean Fragile Lands. Agricultural Economics Working Paper. AEWP-1997-6. Pp.10. University of Missouri. Columbia, MO.

von Braun, J., Hotchkiss, D., and Immink, M. 1989. Nontraditional Export Crops in Guatemala: Effects on Production, Income, and Nutrition. Research Rpt 73. IFPRI. Washington D.C. May.

Walker, T.S. and Jodha, N.S. 1986. How small Farm Households Adapt to Risk. Chapter 2 in Hazel, P., C. Pomareda, and A. Valdés (eds.) Crop Insurance for Agricultural Development. Baltimore: Johns Hopkins University Press.

Washington-Allen, R. 1993. Historical analysis of land use/land-cover change on the Bolivian

Altiplano: a remote sensing perspective. MSc thesis. Range Science Dept. Utah State University.