SMALL RUMINANT AGROPASTORAL RESEARCH COMPONENT BOLIVIA

SR-CRSP/IBTA

TECHNICAL REPORT SERIES

IBTA 181/TECHNICAL REPORT 49/SR-CRSP 47/1996

Peasant Households in Semi-Arid San José: Confronting Risk Through Diversification Strategies.

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ACKNOWLEDGMENTS

This study would not have been possible without the generous cooperation of the families of San José Llanga, who took time off from their busy harvest schedules to teach us and answer our questions. Similarly, the research was facilitated and benefitted in countless ways through the support and collaboration of the researchers and administrators of the SR-CRSP and IBTA. In Missouri, Drs. Michael F. Nolan and Jere L Gilles, principal and co-principal investigators of the sociology program, were instrumental in allowing this research to take place. Their support and counsel is very much appreciated. In Bolivia, Dr. Joao de Queiroz provided advise and technical support on the cluster analysis performed. We are greatly indebted for his support. The data utilized was gathered through the Gender and Livestock Project of the SR-CRSP developed by Drs. Elizabeth Dunn and Corinne Valdivia. Funding for this study was provided by the SR-CRSP USAID Grant DAN 138-G-00-0046-00.

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I. INTRODUCTION

Variability and the probability of negative outcomes risk are inherent to semi-arid environments in the tropics. Peasant households confront risk through a variety of production and consumption strategies that increase food security and allow them to take advantage of an heterogenous resource base. Livestock play an important role in the risk mitigation of agropastoral systems. Other activities are also important in a diversification strategy that contributes to the persistant survival of families at different stages in their life cycle. This paper explores the variation around a "representative" peasant household in a rural community in the Central Altiplano of Bolivia, and draws lessons for technology design in similar settings: semi-arid environments with peasant household production systems in communities partially integrated to markets. Its purpose is to inform scientists about the human dimension of technology innovation in a setting that is characterized by diversity, partial market integration, difficult ecological conditions for household persistence, and the significant role of "social capital."

II. VARIABILITY, RISK, AND PRODUCTIVE ALTERNATIVES

Variation, Risk, Diversification: Background

Variation is characteristic of rural households through the Andean region (Golte, 1980; Martinez-Castilla, 1992; Brush, 1987; Kervyn, 1988; Barrantes and Hopkins, 1987) in their process of adaptation to both the environment and historical processes (Cotlear, 1989; Gonzales de Olarte and Kervyn, *1987*; Jetté, 1993). To consider development of technologies that can contribute to the improvement of the livelihoods of people in semi-arid highland tropics, one has to analyze both the important diversity of agro-ecological conditions (soils, topography and weather) that may be present on a microregional and community level as well as the high degree of perturbations that producers confront daily. People in this environment have learned to adjust to these conditions and have coped successfully which explains their persistence persistence.

Diversification is a risk mitigation strategy in areas where production risk is present, input and product markets are not fully developed, and no insurance markets exist. Bromley and Chavas (1989) state that in areas where risk is borne privately diversification strategiesare necessary. Diversification of agriculture is, then, an indicator of the presence of risk. However, some diversified agricultural practices such as mix cropping have numerous advantages *"...of* which security through diversification is only one." (Ellis, 1993, based on Norman, 1974). Reardon et al. (1992) hypothesize that "diversification can arise from two causes -the struggle to survive in a risky environment, and the desire to build on the base of a dynamic agriculture" (p. 268) as access to roads increases. A diversified portfolio of economic activities may be developed by introducing other agricultural or non-farm activities. Rearden et at state that "...drawing on portfolio theory, households with less land or non-land assets (for example, livestock, food stocks, savings) would be more risk averse and hence more sensitive to the need to diversify to lower overall instability of returns" (p. 269). This should be negatively correlated with the degree of inter-household safety net income transfers (Reardon et al., 1992), such as those which benefit some families at the end of their life cycle (Morduch, 1995; Norton and Alwang, 1993).

Portfolio theory predicts that diversification will take place with activities that are not perfectly correlated (Reardon et al. p. 267): "A less than perfect correlation between the returns of assets allows for gains from diversification by reducing costs, although the gains in risk reduction diminish as the number of assets increases.(Robinson and Barry 1987, p. 142)". Extrapolating to agriculture, diversification can take place within or outside agriculture as long as common events do not affect activities in the same way or to the same degree. Crop diversification is a form of self-insurance (Fabella, 1989).

Some argue that, in the case of environmental risk affecting a particular geographical area, diversification within activities that are highly covariant does not reduce risk (Bromley and Chavas, 1989). Others predict that the introduction of commercial activities (cash crops) leads to specialization and economic development. von Braun (1989)studying cash crops for export markets found substitution between in kind and cash activities in the household, instead of diversification. Specialization reduces costs of production and increases efficiency (von Braun et al., 1989; Bromley and Chavas, 1989). Contingent markets and efficient conditional redistribution schemes would be needed to handle risky outcomes.

However, in Peru, some studies on technological change in the peasant economy of the mountains tend to show that a more intensive agriculture and higher incomes are not strongly correlated with a greater specialization in more profitable crops and activities (Kervyn, 1988). Fafchamps (1992) finds that when imperfect rural food markets exist, basic staples production will remain an important economic activity that will vary with level of wealth but will not disappear. The relation between production and consumption decisions are a result of partial market integration, which in political economy is explained by the integrated forms of production within a capitalistic economy (Friedman, 1980).

Non-market relations play an important role in household peasant persistence allowing families access to resources (land, labor and animals) without cash outlays. Studies of social safety net, social capital, and reciprocity relations show their importance to the success of families, both in the Andean region and in other economies (Guillet, Alberti and Mayer, 1974, Albó and Carter, 1988). Children are the source of security for elderly people (Kusterer, 1989).

Rosenzweig and Binswanger (1993) state that there has been little empirical evidence on the importance of risk in shaping the actual allocation of production resources among farmers differentiated by wealth (p.56), and in the relationship between wealth and risk behavior. They assume that farmers choose a set of assets differentially sensitive to weather variability according to their risk preferences and ex-post abilities to cope with risk (p. 57). They analyse the relationship between exogenous risk and portfolio choice by wealth class and find that the composition of asset portfolio is influenced significantly by risk aversion, wealth and rainfall variability. In riskier environments portfolio assets less sensitive to weather but less profitable were chosen. There was tradeoff between profit variability and average profit return to wealth, and there was loss of efficiency associated with risk mitigation, higher among poorer farmers (hedging results in choosing the outcome less sensitive to weather - drought resistance with lower productivity). Average incomes are lower and income inequality is exacerbated by the presence of risk.

III. SAN JOSE LLANGA, THE FACE OF DIVERSITY

San Jose Llanga is an agropastoral peasant community located 116 Km south of La Paz (Bolivia's capital), in the Province of Aroma Department of La Paz. It is located in the Central Altiplano, at an elevation of 3,725 and 3786 mts. above sea level (Washington-Allen, 1993). The closest town is Patacamaya, 16 km away and accessible via a dirt road. San José is inhabited by approximately one hundred households distributed between six human settlements called zones: Callunimaya, Sabilani, Barrio, Tholatia, Incamaya and Espiritu Wilki. The community extension is 7,200 Has of land: 1993 estimates show 48% covered by native grasses, 31% in fallow, 6% with cultivated forages, 5% with food crops, and the remaining 10%, occupied by buildings, rivers, roads, and uncultivated land (Massy and Valdivia, 1995).

The agropastoral production system in SJL combines sheep and cattle herding on natural rangeland with crop production. The main food and forage crops are potato, quinoa, barley, and alfalfa. Several varieties of these and other crops are planted on small parcels of land. Fallow agricultural land and crop residues are important supplements to grazing (Yazman et al., 1995).

The semi-arid high plateau of the Bolivian Central Altiplano may be characterized as an area with a high degree of abiotic perturbations. Washington-Allen (1993) summarizes these perturbations as periodic drought, frequent frosts, occasional floods and seasonal wind erosion. Mean annual precipitation between 1943 and 1990 at Patacamaya Research Station was 402 with a 31% coefficient of variation and a mean annual temperature of 10.4 degrees Celsius.

Precipitation also varies within the year with very low rainfall from April through August. Rain may start between September and December and last through March. Frosts are considered the main danger for food cultivation. Le Tacon et al. (1992) estimate that in the Patacamaya region potato cultivation has one out of two chances of ending its normal cycle, and quinoa six possibilities in ten. Notable difference in the incidence of first risks at the local community have been found to be a function of topographic characteristics and soil type of the land parcels. These perturbations when combined with partial market integration and lack of insurance markets result in diversification as a strategy for risk reduction and persistence. The latter is defined as viable economic households.

Potatos, quinoa, and llamas are the main indigenous crops and livestock in the region. Criollo sheep and cattle production, together with barley cultivation, have been in the region since the colonial period, and have progressively displaced llama production. Nowadays there are no llamas in the region. During the extension workers 1960s introduced new potato varieties and popularized the use of tractors, fertilizers and pesticides for the cultivation of the new varieties. New breeds of sheep were introduced to improve both meat and wool production.

Crossbreeding with native animals resulted in more meat production and better wool characteristics for the textile industry. This period follows an acceleration of the population growth rate. Most farmers in the village now have at least a few crossbred or improved animals in their herds. Criollo sheep are usually smaller and more resilient than the improved. During the major Bolivian textile firms went bankrupt. Since then, 1980s local fibers find it very difficult to compete with imports.

Although cattle have been in the village for almost as long as sheep, in the past they were used primarily as draft animals. With the introduction of Fomento Lechero (FL) Program (an extension program that organizes production and milk delivery) in 1989, dairy production became more important. Construction of a road from Patacamaya to SJL and agreements with the parastatal dairy program, PIL (*Planta de Industrializacion Lechera*) facilitated adoption of dairy production. PIL sends a truck to SJL each morning to collect milk.

Irrigation is a risk reducing mechanism in agriculture. A 23 km irrigation canal brings water from the Desaguadero river (the main Central Altiplano stream) to a small portion of San José and four other communities at the end of the dry season. This irrigation allows alfalfa cultivation in the area during the period when the main natural forages are exhausted. However, these waters contain a high degree of salts and irrigation could cause serious soil erosion in the long term. Alfalfa is also grown in *fluviosols* along the banks of a small river that crosses the north part of the territory and where water flows after a rainfall. The water table in the area is very high.

Since their arrival, Fomento Lechero extension researchers have been working with community members to expand the dairy herds to include new breeds of cattle. The two most popular breeds to improve milk production are Holstein and Brown Swiss. Cross-breeding with the existing native cattle improves milk yields. Most farmers own at least one crossbred animal in their dairy enterprise. Households in the community have quickly adopted the dairy activity; by 1992-1993, a significant number of households in SJL were selling milk to PIL. Thus, the FL program combined with the construction of a road to SJL with support of a peasant development program financed by the European Community (Programa de Auto Desarrollo Campesino - PAC) has led to significantly higher levels of market integration for families in SJL. Fomento Lechero closed its activity at the end of 1995, and PIL is in the process of being privatized. It has been agreed that milk producer associations of the La Paz and Cochabamba departments will own part of the stock in the new milk firm, but there is a great deal of uncertainty about future prices, transport, and technical support policies.

The study of San José Llanga will shed light on the role of diversity in income generation, degrees of risk, and wealth. Our interest is to understand strategies of household reproduction in areas of high environmental and market uncertainty and risk, to promote development of production technologies and policies that may improve the quality of life.

What are the impacts of the introduction of new technologies on production strategies and income? Is the dairy business leading to a specialization in commercial activities? What are the characteristics of the producers who adopted the new technologies? Are the technologies introduced risk reducing, and are they sustainable allowing for resource regeneration? Do these policies reduce risk in the short run but have a negative effect in the long run?

This study utilized data obtained from a previous survey of 45 families randomly selected to represent the population of San José. The survey was developed by the Gender and Livestock Project to analyse the impact of dairy farming in this community (Valdivia et al. 1995, Céspedes et al. 1995, Dunn et al. 1994). Income, resources and productive activities correspond to calendar year 1992-93. Synthetic variables were constructed with this data, in our view appropriate to establish a San José household production typology. The construction of new variables also relies on the knowledge gained from other research projects on resource access mechanisms, use of labor, and the role of livestock in San José (Cala y Jetté, 1994; Espejo y Jetté, 1995; Markowitz y Jetté, 1994; Sherbourne et al.; Valdivia et al. 1995). These studies influenced the selection of variables for cluster analysis to distinguish groups with distinct household strategies.

Construction of a typology for assessment of appropriate technologies considered groupings as a function of the quality and quantity of key resources and income. In order to understand the selection made it is necessary to present some of the characteristics of the San José household production systems.

Natural and Economic Resources

Potatos are the basic food staple throughout all the Highlands. Potato production in the Andes is very sensitive to weather conditions. Potato market prices vary significantly throughout the year and between years. Although potato cultivation in San José requires a significant investment of cash (to rent the tractor and to purchase fertilizers and pesticides), the product is mainly for home consumption. Only when there is no frost during the production cycle, and rainfall is average, it is possible to sell a significant share of the crop. The tractor is used to till. This saves labor, and its use is also a result of fewer draft animals since dairy cattle are taking their place. Chemical fertilizers, easier to apply than manure, contribute higher yields particularly in parcels with a reduction in the fallow period due to population increase. Pesticides are required for the new potato varieties because these are prone to pests. Potato is a dryland farming activity *[secano]* and each household can plant up to a dozen varieties. Some of these varieties (small and sour ones) are destined to food stock reserves in the form of dehydrated potatoes (*chuño*) (Huanca et al., 1995).

The use of a tractor allows households to devote more time and more land to forage crops: barley, alfalfa and recently oats. Forage crops are cultivated in the irrigated parcels and along the river where soil humidity is higher. Barley is also a dryland crop. These are usually fed to livestock, mainly cattle, and are rarely sold. When available sheep also feed on forages (Yazman et al., 1995).

Sheep are the household's source of meat, wool, manure and cash. They are the main source of animal protein in the diet (Murillo and Markowitz, 1995). Sale of live animals is one of the principal sources of cash to buy food. In times of severe drought, these animals play a critical role in the household economy; they are more resilient and can be sold to buy fodder for the cattle. Dairy cattle in the last five years have become a regular source of cash. At the same time, improving the number and quality of cattle constitute the main forms of capital accumulation.

All household members older than five participate in some way in production activities. Men tend to manage the dairy enterprise, women manage the sheep enterprise, and both manage the crop enterprise (Sherbourne et al, 1996). Children participate in all three, depending on the need for labor at a particular time. Teen age girls are crucial for animal grazing. Boys older than fifteen frequently leave the community to study in an urban college or to learn a trade. Overall, household distribution of labor is flexible. Labor availability constrains the household's ability to crop, herd animals, participate in communal infrastructure building projects, and eventually engage in off-farm activities. Exchanges of labor between households of the same kin are customary, especially during planting and harvesting. A common type of exchange between households in sheep herding consists of a family leaving their animals (or some of them) during one year with another family which in return will keep half of the lambs borne during the year. This is a frequent arrangement between migratory people and their relatives in the community. Only one or two households in the community could afford to hire laborers on a regular basis.

Social Capital

Non market relations are essential to access land. The main form to acquire property rights is through inheritance. Communal rules prohibit the sale of plots to people who are not community members. However, there are ways to access land temporarily through renting or, more importantly, using the land that belongs to a relative who has migrated. This ensures that ownership rights of the migrant will be maintained. These mechanisms mitigate the differences that do exist regarding land ownership in the community. This is one of the reasons why land ownership was not a significant criteria to classify households in the community. Espejo (1994) found no significant correlation between land possessions and animal numbers. Land quality is more important than quantity contributing to farmers wealth.

Inheritance and dowry are the most important sources of initial livestock capital. As the heads of household grow old and their children marry, they progressively redistribute their animals to the new households. Espejo (1994) found a significant correlation between the number of sheep that were inherited and the number of cows that a household possesses. A greater number of sheep at the beginning of the life cycle allows the household to cover the major part of its domestic needs with sheep sales and to accumulate cattle through biological reproduction at a faster rate. Households very rarely buy sheep, except one or two breeding stock every other year. Improved dairy cattle is purchased with earnings from sales of old cows and young males. Part of the profits of cattle sales are invested in land at urban centers, new off-farm businesses, or important social commitments.

The only financial institution present in the region during the 1960s and 1970s was the Bolivian Agricultural Bank (BAB), which supplied credit tied to specific agricultural production projects. Some rural development programs (PAC, *Fomento Lechero*) also provided credits in the form of forage seeds. The BAB was closed, and PAC and *Fomento Lechero* concluded their activities in 1995. This same year new private financial institutions opened offices in Patacamaya. These institutions lend small amounts of money for any purpose on a short term basis and at very high interest rates (2 to 4% per month). The communal authorities or a group of neighbors are asked to guarantee the loans that a person receives.

Selection of variables for the groupings:

1. Life cycle plays a role in defining types of producers that may not be in a position to look for changes and innovation. The age of the male head of household was used as the indicator. When a male was not present, female head of household age was used.

2. Labor, assigned 15 or older a weight of one, adult worker; 9 to 14 years a weight of 0.6 (due mainly to schooling time); 6 to 8 years of age a weight of 0.3, and 4 to 5 a weight of 0.1. These weights were based on previous studies of herding patterns by the young (Ramos et al., 1995; Paredes, 1995). Deere and DeJanvry (1981) used similar weights in their study of demographics and social differentiation among Peruvian peasants.

3. Quality of land considered planted and utilized forage area, including alfalfa and forage barley. The variable was measured in hectares.

4. To capture the potential differences in technology, we used the number of improved sheep belonging to the family, including crossbred animals.

5. The number of criollo sheep belonging to the family captured sheep indigenous technology.

6. The number of improved cattle that belong to the family, including adult and young animals, was an indicator of adoption of a new technology.

7. The number of criollo cattle that belong to the family, including adult and young animals, correspond to the indigenous set of activities.

8. Wages included payments to labor unrelated to the household's agricultural production activities. This is considered important because it is a measure of market integration to other economic activities. It has been found that if this takes place in areas different from where the family unit exists, risk can be spread (Low, 1986).

9. Consumption consisted of the sum of in-kind and cash income generated by food production (potatoes, quinua, wheat, grain barley, phaba beans. For livestock it included consumption and sales of sheep, as well as sheep milk; cattle milk sales, wages and other income such as handcrafts and sales of *thola* (wood shrub) and manure. This is based on Cespedes et al showing sales of sheep to fund household needs. This variable was used to establish differences between groups regarding welfare.

10. Net income from cattle consisted of income generated through the sales of live animals (plus sales of manure and non-PIL milk production). It reflects the households ability to capitalize and reinvest their assets.

Only one variable refers to land holdings. Land property does not represent a significant discriminating criteria. We found that *fluviosols* and irrigated land under cultivation are more representative of distinct producer strategies. Similar findings were established in Peru (Hopkins and Barrantes, 1987). These lands are almost exclusively used for forages in San José. This is consistent with the fact that animal numbers and species reflect more accurately the intensity of agricultural activity and wealth levels.

IV. CHARACTERIZING HOUSEHOLD PEASANT STRATEGIES

Clustering was undertaken using SYSTAT cluster program, Eucledian with standardized variables. Distance metric is 1-Pearson correlation coefficient complete linkage method (Farthest Neighbor). A dendogram was constructed from which four clusters were identified. A rectangular data matrix was used to compute Normalized Eucledian Distances between objects. For the clustering metric normalized distances are root mean square distances. Normalizing by the sample size allows comparison of clustering across different sample sizes with or without missing data. Under distance we chose Pearson product moment correlation between objects i and j (SYSTAT, 1992). The tables below present group averages and standard deviations in parenthesis.

Results from the clustering

Clustering determined two large groups: the "elderly" and the "productive" groups, age and access to labor being the strongest differences between these two large groups. The characteristics of the first two clusters are presented in Table 1.

Table 1: The Elderly and the Productive in San José Llanga

Variable	Group I: The elderly (16 units)	Group II: Productive Years (29 units)
Age (years)**	65.4 (6.7)	43.7 (11.9)
Labor (units)**	1.5 (0.6)	3.4 (1.3)
Criollo Sheep (numbers)**	3 (3.9)	11.9 (13.5)
Improved Sheep (numbers)**	1.1 (4.3)#	17.4 (24.7)
Improved Cattle (numbers)**	0.2 (0.5)	3.0 (2.4)
Criollo Cattle (numbers)	0.7 (1.0)	1.3 (1.9)
Forage (hectares)**	0.6 (0.6)	3.3 (2.9)
Wages (Bolivianos, Bs./year)	120.3 (260.8)	661.6 (1,312.6)
Household Consumption** (Bs./year)	1,337.5 (1,449.3)	4,418.0 (2,610.2)
Cattle Net Income (Bs./year)**	48 (174.3)	1,474 (2,078.9)

\# Only one family had 17 improved animals
** Differences between means, statistically significant at 0.05.

The two variables with significant statistical differences between groups and low standard deviation within groups are age and labor. These clearly define the first two main groups, indicating that state in the life cycle (over 60 years old) is important in defining differences between groups. As indicated, households progressively redistribute their land (preferably to sons) and their animals (to both sons and daughters) as their children establish new households. By the time the heads of household are over sixty, all their children have been married for several years and resources have already been distributed. The statistical differences between almost all the other variables are also significant. Old people keep a few animals and some parcels of land in order to satisfy their basic food needs.

Dendogram analysis shows two sub groupings in each cluster. These are presented in Tables 2 and 3. In the productive cluster, two groups are distinguished: the "improved" and the "criollo", so defined due to the differences in the qualities of animals owned by the families in their productive years.

Table 2: The Productive Group

Variable	Group I: Improved (15 units)	Group II: Criollo (14 units)
Age (years)	45.7 (11.3)	41.6 (12.6)
Labor (units)	3.4 (1.2)	3.3 (1.5)
Criollo Sheep (numbers) **	4.2 (5.8)	20.2 (14.7)
Improved Sheep (numbers)**	27.2 (28.9)	6.9 (13.4))
Improved Cattle (numbers)**	4.8 (1.9)	1.3 (1.6)
Criollo Cattle (numbers)**	0.3 (0.5)	2.5 (2.2)
Forage (hectares)**	4.9 (3.0)	1.6 (1.5)
Wages (Bolivianos, Bs./year)	1,000 (1,718)	299 (507.4)
Household Consumption** (Bs./year)	5,981.3 (2492.8)	2,743 (1,463.4)
Cattle Net Income (Bs./year)**	1,784.2 (2,276.7)	1,142.5 (1,870)

** Statistical difference between means at 0.05.

The above subgroups "improved" and "criollo" present significant statistical differences with respect to the number of cattle and sheep by breed. The group with improved cattle also holds a larger amount of improved sheep. The other group instead has a larger number of criollo cattle and sheep. The "improved" group also has access to almost three times as much forages, and consumption in this group more than doubles the "criollo" group. The "improved" group also generates more wages and net income from cattle, though the last two are not statistically significant. Dunn et al. (1994) find that wage is inversely correlated with dairy production. There is a clear correlation between animal breeds and levels of income. There are very few differences in labor access, and the average age of the "criollo" group is slightly lower. More details about each group will be given below.

Two groups are also identified in the "elderly" cluster: they are defined as the "couples" and the "widowed" due to the fact that, in the first group, the great majority of households are composed by two adult people while, in the second, the great majority are widows. In both groups the largely dominant animal breed is the criollo. The "widowed" group has a larger number of sheep, whereas the "couples" group owns more cows.

Table 3: The Elderly

Variable	Group I: Couples	Group II: Widowed
Age (years)	64,4 (4.6)	66.4 (8.5)
Labor (units)**	1.95 (0.4)	1 (0.1)
Criollo Sheep (numbers)**	0.4 (1.1)	5.6 (4)
Improved Sheep (numbers)	2.1 (6)#	0 (0)
Improved Cattle (numbers)	0.1 (0.4)	0.3 (0.7)
Criollo Cattle (numbers)**	1.3 (1.2)	0.1 (0.4)
Forage (hectares)	0.7 (0.7)	0.5 (0.4)
Wages (Bolivianos, Bs./year)	99.4 (153.3)	141.3 (348.3)
Household Consumption (Bs./year)	1,008.5 (690.1)	1,666.5 (1,943.5)
Cattle Net Income (Bs./year)	8.1 (17.1)	88 (247.3)@

** Statistical difference between means at 0.05
# one sold 17 sheep
@ one sold a cow.

Income generation, cash and in-kind economic activities, and diversification strategies within group.

The following tables give more details about resources, production, and sources of income for each group presented above.

Table 4: Resources and Production by Groups

Variable/ Groups	The Productive Years		The Elderly	
	Improved Techs.	Traditional	Couples	Widows
Potatoes (has)	1.1 (0.5)	0.7 (0.5)	0.6 (0.3)	0.6 (0.7)
Quinoa (has)	1.0 (0.8)	0.7 (0.9)	0.3 (0.2)	0.3 (0.4)
Crop land (has)	3.3 (1.6)	2.5 (2.1)	1.5 (0.8)	1.1 (1.1)
Crop land (plots)	6.2 (2.1)	5.2 (2.8)	4.4 (2.6)	2.8 (1.0)
Alfalfa (has)	3.3 (2.3)	0.8 (0.9)	0.6 (0.7)	0.3 (0.4)
Forage barley (has)	1.6 (1.2)	0.8 (0.8)	0.2 (0.2)	0.2 (0.2)
Irrigation (has)	1.4 (1.4)	0.3 (0.7)	0.4 (0.7)	0.9 (1.9)*
Land renting (has)	1.4 (2.6)	1.9 (2.3)	0.5 (0.8)	0.6 (0.7)
Rangeland (has)	5.6 (6.6)	6.1 (9.0)	1.0 (1.0)	3.1 (3.5)
Fallow fields (has)	11 (9.6)	5.3 (5.5)	2.0 (2.0)	6.7 (9.3)
N sample size	15	14	8	8
Zones	Tholatia (6)	Espiritu Willqui (5)	Sabilani (4)	Sabilani (3)

* One person has five hectares and five have nothing.

Table 5: Income Sources Through the Life Cycle, Quality of Resources and Wealth.

Variables	Productive Years		The Elderly	
	Improved Techs.	Criollo Techs.	Couples	Widows
Total income	11,457.6 (5,413.4)	4,696.8 (3,290.1)	1,434.8 (988.7)	2,005.6 (2,001.2)
Food income	2,534.2 (1,295.6)	1,278.7 (1,134.7)	529.7 (422.6)	570.8 (433.0)
Forages income	3,692.1 (2,957.1)	811.2 (808.4)	418.2 (481.3)	251.1 (254.3)
Sheep income	1,338.8 (1,046.3)	847.1 (897.5)	309.6 (645.6)	259.6 (366.4)
Cattle income	2,700.9 (2,291.3)	1,413.6 (1,946.28)	24.1 (48.4)	88.0 (247.3)
Milk income	916.66 (654.2)	271.0 (892.0)	16.0 (45.3)**	0.0 (0.0)
Total Ag. Income	10,266.0 (4,650.5)	4,350.6 (3,330.5)	1,281.6 (908.5)	1,169.5 (748.4)
Wages	1,000.0 (1,718.3)	299.0 (507.4)	99.4 (153.3)	141.3 (348.2)
Other incomes	191.7 (572.7)	47.1 (75.8)	53.8 (113.8)	694.9 (1648.8)
HH. Consumption	5,981.3 (2,492.8)	2,743.0 (1,463.4)	1008.47 (690.1)	1,655.5 (1,943.5)++
Investment*	5,476.3 (3,754.0)	1,953.8 (2,119.0)	426,3 (480,9)	339,1 (387.8)

* Investment: forages income + net income from cattle.
** In the elderly group, only one family sold milk to PIL in 1992-93
++ one person received a State pension for being a veteran of the *Chaco* war against Paraguay (1932-35).

The productive and middle years with improved breeds and forages: in terms of resources and production, the one critical factor that appears to distinguish these households is that, on average, they have four times more alfalfa and irrigated land cultivated than any other group. This is closely related with the fact that improved animal breeds are dominant in this group and that all but one household sells milk to PILL. These households also cultivate more croplands but the differences with the other groups are insignificant. The higher number of has and parcels of cropland is probably related to the fact that they have more fallow land and more elevated cash income, which allow them to spend more on inputs for crops cultivation. What is noteworthy is that the intensification of forages cultivation and the production of improved stocks have not been accompanied by a reduction of crop cultivation. As a result, total agricultural income in this group is more than double that of the criollo group.

Ages are also significatively higher in this group, but this is primarily related to the fact that three male heads of households earned relatively much higher salaries than any other one: two are schoolteachers and the other owns one of the few small grocery stores in San José. In both the improved and criollo groups about 45% of households did not receive wages income. The general pattern in San José is that off-farm incomes, with few exceptions, does not represent a significant share of total income.

The productive years with native species and extensive practices: two subgroups could be clearly distinguish in this group. One of them is composed in its great majority (5 over 7) by households of Espíritu Willki zone, the one that is farthest from San José's main square and from the milk collection center, and where there is less access to *fluviosols*. In this zone, herders have to rely much more on natural rangeland to feed their animals, which makes it difficult to breed improved species. This is the group that on the average rents the highest quantity of land (2.9 has) to compensate for its poorer (in quality and quantity) land base. Three of these households were in the process of migrating at the time of the survey.

The other subgroup is composed by households with a younger age average (35.7 years old) and a greater labor availability (4.1). They herd almost exclusively criollo sheep but they have a slightly higher number of improved cattle (1.9 on the average vs 1.7 criollo). Four of the seven households of this group sell milk to PIL. Some of these households could be in a process of gradual cattle production intensification. On the other hand the only two "middle years productive" households that are headed by women are part of this subgroup.

The elderly: the *couples* tend to cultivate more land, which is quite understandable given that they count on more labor than the *widows*. It is notable though that all the households without exception cultivate potatoes. On the average, the elderly couples and widows cultivated almost the same potato extension (0.6 has vs 0.7) as the *criollo productive* group. Potato cultivation appears to be the only activity practiced by all the households.

It is difficult to establish other significant differences between the *elderly* and the *widows* given that average differences are often due to the fact that one or two households show higher values than the other members of their group.

With respect to income levels, several households reported very low revenues. The survey included questions on transfers by relatives, but the majority of the old persons answered that they received very few things from their children or other family members. It is possible that the survey underestimated the value of some reciprocity relationships that allow the poorest to survive. In any case, one cannot avoid being struck by the extreme poverty of several households in San José.

V. CONCLUSIONS

Why It Is Important to Add The Socioeconomic Dimension In Devising Policy And Technology.

The results of the cluster analysis show that intensification of livestock and milk production have not been accompanied by a reduction in diversification of agricultural activities. On the contrary, the household group that has adopted new technology (forage cultivation on irrigated plots and improved animal breeds) is also the one that allocates more land to food crops and has the highest off-farm income in absolute terms. Diversification of agricultural activities is a fundamental strategy to cope with a varied and unstable natural environment and with uncertain socio-economic conditions. The cluster also shows that in a relatively small territory occupied by one hundred households there are clear differences between producers regarding resources, production and income.

Several broad conclusions for the design of technology and policies can be drawn from this analysis:

1. The impact of a technology designed to increase the income generated by a specific productive activity will be relative to the place that this activity occupies in the portfolio of a producers group. If, for example, this activity generates 15% of the total household income, a 33% income increase in this activity will have, a short term 5% impact on the total income (Kervyn, 1988). Technological innovations will have a greater impact if they permit increased production in several activities. This is the case of alfalfa cultivation as, it benefits both cattle and sheep production and may be eventually integrated in new mixed crop patterns.

2. Understanding the role and importance of specific activities in the production system and how these activities are interrelated is necessary to measure the overall impact of an intervention. If an increase in the yield and/or income of an activity implies displacement or reduction of the income generated by another activity, the overall impact on income and welfare could be more limited than a evaluation of the individual activity would have predicted.

3. The fact that potato cultivation is practiced by all households without exception, in spite of the high risks associated with this activity, indicates the importance of this crop for household food security. The general tendency of rural development programs and technology research projects in the last ten years has been to not pay any attention to potato culture in the Altiplano because it is too risky, and cannot be considered as a commercial crop. If potato culture should be reduced, it should first be demonstrated that better use of the dryland where potatoes are cultivated is possible, and secondly, that it is economically more profitable to buy potatoes (or other food products that have equivalent nutritive values) in the rural markets.

There are various reasons to think that this would be difficult, and it is probably be more realistic to invest in design of technologies that help reduce risks in potato culture without increasing costs. Though commercial varieties are important, public research should not be solely based on traits to increase yields and income of cash generating crops and products.

4. Infrastructure development (road and irrigation) proved to be critical for the diffusion of more intensive technologies in San José. Distance to market and to the township played a role in adopting dairy in San José Llanga. The adoption of new technology has not resulted in the reduction of diversification in agriculture (Reardon et al find that at high income levels diversification can also exist). What can be said is that it has probably reduced (with few exceptions) the importance of off-farm income in the producer's portfolio.

5. The cluster analysis shows clearly that not all the producers have been able to take advantage of the new window of opportunity provided by *Fomento Lechero*. On one hand, a large group (36%) of households headed by persons over age sixty have access to less resources given the characteristics resource transfer within family as described above. The majority probably are not able to get involved in new intensive technology development programs, but do rely on agriculture to satisfy their food needs. Improvements in potato culture as indicated above could benefit them significantly. More generally, the very low level of income of many people in this group should underline the need for policies designed to improve their welfare. During the last years, for example, food subsidies in the region have been destined to households that have children in school or to people able to work in infrastructure construction ("food for work" projects).

On the other hand, differences exist among the "middle years productive group" that are significant between those breeding improved animals, with access to irrigation and alfalfa production, and the other group that breeds criollo animals on natural rangeland, feeding on crop residues and some forage barley. These differences in San José would probably be more accentuated if our sample would have included households of other communities, because the majority of communities do not have access to irrigation. These differences call our attention to the importance of expanding small irrigation schemes and improving water use, and to the design of technologies appropriate to improving feed resources and animal breeding in situations where irrigation is not possible. In this context, the potential of the criollo breed has to be explored more systematically.

Technology research and diffusion programs tend to work only with producers that are easy to contact and readily available to test and implement their proposals. In San José this has meant that extension agents have rarely paid attention to the needs of Espíritu Willki producers in the outermost zone. In an environment characterized by diversity and uncertainty, comprehensive socio-economic studies are necessary to identify real needs, to estimate impacts and to define the objectives of technology and policy programs.

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