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Sustaining Agropastoralism on the Bolivian Altiplano: The Case of San José Llanga

2001

Chapter 08: Conclusions and Recommendations

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Recommended Citation

Coppock, David Layne; Valdivia, Corinne; Yazman, Jim; Jetté, Christian; de Queiroz, João S.; Markowitz, Lisa; and Ortega, Isaac M., "Chapter 08: Conclusions and Recommendations" (2001). *Sustaining Agropastoralism on the Bolivian Altiplano: The Case of San José Llanga*. 3.

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Conclusions and recommendations

Conclusiones y recomendaciones

by D. Layne Coppock, Corinne Valdivia, Jim Yazman, Christian Jetté, João S. de Queiroz, Lisa Markowitz and Isaac M. Ortega

Summary

The purpose of this chapter is to provide comprehensive briefs of the main points of preceding chapters, offer answers to basic questions posed at the start of the project, and give some ideas for future research, outreach and policy consideration. We close with an epilogue describing recent events in Bolivia between 1996-9.

Because the joint IBTA/SR-CRSP project was only in the field for four years, virtually any conclusion must be viewed with caution. We were unable to conduct research on agronomy, soil management, commodity marketing or management of dairy cattle, and all of these loomed as critical topics where important questions emerged. The uniqueness of some aspects of San José Llanga (SJL) precludes extrapolation of findings elsewhere, but it is argued that there is utility in knowing one place very well. It is hoped our results will inform development dialogue in the Andean zone and beyond.

One prominent question was the degree to which humans, livestock or abiotic forces were responsible for environmental degradation at SJL. If humans and livestock were culpable then some remedial measures could be recommended. We repeat a conclusion reached earlier, that environmental degradation must first be qualified with respect to geomorphic units. Possible sources of mis-management could be identified with regards to crop lands, but for rangelands abiotic processes of salinisation, flooding and drought appeared to dictate system dynamics.

The "major question" posed at the start of the project was: "What is the role of small ruminants in sustaining agropastoralism on the Altiplano, and can this role be strengthened or improved through better use of technology or policy?" Considering inputs from sheep to land, labour and capital, it is offered that the critical roles for sheep are in providing: (1) Manure for crop lands; (2) income, cheap meat and wool to

help sustain the labour component; and (3) a source of liquid assets for capital generation. Of these inputs, the most unique is the manure function. The alleged decline in crop productivity on the alluvial terrace may be traced, in part, to effects of modernisation on reducing manure soil amendments, but this remains to be proven. If we are conservative, however, and must make decisions in the absence of new information, one course of action could be to encourage dialogue among producers, researchers and outreach personnel regarding problems of crop land management, and consider technical and policy options that could shift more manure back onto farmer's fields. This could involve interventions as basic as labour-saving technology (i.e., wheelbarrows or manure spreaders) and/or incentives to discourage manure sales through outreach education and policy instruments. The solutions would probably not be easy to achieve given system constraints, but the alleged problem is important enough for food security that it cannot be ignored. In contrast to manure, other functions of sheep in providing income and capital have been recently complicated by the advent of smallholder dairying and people seeking off-farm employment. These income-generating activities provide alternatives to sheep production, and for some households they offer highly competitive options for investment. For households with choices we speculate that investing in dairy and pasture, or investing in the education of one's children, are superior options compared to lower returns and higher risks of investing in sheep and rangeland improvements. This is not to say that sheep are not vital, just that the marginal returns from making improvements in the sheep subsystem are probably less attractive over the short term than other options in today's economy. Such insights could have been missed if the joint IBTA/SR-CRSP project had not embraced a systems approach when studying SJL. It is also instructive, however, to recall the high variability among households in terms of wealth, production strate-

gies and resource access. Indeed, there are some households for which investment in sheep production will be the most effective development option. It is therefore important not to embrace a "one size fits all" mentality when considering the utility of development interventions.

Finally, our work also revealed that "sustaining agropastoralism on the Altiplano" goes far beyond the question of whether or not to invest in livestock to better maintain soils, incomes and assets. It is clear that there must also be substantive investment in people and communities to promote improved standards of living. If people do not have potable water supplies, electricity, transportation and basic educational opportunities they will be tempted to go elsewhere. While investment in basic public services may never stem the recent high rates of emigration, which appeared to largely be due to "pull" factors of altered expectations among youth rather than "push" factors, they would make places like SJL more desirable to live in. If SJL is a more desirable place to live, the likelihood is greater that emigrants would periodically return and invest in their home areas. This would help strengthen rural social institutions and livelihoods and keep options open for people. In the future the urban economy may become less attractive relative to the rural economy, and people may be compelled to return home to grow food.

Recommendations for future research include attention towards study of : (1) Alleged climate cycles; (2) crop land management; (3) risk management for households and communities including review of relevant policies; (4) human nutrition and health; (5) mitigation of salinisation and frost challenges for important food crops; (6) livestock morbidity causes and cost-effective solutions; and (7) range improvements.

Recommendations for research management include attention towards: (1) Moving the research focus more off-station to better understand rural problems; (2) incorporating more social science (especially household economics and marketing) along with traditional agricultural and biological research; (3) adopting more interdisciplinary thinking, even simply within the biological arena; (4) increase investment in staff and key facilities; and (5) along with shifting the research focus off-station, reduce emphasis on studies of crop and livestock production under optimal conditions.

Recommendations for outreach include engaging local people to discuss: (1) How to improve profitability in sheep marketing; (2) how to

improve management of crop lands, with an emphasis on soil fertility management; (3) how to improve sustainability and effectiveness of irrigation systems; and (4) how to improve human health, nutrition and access to family planning information.

Recent information has been gathered regarding events at IBTA and SJL between 1996-9. Decentralisation of the Bolivian government led to the demise of IBTA by the late 1990s. It is envisioned that IBTA will be replaced by private research centres that will solicit and fund proposals dealing with priority problems in various ecological zones; this plan may be enacted during the year 2000. Many interesting changes have occurred at SJL. The number of households has reportedly risen to 130, a dramatic deviation from our prediction that household number would continue to decline to 80 in the near future. Dairying remains important, but there is a renewed effort to produce improved potatoes for market and home consumption. Land clearing for potato planting has increased due to mechanisation and high potato prices; it is still reported that the land is "tired" and producing below capacity. Efforts to rehabilitate some saline rangelands have occurred with funds from the Popular Participation Act. Smallholder dairying continues to be supported by external donors at least through 2003. Considering local society, it is notable that the first young women to graduate from the secondary school did so in 1999. An incipient potato "boom" and dramatic increase in residents at SJL are critical observations. We hypothesise that the ability to obtain higher incomes drives people in and out of SJL. This validates the idea that investing in rural communities is important to allow people to take advantage of dynamic opportunities in rural and urban sectors. This benefits local society and the nation.

Resumen

El propósito de este capítulo es proveer un informe comprensible de los puntos principales de los capítulos anteriores, entregar respuestas a preguntas básicas postuladas al comienzo del proyecto, y dar algunas ideas para futuras investigaciones, y consideraciones en las políticas y extensión. Cerramos con un epílogo describiendo los recientes eventos en Bolivia entre 1996-9.

Debido a que la unión del proyecto IBTA/SR-CRSP fue solo en el terreno por cuatro años,

virtualmente cualquier conclusión debe ser tomada con precaución. No nos fue posible realizar una investigación en temas críticos como agronomía, manejo del suelo, mercadeo de los productos, o el manejo de los productos lácteos, y todos esos que aparecieron como temas críticos de los cuales emergieron preguntas importantes. Lo excepcional de algunos aspectos de San José Llanga (S JL) previene la extrapolación de los resultados a otro lugar, sin embargo se ha discutido la importancia de tener conocimientos avanzados de un lugar determinado. Esperamos que nuestros resultados informen y ayuden al comienzo de diálogos desarrollados en la zona andina y zonas aledañas.

Una pregunta importante fue el grado en que los humanos, el ganado y las fuerzas abióticas han sido responsables por la degradación del medio ambiente en S JL. Si los humanos y el ganado fueron los culpables, entonces algunas medidas para remediar ésto podrían ser recomendadas. Repetimos una conclusión alcanzada antes, que la degradación del medio ambiente debe ser calificada primero con respecto a unidades geomórficas. Las posibles fuentes de un mal manejo podrían ser identificadas con respecto a las tierras cultivadas, pero para las tierras con ganado el proceso abiótico de salinización, inundaciones y sequías parecieran dictar la dinámica del sistema.

La "principal pregunta" formulada al comienzo del proyecto fue: "¿Cuál es el rol de los pequeños rumiantes en mantener un agropastoralismo en el Altiplano? y ¿Puede este rol ser reforzado o mejorado a través de un mejor uso de tecnología o de políticas?" Considerando la información dada desde la oveja a la tierra, mano de obra y capital, es evidente que los roles críticos de las ovejas son de proveer: (1) Estiércol como abono para las tierras cultivadas; (2) ingreso, carne y lana barata para mantener la mano de obra; y (3) una fuente ingresos liquida por fondos de grupo. De estos datos, el de mayor excepción es la función de abono. La discutida baja de la productividad de la siembras en las terrazas aluviales podría deberse, en parte, a los efectos de modernización al reducir las reformas de abono en el suelo, pero esto queda por probarse. Sin embargo, si somos conservadores y debemos tomar una decisión por falta de nueva información, una línea de acción podría ser el fortalecer un diálogo entre los productores, investigadores y personal designado respecto a los problemas de manejo de las tierras sembradas y considerar técnicas y opciones

políticas que pudiera transportar más estiércol de vuelta a los terrenos de los campesinos. Esto podría involucrar intervenciones tan básicas como tecnología para reducir la mano de obra (ej., carretillas o diseminador de abono) y/o incentivos para disuadirles de la venta de estiércol a través de educación y políticas. Las soluciones probablemente no serían fáciles de lograr dado a las restricciones del sistema, pero dicho problema es suficientemente importante para asegurar que el alimento que no puede ser ignorado. En contraste al estiércol, otras funciones de la oveja al proveer un sueldo y capital se ha complicado por la llegada de pequeñas lecherías y gente buscando empleos fuera de las granjas. Estas actividades generadas por ingresos proveen alternativas a la crianza de ovejas y para algunas familias éstas ofrecen opciones altamente competitivas de inversión. Para familias con alternativas, nosotros especulamos que la inversión en productos lácteos y pastizales, o la inversión en la educación de los niños, son opciones superiores comparadas con las bajas ganancias y los altos riesgos de inversión en ovejas y mejoramiento de los terrenos de agricultura. Esto no quiere decir que la oveja no sea vital, sólo que las ganancias marginales al hacer mejoras en el subsistema de las ovejas son probablemente menos atractivas a través de un período corto que otras opciones en la economía de hoy. Tales conocimientos pudieron no haber sido observados si la unión de los proyectos IBTA/SR-CRSP no hubieran adoptado un sistema de acercamiento cuando estudiaron S JL. Sin embargo, es importante recordar la alta variabilidad entre las familias en términos de bienes, estrategias de producción y acceso a recursos. En verdad, hay algunas familias para las cuales la inversión en la crianza de ovejas será la opción más efectiva de desarrollo. Es por lo tanto importante no adoptar la mentalidad de que "un tamaño le queda a todos" cuando se considere la utilidad de las intervenciones en el desarrollo.

Finalmente, nuestro trabajo también reveló que "el agropastoralismo sostenido en el Altiplano" va más allá de la pregunta de si invertir o no en ganado para mantener mejores suelos, ingresos y bienes. Está claro que además se debe hacer una inversión sustantiva en la gente y en las comunidades para promover mejoramientos en el nivel de vida. Si la gente no tiene un suministro de agua potable, electricidad, transporte y oportunidades a educación básica, la tentación

para ir a otro lugar será mayor. En tanto que la inversión en servicios de salud pública, jamás podrá contener la reciente alta tasa de emigración, la cual pareciera ser causada en gran parte por factores de “tirón” de alteradas expectativas entre los jóvenes en vez de factores de “empuje”, lo que haría que lugares como SJL fuesen deseados para vivir. Si SJL es un lugar más deseable para vivir, la probabilidad es mayor de que los emigrantes pudieran regresar periódicamente e invertir en las áreas cercanas a sus casas. Esto ayudaría a fortalecer las instituciones sociales rurales y de convivencias y dejaría las opciones abiertas a la gente. En el futuro la economía urbana puede ser menos atractiva en relación con la economía rural y la gente podría ser forzada a volver a casa y sembrar alimentos.

Recomendaciones para futuras investigaciones incluye la atención a estudio de : (1) Los supuesto ciclos del clima; (2) manejo de las tierras cultivables; (3) manejo de los riesgos por las familias y comunidades, incluyendo una inspección de las políticas relevantes; (4) nutrición y salud humana; (5) mitigación de la salinidad y desafío al congelamiento para las siembras importantes de alimentos; (6) causas de enfermedades en el ganado y soluciones con costos efectivos; (7) mejoramiento de los pastizales.

Recomendaciones para investigación de manejo incluye la atención a : (1) Cambiar el foco de atención de la investigación más allá de la estación, para entender mejor los problemas rurales; (2) incorporando mejor las ciencias sociales (especialmente economía del hogar y mercadeo) junto a agricultura tradicional e investigaciones biológicas; (3) adoptando un mayor pensamiento interdisciplinario, tan simple como dentro del campo de la biología; (4) aumentar las inversiones en personal y sitios claves; y (5) junto con cambiar el foco de la investigación fuera de la estación, reducir el énfasis en los estudios de siembras y ganado bajo condiciones óptimas.

Recomendaciones para la extensión incluye el compromiso de la gente del lugar para discutir: (1) Como mejorar la rentabilidad del mercadeo de la oveja; (2) cómo mejorar el manejo de las tierras cosechadas, con énfasis en el manejo de fertilidad del suelo; (3) cómo mejorar la efectividad y sostenibilidad de los sistemas de riego; y (4) cómo mejorar la salud humana, nutrición y acceso a información sobre planificación familiar.

Recientemente se reunió información con respecto a eventos en el IBTA y SJL entre 1966-9. La descentralización del gobierno Boliviano llevó a la desaparición de IBTA hacia fines de los 1990s. Se ha envisioned que el IBTA será reemplazada por centros privados de investigación que solicitaran fondos y presentarán propuestas que traten problemas prioritarios en varias zonas ecológicas; este plan podría llevarse a cabo durante el año 2000. Muchos cambios interesantes han ocurrido en SJL. El informe del número de familias ha aumentado a 130, una dramática desviación de nuestra predicción en que el número de familias continuaría declinando a 80 en un futuro cercano. La lechería se mantiene importante, pero hay un esfuerzo renovado para producir mejores papas para el mercado de consumo y el hogar. La tierra arada para el cultivo de papas ha aumentado dado a la mecanización y altos precios de la papa; todavía se informa de que la tierra está “cansada” y produce bajo su capacidad. Se han hecho algunos esfuerzos para rehabilitar los campos salinos, esto gracias a fondos del Acta de Participación Popular. Las pequeñas lecherías continúan siendo ayudadas por donantes externos por al menos hasta el 2003. Considerando la sociedad local, es notable que la primera mujer joven que se graduó de enseñanza secundaria lo hizo en 1999. Algunas otras observaciones de interés incluyen el incipiente “boom” de papas y un dramático aumento en residentes en SJL. Tenemos en mente la hipótesis de que la habilidad para obtener un ingreso más alto llevará a la gente a estar dentro y fuera de SJL. Esto valida la idea de que al invertir en comunidades rurales es importante dejar a la gente tomar ventajas de las oportunidades dinámicas en sectores rurales y urbanos. Esto beneficia tanto a la sociedad local así como al país entero.

8.1 Introduction

Here we review brief summaries by chapter and then derive some integrated conclusions across chapters. Recommendations are presented with respect to further research, outreach and policy consideration. Because several years have passed between the end of our field work and publication of this synthesis volume, we end with an epilogue that highlights changes and key events that happened at San José Llanga (SJL) and with collaborating institutions in Bolivia between 1996-9.

It is important to note that our conclusions and recommendations must be viewed with some caution. The joint IBTA/SR-CRSP project was active in the field at SJL for only four years (i.e., 1991-5) and this makes any conclusion somewhat risky. We were unable to conduct detailed research on such critical topics as agronomy, soil management, livestock marketing or management of dairy cattle. It is also inappropriate to try to generalise our findings beyond SJL because SJL has unique attributes of landscape position, market access, social capital and history of technology transfer. There is great utility, however, in knowing one place very well. San José Llanga does share some common features with other communities of the central Altiplano. What we can hope to achieve from the joint IBTA/SR-CRSP project is to influence general dialogue on rural development problems of the Andean zone and beyond.

8.2 Conclusions

This synthesis volume has focused more on general findings and general conclusions that emerged from dozens of empirical studies. Source materials include theses and technical reports, and readers are urged to consult these for detailed findings and detailed conclusions not reported here. It is also useful for readers to review Chapter 1: *Project objectives and research approach*.

8.2.1 Brief summaries by chapter

Given the length and diversity of this synthesis volume, a concise summary of main points for each chapter is useful. This also allows us to answer disciplinary questions posed in Chapter 1 (Section 1.4.2.4: *Sustainability and environmental degradation* and Section 1.4.2.5: *Other sustainability factors: Community leadership, new technology and urban markets*).

In Chapter 2 (*National, regional and local context*), one conclusion was that after centuries of oppression, changes in national policies since the 1950s appeared to be having some positive results for *Aymara* residents of the Altiplano, especially in terms of improved access to formal education, markets and production technology. Changes in land use policy resulting from the Land Reform Act of 1953, however, have led to more controlled access to higher-value lands on the central Altiplano in some cases, and this has undermined traditions of communal resource use.

The Popular Participation Act of 1994 is a good example of a policy initiative that could yield benefits for SJL residents by increasing access to state revenues for local development initiatives. Some problems may persist, however, in terms of national policies that have discouraged some forms of food production and undermined traditional, but highly adapted, commodities such as camelids and indigenous cereal crops. With respect to selection of SJL as a research site, it was noted that the position of SJL in the middle of the Altiplano, with proximity to large urban markets and the Patacamaya Experiment Station, would confer special ecological, economic and technical attributes that could make generalisation of results difficult. The same features, however, particularly in terms of access to markets and technology, could make for interesting work to reveal effects of technology diffusion and economic change on rural communities.

In Chapter 3 (*Ecology and natural resources of San José Llanga*) the ecological system and climate regime were described. The system resembles “cold-desert shrub” analogues found elsewhere. Native vegetation was dominated by perennial grasses and shrubs found in dozens of community types. Land use was broadly described as rain-fed farming for food crops and forages (about 25% of the area), several forms of saline and fresh-water irrigated farming for food crops and forages (also around 25% of the area), and grazing on native vegetation with moisture variously supplied by rainfall and saline sub-irrigation (about 50% of the area). The cropping matrix was complex; households had land parcels scattered to mitigate risks (i.e., frost, moisture variability and soil pests). Based on 43 years of data, the average annual precipitation was about 406 mm, although with relatively moderate variability (CV = 22%). Although there was no statistical evidence of a long-term decline in precipitation, residents of SJL perceived that the climate was becoming drier--also supported by anecdotal observations that low-lying areas of SJL had been inundated less in recent years compared to the past. Analysis of seven-year running means suggested that precipitation at SJL may have a cyclic element of alternating wetter or drier periods on the order of 11 to 13 years in duration. If this was correct, SJL would currently be in the middle of a drier phase. Precipitation was delivered in a uni-modal pattern, as 78% occurred between November and March. The main growing season of January to April was characterised by variable

rainfall, warmer temperatures and reduced risk of frost. The dry season occurred from May through October and plant production during this time was probably limited more by cold temperatures and frost rather than moisture *per se*. High water tables underlying many range sites, for example, would allow some grasses to access moisture and thus have traces of green tissue well into the dry season. Vegetation dynamics were thus influenced by climate and landscape characteristics. One major conclusion from ecological studies was that it was difficult to generalise about resource degradation. The landscape position of SJL makes it a sink for soil, nutrients and salts--this means it is a particularly difficult site for humans and livestock to degrade, especially compared to hill-slope systems, for example. Geomorphic units differed with respect to land use and sources and patterns of degradation. Although grazing over hundreds of years has probably helped alter the rangeland component of the fluvio-lacustrine plains, contemporary effects of grazing in sacrifice areas nearer settlements appeared relatively minor overall and would be very difficult to address via changes in grazing management. Rather, pervasive influences of salinisation, flooding and drought suggested that abiotic factors overwhelm human factors in explaining condition and trend of most range sites. In contrast to range, the cultivated lands of the alluvial terrace and deltaic deposits may be under more risk from mis-management, although variability in rainfall can obscure effects of humans. The deltaic deposits were threatened by irrigation with saline water, while it was speculated that changes over the past 30 years in soil management (i.e., increased use of chemical fertilisers relative to manure and more tractor tillage relative to animal-drawn tillage) may have contributed to an alleged decline in crop productivity on the alluvial terrace. Effects of humans were not always interpreted to be potentially negative, however. This was best illustrated by the diversion of an ephemeral, fresh-water river channel to create the alluvial fan. The alluvial fan represented an expanding centre for forage and food crop production vital for today's agropastoral system.

In Chapter 4 (*Household economy and community dynamics at San José Llanga*), it was concluded that the community of SJL has always been dynamic in terms of population and economy. Traditions and modern technologies have been combined by SJL residents in recent times to create a diverse and opportunistic ca-

capacity to respond to changing economic conditions, in contrast to some tenets of a mainstream modernisation paradigm that predicts specialisation resulting from market integration and adoption of new technology. In addition, traditional forms of resource sharing persist at SJL that help residents, regardless of economic status, be productive through access to land, labour and capital in the absence of government social insurance mechanisms and in the presence of increased controlled access to higher-value crop lands among wealthier households. Resource sharing has been facilitated by pervasive emigration of SJL residents from both ends of the economic spectrum. Emigrants typically kept links to SJL and contracted resident care-takers to manage resources through a variety of reciprocal agreements. Emigration, both on a short- and long-term basis, has always been vital for SJL. The number of households was around 60 in the 1890s, climbed to 125 by the 1970s, and could fall to 80 in the future. Most recent dynamics have been due to emigration from SJL to urban areas, related to changing aspirations of youths for improved standards of living. Drought can exacerbate rates of emigration. These and other factors have all contributed to what we saw as generally positive trends in the local economy and degree of food security at SJL. Different commodities met varied economic objectives for households. In general, food crops (i.e., indigenous potato, cereals, etc.) and Criollo sheep were consumed in-kind while cross-bred sheep, milk from improved dairy cattle, and improved lines of potatoes tended to be sold for cash. Women controlled sheep sales and used the money for household welfare expenditures. Sheep were routinely sold throughout the year—supply therefore did not appear to be strongly linked with seasonal fluctuation in demand in most cases. Improved dairy cattle were also important to diversify capital assets. Income from milk sales may have been controlled more by males. In terms of labour, males and females shared many productive tasks, but females tended to cover the sheep domain. Women reported that adoption of improved technology and management practices had tended to increase their workloads in some cases. Wealthier households also appeared better able to embrace novel enterprises like smallholder dairying. Both patterns suggested that adoption of new technology was not neutral with respect to gender or wealth class. Although the community appeared to be prospering in many respects, the longer-term implications

of a high degree of household wealth stratification remained unclear. The base of social capital at SJL was very strong and leaders have taken initiative to improve living standards. Formal education has been widely embraced by SJL residents, but local opportunities for youths (especially females) to attend secondary school have been limited. Although food security in terms of energy and protein may be sufficient, dietary deficiencies in some micro-nutrients may occur. Public health (i.e., sanitation), women's reproductive health and child illness and morbidity require attention. Women have little access to the family planning information they desire.

In Chapter 5 (*The grazing livestock of San José Llanga*), it was concluded that the grazing system appeared remarkably efficient, with effective use of range, fallow fields and pasture in well-defined seasonal patterns. Challenges imposed by a complex matrix of controlled-access and communal access land, as well as seasonally dynamic patterns of forage quantity and quality, were ably met by experienced female youths who commonly served as shepherds. Sheep were able to gain weight throughout most of the year because they were guided to high value, remnant plots of forages even during the most stressful periods. This illustrated the key role that clever herding played in this system. Overall, the grazing system of SJL was closed in that animals were not allowed to enter other cantóns, even during drought. Landscape and hydrological features combined to produce a *de facto* deferred grazing system on the fluvio-lacustrine plains. Livestock types were typically complementary in terms of grazed diets, so resource competition was not judged to be a critical issue. The managers would probably attempt to address forage scarcity by selling sheep and intensifying cut-and-carry feeding for high-value dairy cows. Producers attempted to sell sheep to make room for the upcoming lamb crop, interpreted to indicate that they were conscious of stocking rate and grazing capacity. Similarly, it has been suggested that numbers of Criollo cattle have been reduced in some cases to make way for more improved cattle. Sheep management was characterised by low-input methods, although pervasive hands-on attentiveness served to greatly limit mortality of adults and lambs to very low levels. Morbidity due to disease and parasite challenges for sheep was high, however. In terms of productivity of wool and milk, fertility rates for ewes and growth rates for lambs, Criollo animals were less productive than improved crosses. There was

some indication that young improved animals had higher rates of mortality than Criollo animals. Representation of Criollo and improved crosses was mixed throughout the cantón. Settlements having access to plots of cultivated forages under irrigation tended to have a greater proportion of improved sheep in their flocks.

In Chapter 6 (*Household socioeconomic diversity and coping response to a drought year at San José Llanga*), households were broken out into a number of socioeconomic groups. Two major divisions were called "active" or "passive" and these were delineated on the basis of age of household heads and size of the labour pool, which supported theory. Active households were more at a mid-stage of the life cycle. They were twice as numerous and had far more resources than passive households made up of retirees. Further segregation of active households occurred primarily in relation to relative dependence on improved livestock breeds and secondarily in relation to dependence on cultivated forage and dairying, while passive households were further divided on the basis of number of adult household members. Various socioeconomic groups were contrasted in terms of cash and in-kind income as affected by variable rainfall years. It was expected that households more dependent on crops or having lower levels of income would suffer larger relative declines in income compared to households having more dependence on livestock or off-farm employment. The year 1993 was a time of near-average rainfall while 1995 experienced a 40% drop in rainfall compared to the long-term mean. Contrasts were based on 39 households distributed among four socioeconomic groups. Somewhat surprisingly, income rose in the drought year overall for all groups due in part to increases in commodity prices that ranged from 30 to 400% for food and forage crops and 17 to 50% higher for animals and animal products. Significant variation among subgroups was not detected, probably due in part to small sample sizes. A regression approach was used to analyse factors important in affecting change in per capita consumption between 1993 and 1995. Results supported the idea that sheep assets and remittances from off-farm employment helped mitigate fluctuations in consumption due to drought. This supported prevailing theory and illustrated the role of small ruminants, in particular, in helping buffer households from a drought perturbation.

Chapter 7 (*Patterns of technology adoption at San José Llanga*) described how the central Alti-

plano in general, and SJL in particular, have been exposed to changing markets and technology transfer efforts for over 30 years. In particular, USAID and other agencies promoted production of improved sheep and improved potatoes in the 1960s while smallholder dairying has been promoted on a subsidised basis since the late 1980s. While there has been a mixed outcome for some forms of producer cooperatives as well as for efforts to sustain rural finance initiatives, the long-term track record for introducing improved potato and sheep has typically been positive and sustainable. Improved sheep were co-dominant with Criollo sheep in many local flocks 30 years after dissemination. Improved potatoes were still commonly grown in the early 1990s, and associated support technologies such as chemical fertilisers and tractor tillage introduced as part of the “potato package” still predominated in agronomic practices. Recently, smallholder dairying has thrived and offers a concrete example of the importance of a multi-faceted approach to development, with components including improved infrastructure, technology, credit extension and establishment of marketing channels. The success of dairying reflects a need for higher and more reliable cash income in the community. Some adverse consequences of technology transfer have also occurred, however. These include potentially detrimental effects of chemical fertilisers and tractor tillage on sustainable cultivation practices, adoption of dairying by wealthier households that can further contribute to wealth stratification, and the spectre that the community could be vulnerable if price supports for dairying are withdrawn. From an historical perspective, technology adoption patterns at SJL have exhibited various ripple effects. Since any given new technology has been oriented to increase market participation, it is not surprising that success of technology has waxed and waned with market forces. In the 1960s there was a higher market demand for improved potato as well as for wool, while national priorities and interest of international donors to increase milk production were evident by the 1980s. Alfalfa was introduced as support technology for production of improved sheep in the 1960s. While alfalfa establishment had some notable success in the early years, it was argued that strong incentives to expand alfalfa were not realised until the 1980s and 1990s. The advent of improved dairy cows in tandem with rising need for cash incomes and fear of drought, spurred interest in expanding cultivated forage production. This, in turn, has stimulated efforts to

irrigate larger areas of SJL as well as convert some food crop parcels into forage plots. One possible outcome is that the residents of SJL may compromise their ability to grow their own food under the assumption that incomes from dairying will allow them to meet their food needs from the marketplace. Expansion of cultivated forage has then come full circle to recently benefit production of improved sheep as an ancillary focus of livestock production. This historical analysis tells us that the dairy boom will also be ephemeral, and the community needs to mitigate risk and be prepared for new opportunities. Technologies, information and policies that encourage a “vigilant diversification capability” are therefore important.

8.2.2 What is the role of small ruminants, and can it be strengthened or improved?

It is interesting to note that the “major question” posed in Section 1.4.2.1 (*Focus on role of small ruminants in system sustainability and drought management*) can only be answered by integrating disciplinary results across chapters using a systems perspective. The major question was: “What is the role of small ruminants in sustaining agropastoralism on the Altiplano, and can this role be strengthened or improved through better use of technology or policy?” A classic answer to expect would be that sheep are indeed vital and we must make substantive investments in technology and policy formulation to boost sheep production and improve rangeland and rangeland management to strengthen the role of sheep in the system. As one can see from the following discussion, however, this classic answer could be off-track in terms of what really motivates and enables this community to improve their economic welfare at the present time.

Sustaining output from an agropastoral system requires an optimal combination of land, labour and capital (see Figure 1.1). Small ruminants at SJL contributed inputs to the sustainability of agropastoralism at SJL in several direct and indirect ways (Section 1.4.2.3: *Features of agropastoral systems*). Sheep provided: (1) Manure for crop production as an input to the land component; (2) income (i.e., cash and in-kind) for welfare purchases, cheap meat for diets and wool to help sustain the labour component; and (3) a source of liquid assets used for occasional purchase of system inputs (i.e., the capital component).

It was clear from work by the IBTA/SR-CRSP team that forces of modernisation, market integration and technology transfer have had the greatest potential to undermine the first interaction above, namely the sustained and extensive use of sheep manure for fertilising potato crops. The alleged decline in crop productivity on the alluvial terrace could be related, at least in part, to the shift from manure to chemical fertilisers over the past 30 years. Chemical fertilisers provided short-term boosts to potato production and were reportedly much easier to handle than bulky manure. Manure could also contribute weeds to fields, but in one sense weeds could have utility as forage so the “weed factor” was not all negative. Listing benefits and costs for either practice makes it difficult to decide which is more appropriate (see Section 3.3.4.1: *Sustainability of the alluvial terrace*). The trend of declining use of manure may also have been exacerbated by emergence of manure markets, a drop in the labour pool due to emigration, and an increasing incidence of absentee ownership of crop lands—care-takers may be more inclined to expend less effort and apply chemical fertilisers. Although it has been contended that low rainfall is the best hypothesis to explain perceived declines in crop productivity (Dr. J. de Queiroz, IBTA/SR-CRSP, personal communication), the issue of possible mis-management of soil fertility cannot be ignored given the critical nature of crop production for food security—it is a highly viable alternative hypothesis. The need for residents of SJL to maintain suitable levels of crop production cannot be over-emphasised. The thought that people could compensate for declines in crop production by purchasing more food from the marketplace is a risky proposition given the recent history in Bolivia of inflation, for example (see Section 2.2.2.3: *National highlights of social history: 1951 to 1996*). There is little doubt that management of cultivated soils is a key area for further investigation (see next section).

If we are conservative and assume that lack of sheep manure on soils is an important issue to address given that little new research information is likely from SJL, then we simply would need technologies, policies and outreach education that help shift more manure back onto farmers’ fields. Producing more sheep is not an answer here. Patterns of marketing and grazing efficiency suggest that SJL was routinely filled to the brim with sheep. Lifting the lid on carrying capacity for sheep at SJL could be a difficult, expensive and risky proposition.

One problem with trying to adequately answer the “major question” above is that the question implies that sheep are an isolated component of the production system. It was clear from work by the IBTA/SR-CRSP team that sheep were not isolated, but rather an integrated link within a complex socioeconomic web. Team members were emboldened to study the whole system because they realised early on that studies of sheep in isolation would be less relevant.

While sheep were virtually the only realistic source of manure for the cropping system, other and newer components like dairy cattle and wage employment can also provide income and/or assets to sustain the labour force and replenish capital at SJL. These two system functions have thus become more complicated because diverse options now exist. One could argue, for example, that given a choice of investing in more sheep (range), more dairy cattle (pasture), or even education of one’s children in the current economic climate, the marginal risks and returns should first favour investment in cattle or education as evidenced by our observations. Forage improvements for range would be highly problematic due to predominance of communal land tenure and risks of drought, floods and shifting saline ecotones. It is clear that the stimuli for recent investment in pasture improvements have been dairy cattle, not sheep.

Keeping an “on-farm” focus at the moment, the suite of policies and technologies that have recently transformed households at SJL have involved smallholder dairying. This is not to say that sheep production is not vital for the sustainability of the system, but that there is less to be gained from sheep interventions at this point relative to cattle for those households with both options. Sheep are thus a low-input system component while returns to cattle require and probably merit higher levels of investment. Dairying seems to provide the income incentives that even dissuade some household heads from emigrating out of SJL, so it has powerful implications for community stability.

It is important to note, however, that the relatively modest investment required to maintain sheep as a small but reliable source of food and income for households underscores the importance of sheep in the system—especially for the poorest families. In this light it is useful to recall the variability among households in terms of wealth, resource access and production strategies. Some households are in an active (mid-ca-

reer) phase, while others are in a passive (retirement) phase. Resource endowments for forages, water and cultivation can vary markedly among households, dictated to a large extent simply by where people live. It is therefore wise to not embrace a “one size fits all” mentality when considering the utility of specific development interventions. A broad spectrum of choices is most desirable.

For households interested in investing further in sheep production some simple outreach and applied research could be proposed. Since sheep production has traditionally been a low-input enterprise with a somewhat inelastic supply to market (see Section 4.3.3: *Household production system*), getting producers aware of cost-effective productivity gains may be contingent on improving their market awareness (see next section).

Finally, work of the IBTA/SR-CRSP team revealed that an objective of “sustaining agropastoralism on the Altiplano” goes far beyond the question of whether or not to invest in livestock to better maintain local soils, incomes and assets. It was clear that there must also be substantial investment in rural people themselves. The emigration of people from SJL to major metropolitan areas has reportedly occurred because of altered lifestyle expectations, not because they have been pushed by pervasive resource degradation (see Section 1.4.1: *Research setting* and Section 4.3.1: *Human population and resource base*). As long as a majority of emigrants find happiness and suitable options elsewhere, there is no reason to compel them to return to SJL as agropastoralists at the present time. We feel it is in the best long-term interests for Bolivia, however, that cultural and economic linkages be maintained and strengthened between urban and rural areas. This allows society to nurture cultural roots, reduce socioeconomic risks and obtain the best of both worlds. For example, despite the dominance of urban economies and values in contemporary Bolivia, a future episode of inflation or recession could compel many recent urbanites to return to rural areas to produce their own food. Rural areas should thus be maintained in a favourable manner so that such a return could be efficient and feasible. The problem then becomes how to encourage future generations of emigrants to periodically return to communities such as SJL and re-invest time and other resources in their communities. The answer seems to be found in values which have promoted poli-

cies like the 1994 Popular Participation Act and subsidisation of smallholder dairying. In tandem with innovative leadership such as that found at SJL, these policies offer the financial and technical resources to better provide services (i.e., potable water and water delivery systems, freshwater irrigation, electricity, public health and secondary education) vital in maintaining an attractive fabric of rural life. Such interventions would help fortify a cultural home base that would appeal to future migrants and encourage both their periodic return and retention of socioeconomic ties between urban and rural areas. The residents at SJL have already been taking this approach, and we hope policy makers will follow their lead (see Section 8.4: *Epilogue 1996-9*).

8.3 Recommendations

Some major recommendations are presented below for further biological, ecological and social research, research management, education of scientists and community outreach. Readers should also consult theses and technical reports for more details.

8.3.1 Research

8.3.1.1 Trials, studies and surveys

Recommended future research involves basic and applied topics. Some questions merit highly controlled experiments while others require social survey and economic analysis to better understand broader dimensions of technical issues. The work presented in this volume offers many ideas for future research. A few of the more important and generalised ideas are as follows.

(1) One of the findings that deserves more basic research attention from climatologists is the apparent 11- to 13-year cycle of precipitation that emerged from our analysis of seven-year running means (Dr. H. Alzérreca, rangeland ecologist, unpublished analysis). If such a cycle exists it would provide critical information for rural producers as well as policy makers. For example, if dry phases could be predicted, producers could adjust their plans accordingly in terms of relative emphasis on crop and livestock production components and their pursuit of off-farm employment. A better understanding of local precipitation patterns would also help clarify causes of an alleged decline in crop production in places like SJL;

(2) Another high priority would be to focus on the management of rain-fed cropping systems on

the central Altiplano. Alleged declines in yields of food crops need to be investigated using a step-wise approach including participatory rural assessment (PRA) and controlled trials. In cases where detailed research is not possible for financial reasons, feasibility of farmer-managed trials could be explored. This has the dual advantage of getting some research done under tight budgets as well as getting producers directly involved in dialogue concerning cultivation practices. Soil fertility management (i.e., manure versus chemical fertilisers), tillage management (i.e., modifications of tractor tillage practices), improved erosion control (i.e., use of inter-crops, windbreaks, etc), and novel inter-cropping schemes are all viable topics for further study. Preliminary trials were conducted by the joint IBTA/SR-CRSP project concerning possible forages to incorporate into fallow fields at SJL. Results are reviewed in Annex A. Promising species include annuals such as *Bromus catharticus*, *Chenopodium petiolare* and *Taraxa tenella* as well as the perennials *Parastrephia lepidophylla* and *Eragrostis curvula*;

(3) Socioeconomic and policy research could focus on ways to improve household-level risk management, with an aim to find ways to further enhance coping responses to dynamic markets and climate patterns. Like previous "booms," the dairy "boom" will end some day, and communities like SJL should already be thinking about how to position themselves to take advantage of new opportunities. Interventions could involve how to improve the use of information for planning purposes and facilitate economic diversification at the household level. There should also be a review of relevant policies that affect various forms of commodity production on the Altiplano. Policies should be harmonised with rural development objectives and marketing capabilities to promote a diverse mix of profitable options for producers. Effects of the Popular Participation Act on community development should be studied. Effects of the dairy subsidisation programme that has affected so many households at SJL need thorough monitoring and evaluation. The issue of the costs of subsidisation of smallholder dairying in light of the apparent social benefits for the central Altiplano is important. Means to augment traditional social insurance mechanisms through national policy could also be considered. Our work testifies to the positive role that infrastructure and markets can have on mitigating drought impacts for rural people on the Altiplano.

More research on drought effects is needed, however, particularly in terms of technologies and policies to help people cope with multiple-year droughts;

(4) Patterns of human nutrition and health at SJL suggested potential problems with micronutrient deficiencies, maternal well-being and childhood illness (Murillo and Markowitz 1995). Such patterns revealed from social survey and diet recall need to be verified with more rigorous clinical analysis. Some human nutritional and health problems could be addressed through improved delivery of public services and outreach (below);

(5) How to mitigate effects of salinisation and frost on fodder and food-crop production via technology and/or management. One approach to mitigate salinisation effects could be to improve the efficiency of using precipitation for irrigation via water spreading methods. On-station research has traditionally focused on crop selection based on productivity under optimal conditions (Yazman 1995). This focus should shift to crop selection based on salinity and frost tolerance;

(6) Verify causes of livestock morbidity as in Villanueva (1995) and identify cost-effective and socially acceptable means to address livestock morbidity problems. Perhaps the most cost-effective gains in livestock production could be achieved by reducing morbidity through better health management. The increasing level of monetisation and market awareness among producers at SJL may help elevate perceptions that morbidity can reduce profitability in meaningful ways; and

(7) Range improvements for site improvements or rehabilitation. The joint IBTA/SR-CRSP project contributed some work at SJL and Santiago de Machaca that examined performance of introduced and native grasses and halophytic (e.g., salt tolerant) plants (see Annexes B and C). While these trials had some promising results, the aforementioned risks of improving range sites suggest that range investments should ideally come from external donors and not community residents. The unique ecology of the Altiplano has made introduction of exotic forages and crops problematic. More attention to promising native plants, or at least those exotics with demonstrated potential under harsh conditions, is warranted (Yazman 1995). Indigenous knowledge should be used by scientists as a starting point. Priorities should be for species suitable as forage and soil conservation.

8.3.1.2 Management of research

As elsewhere in similar situations world-wide, Bolivian institutions such as IBTA have been steeped in protocols that promote technical, biological investigation and highly disciplinary research. Some points below are modified from Yazman (1995).

(1) The traditions of IBTA have involved a focus with on-station research (Coppock 1995; Yazman 1995). While on-station research has advantages in terms of experimental control, problems can occur when trying to identify real constraints faced by producers on-farm. It is notable, however, that on-station work has yielded significant achievements in terms of genetically improved sheep. We advocate more attention be shifted to off-station research, embracing a participatory process that includes all producers regardless of wealth and gender;

(2) Integrate social and biological sciences. Research projects that aspire to achieve high levels of adoption of new technology by producers must take into account social and economic factors that shape rural societies. National research organisations should seek collaborative agreements with non-governmental organisations (NGOs) active in social science analysis. One vital component would be comprehensive marketing studies and regular PRAs (i.e., outreach) that identify problems and opportunities that should guide technical research. Our work revealed that residents of SJL were highly sensitive to market signals. Before national research organisations invest in technology development they should first ensure that products can be effectively marketed;

(3) Integrate livestock and crop research. Efforts by the joint IBTA/SR-CRSP project indicated that household decisions regarding resource allocation were complex. Producers clearly understood that changes in one component of their system had implications for other components. New technologies may not be adopted because of their negative impact on other components of the production system. Research programmes need to consider the integrated nature of production systems on the Altiplano to create technologies that will have high rates of adoption. One means to improve this area is to better integrate livestock, forage and food crop research.

(4) Invest more in professional and technical staff. There should be a continuous process of training technical staff in new research techniques and keeping them abreast of recent scientific developments. Participation in international elec-

tronic conferences may be one cost-effective means to do this. In the longer term, national organisations need more collaborative research programmes with external entities to improve staff-training options. Investments in laboratories need to be maintained. Qualified researchers and technicians must be adequately compensated to mitigate high rates of turnover;

(5) Place more emphasis on range management within the realm of general forage research. It is often the case that the only economically viable means to improve rangelands is through improved management rather than intervention with introduced forages. A sole reliance on forage intervention can be risky (Annexes A-C); and

(6) Reduce emphasis on station-based development of "elite" livestock breeds. All too commonly agricultural research systems invest a substantial proportion of scarce resources in maintaining station-based livestock with the goal of developing new breeds. Station-based herds and flocks are generally too small to produce the records needed to identify genetically superior individuals with high confidence. Feeding and management conditions on-station are much different from those on-farm. Selection criteria of researchers often differ from those of farmers. Successful breed development programmes elsewhere (i.e., the US Holstein programme) are based on collection of production records from animals on-farm. Selection of animals with superior traits occurs with researchers collaborating with farmers and ranchers. We recommend that national research organisations take a similar approach.

8.3.1.3 Education of scientists

In support of the points made above, it is clear that applied scientists need to be exposed to interdisciplinary research and on-farm participatory techniques. To be most effective these scientists also should have motivations that value assisting rural people solve their problems. If this value system is in place then issues of interdisciplinary science and directly engaging producers begin to solve themselves. Researchers should not see their output as merely publications, but also in terms of how their work translates into positive human impacts. Such criteria could become part of the annual evaluations of scientific staff.

We were very pleased with the training component of the joint IBTA/SR-CRSP project; indeed it is serving as a model for training in the GL-CRSP (Dr. D.L. Coppock, Utah State Univer-

sity, personal observation). The 27 Bolivian students who completed their research projects often lived together in the field and shared a crowded and active workspace back in the office in La Paz. Most of our students came from urban backgrounds. If they initially had any apprehension about working among the campesinos of SJL and elsewhere, it soon evaporated. They learned to appreciate the complex dimensions of rural problems and how their small piece of research fit into a bigger picture. It is our view that more young scientists should be trained in this manner. This cadre of students should have a major impact on future research and development on the Altiplano.

8.3.2 Outreach

As previously mentioned, there were notable topics at SJL that merit more research. There were other problems, however, that may simply require outreach for substantive improvements to be made. Outreach, in turn, may identify new research questions. Many topics are possible, and priorities should reflect what the people perceive as important. To this end, the participation of women, the primary flock managers, should be facilitated with appropriate attention to presentation format. Some of our ideas are listed below. The format would be to hold community seminars or workshops on:

(1) Price fluctuations for lambs, and whether it could be useful for producers to consider forms of reproduction management, health management and/or nutritional management in order to capture more profits from periods of peak demand (see Section 4.3.3: *Household production system*). Such a strategy would vary from the traditional pattern of uncontrolled breeding and selling animals when income is needed, regardless of price. The Cantón of SJL is a community in economic transition. Human behaviour there appears to have a mix of traditional and contemporary elements. Market awareness for sheep production may be fairly recent and exploring this issue may have merit. If it does not have merit, extension personnel and researchers could learn why. Preliminary results from nutritional trials with grazing rams suggested favourable benefit:cost ratios from feeding 300 g/hd/day of a supplement comprised of ground alfalfa hay, ground barley and brans of wheat and *quinoa* (Annex D);

(2) Ways to increase the application of manure on crop lands, assuming that this would be

beneficial for soil structure and fertility. This would need to be linked to applied research. The potential utility and sustainability of simple equipment such as wheelbarrows or spreaders could be examined. Altered herding or coralling practices could be reviewed;

(3) Ways to improve irrigation methods; and

(4) Ways to improve child nutrition and health and increase access to family planning information.

8.4 Epilogue 1996-9

Since closure of the joint IBTA/SR-CRSP project in Bolivia at the end of 1995, a number of events have occurred that merit follow-up discussion. In some instances these clearly challenge the notion that we can predict dynamics of complex systems even a couple years into the future.

Starting in the early 1990s, IBTA was in a continual process of review and renovation. As this occupied IBTA staff it also affected the SR-CRSP. Attempts were underway to reorganise IBTA to make it more responsive to needs of rural people, improve the quality and relevance of research, upgrade staff and enhance morale (Dr. D. L. Coppock, Utah State University, personal observation). A general trend towards decentralisation in the Bolivian government ultimately led to the demise of IBTA by the late 1990s. There is an effort underway at this writing to create private research foundations in the year 2000 (Dr. C. Valdivia, University of Missouri, personal observation). The idea is to have four privately funded research centres that will solicit and fund proposals aimed at solving problems according to priorities identified in recent field assessments and reviews of technology and literature. One such centre would be responsible for research in the Andean zone.

The Cantón of SJL has experienced interesting changes. Except if noted otherwise, the following details were reported by Mr. Pedro Marca, county agent and resident of SJL, as told to Dr. Corinne Valdivia (University of Missouri, personal communication) in November, 1999.

Today SJL is a community of some 130 households. This appears to markedly contradict predictions that SJL would gradually shrink to 80 households as a result of emigration and passing of the older residents (see Section 4.3.1.2: *Living standards, household structure and human population dynamics*). Apparently a number of emigrants have returned to SJL in the past four years.

Fourteen new households have also become established since 1996 as a result of young people at SJL getting married and deciding to settle. The reason that emigrants have returned to SJL, or young people have elected to stay, is reportedly due to an incipient "potato boom." Higher potato prices have apparently been important in encouraging growth in the local population.

Smallholder dairying remains as an important economic activity at SJL, but it appears more concentrated in the main *Barrio* and adjacent settlements. It would thus be interesting to find out if some households have indeed become specialised in dairy production given a longer period of time and relatively stable market opportunities. More distant settlements such as *Inkamaya* and *Espíritu Willq'i* have prioritised production of improved potato for market sales, followed by sheep production. Dairying is not important for people in these settlements. Apparently the issue of improving irrigation, and hence expanding cultivated forage production, has still not been solved in places like *Inkamaya* and *Espíritu Willq'i*. There have also been reports that DANIDA (the Danish development agency) has provided USD 10 million for further development of the dairy industry on the Altiplano for five years starting in 1998 (Dr. C. Valdivia, University of Missouri, personal communication). The funds will largely be used for in-kind credit schemes. In addition to providing technical assistance to farmers, research is being planned by DANIDA to monitor the potential vulnerability of dairy producers to price supports and the effects of dairying on the environment (Dr. C. Valdivia, University of Missouri, personal communication).

Land use patterns have changed at SJL. Some cropping areas formerly designated for growing "bitter" potato have been converted to alfalfa. Apparently the emphasis on bitter potato has declined in favour of improved potato, which is now even used to make traditional foods like *chuño*. The producers are apparently responding to favourable conditions for potato marketing. There is even discussion as to whether to form an association of potato producers. Attempts are being made to reclaim some of the saline rangelands. One NGO is working with households at SJL to rehabilitate parts of the fluvio-lacustrine plains. This effort is founded on planting promising halophytic species (see Annex C). Funds were obtained from the Popular Participation Act to initiate this activity. The fact that this has emerged as a priority for some households undermines the assertion that the sheep/range component of the system would be a lower

priority than the dairy/pasture component (see Section 8.2.2: *What is the role of small ruminants, and can it be strengthened or improved?*). More information needs to be known, however, concerning the choices available to producers involved in rehabilitation of saline lands. For example, range improvements may be the only option they have for increased productivity if they are non-dairy households. The potential risk of planting halophytes, however, appears to be mitigated by the use of public funds.

In general, producers still feel that the crop lands of SJL are "tired" and producing below potential capacity. Larger amounts of land have been tilled because of tractor availability and emergence of higher prices for potatoes.

Finally, in terms of social issues it has been reported that nine young women have graduated from the secondary school at SJL in 1999. These are the first females to do so (C. Jetté, UNDP, personal observation).

If we can assume that information on recent trends at SJL is accurate, it is very illuminating in terms of human-related forces that govern system dynamics. Given that people largely control the fate of several key resources at SJL, forces that affect human decisions are paramount. Perhaps the most important decision is whether or not a person decides to live at SJL. This profoundly affects resource use and allocation. The recent build-up in household numbers, particularly in conjunction with a possible potato boom and the perception that the crop land still seems "tired" tells us a lot. It lends credence to the hypothesis that perceptions about income drives many decisions of where campesinos will live. Prospects for lower incomes drives people out of SJL, and prospects for higher incomes brings people back. This suggests that the emigrant experience is less satisfactory than proposed earlier, at least in terms of the ability of most emigrants to secure higher incomes in urban settings (see Section 4.4: *Conclusions*). This complicates the notion of push and pull factors by making it a "chicken-and-egg" debate. Clearly, however, if environmental degradation was important enough to keep people out of SJL, they would not have come back. We would speculate that the incentive of higher commodity prices apparently is strong enough to over-ride other considerations. The observed pattern could also validate the idea that an important development strategy is to invest in rural communities so that they remain viable places for people to live. Using technology

and policy to maximise options allows people to take advantage of dynamic rural and urban sectors. This also has benefits for the nation.

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