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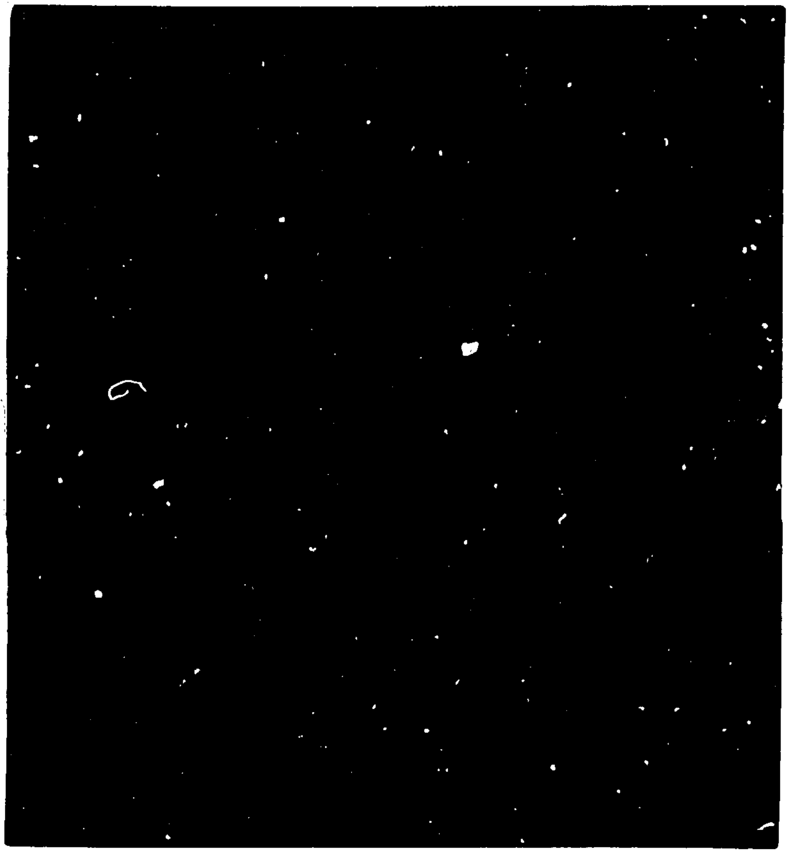

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TECHNOLOGICAL CHANGE IN BOLIVIAN AGRICULTURE: A SURVEY

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Bolivian agriculture is characterized by low yields for most products, a reflection both of land quality and of the traditional methods of production generally employed. Rural income per capita (and, by implication, the productivity of rural labor) is reported to be less than one-eighth that in urban areas. Even though the actual urban-rural differential is not so great (Zuvekas 1977a: 10-13), there is little doubt that it is well above the Latin American average of 2.5:1.

Nevertheless, a comparison of Bolivian crop yields with those in other Latin American countries (see Table 1) shows that the situation is not so bleak as the picture conveyed in some reports. Although yields for some major crops--wheat, rice, barley, potatoes, and sugarcane--are among the lowest in Latin America, those for yucca, soybeans, peanuts, bananas, coffee, and cacao rank relatively high. Corn, pulses, and cotton occupy intermediate positions. While yields per hectare tell us nothing about the relative use of capital and labor, and their productivity, they nevertheless provide useful information on the status of Bolivian agriculture.

Of greater interest are the data showing changes in crop yields. Table 2 indicates that land productivity between 1961-63 and 1973-75 increased at an annual rate of 2 percent or more for only 14 of the 57 crops listed (most of them of minor importance); 8 crops experienced declining yields. 1/ Most of the production gains, particularly since the late

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1/ The quality of the data in Tables 1 and 2 is variable. Note that the Bolivian figures reported by the FAO do not always agree with the most recent data available from the Bolivian Ministry of Agriculture and Rural Affairs.

TABLE 1

YIELDS FOR SELECTED CROPS, 12 LATIN AMERICAN COUNTRIES AND THE UNITED STATES, 1973-1975

(kilograms per hectare)

	Wheat	Rice (Paddy)	Barley	Corn	Potatoes	Yucca	Pulses	Soybeans	Peanuts (in shell)	Cotton	Sugarcane	Bananas	Coffee	Cocoa
Argentina	1,557	3,667	1,305	2,666	15,321	11,410	965	1,526	966	989	54,042	33,122	-	-
BOLIVIA	837	1,675	695	1,326	6,119	13,522	669	1,626	1,390	1,273	46,184	24,836	837	526
Brazil	954	1,479	790	1,522	8,593	12,572	557	1,564	1,251	736	46,464	24,304	571	448
Chile	1,502	2,932	1,792	3,469	10,172	-	858	-	-	-	-	-	-	-
Colombia	1,245	4,211	1,549	1,205	11,956	8,000	646	1,964	1,456	1,467	49,498	14,294	627	400
Ecuador	917	2,704	954	988	12,162	9,410	539	1,389	881	942	59,119	21,389	303	364
Guatemala	1,346	1,779	-	888	4,156	2,841	683	-	1,999	3,178	76,495	8,449	542	444
Mexico	3,358	2,781	1,392	1,202	11,883	-	714	1,665	1,320	2,261	65,943	17,002	675	450
Paraguay	1,263	1,944	-	1,284	5,981	14,043	816	1,962	843	907	36,609	32,158	473	-
Peru	850	4,147	886	1,532	6,802	12,682	782	1,169	940	1,554	166,069	24,214	408	500
Uruguay	1,091	3,895	1,042	1,070	5,033	-	739	1,145	805	1,901	39,782	-	-	-
Venezuela	419	2,767	-	1,151	10,429	7,783	408	-	871	1,062	75,025	19,982	211	260
U.S.	2,010	4,955	2,179	5,204	27,144	-	1,389	1,778	2,757	1,392	78,836	13,044	1,176	-

Source: FAO, Production Yearbook 1975.

- Indicates zero or negligible production, or no data.

TABLE 2

CROP YIELDS, 1961-1975

(kilograms per hectare)

Crop	Average Yields 1961-63	1967-69	1973-75	Annual Rates of Growth 1961-63 to 1967-69	1967-69 to 1973-75	1961-63 to 1973-75
Wheat	507	632	827	3.7	4.6	4.2
Rice (milled)	1,025	1,232	1,159	3.1	-1.0	1.0
Corn	1,233	1,322	1,289	1.2	-0.4	0.4
Barley	661	665	702	0.1	0.9	0.5
Oats	607	657	676	1.3	0.5	0.9
Quinua	491	653	774	4.9	2.8	3.9
Cañahua	n.a.	300[b]	300	n.a.	0.0	n.a.
Rye	n.a.	500	517	n.a.	0.6	n.a.
Potatoes	4,840	6,221	6,395	4.3	0.5	2.3
Yucca	11,023	12,167	13,015	1.7	1.1	1.4
Sweet Potatoes	8,008	9,016	7,509	2.0	-3.1	-0.5
Ocas	3,000[a]	3,000	3,101	0.0	0.6	0.3
Papalizas	1,600[a]	1,631	1,773	0.4	1.4	0.9
Oranges	17,500	16,640	16,457	-0.8	-0.2	-0.5
Tangerines	962	1,030	1,190	1.1	2.4	1.8
Lemons	12,000	11,738	11,860	-0.4	0.2	-0.1
Plantains	16,434	16,480	15,519	0.0	-1.0	-0.5
Bananas	23,333	24,000	23,150	0.5	-0.6	-0.1
Peaches	3,600	3,965	4,067	1.6	0.4	1.0
Grapes	4,703	5,515	5,980	2.7	1.4	2.0
Pears	2,810	4,526	4,550	8.3	0.1	4.1
Apples	4,902	5,302	5,307	1.3	0.0	0.7
Plums	n.a.	n.a.	4,141	n.a.	n.a.	n.a.
Cactus Fruit	n.a.	4,000	3,963	n.a.	-0.2	n.a.
Cherries	n.a.	1,224	1,297	n.a.	1.0	n.a.
Quinces	n.a.	n.a.	6,048	n.a.	n.a.	n.a.
Figs	n.a.	3,000[b]	2,985	n.a.	-0.1	n.a.
Strawberries	n.a.	2,000[b]	2,000	n.a.	0.0	n.a.
Pineapples	9,333	13,000	14,394	5.7	1.7	3.7
Avocados	3,033	3,050	3,212	0.1	0.9	0.6
Chirimoyas	n.a.	6,000[b]	5,982	n.a.	-0.1	n.a.
Mangoes	n.a.	10,000[b]	9,519	n.a.	-1.0	n.a.
Papayas	n.a.	2,000[b]	2,333	n.a.	2.6	n.a.
Corn (choclo)	2,333	2,691	3,004	2.4	1.9	2.1
Tomatoes	12,335	11,783	11,745	-0.8	-0.1	-0.4

TABLE 2

(continued)

Crop	Average Yields 1961-63	1967-69	1973-75	Annual Rates of Growth 1961-63 to 1967-69	1967-69 to 1973-75	1961-63 to 1973-75
Broad Beans	1,603	1,718	2,001	1.2	2.6	1.9
Peas	1.591	1,600	1,092	0.1	-6.6	-3.1
Chick Peas	503	482	522	-0.7	1.3	0.3
Beans	377	381	811	0.2	13.4	6.6
Onions	4,167	5,505	7,452	4.8	5.2	5.0
Carrots	7,000[a]	7,833	7,031	2.3	-1.8	0.0
Lettuce	n.a.	6,000[b]	6,384	n.a.	1.2	n.a.
Cabbage	n.a.	6,000[b]	5,929	n.a.	-0.2	n.a.
Garlic	2,471	2,451	5,928	-0.1	15.9	7.6
Hot Peppers	n.a.	2,000[b]	2,008	n.a.	0.1	n.a.
Sugarcane	39,128	38,195	44,511	-0.4	2.6	1.1
Cotton fiber	473	592	485	3.8	-3.4	0.2
Coffee	690	803	841	2.6	0.7	1.7
Cacao	327	359	441	1.6	3.5	2.5
Tea	n.a.	1,567	1,967	n.a.	3.9	n.a.
Cottonseed	760	1,024	1,027	5.1	0.0	2.5
Peanuts	1,225	1,527	1,470	3.7	-0.6	1.5
Soybeans	n.a.	1,129	1,449	n.a.	4.2	n.a.
Barley (<u>berza</u>)	2,868	3,333	3,503	2.5	0.8	1.7
Alfalfa	15,667	16,833	23,162	1.2	5.5	3.3
Coca	1,600[a]	1,620	1,358	0.2	-3.0	-1.5
Tobacco	689	933	1,267	5.2	5.2	5.2

Source: Bolivia, Ministerio de Asuntos Campesinos y Agropecuarios (MACA), unpublished data.

[a] 1963.

[b] 1969.

n.a. Not available.

1960s, are due to increases in land under cultivation: Table 3 shows that the agricultural frontier expanded by 2.2 percent annually from 1961-63 to 1973-75. 2/

Table 4 provides some data on the livestock sub-sector. The average carcass weight of slaughtered cattle is above the median for South America (plus Mexico and Guatemala) but below the weighted regional mean. Sheep and lamb weights are 10-15 percent below the regional average, reflecting the poor quality of the pastures in the Altiplano and Valles. Swine weights are less than half the regional mean. Milk production per cow, however, exceeds the Latin American average by about 20 percent.

In this paper we shall survey the literature on agricultural technology in Bolivia and attempt to identify the conditions under which new and more efficient technologies have been or could be adopted in that country. As a first step, we shall review the technological limitations imposed on agriculture by soils, topography, climate, and water resources. This will be followed by a general discussion of agricultural technology and closer looks at the use of specific modern inputs and irrigation water. 3/ Government policies affecting the adoption of new technology will also be considered. We shall then be in a position to draw some conclusions about why technological change has been successful in some

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2/ Only 12 percent of agricultural output in 1970-72 was attributed to changes in the factor mix that had occurred since 1963-65 (Wennergren and Whitaker 1975: 121-123).

3/ We had originally planned to include another section focusing on specific crops and livestock, particularly those on which research and extension work has concentrated, and examining production costs by level of technology. Unfortunately, time constraints precluded such an analysis. This information is available, however, and could be examined in the future if this is deemed desirable.

TABLE 3

LAND UNDER CULTIVATION, 1961-1975
(hectares)

	Area Cultivated		
	1961-63	1967-69	1973-75
Wheat	85,383	65,500	73,097
Rice (milled)	26,335	41,437	58,140
Corn	212,863	215,600	221,637
Barley	88,595	82,568	107,793
Oats	6,810	6,291	4,017
Quinua	22,300	13,533	17,377
Cañahua	1,000[a]	3,000[c]	1,123
Rye	1,000[a]	1,000	1,133
Potatoes	109,707	94,278	120,498
Yucca	12,718	16,223	20,483
Sweet Potatoes	1,277	1,277	2,077
Ocas	8,000[b]	9,000	10,387
Papalizas	5,000[b]	5,067	5,637
Oranges	2,476	3,020	3,883
Tangerines	962	1,030	1,190
Lemons	1,211	1,421	1,980
Plantains	2,524	5,611	8,225
Bananas	5,274	8,001	10,753
Peaches	6,055	5,608	5,783
Grapes	1,307	1,843	2,847
Pears	1,150	1,090	1,113
Apples	3,280	3,260	3,360
Plums	250[a]	250[a]	253
Cactus Fruit	275[a]	400[c]	520
Cherries	200[a]	215	193
Quinces	85[a]	130[a]	207
Figs	85[a]	150[c]	207
Strawberries	70[a]	70[c]	70
Pineapples	310	367	557
Avocados	523	613	777
Chirimoyas	120[a]	200[c]	333
Mangoes	200[a]	250[c]	315
Papayas	1,700[a]	2,100[c]	2,600
Corn (choclo)	25,438	39,253	32,817
Tomatoes	4,195	5,554	5,188

TABLE 3

(continued)

	Area Cultivated		
	1961-63	1967-69	1973-75
Broad Beans	21,133	19,067	26,167
Peas	10,621	11,284	12,717
Chick Peas	900	1,037	1,017
Beans	8,183	8,657	2,650
Onions	6,339	6,404	5,990
Carrots	1,600[b]	2,000	2,603
Lettuce	1,270[a]	1,500[c]	1,770
Cabbage	1,850[a]	2,000[c]	2,160
Garlic	273	367	603
Hot Peppers	1,985	2,000[c]	2,017
Sugarcane	18,271	32,590	48,632
Cotton Fiber	2,325	6,016	58,913
Coffee	5,990	11,525	16,700
Cacao	3,371	3,532	4,637
Tea	0[a]	113	303
Cottonseed	d	d	d
Peanuts	4,355	5,914	9,400
Soybeans	0[a]	514	5,740
Barley (berza)	33,937	43,111	56,330
Alfalfa	8,000	12,133	13,883
Coca	3,000[b]	3,060	7,837
Tobacco	1,243	1,083	2,105
TOTAL	773,324	809,111	1,003,904

Source: Bolivia, Ministerio de Asuntos Campesinos y Agropecuarios (MACA), unpublished data.

[a] Author's extrapolation or other estimate.

[b] 1963.

[c] 1969.

[d] Same land as for cotton fiber.

n.a. Not available.

TABLE 4

LIVESTOCK YIELDS,
12 LATIN AMERICAN COUNTRIES AND THE UNITED STATES, 1973-75

	Carcass Weight per Slaughtered Animal			Whole Fresh Cow's Milk (Kg./animal)
	Beef and Veal	Pork	Mutton and Lamb	
Argentina	219	83	18	1,634
BOLIVIA	180	30	14	1,200
Brazil	195	67	16	758
Chile	265	65	17	1,272
Colombia	175	61	13	758
Ecuador	165	50	13	1,316
Guatemala	173	45	15	909
Mexico	167	64	17	1,154
Paraguay	170	60	15	233
Peru	120	60	11	1,311
Uruguay	218	83	14	1,342
Venezuela	176	64	18	1,031
U.S.	265	73	23	4,652

Source: FAO, Production Yearbook 1975.

regions and for some commodities, and not for others. In addition, we shall be able to examine the technological limitations imposed by smallholdings (minifundios), particularly where these holdings are fragmented. Finally, suggestions will be made for future research on technological change in Bolivian agriculture.

SOILS, TOPOGRAPHY, CLIMATE, AND WATER RESOURCES 4/

Any discussion of agricultural technology in Bolivia must take into account the soils, topography, climate, and water resources in the country's various agricultural regions. These factors place restrictions on the types of crops that can be grown, the number of crops per year, and the range of available technologies that can be employed. Detailed environmental descriptions are beyond both the scope of this paper and this writer's competence; but a brief review is in order after we note that the quality of the data available is sometimes less than desirable for making agricultural investment decisions. 5/

The Altiplano

In the Altiplano, frost, hail, water shortages, and alkaline soils limit crop alternatives to the hardier varieties of potatoes, barley,

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4/ This section draws on USAID/Bolivia (1974: 42-49) and Wennergren and Whitaker (1975: 82-89), as well as the other sources cited below.

5/ A national soils map is available (Cochrane et al. 1973), but detailed studies are still lacking for many specific sites. The lack of good hydrologic data has delayed the development of many water resources projects (Paredes Arce and Klohn 1973).

quinua, broad beans, and alfalfa (Ballard et al. 1966: 72). A variety of natural pasture grasses could also thrive if rangelands were properly managed. None of these crops, it should be noted, has any significant export potential.

In the North Altiplano, where Lake Titicaca exercises a moderating influence, the mean temperature is 53°F. 6/ Hillsides are terraced to conserve precipitation, which averages only 25.6 inches annually. "Unfortunately, the high erodability of the steep slopes requires considerable refinement of this practice or revegetation with a perennial plant cover if viable plots are to be maintained" (Wennergren and Whitaker 1975: 84-86). Soil erosion problems apparently began with the arrival of the Spaniards, who introduced sheep and cattle but neglected pastures, forage crops, and control of the number of animals. Further problems were created in the early 20th century, when much of the forest cover was stripped for use in railway construction (Wiggins 1976: 7-8). Constant cultivation has aggravated soil depletion on many plots, which are then put in fallow for 5-10 years (Métraux 1959: 236).

If properly managed, however, soils in the North Altiplano may not be a seriously limiting factor for agricultural development: they are moderately deep, medium to heavy, and rich in phosporous, though lacking in potassium and organic material. According to one U.N. study, salinity is not a major problem provided that irrigation systems are properly managed. However, another U.N. study concluded that 45 percent of the

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6/ As distance from the lake increases, however, frosts are more frequent and rainfall is less (Wiggins 1976: 4).

soils in the Viacha zone were not suitable for irrigation (Wiggins 1976: 5). Irrigation possibilities are limited by the existence of only one major stream, the Desaguadero River, though a U.N. team has identified 60 groundwater sites which could be utilized (Wiggins 1976: 4-5).

In the Central Altiplano, the mean temperature falls to 50°F, annual rainfall averages only 13.8 inches, and high winds add to the climatic problems farmers must face. Soils are more alkaline, and there is even less surface water than in the North Altiplano. Livestock are more important than crops, and overgrazing has resulted in soil erosion.

The Southern Altiplano is even colder and drier, with a mean temperature of 47°F and an average annual precipitation of 9.8 inches. Frosts may occur in any month, and high winds and hail also threaten crops. There is little land suited for irrigated crop production, and livestock activities predominate. As in the rest of the Altiplano, overgrazing has resulted in soil erosion. The presence of several large saltpans also affects the fertility of adjacent land.

In summary, Altiplano farming is plagued not only by productivity limitations, but also by very high risks. "Irregularity of rainfall and freezing temperatures, even around Lake Titicaca, are said to result in the almost total loss of a crop on the average of once every five years and a loss so appreciable during three years that only a single crop during the five-year period is considered a really good one" (Weil 1973: 54). If, as has been suggested (Rice 1974: 326), risk may be an even greater deterrent to the adoption of new practices than profitability, the prospects for technological change in Altiplano farming are poor unless the risks imposed by nature can somehow be covered. Crop insurance, of course, comes to mind; but given the subsistence orientation of many Altiplano farmers and the lack of skills needed to manage such a relatively sophisticated scheme, it is doubtful that it could be implemented in the foreseeable future. If there are no viable alternatives, adoption of modern inputs in the Altiplano may be limited in the foreseeable future to a small number of communities in areas whose location affords some protection against the elements. 7/

The Valles

Conditions in the Valles are more favorable for crop production. The mean temperature ranges from 63° to 72°F, and annual rainfall varies from 15.7 to 47.2 inches. The growing season is usually fairly short (November-March), permitting only one crop per year, but the valley regions are far from homogeneous and double- or even triple-cropping of garden crops is possible in some areas. The probability of frost is low, except on the mountain ridges and plateau areas (the puna). Generally, soils are old and depleted, and erosion is a serious problem on the steep hillsides; water, however, is more readily available than on the Altiplano.

The differences in agricultural conditions within the Valles are illustrated in two recent studies by Joseph Dorsey, one of the Upper Cochabamba Valley (1975a: 2-3) and one of the Lower Cochabamba Valley (1976b: 1-2). In the Upper Valley community of Toralapa, the altitude (9,700 feet) limits the growing season to one crop, even where irrigation

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7/ At least one study of the Altiplano (Rodríguez Pastor 1969) specifically attributes the failure to use fertilizers to the high risk of total crop loss. (The community studied is Llica, in the Southern Altiplano Zone of Potosí Department.) Royden (1972: 62) makes the same argument for campesinos generally.

water is available. Frosts frequently occur in July or August but can occur at any other time. As on the Altiplano, high winds and hail also threaten production. Potatoes are by far the most important crop and are grown on both dry and (unmechanized) irrigated land. Corn, peas, and broad beans are also grown on irrigated land, and peas, broad beans, ocas, papalizas, wheat, barley, and rye grass on dry land. Note that the variety of crops is greater than on the Altiplano.

In the Lower Valley, conditions are even better. Relatively high campesino incomes are attributed to "fertile soil, replenished periodically by alluvion, and the plentiful supply of water for irrigation in most of the region" (Dorsey 19756: 1). Two crops a year are the norm for carrots, onions, and other garden crops, and sometimes 3 crops may be harvested. Other irrigated land is used for alfalfa, dairy cattle, and sweet corn, while dry land is used for corn, wheat, and other grains. A variety of temperate fruits is also grown in the area.

The smallness of some of the valley areas limits farm size and thus the possibilities for large-scale mechanized farming. But other areas, such as Mojocoya in Chuquisaca, could support this type of extensive farming.

The Yungas

Large-scale mechanization is not possible in the steeply-sloped Yungas, the semi-tropical and tropical valleys on the eastern side of the Cordillera Real in La Paz and Cochabamba Departments. Rainfall in this area averages 41.3 inches, there is no pronounced dry season, and multiple cropping is possible. The major crops are coffee, coca, citrus fruits, and bananas. Soils are young and often fertile when initially worked, but they deteriorate rapidly because little attention is paid to soil conservation. Declining yields generally force farmers to take land out of production after 10-15 years (Heath, Erasmus, and Buechler 1969: 195; Jorgenson 1972; Nelson 1973: 160-161).

The Chapare colonization area in Cochabamba ia sometimes considered as part of the Yungas, though much of the land is flat and lies at an attitude of less than 1,000 feet. Rainfall is generally heavy (80-210 inches), and temperatures average about 77°F. Some of the land is well drained, has young alluvial soils of moderate-to-high fertility, and has been described as excellent for farming (Griffin 1961). Elsewhere, however, soils are of lower fertility and the lack of drainage often makes cultivation impossible. General soil surveys, which cover about half the area, show that 7 percent of the land is suitable for annual crops and 16 percent for permanent crops. More than half can be devoted to grazing, and the remainder has good forestry potential (Bolivia, INC, and OAS 1975: 17-22). Detailed studies of specific locales, however, are lacking, and this deficiency, combined with poor technical assistance, has resulted in unwise crop choices in many settlements.

The Oriente

The eastern lowlands may be divided into 5 geographic regions (see Wennergren and Whitaker 1975: 82-89), only one of which is important for crop production. The northernmost region is a sparsely populated Amazonian tropical rain forest, where the gathering of Brazil nuts and a modest amount of rubber production (wild and plantation) are the only important commercial activities. The raising of beef cattle is the principal activity in 3 regions: (1) the Beni Plains, where soils are fairly good but rainfall is heavy (71 inches) and flooding is a problem because of poor drainage; 8/ (2) the Brazilian Shield, with a mean temperature is 77°F and an average precipitation of about 37 inches, but with old, acidic soils almost completely leached of nutrients; and (3) the Chaco, a hot (82°F) semi-arid region with a mean precipitation of 30 inches but a prolonged dry season of 7-8 months.

The remaining region, centered around the city of Santa Cruz, is the smallest in size but by far the most important as a producer of agricultural products. According to one report: "Due to the quality and magnitude of the soils and water resources, the eastern plains of Bolivia should be considered as one of the world's outstanding potentials for agricultural development" (Bolivian-USU-USAID Study Team 1972: 2). Soils generally are recent flood-plain alluvial deposits, with textures ranging from sands to clays. Much of the land is well-suited to mechanized farming, which now is dominant in cotton production and important in rice and sugarcane. These three crops, along with corn, are the most important in the region. Other crops grown, some of which have considerable growth potential, include soybeans, peanuts, wheat, potatoes, pineapples, and tomatoes. Beef and dairy cattle and poultry production are also important activities.

8/ Interestingly, prior to the Spanish conquest the inhabitants of this area (the Mojos tribes) constructed artificial mounds, causeways and canals and grew crops on the fields they drained. The Mojos plains probably once supported several times the present population (Denevan 1963).

The best land in the Santa Cruz region is covered with subtropical forest and must be cleared. Both mechanized and slash-and-burn clearing have been employed, and each can do considerable damage to the soil if not done with care. Temperatures in the region average 77°F and rainfall averages 45 inches. The risk of crop loss during the summer (December-May) is low, even without irrigation (though supplemental water will increase yields). During the winter, however, yields on nonirrigated land are poor. Irrigation possibilities seem promising, particularly for cotton, sugarcane, soybeans, and wheat (Bolivia, MINECON, and Deutsche Projekt Union 1965; Bolivia-USU Study Team 1972); but development of the irrigation potential has been slow, and lack of water control can cause serious flooding in some areas. The subtropical climate creates serious disease and pest control problems, and wind erosion is an added difficulty in the southern part of the area.

Since soil conditions vary within the region, the failure to conduct detailed soil studies prior to the opening up of new lands can result in costly mistakes. In the Yapacaní colonization area, in the northwest part of the region, some land thought suitable for intensive farming on 10-15-ha. plots turned out to be fit only for cattle on 50-ha. plots; and part of the area was too susceptible to flooding to be farmed (Bolivia, Comisión Mixta, 1966; Nelson 1973: 95). Even the better soils are subject to rapid depletion without soil conservation practices, which are employed very little in the region. In view of the high cost of chemical fertilizers, it has been suggested that the best way to maintain or improve soil fertility would be to employ crop rotations and green manures (C.OO.PP. 1975).

TECHNOLOGICAL CHARACTERISTICS: AN OVERVIEW

Factor proportions vary considerably among Bolivia's several geographic regions. In general, labor in the Altiplano and Valles is abundant relative to land and capital, while in the Oriente land is the abundant resource. The highland regions have a large number of minifundios with less than 5 hectares, 9/ while in the Oriente a "small" farm averages about 25 hectares.

The agrarian reform law of 1953 by no means eliminated large farms. In fact, it allowed highly mechanized farms employing wage labor and using modern techniques to be classified as "agricultural enterprises" and thus remain intact. In practice, many hacienda owners not meeting these requirements were able to obtain this classification, and the same has been true for individuals seeking to establish new farm units in the Oriente. As a result, existing land tenure patterns permit the introduction of highly mechanized technologies by some farmers in all areas where this type of farming is technically feasible and economically justifiable. Small farmers can employ highly mechanized technology only by joining together in production cooperatives, which have had a notable lack of success in Bolivia. 10/

9/ It is difficult to define a minifundio in terms of farm size, since land quality must also be considered. Perhaps the best definition is that of the Comité Interamericano de Desarrollo Agrícola (CIDA), which classifies as "subfamily units" those farms which are too small to provide full and productive employment for two people under conditions of typical incomes, markets, and levels of technology prevailing in each region.

10/ This issue will be discussed later in this paper.

The Altiplano

Anthropologist Alfred Métraux (1959: 236) summarized the prevailing technology in the highlands in the late 1950s as follows:

> Manuring is only used for potatoes and even then quite inadequately. The Indians use the rotation system but many of them own so little land that they find it difficult, if not impossible, to give it a rest. They exploit it up to the point where it becomes totally unproductive and are then forced to leave it fallow for four, five, or even ten years and find other resources in the mean time. There is no selection of seeds or cuttings and, what is worse, malformed grains and underdeveloped tubercules are used for sowing. The Indians are powerless against the parasites that attack their crops and, as everyone knows, their implements are rudimentary.

Given the implements used, land preparation was deficient. 11/ Fungicides, pesticides, and other chemicals were virtually unknown, and crop protection relied instead on what one writer termed "a series of absurd magico-religious practices" (Urquidi 1970: 158). 12/

Though some farmers have begun to use chemical fertilizers, improved seeds, and introduced varieties of pasture grasses, the primitive conditions described above continue to prevail in many communities. The practice of leaving land fallow for 3-10 years is difficult to explain. While some fallow period seems desirable for rebuilding fertility and

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11/ Even now, there is often one plowing, 4-6 inches deep, with handmade wooden plows (USAID/Bolivia 1974: 98).

12/ See also Coronel (1973) and Patch (1971).

controlling soil-borne diseases affecting potato production, overgrazing of sheep, llamas, and alpacas on land in fallow results in soil erosion. This is aggravated by a lack of pasture rotation and by the practice of burning, which tends to result in the survival only of the relatively inferior native grasses (Posnansky 1971). It is not clear why legumes for green manure have not been introduced into the rotation pattern; but since legume rotation experiments on the Altiplano began only in 1974 (Wood 1975: 8), it would appear that the benefits are still uncertain. Wood suggests another possible reason for the non-use of legumes: the inability of oxen to plow additional land; but he dismisses it (too easily) as "not a valid reason to continue a program of subsistence farming in the presence of modern technology and local need for food" (p. 4).

The practice of overgrazing is also difficult to understand unless one attaches security and/or social values to the keeping of large numbers of animals. Wood (1975a: 7) maintains that "if the practice of replacing all of the low-grade native rams with good improved rams were combined with a selection and culling program, the income from meat and wool of improved flocks would be increased from only one half the number of animals presently being maintained." The cost to the farmer of adopting these practices, however, is not made clear, and more research is needed to determine whether existing grazing practices constitute rational or irrational economic behavior in the light of farmers' values and access to credit for adopting new practices.

Whitaker and Wennergren (1976) have recently argued that overgrazing is rational <u>individual</u> behavior where rangelands are common property resources, as is usually the case in the Altiplano (and Valles). Individuals, it is argued, will try to capture economic rents by increasing grazing intensity up to the point where marginal private cost equals the average product of grazing activity. This may push grazing intensity beyond its renewable limit, causing forage production to decline in subsequent periods and creating external costs in the form of rainwater runoff and erosion. 13/

Common-property rangelands with uncontrolled access may have been established only with the Agrarian Reform Law of 1953 (Whitaker and Wennergren 1976: 11-17). 14/ Why this was done and why there seem to have been no pressures for controlled access to communal rangelands is not clear, particularly since cultivated communal lands are subject to such controls. Moreover, it is not made clear how grazing rights were, and currently are, determined in the free communities which prior to 1952 accounted for perhaps one-third of the rural population in the Altiplano. Decision-making in grazing activity clearly deserves more attention, not just from economists but also from anthropologists.

Given traditional crop and livestock practices, it is useful to ask if economies of scale are present in Altiplano agriculture. Burke (1967), in examining the effects on production of the breakup of large haciendas in the North Altiplano after 1972, found no evidence of produc-

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13/ See also LeBaron (1974) and Parker (1975). The effects of runoff on the Altiplano extend to the Valles.

14/ Access to public rangelands was controlled by the state under the Inca Empire, and by private property rights during the Colonial and Republican periods (to 1952).

tion economies of size or financial economies of scale. Pre-reform haciendas, he argues, were little more than agglomerations of small campesino farms.

When technological change and thus alternative levels of technology are introduced into the picture, size of farm can be an important factor, as shown in Pou's (1972: 170-260) linear programming model of a cooperative-production zone in the Central Altiplano. Pou obtains optimal solutions for various combinations of cooperative size (125 to 1,650 members), farm size (hectares per member), and degree of mechanization. For each of 6 cooperative sizes, the optimal solution involved full mechanization, with the "optimal among optimals" being a cooperative of 625 members with 8,125 hectares (13 has./person). 15/ When hectares per member are also considered, the optimal solutions involved partial mechanization for the smaller farm sizes. Above 7 hectares per member, only minor income gains could be achieved; 16/ but below 7 hectares, the optimal solutions involved significantly lower incomes.

15/ Because the model is linear and input-output coefficients are the same for all cooperative sizes, maximum income per person could be expected to be equal for the 6 cooperative sizes. The slight differences (less than 1 percent) are due to the indivisibility of certain types of farm machinery (Pou 1972: 187).

16/ Seasonal labor shortages become a limiting factor. Also, the average productivity of land declines as mechanization increases, since the additional land brought under cultivation is of progressively poorer quality.

The Valles

At least in the Northern Valleys, the level of technology is higher than on the Altiplano. After 1952 campesinos in the Lower Cochabamba Valley switched from corn and potatoes to garden crops and began to use greater amounts of irrigation water. This required more attention to crop rotation and soil conservation. More organic fertilizer was used, and some chemical fertilizers began to be purchased, though in relatively small amounts. Use of machinery declined following the agrarian reform but then increased sharply, on a rental basis, between 1967 and 1973. The quality of tools and implements improved, with 85 percent of those interviewed in 3 communities owning steel plows by 1967 (Camacho Saa 1970: 191-192; Dorsey 1975b: 48-52).

In the Upper Valley, where potatoes have continued to be the dominant crop since 1952, use of organic fertilizer seems to have increased, and some farmers are purchasing chemical fertilizers and insecticides. But the amount of fertilizer used is relatively small, even for organic fertilizer. In one community studied by Peinado Sotomayor in 1967 and Dorsey in 1973, use of steel plows and tractors for land preparation was much less common than in the Lower Valley (Peinado Sotomayor 1971; Dorsey 1975a: 44-53).

The Cochabamba Valleys are the most densely populated rural areas in Bolivia, and increased production there probably depends more on higher yields than in other areas. Even so, more land could be brought into production if irrigation facilities were expanded. One writer suggests that irrigation can increase the demand for labor by permitting more intensive production (Carlos Saavedra A., in CODEX 1976: Vol. IV, pp. 316-326). On the other hand, the Corporación de Desarrollo de Cochabamba has suggested that an expansion of irrigation facilities be combined in the long run with a consolidation of small plots into larger production units and a transfer of surplus labor to other sectors of the economy (CORDECO 1975a: 184). Given the strength of the campesino organizations in Cochabamba and the lack of success of production cooperatives, this strategy would be quite difficult to implement.

Livestock technology in the Valles, as on the Altiplano, is primitive. Overgrazing of sheep is again a problem. Dairy cattle and poultry are particularly important in the Cochabamba Valleys, 17/ but there seem to have been few improvements in technology since 1952.

The Oriente

Modern methods of agricultural production are used more widely in Santa Cruz than in any other region in Bolivia. Some large farmers began to mechanize in the mid-1950s in order to seek classification as "agricultural enterprises," thus allowing them to retain large tracts of land under the provisions of the agrarian reform law of 1952. However, the law was applied unevenly, and this deterred other large farmers from making any significant investments until, by the early 1960s, their tenure security had generally been resolved. Those who did mechanize found it inexpensive, since machinery could be rented at low, subsidized rates from a pool established with U.S. assistance (Heath, in Heath, Erasmus, and Buechler 1969: 289-295).

17/ Two-thirds of the milk sold in urban areas in 1972 originated in Cochabamba, and the Department accounts for an estimated 40-45 percent of poultry and egg production (Lucio Antezana and Jorge Meave in CODEX 1976: Vol. IV, pp. 329-334).

Land clearing by unspecialized bulldozers was much more rapid than hand clearing, but the loss of the loamy topsoil exposed the sandy subsoils to leaching from heavy rains and wind erosion. In late 1956, farmers began to revert to hand clearing, a process that was accelerated when machinery rental rates rose sharply the following year to reflect scarcity values more accurately (Heath, in Heath, Erasmus, and Buechler 1969: 295).

Wennergren and Whitaker (1975: 266-267) have identified three levels of technology currently prevailing in the colonization areas:

(1) Most spontaneous colonists employ the slash-and-burn method of land clearing, which generally restricts production to only a few hectares. Initially, they tend to plant dryland rice, which gives them a quick cash return. After two years, however, yields begin to drop because of weed competition and a loss of soil nutrients. Colonists then tend to clear new land, since the alternatives--fertilizer and weed control for rice production, or a switch to permanent crops (sugarcane) or pastures--require credit, and sometimes technical assistance, to which they have little access.

(2) In the directed colonies, where land area is generally limited to 15-20 hectares, not all of it suitable for crop production, chemical inputs must be used to keep the land suitable for production. About half the colonists have adopted these inputs, while most of the others move to nearby spontaneously colonized areas and continue employing the slash-and-burn technology.

(3) Technology is more advanced in the foreign colonies, where tractors, draft animals or hired laborers are used to permit families to cultivate more land. The Japanese colonists also established their own experiment station, which has developed yield-increasing innovations.

Some (but not all) of the large commercial farmers operate with even more advanced levels of technology, using machinery for planting and harvesting, improved seeds, large quantities of chemical inputs, and irrigation. As more commerical farmers adopt these techniques, the income gap between them and the colonists employing slash-and-burn techniques tends to grow and to become more apparent, thus threatening to create what the Comité Departamental de Obras Públicas de Santa Cruz has called a "serious social problem" (C.OO.PP. 1975: 31).

USE OF MODERN INPUTS AND IRRIGATION

Chemical Fertilizers

Use of chemical fertilizers in Bolivia is lower than in any other country in South America. 18/ Consumption (all of which is imported) rose fairly rapidly from 1962 to 1972 (see Table 5), but the increase was erratic: 3 alternative methods of calculating growth rates yielded figures ranging from 4.0 to 12.4 percent. 19/ The peak years of fertilizer use

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18/ Per capita consumption in 1970 was only 9 percent of the continent-wide average, and consumption per hectare of arable land was only 7 percent of the average (USAID/Bolivia 1974: 101).

19/ The compound annual growth rate from 1962 to 1972 was 12.4 percent; using 3-year averages for the beginning and terminal periods, it was 8.1 percent. A trend line fitted to the data ($\log F_t = a + bt$, where F = fertilizer imports and t = time) indicated a growth rate of 4.0 percent. These figures are actually somewhat low, since the 1972 data in Table 5 are incomplete.

TABLE 5

VOLUME OF FERTILIZER IMPORTS, 1962-1972
(metric tons)

Year	Type of Fertilizer					
	Phosphate	Nitrogen	Potassium	Unspecified	Organic	TOTAL
1962	825.8	84.8	4.0	6.8	19.5	941.0
1963	892.0	1,051.9	28.5	12.7	52.0	2,037.1
1964	915.1	1,669.6	a	381.9	-	2,966.6
1965	664.4	2,714.1	0.1	315.9	0.6	3,694.5
1966	2,478.1	1,351.1	0.5	0.1	30.0	3,861.1
1967	2,581.9	5,275.6	-	-	16.1	7,873.5
1968	4,124.8	1,818.3	69.8	109.2	-	6,122.1
1969	3,282.2	514.3	-	1.8	-	3,818.3
1970	2,119.6	903.5	-	2.2	118.8	3,144.2
1971	3,536.5	772.7	-	445.2	163.0	4,917.4
1972[b]	1,173.9	1,221.3	-	627.7	-	3,024.8

Source: Bolivia, MACA (1974: 348).

[a] Less than 0.05 MT.

[b] Incomplete.

were in 1967-68, after which there was a rather sharp decline. The lower figures for 1969-72 cannot be attributed to international price trends, since price increases were rather modest during this period; and only the 1972 figure is affected by the devaluation of the Bolivian peso from 12 to 20 to the U.S. dollar.

The chemical fertilizers imported by Bolivia are used mainly for potatoes. According to a study conducted by the state petroleum organization (YPFB), 90 percent of the chemical fertilizers sold in the 1968-69 crop year were used for potato production (Russel et al. 1970: 39). Even so, a TVA study team estimated that chemical fertilizers were used on only 15,000 of the 88,000 hectares devoted to potatoes in the latter half of the 1960s (Russel et al. 1970: 45). 20/

If the fertilizer import data in Table 5 are compared with trends in potato yields (Table 2), the relationships are difficult to explain. The rapid increase in fertilizer imports through 1967-68 seems to coincide roughly with the significant productivity gains in potatoes (4.3 percent annually) achieved between 1961-63 and 1967-69. However, the annual yield figures tell a different story: namely, that there was very little increase in potato yields until 1968, when they jumped suddenly by 35 percent. Yields continued to increase through 1971, despite the sharp

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20/ More recent data show an average of 102,000 hectares in potatoes during this period (MACA, unpublished data).

decline in fertilizer imports. 21/ In 1972, however, yields fell by 13 percent, resuming a modest upward trend in 1973 but remaining below the peak levels reported for 1968-71.

There are several possible explanations for these puzzling relationships. A data problem is very likely the most important: the high yield figures in 1968-71 coincide with a reported decline in area cultivated during the same period. 22/ While it is possible that marginal potato lands were were taken out of production in 1968 and returned in 1972, this is doubtful. Either the area figures or the total production figures for 1968-71 are probably inconsistent with the rest of the series.

In any event, scattered information from other sources suggests that potato yields have in fact increased since the early 1960s. How much is attributable to chemical fertilizers, though, is difficult to say, since there apparently has been an increase in the use of organic fertilizers as well. Moreover, new seed varieties have been employed by almost 30 percent of potato producers (Ossio S. 1975), and this also accounts for part of the increase in yields.

21/ It is conceivable, but unlikely, that heavy fertilizer imports in 1967-68 represented speculative stockpiling, and that much of this fertilizer was actually used in 1969-71. But it is questionable that Bolivia had appropriate storage facilities for fertilizer. If heavy fertilizer use was concentrated in 1967-68, as seems more likely, the residual benefits in 1969-71 would have been minor.

22/ Reported land under cultivation in 1968-71 was 15 percent lower than the 1961-67 average and 21 percent less than the average for 1972-75.

Factors contributing to low fertilizer use in Bolivia include (1) high prices, a reflection of low volume and high transport costs; 23/ (2) a lack of credit, either from banks or from commerical houses; (3) producer price controls on certain crops, including wheat, rice, and sugarcane; 24/ (4) the availability of land in the colonization areas, making shifting agriculture an attractive alternative to maintaining soil fertility with fertilizers; (5) lack of knowledge of efficient fertilizer practices among farmers, who often use less than desirable amounts, and (6) lack of knowledge on the part of extension agents. 25/

The TVA study (Russel et al. 1970) concluded that construction of a nitrogen complex at Santa Cruz, with a capacity of 60 MT/day, would be feasible only if enough firm export contracts for ammonium nitrate were obtained to permit the plant to operate at two-thirds of capacity. Domestic demand was not expected to reach that level until 1977, and at lower levels of plant utilization production costs were not competitive

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23/ The price paid by farmers for urea in La Paz ranged from US$ 0.35 to $0.48/kg. in 1969. In the more remote rural areas farmers paid several times as much (Russel et al. 1970: 27). The comparable price in the U.S. was about $0.20, and in Mexico, Peru, and Venezuela, $0.20-$0.25. Much of the fertilizer imported into Bolivia at this time was bagged; bulk imports would have been 15-20 percent cheaper (Russel et al. 1970: 61-62).

24/ Price controls at the retail level were instituted in 1963 for other basic commodities, but they have not been very effective (Wennergren and Whitaker 1975: 95).

25/ Of the 73 Extension Service agents working in the late 1960s, only 15 percent were graduates of agricultural colleges. Most of the remainder had little or no training in the use of fertilizer (Russel et al. 1970: 39).

(pp. 3, 63). 26/ The study recommended against construction of a proposed superphosphate plant, since even at full capacity costs would be 50-150 percent higher than the price of imports.

According to the Ministry of Agriculture (Bolivia, MACA, 1976: 124), an "ideal rational and scientific" use of land would have required 179,207 MT of fertilizer in 1974, at a cost of $93.4 million. 27/ Table 6 shows the "ideal" use of chemical fertilizers by crop. More than one-fourth of the ideal fertilizer requirements, according to these estimates, would be for corn; 18 percent would be for potatoes. (Recommended applications, of course, differ from one locale to another; the figures in Table 6 are presumably average or modal recommendations.)

Chemical fertilizers are particularly scarce in the Altiplano, though they are sometimes used together with new seeds. A 1974 survey in the Northern Altiplano Province of Ingavi, conducted by the Corporación Regional de Desarrollo de La Paz, found that none of the farmers interviewed used chemical fertilizers; 94 percent used organic fertilizer for

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26/ The comparative costs to distributors in Cochabamba, for example, were estimated to be as follows (US$ per MT of N):

Cost of Imports	Domestic Production: Capacity Utilization	Domestic Production: Cost	Advantage for Domestic Production
237.86	1/3	428.27	- 187.80
	2/3	267.30	- 26.83
	Full	213.64	26.83

27/ Presumably, this is the estimated cost to importers.

TABLE 6

"IDEAL" FERTILIZER REQUIREMENTS FOR MAJOR CROPS, 1974[a]

Crop	Formula	Kg./ha. Ammonium Phosphate 18-46-0	Kg./ha. Urea 46%	Area Cultivated (Has.)	Fertilizer Require-ments (MT)	Fertilizer Cost per Hectare ($b.)[b]	Fertilizer Cost per Crop ($b. 1000)
Wheat	40-40-00	87	53	73,570	12,875	1,501	5,521
Barley	40-40-00	87	53	107,880	18,771	1,501	8,096
Corn	60-60-00	130	80	219,480	46,091	2,252	24,713
Rice	40-40-40	87	53	45,370[c]	6,352	1,502	3,407
Quinua	40-00-00	-	87	16,890	1,469	922	789
Potatoes	80-80-00	174	106	168,090[c]	33,065	3,003	17,731
Corn-*Choclo*	60-60-00	130	80	32,960	6,922	3,252	3,711
Vegetables	60-60-60	130	80	64,580	13,562	2,252	7,263
Fruits	40-60-00	130	36	47,370	7,769	1,765	4,180
Peanuts	40-40-20	87	53	9,600	1,344	1,502	721
Soybeans	40-60-00	130	36	5,800	951	1,765	512
Cotton	40-40-00	87	53	55,000	7,700	1,502	4,131
Coffee	40-60-00	130	36	16,700	2,739	1,765	1,474
Barley grass	60-40-00	87	96	55,990	9,798	1,957	5,479
Cacao	80-80-40	174	106	2,350[c]	658	3,003	353
Sugarcane	60-60-00	130	80	46,385	9,141	2,252	5,223

Source: MACA (1976: 125).

[a] Does not include potassium.

[b] Cost per kg.: ammonium phosphate, $b. 10.80; urea, $b. 10.67.

[c] More recent estimates of land under cultivation in 1974 are: rice, 53,270 has.; potatoes, 118,205 has.; and cacao, 4,615 has. (MACA, unpublished data).

potatoes, but practically none did so for other crops. A 1975 survey in the Northern Altiplano by the Ministry of Agriculture found that 99 percent of those surveyed used an average of 50 qq. of organic fertilizer per hectare; 46 percent also used chemical fertilizers, but they were always improperly applied. 28/ Since soil conditions have been found to vary considerably in the Altiplano, even within a small area, it is important that fertilizer applications in a particular locale be preceded by soil studies. 29/

Although the use of improved seeds, fertilizers, and insecticides appears to be generally profitable in potato production, one has to be concerned about the limits to the increased use of fertilizer for this crop. Given the low (or negative?) income elasticity of demand for potatoes, and their limited export possibilities, a significant increase in production can be expected to lead to falling prices, thus making chemical fertilizers less attractive and forcing the more inefficient farmers to consider other crops.

Another Altiplano activity for which chemical fertilizers have been recommended is pasture legumes. FAO advisor Percival Bono (1966: 6), for example, advocated the use of triple superphosphate (46 percent P_2O_5). However, unless more attention is paid to overcoming the marketing

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28/ Data on fertilizer use from the 2 studies cited in this paragraph were obtained from Wiggins (1976: 37).

29/ Zavaleta R. (1970: 2) reports that four types of soils were found in a 15-kilometer extension of land around Guaquí, on Lake Titicaca. He also provides data showing how response of potatoes to different fertilizer mixtures varies according to type of soil and specific location. For other research results, see Antezana Terrazas (1974).

problems for meat, wool, and other livestock products, the benefit/cost ratio for fertilizing pastures is likely to be unattractive.

In the Lower Cochabamba Valley, chemical fertilizers were virtually unknown before 1952 (Dorsey 1975b: 48); but a study of 3 communities in this area reported that they were being used in 1967 (Camacho Saa 1970: 191), and this was confirmed in another study of one of these communities at about the same time (E. Clark 1970: 23, 121). 30/ Two of the 3 communities were studied in 1973 by Dorsey (1975b: 48-50), who reported widespread use of fertilizer to maintain soil fertility in the face of high salinity of the irrigation water. Elsewhere, however, Dorsey (1975a: 62) reported that fertilizer use was only a third as high as in the Upper Valley community of Toralapa, where potatoes were the most important crop. Moreover, he found no positive relationship between fertilizer use and income in the Lower Valley.

A study by Camacho Saa (1967: 18) found that no chemical fertilizer and little organic fertilizer was being used in the Upper Cochabamba Valley community of Ucureña, where the principal crops grown were corn, potatoes, and wheat. Interestingly, potatoes were reported to be less profitable than corn (p. 42), though one wonders if this would have been true had more fertilizer been used for potatoes. Peinado Sotomayor's

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30/ E. Clark (1970: 121) also notes that "two crops can be grown with one fertilization before it has to be renewed. Since the soil is well fertilized for the potato crop, immediately after harvesting potatoes, maize is planted to use efficiently the fertilized soil." Fertilizer was also used for carrots and other garden crops in which the community specialized.

(1971) study of 3 other Upper Valley communities indicated that chemical fertilizers were being used in 1967. A subsequent survey of one of these communities found that both organic and chemical fertilizers were used widely in potato production in 1973, and suggests that the returns to fertilizer use were very high (Dorsey 1975a: 44-51). 31/

Fertilizer is used much less widely for wheat, another of the important crops grown in the Valles. Although Roberts (1967: 25) found that the marginal returns to fertilizer on the better lands exceeded the marginal cost, they were probably not too great, and the sharp rise in fertilizer prices in 1974 may have made fertilizer use for wheat attractive only in a relatively small number of areas. The TVA study (Russel et al. 1970: 56) estimated that the benefit/cost ratio for fertilizer was twice as high for wheat as for potatoes; 32/ however, "for farmers who evaluate net gains from fertilizer use, rather than the return on fertilizer investment, potato fertilization is just as profitable as wheat fertilization . . ." (Russel et al. 1970: 57).

Fertilizer use in Santa Cruz appears to be still quite low, notwithstanding the considerable expansion in commercial farming since 1970. A

31/ Simple regression equations, explaining potato output on 10 farms as a function of land, chemical fertilizer, and sheep manure, yielded benefit-cost ratios for fertilizer use of 15:1 to 17:1. Dorsey recognizes, though, that these figures would probably have been lower had data been available to include other inputs (animal traction, labor, etc.) in the equations. It should also be noted that the number of observations is small.

32/ Estimated and projected benefit/cost ratios for 5 Departments at three points in time ranged from 4.3 to 7.5 for wheat and from 2.0 to 4.0 for potatoes.

recent survey included fertilizer in the cost of production tables for only 1 of 9 crops (potatoes), even for mechanized and/or irrigated technologies (Asociación de Consultores 1975: Vol. II, pp. 77-171). A few cotton growers use fertilizer, and one of them reported a 5:1 return on 300 kg. of 15-15-15 in 1968 (Russel 1970: 17). 33/ According to an estimate made in 1970, the potential gains from using fertilizer on cotton were much greater; a very high benefit/cost ratio was also estimated for rice, while that for sugarcane was quite low and most likely not conducive to fertilizer adoption given the risks involved (Russel *et al*. 1970: 57). The specific estimates were:

	Cotton	Rice	Sugarcane
1970	-	-	1.3
1975	50.8	18.5	2.6
1979	37.8	25.9	3.2

While these projected benefit/cost ratios are probably exaggerated, since they are based on experiment station trials, they definitely suggest that fertilizer use can be profitable in both cotton and rice production.

Other Chemical Inputs

Use of other chemical inputs in Bolivia is also low but has increased rapidly in the last few years. In 1971 pesticide imports amounted to only 429,118 kg., valued at US$ 195,101, with insecticides accounting

33/ Note that both the amount and type of fertilizer used differ from the recommendations in Table 6. Considerable additional fertilizer research is needed in Bolivia, and, as pointed out earlier, appropriate fertilizer amounts can vary greatly even within a small area.

for close to 90 percent of the total (Brooks 1974: Annex VI):

Type of Input	Kg. Imported
Insecticides	382,574
Herbicides	11,873
Fungicides	19,194
Disinfectants	12,628
Raticides	2,849

By 1975, however, consumption of pesticides was reported to have reached 9.1 MT (MACA 1976: 126), 34/ due to increased use by growers of cotton, sugarcane, grapes, vegetables, and potatoes (Bolivia, MACA, 1976: 125).

Most of the pesticides imported by Bolivia are used in the Santa Cruz region, particularly for cotton. Huddleston (1971: 6) reported that cotton growers were averaging 6 applications of insecticides per crop in the early 1970s, as the cotton boom was just beginning. Of the 10 insecticides used, none appeared to create a residue problem for wheat planted immediately after cotton. (Wheat could be a major crop in this area if improved sub-tropical varieties can be developed.) Herbicides were also reported to be in general use (Huddleston 1971: 7), but the most widely used type was not compatible with wheat as a second crop. Huddleston also reported that "farmers appear to be very interested in reducing the amount of pesticide use and in the idea of integrated control which makes maximum use of natural controls and minimum use of chemical controls" (p. 8).

Cost-of-production tables prepared for an agricultural survey of Santa Cruz (Asociación de Consultores 1975: Vol. II, pp. 77-171) show

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34/ This figure is suspiciously high and should be verified.

pesticides being used not only for cotton but also for rice, 35/ soybeans, wheat, tomatoes, and potatoes. For sugar, corn, and peanuts, however, pesticide use was reported to be negligible.

Elsewhere in the country it is more difficult to determine pesticide use, though generally speaking it is probably not very common. Sánchez and Wessel (1966) report that pesticides were not being used in the Chapare colonization area of Cochabamba Department in the mid-1960s. In the Cochabamba Valleys, pesticide use has been reported by Brooks (1974: 6) and Dorsey (1975a: 50, for potatoes), but it is not clear how many farmers are involved. In reviewing the literature on the Northern Altiplano, Wiggins (1976: 37) found that pesticides had been introduced there only recently and that they are not generally used. A 1975 survey by the Ministry of Agriculture, he notes, found that only 7 percent of those interviewed treated their seeds; 90 percent, however, were using Aldrin, though in inappropriate amounts. 36/

Improved Seeds

The Ministry of Agriculture estimated seed requirements for the 1974-75 crop year to be 470,442 MT, of which only 1,551 MT would be met by domestic production of improved varieties. Even taking into account imports (mainly of cotton seeds), improved varieties, according to these

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35/ Fairly effective insect control, it was reported, could be achieved with one application; but not all farmers used insecticides. Only a few treated their seeds with disinfectants (pp. 106, 108).

36/ The 90 percent figure seems suspiciously high. Unfortunately, the nature of the sample on which it is based is not known.

estimates, would account for less than 1 percent of the total planted (Bolivia, MACA, 1974: 354).

These figures, however, exclude improved seeds saved from previous harvests and thus ignore the favorable effects on yields that resulted from the introduction of new corn, rice, sugarcane, potato, and quinua varieties under U.S. assistance programs in the 1950s and 1960s. More recently, improved wheat varieties have come to be widely used. 37/

Of those seeds produced domestically (off the farm), wheat varieties are by far the most important, accounting for 83 percent of the total in 1972. Potatoes occupied second place in that year, with 13 percent. The remaining 4 percent was accounted for by small amounts of rice, barley, oats, quinua, and pasture grass varieties (Bolivia, MACA, 1974: 359).

Introduction of improved varieties was a major objective of a U.S.-financed wheat assistance program implemented under a contract signed in 1967 with Utah State University. Prior to this time, only *criollo* seed was being used, but by 1974 an estimated 38 percent of wheat production came from improved varieties. Ideally, adoption of the new varieties should be accompanied by the use of insecticides and herbicides; however,

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37/ Wheat seed requirements in 1972 were probably about 6,500 MT. Imported wheat seeds in that year amounted to 17 MT while domestically produced seed distributed to farmers totalled 180 MT (Bolivia, MACA, 1974: 355, 359). This would mean that improved seeds accounted for only 3 percent of the total planted. The National Wheat Institute, however, estimated that 29 percent of wheat production in 1972 (and 38 percent in 1974) came from improved varieties (Wennergren 1975: 14).

not all farmers planting improved seeds have utilized these additional inputs. Nevertheless, the introduction of new varieties probably accounts for most of the annual growth of wheat yields of 4.6 percent between 1967-69 and 1973-75 (see Table 2). 38/

Machinery and Implements

Machinery and modern implements were not entirely unknown in Bolivia before the 1952 revolution. Particularly in the Lower Cochabamba Valley, labor unrest in the mid-1940s induced landlords to mechanize some crop operations and shift to fruit orchards and dairy farming (Dorsey 1975b: 12). In the years immediately after 1952, however, there is a consensus that mechanization declined in the Altiplano and Valles, as machinery belonging to ex-*hacendados* was destroyed, not repaired, or simply never used by the *campesinos* who established their own farms on expropriated land. 39/ Given the background to the 1952 revolution, both the failure to use machinery and outright Luddism were understandable forms of behavior.

For many parts of the Altiplano and Valles, the pre-1952 extent of mechanization apparently was not achieved again until the late 1960s, after which use of machinery seems to have accelerated. Dorsey's study

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38/ Yields also increased fairly rapidly from 1961-63 to 1967-69 (3.7 percent annually), but this is probably due in part to the withdrawal of some marginal wheat lands from production. In addition, new varieties had a minor effect on average wheat yields during 1967-69.

39/ See, for example, Ballard *et al*. (1966: 75); Burke (1971: 314-317); Camacho Saa (1970: 191-192); and Downing (1964).

of 2 communities in the Lower Cochabamba Valley, for example, notes that only 10 percent of the campesinos in one community, and none in the other, were renting tractors in 1967. By 1973, however, the figures had increased to 75 and 32 percent, respectively (1975b: 51-52). Larger farmers in the area also began to purchase more machinery in the late 1960s as their tenure status appeared to have become reasonably secure.

The effects of the agrarian reform on mechanization in Santa Cruz differed from those in the highlands. In the lowlands, where farm land was abundant relative to labor and the land tenure system less oppressive, there were fewer immediate pressures for significant land redistribution. Nevertheless, large-scale farm operators were aware that their property was subject to expropriation. As noted earlier in this paper, many of them moved quickly to mechanize in order to obtain classification as "agricultural enterprises," permitting them to retain large tracts of land. Mechanization was facilited by the availability of subsidized rental machinery. However, a sharp rise in rental rates, to bring them in line with actual costs, led many farmers to switch back to labor-intensive farming after 1957. As in the rest of the country, machinery use remained low until the late 1960s.

It was noted above that the use of unspecialized equipment to clear land led to rapid soil depletion in many areas. Still, mechanized clearing, even if more expensive, has sometimes been defended as better for the soil than slash-and-burn methods, particularly if the cleared land is first used for grazing and then gradually converted to crop production (Llano G. 1964: viii-ix). 40/ On the other hand, Cordero V. (1964:

40/ For other criticisms of slash-and-burn farming, see Barja Berrios (1973) and Chardón and Leigh (1959).

86–88) found in his Master's Thesis research that land clearing by hand or by burning not only resulted in less loss of fertility than use of a bulldozer or root rake, but also was less expensive. 41/ García M. (1964) also argues that slash-and-burn methods are less harmful to the soil than mechanized clearing, but his statistical results are not entirely clear.

Among smaller farmers, it appears that slash-and-burn methods still are overwhelmingly predominant. This suggests that incomes are perceived to be at least as high using slash-and-burn methods as they would be if machinery were used to permit them to cultivate more of their land. However, another reason for non-mechanized clearing may be a lack of credit, not just for machinery rental but also for fertilizer to maintain soil fertility in a situation where the possibility for shifting agriculture may have disappeared.

Farmers in Santa Cruz use a variety of techniques for land preparation and cultivation. These were recently compared in a recent study by Kenneth Graber (1976). Graber's sample is small: 5 farmers using mule teams, 2 using horses (in the Mennonite colonies), and 2 farmers and 2 cooperatives with tractors. Those using mules, it appeared, were able to cultivate no more than 12-15 hectares. Equipment (including plows, harrows, and seeders) was generally in poor condition, and farmers

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41/ The estimated costs per hectare of the various methods were as follows:

Burning	US$ 40.55
Hand Clearing	86.36
Bulldozer	91.76
Root Rake	141.34

lacked the ability to do adequate repairs. The horse teams were cultivating 15-18 hectares, while those with tractors were farming 40-150, depending on the size of the tractor. A comparison of production costs for corn, 42/ based on the amount of land actually cultivated, showed that those farming with tractors had the lowest per-hectare production costs. However, it was assumed that tractors have a useful life of 10 years, and this seems too long; the same may be true for some of the equipment. If the depreciation period is shortened, it would appear that the per-hectare cost advantages of tractors over animal traction would be minor at best. With equal per-hectare costs, total farm income would be higher because tractors would permit more land to be farmed; but for those farmers with less than 40 hectares of arable land, 43/ per-hectare costs would be higher, and this would probably make tractor ownership uneconomical. Rental of tractor services, however, is an alternative that needs to be explored.

Several additional comments on this study are in order. First of all, there is no indication of any possible differences in yields for the different methods of cultivation employed, particularly if the use of tractors permits more favorable adaptation of the crop cycle to climatic conditions. Secondly, it is not clear if the use of tractors permits

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42/ Graber notes that the costs of shelling and marketing corn are excluded from the cost tables. Also excluded is the opportunity cost of land and, apparently, repair costs.

43/ Actually, if fertilizer is not used and land must be put in fallow after a few years of cultivation, the minimum farm size requirement would be higher.

double cropping of land that otherwise would have to be single-cropped. Third, per-hectare costs of hand cultivation appear to be significantly higher than those for cultivating the optimum number of hectares with animal traction. Finally, it should be emphasized that the sample used in this study is quite small. Nevertheless, comparative technology studies of Bolivian agriculture are rare, and this one is useful for providing preliminary information and suggesting additional lines of inquiry for future research. One important observation Graber makes (p. 10) is that the quality of the land preparation and cultivation depends more on the operator then on the type of technology used. This suggests that crop yields may show little variation among the various methods.

Other comparative data for several crops are found in the agricultural survey of Santa Cruz prepared by the Asociación de Consultores Ltda. (1975: Vol. II, pp. 77-171). As in the case of Graber's study, the data are confined to costs, and in this case only to operating costs; yield estimates are incomplete, and data on farm-gate prices are not supplied. The discussion accompanying the cost tables indicates that most cotton production and almost all soybean production is mechanized. About one-third of the sugarcane is grown with mechanized technology, while for rice and corn the figures are 20 percent and 10 percent, respectively. Various levels of technology are used in the production of wheat and peanuts, but the extent of mechanization is not clear. Tomato producers use tractors for land preparation.

Since the late 1960s the number of tractors imported into Bolivia has increased substantially. While imports of only 186 tractors were reported during the 5-year period 1963-67, the estimated number of tractors imported jumped to 2,016 during 1968-73. 44/ Of the latter figure, 476 tractors were rated at 40-52 HP, 920 were in the 53-72 HP range, and 620 were 72.5 HP and above. Of the 1,321 tractors in good working condition in early 1974, 854 (65 percent) were in the Oriente, 304 (23 percent) in the Valles, and 163 (12 percent) in the Altiplano. A new tractor assembly plant in Cochabamba was expected to open in 1974 with a production of 265 units (Bolivia, MACA, 1974: 368-379).

The estimated stock of other agricultural machinery in 1974 is indicated in Table 7. Some of the smaller items were made in local artisan workshops, but there was no factory production of agricultural machinery in the country. Excluding tractors, imports of machinery and equipment in the early 1970s amounted to about $1 million annually (Bolivia, MACA, 1974: 371).

It should not be assumed that mechanization of Bolivian agriculture is always desirable, even in a region like Santa Cruz where farmers often encounter labor shortages. In the case of cotton, for example, labor shortages could probably be alleviated by allowing wage rates to be determined in the marketplace; although wages would thus be higher than

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44/ On an annual basis, the figures were as follows:

1968	96	1971	386
1969	211	1972	398
1970	236	1973	689

These data are based on interviews with 13 importers and are probably fairly accurate. Figures reported by the Andean Group for this period are much lower--692 for 1968-72--and probably are incomplete (Bolivia, MACA, 1974: 370-373).

TABLE 7

ESTIMATED STOCK OF AGRICULTURAL MACHINERY, 1974

Tractors in good working condition	1,321
Other tractors	881
Plows--2, 3, and 5 rows	370
Plows--2-5 discs	650
Disc harrows--tandem	530
Disc harrows--offset	290
Cultivators	260
Furrowers	110
Grain seeders	330
Corn and cotton seeders	450
Potato seeders	90
Harvesters and threshers	590
Harrows	230
Forage harvesters	50
Stationary threshers	140
Combine harvesters (pulled)	35
Combine threshers (mechanical)	40
Animal-drawn plows in good condition	16,000
Other animal-drawn plows	3,500
Motorized hand cultivators	900
Trailers, 2 and 4 wheels	890

Source: Bolivia, MACA, 1974: 378.

those fixed by the cotton growers' association, the extra costs would be offset by added revenues from the additional area harvested. 45/ A shift to mechanical harvesters would not only displace tens of thousands of seasonal laborers but might be more expensive in the long run if erratic world market conditions force some farmers to keep their machinery idle when prices are unattractive. Moreover, mechanical harvesting lowers the quality of the cotton. On the other hand, mechanization may be desirable if it facilitates double-cropping of cotton with soybeans or wheat. A detailed examination of the implications of alternative technologies would be important for income, output, and balance-of-payments considerations alone. If employment and income distribution are also major objectives, such studies become even more important.

Irrigation

Little has been done to develop irrigation systems in Bolivia. It was estimated that only 16,680 ha., mainly in the Altiplano and Valles, were under irrigation in 1974; this amounted to less than 2 percent of the land under cultivation. 46/ Irrigation has been viewed by some as a necessary investment for increasing productivity on the Altiplano and Valles; but little is known about crop responses to irrigation water in those regions (Wennergren and Whitaker 1975: 115-117).

45/ Up to 20 percent of the crop was lost in the early- and mid-1970s because of labor shortages (see Zuvekas 1977b: 28).

46/ Many of the existing small irrigation systems were developed in the Inca and colonial periods.

In the Oriente, where the government plans to make major irrigation investments in the future (see below), several studies have been undertaken to determine the potential benefits of irrigation. A pre-feasibility study of the proposed Abapó-Izozog (Santa Cruz) and Villamontes (Tarija lowlands) projects in the mid-1960s identified wheat, soybeans, oilseeds, and cotton as domestic-consumption and export crops that could profitably be grown under irrigated conditions (Bolivia, MINECON, and Deutsche Projekt Union 1965). Including the livestock potential of the 357,900 has. in the project areas as then defined, the annual value of production was expected to reach $98.5 million, of which $60.5 million would be exported. (An estimated $50.8 million of the exports would consist of livestock products, equally divided between fattened cattle and processed pork.) Preliminary indications suggested an internal rate of return of 15.9 percent (CORGEPAI 1975).

At the farm level, irrigation was expected to account for 9-12 percent of production costs. Net farm incomes were projected to be quite high by Bolivian standards:

	Total Has.	Average Farm Size (Has.)	Farm Income (U.S.$)
Villamontes	7,900	11.3	2,536
Abapó-Izozog:			
Crops	200,000	50.0	6,400
Livestock	150,000	100.0	21,100

These figures were then compared with an estimated net farm income of only $167 in 3 colonization areas (Chapare, Chimoré, and Yapacaní). This kind of contrast makes the irrigation projects seem too good to be true, and closer inspection of the data for both the colonization and irrigation areas reveals this to be the case. Colonists' net incomes, for example, were based on (admittedly) low 1964 farm prices, and imputed income probably was not adequately taken into account. Net incomes in the irrigation zones underestimated capital costs, and world market prices rather than farm-gate prices were used for export products. 47/

At the project level, the timetable for completing the project was optimistic. Wheat production was regarded as a major crop activity even though it was not clear (and still is not) that suitable and profitable subtropical varieties had been developed. 48/ Hydrologic data were sketchy. In summary, the case for these large-scale irrigation projects was not made. Prospective foreign lenders apparently agreed, and the projects have yet to emerge from the pages of planning documents.

In the early 1970s, a more rigorous effort to determine the effects of irrigation water on lowland crop production was undertaken by a joint Bolivian-Utah State University/USAID team (1972), which found surface and groundwater resources to be good-to-excellent. Cotton was found to have the highest rate of return on farm-level investment in irrigation

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47/ Transport expenses are considered as a cost; but since they are both implicitly and explicitly included as part of the world market price, they are actually not counted. Other payments to intermediaries, together with taxes, further widen the gap between farm-gate and export prices.

48/ The expected annual production of 166,600 tons was about twice the average national output in the mid-1960s. Utah State University advisors believed that little wheat would in fact be grown in the area because of the relatively high price of land, high production costs, and the low bread-making quality of irrigated wheat (McAllister 1966; Roberts 1967). Other crops, they argued, would be more profitable.

(see Table 8). Attractive returns were also found for sugarcane and soybeans as well as for wheat, which was recommended for double-cropping to improve soil structure and reduce weed competition.

While these results are encouraging, the Study Team was careful to warn that some of the underlying data were deficient. In determining irrigation requirements, for example, evapotranspiration had to be estimated because of the lack of evaporation data, and the crop coefficients used are for the western United States (pp. 51-55). Production costs were not determined by survey but based on secondary data and selected interviews; it was recognized that actual costs varied considerably within the region (p. 129). Determination of the social rate of return on large-scale investment in irrigation and related facilities would have to take into account the fact that:

> The total agricultural potential of the eastern plains is so great that a too rapid development could have a major adverse effect on world markets through the production of large surpluses. Therefore any major development program needs to be based upon a careful analysis of both internal and world market demand and elasticity (p. 125).

GOVERNMENT POLICY

Agriculture's Priority in National Economic Planning 49/

National development plans have generally given low priority to the agricultural sector, notwithstanding their brief statements to the contrary. Most have lacked the detailed analysis and programming neces-

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49/ This section is taken in part from Zuvekas (1977a).

TABLE 8

SANTA CRUZ: ESTIMATED INTERNAL RATES OF RETURN UNDER VARIOUS IRRIGATION SYSTEMS, SELECTED CROPS, 1972

(percent)

Crop(s)	Well Water		River Water	
	Sprinkler	Surface	Sprinkler	Surface
Cotton	50	>50	>50	>50
Rice	a	a	15	50
Soybeans	27	35	40	50
Meat (pasture)	<1	<1	9	40
Wheat	16	20	26	>50
Sugarcane	20	26	30	>50
Cotton-Wheat	>50	>50	>50	>50
Cotton-Soybeans	>50	>50	>50	>50
Cotton-Green Manure	50	>50	>50	>50

Source: Bolivian-Utah State/USAID Study Team (1972: 107).

[a] Not estimated.

sary to justify the use of the word "plan," and this shortcoming is particularly true for those parts dealing with agriculture. The 1962-71 Plan (Bolivia, JUNAPLAN, 1961), for example, neglects what by 1960 should have been an obvious major weakness of agrarian reform in the 1950s: the lack of agricultural credit. The long-term "Socio-Economic Strategy" document for 1971-1991 (Bolivia, MINPLAN, 1970) devotes very little space to agriculture, and nothing is said about how planned productivity increases were to be achieved.

The 1972-76 Plan (Bolivia, CONEPLAN, 1973b), in the words of a comprehensive sector assessment by USAID/Bolivia (1974: 230), "virtually ignores the agricultural sector." This oversight was partially compensated for in 1973, when the government adopted twin sector goals of increasing per capita income and achieving a more equitable distribution of agricultural income (USAID/Bolivia 1974: 230-231). The 1976-80 Plan (Bolivia, MINPLAN, 1976), however, does not deal directly with rural income distribution or employment; and it does not give agriculture a particularly prominent place, despite establishing a target sector growth rate of 7.4 percent (compared with 2.0 during 1968-75). Even the more detailed *Plan Quinquenal Agropecuario* for the same period (Bolivia, MACA, 1976), while mentioning rural income redistribution as a goal, makes no clear connection between specific programs or technologies and achievement of this objective.

The 1976-80 Plan does show, however, increased spending to improve agricultural technology. Investment by the Instituto Boliviano de Tecnología Agropecuaria, formed in December 1975 by bringing the research and extension agencies under a single roof, is projected to increase from $b. 36 million (US$ 1.8 million) in 1976 to $b. 60 million (US$ 3 million) in 1980. Total investment spending 50/ is expected to rise substantially from an average of US$ 35 million in 1976-77 to US$ 59 million in 1979-80 (Bolivia, MACA, 1976: 188). Most of the planned increase is to be devoted to expanding agricultural production in the Oriente.

Despite the relatively low priority given to agriculture in the national development plans, interest in agricultural development in Bolivia is clearly increasing. For example, loans for agricultural projects totalling $66.3 million were received during 1974-76 from USAID, the World Bank Group, and the Inter-American Development Bank (see Table 9). Increased technical assistance has also been obtained, from these and other sources. In fact, there is reason to believe that the Bolivian government is now finding it difficult to provide the necessary financial, logistical, and counterpart support to the projects to which it has made commitments. This leads to a brief consideration of the limitations on agricultural planning and program implementation imposed by administrative shortcomings.

A review of the Ministry's administrative capabilities in 1974 (USAID/Bolivia, 1974) made the following observations:

50/ Though identified as investment expenditure, these figures probably include current expenditures as well. Insufficient data are provided to check this suspicion.

TABLE 9

AGRICULTURAL LOANS TO BOLIVIA AUTHORIZED BY USAID, THE WORLD BANK GROUP, AND THE INTER-AMERICAN DEVELOPMENT BANK, 1974-76

Agency and Project	Date Authorized	Amount (millions of dollars)
IDB		
Pork Production--Chuquisaca	03-06-75	$ 2.2
Animal Health	01-29-76	4.2
IBRD Group		
Agricultural Credit	06-19-75	7.5
Ingavi Rural Development	02-17-76	9.5
AID		
Sub-Tropical Lands Development	06-14-74	9.7
Basic Foods Production	12-31-74	8.0
Agricultural Sector Loan	12-31-74	9.2
Small Farmer Organizations	12-31-75	7.5
Rural Access Roads	06-30-76	8.5
TOTAL		$66.3

> Less than one third of the MACAG [Ministerio de Asuntos Campesinos y Agropeuarios] staff are university graduates, and there is only one person with a Ph.D. and eight with Master's degrees. University graduates generally have little or no practical experience in agriculture. Few have the advantage of rural backgrounds. A critical problem in attracting more qualified personnel are relatively low salaries compared to other GOB agencies. . . . [P]olitical considerations often determine who gets the jobs (pp. 171, 173).
>
> None of the personnel of [the Ministry's planning] office hold advanced degrees and their training for analysis in economics and agricultural planning is inadequate for the job which is needed (p. 230).

Another review of the Ministry's operations described the bureaucratic structure as being characterized by "unnecessary complexity, inflexibility, sluggishness, delay, routine, confusion, and, finally, inefficiency" (IDB 1973: 137; translation).

Some of the key decision-makers in the Ministry are well aware of these shortcomings, and some steps have recently been taken to overcome them. But bureaucratic structures are notoriously resistant to change, and in the absence of major government-wide decisions (e.g., changes in the structure of professional salaries and a streamlining of administrative procedures), progress toward better implementation of agricultural programs will be slow.

Agricultural Research

Agricultural research in Bolivia began in 1946 and was expanded until 1964 with the assistance of the U.S. government under the Servicio arrangement in which U.S. and Bolivian personnel shared administrative responsibilities in an environment largely insulated from normal bureaucratic processes. Since the sudden termination of the Bolivian Servicio

Agrícola Interamericano in the early 1960s, the result of a continent-wide policy determination by the U.S. government, the quality of agricultural research in Bolivia, in the opinion of qualified observers, has declined. 51/

Loss of skilled researchers trained during the Servicio period has been a major problem (Riera and Barja 1974; USAID/Bolivia 1974: 209). Salaries are now quite low compared with those in the Bolivian private sector or private and public organizations abroad. In 1974 the research organization had just 1 Ph.D. and 7 M.A.-level specialists, and their duties were largely administrative. Below them were only 35 researchers with agricultural degrees from Bolivian universities; most had very limited research experience. Research budgets have been limited (US$ 350,000 in 1974) and spread thinly over 15 research stations and a large number of crop and livestock activities. Facilities are poorly equipped. The economic aspects of agricultural research (e.g., relative profitability of various crops and livestock) have received too little attention (Echandi et al. 1972; USAID/Bolivia 1974: 204-207, 209-211). 52/

Despite these shortcomings, there have been a few bright spots. Research on livestock, which accompanied the introduction of Zebu cattle into the Beni in the 1950s, helped Bolivia move from a beef-importing

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51/ The Servicio organizations were concerned primarily with agricultural extension, but research was an important component of the overall effort. For an excellent evaluation of the Servicios and their disappointing long-run impact, see Rice (1974).

52/ For a more favorable view of the quality of research personnel and facilities, see Watkins (1974).

to beef-exporting country (USAID/Bolivia 1974: 207). Recent livestock research, however, has been very weak (Asociación de Consultores 1975: Vol. III, pp. 108-110; Bolivia, CONEPLAN, 1973a; and Bolivia, MACA, and IICA 1974).

New rice and corn varieties were developed in the 1950s and 1960s, and by 1967 nearly all of the rice and corn grown in Santa Cruz used seed developed under these programs. Since the late 1960s, however, yields of both these crops have apparently declined (see Table 2), and even the improved varieties of rice are not of export quality. Research on wheat, potatoes, and quinua has developed higher yielding varieties, but hopes for development of a commercially viable sub-tropical wheat variety (admittedly a difficult task) have not been realized (Long 1975a). Moreover, adoption of the new hard wheat varieties in the highlands has been far from universal: many farmers favor the soft criollo varieties which are preferred for on-farm consumption, produce more straw (for animal feed), do not require improved cultural practices, and yield almost as well as the new varieties in areas where the soil is fertile and disease problems are not serious (Long 1975b: 4-5). This suggests that agricultural researchers in Bolivia should spend more time consulting with farmers about desired seed characteristics before deciding which varieties should be chosen for adaptive research.

In other cases, the limited diffusion of new varieties can be attributed in part to a lack of coordination between the research and extension organizations, a problem common to most Latin American countries. This leads us to a review of agricultural extension and other technical assistance activities.

Technical Assistance

Agricultural extension in Bolivia, like research, has suffered from low funding levels and inadequately trained staff, particularly since its transfer from the *Servicio* to the Ministry in 1961. As budgets were reduced and salaries lowered, overseas-trained extension workers who had not already left the program began to seek greener pastures, and all were gone by 1964. 53/ Low salaries and budget reductions also caused many Bolivian-trained agents to leave. 54/ By 1974 the ratio of extension agents to farm families was 1: 7,500. Only 1 of the 97 field personnel in that year had a Master's degree, and only 26 others were university graduates. The coordination between research and extension developed under the *Servicio* had disappeared. Lack of instructional materials further limited the effectiveness of extension agents (USAID/Bolivia 1974: 211-217). The number of vehicles was greatly increased in 1974, but lack of funds for gasoline and travel expenses continue to restrict extensionists' mobility (Michaelsen 1975a: 12). In summary, the extension service has been a weak and not particularly effective organization (Castañón Pasquel 1968; Echandi *et al*. 1972; Michaelsen 1975a; and Rice 1974). It has been estimated that only 6 percent of the economically active population affected by proposed development programs had received productive training from extension programs (ILO-PREALC 1975: V-5).

53/ As early as 1960, 33 of 57 persons trained overseas had left (USAID/Bolivia 1974: 213).

54/ For a comparison of extensionists' salaries and benefits with those of other rural development technicians, see Michaelsen (1975a: 10).

The poor record of extension in Bolivia is not unique in Latin America. Indeed, a major study by E.B. Rice (1974) of U.S. assisted extension organizations in the hemisphere found this to be true generally. Bolivia's rating was quite low by some measures (p. 143). Rice argues that government extension services in Latin America are neither necessary nor sufficient for the diffusion of new technology, though he does not deny the importance of the extension function. Extension, he argues, must be integrated with other development activities (p. 385), particularly credit and marketing (pp. 326, 391). Stated another way,

> Management may be the key to understanding the process of progress [in the countries studied]. The successes usually involve strong institutional organization and direction of the production-distribution system. It may have been provided by a private company, a farmers [organization], or [government].... The extension services typically have not been directly involved in these institutional arrangements (p. 328; emphasis added).

As noted above, the Bolivian extension service received a relatively low rating. In Santa Cruz, however, Rice argues that it seemed to play an important coordinating role in the diffusion of new technology during the *Servicio* period. 55/ Road construction, colonization programs, and the machinery program were cited as other elements in the development efforts in this region (pp. 359-360). The availability of credit was another important component. This favorable view, however,

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55/ ". . . this is the only important regional extension development program investigated in the [countries studied] where persons outside the official extension service were willing to support the extension service's claim for recognition" (Rice 1975: 359).

can be challenged. According to a United States Senate report (U.S. Congress, Senate, 1960), Servicio operations in Santa Cruz were plagued by an unusually high degree of mismanagement and poor judgement. The subsidized machinery pool discussed above is one example. Dwight Heath (in Heath, Erasmus, and Buechler 1969: 343-344) notes a number of other problems, including lack of expertise in tropical agriculture and inattention to small farmers. This suggests that the marginal contribution of the extension service, which Rice admits would be very difficult to measure, may have been rather small.

We noted earlier that the current Plan calls for a significant increase in spending by the Instituto Boliviano de Tecnología Agropecuaria (IBTA) between 1976 and 1980. However, IBTA's programmed activities in extension are held at a constant level throughout the Plan period. This suggests that most or all of the planned increase in IBTA's budget will be devoted to research.

The apparent decision to give low priority to the extension organization should not necessarily be lamented. As Rice has argued, alternative means of providing the extension function should be explored. In particular, he believes that extensionists can be more effective working in various types of fomento organizations where their role would be not only to transmit new information but actively to guide farmers into adopting new technologies. 56/ During the Servicio period, this kind of advocacy role for extentionists had been rejected on philosophical grounds. Advocacy, of course, can be dangerous if

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56/ Such organizations include, but are not limited to, development banks, land reform agencies, and production and marketing organizations for specific crops.

what is advocated is of dubious merit from a benefit-cost standpoint—as has sometimes been the case in Bolivia in the post-Servicio period (Michaelsen 1975: 14-15). 57/ One way to minimize the amount of poor advice would be to give extensionists more training in economics: "The fact that professional extensionists were not linked to professional economic analytical talent ranks along with the underdeveloped extension-research linkage as one of the principal weaknesses in the extension institution building experience" (Rice 1974: 429). 58/

Notwithstanding his criticism of the institution-building effort in extension, Rice cautions against completely abandoning extension organizations, which are potentially valuable resources despite their shortcomings. Rather, he says, they should be integrated with other functions (p. 426). What Rice has in mind is not coordination, but absorption of the extension organization by some larger entity: "The loss of institutional identity will be hard to accept, but it was a mistake to begin with and the mistake has to be corrected" (p. 427).

Utah State University adviser Leon Michaelsen (1975: 29-35), while accepting Rice's argument that extension work must be closely

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57/ For example, extensionists were asked to promote dairy production among campesinos in order to save a milk plant in La Paz. No benefit-cost analysis had been conducted, but the available evidence for the area in question suggested that such activity was not economically viable. Autarchic pressures to increase wheat production have also failed to consider benefits and costs.

58/ In the Bolivian cases cited by Michaelsen, however, the problem was not so much with the extensionists as with those making political decisions.

integrated with other development activities, believes that extension can become viable as a separate development institution by concentrating its efforts in fewer communities and emphasizing activities for which quick, direct benefits to campesinos can be expected. He especially emphasizes closer ties with the research and community development organizations, and with the campesinos themselves.

Whatever one's position on the independence of the extension organization, there seems little doubt that the extension function should be more closely integrated with other development efforts. The bringing together of the extension and research organizations to create IBTA seems to be a step in this direction, and the Plan Quinquenal Agropecuario (Bolivia, MACA, 1976: 82) states that extension activities will be coordinated with other institutions. But extension activities still seem to be spread too thinly, and the low level of support for extension suggests that it continues to have a relatively low priority.

Before ending this discussion of technical assistance, it is useful to examine briefly the work of the Servicio Nacional de Desarrollo de la Comunidad (SNDC), which attempts to stimulate rural communities to undertake self-help infrastructure projects reflecting their own felt needs. Projects which the SNDC is helping to finance include small irrigation works and storage facilities for potatoes, cereals, and forage crops. During the current Plan period (1976-1980) SNDC is seeking to strengthen at least 200 campesino organizations through technical assistance, leadership training programs, and credit (Bolivia, MACA, 1976: 99-109). Some of its activities can be considered as agricultural extension: in the Northern Altiplano, for example, it has helped promote the introduction of new potato and quinua varieties (Wiggins 1976: 51).

During 1966-69 the SNDC was given considerable technical assistance and other project support (US$ 1.3 million) by U.S. AID and the Peace Corps. After 1970, when the Peace Corps was ordered out of the country, U.S. technical assistance was curtailed; but financial support to SNDC increased, rising to US$ 3.9 million during 1970-73 (Wennergren and Whitaker 1975: 270).

Evaluations of the effectiveness of the SNDC are mixed. Wennergren and Whitaker (1975: 269-271) present a favorable view, pointing out that more than half the communities assisted by the SNDC have returned to request support for other projects. The SNDC, in their opinion, "enjoys a reasonably good reputation with campesinos" (p. 271). An AID-sponsored evaluation of 36 programs in 11 African and Latin American countries gave a high rating to the SNDC, praising its reliance on local leadership and pointing to significant income gains from infrastructure projects (Morss _et al_. 1975: Vol. II., pp. G.24-G.35). Wiggins (1976: 51), in reviewing agricultural development on the Altiplano, concurs in these judgments. On the other hand, Camacho Saa (1970: 198), in discussing the SNDC's work in the Lower Cochabamba Valley, argues that it was not helping _campesinos_ because it attempted to create new community organizations instead of relying on existing _sindicatos_; moreover, it was reluctant to help communities finish projects they had already begun on their own. Rice (1974: 228) reports that extension service personnel challenged the SNDC's reputation as "the only rural development agency that is getting anything done"; but given the competition between the extension organization and the SNDC in some communities, this opinion cannot be regarded as unbiased.

It is possible, of course, to reconcile these conflicting viewpoints by hypothesizing that the SNDC's performance has improved over time and that criticisms have been based on institutional rivalry and generalizations from small samples. Even though this hypothesis may be too optimistic, consideration should be given to Wennergren and Whitaker's view that the SNDC has the potential to "substantially contribute to changing the technology of small-farm agriculture in the Altiplano and Valley regions" and that it might serve as "a model to be followed in providing research, extension, colonization, and other public services to agriculture" (1975: 271). But for this to happen, they argue, considerable technical and financial support will continue to be needed.

This model, of course, is only one of several that should be explored for purposes of providing more effective extension services. An alternative which deserves careful consideration is to tie extension services more closely to agricultural lending.

Increasing the Supply of Modern Inputs

Government policy can affect the supply and cost of modern inputs in a variety of ways. Recently, for example, the Bolivian government began to establish processing plants for improved seeds. By mid-1977, 6 plants with a total installed capacity of 11 tons per hour are expected to be in operation. Seed multiplication is to be promoted through contracts with progressive farmers that guarantee a market for seeds meeting specified standards (Bolivia, MACA, 1976: 120-124). The ambitious schedule for increasing land area planted with improved seeds during the current Plan period is indicated in Table 10.

Imports of modern inputs can be affected by fiscal, credit, and exchange-rate policies. Tariffs on machinery, equipment, fertilizers, other chemical inputs, and improved seeds can be lowered (or increased); tax credits or other types of subsidies for the adoption of modern inputs may be given (or taken away). An overvalued exchange rate will stimulate imports, while an undervalued rate will discourage them. Tinkering with input prices, however, is a tricky game whose fiscal, employment, and distributional implications should be taken into account. Other things equal, a reduction in the cost of imported inputs—especially machinery and equipment—is likely to benefit medium- and large-scale farmers more than small farmers, and in some cases agricultural employment will decrease. Lowering tariffs or granting subsidies will also reduce budget revenues. Credit policy affects the choice of technology if loan funds cannot be used to hire labor. Even if there are no restrictions on the use of inputs, the distribution of credit between large, medium, and small farmers will affect the types of modern inputs demanded (e.g., tractors vs. fertilizer).

The above remarks should not be construed as an argument against all mechanization and automatic support for labor-intensive technologies emphasizing improved seeds, fertilizers, and other chemical inputs. Labor-intensive technologies, like capital-intensive technologies, can be artificially stimulated, and for certain crops this would be inadvisable. In a world of imperfect markets, of course, it is not always easy to determine what constitutes an "artificial" incentive to use one

TABLE 10

ESTIMATED PERCENTAGES OF LAND AREA PLANTED WITH IMPROVED SEEDS, MAJOR CROPS, 1976 AND 1980

Crop	1976	1980
Wheat	36.6	60.0
Soybeans	75.6	32.3[a]
Rice	11.6	51.7
Corn	5.0	25.0
Barley	1.0	20.0
Quinua	11.2	42.0
Cotton	100.0	b
Potatoes	14.9	19.0
Pulses	0.0	7.2
Alfalfa	27.4	50.0
Other forage crops	50.0	70.0
Sugarcane	29.1	50.0

Source: MACA (1976: 122).

[a] The absolute number of hectares planted with improved seed is projected to nearly triple; but land area devoted to soybeans is expected to increase by 6-1/2 times.

[b] Because of an arithmetic error, the figure indicated in the source is more than 100 percent.

type of input rather than another. But some cases are obvious, and these should be examined closely to see if a broad definition of net benefits justifies their continued use.

If it is accepted that the government should promote increased use of modern inputs, a better approach would seem to be to promote more domestic production of inputs and a reduction of marketing costs. Improved seeds, as already mentioned, are now being produced locally. Domestic production of nitrogen fertilizer, given the sharp rise in import prices in 1974, now seems justifiable. The importation of bulk rather than bagged fertilizer has been mentioned as an example of how marketing costs can be lowered. Other marketing improvements include better crop forecasting and the establishment of a market information service providing data on both input and output prices (Brooks 1974: 7).

Irrigation

The current 5-year Plan (1976-80) calls for the irrigation of an additional 22,000 hectares, of which 9,200 are in the Altiplano and 12,800 in the Valles. Some 9,500 families are expected to benefit (Bolivia, MACA, 1976: 137-142). Long-run plans focus on the Oriente. By far the largest proposal—and one that has already been studied in some detail—is the Abapó-Izozog project in the Department of Santa Cruz, which once was expected to irrigate 470,000 has, though a recent feasibility study by the Bechtel Corporation proposes a much lower figure. Studies have also been conducted for the proposed Villamontes project in the Tarija lowlands (20,000 hectares). An additional 225,000 hectares, mostly in the Oriente, are being considered; but the feasibility of irrigating these lands has not yet been demonstrated (Wennergren and Whitaker 1975: 115-119; Bolivia, MACA, 1976: 140).

In the Altiplano, as noted earlier in this paper, little surface water is available and hopes for irrigation rest largely on groundwater. Studies to determine the availability of water resources have concentrated on the northern region. A United Nations team identified 60 exploitable underground water sites there (CORDEPAZ 1972; UNDP 1974; Wiggins 1976: 4-5), and work was then undertaken to determine the suitability of soils for irrigation. The IBRD's Ingavi Rural Development loan (1976) provides for development of some of these sites. Less is known about the central and southern Altiplano, though soil salinity is clearly a problem in some areas.

Price Policies

Ceilings on prices paid to farmers restrict the adoption of modern production inputs by making benefit-cost ratios lower than those that would prevail with market-determined prices. One must be careful, however, in suggesting the removal of price ceilings, since they are an important means of mobilizing and retaining political support in urban areas. Economists may talk themselves blue in the face trying to explain that seemingly equitable social policy in the short run may lead to even higher prices in the future; but politicians live in the short run, and they fear that a more patient attitude toward "equitable" agricultural prices might hasten the arrival of the long-run outcome Keynes said was waiting for us. The recent experiences of Messrs. Gierek and Sadat will not be lost on political leaders in other countries, especially those in which the option of keeping retail prices low by subsidizing producers is not available for lack of funds.

Notwithstanding these constraints, governments in less developed countries have some scope for encouraging increased production by relaxing controls on food prices. In Bolivia, domestic prices of sugar, rice, and some other commodities were allowed to rise to near-world market levels in January 1974, and the government was able to contain the resulting protests. 59/

Price controls on beef, which also had been set at levels well below world market prices, encouraged contraband exports to neighboring countries where higher prices could be obtained (Asociación de Consultores 1975: Vol III, pp. 61, 76). Rice also entered into illegal export channels. However, contraband (or even legal) export opportunities were limited: as the current agricultural development plan points out, price controls tend to discourage the improvements in productivity and quality necessary for significant participation in world markets (Bolivia, MACA, 1976: 21).

Prices of cotton and coffee are also controlled in the domestic market, and only after domestic demand is met can exports at the world market price be undertaken (Wennergren and Whitaker 1975: 94). Exports of beef were temporarily banned in the early 1970s (Herrman 1974: 4). Control of the prices of imported foodstuffs (wheat flour, edible oils, lard, and milk products), through various subsidy arrangements, probably has discouraged import substitution in these products. 60/ Prices

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59/ Opposition was particularly strong in Cochabamba, whose temperate crops were not favored by the price increases authorized (Whitehead 1976: 64).

60/ After 1972, though, food subsidies were lowered because of budgetary problems arising from the 1972 devaluation (Herrman 1974: 3).

of potatoes and garden vegetables have also been controlled since the late 1950s, though probably not very successfully (Gardner 1974; Wennergren and Whitaker 1975: 95).

Just how much could agricultural production be expected to increase if all price controls, import subsidies, and quantitative restrictions were removed? Herrman (1974: 1) argues that "the rate of growth of agricultural output would increase appreciably"; but statistical investigations of the supply response capability of Bolivian agriculture (using admittedly poor data) suggest that the aggregate supply response would be rather modest, in large part because most farmers have access only to traditional technology (Whitaker 1975: 16). Higher prices paid to farmers might be considered as a means of increasing output of specific crops whose supply elasticity seems fairly high (e.g., rice, sugarcane, and cotton), but this might be accomplished only at the expense of other crops. In Whitaker's view, the most promising approach to increasing aggregate supply is not price manipulation but rather "investments in improving factor and product markets and research and extension services" (1975: 19).

Credit 61/

The adoption of modern production inputs has been limited by the low volume of credit available to Bolivian farmers. Moreover, the heavy concentration of credit among medium- and large-scale farmers has restricted technological change among the *campesinos*. Even among larger farmers, marketing credit sometimes exceeded production credit (Deere 1971).

61/ For a detailed examination of agricultural credit in Bolivia, see Ladman, Tinnermeier, and Torrico (1977).

Table 11 shows agricultural credit trends between 1966 and 1975. At the beginning of the period, the annual flow of bank credit to the agricultural sector was $b.126.6 million. During the next 2 years this already low volume of credit was cut by about 60 percent, and it was not until 1971 that the 1966 volume was attained again even in nominal terms; in real terms the recovery was not complete until the following year.

Between 1971 and 1974 nominal agricultural credit nearly quadrupled; but the real increase was much less, and after reaching a peak in 1973 real agricultural credit fell by 32 percent during the next 2 years. Still, real agricultural credit in 1975 was 52 percent higher than in 1966. The nominal 1975 figure of $b.610.8 million was equivalent to US $30.5 million.

The increase in agricultural credit between 1966 and 1975 was due mainly to an expansion of activity by the government-owned Banco Agrícola de Bolivia (BAB), which during 1973-73 accounted for 63 percent of all bank lending to agriculture. The remainder was split between the Banco del Estado and private commercial banks. 62/ The informal credit market is thought to be important, but observers are reluctant to attach a figure to it.

62/ Unfortunately, data on annual credit flows by type of institution are incomplete. Data on year-end portfolio balances suggest that the Banco del Estado was twice as important as private commercial banks during 1973-75; but since the Banco del Estado had higher delinquency rates, its relative importance is overstated (Ladman, Tinnermeier, and Torrico 1977: 20-31).

TABLE 11

ANNUAL AGRICULTURAL CREDIT VOLUME, 1966-1975
(millions of pesos)

A. Current Prices

Year	Total Bank Credit	Agricultural Credit			Agricultural Credit as a % of the Total
		Total	BAB[a]	Other[b]	
1966	600.1	126.6	36.2	90.4	21.1
1967	632.5	46.3	41.7	4.6	7.3
1968	754.5	53.4	39.5	13.9	7.1
1969	837.6	95.5	79.1	16.4	11.4
1970	886.0	92.3	68.6	23.7	10.4
1971	1,051.3	158.0	69.3	88.7	15.0
1972	1,854.5	245.3	149.6	95.7	13.2
1973	2,756.1	506.9	321.5	185.4	18.4
1974	3,611.0	611.2	404.5	206.7	16.9
1975	3,777.1	610.8	350.2	260.6	16.2

B. Constant (1966) Prices[c]

Year	Total Bank Credit	Agricultural Credit		
		Total	BAB[a]	Other[b]
1966	600.1	126.6	36.2	90.4
1967	568.9	41.6	37.5	4.1
1968	643.3	45.5	33.7	11.8
1969	698.7	79.7	66.0	13.7
1970	711.5	74.1	55.1	19.0
1971	814.3	122.3	53.7	68.7
1972	1,348.6	178.4	108.8	69.6
1973	1,524.1	280.3	177.8	102.5
1974	1,226.4	207.6	137.4	70.2
1975	1,188.1	192.1	110.1	82.0

Source: Ladman, Tinnermeier, and Torrico (1977: 23 and 36).

[a]Banco Agrícola de Bolivia.

[b]Banco del Estado and private commercial banks.

[c]Based on the Consumer Price Index for La Paz.

The Banco Agrícola de Bolivia was founded in 1942 and reorganized in 1954 as a development bank which was to give priority to campesinos, either as individuals or organized into cooperatives. Even in the years immediately after the reorganization, however, campesinos benefited little from the presumed reorientation of policy. In 1955, for example, campesinos received 463 loans, 32 percent of the total number but only 6 percent of the total amount; the remaining 94 percent went to 989 medium- and large-scale commercial farmers (Royden 1972: 36).

During the 1960s the campesinos' already low share of BAB loans began to decline. By 1971 only 97 loans, for US$ 49,000, were made to individual campesinos (compared with 421 loans for US$ 274,000 in 1965). For the period 1964-71, individual campesinos received only 3.5 percent of the volume of BAB lending. Other campesinos benefited as members of cooperatives, which received 30.8 percent of the loan volume during this period; but these cooperatives included medium- and large-scale farmers, and the amount received by campesino cooperatives seems to have been relatively small. The BAB's latest Memoria (No. 31-32), covering the period July 1973 - December 1975, shows that individual campesinos received less than 3 percent of the credit made available. The share of cooperatives was down slightly to 29.3 percent.

The BAB's nominal loan volume, as shown in Table 11, rose from an average of $b.39 million during 1966-68 to $b.359 million during 1973-75.

Much of this increase has been made possible by loans from AID and other international lending agencies. Both the BAB and the Banco del Estado have also taken advantage of rediscount funds established in the Central Bank under foreign loans. 63/

Lending by the BAB has been highly concentrated not only by farm size but also by geographic region and by product. During 1968-73, 84 percent of all loans went to the Oriente, with the balance evenly split between the Altiplano and Valles. For the period July 1973-December 1975, the Oriente's share rose to 87 percent.

Fifty-four percent of the loan volume during 1968-72 went for cotton and livestock production, with medium- and large-scale farmers getting virtually the entire amount. A few small farmers benefited from the 30 percent of loan volume in that period made available for sugarcane and rice. In the more recent 30-month period, the concentration of loans was even greater, with 65 percent going to cotton and 14 percent to livestock. Credit policy and other policies favoring large ranchers, it has been argued, threaten to squeeze small ranchers (Asociación de Consultores 1975, Vol. III, p. 133; R. Clark 1974).

63/ During 1967-71, use of the discount facility by the Banco del Estado for agricultural lending averaged US$ 0.7 million annually (Royden 1972: 28).

During the 1960s, the BAB had become quite disillusioned with its loans to campesinos and campesino cooperatives, whose repayment record had been poor 64/ because of inadequate technical assistance and weakness in the structure and management of the cooperatives (Royden 1972: 50-56 and passim.; USAID/Bolivia 1974: 68). The Bank argued that a separate institution was needed to make supervised loans to campesinos. As Royden points out, the BAB had a point: although it was the only development bank in the hemisphere not subsidized by the central government, as a public entity it was not free to operate on a strictly commercial basis. The average loan to campesinos during 1965-71 was only about US$ 600, but the BAB's break-even point was said to be US$ 6,000 65/ (Royden 1972: 44-45, 50-53, 64).

64/ Rescheduling and delinquency rates (percent) during 1964-71, based on loan amounts, were as follows (Royden 1972: 54):

Class of Borrower	Rescheduling	Delinquency
Ranchers	59.0	27.1
Cooperatives	54.3	19.1
Farmers	47.7	13.5
Farmer-Ranchers	43.6	16.6
Associations	25.6	10.5
Cooperatives	77.1	6.5

The BAB had little success in its efforts to improve the repayment record of ranchers, whose political power was considerable.

65/ Based on a study by Fernández Baca (1975). This figure seems somewhat high, given the relativly poor supervision provided, and it suggests the possibility of overstaffing or inefficient use of staff in the BAB.

Given the conditions under which credit was available from the BAB, and the perceived risks of using modern inputs, many small farmers found credit and technological change unattractive:

> If the crop fails, the farmer is immediately faced with total loss of his working capital plus a very punitive attitude from the Bank which wants to embargo his few remaining assets such as farm animals, pledged as collateral.
>
> Faced with this prospect the campesino would rather not gamble with modern inputs (Royden 1972: 62).

Small farmers have few other sources of credit, and those which are available are not always well utilized because of inadequate technical assistance. Commercial banks will not lend to campesinos, who cannot pledge their land as collateral; and supply houses (with one exception) will sell to them only on a cash basis (Royden 1972: 77-80). A small loan fund for campesinos, channeled by AID through the credit union federation, was not very successful (ATAC 1971). The national petroleum organization (YPFB) started a loan program for fertilizer purchases in 1968 but abandoned it in 1972 after experiencing a repayment rate of only 58 percent. There was very little supervision of these loans, which often were made without market analyses or benefit-cost calculations (Royden 1972: 75-78). Credit is available from private intermediaries (rescatadores) in the informal market, but the interest rate charged generally ranges from 8 to 10 percent a month (Pou 1972: 28; Royden 1972: 77-80).

Large farmers in the Altiplano and Valles have some access to credit from commercial houses, but private banks in these regions make few agricultural loans. In Santa Cruz, however, the story is quite different. Of the US$ 8.1 million in agricultural and livestock loans made by private banks in the first 9 months of 1974, 66/ Santa Cruz accounted for approximately 90 percent (Federación Departmental de Empresarios Privados de Santa Cruz 1975: 110-111). Like the BAB, private banks have particularly favored cotton and livestock. Credit from commercial houses is probably also important, but the amounts involved are not known.

The current 5-year agricultural plan calls for a sharp increase in BAB credit, from US$ 14.7 million in 1976 to US$ 110.0 million by 1980 (see Table 12). Most of the increase is expected to come from external loans which recently have been signed or are being negotiated. Significant changes are expected to occur in both the regional and commodity distribution of loans, and campesinos are scheduled to get a much higher share of the loan volume. With regard to specific crops, the most dramatic changes planned are (1) a precipitous decline in the proportion of lending for cotton (which has already occurred because of unfavorable market conditions) and (2) a significant increase in the relative importance of potatoes, which are to go to the head of the list with one-fourth of all BAB lending during the plan period. In addition to the latter development, small farmers in the Altiplano and Valles would benefit from greatly increased lending for horticultural crops.

There is reason to be concerned about several aspects of this planned increase in credit. First of all, it imposes a considerable management burden on an institution which up to the present has had

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66/ On an annual basis, this would amount to $10.8 million. During 1963-70, annual lending by private banks for agriculture and livestock had averaged less than US$ 2 million. The sharp rise began in 1971. Note that these figures are higher than those suggested in Table 11.

TABLE 12

PROJECTED LENDING BY THE BANCO AGRÍCOLA DE BOLIVIA
UNDER THE 5-YEAR PLAN, 1976-1980

	1976	1977	1978	1979	1980	1976-1980
	millions of U.S. dollars					
Total Lending	14.7	88.7	108.7	106.7	110.0	428.8
Domestic Financing	10.3	26.6	27.5	22.5	22.5	109.4
External Financing	4.4	62.1	81.2	84.2	87.5	319.4
	percentage distribution					
All Commodities	100.0	100.0	100.0	100.0	100.0	100.0
Sugarcane	37.5	9.8	8.5	9.2	9.5	10.2
Cotton	6.9	13.0	10.9	11.5	11.5	11.5
Coffee	0.1	1.3	1.1	1.2	1.3	1.2
Peanuts	0.7	0.6	0.8	0.8	0.8	0.7
Soybeans	5.7	6.7	7.4	10.2	13.4	9.4
Wheat	4.0	1.3	1.4	2.0	2.4	1.9
Barley	1.5	1.0	1.2	1.2	1.6	1.3
Rice	14.0	2.6	2.6	3.1	4.0	3.5
Potatoes	3.2	27.5	25.7	26.3	25.6	25.4
Garden Crops	1.4	4.9	5.6	5.8	5.7	5.4
Grapes	3.1	2.4	2.2	2.5	2.8	2.5
Pulses	0.4	0.3	0.6	1.2	1.1	0.8
Yellow corn (hard)	6.2	3.4	2.8	2.5	2.5	2.9
Fruit	0.5	0.2	0.2	0.3	0.3	0.3
Cattle	3.4	19.6	21.3	14.3	7.5	15.1
Sheep	-	2.3	3.8	3.8	3.7	3.3
Pigs	-		1.3	1.4	3.6	1.6
Poultry	1.0	1.0	0.8	0.8	0.8	0.8
Milk	-	0.3	0.2	0.2	0.2	0.2
Forestry	10.3	1.8	1.6	1.7	1.8	2.0

Source: Bolivia, MACA, 1976: 175-176.

a difficult time effectively administering a much more modest budget. Secondly, previous experience with loans to small farmers indicates that close supervision is required, and the BAB will find it difficult, even with technical assistance, to provide either the quantity or the quality of extension work needed for effective utilization of these loans. Thirdly, the strong emphasis on potatoes is questionable, since it is based on the presumption of a large export market ($28.8 million in 1980) whose existence may be doubted. If this market does not exist, or is much smaller than presumed, increased lending to raise potato yields (while keeping land area in potatoes constant) could lead to falling prices, making it unattractive to use modern inputs.

Recent AID loans (see Table 9) are attempting to deal with the administrative obstacles to greatly increased agricultural lending in several ways. First of all, much of the technical assistance associated with AID-financed credit programs will be provided by the Community Development Service (SNDC), which will also promote the formation of cooperatives and other small farmer groups. Loans to such groups should require significantly lower administrative costs than loans to individual farmers. Secondly, to ease administrative burdens on the BAB, some AID loans are being channeled through rediscount funds in the Central Bank, on which private banks (as well as the BAB) can draw, or directly through the Banco del Estado, a 1970 offshoot of the Central Bank. It is hoped that these loans will increase the number of small-farmer credit subjects from less than 1,000 to 40,000. Disbursement of AID loans is proceeding slowly, however, and the targeted number of beneficiaries may prove to be much too ambitious.

Agricultural Education

Agricultural education at all levels is seriously deficient in both quantity and quality (Chirikos et al. 1971; Comitas 1968; ILO-PREALC 1975; Musto 1973; Wennergren and Whitaker 1975: 238-249). Illiteracy is high--an estimated 83 percent of the rural population 15 and over in 1972--and primary and secondary curricula, with few exceptions, are more academic than vocational. Enrolment figures for 1969 indicated that only 40 percent of the 6-14 age group in rural areas was in primary school, and only 2 percent of the appropriate age group was in secondary school. 67/ Dropout rates were high nationally and probably much higher in rural areas than in the cities. 68/ A survey of parents' attitudes revealed that 78 percent of all parents perceived the value added of additional education to be zero or negative at some point between grades 1 and 6 (Wennergren and Whitaker 1975: 242).

Low levels of educational attainment are not particularly surprising. Even though the government spends a relatively high share of its budget on education, the total budget is limited by the country's low level of development. Available resources could be better utilized to meet development objectives, but Bolivia's emphasis on academic rather than technical skills is not at all unusual for a less developed country.

Emphasis on academic skills carries over into university training. Space and equipment for teaching technical skills are limited. Only

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67/ Actual figures were higher because (1) population in the 6-14 age group was overestimated and (2) some rural residents attended school in nearby urban areas. Still, enrolment rates among rural residents lagged well behind those of city dwellers.

68/ Nationally, only 22 percent of those starting the first grade in 1963 were in the sixth grade in 1968.

10 percent of the faculty in the early 1970s was engaged in research of their own, and just 17 percent had any training outside Bolivia (Wennergren and Whitaker 1975: 248). Few courses were available in agricultural economics or rural sociology. The great majority of the agricultural technicians in the Ministry of Agriculture and other government agencies were judged to be incapable of dealing with basic management problems in crop and livestock production (Farnsworth and Michaelsen 1973).

As in most less developed countries, agricultural education in Bolivia has had a low status. The low salaries of agricultural technicians limit the supply of high school graduates interested in university studies in agriculture. However, effective demand is also low, and in terms of numbers of technicians the supply has more than kept up (Cosío M. 1971). If agriculture had a higher priority in national development programs, of course, considerably larger numbers of agricultural specialists could be utilized. But for investment in additional specialists to be productive, university programs will have to be restructured.

Some steps have already been taken in this direction. Physical facilities have been improved through loans from the IDB, and AID has financed technical assistance for upgrading and supplementing teaching staff. Future graduates will be better trained, but the government will have difficulty hiring or retaining them unless salaries are significantly increased.

Attention should also be given, of course, to altering the structure of basic primary and secondary education. Again, some movement in this direction is evident; but whether it will be productive, or suffer the fate of previous reform efforts, remains to be seen.

Improved Livestock Management

Bolivia now exports some beef and live cattle, but export supplies—and meat for domestic consumption—could be increased considerably with improved livestock management. The government has sponsored some livestock research, but the results have been disappointing. The Planning Board has attributed this to inadequate funding, a shortage of trained technicians, and lack of continuity (Bolivia, CONEPLAN, 1973: 3, 18). Improved pasture management, in its view, could result in a tripling of cattle herds (p. 13). According to another estimate, reported by Ruff (1974: 11), Santa Cruz Department alone could support an additional 8 million cattle, or more than twice the national total of 3.6 million in the early 1970s. The Beni, according to Nelson (1973: 135), could support 5 million head. Export markets exist in Brazil, Chile, Peru, and in more distant countries, but large-scale exporting will require improvements in quality.

Increased production to date has been based on the opening of new lands and the importation of improved breeds. Little has been done, however, to combat hoof-and-mouth disease (aftosa), rabies, and brucellosis. Locally produced aftosa vaccine was sufficient to immunize only 2 percent of Bolivia's cattle in 1975, and the other vaccines were not produced at all. 69/ The 1976-80 Plan (Bolivia, MACA, 1976: 127) calls for domestic production of most vaccine requirements by 1981. Technical assistance for this ambitious program was received from the IDB in 1974.

69/ In 1970, 3,700 doses of anti-brucellosis vaccine were produced in Bolivia "but not sold or used because of lack of promotion and lack of education among ranchers, who were ignorant of or undervalued the benefits of preventive treatments" (Bolivia, MACA, 1974: 363). However, 13,000 doses were imported that year, which suggests that there were administrative problems with the government's program.

Pasture management is perhaps even more deficient for sheep, llamas, and alpacas than for cattle. Overgrazing, as noted earlier in this paper, is a serious problem. With improved practices, the existing output of meat and wool could be produced at lower costs to the farmer, while external costs in the form of erosion and flooding would also be reduced. Significant increases in production, however, require not only greater attention to supply factors but also to the solution of marketing problems which limit the effective demand for meat and wool. 70/

EXPLAINING TECHNOLOGICAL CHANGE

Rice's contention (1974: 245) that an extension organization is neither a necessary nor a sufficient condition for economic advancement in rural areas is generally supported by the available evidence for Bolivia. For example, though Rice assigns an important role to the extension service in the Department of Santa Cruz (1974: 359-360), rising incomes for many families can be attributed largely to knowledge of domestic and overseas market opportunities obtained from other sources. In the Cochabamba Valleys, favorable location with respect to major urban markets stimulated a switch to cash crops and to increased use of modern inputs shortly after the land reform, even in communities where there was little or no contact with extension personnel (Dorsey 1975a: 77; Dorsey 1975b: 84-86).

70/ The poor quality of the wool is a supply problem; but even if this is solved marketing problems would make it difficult for Bolivia to compete in world markets.

A more detailed examination of extension successes and failures is useful both to support this position and to identify other specific factors related to the effectiveness of the extension service in Bolivia. Let us look first at those cases where the work of the extension service is said to have been successful.

Utah State University extension adviser Leon Michaelsen (1975a: 18, 22-24) has identified 6 examples of productive extension work:

(1) The 4-H program, which generally can be considered a failure, was highly successful in the community of Coimata in the Department of Tarija. In 1964, fourteen 16-year-old boys obtained 2 hectares of rocky land which they cleared and then planted with trees. By 1973 they had sold \$b. 20,000 worth of timber, and their original stand was worth \$b. 110,000. They had also made a second, larger, planting; added to the community school; built a 500-meter canal to irrigate 50 hectares; constructed a community recreation facility; and built a 1 1/2-km. access road. Their sheep herd was community-owned and grazed under conditions of pasture rotation, two developments which appeared to be unique in Bolivia. Unfortunately, it is not clear <u>how</u> the local extension advisor was able to stimulate such a remarkable amount of change. Nor is it clear if credit or other non-extension inputs played crucial roles.

Michaelsen does provide, however, an interesting comment on 4-H work generally: several older extension workers, he notes, reported that many former 4-H leaders had assumed leadership positions in community affairs or in the <u>sindicatos</u>. The importance of this phenomenon is not clear, but it is possible that it is more significant than assumed by Rice, who did not examine the results of extension work with 4-H clubs (or homemakers). This might be an interesting thesis topic for a Bolivian student in rural sociology.

(2) Extension agents' reports indicate the extension service played an important role in forming associations of cane, rice, and coffee growers, which have been active in marketing these 3 crops. Cooperatives, such as the PIL Dairy Cooperative in Cochabamba, were also assisted. Some of these groups, under extension leadership, built schools, dams, water systems, and roads. This seems to be a clear example of the kind of _fomento_ work advocated by Rice and strongly supported by Michaelsen (1975c).

(3) In the community of Comarapa, the extension agent promoted an expansion of irrigation and the introduction of tomatoes as a new crop. Income "doubled and redoubled manifold."

(4) An agent in Tarija used group dynamics techniques to establish a new grape industry and several wheat cooperatives in his zone. The extent of the benefits to farmers, though, is not made clear.

(5) In the Pampa Lequezama area in Potosí, an extension agent organized a cooperative and put together an area development plan supported by other agencies, including the nearby experiment station. Average _campesino_ earnings reportedly rose from $b. 1,000 to $b. 24,000 annually.

(6) In 1973 extension service personnel were used to screen loan applications for soybean production in Santa Cruz, and then to supervise loan implementation on some 15,000 hectares. Farmers' willingness to pay for the extensionists' gasoline suggests that the inspection visits were valued.

Examples of successful technical assistance have been noted by several other writers:

(7) A Master's Thesis by Mendoza M. (1970) reports that the extension agent in Tomino Province, Chuquisaca, stimulated the adoption of new techniques through effective teaching methods and repeated exposure of campesinos to new ideas. The most widely adopted practices were (a) control of household insects, (b) livestock castration, (c) control of external parasites in sheep, (d) control of internal parasites in sheep, and (e) use of chemical fertilizers. The extent to which campesinos benefited from these new practices, though, is not clear.

(8) Kornfeld (1969) notes that campesinos in Capinota (Cochabamba) were buying metal-tipped plows from a store operated by the local extension agent. They were also using fertilizer, with "excellent" results. Though quantitative information was not provided, incomes seemed clearly to be rising. Carrots, beets, and grapes were the chief cash crops, though other crop and livestock products were also marketed. The precise role of the extension agent is not clear, and rising incomes may be due in large part to favorable location on the road between Cochabamba and Oruro.

(9) Pou (1972: 24-39) describes the activities of extension personnel associated with the Patacamaya Experiment station in southern La Paz Department. A decision was made in 1966 to establish a regional Development Area, and by 1970 extension agents had helped organize 21 production cooperatives. Extension agents were clearly acting as fomentadores, concentrating on the promotion of improved seeds, fertilizer, irrigation, and machinery, the purchase of which was financed with money borrowed from

the Banco Agrícola de Bolivia. 71/ A central agency was established in 1969 to provide educational and marketing services; management was controlled by extension personnel but eventually was to be transferred to the cooperatives themselves. Pou's linear programming model indicated that the prospects for significantly increased income in the Development Area were good. What has actually happened, however, is not known.

These reports of extension successes can be offset by a number of cases where extension service efforts have been judged unproductive. Again we may start with Michaelsen (1975a: 27-29):

(1) Work in the Challapata area (Oruro) was considered successful by some observers because campesinos were selling alfalfa at very high prices. But Michaelsen considers this extension effort a failure because much higher incomes could be attained by consolidating output on the best soils, mechanizing production, and ceasing to use alfalfa to build up unproductive sheep herds.

(2) The cooperative "Exaltación" had a good herd of purebred sheep with a high lamb crop (70-90 percent). As a cooperative activity, this venture seemed to be quite profitable. However, only because of plentiful rainfall was production of alfalfa sufficient to avoid the loss of many lambs in 1973; availability of supplemental feed, in other words, was not being carefully planned. Furthermore, even after 10 years individual cooperative members were still grazing criollo sheep and not planting alfalfa on their private plots. A cooperative dairy enterprise was unprofitable. The reasons for this incomplete assimilation of new techniques are not made clear.

71/ Machinery purchased by these cooperatives included tractors, plows, harrows, motors and pumps, sprayers, sorters, and wagons (Pou 1972: 29).

Michaelsen adds the example of an individual campesino in the Patacamaya area and also notes that extension efforts generally were not effective in inducing campesinos to adopt such practices as better sheep shearing, construction of dippiug vats, and animal health measures. Excess livestock numbers led to destruction of many new seedlings of alfalfa and pasture. Most of the required changes, he argues (pp. 28-29) "depend on community action and an integrated program in managing range and livestock". One can view Michaelsen's examples, however, as a glass that is half full, not half empty. In both of the two communities he describes, incomes seem to have increased with the adoption, however incomplete, of new practices. Michaelsen would be correct in using the term "failure", however, if the benefits obtained were only temporary (as seems possible) or if extension efforts with sheep have neglected to deal with obstacles in marketing (as seems quite likely).

Other reported failures include the following:

(3) Leonard (1966: xiii) reports that 2 Altiplano communities receiving technical assistance, one in La Paz and one Potosí, did little to shift to new crops or adopt new practices because extension agents frequently changed, emphasized different crops or practices, and lacked a long-run vision or plan.

(4) Barnes de Marschall (1970) notes that extension agents were active in the Yungas region of the Department of La Paz but had little success in getting campesinos to adopt new methods of production. One suspects that high transport costs, which raise input prices and lower farm gate prices, may have acted as a disincentive.

(5) Camacho Saa (1970: 197) reports that extension efforts in the Lower Cochabamba Valley met with little success because of low budgets, poorly qualified agents, and a failure to concentrate on specific projects. In 2 of the communities he studied, the extension service had carried out fertilizer trials, successfully in one case but not in the other. Fertilizer use was higher in the former than in the latter, suggesting extension effectiveness in this one instance.

(6) Ugarte (1971), who studied 3 communities in Tarija, attributed the slow adoption of new techniques both to campesinos' fears of risk-taking and to communications problems with the local extension agent, who confined his efforts to large-scale demonstrations and did not visit individual farmers. Farmers reportedly were aware of production costs for corn, the principal crop, but not for alternative crops such as wheat and potatoes.

(7) Simmons' study of 2 communities in the Upper Cochabamba Valley (1974: 95-98) found that farmers generally did not buy improved seeds from a nearby experiment station because the seeds were expensive and the farmers feared going into debt. An extension agent who had visited one of the communities was not trusted; Simmons attributed this to ignorance, which local sindicato leaders wanted to maintain for manipulative reasons. A Peace Corps Volunteer stated that local extension agents were condescending. Extension had had little impact in the 2 communities studied.

(8) Rice (1974: 232-238, 319-324) also studied the Upper Cochabamba Valley, whose 4 extension offices, established in 1951-52, were among the first in Bolivia. Like Simmons, Rice found that political factors affected the extension service's work. Agents frequently had been

withdrawn from all 4 offices, and the Cliza office had been closed nearly 50 percent of the time since it was first opened in 1951. Notwithstanding these difficulties, the extension input in the Upper Valley was probably greater than in any other area in Bolivia. Of the 114 villages for which information was obtained, however, the percentage classified as "progressive" was not particularly high in comparison with 6 other regions in Latin America subjected to the same analysis. Furthermore, the extension service had made a "concentrated" effort in less than half of the progressive villages, 72/ which included some of the politically volatile communities where extension agents were unable to work.

Rice found that the level of technology in the Upper Valley had remained quite low. Little chemical fertilizer was used in potato production (though in the more progressive higher-elevation lands greater use of fertilizer was directly tied to work by extension agents). A government plan to increase wheat production in the Upper Valley, based on improved seeds and fertilizer, fell far short of its goals. In Rice's view:

> The lesson of the extension experience in the Upper Valley is consistent with findings in the other study districts. In short, it is that extension cannot sell an unprofitable technology [wheat], or, without the help of credit, a high cost technology of relatively low profitability [potatoes], and that there are no costless improvements which extension can offer that will significantly change the landscape (p. 323).

72/ Of the villages in which a concentrated effort was made, however, 73 percent were progressive.

(9) Urioste de C. (1976) reports that extension agents in the Northern Altiplano were providing good technical advice, but campesinos were reluctant to adopt modern inputs because government price policy made their use unattractive. This is a good example of how failure to coordinate government policies can make extension work ineffective.

(10) Finally, we may note that many of Bolivia's directed colonization projects had significant extension inputs, with disappointing results. Much of the extension advice appears to have been poor (failure to learn about local soil conditions, lack of attention to crop marketability, etc.). Given the abundant supply of land and the high marketing costs faced by many of the colonists, concentration on subsistence farming with slash-and-burn techniques may have been rational economic behavior. If extension agents had worked within this framework, their advice might have been more useful to farmers.

It is clear from our review of successes and failures that close coordination between extension and other activities is important if extension work is to succeed. In some cases, individual extension agents can put together a "package" on their own; most of them, however, lack the training in economics necessary to take advantage of existing opportunities and to avoid promoting crops or inputs with unfavorable benefit-cost relationships for the particular farmers with whom they are working. Extension personnel have recently been exposed to some training in economics and other social sciences, but this training needs to be increased and institutionalized.

Even the extension agent who is well aware of economic relationships will have a difficult time promoting income-increasing innovations if extension activities are not coordinated with other government policies and programs at the national level. Wheat policies are the most glaringly inconsistent, but policies toward other commodities are also out of harmony. Something is surely wrong, for example, when a country can accumulate a 3-year stock of rice with almost no capacity to export. Fertilizer and other inputs will continue to face limited demands unless steps are taken to lower their prices, reduce farmers' marketing costs, provide credit, and ease restrictions on the prices of farm output. These kinds of decisions are beyond the extension agent's control and must be made at a higher level. Meanwhile, if extension agents are promoting unprofitable crops or inputs, either on their own or because of instructions from a higher level, campesinos are likely to have little confidence in the extension service and will look elsewhere for advice on how to improve their economic situations.

One major survey of small farmers (Methodist Church in Bolivia 1972: 49-50) has indeed shown that the extension service is far from being the preferred source of technical assistance. Of 470 farmers interviewed in 10 colonies north of Santa Cruz, 43 percent said they would go to their neighbors if they needed technical advice; 23 percent would go to their cooperatives; 12 percent would go to the experiment station (at Saavedra), and only 9 percent would go to the Ministry of Agriculture (extension service). 73/ Findings such as these tend to support Rice's contention that a government extension institution is not indispensable. Also supporting this position

73/ Four percent said they would go to commercial houses and the remaining 9 percent to other sources of assistance.

are examples of successful extension work reported for such institutions as the Community Development Service (SNDC) and DESEC, a private community development organization (Morss et al. 1975: Vol. II, pp. G.1-G.35).

Most recent studies of small farmers in Bolivia indicate that technical assistance is desired, and in some communities there are strong complaints about not receiving it. Many campesinos, however, are reluctant to initiate contacts with extension agents, just as the agents themselves sometimes do not take the initiative. Effective communications are very important in extension work, as the success/failure stories described above have shown. Michaelsen (1975a: 1) argues that "because of indigenous situational differences a powerful educational-change program at the campesino level is the most critical of development inputs."

Breaking down obstacles to communication will not be easy. Extension agents can benefit from human relations training, but they also need better technical information to communicate. Many communities are suspicious because of unsatisfactory experiences with government-promoted cooperatives in the 1950s. In other communities, political obstacles inhibit communication. A language barrier often exists and is difficult to overcome without Quechua- or Aymara-speaking extension agents. Given these obstacles, plus the restrictions on economic potential imposed by government price policy, transportation costs, etc., it is unrealistic to expect that the extension service could be effective in every rural community. Concentration on a small number of carefully selected communities seems desirable, especially if a significant increase in the extension service budget does not seem possible.

Michaelsen (1975c) recommends that the extension service concentrate its efforts in the Altiplano and Valles. There is much merit to this suggestion, since the extension function in the Oriente is already being performed by the Banco Agrícola de Bolivia, commercial houses, cooperatives, and other institutions which do not have much of a presence in the highlands. True, many small farmers are not direct beneficiaries, but communications within the Oriente seem to be much better than elsewhere.

Michaelsen believes that extension work has potentially high payoffs if it emphasizes the formulation of regional development plans and works with a few pilot communities or cooperatives in each region. Unlike Rice, he would promote the strengthening of the extension service to make it a viable institution. Nevertheless, he calls for an integration of extension, research, and community development activities and the development of linkages with other institutions, public and private. Utah State economist Morris Whitaker also supports a greater extension effort, arguing that Bolivian agriculture would be more responsive to investment in research and extension than to an increase in agricultural prices (1975: 19). 74/

The key input for achieving technological change in Bolivian agriculture, however, may not be extension, but credit. In summarizing

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74/ The Bolivian government itself has argued that the country lacks the marketing and storage infrastructure necessary for an effective price-support policy (Bolivia, MINPLAN, 1970: 175-184).

his findings from detailed studies in 6 countries, Rice (1974: 326) notes that

> extension agents, fertilizer dealers, and most other observers are quick to attribute to credit the leading role in explaining dramatic surges in the use of purchased inputs, or to the absence of credit the lack of such progress. . . . The coincidence and close phasing of credit inputs, on the one hand, and the growth in fertilizer consumption, on the other hand, is evidence that most peasant farmers require credit before they accept technologies that cost them money (emphasis added).

If this assessment is accurate, the increased credit that will be available to Bolivian campesinos in the coming years bodes well for greater use of modern inputs and rising incomes. It is well to remember, however, that past experience with campesino credit in Bolivia has not been good. This suggests that extension activities should concentrate heavily on those crops and geographic areas that will benefit from the new loan programs.

MINIFUNDIOS AND FRAGMENTED HOLDINGS AS OBSTACLES TO TECHNOLOGICAL CHANGE

Both the Altiplano and Valles are characterized by the predominance of minifundios of 5 hectares or less. 75/ Inheritance practices have resulted in the further subdivision of already small plots received under the Agrarian Reform law.

Fragmentation of landholdings is common. In the Upper Cochabamba Valley, Camacho Saa (1967) found that campesinos in Ucureña usually

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75/ For details on the distribution of landholdings, see Zuvekas (1977a).

had 2-4 separate plots. All families in the 3 communities studied by Peinado Sotomayor (1971) had more than one plot. The degree of fragmentation in the Northern Altiplano is even greater. Métraux (1959: 236), for example, reports that

> in the Conima region on the east shore of Lake Titicaca the peasants told me that there is not a single holding that is not broken up into 15 or 20 plots. Many . . . complain that they only own isolated furrows located a great distance apart.

Carter (1963) found that campesinos in Aymara communities, in addition to their basic landholdings (sayañas) of perhaps 6-8 hectares (Burke 1971: 316) 76/ had extremely fragmented holdings on the adjacent aynoka lands. These separate plots (kallpas) averaged only 0.10-0.15 hectare, and an individual family might have up to 90 separate plots on 3 or more aynokas (as reported in Wiggins 1976: 25).

Fragmented holdings are usually considered detrimental to productivity even with very rudimentary technology. However, Dorsey (1975a) has challenged this view, at least for Bolivia. In commenting on Peinado Sotomayor's proposals for consolidating fragmented holdings in order to reduce costs, Dorsey argues:

> In fact, such costs either do not exist or are of negligible importance in many areas of Bolivia. Fragmented holdings may actually benefit campesinos since spreading the farming operation over several locations creates some diversification of risk,

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76/ The sayañas were sometimes held by extended families rather than nuclear families.

> especially where frosts and other climatological phenomena are localized. It also permits growing different crops on land most suited to their production: irrigated land for an "early" crop of potatoes, corn and broad beans on unirrigated land, wheat and barley on drier land at a higher elevation. Where such costs are significant, one would expect to find campesinos selling and buying or exchanging plots to consolidate holdings, something not observed on Toralapa or anywhere else in the areas of Bolivia most affected by the reform.

Dorsey's argument, while correctly pointing out that fragmentation can have some advantages in communities with different types of land, ignores non-economic reasons for the existence of fragmented holdings and the difficulties involved in changing land tenure patterns. Moreover, his argument seems less valid for the Northern Altiplano than for the Upper Cochabamba Valley. It would be difficult to provide an economic justification for extreme fragmentation under any circumstances.

While there may be no significant economies of scale with traditional, rudimentary technologies (Burke 1971: 313; Camacho Saa 1967), fragmented holdings, and the diversified production patterns they imply, may seriously limit the ability of farmers to adopt modern technologies. If the alternative technologies we might consider are restricted to non-mechanized types involving the use of improved seeds, chemical fertilizers, pesticides, and possibly irrigation, there may well be no significant economies of scale <u>for the producer</u>, at least if the comparison is made between "large" <u>minifundistas</u>, on the one hand, and medium- and large-scale farmers, on the other. However, widespread adoption of such technologies requires credit and technical assistance, the provision of which <u>is</u> characterized by declining unit costs as farm size increases. This implies the presence of what might be called social economies of scale. These will not be apparent at the farm level if the differential costs of credit, and all costs of technical assistance, are absorbed by the providing agencies. 77/

These social economies of scale (and sometimes presumed production economies) have prompted numerous observers to argue in favor of some form of communal or cooperative system of production which groups together a large number of campesino families into a single unit (Asociación de Consultores 1975: Vol. V, pp. 6-10; Bolivia, MACA, 1976: 56-57; Chueca Sotomayor 1974; Coronel 1973; CORDECO 1975a: 184, 191-196 and 1975b; Díez de Medina 1975: 169; Ferragut 1963: 150-151 and 1964; Gandarillas and Bustillo 1970; Larrea Cadena 1975; Michaelsen 1971 and 1974; Moller 1962; Zeballos Hurtado 1959; and the Bolivian government promoters of the Patacamaya area development scheme as reported in Pou 1972: 26-29). Such proposals deserve serious consideration if production economies exist, or if they can stimulate the provision of the credit and technical assistance that might not otherwise have been forthcoming because of the diseconomies of dealing with individual campesinos.

Anthropological and other studies, however, suggest that the basis for communal or cooperative farming in Bolivia is not as strong as has often been presumed. Cultivation in the "free communities" is based on individual plots, and there seems to be little cooperative work in Aymara communities outside the confines of the extended family (Buechler, in

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77/ This is a hypothesis which will have to be tested by field research. Included in the hypothesis is the presumption that there are economies of scale for these technologies as one moves from "small" to "large" minifundistas.

Heath, Erasmus, and Buechler 1969: 169-170, 238; Carter 1963 and 1965; Heath 1973: 84-85; and Urquidi 1970: 149). Michaelsen's survey of farmers' attitudes in the Altiplano community of Caracollo revealed negative attitudes toward cooperative sheep raising (1975b). Simmons (1974: 70) reports that there is little use of cooperative labor in the Upper Cochabamba Valley community of Palca. Díez de Medina (1975: 159-169) found no truly cooperative work effort among small sugar growers in Santa Cruz, even though 77 percent thought that cooperatives offered the best prospects for increasing their income. Strong opposition to cooperative farming has also been reported by Buechler and Buechler (1971); E. Clark (1970: 96); Erasmus in Heath, Erasmus, and Buechler (1969: 154-155); Hennessy (1964); Lockwood (1956: 383); Patch, Marus, and Monje Rada (1962); and Warriner (1969: 246).

These studies suggest that considerable educational and promotional effort would be required to organize production cooperatives in Bolivia. Given the government's limited resources, it is questionable that such an effort can or should be undertaken. It might be more feasible to organize marketing cooperatives, but even in this case direct government promotion might meet with strong resistance from those who remember the government's poorly-executed efforts to form production cooperatives in the 1950s.

Where production cooperatives are not viable in areas characterized by <u>minifundios</u>, the range of technological alternatives is of course limited, paricularly if production credit is not available for individual farmers. Still, technological change is possible if prices or location with respect to markets provide sufficient incentives.

DIRECTIONS FOR FUTURE RESEARCH

Particularly in the Santa Cruz area, where mechanization of farm operations is most advanced, research should be conducted on the implications of mechanized technologies for income distribution, employment, crop yields, and the balance of payments. The extent to which government policy artificially stimulates mechanization should be determined for the major crops in this area. In the absence of such research, questionable mechanization, like that described above for cotton, might be encouraged. Research of this nature would require outside assistance and might be provided, for example, under the contract between MACA and the Consortium for International Development.

In colonization areas dominated by smallholdings, where relatively little mechanization is likely to occur, research on alternative technologies should focus on the benefits and costs of purchased inputs such as improved seeds, fertilizers, and pesticides. Too many unsound recommendations for these areas have been made in the past because inputs were promoted whose profitability had not been determined. 78/ It has already been demonstrated that much of this research can be conducted by Bolivian university students (as thesis projects); but there needs to be relatively greater emphasis on farm-level studies and a corresponding decrease in the relative importance of research conducted at the experimental stations.

78/ Inadequate soils studies have also resulted in poor recommendations. In addition, lack of attention to marketing has led to the promotion of unprofitable crops in many colonization areas.

Existing production cooperatives, such as those in the Patacamaya area, might be surveyed to determine how successful they have been in promoting technological change and raising farmers' incomes. Such a study should also focus on the factors which facilitate farmers' acceptance of cooperative farming. This would be an appropriate topic for a Master's thesis or possibly a Ph.D. dissertation.

Considerable research on improved livestock technology has already been undertaken by MACA and advisors from Utah State University. Still, change has been slow, particularly on the Altiplano, despite research findings suggesting that sharply higher incomes from livestock operations are possible. Future research should concentrate on the obstacles to transferring new livestock technology to campesinos and to the likelihood (suggested by some researchers) that marketing and price considerations are major constraints to the adoption of improved livestock practices. Greater attention should also be paid to security and other non-pecuniary motives for holding livestock.

Given the significant increase in small farmer credit planned for the immediate future, particularly from AID loans, it is important that good socioeconomic data be collected at this time to provide an adequate base for evaluating the benefits of credit programs at the project, cooperative, and individual farmer levels. Too often this aspect of the evaluation process is ignored, even if provided for in program planning documents. The necessary base data are best collected by those on the spot--the technicians serving in an extension capacity. However, since these technicians are often reluctant to become involved in data collection, the availability of good base data will be very dependent upon program managers' commitments to evaluation.

Finally, some thought might be given to research on how technological change might be promoted in areas where the predominance of *minifundios* and the reluctance to form cooperatives make it unlikely that individual farmers will have access to institutional credit. If, as some Bolivian case studies argue, improved access to markets can induce technological change even if institutional credit is unavailable, it would be useful to determine the scope for increasing marketing opportunities through additional road construction and other means of linking farmers more closely to markets.

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