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Adapting to Change in the Andes: Practices and strategies for vulnerable ecosystems

Some lessons learned

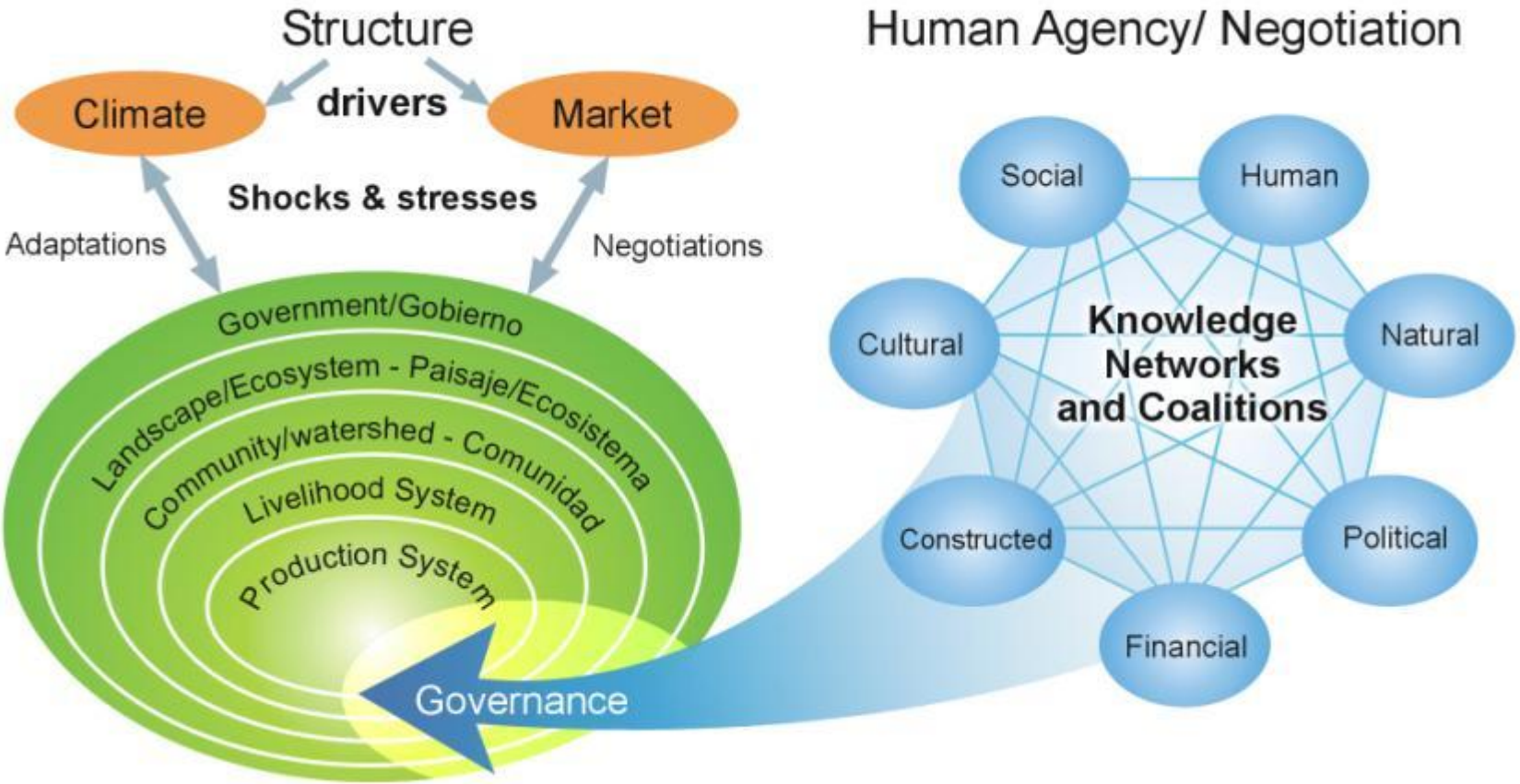
SANREM CRSP


Illampu, Bolivia 2009

Climate change, agriculture and adaptation

- Climate change will increase food insecurity in Tropical regions (Lobell et at, 2008, Science)
- **Three groups of questions in the context of the Andes**
  - What do we know about Andean Climate Trends and Change? Are the impacts and issues the same? (Brown and Funk, 2008, Science)
  - How are livelihood strategies shaped in Altiplano ecosystems by markets and capitals & are the impacts of climate change the same?
  - What do we know about access and use of climate and forecast information in rural areas of the Tropics?
    - Participatory research and institutions in the development of community adaptation strategies.

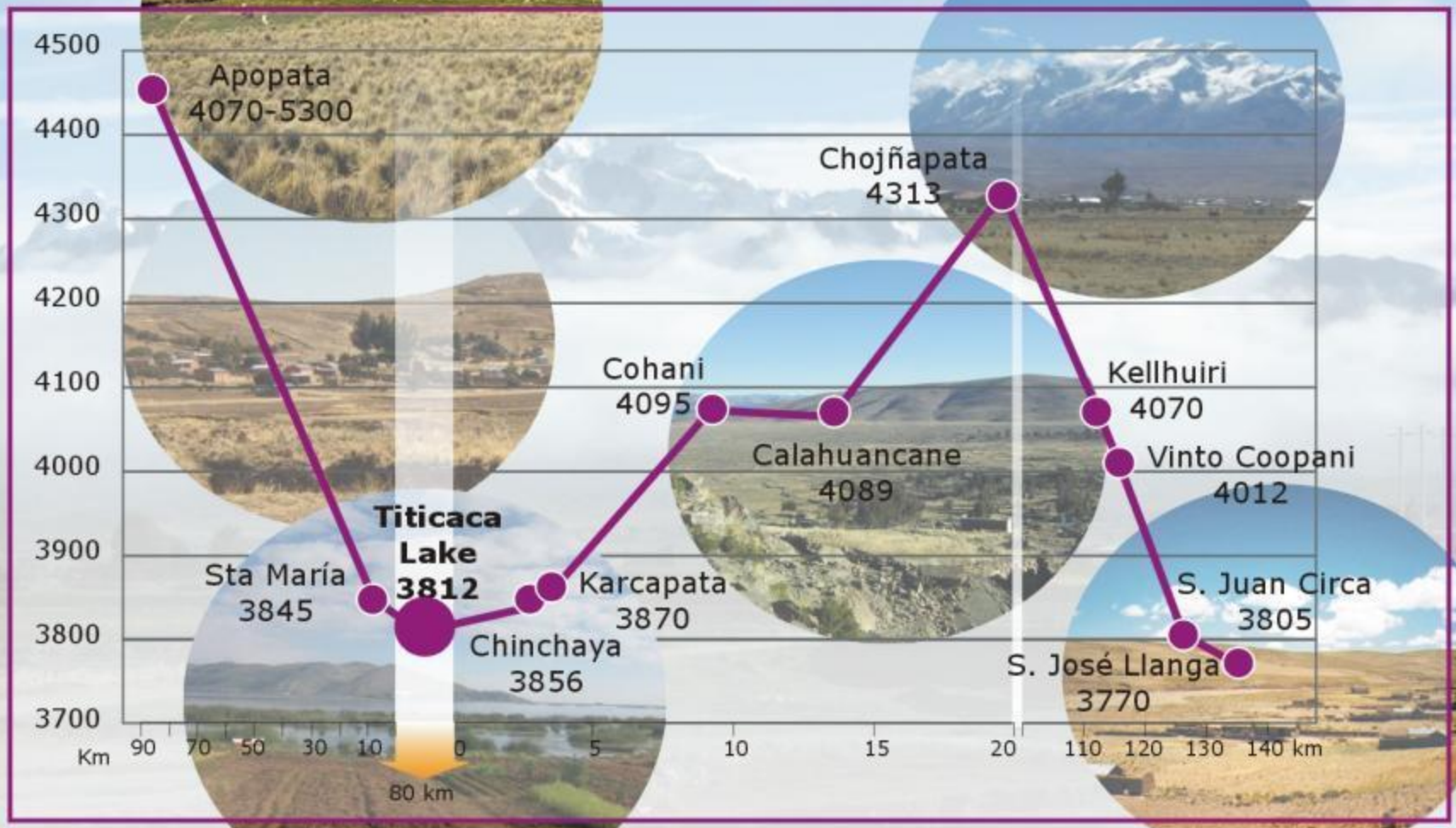
ADAPTING TO CHANGE IN ANDEAN ECOSYSTEMS



Dynamics and interactions of the human and biophysical systems at multiple scales

Transformative Hypotheses of capitals, capabilities and institutions for adaptive capacities

ALTIPLANO LANDSCAPES



Linking Knowledge Systems for Rural Livelihoods Adaptation Under Uncertainty: Drying and Warming in Andean Ecosystems

C. Valdivia[1], J. Gilles[1], A. Seth[2], J. Thibeault[2], E. Jimenez[3], M. García[4], E. Yucra[4], K. Garrett[5]

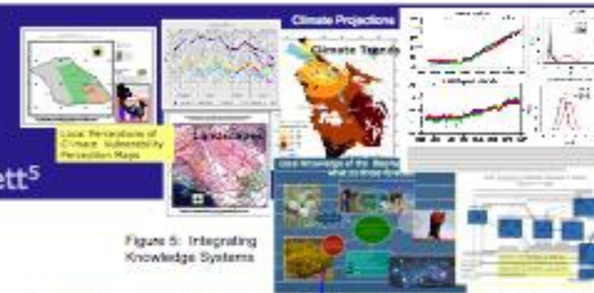


Figure 5: Integrating Knowledge Systems

ABSTRACT

Climate change will reduce food security in agricultural regions of the developing world such as the Andes (Loeb et al *Science* **2008**,319,607-610; Brown and Funk, *Science* **2008**,319,580-581). The rural populations of the Altiplano of Peru and Bolivia are particularly vulnerable as they produce in a risky environment, relying mostly on local safety nets and institutions. This is exacerbated by lack of government resources and infrastructure to respond to their conditions. Climate changes are being perceived in the Altiplano. Local knowledge observations are explained by observed trends. Projections show increases in variability and shifts in the distributions of temperature and precipitation, creating an environment of uncertainty for decision makers.

THE PROJECT

Adapting to change in Vulnerable Andean Ecosystems, funded by the Sustainable Agriculture and Resource Management Collaborative Research Support Program SANREM-CRSP, is a collaborative research and capacity building effort of eight universities, an NGO, an international research center, and ten rural communities in Bolivia, Peru and the USA, since 2006. The objectives are to understand drivers of change and identify practices and strategies that lead to adaptation in Altiplano ecosystems. Disciplinary, cross disciplinary, and participatory research in livelihoods, markets, soils, biodiversity, pests and diseases, climate trends and climate change, landscapes, is developed integrating local knowledge (figure 1). The rural landscapes are presented in figure 2. A transformational dimension of the project focuses on capacities and capabilities of all stakeholders involved (figures 1 and 4).

THE RESEACH FOCUS & APPROACH

The SANREM-CRSP program in the Altiplano is studying the biological, physical, social and economic drivers that are changing agricultural production systems, as well as the local knowledge and perceptions of farmers, the way they assess the risks of climate hazards and change (Slovic and Weber 2002). Although trust in traditional decision making tools is declining, trust in scientific knowledge is almost non-existent (Gilles and Valdivia 2009). Two-way participatory communication can enhance this trust and build knowledge that can facilitate adaptation. Using traditional scientific research methods combined with participatory research, the project is building new knowledge base, which returns to decision makers' as information about their livelihoods, their resources and market integration capacity. It seeks to build new knowledge by bridging scientific and local knowledge systems, and by strengthening human, social and political capitals of decision makers to enable human agency for adaptation. This includes agronomic trials to identify new varieties, crops, or production techniques that can buffer the new risks of changing weather patterns. In addition to involving farmers in the evaluation of research findings, members of vulnerable groups are purposely included to engage them in the discussions and plans necessary to develop adaptation strategies that will require extra-community resources to be successful. Livelihood strategies and risk perceptions analysis are presented in figure 3, as an example of the diversity of livelihoods and perceptions, conditions under which local and new knowledge on climate change are being developed and socialized by the project (Figure 3).

CLIMATE

Analysis of observational data collected to study climate trends of the past thirty years showed warming in the Central Altiplano and drying in the Northern Altiplano. Projections of climate change for the Altiplano suggest increasing temperatures and later onset of rains during the planting season. Analysis of extreme events show increases in variability. The overall scenario for decision making is one of increased uncertainty. Weather related risks are the greatest threat to the livelihoods of Andean farmers (figure 3), so they have developed a large number of strategies to reduce and mitigate them. These strategies revolve around the use of climate indicators to help farmers decide, when, where and what to plant, so as to minimize losses to droughts, floods, frosts and hail. Stars, clouds, winds, plants and animals are observed to help make production decisions. In some cases, (Orlove et al 2000 *Nature* **403**, 68–71, Orlove et al 2002 *American Scientist* **90**, 428–435) the scientific validity of these practices has been confirmed.

CLIMATE KNOWLEDGE SYSTEMS FINDINGS

Climate Highlights: Projected Changes in Annual Cycle Northern Altiplano
- Temperature: 1.5 - 2 C increase in mean by 2030; 4-5 C increases by end of century.
- Precipitation: possible small decrease in SON, sig. increase in DJFMA
- Both changes are larger and significant by end of century.

Climate – Projected Changes in Extremes
- Temperature extremes are consistent with warmer temperatures (increases in Warm Nights, Heat Waves*, Extreme Temperature Range, and decrease in Frost Days**).
- Precipitation extremes suggest redistribution with more precipitation in fewer rainy days (increases in Dry Days, Max 5 day, Simple intensity, and Heavy precipitation) - in accordance with station data from Patacamaya.

Farmers Workshop Results
- Climate becoming warmer and drier.
- Less predictable—droughts and floods make farming more difficult.
- More extreme and intense events, later arrival of rains.

Figure 1.
Conceptual cross disciplinary and participatory research model, with a livelihoods and agency approach, implemented in Adapting to change. Climate, soils, pests and diseases, biodiversity, and landscape analysis, is intertwined with social sciences research, and local knowledge systems to develop practices and strategies for adaptation.

Figure 2.
Landscapes of the three regions, in the Northern and Central Altiplano of Bolivia, and Southern Altiplano of Peru, are represented in Altiplano Ecosystems. Eleven rural communities, and 450 households comprise the household survey. Ten collaborative research groups participate in identification research and evaluation of practices and strategies. Results from ten communities are presented here.

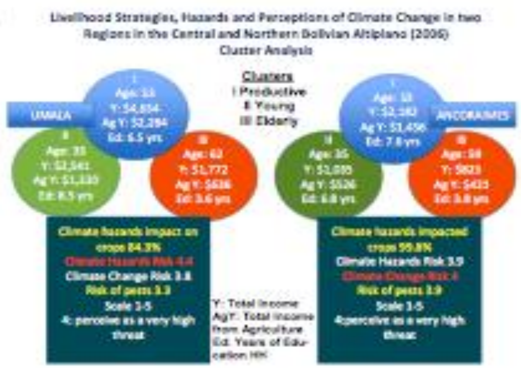


Figure 3.
Cluster Analysis of 330 households identified three groups in each region with livelihood strategies that differ between and within regions by wealth, life cycle and education, dread of c… perceived to be high. A s… climate shocks in 2006. … climate event, multiple … Bolivia), and climate cha… Altiplano).

Figure 4.
Participatory research approaches are studied and their impact is evaluated among households through on going evaluation and ex-post household surveys. The process integrates local knowledge on indicators, perception maps of vulnerabilities, with analysis of data on climate observations, climate trends of past 30 years, and discussions about climate projections, a process of socializing knowledge.

DISCUSSION

Extreme event projections from the models relate a sense of uncertainty and variability, w… presentations unlike the present, with potential for more stress in access to water, and m… extreme events in temperature and precipitation that affect agriculture, today the main source of livelihood of families in the Andes.

In the Altiplano of Bolivia, changes in climate, particularly associated with later on-set of t… rainy season and the presentation of more extreme rainfall, drought, and frost events hav… undermined the production strategies tied to the use of these indicators. The later onset … the rains is also reducing the options that farmers have for planting dates and is threaten… the production of two of the most important sources of plant protein in their diets (quinoa … fava beans). In addition, the behavior of certain indicator species has been changing du… climate and environmental changes. So while climate is changing, the ability to respond t… climate related risks is declining.

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Mizzou University of Missouri-Columbia

Universidad Mayor de San Andres

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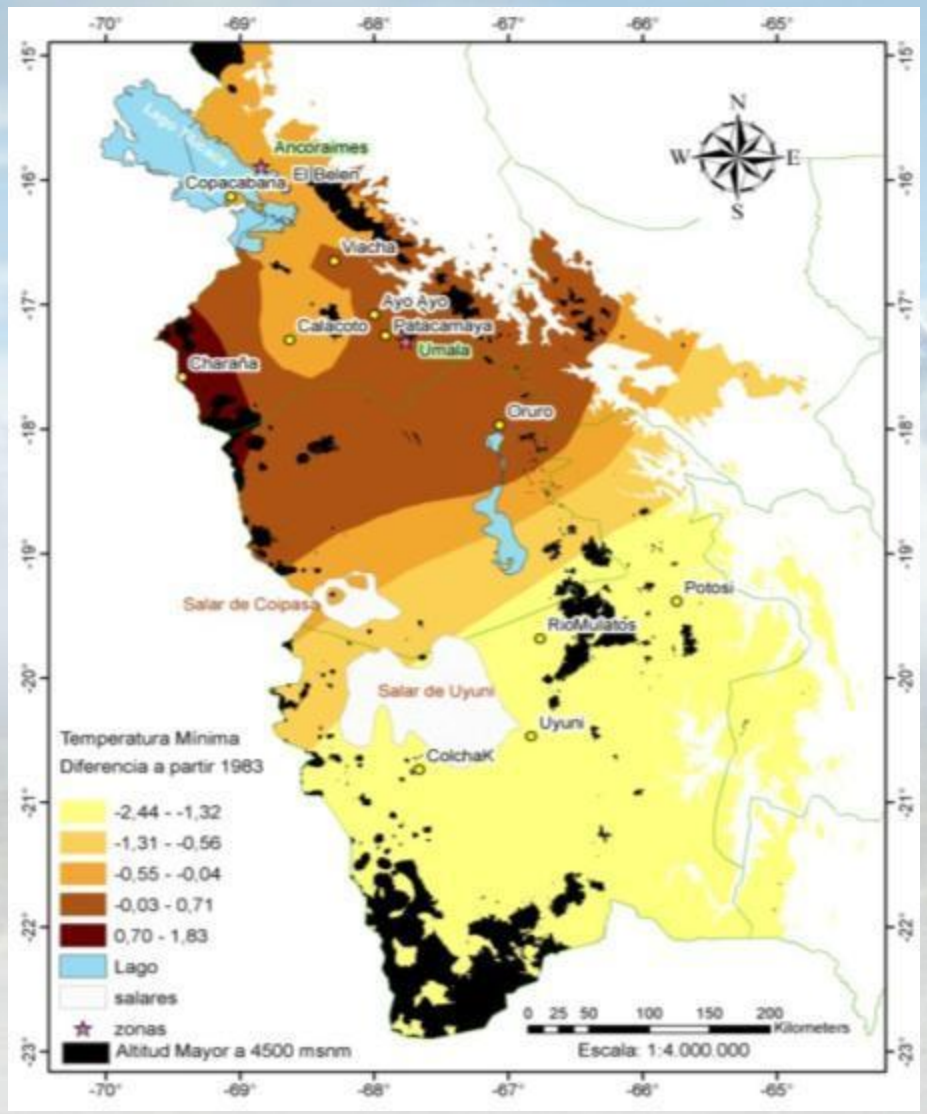
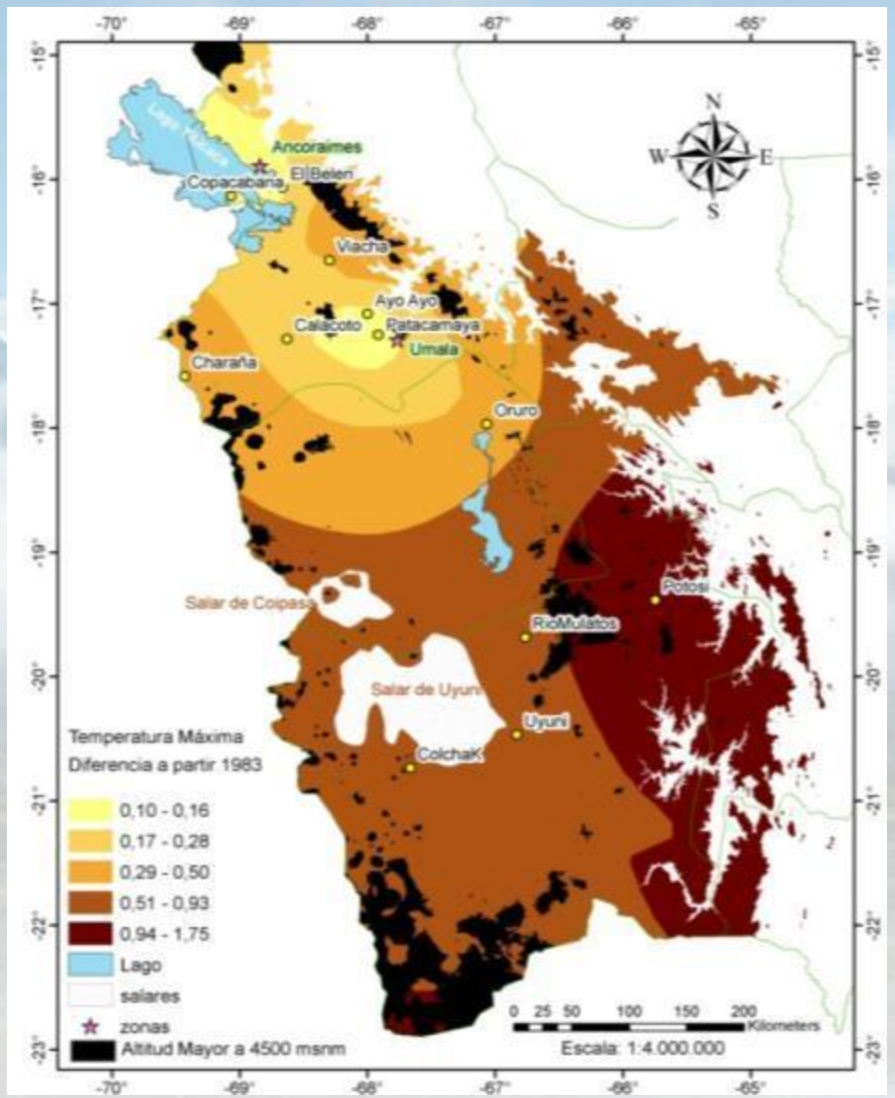
Altiplano Temperature Trends Differences (1950/60-2004)

(Valdivia et al submitted) CHANGE IN CLIMATE REGIME

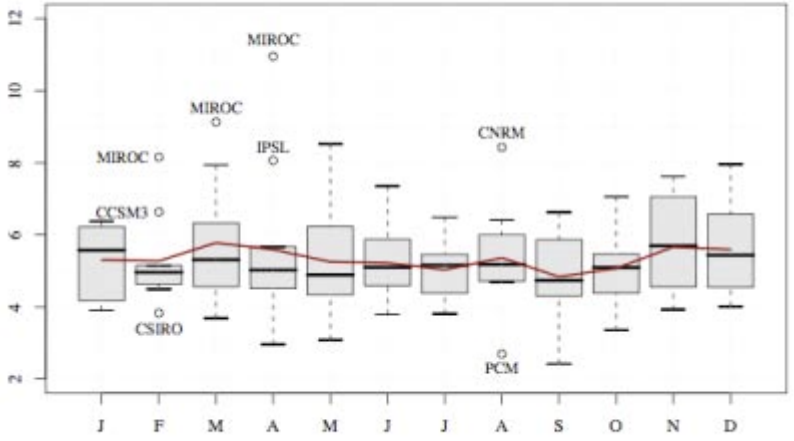




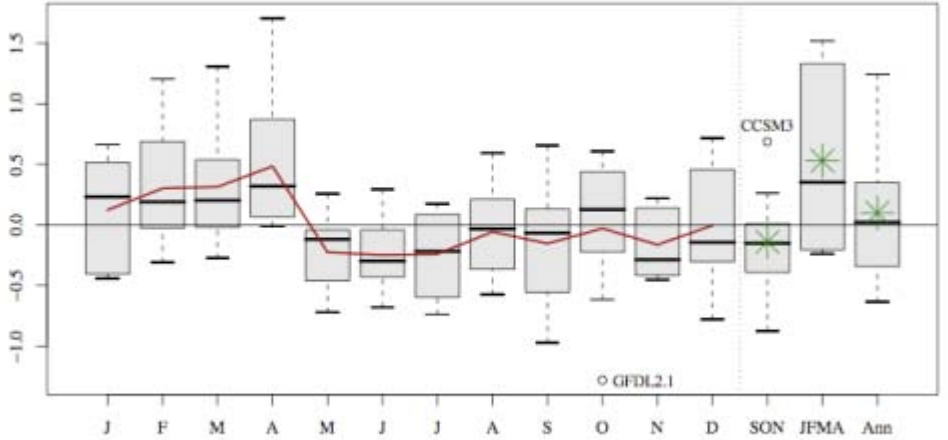
Significant warming trends in Central and Northern Altiplano, larger in Minimum Temperatures

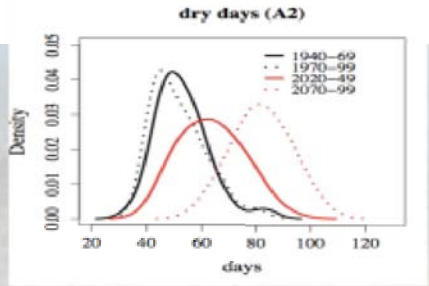
Altiplano dryer in spring wetter in summer. 5-6σ increases in temperature!

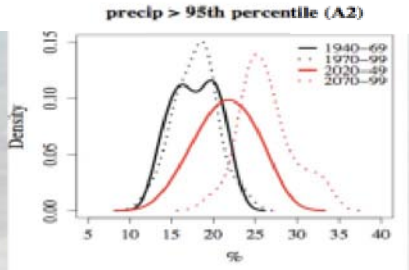
Temperature

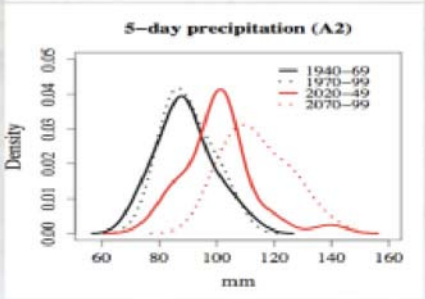


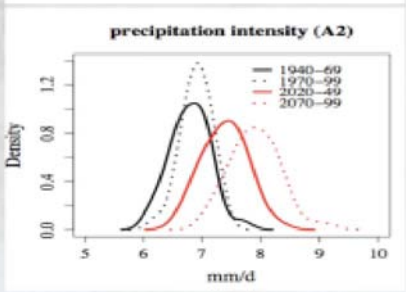
Precipitation











SHIFT IN THE DISTRIBUTION OF EVENTS

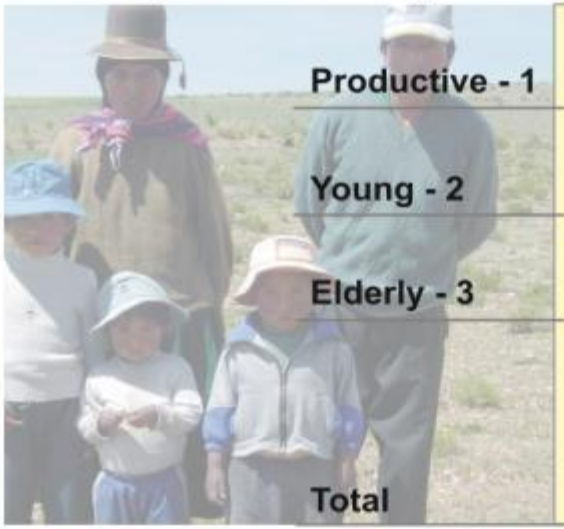
PAST EXPERIENCE?

Seth et. al., GRL, 2009

Table 2: Experience with Shocks (% losses) and Wealth Distribution by Location in the Watershed, North and Central Altiplano in 2006

Sources of losses in 2006	N 330	Northern Altiplano Low	Northern Altiplano Mid	Northern Altiplano High	Central Altiplano Low	Central Altiplano High
Drought	34	40	23	0	27	19
Floods	50	21	0	28	28	12
Frosts	107	19	19	25	22	0
Hail	48	17	22	20	21	21
Crop losses to pests	278	28	32	22	12	11
Livestock to frost	40	29	25	30	9	5
Livestock to diseases	164	14	17	18	18	15

Distribution of the Population by Life Cycle/Wealth Groups * N		Northern Altiplano Low	Northern Altiplano Mid	Northern Altiplano High	Central Altiplano Low	Central Altiplano High
Productive - 1	68	5	0	3	46	14
Young - 2	124	23	32	11	40	18
Elderly - 3	136	29	32	12	41	22
Total	328	57	64	26	127	54



Participatory Research

- Given climate trends and projections, uncertainty will likely increase; participatory approaches may enhance local knowledge, in this case building trust through two-way participatory communication (Wilkins, 2001).
  - Participatory research allows farmers and producers to develop a common set of expectations and language to discuss alternative strategies.
  - By participating in research farmers can make own observations and can derive lessons from research beyond those conclusions presented by the researcher.

Climate change, climate risk and associated changes in insect pest populations are the main challenges to small producers in the region.

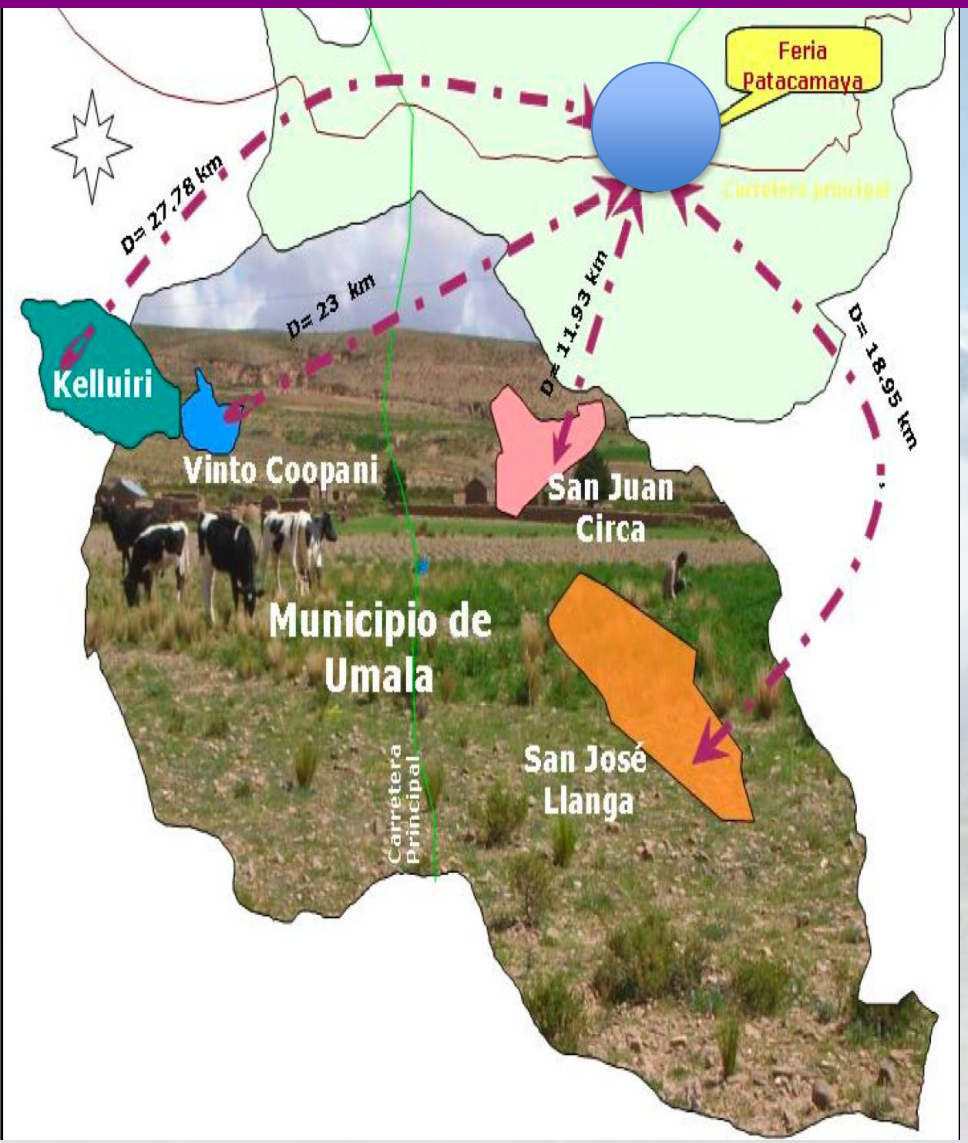
- *Implications:* 1) Any project in the region must take these factors in its project design. Since conditions are changing, past experiences are less valid and more emphasis must be placed on developing adaptive capacities rather than promotion of specific technologies; 2) there should be a participatory climate assessment component in project design.

STRENGTHENING CAPACITIES

Students from rural indigenous families are excluded from studying abroad or higher education because of lack of training in foreign languages and lack of resources

- *Implication:* Providing bilingual students with research grants and scholarships in Bolivian universities provides an opportunity for students from less privileged backgrounds to work with experienced U.S. and foreign trained experts.

Markets in Umala –Central Altiplano



- A dairy policy that supported the development of milk markets.
- A development of potato markets in the last decade that resulted in a shift from consumption to market varieties.
- Transaction costs in access to markets and technologies vary within and between communities.

Prepared by U. de la Cordillera

MARKETS: SIGNIFICANT FINDINGS

- Households that have higher capitals depend more on income derived from commercialization and less on migration; depend less on intermediaries and tend to sell at larger regional markets; women and men negotiate together.
- Households that have lower capitals depend more on migration. Commercialization is frequent, mostly in at local markets, where prices are lower, and at lower scale; carried out by women mostly.
- Knowledge sharing with farmers in participatory processes is not only rising awareness but resulting in discussions of what next – Advocacy coalitions
- In the context of climate change?

Soils: Significant Findings

- Climate change and socioeconomic factors in have led to increased increased soil degradation.
- Organic and inorganic soil amendments had both initial and residual effects on improving crop production on potato and subsequent crop (e.g. quinoa) in the rotation
- Organic amendments improved soils organic, water retention and bulk density reduction that may mitigate soil degradation and climate change effects.
- A rapid method to assess nitrogen content in potato may assist farmers and agricultural professional.



Integrated pest/disease management in the altiplano

We have evaluated management strategies for current invasive pest scenarios and for future climate change scenarios

Development impact: tactics and strategies for current and long-term pest/disease management – new information, farmer training and input for policy

Improved capacity in IPM for Andean potato weevil (*Premnotrypes spp*)

29 Participants

12 Men
17 Women

50% knowledge

Andean potato weevil workshop 1

Andean potato weevil IPM workshop 2

Soil tillage taller 3

Living barriers workshop 4

Manual harvesting workshops 5

Hilling workshop 6

Best harvesting practices workshop 7

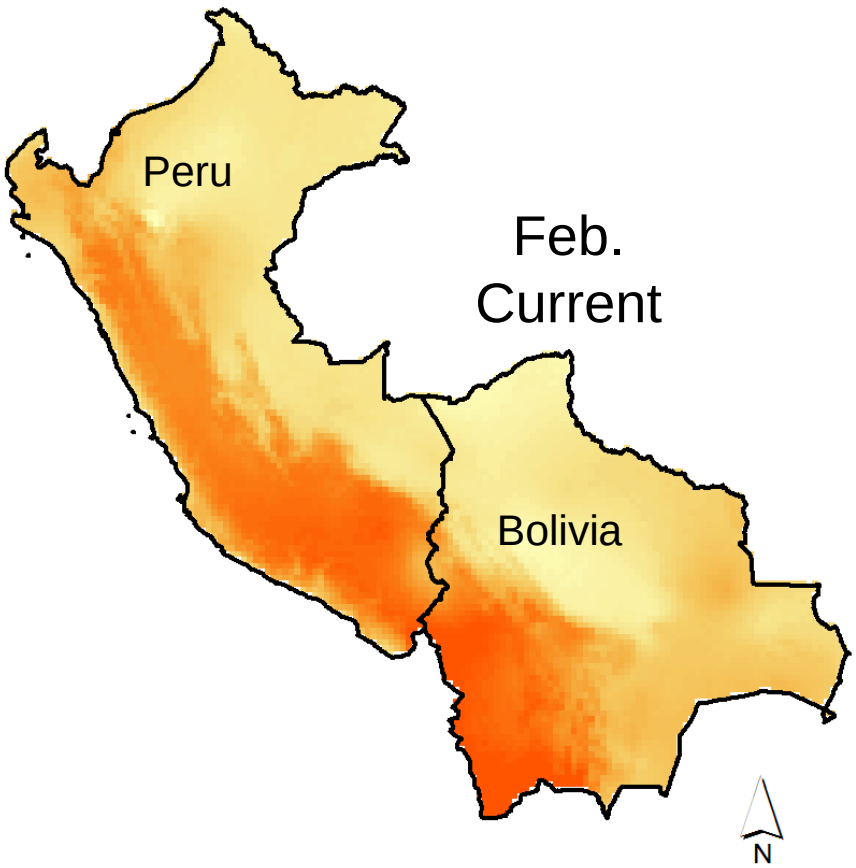
Postharvest management workshop 8

25 Participants

11 Men
14 Women

88% knowledge (Increase of 38%)

Estimated potato late blight risk under climate scenarios



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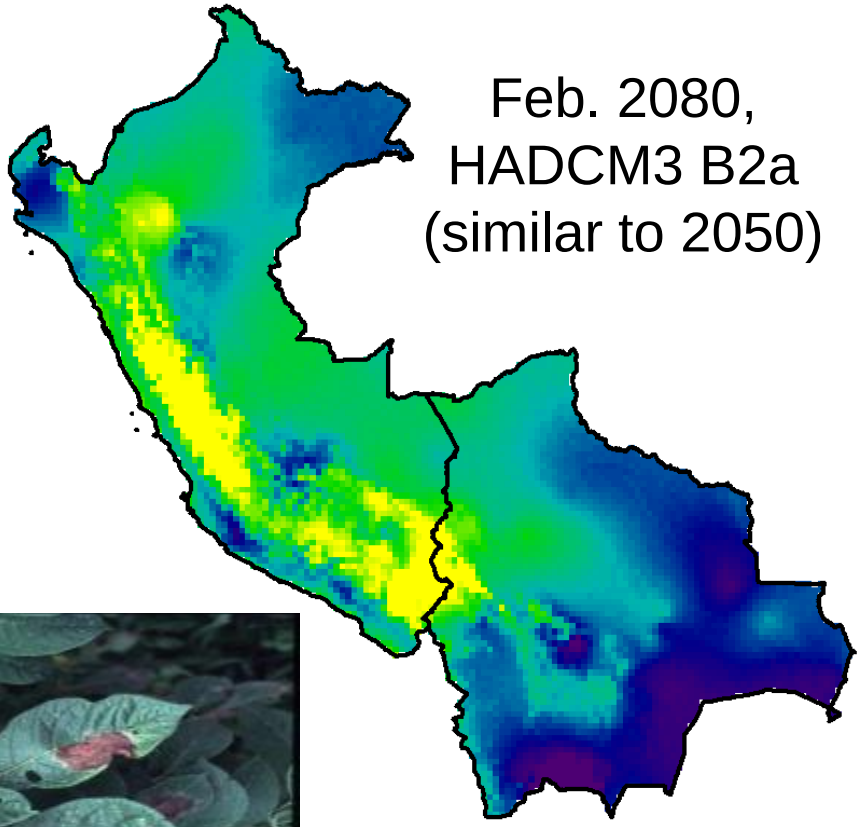
Current



Feb. 2080,
HADCM3 B2a
(similar to 2050)

Sparks et al., in prep

0

12.2

Increasing measure of disease risk

Complexity in the effects of global change on plant disease

- Developed a research team for presentation of initial ideas at Copenhagen climate meetings
- Submitted NSF Research Coordination Network proposal emphasizing science and policy link
- Developing a workshop linking science and development context – USAID participation would be wonderful

Dread and risk of climate change, and threat of pests and disease are high.

Climate shocks and pests have a high impact on production, and differ by livelihoods and the capitals and diversification strategies.

There is a need to understand changes in dynamics, build new knowledge, and determine how this information can flow to strengthen decision making for adaptation.

Acknowledgments

- The 330 families from the rural communities who participate in the research on change and adaptation
- The SANREM CRSP
- Apolinar Contreras, Alejandro Romero, research assistants at U. C.
- Patricia Valdivia for the graphics

Table 1: Perceptions of Risks to Household Wellbeing of Various Climate and Market Hazards in Rural Communities of the Central and Northern Altiplano of Bolivia (2006)

Type of Threat	Ancoraimes Municipality Northern Altiplano			Umala Municipality Central Altiplano		
Communities	Low Lands	Mid Land	High Land	Low Lands	High Lands	
No Households	57	65	27	127	54	330
Hail impacts crops & livestock	3.51	3.97	3.56	3.85	4.28	***
Impact of floods	3.96	3.82	3.85	4.42	4.00	***
Impact of drought	2.41	2.97	2.67	2.96	3.00	***
Impact of frost	3.89	4.06	3.59	4.35	4.50	***
Impact of changing climate	3.79	4.17	4.11	3.87	3.53	***
Impact of pests	3.68	4.11	3.78	3.13	3.67	***
Soil fertility loss	3.91	4.23	4.00	3.44	3.68	***
Impact of low livestock prices	3.84	4.12	3.78	3.72	3.83	***
Impact of an adult becoming unemployed	3.70	4.23	4.04	2.33	2.98	***

Source: Household Survey of Capitals, Practices and Perceptions. *** P<0.001

1 = it is not a threat
2 = it is a minimal threat
3 = it is a moderate threat
4 = it is a very strong threat
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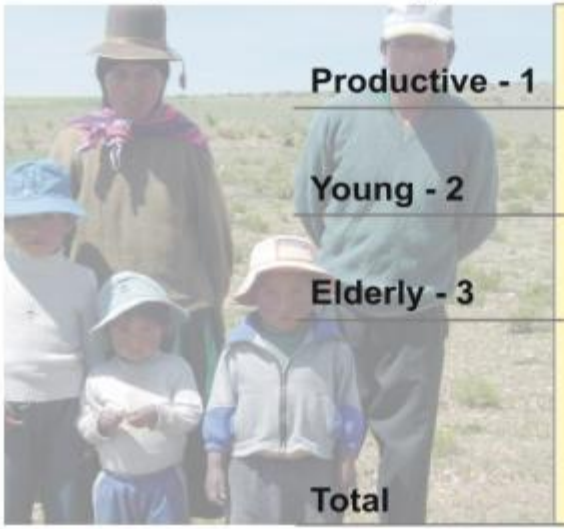

Table 4: Income Source in the Central and Northern Altiplano of Bolivia (2006)

Communities	Ancoraimes Municipality Northern Altiplano			Umala Municipality Central Altiplano		
	Low Lands	Mid Lands	High Lands	Low Lands	High Lands	
Income Sources						
Total Income -cash & in kind	10171	4266	5910	23749	12916	***
Total Ag Income -cash & in kind	8242	2270	4482	21601	10035	***
Total Income - cash	8700	3228	4077	14100	7187	***
Income Ag Cash Crops	5278	346	265	4599	370	***
Income from Quinoa (46)	81	32	0	3897	2565	NS
Income from Milk (170)	625	485	460	3991	1587	***
Income from Chuño (325)	216	152	232	1229	1128	***
Income from Potatoes (230)	201	319	150	4348	999	***
Value added products income	911	291	800	4639	1863	***
Livestock sales	581	594	1584	2712	2072	***

Source: SANREM CRSP LTRA4 Household Survey of capitals, practices and perceptions.
***P<0.000
NS no significant differences ANOVA

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Table 3: Capitals by Landscapes in the Northern and Central Altiplano 2006

Production Systems	Ancoraimes Municipality Northern Altiplano			Umala Municipality Central Altiplano		
	Near the Lake	Mid Altitude	High Altitude	Low Lands	High Lands	
No Households	57	65	27	127	54	
Human Capital Education head of household (yrs)	7.46	5.41	4.42	7.47	5.48	***
Natural Capital Diversity Potato (# of varieties)	1.88	1.98	2.67	3.64	4.07	***
Crops (Diversity Index)	2.12	2.63	2.67	1.80	1.72	***
Has Fallow	1.63	0.5	0.7	4.78	4.30	***
Social Capital Access to credit (% of Hhs)	19	31	30	26	20	***
Cultural Capital Knowledge Biophysical Indicators (% of Hhs)	31.6	53.8	55.6	58.2	43.3	
Economic Capital Sheep (head)	14.6	15.5	42.7	34.4	37.6	***
Buffers Chuño (arroba =11kg)	5.05	2.61	4.72	22.85	22.14	***

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Total Income - cash	8700	3228	4077	14100	7187	***
Income Ag Cash Crops	5278	346	265	4599	370	***
Income from Quinoa (46)	81	32	0	3897	2565	NS
Income from Milk (170)	625	485	460	3991	1587	***
Income from Chuño (325)	216	152	232	1229	1128	***
Income from Potatoes (230)	201	319	150	4348	999	***
Value added products income	911	291	800	4639	1863	***
Livestock sales	581	594	1584	2712	2072	***

Source: SANREM CRSP LTRA4 Household Survey of capitals, practices and perceptions.
***P<0.000
NS no significant differences ANOVA