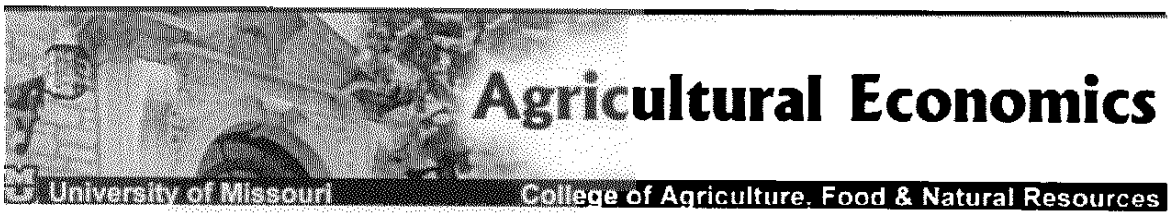

Household Production Strategies in a Climatic Variable Zone

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Susan Materer and Corinne Valdivia[1]
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ABSTRACT

This paper examines the types of strategies rural households in the Bolivian Altiplano utilize to secure income and food consumption. Constrains to choice sets, climate, knowledge systems and social and human capital have influential roles in the ability of a household to secure income and food, and the livelihood strategies employed. For household welfare to increase development agencies must take into account the factors influencing these strategies. Climate, local knowledge systems and modern technology are important in shaping household production strategies. Production decisions are made within the household and are influenced by the social and human capital embedded within the household unit. A livelihood strategies approach was used to conduct the research that would reflect the diverse strategies and influences that a household confronts and uses annual to make production decisions.

Research was conducted over a seven-year period in San Jose Llanga, Bolivia, which is a small rural town 90 Km south of the capital of the country, La Paz. Each year of the survey data was collected from 45 households. Twenty-nine of these households were surveyed three times during the seven-year period (1993, 1995 and 1999). The study using factor analysis shows that there are four essential factors, which are important in securing income and food: human capital, traditional agricultural practices, food plots, grazed cows, and remittances. These five factors are important diversification strategies for households, present over the seven-year research period. Human capital and food plots were statistically significant in explaining income, highlighting the importance of household characteristics and spatial diversification for this region.

INTRODUCTION

Production strategies of peasant farmers are influenced by a variety of factors, such as political stability, market structure, and access to resources. But the role of climatic forces in the lives of those who depend on the land for income and food security is especially important. Farmers in mountain regions are especially susceptible to harsh climatic conditions because of high spatial variability and interannual variation (Price, 1995). To survive under these conditions peasant farmers have developed unique agricultural systems (Price, 1995, Valdivia et al, 2000), which are characterized by diverse economic portfolios (Kusterer, 1989). The diversification of income sources spreads risk amongst the various economic activities and provides security of income and food consumption (Kusterer, 1989). In order to understand what strategies households employ a livelihoods strategies approach is used. This approach identifies the strategies used by households, which depends on their access to resources, stage in the life cycle and their ability to use human and social capital to increase production or security (Valdivia et. al, 2000).

This paper will explain the importance of using a livelihood strategy approach to address research problems in rural communities. First, the livelihood strategy approach of rural households will be discussed. This approach will then be discussed in the context of the research problem and setting. The methodology is discussed in the next section, and how variables are identified. The fourth section explains the main strategies of pursued in the region through factor analysis. These strategies are used in a linear regression analysis in the fifth section, to understand how well these explain income. Research findings are discussed, and how can be applied to development projects. Finally a discussion of insights and future research steps are examined.

LIVELIHOOD STRATEGIES

The political, social and physical environment of rural households' surroundings influences the stability and decisions of households. Any changes in these factors can affect the ability of households to secure income and food for present and future consumption. Therefore rural households construct diverse portfolios of economic activities and secure social support systems in order to stabilize or increase household welfare (Ellis, 1998). Diversified household portfolios help to mitigate risk associated with markets, climate and other unforeseen factors. The economic activities of the household portfolio characterize it as both a producer and a consumer. The household must produce to secure income but also to ensure that there is an adequate supply of food throughout the agricultural year. Ellis (1993) describes this as a partial engagement of the household in market activities, which will fluctuate depending on market prices, agricultural productivity, and household needs. The unreliability of markets to adequately provide food at stable prices and a consistent supply does not guarantee that households will have a secure source of food. Therefore households must include food production in their portfolios in order to secure their livelihoods.

The diversification of economic activities will depend on household's access to resources, available labor supply and goals. These constraints define the options available to households, or the available choice sets (North, 1990). Households' access to these resources depends on the amount of physical, human and social capital they have. If a household is constrained by land then an increase in the number of livestock or crops produced will not be a viable option, unless other institutions are employed to access more land. Also if labor is the limiting factor then households may invest in labor saving activities. Oftentimes households access their social capital to secure land and labor through the method of sharing and trading resources.

The goals or objectives of the household also influence income diversification. A household concerned with risk management will invest in activities that secure income and food, as opposed to households that aim to secure goods and services for future use (Ellis, 1998 and Reardon, 1998). These factors constrain the choice sets of households and influence production strategies and ability to increase their standards of living.

Climate variability is an important contribution to the risk households will encounter during the agricultural year, thus affecting diversification strategies. Crops and livestock productivity are affected by climate variability, such as frosts, droughts and interannual variations. This type of risk contributes to low investment in agriculture, especially when farmers have limited coping strategies (Rosenzweig and Binswanger, 1993). These limitations increase the need to include risk management techniques, such as diversification; spatial variability of food plots, the use of native breeds of crops and livestock (Walker and Jodha, 1986).

While some climatic variation is a common occurrence, there are some climatic anomalies, which drastically affect the security of households. One of these events is El Niño Southern Oscillation (ENSO) event, which warms and cools the water of the equatorial Pacific Ocean (Stern and Easterling, 1999). These events impact dramatically the Andean countries of South America, such as floods in Peru and Ecuador and drought in Bolivia and NE Brazil (Finan, 1999 and Broad, 1999). These events make the incorporation of risk-management and diversification strategies a necessity for peasant

households. The large amount of risk associated with climate variability increases diversification methods and strategies of households to incorporate activities that do not have covariant movement (Rosenzweig and Binswanger, 1993). Households in these environments deal with stress from year to year, adapting their production strategies to it. In other situations shocks affect the ability of households to produce and new activities have to be incorporated, such is the case of off farm employment.

In response to climatic variability farmers have developed intricate and complex forecasting indicators to help predict weather and climate. Indicators, such as animals, constellation, plants and abiotic factors aid farmers planning risk management strategies (Bharara, 1994 and Osunade, 1994, Hatch, 1983). These indicators developed by observations, experiences and information passed down by previous generations constitute a local knowledge base (Hatch, 1983 and Céspedes and Rodriguez, unpublished). Although the successes of these indicators are not supported by statistical analysis (Osunade, 1994), they provide farmers with a set of rules and strategies to employ when specific events are observed (Bharara, 1994). These sets of rules, or local knowledge systems have not been completely replaced by scientific forecasting methods (Bharara, 1994 and Osunade, 1994). Instead they have melded with modern technology. Farmers have incorporated modern practices into their local practices (Markowitz and Valdivia, forthcoming) by a process of revising local knowledge systems, reinterpreting prior ideas and incorporating new systems (Bebbington, 1991). These revisions and modifications demonstrate the dynamic nature of production strategies and the ability of farmers to adjust to changing circumstances (Bebbington, 1991).

Production factors and household characteristics can be measured but there are other important factors that shape livelihood strategies, which are embedded in relations and expressed as institutions. The embedded nature of social and human capital often explain why some households may use different strategies or have access to diverse resources (de Haan, forthcoming). Social capital is a public good (Putnam, 1993) and is a by-product of social activities (Coleman, 1998). According to de Haan (1999) social capital relates to the ability for individuals or households to access resources through membership in networks or social structures. Coleman (1998) believes that social capital also helps to facilitate certain actions within a social structure. In the context of livelihood strategies social capital aids households in accessing resources and meeting production goals that are not obtainable through the physical capital owned by a household nor through the market. Therefore social capital is expressed through memberships in organizations and networks, and institutions that rely on social relations facilitated by norms and traditions of households and communities.

Households with a high amount of social capital increase economic activities and opportunities, since they will have more linkages to credit and social networks (Light, 1972). But social capital can also hinder economic growth by constraining choice sets (Portes and Sesenbreener, 1999) and not encouraging certain forms of production if they are outside the social structure or norms. Although the direct effect of social capital is debated, it can play an important role in a peasant household whose production strategies are constrained by lack of resources or credit. Household human capital is also an important factor and is defined as the amount of labor and educational levels within a family. Human capital affects the decisions of households and also affects their ability to access resources. The number of people in a household will increase the ability to

diversify, and high educational levels may increase the ability of households to access information, resources and new technologies.

Therefore in order to understand how households decide what economic activities to invest in, there is a need to comprehend their livelihood strategies. Constraints to choice sets, climate, knowledge systems, and social and human capital have influential roles in the ability of a household to secure income and food. For household welfare to increase development agencies must take into account the factors influencing strategies.

RESEARCH PROBLEM

A lack of panel data in developing countries has hindered the analysis of livelihood strategies (Walker and Jodha, 1986). In order to improve the welfare of households through economic and development policies an understanding of important economic activities over a period of years is necessary. This research attempts to address the question of strategies that are consistently employed by households in a rural community in which households have constrained choice sets, climatic variability, local and modern knowledge systems, and social and human capital. The objective is to identify the main strategies employed by households over the seven-year period and to explore the impact of these strategies on total income. Factor analysis will be employed to analyze the variables that identify production strategies. Human capital accumulated, social capital and traditional practices are hypothesized as strategies employed by households through time. The first two are forms of capital produced by the household, in the peasant household framework defined as Z goods (Valdivia and Gilles, forthcoming), and the third secures food production in highly variable environments.

PROJECT SETTTING:

The Bolivian highland was chosen because it is particularly vulnerable to climate variability, which affects the production practices and economic activities of the Aymara and Quechua communities that farm and reside in the harsh Andean climate. Droughts, frosts and wind erosion are common occurrences but during El Niño events droughts are more prevalent. Over 285,000 residents live in the highlands, which is located between 3650 and 4800 meters above sea level (Francois, 1999). Food insecurity is a daily concern and small farmers produce for home consumption and local markets (Jovel, 1989; Francois, 1999). Households in this region are constrained by the political and social environment, which lead to the instability of market prices and the economy as a whole (Library of Congress, 2000). Therefore peasant farmers can be described, as both producers and consumers, and the livelihood strategy approach provides a framework for analysis of their economic activities.

Research was conducted in the community of San José Llanga, located in the Bolivian Altiplano 116km south of La Paz, at an altitude between 3,725 and 3,786 meters above sea level (Valdivia and Jetté, 1997). The community land comprises approximately 7,200 hectares, which are divided into six distinct zones or neighborhoods: Espíritu Willqui, Incamaya, Tholatia, Barrio, Savilani, and Callunimaya (Alvarez, 1994). There were approximately 430 people living in the community in 118 households (Céspedes-Estevez, 1993) in 1992. Due to its high altitude San José Llanga is susceptible to extremes in temperature, frosts, droughts and other climatic variations characteristic of mountain regions (Alvarez, 1994). Although San José has more than thirty years of experience with the introduction of improved technology and information, there has been little specialization of household production systems (Markowitz and Valdivia, forthcoming).

RESEARCH DESIGN:

The community of San Jose participated on a research program to understand the sustainability of agropastoral systems with the University of Missouri , through the Small Ruminant Collaborative Research Support Program-Bolivia (SR-CRSP) between1992 to 1995. Currently the project Climate Variability and Household Welfare in the Andes: Farmer Adaptation and Use of Weather Forecasts in Decision-Making at the University of Missouri (MU), through support from the Office of Global Programs, National Oceanic and Atmospheric Administration (OGP-NOAA) is working with community members to study adaptation and alternative technologies. Three household production surveys have been conducted in conjunction with these research projects. Two surveys in 1993 and 1995 during the SR-CRSP and the MU project collected data in 1999. Only twenty-nine households participated consistently in the three time periods. Households discontinued collaboration with the project due to migration, death, or lack of interest.

The surveys collected data on production strategies and household characteristics. Households were asked to give information on number of animals owned, the types, and economic activities associated with the animals. Also questions were asked about crop production, number of food plots grown and crop sales. Demographic data was also collected, data on the number of household members, ages and educational level. Consumption of crops and animals, and off farm income and transfers of money were also recorded. Therefore through the three surveys, consistent data was collected to determine the crop and livestock production strategies, and the characteristics of the household through time. The level of economic activity and home consumption of crop production was estimated from the data. The survey in 1999 asked more detailed questions on the impact of climate on the production strategies of households.

The surveys conducted can be analyzed using factor analysis to determine the main strategies that were employed by households to generate income. As mentioned earlier households have four main sources of income, and different strategies to pursue these: 1) Crop production, 2) Livestock production, 3) Off farm income, and 4) Transfers. These activities are affected by the household's characteristics. Although these activities can be broken down into four distinct types, and a household's characteristics, there are important components of each one that are related to similar risk mitigation and capital accumulation goals. For example households use native and improved animals for different purposes. Also the use of sharing land ("al partir") and labor ("ayni") exhibit the use of social capital to access resources and to share risk (mitigation). Factor analysis can be used to determine which variables are correlated and grouped together to explain similar livelihood strategies. The use of the three surveys is especially important since an analysis can be done over time to understand the role of these strategies on the livelihood goal of securing and improving welfare.

A LIVELIHOOD STRATEGY APPROACH

In order to construct a livelihood strategy approach, the household needs to be defined as a producer and consumer and the variables grouped according to the particular strategy exemplified. Calculating total income as both in-kind and cash income for the agricultural year supports the household definition employed. The variables can be grouped into four main types of production strategies: 1) Off farm income, 2) Crop production, 3) Livestock production, and 4) Transfers. Household characteristics are also identified to describe the human capital element and life cycle's role in the livelihood strategies. Social capital can be embedded in some of these components.

IDENTIFICATION OF VARIABLES:

Total income is calculated by summing cash and in-kind income. Cash income is the total of agricultural sales and off farm income. In-kind income is calculated as the consumption of goods valued at their opportunity cost. The income variable captures the importance of food security and purchasing power of households. The components of income are production of crops and livestock, off farm income, transfers or other income sources, such as sale of handcrafts or collected fuel wood. Summing cash received from market sales and the opportunity cost of consuming the remaining production at home equals the total income earned from crops and livestock. Other sources of income, such as selling of artisan products, transfers, or other off farm wages were added to the previous amount to obtain the total income of the household. Total income was first calculated in the Bolivian currency and transformed into dollars using the official exchanges rate. Sample size is 57 since total income was only available for 1993 and 1995. The mean for the two years was $1,199.74, with a range of $4,027.86, indicating a wide disparity in income earned by households (See Table 1). The minimum income earned was only $26. One household had an income greater than $8,000 and was identified as an outlier through preliminary scatter plot analysis. The household exhibited unique characteristics and was deleted from the sample due to requirements of the techniques employed.

TABLE 1: Total Income in San Jose Llanga (Dollars), 1993-1995

	Mean	Std. Deviation	Minimum	Maximum
Income Dollars	1199.74	987.4	26	4053.86

Source: SR-CRSP Bolivia Database 1993-1995

Twelve independent variables were isolated or constructed from the surveys to identify the five components important to shaping distinct livelihood strategies. A complete set of these variables was available for 1993, 1995 and 1999.

The first set of independent variables relates to household characteristics. The educational level of the household was calculated as the sum of the number of years of education obtained by household members over the age of 18. Calculation of household members of 18 years of age or older was chosen, since the majority San José Llanga

residents finish their schooling by this age or begin their own family. Second, the number of household members was added to calculate the size of the household. The third factor was household age, which is an important indicator of the household's life cycle, along with size of the family and number of adults. The age of the household was calculated as the age of male head or if there was no male head of household, then the age of the female. Single female head of household is common among the elderly population. Finally, it was necessary to calculate a labor equivalency unit, since each member does not contribute equal amounts of labor to the household. The unit was calculated by weighing each household member by age, which indicates the amount of labor each person contributes (See Table 2). The calculated total provides the adult labor equivalency amount. Similar studies on the effect family labor and life cycle on production strategies (Deere and de Janvry, 1981; O'Brien et al., 1998; Valdivia et. al, 1995) also employed this process. Note that male and female are weighted similarly, since they both have important but distinct roles in the household (Valdivia et. al, 1995).

TABLE 2 Labor Household Weights to Calculate Adult Equivalents

AGE GROUPING	WEIGHT
0-3 YEARS	0
4-5 YEARS	0.1
6-8 YEARS	0.3
9-12 YEARS	0.5
13-17 YEARS	0.8
18-59 YEARS	1.0
60-65 YEARS	0.8
76+ YEARS	0.3

* This table was extracted from Deere and de Janvry, 1981 "Demographic and Social Differentiation Among Northern Peruvian Peasants." Journal of Peasant Studies 8(3): 344.

The second set of variables identifies with livestock production, which has five distinct variables representing different strategies. The first two are raising native and raising improved livestock, which are different strategic mechanisms for households, since native breeds are more resilient to the harsh climate and improved breeds provide a greater monetary source of income (larger animals in a shorter period of time). Sheep sharing ("al partir") and grazing of sheep for other households are important mechanisms for families to increase resources and mitigate risk, by accessing their social capital. The last strategy related to livestock production is the number of cattle the family grazes for other households, as a mechanism of accumulating through social capital. The grazing of cows that do not belong to the family is an important investment function and indicates the desire for a family to diversify their economic activities. Social capital is an embedded element in these last two strategies, since the ability to access more animals or labor indicates a high number of social networks, i.e. higher social capital. Networks are an important means to access these resources through the social structure of the

community that has created these institutions, important in facilitating diversification of activities by households.

The number of food plots a family plants is also an important ex-ante risk management strategy (Walker and Jodha, 1986). Crop production is both a commercial and food security activity, and is very sensitive to climatic conditions (Reardon, 1992). By increasing the number and dispersion of food plots planted households decrease risks, taking advantage of various microclimates found in the different areas. Social capital also plays an important role in this strategy since it requires ability to access land or labor to farm an increased number of food plots. Once again the institutions of the community and networks strengthened aid in a household's ability to secure these resources.

Finally, the last activity, a strategy that decreases the risk from relying only on agriculture, relates to acquiring income from off farm activities. Off farm income has been noted to be an important coping strategy for households affected by climatic shocks (Reardon, 1998 and 1992; Bebbington, 1999; and Ellis, 1998). Off farm income helps households smooth income throughout the year and diversifies economic portfolios through the incorporation of non-covariant income sources with agriculture. This variable (yes or no in this study) indicates the family's ability to work off the farm. Transfers are another form of off farm income, which is employed by households to diversify income often in times of stress or shocks (Rosenzweig and Stark, 1989). These are commonly received in the form of cash from family members who reside in other regions. Remittances are a smoothing technique employed typically by older households, but also by younger families in times of stress. For this study the monetary amount of remittances, sometime in-kind gifts, was converted to dollars.

The sample size for the twelve independent variables is 87, since it is for three years of the survey (See Table 3). Many of the entries for some variables are zero (minimum value), which characterizes elderly households that have limited choices. The large standard deviation of some of the variables is indicative of varying importance of the activities and strategies for the households' livelihoods. In order to understand overall patterns of production strategies amongst the households, factor analysis groups variables together into a new explanatory variable, a latent variable.

TABLE 3: Descriptive Statistics of Independent Variables: 1993, 1995 and 1999.

	Mean	Std. Deviation	Minimum	Maximum
Food Plots	4.70	2.84	.00	15.00
Native Animals	10.33	15.82	.00	70
Improved Animals	21.54	33.83	.00	166
Grazed Cows	.89	1.73	.00	9.00
Shared Sheep	3.41	10.99	.00	88.00
Grazed Sheep	17.17	24.49	.00	130.00
Remittances	27.42	73.15	.00	336.00
Family Size	4.62	2.90	1.00	12.00
Household Age	53.84	15.89	4	100
Adult Equivalency Unit	3.11	1.99	.5	9.10
Education Equivalency Unit	14.65	15.22	.00	74.00
Off farm income	.47	.50	.00	1.00

FACTOR ANALYSIS OF VARIABLES

Factor analysis was employed to analyze and group together the twelve independent variables. This analysis finds patterns among the variations in the values of several variables, or clusters of highly correlated variables. By clustering group of variables together, factor analysis enables a large number of variables to be aggregated into latent variables. Latent variables describe characteristics that cannot be directly measured or identified. In factor analysis the variables are analyzed according to principal component analysis. Components are a group of variables and will be analyzed according to the amount of variance explained and their eigenvalues. Components that explain a high amount of variance will be selected and examined. Eigenvalues indicate how much of the variation in the original group of variables is accounted for by a particular factor. If the eigenvalue is greater than 1.0 the component can be considered statistically significant (Vogt, 1999). The statistical software used for the analysis is SPSS.

This type of analysis is especially important in this research problem since it will enable the number of variables to be reduced, important in dealing with a small sample size. Factor analysis will also identify particular strategies that were important to household production during the three years of survey data, which span a seven-year period. Factor analysis will identify characteristics of households that cannot be directly measured. These characteristics will be identified as latent variables and will describe the main strategies of the households over the seven-year period (Vogt, 1999).

IDENTIFICATION OF LATENT VARIABLES:

The variables related to household characteristics were grouped into a separate factor, since the characteristics may be correlated to the other variables. Factor analysis included the following variables: education equivalency unit, the adult equivalency unit, family size, and household ages. The first component extracted explained 73.362% of the variance and had an eigenvalue of 2.934 (See Table 4). The other three components were not significant to the analysis, since their eigenvalues were less then 1.0 and did not explain much of the variance.

TABLE 4: Factor Analysis of Household Characteristics

	Initial Eigenvalues	
Component	Total	% Of Variance
1	2.934	73.362
2	.706	17.651
3	.295	7.383
4	6.417E-02	1.604

Extraction Method: Principal Component Analysis.

The first component was comprised of the adult equivalence and education equivalence unit (See Table 5). Family size loaded high in both components, indicating a poor measurement. Household age was not significant in the first component. Therefore

this component can be described as Human Capital, since it explains household characteristics related to labor quantity and quality.

TABLE 5: Principal Component Analysis According to Variables

	Component	
	1	2
Education Equivalency Unit	.935	7.951E-02
Adult Equivalency Unit	.832	.477
Family Size	.707	.635
Household Age	-.167	-.953

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations

A second factor analysis was conducted for the remaining eight independent variables. In the initial analysis off farm income did not load high in any of the components and was omitted. Also the number of improved animals was omitted, since it loaded high in components two and three, indicating a poor measure. Factor analysis was then conducted on the remaining six variables (See Table 6). The first three components explained 73.1590% of variance and had Eigenvalues of 2.134, 1.300 and .957 respectively. These three components were analyzed to explore what characteristics they exemplified.

TABLE 6: Factor Analysis of Production Strategy Variables

	Initial Eigenvalues		
Component	Total	% Of Variance	Cumulative %
1	2.134	35.565	35.565
2	1.300	21.670	57.235
3	.957	15.955	73.190
4	.648	10.804	83.994
5	.582	9.702	93.696
6	.378	6.304	100.000

Extraction Method: Principal Component Analysis.

The first component loaded three variables; number of sheep shared, number of sheep grazed for other families, and number of native animals. These three variables identify traditional livestock practices that households employ to mange risk, such as production of native breeds and expansion of own livestock by sharing and grazing other sheep. This component will be identified as Traditional Practices.

The second component consisted of cows grazed for other families, and number of food plots, which identify two distinct production strategies (See Table 7). Cows grazed for other families helps households accumulate resources for the future and increase the amount of income earned through the market. This variable is also an

indicator of social capital since access to this production/accumulation strategy depends on social networks. The number of food plots is a risk management technique, which decreases risks associated with climate by using spatial diversification, and therefore ensure access to food. High levels of food plots provide food security and possibly some surplus that can be sold at the market.

For the third component only remittances loaded and will be included as a distinct household strategy (See Table 7). Remittances provide income security to households during low production years and are especially important to elderly households in ensuring food security. This variable is also important in reflecting life cycle objectives.

TABLE 7: Principal Component Analysis According to Variables

	Component		
	1	2	3
Shared Sheep	.827	.247	-.119
Grazed Sheep	.751	.324	-9.981E-02
Native Animal	.726	-.389	.310
Grazed Cows	2.187E-02	.833	9.431E-02
Food Plots	.322	.658	.160
Remmitances	-5.306E-02	.192	.935

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Before these components can be identified as distinct latent variables an alpha reliability test is required. An alpha reliability test examines the validity of combing variables into distinct components. Alpha values range from .00 to 1.0 and values greater than 0.6 will be assumed to have high validity (Vogt, 1999). The variables in the Human Capital component have an alpha reliability of .8482 (See Table 8). Therefore this component can be identified as a latent variable. The variables of the Traditional Practices component also have a high alpha reliability of .6703 (See Table 8) and will be kept as a latent variable. The second component that was identified in the final factor analysis did not have a high alpha reliability (See Table 8) and it was concluded that food plots and grazed cows could not be clustered together as a latent variable.

TABLE 8: Alpha Reliability Test of Latent Variables

FACTORS	VARIABLES	STANDARDIZED ITEM ALPHA
Human Capital	Adult Equivalency Unit Education Equivalency Unit	.8473
Traditional Practices	Native Animals Shared Sheep Grazed Sheep	.6703
Second Component	Food Plots Grazed Cows	.5225

By using factor analysis, variables could be grouped together to identify similar strategies and define specific latent variables. Factor analysis of the preliminary twelve independent variables reveled five important production strategies that were used over a seven-year period. The first can be described as the Human Capital component, which consists of the adult equivalency unit and the education equivalency unit. The second latent variable is the Traditional Practices, which combines shared sheep and grazed sheep. The other three variables identified as production strategies will be identified separately, food plots, number of cows grazed for other families and remittances (See Table 9).

TABLE 9: Summary of Identified Production Strategies

VARIABLES	COMPONENTS
Human Capital	Adult Equivalency Unit Education Equivalency Unit
Traditional Practices	Native Animals, Shared Sheep Grazed Sheep
Crop Production	Food Plots
Capital Accumulation	Grazed Cows
Transfers	Remittances.

EXPLANATION OF INCOME ACCORDING TO PRODUCTION STRATEGIES

By utilizing factor analysis five key production strategies were identified as important household strategies and can be used in a liner regression analysis with total income in dollars as the dependent variable. An initial analysis of scatter plots of the independent variables against total income displayed a skewed pattern. Therefore the log was taken to conduct the analysis. Total income is only available for 1993 and 1995 these two years and these years will be used in the regression analysis. A dummy variable will also be included to identify the effect of year on the model; 1993 will be identified as zero and 1995 as one. Total income generated depends or is a function of:

> Y= F (Human Capital (HC), (HC), traditional practices (TP), food plots (FP), cows grazed and not owned (GC), remittances (REM), YEAR)

A preliminary analysis of the regression model indicated a Durbin-Watson value of 2.152. This value indicates that there is no auto correlation in the model; therefore the two years of data can be pooled and the dummy variable was dropped from the model. The regression analysis of the five production strategies against the log of total income had an adjusted R-square of .445 and an F value of 8.353 (See Table 10). In this model food plots and human capital are statistically significant. Remittances, grazed cows, and traditional practices were not statistically significant at the .05 level (See Table 11). Also remittances, grazed cows, and traditional practices had negative coefficients. The result of the linear regression were as follows (t-values are in parentheses):

Y = 2.634+ .363 HC -1.637E-02 TP +6.577E-02 FP –3.896E-02 GC+2.094E-04 REM
(20.72) (3.660) (-.274) (3.111) (-1.050) (.284)

TABLE 10: Summary of Linear Regression Model

Model	R	R Square	Adjusted R Square	F	Std. Error of the Estimate
1	.667	.445	.392	8.353	.4178

a. Predictors: (Constant), Human capital, Remittances, Pasturing of Cows, Food Plots, Traditional Practices

TABLE 11: Summary of Independent Variable Coefficients

	Unstandardized Coefficients		Sig.
	B	Std. Error	
(Constant)	2.634	.130	.000
Remittances	2.094E-04	.001	.778
Grazed Cows	-3.896E-02	.037	.299
Food Plots	6.577E-02	.021	.003
Traditional Practices	-1.637E-02	.060	.786
Human capital	.363	.099	.001

TECHNICAL DISCUSSION:

The model presented may have problems of multicollinearity. Multicollinearity is a potential problem with multiple regression analysis when two or more independent variables are correlated. When independent variables are highly correlated the ability to separate the individual effects of independent variables on the dependent variable is hard to determine (Vogt, 1999). Table 12 summarizes the correlations between the independent variables identified in the factor analysis. Human capital is only correlated with traditional practices at the .01 level. An analysis of the three variables that are included in the traditional practices latent variable is necessary to determine if one of these variables can be a proxy for the strategy identified. If one of the variables is a good proxy for traditional practices and is not highly correlated with human capital then the model could be improved. Also the variable Traditional Practices is also highly correlated with food plots, which could be affecting the estimation of the coefficients. Grazed cows and food plots are also highly correlated at the .01 level.

TABLE 12: Correlations of Independent Variables

		Traditional Practices	Human capital	Remittances	Food Plots	Grazed Cows
Traditional Practices	Pearson Correlation	1.000	.345**	-.053	.322**	.022
	Sig. (2-tailed)	.	.001	.625	.002	.841
Human capital	Pearson Correlation	.345**	1.000	-.114	.142	.268
	Sig. (2-tailed)	.001	.	.293	.191	.012
Remittances	Pearson Correlation	-.053	-.114	1.000	.159	.185
	Sig. (2-tailed)	.625	.293	.	.142	.086
Food Plots	Pearson Correlation	.322**	.142	.159	1.000	.356**
	Sig. (2-tailed)	.002	.191	.142	.	.001
Grazed Cows	Pearson Correlation	.022	.268	.185	.356**	1.000
	Sig. (2-tailed)	.841	.012	.086	.001	.

** Correlation is significant at the 0.01 level (2-tailed).

The problem of correlation between the independent variables could give inaccurate results of the significance and effect of certain variables on the dependent variable. For example human capital is composed of household characteristics that affect

production decisions, such as owning and caring for livestock or cultivation of land. The high correlation of traditional practices and human capital could be attributed to the fact that household characteristics is embedded within this independent variable. Traditional practices relate to human and social capital since it is composed of variables that are labor intensive and requires use of networks and social institutions.

In order to improve the analysis the variables in traditional practices need to be evaluated to determine if there is a better proxy for this strategy. This would decrease the problems of multicollinearity associated with human capital and traditional practices. Also this might decrease the correlation with the variable food plots. Also the correlation between food plots and grazed cows is high, which is indicative of what was found in the initial factor analysis. Standardizing these variables could improve the alpha reliability between food plots and grazed cows and support a latent variable describing this household strategy. It would also be beneficial to standardize the variables since each variable is measured in different units. Also the index used to construct the adult equivalency unit was based on a Peruvian study in a zone that did not practice agropastoralism. It would be beneficial to use an index that was based on the region in study.

Another possible improvement of this analysis is that the factor analysis was done with three years (1993, 1995, and 1999), whereas only two years were used in the regression (1993 and 1995). Although the research objective was to identify the main production strategies employed over the seven-year period, this might have been a problem in the final regression results. Further research will be conducted using total income from 1999. It may also be necessary to explore the possibility of a recursive analysis due to the correlation of many of the independent variables.

The regression analysis is important to this research in order to understand how the production strategies identified explain total income of households. However it is necessary to explore how the variables impact the household and are related to one another. Household diversify their strategies to mitigate risk and accumulate capital, therefore within and amongst production strategies there may be a multitude of household goals and objectives. Access to sheep, cows, and food plots are related to social and human capital resources of a household. By incorporating the ideas discussed in this section and through a careful analysis of the latent variables a better understanding of their impact on households and how they can be used to explain income can be achieved.

FINDINGS AND IMPLICATIONS

Utilizing a livelihood strategy approach in the analysis of panel data extracted from a community in the Bolivian Altiplano, five main components were identified as important methods employed by households. These strategies are, Human Capital, Traditional Practices, the number of food plots, amount of cattle graze but not owned by the household, and remittances. Embedded in these components are important influences, such as climatic events, knowledge systems, and human and social capital. These factors influence small household production decisions, since they affect access to resources and constrain choice sets. These diverse production strategies help household spread risks and ensure income and food security. Diversification strategies are a necessary component in this region because of the large amount of varying factors that affect household welfare and stability. It is also essential to use panel data to explore these diversification strategies, because it revels different insights into production strategies employed by rural households. Every year households analyze economic, political and climatic conditions and decide what strategies will maximize their resources and output. For example during a drought year, or a climatically vulnerable year, off farm income may be more important. Therefore analyzing diversification strategies over a time period will allow researchers to understand the dominant strategies.

Human Capital and food plots were the only components that were statistically significant in the regression analysis, which has important implications for policy and development issues. For example, investment in human capital could aid economic development more than the research in improved agricultural production techniques (Bebbington, 1999). Also the number of food plots planted by household indicates that production of staple crops is an important production strategy. Development projects that encourage production of subsistence crops could improve household welfare by generating surplus production that could be sold at markets. Since staple crops are integral to the production strategies of the household it is essential to invest in research that will improve the productivity of traditional crops. For example, promoting and improving seed quality and development drought resistant and marketable varieties will improve households' livelihoods. This research also negates the view that specialization and monoproduction is an indicator of development. Households diversify their strategies in order to secure income and food consumption. Spatial diversification of food plots and the management of different animals is an important mechanism for risk adverse households.

Another important conclusion from this analysis is the fusion of modern and local knowledge systems. Although not statistically significant the identification of traditional practices and grazed cows as essential strategies indicated that households are incorporating technology with local systems. Traditional practices are an important coping and food security strategy, while modern technology; such as the number cows grazed by the family increases the diversity of economic activities. While the fusion of these systems is important some households may chose one system over the other, which depends on resources and goals. Therefore these strategies may not have been significant for the sample size because some household may practice one more than the other.

Therefore as indicated earlier, a multitude of strategies are employed at the household level. Human capital is an important indicator of what strategies a household

can invest in to minimize risk and accumulate resources for future goals. Also social capital can be identified in the production strategies of grazed cows, food plots, shared sheep and grazed sheep. The uses of these strategies indicate that households can access important social networks. This is also true of the use of remittances to smooth income. The fusion of knowledge systems indicate that households will continue to rely on local methods but also incorporate appropriate technology when it meets the needs of the household. More studies utilizing panel data are necessary to show what strategies households to use to secure and increase their standard of living. The results will have positive impacts on development projects and economic policies in less developed countries worldwide.

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