2001

Chapter 07: Patterns of Technology Adoption at San José Llanga: Lessons in Agricultural Change

Lisa Markowitz
Small Ruminant Collaborative Research Support Program

Corinne Valdivia
University of Missouri

Chapter 7

Patterns of technology adoption at San José Llanga: Lessons in agricultural change

Patrones de adopción tecnológica en San José Llanga: Lecciones sobre el cambio agrícola

by Lisa Markowitz and Corinne Valdivia

Summary

Technological development programs on the Altiplano were introduced with the hopes of increasing productivity and supply of commodities for domestic and international markets. The development paradigm has been based on the promotion of "modernisation," which pervades aid efforts throughout the world. This paradigm is founded on the belief that technologies developed elsewhere could be diffused in developing countries. This chapter presents the economic and social events that influenced the fate of key technological innovations at San José Llanga (SJL), including characteristics of households and resources that influenced technology adoption. Attention is also given to how technologies have influenced the sustainability (e.g., household reproduction) of the system.

Three spheres of technological change were analysed that spanned 30 years: Sheep, potatoes and dairy. Interdisciplinary approaches in social sciences were used to study technical change. These have a greater emphasis on anthropology, sociology and economics to understand paradigm shifts in technology diffusion. Methods used to collect data included informal and formal interviews of sampled households. Analyses for sheep involved SJL and other neighbouring communities while analyses for dairy and potatoes focused solely on SJL.

Several development programs were introduced on the central Altiplano starting in the mid-1950's. One of the first efforts was creation of the Patacamaya Experiment Station with support of the Institute for Inter-American Affairs, a US technical assistance program. This station focused on improvement and management of sheep. International cooperation in the 1950s and 1960s promoted production of improved sheep with an extension emphasis on distribution of Corriedale rams and supporting technologies. Between 1965 and 1975 a sheep production and marketing program was introduced to improve wool exports—Utah State University was an important collaborator. Our study of the long-term outcome of this effort, involving 80 households in seven communities, revealed that improved sheep have been an important component of production systems even though wool markets are no longer attractive. Adoption patterns for improved sheep indicated that community location (in the plains) and training through extension programs were positive factors increasing the likelihood that improved sheep would be adopted.

An effort to improve food supply was introduction of new potato varieties suitable for urban consumption during the mid-1960s. Traditionally only "bitter" varieties adapted to the Altiplano environment were grown by peasant households. Traditional growing methods included use of sheep manure as fertiliser and tillage with human labour or animal draft power. The new technological package included use of chemical fertiliser and tractors for tillage. A cooperative was formed at SJL and a tractor was purchased on credit by the community. The cooperative eventually disintegrated, but producers continued to plant these new potato varieties—they remained common through 1995. Emphasis on introduced potato varieties was diminished with the drought of 1982-3. Despite a decline in emphasis on production of improved potatoes, the ancillary technologies of chemical fertilisers and tractor tillage remained widespread at SJL in the 1990s.

Dairy is the latest technological change, and this has boomed on the central Altiplano. A secure market with infrastructure, price supports, extension programs and credit were factors explaining how two-thirds of households at SJL became involved in this activity between 1989 and 1995. A drought also motivated producers to seek income via smallholder dairying. A study of fac-

tors that explain the probability of adoption of dairy husbandry using a logistic regression analysis revealed that increased access to alfalfa fields and level of wealth (e.g., income) had significant and positive effects.

The blending of new and traditional technologies has led to diversification and opportunism rather than specialisation predicted in the "Modernisation Paradigm." By incorporating new technologies in varying proportions, producers guaranteed their household consumption requirements and gained advantage from markets when possible. Rather than specialisation, diversification seemed to be the strategy for persistence and growth in this region characterised by erratic economic and climatic features.

We found that the impacts of technological changes were not merely neutral or positive. Increase in the use of tractors has resulted in an increased labour demand for weeding and herding sheep, both female activities. The probability of adopting dairy was affected by income and quality of resources available to households; therefore, wealthier producers have been able to initially capture most of the benefits of this technology. For improved potato production, chemical fertilisers and herbicides were required to obtain profitable yields. Therefore wealthier households with cash were also able to invest in this technology and reap initial benefits. Chemical fertilisers, by replacing manure, may have led to soil management problems. Benefits of technology adoption, overall, have accrued more to wealthier groups. More labour burdens have been placed on females.

The community of SJL has provided a useful case study of technology transfer. The community has successfully integrated improved sheep and potatoes into the traditional production system, although emphasis on innovations waxes and wanes with market opportunities. Overall, technology adoption has been a dynamic and somewhat episodic process. The trend towards modernisation may be gradually undermining the ability of the community to grow their own food, possibly due, in part, to unintended consequences of technology packages and increasing monetisation.

A critical lesson is that change is the rule, not the exception. The current dairy boom will also end some day and other opportunities may come forward. Technical, outreach and policy measures should therefore promote a dynamic market awareness and an opportunistic capacity to respond to change in communities like SJL.

Resumen

En el Altiplano, se han llevado a cabo muchos proyectos de cambio tecnológico con el objeto de incrementar la producción y la oferta para los mercados doméstico e internacional. El paradigma de desarrollo tecnológico ha estado basado en la "modernización" —concepto prevaleciente en las agencias de desarrollo en el mundo—que fomenta el incremento de la especialización como base de la eficiencia económica y por lo tanto del crecimiento. Este capítulo presenta los eventos históricos, económicos, y sociales que fueron claves en la introducción de tecnologías en San José Llanga. Se estudian las características de las unidades económicas familiares y sus recursos con relación a la adopción de nuevas tecnologías. El papel de género también es discutido, al mismo tiempo que la influencia de todos estos cambios tecnológicos en la sustentabilidad del sistema de producción.

En este capítulo se estudian tres esferas de cambio tecnológico que abarcan 30 años de la historia de San José. Los cambios en las esferas de producción de papa, del ganado ovino, y del vacuno. Los métodos utilizados para la recolección de información de los estudios que sustenta este capítulo incluyen encuestas formales, entrevistas formales e informales, y la revisión de material histórico relacionado a los eventos que motivaron estos cambios. En el caso del estudio de las tecnologías de ovino introducidas en los sesenta, se hizo una encuesta de 80 productores en 7 comunidades de la zona del altiplano. En el estudio de la ganadería lechera el análisis se informa de dos encuestas, una de 45 productores jóvenes de la comunidad, y una segunda encuesta para el estudio de género y ganadería con selección de 45 familias al azar que representan toda la población de la comunidad. Para el estudio de la papa se contó con los estudios de tesis sobre cambio tecnológico en la producción de la papa, y sobre los costos de las tecnologías de papa. El análisis de cambio tecnológico se hace a partir de un enfoque interdisciplinario en ciencias sociales, que incluye la antropología, la economía, la historia y la sociología. Este enfoque nos permite comprender mejor el paradigma de desarrollo y las acciones de las familias de San José.

A partir de mediados de los cincuenta, se introdujeron muchos cambios tecnológicos en SJL, comenzando por el establecimiento de la Estación Experimental de Patacamaya con el apoyo del Instituto de Asuntos Interamericanos de los Estados Unidos. Esta estación tenía como una de sus misiones la investigación para el mejoramiento de la producción ganadera, en esos tiempos con énfasis en el mejoramiento ovino. Con este programa de apoyo se distribuyeron carneros Corriedale, al igual que otras tecnologías para su manejo. Entre 1965 y 1975 el programa para la producción y comercialización de ovinos se difundió con la colaboración de la Universidad del Estado de Utah, con la esperanza de mejorar la exportación de lana. Un estudio del efecto de este programa, en 1993 con 80 productores de la zona en 7 comunidades campesinas del altiplano, muestra que los ovinos mejorados persisten como una tecnología, aún cuando ya no se exporta lana. El estudio de adopción muestra que el factor agroecológico, comunidades situadas en la pampa, influyen positivamente en las posibilidades de adopción. La propiedad del ganado ovino criollo también influencia positivamente las probabilidades de adopción del ganado mejorado. Una sorpresa del estudio es que la variable género no es significativa, a pesar de que esta actividad es del dominio de las mujeres. Problemas de autoselección pueden explicar este resultado, pues la muestra sólo tenía un 25% de mujeres encuestadas. Un segundo esfuerzo para incrementar la oferta al mercado se hizo con los cambios tecnológicos en la producción de nuevas variedades de papa con mayor demanda en zonas urbanas, la papa blanca. Esto sucedió a mediados de los sesenta. En esta zona las variedades de papa amarga eran cultivadas con el principal objetivo de satisfacer las necesidades del hogar. El cambio tecnológico comprendió nuevas variedades, el uso de fertilizantes químicos y el uso del tractor. Para acceder al crédito se creó una cooperativa, la que luego se disolvió. Sin embargo los productores continuaron con la producción de las nuevas variedades. El auge de esta actividad terminó con la sequía del 1982-1983. Los productores en las entrevistas realizadas reportaron que la producción desde ese entonces no ha sido la misma. Sin embargo los estudios muestran que se continúa con estas variedades de papa dulce, en combinación con las amargas, al igual que se continúa con el uso del tractor en la preparación del terreno. La ganadería lechera es la última actividad introducida en esta comunidad, y está en auge en todo el altiplano. Un mercado seguro, precios fijos, programas de extensión y crédito, son algunos de los factores que han hecho posible este auge. En este capítulo se muestran las características que influyen en su adopción. Los productores de San José han optado por mantener una diversidad de actividades, lo cual se refleja en el portafolio económico. En vez de optar por la especialización, se ha optado por un comportamiento oportunista, que les permite aprovechar las tecnologías que los ayuden a persistir en la región, y acumular, en vez de incrementar su vulnerabilidad frente al ambiente o al mercado. Encontramos que el cambio tecnológico no es neutral. Los cambios en las variedades de papa y la ganadería lechera han beneficiado más a las familias de más recursos. Todas las tecnologías han aumentado la demanda del trabajo femenino, pues son ellas las que ordeñan, deshierban, y pastorean el ganado. Por eso señalamos que las tecnologías no han tenido un impacto neutral. Tampoco lo han sido en su impacto en el medio ambiente, pero más estudios son necesarios para determinar las causas de la degradación en los campos de cultivo y los problemas de salinidad en los de regadío.

La comunidad de SJL nos ha proporcionado un estudio de caso muy útil para entender la transferencia de tecnología. La comunidad ha logrado integrar exitosamente el ganado mejorado y la producción de nuevas variedades de papa a su sistema de producción, aun cuando el énfasis en las innovaciones decrece cuando las oportunidades del mercado desaparecen. Sobre todo, la adopción de tecnología ha sido dinámica y más o menos un proceso episódico. Las tendencias hacia la modernidad pueden socavar la habilidad que tienen las comunidades de producir sus propios alimentos, en parte debido a las consecuencias no esperadas de los paquetes tecnológicos, y al incremento en la monetización de su economía.

Una lección crítica de este capítulo es que el cambio es la regla y no la excepción. El auge actual en la lechería también terminará un día, y puede ser que entonces se presenten otras oportunidades. Las medidas de carácter técnico, de extensión y de política deben por lo tanto promover un conocimiento constante de las dinámicas del mercado y una capacidad para responder oportunistamente al cambio en comunidades como SJL.

7.1 Introduction

As previously noted in Chapter 4: *Household economy and community dynamics at San José Llanga*, the production system incorporated a mix of introduced and indigenous technologies. This reflected the community's history as recipient of imported technologies and use of time-tested local practices to meet the challenges of food production on the central Altiplano. The ability of local residents to opportunistically and effectively integrate innovations into their productive regime in response to changing economic conditions has played a large part in helping maintain a diversity of crop and livestock enterprises that facilitates coping with perturbations (Jetté 1993; Murillo and Markowitz 1995; Chapter 6: *Household socioeconomic diversity and coping response to a drought year at San José Llanga*). This reliance on diversity contrasts with predictions of classical modernisation theory which holds that economic growth and specialisation go hand-in-hand, the latter being a condition for the former to take place (Bromley and Chavas 1989). In San José Llanga we have found an alternative path, namely one of opportunistic behaviour that maintains flexibility and diversification that ensures cash and in-kind income in the face of climatic and market vicissitudes (Chapter 6: *Household socioeconomic diversity and coping response to a drought year at San José Llanga*).

The objectives for this chapter include determination of: (1) How social and economic events have influenced key phases of technology transfer at San José Llanga (SJL); (2) how household-level factors have influenced adoption of new technology; (3) whether males and females, as well as various wealth classes, have similarly benefited from adoption of new technology; and (4) whether technology adoption has influenced sustainability of the production system. Answering these questions helps us understand what factors facilitate or constrain technology transfer to rural producers. Technology transfer is a vital, culminating and problematic process for research.

To achieve these objectives, this chapter takes a chronological approach to tracing the course of technological intervention and uptake at SJL to understand development and configuration of the current production system. The account integrates material from a number of independent investigations to examine technological change in three critical spheres of household production: Sheep, potatoes and dairy. The history and policy antecedents of each episode of intervention are described both to better contextualize SJL within broader political-economic systems and to identify critical points of macro-micro articulation (Berdegué and Escobar 1995; Valdivia 1995).

7.2 Methods

7.2.1 Review of technology paradigms

Placing technological interventions at SJL within a broader framework recognises that technologies are not neutral in either their genesis, dissemination or local impacts; nor can these processes be fully assessed without consideration of the overarching political economy (Biggs and Clay 1988; Smillie 1991; Pfaffenberger 1992). This perspective departs from the relatively non-problematic treatment of technology within the Modernisation Paradigm which informed the creation and operation of most of the programs that have influenced the contemporary system of SJL. Modernisation theory posits the presence of modern and traditional sectors and assumes the goal of development is transformation of the traditional into the modern. Transfer of technology is key in that it offers a means to accelerate this transformation (Biggs and Clay 1988: 22-3). In this vision of development, technology itself becomes a positive, modernising force (Escobar 1995, 36). Accordingly, the ability to specialise is a reflection of economic development (Bromley and Chavas 1989).

Challenges to this understanding of technology transfer have arisen from many theoretical quarters, but three in particular inform our approach. Recent work in a post-structuralist vein examines the political and ideological underpinnings of this notion of transformation and contends that the language, assumptions and institutions that constitute the development enterprise have served to perpetuate global inequalities (Sachs 1992; Escobar 1995). This provocative critique, although difficult for many involved in agricultural development to embrace, compels attention to the political and historical contexts of technical assistance programs.

At a more operational level, systems-oriented researchers have documented the important interactions between technology uptake and policy, support systems and macro-conditions (Valdivia 1995), matters too often excluded from consideration by their definition as "external parameters." A recent review of the systems

approach in Latin America calls for greater attention to non-farm variables in general and "intermediate agrarian institutions" in particular (Berdegué and Escobar 1995; Valdivia 1995). This expanded focus has characterised social science research in the IBTA/SR-CRSP project and here we emphasise the nature of extension work in the region and community.

A third challenge arises from scholars and development practitioners who have combined concepts from agroecology with an interest in the revalorisation of Andean technologies. In the face of the diffusion of imported technologies and the denigration of Andean cultures, there is burgeoning recognition that recuperation of technologies specifically developed to cope with the Altiplano and Cordillera environments has much to offer contemporary producers (Rengifo and Kohler 1992; Healy 1996). Revalorisation encompasses appreciation of Andean cosmologies in the many ways religious belief orders peoples' relation with the natural world. From an *Aymara* perspective, religious practice is inextricably linked with productive activities (van den Berg 1992), leading van Kessel (1992, 198) to term such practices the "symbolic dimension" of Andean technology.

7.2.2 Specific methodologies

Overall methods used to collect data for this chapter involved formal and informal interviews of sampled populations of the community, focus group sessions, household-level case studies, participant observation and reviews of archival data sources. Highlights of key contributions are noted below.

The history of technology transfer and extension programs in the central Altiplano since the 1950s was reconstructed through archival research and open-ended interviews with current and former extension agents in the SJL area (Markowitz and Valdivia 1995). To assess research undertaken at the Patacamaya Experiment Station, Quino (1994) reviewed technical reports from station archives from 1960 to the early 1990s.

The adoption and contemporary role of improved sheep breeds for SJL households was addressed by Espejo (1994) while other economic issues pertaining to improved sheep were studied by Valdivia and Jetté (1996).

Spatial diffusion of improved sheep breeds over the past three decades was examined by using a census of flocks held by 80 households at SJL and seven other nearby communities in the plains and hills of the Province of Aroma (Markowitz 1995). The communities, selected on the basis of past involvement with technology transfer programs, varied with respect to local climate, ecology and degree to which irrigation was used in livestock and crop production. Sheep were categorised as either Criollo or 50% cross-breeds of Criollo x Corriedale according to phenotypic characteristics. Probability of adoption of improved sheep by households was assessed as a function of seven variables by Sheikh and Valdivia (IBTA/SR-CRSP, unpublished) using a logit model (Kmeta 1986). Independent variables were selected to characterise features of the resource base, gender and age of household heads, years of formal education, and access to training or extension activities. For example, producers having a resource base oriented more toward plains agriculture rather than a mix of plains and hillside agriculture were expected to be more likely to adopt improved sheep because plains resources were more conducive to intensification of sheep husbandry through methods involving crop residues and improved forages. Female household heads who were also younger and had received special extension training in sheep husbandry were also thought to be more likely to adopt improved sheep. Since other studies had shown that sheep husbandry is a female dominated activity (Section 4.3.3: *Household production system*), gender was expected to influence adoption. One-quarter of the households in the analysis were headed by women. Life cycle, with an arbitrary demarcation between household heads older or younger than 50 years, was expected to influence adoption because younger, "mid-career" household heads had a greater abundance of labour and a proclivity to invest in improved technology (see Section 6.3.1: *Socioeconomic groups*). As will be noted later in this chapter, special training in husbandry of improved sheep had been provided for several decades in the region, although only about one-quarter of survey respondents had actually participated in a training opportunity (Markowitz 1995). There was some degree of self-selection of participants in the survey, simply because some potential respondents elected not to participate. Unlike residents of SJL, residents of nearby communities were less familiar with the IBTA/SR-CRSP project and more wary of participating in surveys. Self-selection in surveys can result in bias of regression coefficients (Maddala 1983). We felt, however, that a reasonable cross-section of participants was achieved.

Probability of adoption (z) by the ith household was assessed as a function of seven variables using the following model:

$$Z_i = a + b_1(\text{COMMTY}) + b_2(\text{AGE}) + b_3(\text{GENDER}) + b_4(\text{TRAIN}) + b_5(\text{CROPAREA}) + b_6(\text{TOTALCRI}) + b_7(\text{ALFAREA}) + e$$

The variables are proxies for hypotheses noted above. The statistical analysis was conducted using the LOGISTIC procedure in SAS (SAS 1990). Interviews for the 80 households were also used to assess how revenue from sheep sales was spent and various aspects of sheep management (Markowitz 1995).

Huanca (1995) conducted a study of potato cultivation. She examined producer attitudes towards change in potato production and events which led to introduction of mechanised tillage and adoption of other novel inputs at SJL using archival records and participant observation, oral history, and structured interviews for 30 households (Huanca 1995; Huanca et al 1995). Lizárraga (1994) assessed the economic costs and benefits of new technologies by using structured interviews of 36 households and collecting production data from 55 parcels of their crop land (Lizárraga1994; Lizárraga et al 1995). Victoria et al (1994) interviewed 25 community members in their study focused on relative merits of sheep manure versus introduced chemical fertilisers.

Adoption of dairy technology and promotion of dairy cooperatives were topics studied by by Illanes (1994) and Illanes et al (1995). They conducted informal and structured interviews and focus group meetings with 46 randomly selected producers to identify behavioural and economic variables influencing participation in small-scale commercial dairying. Dairy adopters and non-adopters were contrasted in terms of various household and resource features using *t*-tests. In addition, Dr. L. Markowitz (IBTA/SR-CRSP, unpublished data) interviewed 32 of the most active milk producers at SJL to determine their patterns of technology adoption.

Statistical analysis of dairy producers at SJL involved a logistic regression (Valdivia 1998) that looked at the variables affecting adoption of this enterprise among 45 households. Procedures were similar to the analysis for sheep. The statistical package used was SPSS (1998). The model attempted to explain dairy adoption as a function of alfalfa area, total income and household economic diversity.

7.3 Results and discussion

7.3.1 History of technical assistance at San José Llanga

The scope and tenor for international assistance programs of the US Government was set in the Inaugural Address of US president Harry S. Truman on January 20, 1949. A key excerpt follows of "The Point IV Speech" (Baldwin 1966, 61):

> "Fourth. We must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas. ...The United States is pre-eminent among nations in the development of industrial and scientific techniques. The material resources which we can afford to use for the assistance of other peoples are limited. But our imponderable resources in technical knowledge are constantly growing and inexhaustible."

The Cantón of SJL has been subject to a series of technology assistance projects supported by foreign donors since the early 1960s. This was part of a broad US involvement in Altiplano agriculture starting in the 1950s (see Section 1.4.1: *Research setting*). Implementation rested on the direct transfer of technologies developed in Europe and North America. The assumption of northern technological beneficence appears in the diffusion processes described below. As noted by Healy (1996, 14) in the models of Altiplano agricultural development that followed over the following decades, "the Bolivian extension agent was the key actor and peasant farmers remained backward and passive."

By 1954 the US technical assistance program to Bolivia, financed through the Institute of Inter-American Affairs, was the second largest in the hemisphere. The vehicle for much of this effort was the Inter-American Agricultural Service (or SAI—Servicios Agrícolas Interamericanos), a descendant of the servicios established in 1942 as means to acquire strategic defense materials from Latin America (Iverson 1951, 223). A servicio was conceived as a flexible administrative entity that could undertake whatever technical cooperation was agreed upon (Mosher 1957, 323). Through the early 1960s the SAI supplied much of the direction and budget for the Bolivian Ministry of Agriculture [see Rice (1971) for discussion and evaluation of the SAI's structure and programs]. Although

SAI activities focused mostly on tropical eastern Bolivia, their priority in the Altiplano was creation of agricultural research and demonstration centres. As an example, the Patacamaya Experiment Station was constructed in 1958 on lands of the former hacienda Culta Arajllanga (PES 1962-3, 5).

The initial mission of the Patacamaya Experiment Station was to improve the quality of Altiplano sheep. Researchers thus carried out experiments dealing with sheep genetics, management, health and nutrition. To this end a variety of breeds including Romney Marsh, Corriedale, Rambouillet, Hampshire Down and Targhee were imported from Chile, Peru, Uruguay and the US. A review of station research (Quino 1994) revealed several important accomplishments by station staff. Most notable was the development of a crossbred sheep (i.e., Corriedale x Criollo) that was well-adapted to the elevation and climatic extremes and able to be more productive than other pure-breds or crosses (see Section 5.3.3: *Management and productivity of sheep*). Quino (1994) noted a tendency, however, for researchers to rely on on-station tests and not consider on-farm conditions. Similarly, nutrition research tended to focus on feed resources that were too expensive for most local producers to acquire. Finally, basic health problems received little attention compared to research on uncommon, but more interesting, ailments (Quino 1994).

In the late 1950s and 1960s the Patacamaya Experiment Station also served as a base for international cooperation programs and as an extension centre. According to informants, SAI extension teams worked with community leaders focusing on establishing cooperatives meant as vehicles for training, extension of credit, parasite control (i.e., construction of at least 2000 sheep dips) and improved breeding (i.e., distribution of up to 3000 Corriedale rams). Although the SAI teams operated independently of the Patacamaya Experiment Station, feedback concerning success of research applications was maintained. In 1962 the Patacamaya Experiment Station designated its own extension personnel who began to organise formal outreach meetings and short-courses. These facilitated formation of a regional ranchers association (AREGA–Asociación Regional de Agricultores; PES 1962-3) a grouping of cooperatives from over 20 communities from the central Altiplano, including SJL.

More technical assistance from the US was directed to the Altiplano by 1965. During the same period political fears over left-wing insurgencies led to higher levels of overall aid to Bolivia (Wilkie 1982, 84). A major effort on the Altiplano from 1965-75 was the Utah State University/USAID Sheep Production and Marketing Program (abbreviated as USU/USAID/SPMP) which, like SAI, operated within the Bolivian Ministry of Agriculture. This program aimed to improve rural conditions through development of agricultural research and extension and to improve the country's balance of payments through development of exports and import substitutes (Wennergren 1975, 6).

Program participants included Bolivian technicians and university faculty from Utah, where "cold desert" conditions parallel those of the Altiplano. Like their predecessors, these people were primarily concerned with sheep production, especially breeding, wool marketing and forage improvement. They arranged to import some 2000 pure-bred sheep (i.e., Targhee and Corriedale) and distributed rams among Altiplano communities, often building on previous work of SAI teams. Extension teams conducted shearing demonstrations in support of a revitalised national wool market. On-farm forage trials contributed to the testing and widespread dissemination of new varieties of alfalfa and other cultivated forages (Haws 1975).

Another form of technical assistance in the region was extension of credit for purchase of farm inputs (Huanca 1995). By the mid-1960s funds for communities in Aroma Province were available from the Inter-American Development Bank and USAID via the Agrarian Bank of Bolivia. Little credit, however, was directly given to smallholders (Heilman 1982). Agencies considered rural cooperatives better risks, a view consonant with the goals of community development. Within Aroma new cooperatives proliferated, often established on the basis of the rancher groups (e.g., AREGA) created a few years earlier.

Residents of SJL organised a cooperative in 1966 to receive loans under rural development and commodity support programs aimed at increasing food production for urban markets through intensified cultivation (Huanca 1995). With the credit arrived a "technology package" consisting of seeds for "improved" potatoes (e.g., *Papa dulce*) developed for urban tastes along with mechanised tillage, chemical fertiliser and herbicide.

The most recent technological change at SJL has been development of smallholder commercial dairying that began in the late 1980s (see Section 4.3.3: *Household production system*), but its institutional antecedents actually dated back to the mid-1950s. The UNICEF (United Nations

Children's Fund) had identified increasing milk production as a goal for Bolivian economic and agricultural development and subsequently financed construction of milk processing plants in Cochabamba, Tarija, Chuquisaca, Santa Cruz and La Paz. To coordinate milk promotion programs, the FAO (Food and Agriculture Organization of the United Nations) worked with the Bolivian government in 1970 to design a framework for increasing dairy production and consumption. The following objectives emerged: (1) Increasing on-farm milk production and rural incomes; (2) creation of a milk industry infrastructure; (3) encouraging milk consumption as a response to endemic malnutrition; and (4) supplying an import substitute (Catacora 1993). Since this time most multi-lateral assistance to the dairy sector has fallen within the contours of this master-plan. See Illanes et al (1995) for further details.

For milk producers on the central Altiplano, the most visible support for dairying was a parastatal organization called PROFOLE (Programa de Fomento Lechero, or Milk Promotion Program). Starting in 1978 PROFOLE extension agents provided technical assistance to smallholders in scores of Altiplano communities. Their primary financial backing has come from the WFP (World Food Program of the United Nations) which began in 1984 to coordinate contributions of milk solids and butterfat to Bolivia by international donors. The La Paz milk plant reconstituted dried solids into liquid milk, which was then sold to generate revenues for PROFOLE extension activities. Between 1980 and 1990 donations accounted for about 40% of the total national milk supply (Materson et al 1991).

In more recent times producers on the central Altiplano have sold milk to PIL (Programa de Industrialización Lechera) through community-based collection centres (centros de acopio) or through more elaborate producers' associations called módulos. These organisations have a dual role; on one hand they were meant to facilitate transmission of information from extensionist to farmer, perpetuating a one-way model of technology transfer, while on another they were conceived as organisational vehicles to engender community activism and autonomy (Catacora 1993).

While some residents of SJL had previously raised a few cows for draft power and household milk production, the severe drought of 1982-3 spurred widespread interest in dairying (and animal husbandry in general) as a potentially more secure livelihood option compared to cultivation (Markowitz 1993). This interest coincided with construction of a 23-km irrigation canal by local residents from the Rio Desaguadero to SJL and three surrounding communities (Section 3.3.2: *Description of natural resources*). Irrigation permitted more intensive use of what had been grazing or more marginal rain-fed crop land. Alfalfa thrived in this area, as well as along the *Khora Jahuíra* River. Also, in the mid-1980s the Programa de Ayuda Campesina (Peasant Self-Development Program) sponsored by the EEC (European Economic Community) started to distribute forage seeds, and in 1989 improved the dirt track leading into the main *Barrio* at SJL in part to facilitate milk commercialisation. The PROFOLE extensionists began work at SJL that same year and a módulo was established in 1990.

Participation in the módulo at SJL has facilitated access of members to various dairy technologies. Improved calves, usually Friesian (i.e., Holstein) or Brown Swiss crossed with Criollo, are given to members via a lottery with the understanding that in three years time a calf will be returned to PROFOLE to pass to other producers in need. The practice for SJL, however, has been for calves to go to the most active members. The PROFOLE advances credit to producers, and this is to be repaid out of future milk revenues for purchase of forage seed (i.e., oats, alfalfa, and barley). The PROFOLE also delivered feed supplements on 30-day credit. Larger loans have been available for such infrastructural improvements as sinking pumps and animal holding facilities. Tractor rentals, artificial insemination and weekly veterinary visits have been other perquisites of membership.

7.3.2 Diffusion and use of new technologies

As introduced above, major changes in sheep, potato and milk production enterprises have occurred over the past 30 years at SJL. The key role of new technology in community development and change is outlined below.

7.3.2.1 Improved sheep breeds

A look at the contemporary use of disseminated technologies has helped us evaluate the success of extension efforts involving improved sheep in the 1960s. Impact was evident in the composition of local flocks in the early 1990s. A

census of all households at SJL in May, 1994, revealed that out of a total of 4635 sheep, 2779 (60%) were at least a 50% cross of Corriedale x Criollo (henceforth referred to here as "improved"). The remaining 1856 (40%) were less than a 50% cross with the phenotype dominated by Criollo features (Drs. L. Markowitz and C. Valdivia, IBTA/SR-CRSP, unpublished data). The proportion of improved animals at SJL was two to twelve-times higher than proportions of improved animals observed in seven neighbouring communities (Table 7.1). Considered overall across eight communities (including SJL) and a grand total of 9724 sheep, about 5338 (or 55%) were improved crosses.

The analysis of what influenced adoption of improved sheep revealed three associated factors, namely, community location, training and Criollo sheep held. Statistics are shown in Table 7.2. As predicted, operations dominated by plains resources were positively associated with having improved sheep but, paradoxically, the finer-scaled variables of total cropped area or area planted to alfalfa were not significant ($P>0.37$). Exposure to extension training was also a positive factor. Ownership of Criollo sheep was negatively associated with adoption of improved sheep, presumably a substitution effect (Table 7.2).

As previously indicated, the non-random process of sample selection may have lead to biased coefficients; therefore, these results should be interpreted with care. A relatively low representation of female household heads and difficulty for women to attend extension meetings may help explain why gender was not significant in the final model. The result was surprising because sheep management is in the domain of women on the Altiplano.

In Section 4.3.3.4: *Gender, livestock and household welfare*, it was noted that income from sales of live sheep and sheep products was used for welfare expenses at SJL. The survey of 80 neighbouring households in seven other communities gave similar results (Markowitz 1995). Most of the 80 households (i.e., 72%) listed food as the top priority purchase item from sheep sales while 11% listed school supplies and 6% listed clothing as top priorities.

7.3.2.2 Improved potato production

Introduction of new potato technology in the 1960s fundamentally altered potato production at SJL, as revealed by Huanca's (1995) interviews with elderly residents. Before the intervention, people mostly raised indigenous potatoes such as the "bitter" varieties (i.e., *amarga—k'ullu* and *luk'i*) and "sweet" varieties (i.e., *dulce—ajawiri*, *sultana* and *saqampaya*). Producers used ox-drawn wooden plows for tillage, coats of ashes on top soil to help control pests, and partially decomposed and fermented sheep manure (*wanu*) as fertiliser. Producers would either apply decomposed manure at the moment of planting or spread the fields with fresh manure about five months before planting to allow its gradual disintegration. Typically between 40 and 60 quintals of *wanu* was used per hectare. Potato fields were fallowed for six to 10 years in a rotational scheme. In response to the aforementioned potato technical package, some 30 campesinos formed a cooperative in 1966. By 1967 they secured credit to purchase a tractor, truck, seeds and other inputs for collective potato cropping. Initially production boomed. Elderly informants recall that trucks laden with potatoes would roll out of the community on a weekly basis during the harvest season (Jetté 1993).

Informants who had been former members of the cooperative pointed out that while profits from increased potato production were high enough to eventually pay off debt incurred by the cooperative, participation brought the majority of members no long-term economic benefits (Huanca 1995). The cooperative eventually disintegrated as farmers began to apply technology packages to their own private parcels. Residents of SJL have reported that potato production has subsequently declined. Drops in soil fertility and shifts in other management practices have been implicated in the decline of potato production at SJL, but the most pervasive explanation may be cyclic declines in precipitation (see Section 3.3.4: *Integration of ecological findings*). The drought of 1982-3 was thought by campesinos to be the termination point of the "potato boom," which persisted for nearly 15 years (Huanca et al 1995).

Despite a perceived decline in levels of potato production, producers in SJL during the early 1990s still employed a combination of indigenous and introduced methods for potato production. In other words, the innovations of the 1960s have been retained. The campesinos also expressed a range of opinions and rationales concerning the relative merits of indigenous and introduced modes of potato production. Table 7.3 summarises some aspects discussed more fully below.

First, cultivation of introduced potato varieties (i.e., *Papa alpha* and *Papa sani imilla*) remained

Table 7.1. *Apparent breed composition of sheep flocks in seven rural communities in the Province of* Aroma *in 1994.*[1] Source: Dr. L. Markowitz and J. Valdivia (IBTA/SR-CRSP, unpublished data).

		Breed Composition[2]		
			Corriedale x Criollo	
Community	Total Sheep[1]	Criollo	50%	>50%
Ayamaya	1256	1009 (80%)	244 (19%)	3 (<1%)
Culli Culli	381	237 (62%)	144 (38%)	0 (0%)
Chiarumani	638	430 (67%)	208 (33%)	0 (0%)
Huari Belen	1217	450 (37%)	671 (65%)	96 (8%)
Inacamaya	981	204 (21%)	455 (46%)	322 (33%)
Patarani	243	163 (67%)	79 (33%)	1 (<1%)
Pomani	373	37 (10%)	186 (50%)	150 (40%)
All	5089	2530 (50%)	1987 (39%)	572 (11%)

[1]Based on census of community flocks.

[2]Where breed composition was discerned on the basis of phenotypic characters (see text for details). The 50% column refers to animals which appeared to be a 50:50 cross of Corriedale x Criollo. The >50% column refers to animals which were dominated by the Corriedale phenotype.

widespread at SJL in 1992-3. Lizárraga (1994) found that during the 1992-3 agricultural cycle these were planted in 91% of the plots controlled by sampled households. Farmers cultivated a mix of seeds from indigenous and introduced varieties in 78% of these fields, while just 9% of parcels contained only indigenous seeds. The different cultivars were either planted in separate rows or intermingled within furrows.

Diversification of potato production reflects varied household needs for consumption, exchange and production (Lizárraga 1994). Indigenous varieties are better suited for making freeze-dried *chuño* (see Section 4.3.3.1: *Household ac-*

Table 7.2. *Logit model coefficients, and respective P values, for seven variables postulated to be important factors in the process of adopting improved breeds of sheep among residents of the Province of* Aroma *in 1994*[1]. Source: Adapted from Sheikh and Valdivia (IBTA/SR-CRSP, unpublished).

		Statistics	
Variable[2]	Definition	b[2]	Pr[3]
Intercept	y-intercept	2.38	0.21
COMMTY	Location	-1.49	0.05*
AGE	Age of household head	0.01	0.74
GENDER	Gender of household head	-0.15	0.84
TRAIN	Exposure to extension	2.63	0.06*
CROPAREA	Total area cultivated	<0.01	0.99
TOTALCRI	Criollo sheep owned	-0.03	<0.01*
ALFAREA	Alfalfa area cultivated	0.21	0.37

[1]Based on a survey of seven communities (N=80 households). See text for a description of the logit model.

[2]The equation was thus: $Z_i = 2.38 + -1.49(COMMTY) + 2.63(TRAIN) - 0.03\ (TOTALCRI)$

[3]Probability (Pr) values ≤ 0.10 are regarded as statistically significant and labeled with an asterisk(*).

tivities and economy) and for certain types of food preparation. In contrast to the indigenous varieties, however, the higher yielding introduced varieties received better market prices during bumper years when sales were more likely. Introduced varieties, although less frost-resistant than indigenous varieties, had shorter growing periods which reduced their vulnerability to drought in the early spring and frost in late summer (Lizáragga et al 1995). Farmers attempted to avert risk by staggering sowing over three distinct periods within the spring planting season (i.e., August through November) and by adjusting planting schedules to presence or absence of early rains and forecasts they drew from star patterns in the night sky and observing behaviour of wild animals (Huanca 1995). The aforementioned spatial dispersion of varieties also served as another means to lessen the risk of frost damage (see Section 4.3.3.1: *Household activities and economy*).

The use of tractor tillage has become widespread at SJL largely because it has offered a great savings of labour and time. Huanca (1995) found that all households in her sample of 30 households used tractor tillage for at least the initial stages of field preparation such as clearing debris and furrowing. To plow one hectare with animals takes one person four days. In contrast, a tractor could cover the same field in about three hours, with the cost equivalent to about USD 28 in 1993. Animal power still predominated, however, for the more delicate tasks of planting and soil mounding (*el aporque*) for potato production.

Table 7.3. *Use (frequency, %) of various options[1] for potato production practices among a sample of 30 households in San José Llanga in 1992-3.* Source: Adapted from Huanca (1995).

Practice	Options			
Tillage	Animal-drawn plough only	Tractor only	Plough and tractor	Manual only
	17 (57%)	11 (37%)	2 (6%)	0 (0%)
Soil mounding[2]	Animal-drawn plough only	Tractor only	Plough and tractor	Manual only
	22 (77%)	3 (10%)	2 (7%)	3 (10%)
Fertiliser use	Manure only	Chemical only	Manure and chemical	None
	3 (10%)	11 (37%)	16 (53%)	0 (0%)

[1]Where tractors and chemical fertilisers were introduced in the 1960s. Huanca (1995) also reported ubiquitous use of tractors for clearing of field debris in the initial steps of field preparation.

[2]Soil mounding is the process of creating small mounds around young potato plants.

A second factor mitigating against heavy reliance on animal traction has been the rise of smallholder dairying, which has led to reductions in numbers of Criollo bulls and oxen in household herds (Huanca 1995, 163). Presumably this trend resulted from attempts to reduce competition between high-value dairy cows and lower-value oxen for limited forage resources. The campesinos also preferred to avoid using cattle for furrowing and other activities which imposed high degrees of stress (Huanca 1995, 163). It is possible that increased reliance on tractor tillage has undermined some aspects of the sustainability of the cropping matrix at SJL (see Section 3.3.4: *Integration of ecological findings*).

The application of chemical fertilisers in place of, or in combination with, *wanu* was also common at SJL (Table 7.3). The motivations for increased reliance on chemical fertilisers varied, but most involved the relative ease of applying chemical fertilisers compared to manure application. Other aspects include perceived boosts for potato production, at least over the short term. Victoria et al (1994) found that nearly half of 25 households in her survey at SJL reported that labour was a key reason for greater reliance on chemical fertilisers. Today fresh manure—not decomposed—is applied to fields by hand at the moment of planting. Donkeys with wooden packs or pulling sleds haul *wanu* from livestock corrals near homesteads to the widely dispersed parcels. Contemporary farmers use, on average, 18.5 quintals (833 kg) of manure per hectare (Lizárraga et al 1995). Even though this amount is less than half that used by producers in the early 1960s (Huanca 1995), applying *wanu* to a hectare of land takes much more labour than does applying a 45-kg sack of chemical fertiliser typically used

for the same-sized plot (Lizárraga 1994). It should be noted that this quantity of chemical fertiliser is much less than the 225 kg per hectare recommended by local agronomists (Lizárraga 1994). About half of surveyed households perceived that chemical fertilisers boost crop production more than manure does (Victoria et al 1994). Lizárraga (1994) measured potato fresh-weight yields from plots treated with chemical fertilisers or manure during the 1992-3 production year. The 14 plots fertilised with manure produced an average of 45 kg fresh weight of potatoes per hectare, while 48 plots fertilised with urea produced an average of 88 kg fresh weight. A third important reason producers use chemical fertilisers is their perception that the chemical fertilisers can still be effective even if rainfall is deficient. Higher levels of rainfall were seen as necessary for effective decomposition of manure and recycling of nutrients (Huanca 1995). Similarly, Victoria et al (1994, 14) found that 40% of interviewed households noted that use of manure appears to exacerbate dry soil conditions in drought years, a perception that may have to do with water-retention properties of organic material in manure (see Section 3.3.4: *Integration of ecological findings*). Finally, producers explained to Huanca (1995) that two other benefits of chemical fertilisers were a reduced presence of worms and weed seeds.

Advantages of using manure have also been noted by Victoria et al (1994) and Huanca et al (1995). These include the fact that manure use does not require a cash outlay—a 45-kg sack of chemical fertiliser cost around USD 26 during the time of our study—and that potatoes grown with manure reportedly have a better flavour. Victoria et al (1994, 14) found that half of her informants thought that manure improved "the physical properties of soil," in contrast to use of chemical fertilisers. A common local opinion used to explain a perceived, gradual decline in crop production at SJL was that "the land seems tired" (Huanca 1995, 147). We speculate that there could be a causal link between this perception and a long-term decline in manure use. Our IBTA/SR-CRSP project, however, was unable to conduct a detailed investigation of soil management on crop lands. Priorities for future research are found in Section 8.3: *Recommendations*.

7.3.2.3 Dairy production

By 1995, over one-third of households at SJL participated in the PIL dairy cooperative activity. By early 1994 the producers at SJL were selling more milk compared to those in any of 24 other communities in the Aroma sector (Markowitz and Valdivia 1995). This program has spurred investment in improved cattle at SJL and fostered a reallocation of some land from food crop production to cultivated forage production. Of 33 core módulo members surveyed, nearly half (i.e., 17) had taken advantage of the PROFOLE rotating credit scheme to purchase forage seed and two thirds (i.e., 22) had acquired improved cattle (Dr. L. Markowitz, IBTA/SR-CRSP, unpublished data). Some 65 individuals were currently associates of the program, and about half of the members regularly delivered milk to the PIL main office. Milk sales seasonally varied and this reflected calving patterns, rainfall and forage conditions. Rain-fed forage conditions were particularly important for poorer or more marginalised dairy producers who were less able to gain access to irrigated forage plots (Espejo 1994, 178).

Despite fears that the PIL could be privatised (Drs. L. Markowitz and C. Valdivia, IBTA/SR-CRSP, personal observations), milk sales in SJL and other communities in Aroma Province rapidly increased, doubling between 1990 and 1992 (Illanes et al 1995). In 1992 producers in SJL delivered about 85 000 l of milk. A major stimulus of further involvement in milk commercialisation at SJL was a drought in 1991. Many campesinos lost their entire potato crop that year, rendering milk sales a crucial source of cash income. The prospect that dairying, at least when based on irrigated forage cultivation, could become a relatively stable source of income in the face of wide swings in annual rainfall, became increasingly attractive (Jetté 1993).

The potential for a higher and more stable income appears to strongly motivate households at SJL to invest in dairy cattle, along with support technologies such as irrigated alfalfa plots (Illanes et al 1995). Households begin to rely on the higher plane of income derived from dairying, and they want to protect their large investment in improved cows. While a Criollo cow may cost USD 250 to 300, the improved crosses can easily cost twice as much (see Section 4.3.3.1: *Household activities and economy*). It was only through improved animals that households could realise substantial increase in earnings: a Criollo cow gave at best 3 to 4 l of milk per day, while an improved animal yielded 10 to 12 l per day (Illanes 1994).

Out of 46 households sampled at SJL, Illanes et al (1995) found 28 to be involved in dairying while 18 were not. Household attributes are con-

trasted in Table 7.4. Particularly notable differences occurred in terms of total crop land, cultivated forage and improved cattle.

Results from the logistic regression on dairy adoption are shown in Table 7.5. The model correctly predicted the non-adopters and 94% of adopters. Access to cultivated feed resources and wealth largely explained adoption. Wealth was important because it conferred risk tolerance. We expected that more diversified producers would also adopt dairying, but other studies have shown that involvement in dairying reduced the need for off-farm employment (Céspedes et al 1995).

Synergisms between dairying and production of improved sheep have been observed. Dairying has been shown to be positively correlated with having improved sheep. It has also been noted that the stimulus to adopt dairy cattle has spurred the spread of cultivated forage which, in turn, has further affected production of improved sheep as a secondary effect (Yazman et al 1995; Valdivia and Jetté 1996).

7.4 Conclusions

The residents of San José Llanga have experienced an exceptional degree of exposure to extension initiatives and market incentives to alter their time-tested traditions. It indeed has been an ideal "living laboratory" for study of development processes.

Our review of technology transfer indicates that interventions involving improved sheep and improved potatoes have been sustained for about 30 years, and there was no sign that their basic utility would wane in the near future. As described in previous chapters, these interventions have been successful in terms of economic impact, at least over the short- to medium-term.

Because interventions have involved production of more marketable commodities, it was not surprising that the relative emphasis on various commodities appeared to wax and wane with market signals. In the case of smallholder dairying, drought provided additional incentive for

Table 7.4. *Various contrasts (means) for households that had adopted dairying (n = 28) and those that had not adopted dairying (n = 18) at San José Llanga in 1993.* Source: Adapted from Illanes et al (1995).

Variable	Dairy Producers	Non-Dairy Producers	P^1
Children living in SJL (number)	3.5	2.9	≤0.10
Children living away from home (number)	1.3	0.3	≤0.10
Education of household head (years)	6.8	5.3	≤0.10
Total crop land[2] (hectares)	34.0	14.0	≤0.10
Forage[2] (hectares)	5.3	2.6	≤0.10
Fallow (hectares)	11.3	3.9	≤0.10
Number of cattle (head)	6.4	4.9	≤0.10
Improved cattle (head)	4.8	1.9	≤0.10

[1]Significant difference among means in each row established using *t*-tests.

[2]Controlled access including cultivated forage.

Table 7.5. *Logistic regression statistics for adoption of dairying among 45 households at San José Llanga in 1993.* Source: Adapted from Dr. C. Valdivia (IBTA/SR-CRSP, unpublished data).

	Statistics		
Variable	Coefficient	Wald	*P*
Alfalfa Hectares	2.8	3.8	0.05
Diversity Index	1.4	2.02	NS
Total Income	0.001	3.02	0.08
Constant	-10	3.8	0.01

adoption. Macro-events thus seem to set the stage for technology adoption, rather than merely micro-level (e.g., household-level) events. The political economy therefore influences these dynamics because it influences windows of economic opportunity.

As reviewed in previous chapters, introduced technologies have been effectively mixed with traditional options at SJL. Consequences of introduced technologies have not all been positive or neutral, however. Many consequences have been unintended or unforeseen. Technology packages for improved potato may have ultimately compromised soils in the crop land matrix. Benefits of dairying may be biased towards males and the wealthier strata of society, contributing further to wealth polarisation. Because of their traditional socioeconomic role, improved sheep have a gender bias in favour of female managers. An increasingly parcelised and diverse cropping matrix may yield more work for females, both in terms of attentive shepherding and field maintenance.

The ability of households to adopt dairying or improved sheep was inextricably linked to their access to cultivated forages. The ability to cultivate forages was linked to landscape location. It is likely that synergisms occur among technologies that affect their prevalence over time. Although adoption and relative emphasis on any particular innovation appear to have a dynamic or episodic character, the overall push towards modernisation may be compromising the ability of the people to grow their own food.

Recently we have entered the "dairy boom." One lesson from our historical analysis is that change is constant. The dairy boom will end, and something else will take its place. It would be wise, therefore, to emphasise technical, outreach and policy measures that promote a dynamic market awareness and an opportunistic capacity to respond to change in communities like SJL (see Section 8.3: *Recommendations*). Rampant ecological and economic shocks dictate that the most economically diverse households will be the least vulnerable over the long haul.

7.5 Literature cited

Baldwin D. 1966. *Foreign Aid and American Foreign Policy: A Documentary Analysis.* Praeger, New York, New York, USA. 257 pp.

Berdegué J. and Escobar G. 1995. New directions of the systems approach for the modernization of Latin American peasant agriculture. *Journal for Farming Systems Research-Extension* 5:1-30.

Biggs S. and Clay E. 1988. Generation and diffusion of agricultural technology: Theories and experiences. In: Ahmed I. and Ruttan V. (eds), *Generation and Diffusion of Agricultural Innovation: The Role of Institutional Factors.* Gower, Brookfield, USA. pp. 19-67.

Bromley D. and Chavas J.P. 1989. On risk, transactions, and economic development in the semi-

arid tropics. *Economic Development and Cultural Change* 3:719-736.

Catacora A. 1993. La cooperación del programa mundial de alimentos al desarrollo lechero nacional. *Procampo* August/September, pp. 2-16.

Céspedes J., Dunn E. y Valdivia C. 1995. *Impactos de la Introduccion de Leche en el Ingreso Familiar.* IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/ Small Ruminant Collaborative Research Support Program). IBTA 144/Boletín Técnico 12/SR-CRSP 14, La Paz, Bolivia. 43 pp.

Dunn E. and Valdivia C. 1993. *Gender and Livestock: Dairy Expansion and Traditional Agropastoral Systems in the Bolivian Highlands Data Base*. Unpublished SR-CRSP (Small Ruminant Collaborative Research Support Program) report. University of Missiouri, Columbia.

Dunn E., Valdivia C. and Nolan M. 1992. *The Dynamics of Livestock and Community Change and Their Impact on Gender Roles.* Special Needs Funds Pool, unpublished SR-CRSP (Small Ruminant Collaborative Research Support Program) report. University of Missouri, Columbia. 4 pp.

Escobar A. 1995. *Encountering Development: The Making and Unmaking of the Third World.* Princeton University Press, Princeton, New Jersey, USA. 290 pp.

Espejo R. 1994. *Practicas Socieconomicas de Tenencia y Adquisición de Ganado, Estudio de Caso: Comunidad San José Llanga*. BA Tesis, Universidad Mayor de San Andrés, La Paz, Bolivia. 147 pp.

Fender K. 1997. *Empowerment Within the Household: A Study of Income Allocation in Bolivia*. MS thesis, University of Missouri, Columbia, Missouri, USA. 187 pp.

Haws G. 1975. Bolivia and Utah State University: A decade of contracts. Summary report 1965-75. *Utah State University Bulletin* 75(12). Logan, Utah, USA. 200 pp.

Healy K. 1996. Ethno-development of indigenous Bolivian communities: Emerging paradigms. In: Kolata A (ed), *Tiwanaku and its Hiterland: Archaeology and Paleoecology of an Andean Civilization, Volume 1: Agro-Ecology*. Smithsonian Press, Washington, DC, USA. pp. 243-263.

Heilman L. 1982. *U.S. Development Assistance to Rural Bolivia, 1941-1974: the Search for a Development Strategy.* PhD dissertation, American University, Washington, DC, USA. 303 pp.

Huanca J. 1995. *El Sistema Tecnico en el Cultivo de la Papa, Estudio de Caso: Comunidad San José Llanga, Provincia Aroma (Dept. La Paz).* BA tesis, Universidad Mayor de San Andrés, La Paz, Bolivia. 186 pp.

Huanca J., Markowitz L. and Jetté C. 1995. *El Proceso de Cambio Tecnologico: Perspectiva de los Productores de una Comunidad Agropastoril*. IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 158/Boletín Técnico 26/SR-CRSP 24. 25 pp.

Illanes P. 1994. *Adopción de Tecnologia en la Producción Lechera Estudio de Caso de los Cantones San José Llanga y Chijmuni.* BA Tesis. Universidad Mayor de San Andrés, La Paz, Bolivia. 159 pp.

Illanes P., Cuesta M. and Céspedes J. 1995. *Adopcion de Tecnologia en la Produccion Lechera: Estudio de la Communidad San José Llanga*. IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 147/Boletín Técnico 15/SR-CRSP 17. 35 pp.

Iverson K. 1951. The "servicio" in theory and practice. *Public Administration Review* 11:223-228.

Jetté C. 1993. *A diachronic analysis of changing resource use patterns on the central Bolivian highlands*. Small Ruminant Workshop, San Juan, Puerto Rico. 11 pp.

Kmenta J. 1986. *Elements of Econometrics.* Macmillan Publishing Company, New York, New York, USA. 796 pp.

Lizárraga M.R. 1994. *Cambio Tecnologico en el Cultivo de la Papa en la Comunidad de San José Llanga*. BA tesis, Universidad Mayor de San Andrés, La Paz, Bolivia.

Lizárraga M.R., Cuesta M. and Céspedes J. 1995. *Cambio Tecnologico en el Cultivo de la Papa en la Comunidad de San José Llanga.* IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 163/Boletín Técnico 31/SR-CRSP 29. La Paz, Bolivia. 38 pp.

Maddala G.S. 1983. *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge University Press, Cambridge, UK. 401 pp.

Markowitz 1993. *Till the Cows Come Home: Small Scale Dairying on the Central Bolivian Altiplano.* Paper presented at the 94th Annual Meeting of the American Anthropological Association. Washington, DC, USA. 12 pp.

Markowitz L. 1995. *The Impact of Improved Sheep Technologies in the Province of Aroma: Preliminary Findings.* Unpublished SR-CRSP (Small Ruminant Collaborative Research Support Program) report. University of Missouri, Columbia. 5 pp.

Markowitz L. and Valdivia C. 1995. *Technologies Through Time: Contradictions in an Andean System of Production*. Paper presented at the 94th Annual Meetings of the American Anthropological Association. Washington, DC, USA. 11 pp.

Materson D., Wyeth J., Stobberup J., and Anderson E. 1991. *Bolivia Dairy Sector Study*. Draft Report. DANIDA (Danish International Development Agency). Copenhagen, Denmark. 163 pp.

Mosher A. 1957. *Technical Cooperation in Latin American Agriculture*. University of Chicago Press, Chicago, Illinois, USA. 449 pp.

Murillo C. and Markowitz L. 1995. *Food and Nutrition in San José Llanga, an Agropastoral Community in the Central Altiplano of Bolivia*. IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 171/ Boletín Técnico 41/SR-CRSP 39. 37 pp.

PES (Patacamaya Experiment Station). 1962-3. *Informe Anuales.* Patacamaya Experiment Station, Patacamaya, Bolivia.

Pfaffenberger B. 1992. Social anthropology of technology. *Annual Review of Anthropology* 21:491-516.

Quino E. 1994. *Evaluación de Investigaciones de la Estación Experimental de Patacamaya*. RISPAL (Red de Investigacion en Sistemas de Produción Animal). American Latina.

Rengifo G. and Kohler A. (eds). 1989. *Revalorización de Tecnologías Campesinas Andinas*. HISBOL (Institute of Historia Boliviana), La Paz, Bolivia.

Rice E.B. 1971. *Extension in the Andes: An Evaluation of Official U.S. Assistance to Agricultural Extension Services in Central and South America*. MIT Press, Cambridge, Massachusetts, USA. 552 pp.

Sachs W. (ed). 1992. *The Development Dictionary: A Guide to Knowledge as Power.* Zed Books, London, UK. 305 pp.

SAS (Statistical Analysis System). 1990. *SAS/STAT™ User's Guide. Volume 2, GLM-VARCOMP. Version 6.* Fourth Edition. SAS Institute Inc., Cary, North Carolina.

Sherbourne J., Dunn E., Valdivia C. and Nolan M. 1995. *Agropastoral Production Systems, Intra-household Resource Allocation and Household Members Domains: Five Case Studies from the Community of San José Llanga.* IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 171/Boletín Técnico 171/SR-CRSP 39. La Paz, Bolivia. 34 pp.

Shucksmith M. 1993. Farm household behaviour and the transition to post-productionism. *Journal of Agricultural Economics* 44(3):466-478.

Smillie I. 1991. *Mastering the Machine.* Westview Press, Boulder, Colorado, USA. 268 pp.

SPSS 1999. *The SPSS Base 10.0 Applications Guide*. 537 pp.

Valdivia C. 1995. Policy impact assessment in small-ruminant production systems: The Peruvian case. In: Ruiz M., Seré C., Li Pun H. (eds), *Animal Production Systems Global Workshop*. IDRC/ IICA/RISPAL (Inter-American Institute for cooperation on Agriculture/Latin American Research Network for Animal Production Systems). San Jose, Costa Rica. pp. 385-415.

Valdivia C. and C. Jetté. 1996. *Peasant Households in Semi-Arid San José: Confronting Risk Through Diversification Strategies*. IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/ Small Ruminant Collaborative Research Support Program). IBTA 181/ Boletín Técnico 181/SR-CRSP 47. La Paz, Bolivia. 24 pp.

Valdivia C., Dunn E., and Sherbourne J. 1996. *Gender, Livestock and Household Peasant Production: Dairy and Diversification in Crop-Livestock Systems of an Andean Community.* IBTA/ SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 165/ Boletín Técnico 33/SR-CRSP 31. La Paz, Bolivia. 42 pp.

van den Berg H. 1992. Religión Aymara. In: van den Berg H. and Schiffers N. (eds), *La Cosmovisión* Aymara. UCB/HISBOL. La Paz, Bolivia, pp. 291-308.

van Kessel J. 1992. Technologia Aymara: Un enfoque cultural. En: van den Berg H. and Schiffers N. (eds), *La Cosmovisión* Aymara. UCB/HISBOL. La Paz, Bolivia. pp. 187-219.

Victoria Z., de Queiroz, J., and Norton B. 1994. Production and utilization of manure in an agropastoral community in the central Altiplano of Bolivia. *ReRumen Newsletter* 3:13-15.

Wennergren E.B. 1975. *An Evaluation of the Utah State University/USAID Sheep Production and Marketing Program in Bolivia*. Utah State University Series 7/75. La Paz, Bolivia (also USU archives). 79 pp.

Wilkie J.W. 1982. U.S. foreign policy and economic assistance in Bolivia: 1948-1979. In: Landman J. (ed), *Modern-day Bolivia*: *Legacy of the Revolution and Prospects for the Future*. Centre for Latin American Studies, Arizona State University, Tempe, Arizona, USA. pp. 38-121.

Yazman J., Jetté C., and Cáceres M. 1995. *Producción de Ovinos en Sistemas Agropastoriles en el Altiplano Central de Bolivia*. IBTA/SR-CRSP (Instituto Boliviano de Tecnología Agropecuria/Small Ruminant Collaborative Research Support Program). IBTA 148/ Boletín Técnico 16/ SR-CRSP 10. La Paz, Bolivia. 27 pp.