Climate variability, a producer typology and the use of forecasts:

Experiences from Andean semiarid small holder producers

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Abstract

Farmers in highland semiarid production systems of the Andean region develop their livelihood strategies facing climatic variability, characterized by periodic drought, frosts and El Niño Southern Oscillation (ENSO) events. In order to determine who may benefit from forecast information producer profiles are needed. Some argue that more specialized larger producers dependent on rainfall would be the ones to benefit. Using a peasant household framework a profile of households pursuing distinct livelihood strategies is developed, and applied to a normal rainfall and drought years. Producers in general shifted to less vulnerable production activities during the drought year of 1995. Using this typology, farmers whom were aware of the 1997 El Niño event were identified, and an analysis of the impact on potato production was undertaken comparing 1997 and 1998 production decisions. A large proportion of innovators, characterized as diversified wealthier rural households with off-farm income, used the information to change production decisions during El Niño. This group experienced a lower change in production than other groups between 1997 and 1998. Local knowledge systems, such as knowledge learned from the elders, abiotic and biological indicators, were sources to predict the impact of weather and climate on the year's potato production. Only four percent used the media for their decisions, and sixteen percent used community networks. Implications for future research development on forecasts for the region are discussed.

Introduction

Farmers in highland semiarid production systems of the Andes face climatic variability, characterized by periodic droughts and El Niño Southern Oscillation (ENSO) events. These events, along with economic, social, cultural and biotic factors, affect the choice and mix of crops and livestock (Valdivia and Jetté, 1997; Valdivia et al. 1996), their productivity, and the food security of rural households. Since General Circulation Models (GCMs) are improving in accuracy (Blench, 1999), many argue that forecasts, such as ENSO's, could be more effective at reducing the negative impacts of events by improving disaster preparedness. Forecasts could also increase information provided to small holder farmers and therefore reduce vulnerability. In order for forecast information to be useful to farmers, it must address current needs and problems, be expressed in the language of the users, and provide the communities with appropriate alternatives to current production methods (Price, 1995; Stricherz, 1999; Blench, 1999; Stern and Easterling, 1999). It also requires that trust and communication exist between users and providers of climate forecast (Finan, 1999). Blench (1999) and Finan (1999) argue that these forecasts will probably be useful only to certain types of producers, as not all farmers can equally access nor use the information. An approach to evaluate rural livelihood strategies is developed to determine the conditions that may induce households to make use of information. Current sources of climate information for potato production decisions are analyzed, as this is a vulnerable crop grown in the highlands of Bolivia.

Objectives

Current research in this region aims to answer the following questions: 1) What are successful strategies developed by farmers to cope with climatic variation in the Andean region; 2) How do farmers currently use information from forecasts and local sources to make production and consumption decisions; and 3) Are there differences among these farmers in the actual or potential use of climate forecasts.

Forecasts are only useful if they are skillful, timely and relevant to actions, which potential users can incorporate into production decisions to improve potential outcomes (Stern and Easterling, 1999). Even when these requirements are met, Blench (1999) argues that forecasts are only relevant to producers that conform to the following profile: large and specialized operations, high in resources like education, safety nets and information, and dependent on rainfall. According to him only these type 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, other studies show (Ellis, 1998; Cotlear, 1989) that there may be also a positive correlation between wealth and diversification in rural areas, which implies that not only specialized rich farmers may benefit from forecasts. This study presents an approach to identify groups of producer/rural livelihood strategies in the Andean region, through a peasant household approach that analyzes interactions between production and consumption, and agriculture and non agricultural activities. The level of diversification of farm households and their use of climate forecasts (local or modern) can be evaluated in this framework. The study proposes that diversification and use of forecasts may also go hand in hand.

Rural Livelihood Strategies, Climate, and Forecasts

Rural livelihood strategies are shaped by several factors. In the Andean region climate plays an important role in production and consumption decisions. Other factors affecting what rural households can do, are access and control of resources, human, cultural and social capital (Bebbington, 1999), markets, institutions, and the political environment.

Interactions between climate, the production systems, and potatoes

Periodic droughts, frosts, and ENSO events make climate an especially important factor in the Bolivian Altiplano. The impact of El Niño in 1997-98 was significant for Bolivia, with the drought contributing 53% of the total $527 million damage suffered by Bolivia, according to a study by the Coorporacion Andina de Fomento-Bolivia CAF (Jovel, 1998). The Ministry of Agriculture's evaluation of the agriculture in 1998-1999 found a decrease in the production of food crops. Among these were potato *(Solanum tuberosum ssp. Andigena*) and quinoa (*Chenopodium quinoa*), two important traditional food crops grown in the Andes. The decrease in potato production especially affected the poor and seed production (Jovel, 1998).

In the region of study, Aroma Province in the Department of La Paz, average rainfall is 404mm. During the 1983 El Niño total rainfall was 197.6 mm, while it was 231 mm during the 1989 event. The differences in total rainfall during El Niño years indicates a measure of unpredictability, even if producers know it will be an El Niño year. Rainfall is also erratic during non EL Niño years. In 1992-1993 the annual rainfall was 388.5mm, and fell to 241.9mm in 1994-1995. Besides the variation from year to year, farmers have to deal with the uncertainty of when the rains will start, and the variation in rainfall throughout the growing season. Between July and April the uncertainty is especially important, since this time period is crucial for crops. For example in 1998-99 precipitation was 422mm 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 had a 50% surplus in 1998-99 (Bolivia-MAGDR, 1999).

Coupled with droughts are frost events, which represent another risk to many crops. Potato and quinoa are vulnerable to both (Le Tacon et al., 1991). The probability that potato growth will be affected by frost is 30%. The probability of 90 days of potato production without frost in the Patacamaya region is 62%, while for 120 days is 45% (Le Tacon et al., 1991).

Two strategies to deal with production risk are spatial variation, with several plots of different soil types geographically dispersed, and the use of several potato varieties in staggered planting through the onset of the rainy period. Lighter soils are less subject to frost, so spatial diversification is important in dealing with frost (Le Tacon et al., 1991).

Livelihood strategies, sources of income, and vulnerable incomes.

Rural livelihoods are shaped by the ability of households and individuals to access resources, and the investments decisions they make to deal with climatic variability, economic events, policies and institutional change. These are diverse (Ellis, 1998), a function of the level and type of assets and resources families can access, both in and out of agriculture. Age, education and stage in the life cycle also affect these strategies (Valdivia and Jetté, 1997).

Life cycle stage, household's access to resources, and risk and loss management strategies to cope with a shock, determine the degree of diversification. In areas of greater risk household strategies are expected to be more diversified as a mechanism to minimize the effects of 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., 1992). 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 (Dunn et al., 1996).

Life cycle stage affects the degree of diversification of livelihood strategies. Households in their initial stages are starting to accumulate assets and therefore their ability to alter their portfolio is limited. As assets accumulate, diversification in agriculture and in non agricultural activities take place. As families become old and resources are bequeathed households become less diversified (Kusterer, 1989).

Diversification is also a strategy to maximize resource use (Ellis, 1993;1998). Therefore, diversification will persist with greater levels of wealth in environments such as the Andean region (Cotlear, 1989). The type of resources, natural, human and productive accessed, determines how households diversify. In agriculture households engage in several activities through the year to ensure a constant flow of income (Ellis, 1993).

When climatic perturbations or any idiosyncratic risk take place, households may access resources through networks of families and friends, defined as social capital. These are ex-post, consumption smoothing management strategies. Besides accessing networks, other strategies may include liquidation of assets, and temporal migration (Dunn et al., 1996; Valdivia et al., 1996 ;Ellis, 1998; Bebbington, 1999).

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, 1999; Finan, 1999). The lack of utilization of the forecast information in regions that were vulnerable to there events suggests that: a) a gap exists between the information needed and delivered (Blench, 1999); b) there is a lack of trust or miscommunication between users and providers (Finan, 1999); and c) that even if the information is available the ability to respond by changing practices is limited or non existent (Finan, 1999; Broad, 1999).

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 these probabilistic models 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 different 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, 1985; Bharara and Seeland, 1994; Osunade, 1994). Users' forecasts provide more than just information about the forecast. The forecasts provide a set of behavioral rules that households and communities follow when certain indicators are or are not observed, predicting a specific weather pattern or event. 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, 1985). Bharara and Seeland (1994) conclude that local indicators and local knowledge systems will not be replaced with scientific knowledge, because these are holistic, providing farmers with the ability to make informed production decisions and prepare themselves psychologically for the coming agricultural year. On the other hand Bebbington (1991) defines local knowledge as a changing system, where western knowledge has a place. Farmers access knowledge and incorporate it only if it is useful. In some areas, even with skillful forecasts of climate, producers may not be able to modify their current production strategies to reduce vulnerability due to economic or other structural constraints (Muchna and Iglesias, 1992; Finan, 1999). In other cases communication is a hindrance to incorporation of forecast information and steps should be taken to encourage communication and dialogue. Local forecasts are embedded, containing the culture and belief systems, and are fluid, adapting to change (Markowitz and Valdivia) as their livelihood strategies do.

The case study of San José Llanga illustrates two issues. The first is that rural livelihood strategies in the Andes are diverse, and 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. The following section looks at the effect of El Niño and La Niña on potatoes, and discusses the factors affecting planting in 1998. A final section looks at the actions taken by groups aware of El Niño, and its impacts on potato production, and effects La Niña. the following year.

Location and Methods

San José Llanga is an agropastoral community, 116 Km south of La Paz, Bolivia's capital. Located in the central Altiplano, it is 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, 1993). 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 manages 7,200 has of land, with six settlements or neighborhoods. (Valdivia and Jetté, 1997). Fallow agricultural land and crop residues are important in the integration of cropping and livestock production.

In order to unveil distinct household strategies, a household/peasant economic portfolio approach is used to develop a typology of producers. 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 1993 and 1995, to identify the types of production strategies pursued by households, as well as understanding their distinct nature. Nine variables were used to identify groups of producers with similar strategies through cluster analysis (Valdivia and Jetté, 1996). The variables were chosen to reflect stage in the life cycle, types of technologies used, 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. These set of variables correspond to a household peasant economics framework. The operational variables chosen were the following: labor available to the household measured in adult equivalents (Valdivia and Jetté, 1997), 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).

Through cluster analysis with the variables diverse strategies are captured. 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, which is represented by forage area, represents resources 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, in this case commercial dairy production. 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 representing distinct strategies. The inverse Simpson (Valdivia et al, 1996) is used to calculate the number of activities and their share on the income being generated. Kusterer (1989) indicates that as families mature strategies of accumulation lead to diversification. Later in life assets are bequeathed to their children, and their level of diversification drops, as the children become their main source of support when old.

By analyzing the household strategies a pattern is revealed as to how household families produce in a climatic variable zone. The meaning of these activities pursued in 1993 and 1995 are explored to understand how households respond to two different climate events, 1993 a ‘normal’ rainfall year, and 1995 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.

Results

What are successful strategies developed to cope with climatic variation

The analysis of the surveys from 1993 and 1995 provide information about the livelihood strategies pursued by households, with decisions informed by local knowledge systems. Table 1 presents the characteristics of each distinct strategy for both years. The first year rainfall patterns are near the average for 44 years, while 1995 was characterized by delayed rains and low rainfall levels. Forty-five families were interviewed in 1993 and 1995. The sample in 1995 consists of 39 families from 1993 and 6 new families to replace those that migrated. The purpose of comparing both years is to understand the change in the livelihood strategies, and the nature of the change.

Livelihood Strategies in 1993

The results of cluster analysis indicate that two distinct rural livelihood strategies exist, shaped family life cycle. Age and access to labor are the two variables that capture this. As a result two groups are identified, the productive and the elderly. The former has younger families that are engaged in several activities. The elderly have less access to all the resources, and other studies show that this group relies mostly on potato production and remittances from family members (Valdivia et al., 1996; Valdivia and Jetté, 1997).

The productive group is further subdivided in two groups, also pursuing different strategies. The first group is identified as the innovator group. This group adopted both improved sheep and cattle, and engaged in commercial production of milk, due to their access to forages. The households in this group were wealthier, consumption and income from off-farm activities double that of the other productive group. The second subgroup, was defined as the extensive group, because criollo animals, sheep and cattle, were more important and raised on grazing areas.

Livelihood Strategies in 1995

Livelihood strategies, as in 1993, are defined by the stage in the life cycle. Two major groups reflecting distinct strategies are identified, again defined as the productive and the elderly. The average amount of improved livestock assets by the elderly increases, along with forage when compared to 1993, while the criollo animal numbers fall, though all the changes are small. The productive group is divided in two subgroups, one is further subdivided in two more groups. Table 1 presents these as three, productive innovator, and two productive, 2a and 2b. The productive innovator is younger, and depends on off-farm employment to complement farming activities. Their farming operation is stable, it has not changed when compared to 1993, with off-farm income being very important. The productive 2 a and b subgroups indicate different strategies. The 2a subgroup has less off farm income than innovators and group 2b, it relies basically on farming, with less that 10 percent of income from off farm sources. The productive 2b relies heavily on agriculture but has more labor and forage resources. The amount of off farm income they obtain is three times larger than group 2a.

In terms of shifting from one group to another between 1993 and 1995, five families moved from the extensive productive group to the innovators, while six families from the innovator group moved to the productive subgroups, three to each (the same or more forages). Two risk reducing activities are being incorporated to manage risk, off farm employment and increase in livestock/forage production. The former is reflected in the growth of off-farm income (Table 1). Those with significant off farm income increase in the productive innovator group, and those with more dependence on forage/livestock in 2 a and 2b. Forage production also grows in the elderly group.

Diversification

Diversification, as mentioned before, allows families to reduce the vulnerability caused by climatic variability. An Inverse Sympson Index is calculated for each household in 1993 and 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 in 1993 there were differences between the elderly and the productive in the degree of diversification. As expected (Kusterer, 1989) older households are less diversified than younger households. There were also differences between the innovators and extensive, with the former having a larger diversity index.

In 1995 the diversity index decreases for the productive groups, as the income from crop production falls. Those that maintain a greater index are the Productive Innovator that are incorporation off farm as crops fall. The productive 2b and 2a experience a loss in the diversity of income, as their strategy for that year relies mostly on the farm activities. Finally the diversity income for the elderly grows, as livestock and off farm income grow as shares of the total income.

The productive innovators perform better in terms of income growth and diversification. The correlation between diversity and income is positive, indicating that diversity and wealth grow together in this community (Ellis, 1998; Cotlear, 1989). Diversification is not only a risk reducing strategy, but also maximizes use of resources. The innovators improve their livelihoods in 1995 through off-farm income, suggesting that their linkages to markets allow them access to information and other income improving opportunities.

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 sweet varieties, others are introduced. Native bitter varieties, tolerant to frosts and droughts, mostly are no longer being farmed in this community. The main reason for potato production is consumption, and native varieties are grown primarily for this purpose. Introduced varieties are mostly produced for the market. Table 2 shows the mean area planted to potatoes in 1993, 1997-8 and 1998-1999. The area planted to potatoes has grown, especially for the group of extensive producers. While in 1993 post-hoc analysis of the area planted shows that there are only differences between the innovators and all other groups, in 1997-8 the extensive productive households have a similar area to the productive innovators, and both are different from the elderly. In 1998-9 similar results are obtained from the comparisons among groups. Mean area planted grows for all groups during La Niña.

<u>*Vulnerability to droughts: Potatoes*</u>

The change in potato production between 97-98 and 98-99 is significant. Table 3 shows the differences between area planted to potatoes, the number of plots used (indications spatial diversification), and total production of potatoes between 1997 and 1998. Area planted and plots are normally distributed, while quantity harvested is not, as there are some producers that are able to obtain very high yields. In the later case two approaches are used to test differences in total potato production between years, a non parametric test (Wilcoxon Signed Ranks Test), and a paired t- test that excludes outliers (2 in 1997 and 3 in 1998). In both tests there are significant differences between years in the amount of potato produced. The latter is presented in table 3 along with the other analysis. The differences between means in area planted and quantity harvested are significant. There are no differences among groups on the plots of land managed each year, indicating that spatial diversification is similar. Staggered planting is a mechanisms to deal with uncertainty of rainfall distribution.

Table 4 shows that the only significant differences in area planted and quantity harvested are for the productive group. The non parametric test for area harvested is significant at 10 percent for the extensive group. Table 5 shows the mean quantity harvested in both years. The groups experiencing the greater percentage changes are the extensive producers and the elderly, indicating these were more vulnerable to El Niño. These groups proportionally were less aware of El Niño. However, even those who were aware of el Niño were unlikely to change their production strategies (Table 6). Nonetheless, in absolute terms, the innovators achieved higher production levels in both 1997 and 1998.

Reasons why producers did not increase production in 1998

Reasons why producers did not increase potato production in 1998 are presented in table 7. 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 extensive group had monetary constraints and could not purchase more seed and fertilizer, compared to other groups. The proportion of households where access to more land for planting was a constraint was similar for both extensive and elderly groups. Overall economic constraints were more important for the extensive and elderly groups. Very few households believed that the 1998-99 year 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 productive group.

Use of information about el Niño and Impact on Decisions: Are there differences among these farmers in the actual or potential use of climate forecasts

For the most part, farmers knowledge of climate came from natural indicators and traditional knowledge (Table 8), which can be defined as local knowledge systems. Nearly all farmers (98%) used natural indicators such as the wind direction in early August and biological indicators such as the flowering of T'ola (*Parastrephia lepidophylla*) and the behavior of birds and other animals. Traditional knowledge of weather patterns obtained from elders was also important for the productive households. Only 4% directly used mass media to obtain information, and 16% relied on neighbors. None used the technical knowledge produced by governmental or non-governmental organizations and institutions. While farmers still relied on local and traditional knowledge to understand climate, there was a growing concern about these indicators. Many felt that weather patterns in the region had changed and traditional indicators were not as reliable as they were in the past. However they have not been replaced or modified to date.

While traditional indicators and local knowledge were the sources of virtually all of the farmer's ideas about climate, 75% were aware of the 1997-1998 El Niño event. Only the elderly appeared ignorant of the phenomenon (86% of the others had knowledge). This information raises two interesting possibilities: 1) that awareness of the El Niño phenomena is not connected to the farmer's understanding of climate and 2) that the knowledge of El Niño came indirectly through personal networks and not from forecasts or official sources.

On the individual farm level, only the farmers who reacted to climate forecasts were the most prosperous farmers who had significant off-farm sources of income. 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. This limitation stems from the fact that timing of rainfall and frosts is more critical for crop yields than seasonal rainfall and temperature averages.

The users and potential beneficiaries of climate forecasting seem to be the richer farmers (innovators) who have off farm investments and sources of income. 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 it has increased it reliance on potato production, but their ability to adjust production in light of forecasts has not. As compared to the innovators, these groups did not react nor changed practices with knowledge of El Niño. Furthermore, their ability to expand production after a dry year based upon forecasts is limited by their access to cash. 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 also are unlikely to benefit from forecasts. They too 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.

Interestingly enough, the group of farmers who are most likely to change farming practices in response to weather forecasts are those farmers who had significant amounts of off farm income. To some extent, this finding is contrary to what we would expect. We hypothesized following Blench’s arguments, that specialized 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. 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 allow the specialized agricultural producers to develop strategies to respond to forecasts.

Conclusions

The approach proposed unveiled household strategies and the ability of different households 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 in comparing strategies in 1993 and 1995 there is a move towards livestock production strategies, which is an activity less vulnerable to weather fluctuations.

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 innovator group, while those who accessed information from community networks were in the productive group. The greater proportion of households who knew about of El Niño were in the wealthier group. This is also the group that reported changing their production decisions from previous years. Access to off-farm income opportunities to diversify was related with knowledge of el Niño. 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. This may have been due to the time of onset, if this is true research relating to the timing of El Niño may be very useful. The second is that periodic droughts are common during non El Niño years, 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. Modern forecast systems were unable to forecast this event. Therefore total reliance on modern forecast information should not be the only strategy employed by farmers in the Altiplano. If the forecasts are to be incorporated, it will be done in combination with local knowledge systems, providing farmers with a back up strategy in decision making processes. In Bolivia, information about El Niño in 1997 and La Niña in 1998 was provided through the National Early Warning and Food Security System (SINSAAT Sistema Nacional de Seguimiento de la Seguridad Alimentaria y Alerta Temprana), and was used mostly to assess the impact at the regional level. Given the variability observed this seems to be the most appropriate use of this information. For this information to be used at the local level, farmers need assistance in linking local situations to the regional forecasts produced.

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

	1993			1995			
	Productive Innovators	Productive Extensive	Elderly	Productive Innovator	Productive 2a	Productive 2b	Elderly
Age (years)	45.7	41.6	65	41.9	49	47.7	67
Labor (adult equ.)	3.4	3.3	1.5	2.9	2.8	3.9	1.4
Criollo Sheep (head)	4.2	20.2	3	4.7	16	19.1	1.2
Criollo Cattle (head)	0.3	2.5	0.7	1.3	4.4	0.4	0.6
Improved Sheep (head)	27.2	6.9	1	42.3	12.4	10.1	6.2
Improved Cattle (Head)	4.8	1.3	0.2	5.8	5.3	5.2	0.6
Forages (has)	4.9	1.6	0.6	4.1	4.2	7.3	1.6
Consumption (Dollars)	1,477	677	330	2,123	930	1,277	425
Off-farm Income (Dollars)	247	74	30	1,052	73	208	66
Diversity Index*	3.57	3.24	2.26	3.3	2.95	2.97	2.64

Sources: Surveys of rural households in San José Llanga in 1993 and 1995
*Valdivia et al.,1996.

Table 2. Analysis of Variance: Differences Between Groups in Area (Has) Planted to Potatoes in 1993, 1997 and 1998, and Area (Has) and Plots (#) of Food in 1993.

	Potatoes			Food Crops*	
Cluster	Area 97	Area 98	Area 93	Area 93	Plots93

Innovators	1.49	a	1.72	a	1.1a		3.3a		6.3a
Extensive	1.39	a	1.75	a	0.7b		2.6ab		5.2a
Elderly Couples		0.59	b	0.61	b	0.6b		1.5b	4.5b
Elderly Single		0.85	b	0.90	b	0.6b		1.1b	2.8b

Post-hoc analysis: Least Significant Differences. Significant at 0.05. Differences between groups when letters are different in a given year.
* Data for 1993 from C. Valdivia and C. Jetté, 1996. Peasant Households in Semi-arid San José: Confronting Risk Through Diversification Strategies. IBTA 181 Technical Report 49/ SR-CRSP 47, and Valdivia, C. Household socioeconomic diversity and coping response to a drought year in San José. Chapter 6 in Coppock, L. and C. Valdivia (eds). Sustaining Agropastoralism on the Bolivian Altiplano: The Case of San José Llanga. (forthcoming) Published by the Global Livestock CRSP and International Livestock Research Institute.

Table 3. Mean Differences in Area Planted (Has), Plots and Quantity (quintals*) Harvested between 1997 and 1998. (Paired T -Tests)

	Mean	t	df	Sig.
Difference in area planted 97-98	-0.2249	-2.319	44	*
Differences total area potato 97-98	-0.2219	-1.419	44	n.s.
Differences in number of plots 97-98	-0.666	-1.427	44	n.s.
Differences in quantity harvested 97-98	-34.65	-2.357	40	*

* Significant at 0.05 probability level.
Source: Survey of 1999.
* Quintals: one unit equals 100 pounds, for potatoes one quintal equals 50Kg.

Table 4. Paired T-Tests by Clusters Between 1997 and 1998 in Area planted (Has) and Quantity Harvested (quintals) to Potatoes.

	Productive	Innovators	Extensive	Elderly
Difference Means				
Area 97-98	-0.2955	-0.2353	-0.3594	-0.0308
Paired Ts	-2.300	-1.255	-2.000	-0.471
df	32	16	15	11
Significance	.028	n.s.	0.064.	n.s.
	Productive	Innovators	Extensive	Elderly
Difference Means				
Quantity 97-98	-37.7667	-28.733	-46.800	–26.1591
Paired Ts	-1.980	-1.147	-1.588	-1.428
df	29	14	14	10
Significance	0.057	n.s.	n.s.*	n.s

* Non parametric S test -1.92, Asymp. Sig. 0.054 (Wilcoxon Signed Ranks Test).
Source: Survey of 1999.

Table 5. Mean Amount of Potato Harvested (quintals) by Group and Growth between 1997 and 1998

Cluster	Harvest 97	Harvest 98	Growth %
Innovators (17)	107.882	179.706	67
Extensive (16)	98.375	179.125	82
Elderly (12)	44.271	115.667	161

Source: Survey of 1999 with 45 observations.

Table 6. Knowledge of El Niño Event, and Change in Planting Area by Group in 1997.

Group	Knowledge	Change Area	Did Not Change	Total
Innovator	No	0	3	3
	Yes	6	7	13
Extensive	No	0	1	1
	Yes	2	13	15
Elderly	No	0	7	7
	Yes	1	4	5
Total	No	0	11	11
	Yes	9	24	33

Source: Survey of 1999.

Table7. 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	65	69	58
R2: Did not have more land available	18	25	42
R3: No more money to purchase seed	47	63	42
R4: There was no seed available in market	0	13	17
R5: Could not purchase more fertilizer	6	31	8
R6: Did not have cash to purchase pesticide	12	0	9
R7: Did not want to grow more of the type	0	0	0
R8: Feared the climate would not be good	6	6	0
R9: Feared the year would not be good	12	6	0
R10: Did not have more prepared land	29	38	50
R11: The variety is not marketed	6	0	0

Source: Survey 1999. Group 1: innovator. Group 2: extensive production. Group 3: the elderly.

Table8. How do you know if the climate will be good or bad: Sources of Information in San José Llanga (percent responding they use the source).

Factors that contribute to knowledge about climate	Respondents Yes %
1. Knowledge from our grandparents	56
2. Information from radio or TV	4
3. Neighbors in the community	16
4. Neighbors from other communities	0
5. Technical personnel from Organizations or Institutions	0
6. The Bristol Calendar (Farmers Almanac Bristol)	4
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

Survey of 45 households in 1999.

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