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NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN LATIN AMERICA AND THE CARIBBEAN: CHANGES AND CHALLENGES

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ABSTRACT

In the 1960s and 1970s, the success of national agricultural research systems (NARS) consisted in their capacity to adapt and transfer the new technologies derived from the Green Revolution. The crisis and the reduction of public expenditure affected almost all the specialized institutions dedicated to agricultural research, including national institutes and universities. The implementation of structural reforms and, mainly, the deregulation of the regional economies, combined with urban growth, created new technological demands related to improving quality and competitiveness. In spite of all the transformations that have occurred in the region, problems such as poverty, deterioration of the natural resources, the environment and biodiversity have seriously increased, demanding urgent attention. Institutions within NARS are encouraged to respond to these challenges. For this purpose, national institutes of agricultural research have implemented several reforms in different fields, including reforms to increase the efficiency in resource management, to reduce expenses, to orient research activities according to clients' demands and to address poverty, natural resources, environment and biodiversity.

Numerous changes have been incorporated into the objectives and structure of NARS institutions. At the same time, new agents have appeared in the field of agricultural research and technology transfer, including foundations and non-governmental organizations. Some governments have implemented new financing for these activities, generally under the modality of competition among projects both within and among institutions. These are called competitive funds.

This document presents the current situation of the national agricultural research systems, the case of the national agricultural research institutes, the main changes implemented, their modalities and the challenges they face for the near future. The cases of Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico and Uruguay are analyzed with different degrees of detail, according to the available information.

RESUMEN

El éxito de los sistemas nacionales de investigación agrícola en los años sesenta y setenta se debió a su capacidad de adaptación y transferencia de nuevas tecnologías derivadas de la "Revolución verde". La crisis y la reducción de los gastos públicos afectaron prácticamente a todas las instituciones especializadas que se dedican a la investigación agrícola, incluidos los institutos nacionales y las universidades. La aplicación de reformas estructurales y, sobre todo, la desregulación de las economías de la región, unidas al crecimiento urbano, dieron origen a nuevas demandas tecnológicas de perfeccionamiento cualitativo e incremento de la competitividad. Pese a todos los cambios registrados en la región, hay problemas que se han agravado considerablemente -entre otros, la pobreza, y el deterioro de los recursos naturales, el medio ambiente y la biodiversidad-, a los que se debe prestar urgente atención. En vista de la conveniencia de que las instituciones que forman parte de los sistemas nacionales de investigación agrícola respondan a este desafío, han introducido reformas en diversas áreas, entre otras reformas destinadas al manejo más eficaz de los recursos, a reducir gastos, a adecuar las actividades de investigación a las demandas de los clientes y a solucionar los problemas relacionados con la pobreza, los recursos naturales, el medio ambiente y la biodiversidad.

Los objetivos y la estructura de estas instituciones han sido objeto de numerosos cambios. Además, en el ámbito de las investigaciones agrícolas y la transferencia de tecnología han aparecido nuevos agentes, entre otros fundaciones y organizaciones no gubernamentales. Algunos gobiernos han adoptado nuevas formas de financiamiento de estas actividades; la modalidad más común es la de "fondos competitivos", por los que compiten diversos proyectos de una misma o varias instituciones.

En este documento se da a conocer la situación actual de los sistemas e institutos nacionales de investigación agrícola, y se describen los cambios más importantes que han adoptado, sus características y los desafíos a los que se enfrentan en el futuro inmediato. En forma más o menos detallada, de acuerdo con la información disponible, se analizan los casos de Argentina, Brasil, Chile, Colombia, Costa Rica, Ecuador, México y Uruguay.

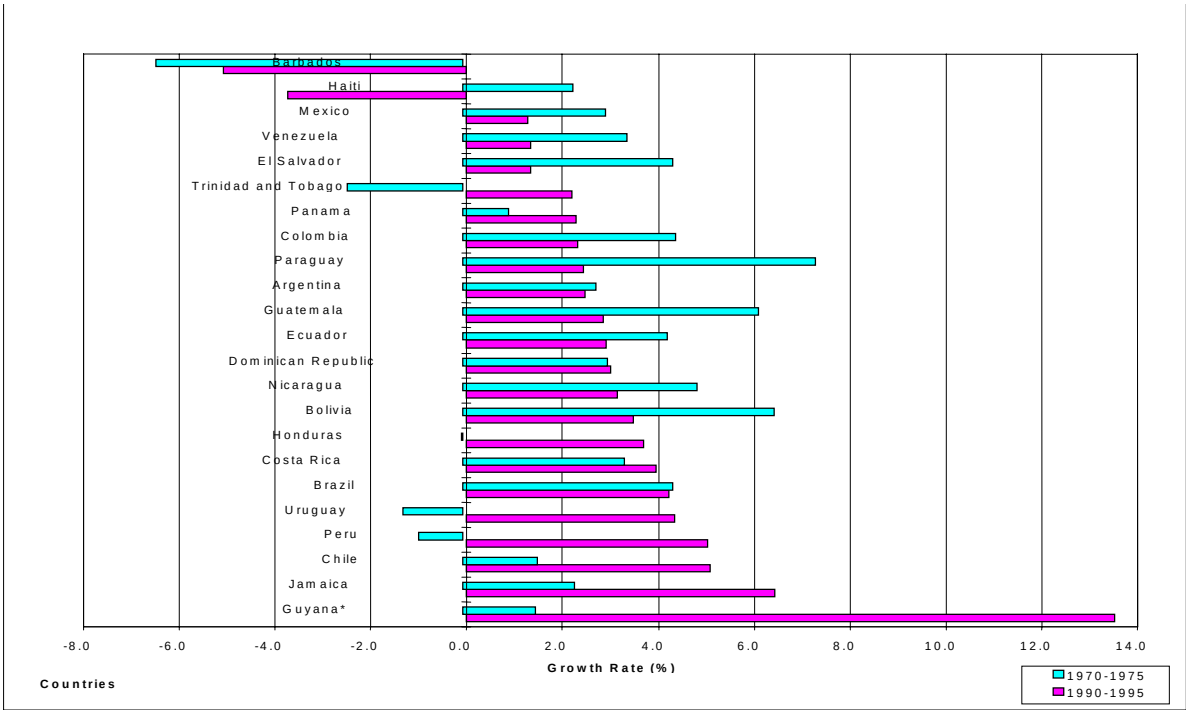
I. AGRICULTURE IN LATIN AMERICA AND THE CARIBBEAN

1. Introduction

The agricultural sector in Latin America and the Caribbean has undergone dramatic changes in the last three decades, as reflected in a diminishing contribution to gross domestic product (GDP) and a decreasing population engaged in agriculture. This has resulted from a continuous migration from rural to urban areas, with dramatic growth of the metropolitan cities in almost all countries in the region. At the same time, agriculture experienced a growth rate of 2.9% in the period 1990-1995, which can be qualified as acceptable on average. This average, however, hides a highly varied situation both within and among countries, as shown in figure 1.

Figure 1

LATIN AMERICA AND THE CARIBBEAN: AVERAGE ANNUAL GROWTH RATES OF AGRICULTURAL GROSS DOMESTIC PRODUCT (GDP), 1970-1995



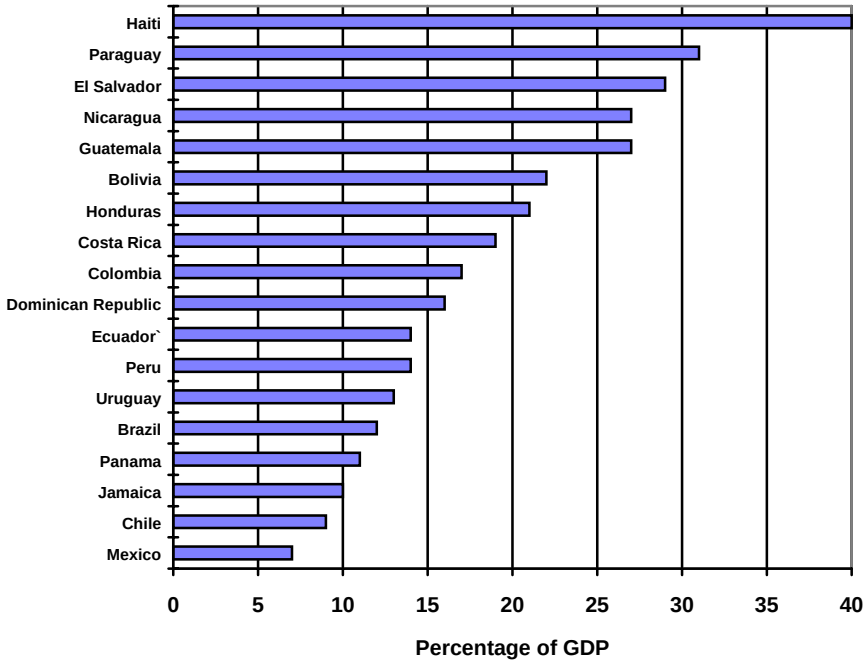
Source: Agricultural Development Unit, ECLAC.

Historically, agricultural development has been decisive for economic development in a significant number of countries in the region. The region's unbalanced and asymmetric development style created a remarkable pattern of heterogeneity, and the agricultural sector probably is the most heterogeneous of all, having been a permanent source of poverty and migration to urban areas. Within the sector very modern activities which use the most advanced technologies, are oriented to very sophisticated markets and exhibit a high dynamism coexist beside traditional forms of production, including the peasant and indigenous production units which are highly significant in many countries.

The sector's participation in GDP varies from slightly over 5% in Mexico to 40% in Haiti. The tendency is toward decreasing participation, but the situation is very different among countries. Even so, agricultural activities are still crucial in most countries of the region, measured not only by participation, but also by employment generation and contribution to total exports. Figure 2 shows this situation for 1994.

Figure 2

LATIN AMERICA AND THE CARIBBEAN: AGRICULTURE AS A SHARE OF GROSS DOMESTIC PRODUCT (GDP)



The contribution of the agricultural sector to GDP is below 12% in Mexico, Chile, Jamaica and Panama. A second group (Brazil, Uruguay, Peru, Ecuador and Dominican Republic) exhibits an intermediate contribution, between 13% and 17%; the next group, with a contribution of 17 to 23%, includes Colombia, Costa Rica, Honduras and Bolivia. Finally, countries in which agriculture is the largest and the most important activity, with a contribution to GDP between 23% and 40%, include Guatemala, Nicaragua, El Salvador, Paraguay and Haiti, most of which are in Central America.

The macroeconomic environment has largely determined the outlook for the agricultural sector in the region in the last five years. The application of measures to deregulate the agricultural and rural economy has had different effects across the sector. Adjustment of the exchange rate has favoured the prices of tradable goods and influenced the production structure. This policy has usually been followed by public policies to promote non-traditional exports, resulting in an increase in agricultural export flows as a whole and a fast increase in the growth rate of non-traditional goods, mainly horticultural products.

The reduction of public support for the agricultural sector has been reflected in higher credit costs and in the reduction or elimination of subsidies and taxes on agricultural activities. At the same time, the overall demand-reducing effects of fiscal and monetary restraints also play an important role. As is well known, the rural sector incorporates most of the poor, especially the poorest of the poor. Some people think that the reforms have increased inequity in rural areas. According to ECLAC, the intensification of the process of market liberalization in the 1990s has resulted in a disappointing performance for the sector. The growth rate of agricultural production is clearly insufficient to allow the sector to contribute adequately to food security and the general economic growth of the region. The 1990s witnessed a significant improvement in average yields, which reached an annual increase of 3.3%, compared to 1.3% in the 1980s. During this same period, however, the cultivated area declined at a rate of 2.2% annually. This mediocre performance reflects different factors not necessarily related to structural reforms, but the overvalued exchange rate, the reduction of public support, higher credit costs and the overall demand-reducing effects of fiscal and monetary restraint have undoubtedly played an important role.

2. Land use and production

The main long-term changes in land use are shown in table 1, for the period 1965-1994. While arable land increased more than 45 million hectares (from 92 millions to 138 million), forest area diminished by around 20 million hectares. The most important change in relative terms is for irrigated lands, which more than doubled.

Table 1
LATIN AMERICA AND THE CARIBBEAN: LAND USE, 1965-1994
(in millions of hectares)

Land use	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994
Arable land	91.88	98.94	107.54	117.52	122.29	125.30	124.51	124.43	122.43	124.09
Permanent culture	16.71	17.79	18.83	21.15	20.69	18.94	18.63	19.24	18.79	19.43
Permanent grasslands	520.03	539.37	553.89	565.08	576.84	588.28	589.99	591.74	590.05	590.15
Forestry lands	1,026.22	1,006.69	985.54	965.68	945.66	927.29	923.20	918.84	921.58	921.58
Irrigated area	8.85	10.00	11.86	13.62	14.86	16.45	16.78	17.30	17.39	17.67

Source: Food and Agriculture Organization of the United nations (FAO), *The state of food and agriculture*, Rome, 1997.

A wide range of agro-ecological systems, with conditions that vary from humid tropical forests to the most extreme desert conditions, offers a wide range of possibilities and limitations. This factor strongly contributes to the heterogeneous panorama of the region.

Food production has increased significantly in the region. The index for food production shows that food production, in global terms, has almost doubled in 30 years, during the period 1965-1995. In per capita terms, however, the increase is less significant, peaking in 1992 and then dropping in the following years (see table 2). For the same period, agricultural production shows an increasing trend but stagnation in per capita terms since 1980.

Table 2

LATIN AMERICA AND THE CARIBBEAN: EVOLUTION OF FOOD PRODUCTION, 1965-1995
(in thousands of tons)

	Index /year	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995
Food production												
Total	1989-1991 = 100	52.5	60.0	67.8	80.5	92.6	99.6	101.9	103.9	105.1	109.0	111.2
Per capita	1989-1991 = 100	93.1	93.0	92.3	95.7	96.1	101.1	99.5	103.5	98.9	99.7	97.7
Agricultural production												
Total	1989-1991 = 100	48.9	58.4	66.1	79.5	91.6	99.5	101.9	104.5	106.3	110.8	112.9
Per capita	1989-1991 = 100	94.0	96.3	94.6	99.0	99.1	100.9	99.7	101.9	99.1	100.0	99.9

Source: Food and Agriculture Organization of the United Nations (FAO), *The state of food and agriculture*, Rome, 1996.

Table 3 shows the evolution of the production of basic food commodities for selected years in the period 1965-1995. The production of cereals has doubled in the last 20 years. Roots and tubers have grown very little, while fruit and horticultural production has more than doubled.

Figure 3 illustrates the evolution of cereals production in the region during the last 20 years. Maize is, on aggregate, the most important cereal in the region, although the relative importance of each cereal varies according to the country.

Table 4 shows the average level of production for the main staples, contrasting the values obtained at the beginning of the 1980s and current values. The implicit average growth rates of production, yields and area are also shown. The highest growth rates in production have taken place in wheat, maize and rice, due to significant yield increases in wheat and rice, and, to a lesser degree, in maize and potatoes. Cassava production has grown very little, due to a significant reduction in the area sown. Total production of sweet potato has actually decreased in absolute terms over the past 15 years. The production of milk per head of stock has improved and the cattle stock has expanded, particularly for milk production.

Table 3

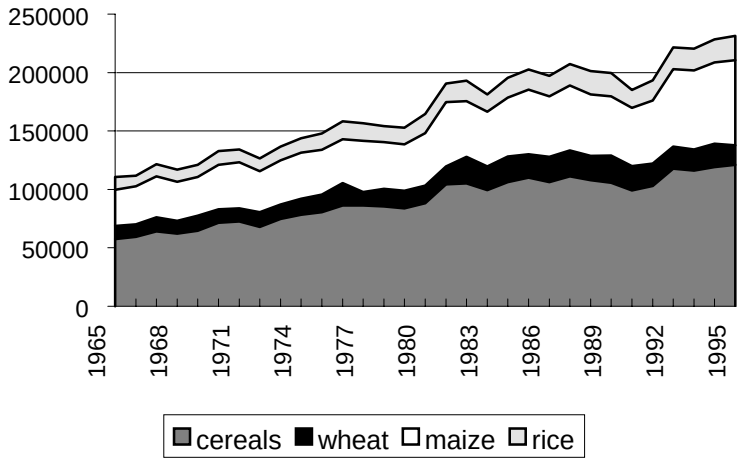
LATIN AMERICA AND THE CARIBBEAN: BASIC FOOD PRODUCTION, 1965-1995
(in millions of tons)

Item	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995
Cereals	57.639	71.365	80.552	88.271	110.057	99.110	102.846	117.757	116.201	119.053	120.926
Roots and tubers	42.088	49.216	45.737	43.909	45.119	46.944	46.375	43.558	44.829	48.585	50.039
Dry legumes	4.300	4.375	4.704	4.320	5.046	5.236	5.922	5.165	5.311	6.334	5.862
Oilseeds	2.559	3.145	4.428	6.532	8.643	10.089	9.342	9.729	9.918	11.218	12.168
Vegetables	9.005	10.629	12.622	15.475	17.644	20.236	20.517	19.768	20.697	21.597	22.200
Sugar	20.240	23.390	23.821	26.411	27.935	27.565	29.770	29.820	27.547	29.520	30.386
Coffee	3.617	2.189	2.854	2.987	3.855	3.891	3.937	3.933	3.802	3.497	3.378
Cacao	0.323	0.381	0.497	0.553	0.736	0.655	0.625	0.624	0.644	0.631	0.642
Fruits	36.657	43.477	48.445	59.226	67.257	76.957	79.958	83.021	82.794	85.160	87.923
Cotton (fiber)	1.697	1.562	1.588	1.635	1.921	1.640	1.749	1.328	0.890	1.174	1.472
Beef	5.691	7.024	7.309	8.835	9.690	10.243	10.335	10.425	11.026	11.132	11.223
Pork	1.656	1.960	2.446	3.196	3.109	3.007	3.111	3.305	3.300	3.433	3.508
Poultry	0.798	1.195	1.760	3.105	3.679	5.175	5.833	6.400	7.025	7.678	8.316

Source: Food and Agriculture Organization of the United Nations (FAO) data base.

Figure 3

LATIN AMERICA AND THE CARIBBEAN: CEREAL PRODUCTION, 1965-1995



Source: Food and Agriculture Organization of the United Nations (FAO), *The state of food and agriculture*, Rome, 1997.

Table 4

LATIN AMERICA AND THE CARIBBEAN: PRODUCTION OF BASIC COMMODITIES AND GROWTH RATES OF YIELDS AND AREA, 1979-1981 AND 1994-1996

Products	Production		Annual average growth rates 1979/1981-1994/1995		
	1979-1981	1994-1996	Production	Yields	Area
	(millions of metric tons)		*(percentages)*		
Wheat	15.15	22.42	2.65	3.04	-0.40.
Rice	15.04	20.15	1.97	3.15	-1.14.
Maize	47.35	69.47	2.59	1.84	0.78
Beans	4.88	5.60	0.92	0.80	1.14
Potatoes	11.49	13.71	1.18	1.73	-0.54.
Cassava	30.95	31.41	0.10	0.47	-0.37.
Sweet potatoes	2.16	1.85	-1.01.	0.73	-1.72.
				per head	stock
Beef	8.97	11.39	1.60	0.38	1.22
Milk	34.77	51.27	2.62	1.07	1.53

Source: Agricultural Development Unit, ECLAC, on the basis of official data from the Food and Agriculture Organization of the United Nations (FAO).

3. International trade

Latin America is traditionally a net exporting region for agricultural products. As can be appreciated in table 5, the increase in export volumes for agricultural products from Latin American countries in the 1990s has been larger than the increase in value. At the same time, agricultural imports have grown more than exports, both in value and volume.

Table 5

LATIN AMERICA AND THE CARIBBEAN: FOREIGN TRADE INDEXES

Item	Element	Unit	1990	1991	1992	1993	1994
Agricultural trade	Imports	millions of dollars	14.72	15.66	18.15	19.25	23.01
Agricultural trade	Exports	millions of dollars	35.37	32.71	33.10	32.93	39.90
Total	Imports	millions of dollars	120.37	134.99	158.05	168.27	198.36
Total	Exports	millions of dollars	134.09	129.18	134.31	138.08	158.60
Agricultural trade	Import value	1979/81 = 100	106.90	116.00	133.10	139.30	167.80
Agricultural trade	Import volume	1979/81 = 100	107.90	120.90	136.00	140.20	165.10
Agricultural trade	Export value	1979/81 = 100	114.00	104.30	104.40	102.60	124.20
Agricultural trade	Export volume	1979/81 = 100	129.30	128.60	135.70	132.80	139.50

Source: Food and Agriculture Organization of the United Nations (FAO), *The state of food and agriculture*, Rome, 1996.

According to World Bank projections, developing countries have an excellent opportunity to increase significantly their participation in international trade. The growth rate of international trade is estimated at 6% in the long term. This could represent the best opportunity in many decades for developing countries. The participation of agricultural trade in total trade is less important than it was in the past; between 1984 and 1994 the participation of Latin America and the Caribbean in total trade decreased from 14.5% to 11.9%, mainly as a result of the price of agricultural raw materials.

Some important changes in exports destination have taken place. Between 1980 and 1994, North America bought less from Latin America (from 37% to 29.1% of the total), while the participation of Europe fell slightly from 11.9% to 10.3% and Japan remained stable at 5%.

Table 6 presents a matrix of international agricultural trade by region for 1994. As can be seen, the main destination for North American agricultural exports is Asia, followed by North America itself. For Latin America, Europe is the most important destination for agricultural exports, followed by North America, Latin America and Asia. Latin America exhibits a high degree of diversification compared to other regions.

Table 6

REGIONAL STRUCTURE OF WORLD EXPORTS OF AGRICULTURAL PRODUCTS, 1994

Origin	Destination							
	North America	Latin America	Western Europe	Central and Eastern Europe and ex-USSR	Africa	Middle East	Asia	World total a/
A. Value (*billions of dollars)*								
North America	24	11	16	1	3	3	36	95
Latin America	13	8	18	1	1	1	6	49
Western Europe	9	4	160	11	7	6	12	211
Central and Eastern Europe and ex-USSR	0	0	9	2	0	0	3	16
Africa	1	0	10	0	2	0	3	17
Middle East	0	0	2	0	0	2	1	5
Asia	10	1	14	2	2	3	59	95
World total	58	25	228	18	17	16	120	487
B. Participation of inter-regional trade flows in total exports of merchandise of each region *(%)*								
North America	25.5	11.4	16.6	1.6	3.3	2.9	38.3	100.0
Latin America	26.0	16.7	36.8	2.4	2.3	2.4	13.2	100.0
Western Europe	4.4	1.9	75.8	5.0	3.4	3.0	5.8	100.0
Central and Eastern Europe and ex-USSR	2.9	1.4	58.2	13.9	2.1	1.5	19.5	100.0
Africa	4.9	1.3	58.0	2.2	13.8	2.0	17.8	100.0
Middle East	2.4	1.1	35.7	3.1	5.3	38.7	10.7	100.0
Asia	10.7	1.3	14.4	2.1	2.4	3.6	62.1	100.0
World total	11.8	5.1	46.9	3.7	3.4	3.3	24.7	100.0

Source: World Trade Organization, *El comercio internacional. Tendencias y estadísticas*, Geneva, 1995.

a/ Includes unspecified destinations. In Africa, exports to unspecified destinations are significant.

Tables 7 and 8 contain information on total Latin American exports and imports (not including the Caribbean) of the nine commodities in which the Consultative Group on International Agricultural Research (CGIAR) is involved.

Table 7
LATIN AMERICA: TOTAL REGIONAL EXPORTS OF SELECTED COMMODITIES, 1986-1995
(in millions of dollars)

Product	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Beef	521.2	659.7	923.6	778.4	798.4	786.3	815.3	827.2	946.4	1,019.0
Milk	0.9	0.3	31.4	30.3	40.2	12.5	7.7	26.0	10.5	12.1
Wheat	244.0	195.2	212.0	435.4	580.9	138.3	134.7	159.8	87.2	293.6
Rice	17.4	39.8	62.1	59.1	10.2	1.9	10.9	15.2	9.5	41.0
Maize	532.4	282.1	357.1	238.4	269.1	308.8	506.6	281.7	260.2	503.1
Potatoes	4.7	1.7	1.0	0.7	0.9	0.7	1.1	1.0	1.2	0.4
Beans, lentils and other	104.1	91.9	89.8	100.0	98.8	128.7	122.3	99.7	135.3	160.0
Cassava	12.4	12.5	16.1	20.9	24.9	29.5	34.7	40.1	50.8	54.9
Sweet potatoes and other	0.2	0.4	0.7	0.7	0.3	0.8	0.2	0.2	0.1	0.4
TOTAL	1,437.1	1,283.7	1,693.8	1,663.9	1,823.7	1,407.6	1,633.6	1,451.0	1,501.3	2,084.5

Source: United Nations, ECLAC and the External Trade Data Bank for Latin America and the Caribbean (BADECEL).

Table 8
LATIN AMERICA: TOTAL REGIONAL IMPORTS OF SELECTED COMMODITIES, 1986-1994
(in millions of dollars)

Product	1986	1987	1988	1989	1990	1991	1992	1993	1994
Beef	268.6	150.7	78.0	177.5	126.5	338.1	477.2	232.9	337.1
Milk	471.7	451.6	621.2	915.5	822.7	602.9	896.5	875.5	784.7
Wheat	673.7	665.9	630.3	596.9	552.3	543.8	704.3	894.3	957.3
Rice	288.9	50.2	69.2	193.6	202.4	373.1	261.8	218.3	390.3
Maize	381.0	468.2	547.6	577.1	690.2	391.6	467.9	395.0	810.0
Potatoes	32.8	19.4	20.4	10.8	24.1	20.7	28.4	34.1	28.9
Beans, lentils and other	110.6	75.2	92.2	148.2	282.8	105.0	95.5	75.3	164.4
Cassava	0.2	0.3	0.5	0.6	0.8	4.2	4.4	3.4	2.1
Sweet potatoes and other	0.4	0.4	0.4	0.9	0.4	0.2	0.3	0.1	0.6
TOTAL	2,227.9	1,881.8	2,059.8	2,621.1	2,702.3	2,379.6	2,936.4	2,728.9	3,475.4

Source: United Nations, ECLAC and the External Trade Data Bank for Latin America and the Caribbean (BADECEL).

4. Population

At present, almost all the Latin American countries exhibit an increasing difference between the active agricultural population and the active rural population. The active agricultural population represents only 70% of the active rural population, and an increasing number of workers from urban areas are employed in agricultural activities. In some countries, such as Argentina, Brazil, Chile and Venezuela, this category represents 20% or more of agricultural workers (Dirven, 1997).

Table 9 shows the total population and economically active population considered by rural and agricultural categories. The relative participation of the rural population decreased in relation to the total. At the same time, the active rural category increased faster than the active agricultural population. The changes observed between 1980 and 1995 illustrate the decline in absolute terms of the rural population and of the population engaged in agriculture.

Table 9

LATIN AMERICA AND THE CARIBBEAN: TOTAL ECONOMICALLY ACTIVE AGRICULTURAL AND RURAL POPULATION, 1970-1995
(in millions)

Year	Total population (1)	Rural population (2)	(2)/(1) *100	Agricultural population	Total economically active (3)	Economically active agri-cultural (4)	(4)/(3) *100
1970	283.5	120.7	42.57	n/a	n/a	n/a	n/a
1975	320.2	123.8	38.66	n/a	n/a	n/a	n/a
1980	359.3	125.4	34.90	123.2	130.6	44.7	34.23
1985	398.3	125.8	31.58	119.4	151.4	45.2	29.85
1990	437.8	125.0	28.55	112.6	175.7	44.7	25.44
1991	445.7	124.7	27.98	111.3	180.2	44.5	24.69
1992	453.5	124.4	27.43	110.1	184.5	44.2	23.96
1993	461.2	124.0	26.89	108.9	188.6	43.9	23.28
1994	468.9	123.5	26.34	107.8	192.7	43.7	22.68
1995	476.6	122.9	25.79	106.8	197.0	43.5	22.08
1996	484.3	122.3	25.25	105.8	201.3	43.3	21.51

Source: Food and Agriculture Organization of the United Nations. (FAO), *The state of food and agriculture*, Rome, 1997.

Table 9 illustrates the principal changes experienced by the population over the last few decades. In absolute terms, the rural population grew until 1985 and thereafter gradually began to shrink. In relative terms, the rural population has been steadily decreasing in size ever since 1970, and by 1996 represented only one fourth of the total population. The economically active agricultural population has declined only slightly in absolute terms, but has decreased quite sharply as a percentage of the total economically active population.

5. Poverty

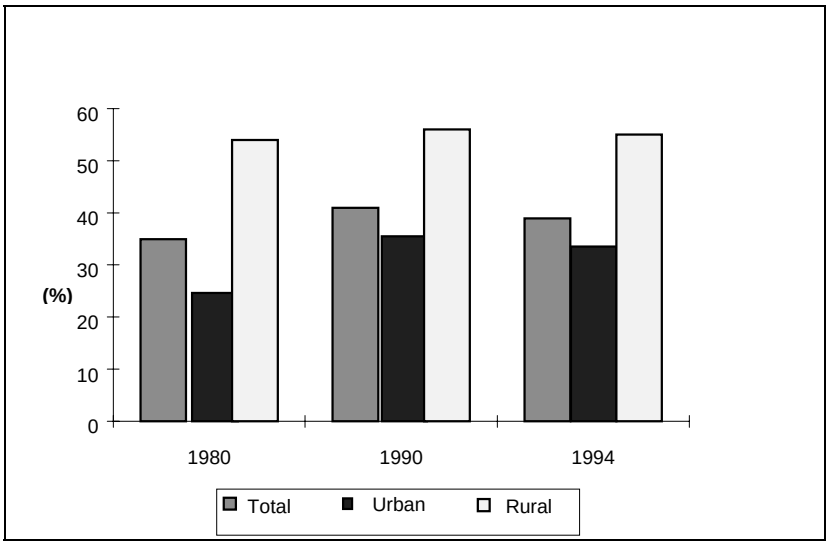
According to the World Bank, Central America and northeastern Brazil are the poorest regions in Latin America, with 60% of the population below the poverty line. One-quarter of the population lives on less than one dollar per day. Between 1960 and 1990, the total population of Latin America and the Caribbean grew by 60%, but the population living in poverty grew even more, by 62%.

At the end of the 1980s, urban poor, at slightly more than one hundred million people, exceeded rural poor, at around 70 million people, for the first time. Nevertheless, extreme poverty grew in both relative and absolute terms. Additionally, an increasing percentage of the urban poor has recently originated in the rural areas.

According to the Food and Agriculture Organization (FAO), small farmers represent most of the rural poor, with two-third of the total, followed by peasants without land and Indian native groups, with 30% and 4% respectively. Figure 4 shows the results of household surveys conducted in different countries of the region. Between 1980 and 1994, urban poverty increased from 25% to 36%, while rural poverty increased slightly from 54% to 55%.

Figure 4

POVERTY IN LATIN AMERICA AND THE CARIBBEAN



Source: Agricultural Development Unit, ECLAC, based on ECLAC Household Surveys, 1996.

More than half the rural poor cannot generate an adequate income from agriculture. This encompasses around 40 million people, or 55% of total rural poor. Inequity in land and water distribution and low investment in human capital contribute significantly to maintaining rural poverty, in spite of the relative abundance of land in the region. For example, the Gini coefficient for land distribution reached 0.86 in Brazil, 0.92 in Venezuela and 0.94 in Paraguay. Competition in the current context of open economies makes the survival of small farmers even more difficult, given that they are mainly engaged in the production of staples, which compete with cheaper imports.

6. Nutrition and food security

The nutrition situation in Latin America and the Caribbean has improved significantly. In fact, in the 1990s, average energy consumption was 2,700 calories per day, which is similar to the world average and 8% over the average for developing countries. Regarding infant nutrition, Latin America and the Caribbean exhibit better indicators than other developing countries, but infant malnutrition is still high: 20% of the infant population exhibits some degree of nutrition problems. Tables 10 and 11 outline food availability and infant nutrition for 1990 with projections to 2020, according to three different scenarios: (a) the basic scenario, (b) low investment and growth, and (c) trade liberalization. As can be seen, the results for the basic scenario are not so different from the scenario with trade liberalization.

Table 10

PER CAPITA FOOD AVAILABILITY
(in kilocalories per day)

	1990	2020		
		(a)	(b)	(c)
World total	2 773	2 895	2 758	2 897
Developed countries	3 353	3 532	3 492	3 512
Developing countries	2 500	2 821	2 662	2 836
Latin America and the Caribbean	2 722	3 026	2 878	2 963

Source: M. Rosegrant et al "Global Food Projections to 2020: Implications for Investment", Food, Agriculture, and the Environment Discussion Paper, No. 5, Washington, D.C., International Food Policy Research Institute (IFPRI), 1995.

(a) Projections according to conditions prevalent in 1990.

(b) Projections considering low investment and growth.

(c) Projections considering trade liberalization.

(d)

Table 11

INFANT MALNUTRITION AS A PERCENTAGE OF TOTAL INFANT POPULATION

	1990	2020		
		(a)	(b)	(c)
Developing countries	34	25	33	25
China	22	14	20	14
India	63	45	56	44
Sub-Saharan Africa	28	25	31	26
Latin America and the Caribbean	20	14	23	15

Source: M. Rosegrant et al "Global Food Projections to 2020: Implications for Investment", Food, Agriculture, and the Environment Discussion Paper, No. 5, Washington, D.C., International Food Policy Research Institute (IFPRI), 1995.

(a) Projections according to conditions prevalent in 1990.

(b) Projections considering low investment and growth.

(c) Projections considering trade liberalization.

II. NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN LATIN AMERICA

In the 1960s and 1970s national agricultural research systems (NARS), and especially public institutes for agricultural research, received strong financial support from governments and specialized agencies, which sought to promote agricultural modernization through the dissemination of new technologies developed during the Green Revolution. The crisis and adjustment programmes of the 1980s caused public funds for agricultural research to diminish sharply. Total expenditure on agricultural research dropped, but expenditure per researcher fell even more because of continued personnel increases, which severely affected research activities. Expenditure per researcher dropped dramatically in 10 out of 14 public institutes for agricultural research, in some cases by as much as 40%.

During the same period, almost all the public institutes for agricultural research in the region implemented reforms, mainly to improve efficiency in the administration and management of financial resources and to reorient research priorities according to demand-driven criteria. Market mechanisms such as competitive funds were introduced, and significant efforts were made to increase the institutes' ability to generate their own resources through the sale of goods and services. At the same time, objectives related to poverty, natural resources and the environment were included in the agricultural research agenda. In the 1990s, the situation improved significantly for most public institutes for agricultural research as a result of a better financial situation in the public treasury and new sources of financing, such as foundations for agricultural research and technology transfer and other non-governmental organizations (NGOs). Budgets for agricultural research have generally increased, recovering their previous levels and in some cases overpassing them.

However, deep changes in the political, social and economic environment have led to a profound crisis in agricultural research and technology transfer. Two decades ago, these activities were actively promoted because agricultural transformation and modernization was considered a condition for general development, and the State was identified as the main actor responsible for promoting economic and social development. Technology was seen as a public good, and it was transferred massively from developed countries through specialized public institutions. Since then, the situation has changed dramatically: the most important elements characterizing the present environment include structural reforms and adjustment policies implemented after the crisis of the 1980s, major global political changes, increasing demands to diminish the size of the public sector and to reduce public intervention, a more active role for the private sector, scarcity of public and international resources for agricultural research and significant scientific advances and institutional developments.

1. Old and new technology demands

Food supply was identified as a bottleneck for development in the 1960s and consequently agricultural modernization was a strategic objective. Technologies to increase productivity of basic foods were promoted and diffused as a public good, because they were considered an effective way to contribute to solving world hunger and poverty. By the 1980s, agriculture had diversified, responding to new consumption patterns derived from deregulation processes, particularly trade liberalization, and fast

urban growth. Demands have changed in favour of post-harvest technologies, new agroindustrial products, quality control and processes to increase value added and improve competitiveness. Similarly, discussions on the allocation of funds are dominated by topics such as genetics and biotechnology development.

Poverty and extreme poverty have dramatically increased, however, while natural resources experienced fast and increasing deterioration. Poor agricultural performance is at the heart of increasing poverty and the rapidly deteriorating natural resource base, including deforestation, soil erosion, waterlogging, salinization and desertification of soils, contamination of surface and ground waters and loss of biodiversity.

A number of issues will affect the evolution of agricultural and technological demand and opportunities over the coming decades. These include the changing nature of poverty, the repositioning of agriculture in national economies, the impact of urbanization on the demand for food and the impact of trade liberalization and regional economic integration (Trigo, 1995).

The following trends will affect NARS:

- A structural change in NARS as a result of a reduction in the 1980s of public and international funds for public institutes for agricultural research, other institutions related to agricultural research and public and semi-public universities;
- Strong demands for public institutes for agricultural research and other public institutions to improve efficiency in the allocation, administration and management of resources and to increase the generation of financial resources through the sale of properties, services and products;
- Increasing participation of the private sector in research and technology transfer;
- A reorientation of research priorities to incorporate demand-driven or client-demand criteria and to address poverty and ecological issues, as a result of (a) agricultural diversification in response to urbanization and an open economy and (b) a dramatic increase in the number of people living in poverty in Latin America and the Caribbean despite the success of the modernization of cereals and commodity technologies;
- The close relation between marginalism, rural poverty and natural resource degradation, and the extent of deforestation, over-exploitation and degradation of soils, water and air pollution and loss of biodiversity in almost all the ecosystems of the region.

In this environment, the institutions of agricultural research are encouraged to generate more of their own resources in order to be less dependent on public funds. At the same time, governments and the private sector have implemented new mechanisms for obtaining funds and applying them more efficiently. These initiatives and those that reinforce and create organizations encompassing products (such as the case of coffee, sugar and rice in Colombia) characterize this period. The most important of these initiatives, as mentioned before, are the competitive funds and the foundations.

2. New sources of funding

Competitive funds

Argentina, Brazil, Chile, Colombia and Costa Rica are among the countries of the region that have created special competitive funds for agricultural research. There are

two kinds of funds: those that finance scientific research projects and those that promote innovation and technology transfer through improved linkages between the public and private sectors. These funds aim to increase the accountability of researchers; to improve research resource allocation and technology transfer by promoting more effective linkages between research institutes and agricultural producers; and to lower costs by supporting demand-driven research.

Research foundations

These non-governmental organizations are an alternative mechanism for funding and coordinating agricultural research and technology transfer. Most foundations work with the commercial private sector, especially in export crops and agribusiness. In general, foundations can be classified in three types.

(a) Foundations that finance and execute agricultural research. In this group we find the more mature, financially independent foundations that are endowed and that evolved from the private sector. These include POLAR (Venezuela), FUSAGRI (Peru) and the Honduran Foundation for Agricultural Research (FHIA) (Honduras).

(b) Foundations that act as intermediaries for research funds but are not involved in implementing research activities. This group closely depends on external donor agencies, especially the United States Agency for International Development (USAID). These foundations channel donor resources to programmes and projects in national research institutions, strengthen management capabilities and monitor research execution.

(c) Foundations that link scientific and technological capabilities with research and development needs and implement projects. This type of foundation is much less common. Examples include the Chile Foundation and ArgenInta, which facilitate the mobilization of resources and link research and technological capabilities with innovation and investment opportunities.

3. The present situation

It is difficult to present an accurate picture of the current situation in funding for agricultural research. The last comprehensive studies on institutes for agricultural research were conducted around 1992 (e.g., Lindarte, 1995). Other information is partial, fragmentary and sometimes contradictory. Probably as a result of severe criticism of their resource administration and management, public institutes for agricultural research and other institutions are not willing to provide information on funding sources and use of funds. Finally, reporting of budget sources is sometimes ambiguous. The Institute for Agricultural Research (INIA) in Chile, for instance, lists the private sector as a financing source, but this corresponds to the sale of goods, services and assets as well as contracts made with the private sector. In the case of Argentina's National Institute for Agricultural Research (INTA), funding from a special tax is presented as "own resources" despite the fact that it is a public source of funds with a specific purpose.

NARS in Latin America and the Caribbean are very heterogeneous in terms of resource allocation and the number of researchers employed. The largest NARS are in Brazil, Mexico and Argentina; at the other extreme, the smallest NARS are in Central America and the Caribbean countries. In all cases, public institutions are by far the main components of NARS, and public resources, the main source of funding. Generally, agricultural research activities and technology transfer are managed by different,

specialized institutions, although the National Institute for Agricultural, Livestock and Forestry Research (INIFAP) in Mexico and the National Institute for Agricultural Technology (INTA) in Argentina combine these activities.

Almost all the public institutes for agricultural research have introduced or are planning reforms to adapt to the new demands and scarcity of funds. The effects of these reforms are reflected in the objectives, programmes and project contents of the institutions, which identify their priorities as poverty, natural resource degradation and the environment. Competitiveness is another important consideration which appears in almost all the programmes together with concerns about biotechnology development.

While new demands have been placed on NARS, total expenditure in agricultural research declined in a number of countries of the region. Between the early 1980s and the early 1990s, the average research budgets of public institutes for agricultural research were reduced by 13-15%; at the same time, the number of personnel increased by 22-27%.[1] This resulted in a reduction of expenditure per researcher and sometimes even in reductions of the salaries of qualified personnel, together with lower operating budgets. Such difficulties have negatively affected the performance of public institutions dedicated to agricultural research.

The participation of the private sector in agricultural research activities has increased, but it has only reached 15% of total resources invested, which is not enough to replace lost funds. Private-sector participation is more significant in some countries such as Colombia, where efforts from the public and private sectors were combined to organize farmers specializing in coffee, sugar cane, cattle and other products.

Public institutes for agricultural research are still the most important component of NARS in almost all the countries of the region. Recent estimates for selected countries show that such institutes have the highest share in agricultural research expenditures realized by different institutions in the public, semi-public and private sectors. In Argentina INTA represents 89% of total agricultural research expenditure, while Colombia exhibits the highest participation of farmers' groups (29% of the total) and Ecuador the highest participation of private companies (see table 12).

Table 12

ESTIMATED BREAKDOWN OF AGRICULTURAL RESEARCH EXPENDITURE, 1995
(in percentages)

Countries	Public institutes	Universities	Farmers' groups	Private companies	Total
Argentina	89	5	0	6	100
Brazil a/	63	29	0	8	100
Chile	75	20	1	4	100
Colombia b/	61	2	29	8	100
Ecuador	52	5	7	36	100
Mexico	50	17	5	28	100
Peru	65	20	10	5	100
Venezuela	80	10	1	9	100

Source: R. Echeverría, E. J. Trigo and D. Byerlee, *Institutional change and effective financing of agricultural research in Latin America*, Technical Paper, No. 330, Washington, D.C., World Bank, August 1995.

a/ 1991.

b/ 1993.

[1] Lindarte (1995); Echeverría et al. (1996).

4. Human resources

Approximately 43,854 people were involved in agricultural research activities and support activities in Latin America and the Caribbean in 1992; of these, 8,522 (19.4%) were researchers with at least a university degree: 15.8% have a doctorate degree, 38.5% have a master's degree and the other 45.7% have a bachelor's degree. Around 64.5% work in public institutes for agricultural research (Lindarte, 1995).

Almost 60% of the researchers are working in institutions located in the Southern subregion of Latin America and the Caribbean, while at the other extreme, the Caribbean countries have only 1.3% of the total. A similar distribution is found with respect to the level of qualification of human resources. The Southern subregion concentrates almost 71% of the master's and doctorate degrees in Latin America and the Caribbean, while Central America has 9.7% and the Caribbean countries only 1.4%. Table 13 shows these figures by subregions.

Table 13

LATIN AMERICA AND THE CARIBBEAN: DISTRIBUTION OF HUMAN RESOURCES BY SUBREGION, 1992

	Subregions				
	Caribbean	Central America	Andean	Brazil and Southern Cone	Total
Total number directly involved in research activities	118	1,538	3,386	5,692	10,734
Researchers:					
with bachelor's degree	43	861	1,228	1,762	3,891
with master's degree.	54	306	600	2,321	3,284
with doctorate	12	141	239	955	1,347
Total researchers	109	1,308	2,067	5,038	8,522
Percentage by subregion	1.3	15.3	24.3	59.1	100

Source: E. Lindarte, *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

As can be expected, heterogeneity and asymmetries are also present among public institutes for agricultural research within each subregion. Table 14 classifies researchers according to their university degree for selected public institutes. The Brazilian Agricultural Research Enterprise (EMBRAPA), INIFAP in Mexico and INTA in Argentina, concentrate a high proportion of the total number of researchers. EMBRAPA exhibits the highest proportion of researchers with master's and doctorate degrees; it also shows an enormous effort to improve human resource qualifications between 1983 and 1997. At the other extreme, Bolivia and Paraguay show the weakest situation in terms of both total researchers and the level of qualification of human resources.

Table 14

STAFF RESEARCHERS IN LATIN AMERICAN RESEARCH INSTITUTES, 1983-1997

Institute	1983				1993				1997			
	Total	Bachelor's degree (%)	Master's degree (%)	Doctorate (%)	Total	Bachelor's degree (%)	Master's degree (%)	Doctorate (%)	Total	Bachelor's degree (%)	Master's degree (%)	Doctorate (%)
EMBRAPA (Brazil)	1,609	22.0	61.3	16.7	2,088	15.2	54.0	30.8	2,082	15.0	54.0	31.0
INIFAP (Mexico)	1,440	69.0	23.0	8.0	1,716	32.8	51.8	15.4	1,384	25.9	64.1	10.0
INTA (Argentina)	1,005	83.2	13.7	3.1	1,015	75.7	18.9	5.4	1,200	53.3	33.4	13.3
FONAIAP (Venezuela)	383	59.2	35.2	5.6	504	49.9	45.2	4.9				
ICA (Colombia)	373	51.1	44.2	4.7	422	40.9	41.4	17.7				
INIA (Chile)	274	61.6	23.4	15.0	162	46.2	39.6	14.2	212	53.9	25.9	20.2
INIAP (Ecuador)	232	72.8	25.0	2.2	238	68.7	27.3	4.0	191	61.2	35.1	3.7
SNITTA (Costa Rica)									179	63.7	25.7	10.6
ICTA (Guatemala)	176	87.0	11.9	1.1	164	81.8	17.0	1.2				
INIA (Peru)	273	87.5	11.0	1.5	153	87.0	9.8	3.2				
INIA (Uruguay)	80	77.5	22.5	0	126	59.6	36.5	3.9	123	48.0	43.1	8.9
IDIAP (Panama)	135	63.8	23.7	12.5	124	60.6	31.4	8.0				
IAN (Paraguay)									114	71.0	27.2	1.8
IBTA (Bolivia)	104	68.3	29.8	1.9	115	83.5	13.9	2.6				
TOTAL	6,084				6,827							

Source: E. Lindarte, *Los institutos nacionales de investigación agropecuaria: Apuntes sobre su papel y evolución*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1994. Data for 1997 based on information from the institutes.

5. Resource allocation

Total resources allocated for agricultural research in the region are important, but they appear to be insufficient to meet current demands for technology. As mentioned above, budget allocations experienced strong cutbacks in the 1980s because of the crisis and adjustment programmes. Many public institutes for agricultural research were able to improve their financial situation by implementing reforms, finding new sources of funding and generating their own resources in order to be more independent from the public treasury, but sometimes without regaining their previous levels, particularly in terms of resources per researcher. Table 15 shows the total budgets for selected institutes.

Table 15

LATIN AMERICA AND THE CARIBBEAN: TOTAL BUDGET OF SELECTED PUBLIC INSTITUTES FOR AGRICULTURAL RESEARCH

Public Institute	Year	Budget allocations (millions of dollars)
EMBRAPA (Brazil)	1996	509.0
INTA (Argentina)	1995	133.5
INIFAP (Mexico)	1996	50.9
ICA-CORPOICA (Colombia)	1994	41.0
INIA (Chile)	1996	39.0
INIA Uruguay	1996	13.8
INIAP (Ecuador)	1996	7.0
IDIAP (Panama)	1996	5.5

Source: Official figures from the institutes.

The allocation of financial resources shows the same asymmetries among subregions of Latin America and the Caribbean (see tables 16, 17 and 18). The Southern subregion concentrates more than three-quarters of total resources, while the Caribbean receives only 0.3% of the total. As can be expected, salaries represent the largest item in the budgets, accounting for 66.7% of the regional total, followed by operative costs (18.5%) and investment (14.8%). The Southern subregion accounts for 82.8% of total regional expenditures on salaries, while the Caribbean represents only 0.3%. Table 17 reveals that Central America allocates fewer resources to pay salaries (41.7%), while the Southern subregion allocates 71.4% for this purpose.

Table 16

LATIN AMERICA AND THE CARIBBEAN: BUDGETS BY SUBREGIONS,1992
(in percentages and billions dollars)

	Central America	Caribbean	Andean	Brazil and Southern Cone	Regional total	
	(%)	(%)	(%)	(%)	Billions of dollars	(%)
Salaries	5.3	0.3	11.6	82.8	346.76	100
Operative Costs	11.1	0.3	14.1	74.5	96.05	100
Investment	19.6	0.2	23.3	56.9	76.79	100
Total	8.5	0.3	13.8	77.4	519.60	100

Source: E. Lindarte, *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

Table 17

LATIN AMERICA AND THE CARIBBEAN: EXPENDITURES AS A PERCENTAGE OF TOTAL BUDGET, 1992
(in percentages)

	Central America	Caribbean	Andean	Brazil and Southern Cone	Regional total
Salaries	41.7	69.1	56.1	71.4	66.7
Operative costs	24.1	22.3	18.9	17.8	18.5
Investment	34.2	8.6	25.0	10.9	14.8
Total	100	100	100	100	100

Source: E. Lindarte, *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

Table 18

LATIN AMERICA AND THE CARIBBEAN: SOURCE OF FUNDING FOR AGRICULTURAL RESEARCH
(in percentages and billions of dollars)

	Central America	Caribbean	Andean	Brazil and Southern Cone	Regional total	
	(%)	(%)	(%)	(%)	Billions of dollars	(%)
Government	37.2	72.7	71.6	82.4	433.51	77.1
Own resources	14.8	20.3	10.9	8.5	52.62	9.4
External resources	47.8	6.4	9.2	7.5	61.73	11.0
Other incomes	0.2	0.55	8.3	1.7	14.06	2.5
Total income	100.0	100.0	100.0	100.0	561.92	100.0
Total income as percentage of regional total	8.1	0.3	14.2	77.4	561.918	100.0

Source: E. Lindarte, *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

Public institutes and centralized public sector programmes receive most of the resources allocated for agricultural research. Public institutes account for 85% of the resources allocated to institutions dedicated to agricultural research (i.e., public institutes for agricultural research, central agricultural research programmes, other public institutions, universities and semi-private entities). In general, the Government is the main source of funds for Latin American countries: in 1992, 77.1% of the total came from the public sector (see table 18). External sources provided 11.0% of the total, followed by "own resources" [2] with 9.4%. Government provides 82.4% of total funds in the Andean subregion, whereas in Central America, external resources are more important than government funds, with 46.8% and 37.2%, respectively. Resources are

[2] For some institutions, "own resources" implies the sale of goods and services (such as certified seeds and laboratory tests), while in others, such as INTA in Argentina, it refers to a specific source of funds, including special taxes.

unevenly distributed among the subregions: the Southern subregion receives 77.4% of the regional total, followed by the Andean subregion (14.2%), Central America (8.1%) and the Caribbean (0.3%).

6. Expenditure per researcher

In a number of countries in the region, expenditure per researcher diminished strongly in the 1980s and then recovered somewhat in the 1990s, but without reaching previous levels. This indicator varies widely among subregions: salaries and operative costs for 1992 vary from US$ 71,354 in the Southern subregion to US$ 28,406 in the Caribbean countries. Among the institutions, public institutes for agricultural research have the highest expenditure per researcher (see table 19).

Ten out of fourteen public institutes for agricultural research increased the number of researchers while the resources allocated for agricultural research fell (Lindarte, 1995). Thus, total expenditures per researcher dropped 40% between 1980 and 1985. Direct information from public institutes, however, shows a slightly different picture because of variation in the number of researchers. Figure 5 and tables 20 and 21 show the evolution of expenditure per researcher, considering total allocated resources and operative costs and salaries only. Expenditures decreased during the crisis and adjustment process in Brazil, Argentina and Ecuador and then recovered and even overtook their original levels. Since 1992, Chile also exhibits an increase in this indicator.

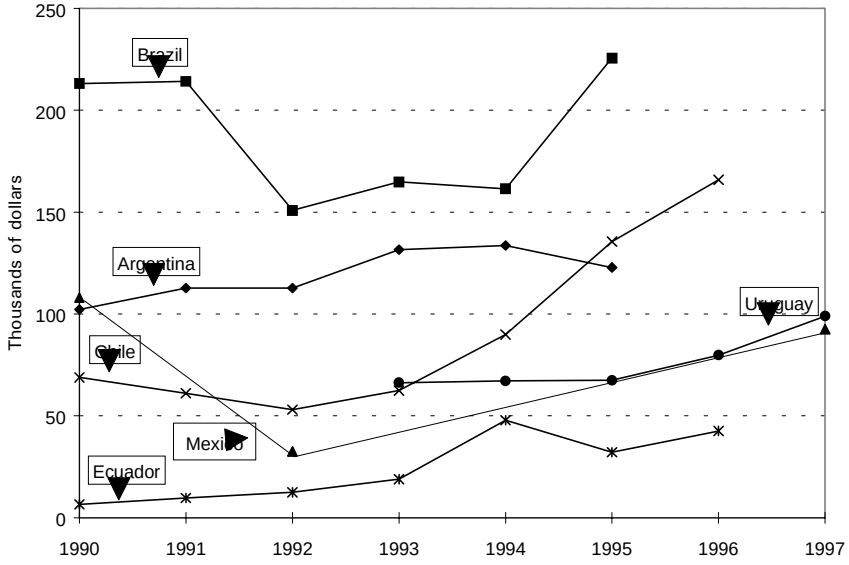
Table 19

LATIN AMERICA AND THE CARIBBEAN: EXPENDITURE PER RESEARCHER
BY SUBREGION AND INSTITUTIONS, 1992
(in dollars)

	Salaries and operative costs	Total expenditures
Subregion		
Caribbean	28,406	29,559
Central	35,445	48,361
Andean	47,112	57,077
Brazil and Southern Cone	71,354	80,051
Total Latin America and the Caribbean	59,413	69,010
Institutions		
Public institutes for agricultural research	68,080	79,715
Natural resource institutes	11,306	20,728
Other public-sector institutes	36,050	42,460
Universities	23,683	29,375
International centres	79,660	85,502

Source: E. Lindarte, *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

Figure 5
LATIN AMERICA AND THE CARIBBEAN: TOTAL EXPENDITURE PER RESEARCHER



Source: Various national institutes for agricultural research, on the basis of official data.

Table 20
LATIN AMERICA AND THE CARIBBEAN: EVOLUTION OF EXPENDITURE PER RESEARCHER
(in 1992 dollars)

Country	1981-1985	1992-1993
Argentina	46,700	70,400
Brazil	248,900	217,300
Paraguay	11,800	1,600
Uruguay	4,300	12,600
Bolivia	1,300	5,000
Colombia	19,900	18,800
Ecuador	11,900	4,300
Peru	13,800	22,700
Venezuela	44,700	20,600
El Salvador	4,500	800
Guatemala	6,800	4,300
Honduras	2,600	500
Mexico	114,300	83,600
Panama	7,000	5,400

Sources: International Service for National Agricultural Research (ISNAR) in P.G. Pardey, J. Roseboom and J. Anderson (eds.), *Agricultural research policy: International quantitative perspectives*, Cambridge, Cambridge University Press, 1991 adjusted to 1992 dollars; and E. Lindarte; *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

Table 21

LATIN AMERICA AND THE CARIBBEAN: EXPENDITURE PER RESEARCHER IN PUBLIC INSTITUTES FOR AGRICULTURAL RESEARCH, SELECTED COUNTRIES
(in millions of 1992 dollars)

Year	Total expenditure						Operational expenditure				
	Argentina	Brazil	Mexico	Chile	Ecuador	Uruguay	Argentina	Brazil	Chile	Ecuador	Uruguay
1981	136.6	324.2		93.7			112.0	247.7	84.3		
1982	44.6	400.9		72.5			36.6	209.6	70.9		
1983	42.9	285.6		67.1			35.2	226.2	64.7		
1985	57.6	280.4	108.0	63.8			47.2	220.5	61.5		
1986	51.5	267.1		96.0			42.2	201.2	71.1	1.1	
1987	66.7	235.1		106.6	84.0		54.7	174.4	70.5	1.4	
1988	79.0	230.9		93.8	59.2		64.8	188.0	70.0	2.0	
1989	84.1	275.8		96.4	20.1		69.0	251.9	71.3	3.1	
1990	102.2	213.1		68.8	23.2		83.8	184.6	62.4	4.6	
1991	112.7	214.2		61.1	22.5		98.3	190.1	58.7	7.0	
1992	112.7	150.8		53.0	18.9		102.5	132.1	46.9	9.1	
1993	131.6	164.8	48.3	62.4	26.2	66.3	107.2	142.7	57.5	12.8	32.0
1994	133.6	161.5		89.9	37.2	67.1	116.1	131.3	67.2	40.1	30.0
1995	122.9	225.6		135.5	36.8	67.4	104.0	165.1	109.7	21.1	26.2
1996			92.5	165.9	55.9	79.8			128.8	29.3	34.1
1997					64.4	98.9					39.0

Source: Various institutional publications and direct information from public institutes for agricultural research.

7. Scope of research

Data collected in 1992-1993 reveals that NARS have concentrated their efforts on animal production and cereals, involving 20% of their programmes and 23% of researchers (Lindarte,1995). If animal health and forages are considered, proportions increase even more. Tables 22 and 23 list the programme areas in which research activities in Latin American countries focus (with the exception of EMBRAPA). More detailed information will be examined in each national case in the following chapter.

Table 22

LATIN AMERICA AND THE CARIBBEAN: NUMBER OF PROGRAMMES DEVELOPED WITHIN THE NATIONAL AGRICULTURAL RESEARCH SYSTEMS, BY SUBREGION

Programme area	Subregions a/				Total		Total researchers	
	Central America	Caribbean	Andean	Brazil and Southern Cone	No.	%	No.	%
Cereals and grains	14	3	17	30	64	8	666	10
Legumes	5	3	7	7	22	3	204	3
Oilseeds	5		7	15	27	3	257	4
Roots and tubers	2	5	7	6	20	3	216	3
Vegetables	7	5	5	14	31	4	392	6
Fruits	16	5	9	24	54	7	514	8
Coffee and sugar cane	1	1	3	6	11	1	165	2
Forestry	12	6	21	15	54	7	182	3
Animal nutrition, grass and forages	6	15	6	7	34	4	186	3
Animal production	18	21	18	40	97	12	887	13
Soil, water, climate, irrigation	9	6	5	18	38	5	355	5
Animal and vegetable health	27	5	6	22	60	8	473	7
Phytotechnology	26	11	4	18	59	7	420	6
Genetic resources	13	2	13	20	48	6	382	6
Natural resources	10		5	17	32	4	394	6
Economics and social studies	25	7	11	22	65	8	578	9
Other	24	5	13	29	71	9	442	7
Total no.	220	100	157	310	787	99	6693	101
%	28	13	20	39		100		100

Source: E. Lindarte; *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

a/ Does not include Brazil.

Table 23

LATIN AMERICA AND THE CARIBBEAN: NUMBER OF PROGRAMMES DEVELOPED WITHIN THE NATIONAL AGRICULTURAL RESEARCH SYSTEMS, BY TYPE OF INSTITUTION

Programme area	Type of institution a/						
	Public institutes for agricultural research	Natural resource entities	Other public entities	Universities and semi private entities	Regional and international centres	Total (no.)	Total (%)
Cereals y grains	37		23	3	1	64	8
Legumes	12		5	4	1	22	3
Oilseeds	15		9	3		27	3
Roots and tubers	12		7		1	20	3
Vegetables	16		8	7		31	4
Fruits	25		18	11		54	7
Coffee and sugar cane	4		7			11	1
Forestry	8	33	7	5	1	54	7
Animal nutrition, grass and forages	9		7	14	4	34	4
Animal production	42	1	26	23	5	97	12
Soil, water, climate, irrigation	14		15	6	3	38	5
Animal and vegetable health	21		24	9	6	60	8
Phytotechnology	10	5	28	9	7	59	7
Genetic resources	22	1	17	3	5	48	6
Natural resources	7	10	12	2	1	32	4
Economics and social studies	24	2	21	8	10	65	8
Other	22	2	30	13	4	71	9
Totals no.	300	54	264	120	49	787	
%	38	7	34	15	6		100

Source: E. Lindarte; *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

a/ Does not include Brazil.

III. NATIONAL CASES OF AGRICULTURAL RESEARCH SYSTEMS IN LATIN AMERICA AND THE CARIBBEAN

1. Argentina: National Institute for Agricultural Technology (INTA)

Institutional organization. The National Institute for Agricultural Technology (INTA) is a national, decentralized institution within the Department of Agriculture, Livestock and Fisheries. INTA is in charge of agricultural research and technology extension. INTA currently has three Strategic Research Centres in Castelar (400 kilometers from Buenos Aires), which incorporate 12 institutes,[3] and the Economic and Social Studies Institute. INTA has 15 regional centres, 41 experimental stations and about 200 extension agencies. Activities are organized in 17 national programmes, and INTA has defined seven special areas according to national priorities (see figure 6 and tables 24 and 25).

Personnel. After its creation, INTA increased the total number of employees peaking in 1975 with 5,845 employees and then holding steady through 1990. The implementation of adjustment programmes led to a contraction of personnel. The ratio of support staff to research personnel dropped from 2.4 in 1990 to 1.91 in 1997 as a result of successive reductions in support personnel (see table 26). INTA now has around 1,200 professionals working in different programmes and projects; 13% of these have a Ph.D. and 33% have a master's degree. The qualification of its human resources has improved significantly: between 1985 and 1997, the number of master's degrees almost tripled and the number of doctorates more than doubled (see table 27).

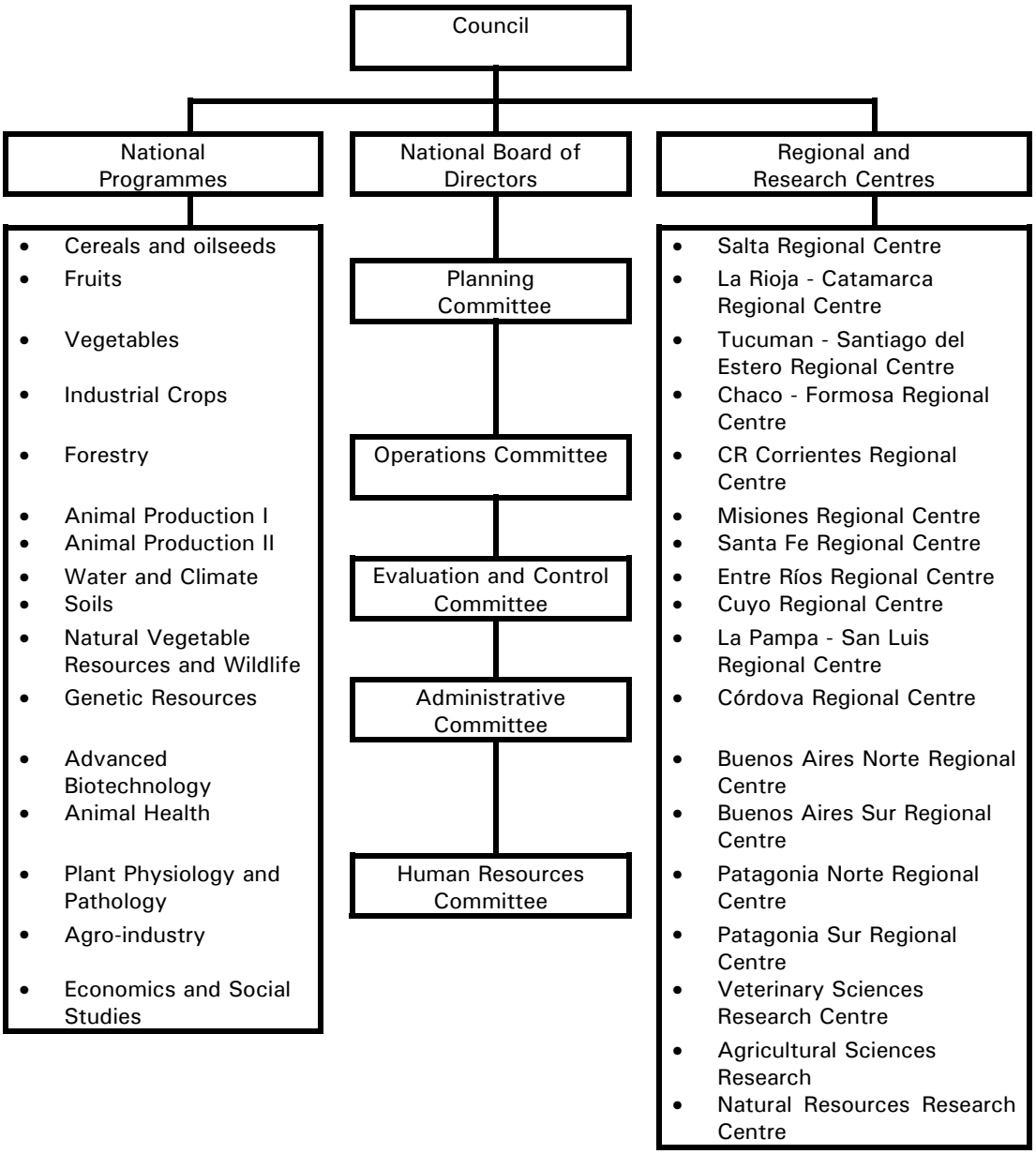
Specialties and focus areas. Agronomy is the most important specialty, followed by veterinary medicine and forestry engineering (see table 28). Similarly, Vegetable Production, Vegetable Protection and Animal Production are the main programme areas in which researchers are concentrated (see table 29).

Resources: Until 1980, INTA was financed through a special tax of 2% on traditional exports. In 1981-1983, the special tax was eliminated, and INTA received funds from the public treasury. In 1984, the special tax was reinstated at 1.5%. This measure allowed INTA to recover its original budget level. In 1993 the Government replaced the special tax on exports with a new tax on imports subject to the so-called statistical tax. This measure was implemented to promote exports. As tables 30 and 31 illustrate, tax revenue is INTA's most important source of financing, accounting for around 83% of the total budget.

[3] The Veterinary Sciences Centre operates the institutes for Virology, Bacteriology, Pathology, Food Technology and Molecular Biology. The Research Centre for Agricultural Sciences has institutes on Genetics, Vegetal Pathology, Phytovirology, Microbiology and Rural Engineering. The Research Centre for Natural Resources includes the institutes of Biological Resources, Soils, and Climate and Water.

Figure 6

ARGENTINA: INSTITUTIONAL ORGANIZATION OF THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHONOLOGY (INTA)



Source: National Institute for Agricultural Technology (INTA) Annual Reports.

Table 24

ARGENTINA: PRIORITY RESEARCH AREAS OF THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)

Priority areas	Objectives	Expected impact
Sustainable increase of grain production	Generation and adaptation of technology for intensive and sustainable grain production, emphasizing irrigation, precision technology, post-harvest, etc. Development of products with high value added, monitoring of contamination levels and sustaining services.	7,000,000 tons, or one billion dollars, of additional annual exports.
Sustainable increase of meat and milk production	Generation of technology for intensifying production, with emphasis on quality. Use of high quality forages and animal feeds; intensive calf breeding and fattening; and intensive dairy production in order to increase exports to world markets and raise value added.	More than US$ 500 million of additional exports per year.
Fruits, vegetables and related products	Technological support for intensified production, especially in non-pampas areas. Quality and grade certification for value added; targeting competitive markets. Post-harvest, preservation and agro-industrial processes for a growing food sector.	More than US$ 50 million through improved quality
Forestry	Research and technology transfer to increase forested areas. Sustainable increase of productivity. Specific modules for Argentina's different regions.	Over US$ 30 million annually through higher productivity.
Sustainable production in arid and semi-arid zones	Develop technology to match efficient use of natural resources with productivity and diversification in arid and semi-arid areas	Sustainable development of critical areas.
Natural resource management and conservation	Technology for preservation of natural resources and biodiversity. Study of climatic changes; monitoring and evaluation of resources.	Preservation of natural resources.
Food technology	Better penetration and integration of primary food production with manufacturing, distribution and consumers.	Higher value added for better competitiveness in foreign markets.

Source: National Institute for Agricultural Technology (INTA).

Table 25

ARGENTINA: PROGRAMMES AND PROJECTS WITHIN THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)

National programmes	Activities
Technology Generation Programme	• Horticulture: (a) vegetable crop production; (b) diagnostic methods for pathogen-plant relations: (c) pest and disease management systems for tomato crops. • Forestry: dynamic conservation of Andean-Patagonian forests. • Animal production I and II: Vaccines for control of Babesiosis. • Native plant and wildlife resources: ecology and management of livestock ecosystems on range land in semi-arid and arid regions.
Rural Change	• Productive conversion of small- and medium-sized farms. • Extension activities reaching 1,500 groups of farmers, employing 1,700 professionals, 120 project promotors and 1,600 advisors on production systems.
Prohuerta	• Improving the quality and quantity of food consumed, small-scale self-production and the use and distribution of income for food. • Promoting community participation in the solution of food problems.
Research and extension for small-scale farmers	• Improving income and quality of life of smallholders. • Transforming farmers into small-scale capitalists by promoting self-sustainable development.

Source: National Institute for Agricultural Technology (INTA).

Table 26

ARGENTINA: EVOLUTION OF HUMAN RESOURCES AT THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)
(number of persons)

	1958	1965	1975	1985	1990	1991	1993	1995	1997
University degree (a)	640	1045	1558	1460	1660	1354	1341	1377	1200
Support (b)	2016	2357	4287	3980	4015	2827	2790	2707	2300
Total	2656	3402	5845	5440	5675	4181	4131	4084	3500
Ratio (a:b)	3.15	2.26	2.75	2.73	2.42	2.09	2.08	1.97	1.92

Source: G. Ghezan, "El sistema de ciencia y tecnología en Argentina", consultancy paper prepared for the Agricultural Development Unit, ECLAC, Santiago, Chile, 1996 (unpublished); and C. Morales personal communication, 1997.

Table 27

ARGENTINA: EDUCATION LEVEL OF RESEARCHERS AT THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)
(in percentages)

	1985	1991	1995	1997
Ph.D.	4	6	11	13
Master's degree	13	20	29	33
Bachelor's degree	83	74	60	54
Total	100	100	100	100

Source: G. Ghezan, "El sistema de ciencia y tecnología en Argentina", consultancy paper prepared for the Agricultural Development Unit, ECLAC, Santiago, Chile, 1996 (unpublished); and C. Morales personal communication, 1997.

Table 28

ARGENTINA: RESEARCH STAFF COMPOSITION AT THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA), 1997

	Agronomy		Veterinary medicine		Forestry engineering		Economics		Other		Total	
Level of education	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
PhD	11.0	97	23.6	30	-	-	71.4	5	15.8	26	13.2	158
Master's degree	36.6	323	30.7	39	5.2	1	28.6	2	17.0	28	32.8	393
Bachelor's degree	51.2	452	45.7	58	94.8	18	-		61.2	101	52.2	629
Technician	1.2	10	-	-	-	-	-		6.0	10	1.8	20
Total	100	882	100	127	100	19	100	7	100	165	100	120

Source: National Institute For Agricultural Technology (INTA) Data Base.

Table 29

ARGENTINA: DISTRIBUTION OF RESEARCHERS BY PROGRAMME AREA AT THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA), 1997

Programme area	Percentage
Vegetable production	21.9
Vegetable protection	11.6
Genetics resources	1.9
Biotechnology	3.0
Forestry	3.7
Animal production	14.4
Animal health	8.5
Natural plant resources and wildlife	3.9
Animal production (non-ruminants)	1.5
Agro-industry	2.8
Soils	12.6
Water and climate	3.2
Economics and social studies	7.9
Statistics and informatics	2.3
Total researchers	100.0

Source:R. Martínez Nogueira, "The descentralization process in the Instituto Nacional de Tecnología Agropecuaria of Argentina", discussion paper, The Hague, International Service for National Agriculture Research (ISNAR), 1988; and the National Institute for Agricultural Technology (INTA) Data Base.

Table 30

ARGENTINA: BUDGET AND SOURCES OF FUNDING FOR THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)

Year	Total budget (millions of dollars)	Sources of Funding	
		Export/ import tax (%)	Other (%)
1980	11.79	71.1	28.8
1981	79.66	0.2	99.8
1982	29.30	0.0	100.0
1983	30.60	0.0	100.0
1984	40.25	84.5	15.5
1985	64.49	84.1	15.9
1986	60.03	82.2	17.8
1991	109.34	n/a	n/a
1992	112.27	n/a	n/a
1993	139.63	83.1	16.9
1994	132.76	87.7	12.3
1995	133.45	49.6	50.4

Source:R. Martínez Nogueira, "The descentralization process in the Instituto Nacional de Tecnología Agropecuaria of Argentina", discussion paper, The Hague, International Service for National Agriculture Research (ISNAR), 1988; and the National Institute for Agricultural Technology (INTA) Data Base.

Table 31

ARGENTINA: SOURCES OF FUNDING FOR THE NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)
(in percentages)

Source	1993	1994	1995
Public Sector	14.7	1.3	43.0
Own resources a/	**85.5**	**89.2**	**52.7**
Taxes	83.1	87.7	49.6
Non-tax revenue	2.4	1.5	3.1
External loans	0.2	1.2	1.2
Other	0.0	8.3	3.0
Total	100.0	100.0	100.0

Source: National Institute for Agricultural Technology (INTA).
a/ Own resources correspond mainly to a special tax levied to finance INTA activities.

In 1995 the INTA budget underwent important changes: the implementation of the Mercosur commercial agreement reduced import and export taxes. Consequently, the participation of the public treasury as a source of financing for INTA increased from 1.3% of total funding to 43% between 1994 and 1995, while special taxes dropped from 88% to 50%. In spite the fact that non-tax revenues are still low, they have a good potential. The main sources of non-tax revenues are sales of own production, technological agreements (see next section) and others. In regional centres, this source is becoming more important. Finally, a breakdown of expenditures by item demostrates the importance of personnel costs within the budget (see table 32). Around 72% of INTA's total expenditures corresponds to salaries. Almost 20% of this sum corresponds to headquarters offices and 80% to the regional centres, mainly in the Pampas region. Two important new programmes for small farmers (i.e., the Social Agricultural Programme and the Rural Change Programme) explain the increase in the total budget in 1993. They were implemented with funds from the public treasury, reaching 14.3% of the total budget.

Table 32

ARGENTINA: EXPENDITURE BY ITEM, NATIONAL INSTITUTE FOR AGRICULTURAL TECHNOLOGY (INTA)
(in percentages)

Expenditure	1991	1992	1993	1994	1995
Staff salaries	71.26	71.42	60.11	61.95	72.7
Non-personnel goods and services	15.66	19.51	21.32	25.02	11.9
Debt	2.09	4.66	4.03	3.99	4.1
Transferences	5.39	1.79	9.07	4.83	9.8
Investment	5.29	2.62	5.47	4.26	1.5
Total (percent)	100.00	100.00	100.00	100.00	100.00
Total (millions of dollars)	109.34	112.70	135.55	141.04	133.45

Source: National Institute for Agricultural Technology (INTA).

Links with the private sector. In 1987 INTA created a specialized unit linked with the private sector. The unit manages the technologies generated by INTA through Agreements on Technological Links (CVT), which provide royalties for the transferred technology. Joint Venture Agreements with the private sector are used to develop specific innovations. Between 1991 and 1995, 82% of these agreements established links with private companies and 15% with farmers' organizations. Approximately half of the agreements are joint ventures, mainly related to genetic improvement, animal health, diagnosis tests and agricultural machinery. The other half are agreements with the private sector for improved seeds, diagnosis tests for animals, etc. In 1995 a total of 61 special agreements generated US$ 2 million in revenues and accounted for 10% of the operating costs. Regional Centres now have the power to sign letters of agreements with local companies in order to obtain resources for their activities. In 1994 the Buenos Aires Regional Centre financed 26% of its operating costs through Agreements on Technological Links and local letters of agreements.

2. Brazil: Brazilian Agricultural Research Enterprise (EMBRAPA)

Institutional organization. The Brazilian Agricultural Research Enterprise (EMBRAPA) created on 26 April 1973, is a public company linked to the Ministry of Agriculture, Food Supply and Agrarian Reform, with legal characteristics similar to a private company. EMBRAPA covers all the regions of the country, networking through 37 regional research units, two services and 15 central units. EMBRAPA's mission is to generate, promote and transfer knowledge and technology for the sustainable development of agriculture, agro-industry and forestry. Since 1990, EMBRAPA has carried out a global institutional evaluation, involving all of its units in the strategic plan.

The mandate and scope of EMBRAPA's research centres vary widely, from strategic or commodities research at the national level to regional adaptive research. In the past, market-oriented farmers were the main clients. Since 1990, however, EMBRAPA has broadened the range of clients to include small farmers, agro-industries, consumers and environmental organizations. In 1994, EMBRAPA adopted a new planning system, the Strategic Planning System (SEP), which emphasizes the demand side through agricultural and agroindustrial producers. The new system promotes the optimization of resources in its multidisciplinary projects. A set of 16 priority programmes was defined, covering research activities, support and institutional development. EMBRAPA also carries out projects in international cooperation in order to extend technical and scientific know-how or to share knowledge and technology with other countries.

EMBRAPA has generated and recommended more than 8,000 technologies for Brazilian agriculture, reduced production costs and helped Brazil to increase the supply of food, while at the same time preserving natural resources and the environment and diminishing external dependence on technologies and basic products.

Personnel. EMBRAPA is the largest public institute for agricultural research in Latin America and the Caribbean. It has 9,101 employees, 2,082 of which are researchers. Of this group of researchers, 54% have a master's degree and 31% have a doctorate. EMBRAPA has the highest proportion of qualified researchers in the region. The institution's effort to improve the qualification of its human resources is noteworthy: between 1983 and 1997, the number of researchers with doctorates almost doubled (see table 14). EMBRAPA coordinates the national agricultural research system together with other institutions, carrying out research in geographical areas or in particular fields of scientific knowledge.

Specialties and focus areas. Animal production, fruits and vegetables and cereals are the main focuses of EMBRAPA's research (see table 33). The allocation of resources by programme area has recently undergone several important changes: cereals; evaluation, management, and production system; genetic resources; agricultural diversification; and industrial agricultural products lost importance between 1989 and 1993, while oilseeds, especially soybean, biotechnology and some basic foods such as cassava improved their position (see table 34). These changes in the allocation of resources reflect the new priorities established by EMBRAPA since 1990.

Table 33

BRAZIL: PROGRAMMES AND PROJECTS WITHIN THE BRAZILIAN AGRICULTURAL RESEARCH ENTERPRISE (EMBRAPA)

Programmes	Number of projects			
	1994	1995	1996	Total
Natural resource evaluation, management and recovery	29	11	7	47
Conservation and application of genetic resources	38	5	6	49
Basic research on biotechnology	22	3	8	33
Cereal production systems	47	3	3	53
Fruit and vegetable production systems	43	6	10	59
Animal production systems	52	8	2	62
Raw material production systems	21	6	1	28
Forestry production systems	16	1	3	20
Small-scale farming	14	2	5	21
Post-harvest, extraction, transformation and preservation of agricultural products	15	3	7	25
Environmental protection and evaluation	14	5	3	22
Agricultural automation	11	6	7	24
Rural and regional development support	22	11	11	44
Production and exchange of information to support research and development	11	5	6	22
Improvement and modernization of state systems of agricultural research	0	0	22	22
Administration and institutional development	3		62	65
Total	358	75	163	596

Source: Brazilian Agricultural Research Enterprise (EMBRAPA). Brazilian Agricultural Research Enterprise (EMBRAPA).

Table 34

BRAZIL: RESOURCES ALLOCATED BY PRODUCTS WITHIN THE BRAZILIAN AGRICULTURAL RESEARCH ENTERPRISE (EMBRAPA),1989-1993
(in percentages)

Programme area	1989	1990	1991	1992	1993
Cereals	12.5	13.6	13.6	13.6	7.1
Oilseeds	6.4	6.5	6.5	10.3	10.3
Cattle	13.2	12.2	11.5	11.5	13.7
Fruits	5.3	2.3	2.3	2.3	3.4
Horticultural products	5.2	4.0	4.0	4.0	6.8
Industrial agricultural products	5.2	2.2	3.5	3.0	1.1
Soils	6.0	5.4	5.4	5.4	5.8
Evaluation, management and production systems	14.2	12.8	12.3	10.4	3.9
Forestry	2.6	3.1	3.0	3.0	3.8
Agricultural diversification	7.1	7.2	7.3	7.0	2.6
Genetic resources	8.0	6.4	6.3	6.0	1.1
Other	14.3	24.3	24.3	23.5	40.4 a/
Total	100.0	100.0	100.0	100.0	100.0

Source: Based on information submitted by M. B. Alburquerque David, Institute of Applied Economic Research (IPEA), Brazil, 1997.

a/ Biotechnology, 13.9%; cassava 1.9%; soybean, 8.0%.

Resources: Allocation of resources to agricultural research through EMBRAPA peaked in 1989. EMBRAPA then experienced a steady reduction through 1993. Availability of resources has recovered rapidly regaining previous levels. The Federal Government is the main source of funds, reaching its highest contribution (90.3%) in 1989. In 1995 this public contribution was 75%. Own resources currently finance only around 8% of the total budget, but they are expected to increase in importance (see table 35).The largest item in the budget is salaries, which accounted for 81% of total expenditures in 1989 and then fell to only 48% in 1995 (see table 36).

Table 35
BRAZIL: SOURCES OF FUNDING FOR THE BRAZILIAN AGRICULTURAL RESEARCH ENTERPRISE (EMBRAPA), 1985-1995
(in percentages)

Year	Own resources	Federal Government	Agreements	Domestic loans	External loans	Previous balance	Total
1985	8.3	70.5	0.15	0.0	19.3	0.4	100
1986	10.9	73.5	1.8	0.03	11.7	2.2	100
1987	7.2	74.9	1.5	0.02	13.3	3.0	100
1988	6.1	75.6	1.8	0.0	15.6	0.9	100
1989	3.0	90.3	0.6	0.0	5.4	0.7	100
1990	5.8	83.4	0.5	0.0	9.8	0.6	100
1991	5.2	79.6	0.7	0.0	9.4	5.1	100
1992	6.1	83.3	0.5	0.0	9.3	0.8	100
1993	5.9	80.8	0.0	0.0	12.8	0.5	100
1994	8.1	80.1	0.0	0.0	11.4	0.4	100
1995	7.7	75.2	0.0	0.0	17.1	0.0	100

Source: Brazilian Agricultural Research Enterprise (EMBRAPA).

Table 36

BRAZIL: EXPENDITURES BY ITEM WITHIN THE BRAZILIAN AGRICULTURAL RESEARCH ENTERPRISE (EMBRAPA), 1981-1995
(000 US$ Dollars)

Year	Salaries		Other Costs		Buildings		Investments		Transferences		Total	
	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
1981	153 005.6	46.2	99 980.7	30.2	27 667.7	8.4	16 621.0	5.0	33 828.2	10.2	331 103.2	100
1982	219 898.7	49.9	104 214.7	23.7	22 759.4	5.2	53 245.6	12.1	40 364.8	9.2	440 481.9	100
1983	161 806.9	49.6	96 558.9	29.6	18 498.7	5.7	26 447.2	8.12	22 895.2	7.0	326 207.0	100
1984	126 266.5	39.8	108 492.9	34.2	19 446.9	6.1	45 794.1	14.4	17 617.1	5.6	317 617.5	100
1985	171 851.1	48.4	107 251.1	30.2	27 147.1	7.7	33 836.1	9.5	14 941.2	4.2	355 026.6	100
1986	163 283.3	45.4	108 271.2	30.0	40 063.1	11.1	27 212.5	7.6	21 766.5	6.0	360 596.6	100
1987	176 217.0	49.5	88 016.1	24.7	27 673.8	7.8	43 820.4	12.3	20 350.5	5.7	356 077.7	100
1988	163 336.8	43.9	139 330.9	37.5	25 728.0	6.9	31 590.5	8.5	11 797.3	3.2	371 783.5	100
1989	429 717.1	81.4	52 299.9	9.9	17 925.2	3.4	25 218.7	4.8	2 614.6	0.5	527 775.6	100
1990	276 435.4	63.4	92 376.2	21.2	61 52.6	1.4	24 688.6	5.7	36 121.2	8.3	425 774.0	100
1991	267 688.5	61.2	120 449.0	27.5	18 083.8	4.1	31 090.7	7.1	276.5	0.1	437 558.5	100
1992	227 474.2	72.2	48 398.6	15.4	54 45.2	1.7	11 285.2	3.6	22 270.4	7.1	314 874.1	100
1993	226 685.1	64.5	77 445.2	22.0	6 526.4	1.9	19 845.4	5.7	20 859.6	5.9	351 361.8	100
1994	201 165.3	56.8	86 940.1	24.5	22 526.6	6.4	43 605.1	12.3	0.0	0.0	354 237.1	100
1995	244 609.2	48.0	128 629.2	25.2	36 281.9	7.1	100 317.7	19.7	0.0	0.0	509 838.1	100

Source: M. B. Alburquerque David, Institute of Applied Economic Research (IPEA), Brazil, 1997.

Programme objectives. EMBRAPA administers sixteen main programme areas. These programmes and their primary objectives are listed below.

Natural resource evaluation, management and recovery: To understand and evaluate natural resources management in order to develop sustainable agricultural technologies, mainly in degraded areas.

Conservation and application of genetic resources: To preserve native and exotic genetic resources which are socially and economically important to the country, in order to develop appropriate agricultural technologies.

Basic research on biotechnology: To develop new plant varieties resistant to agroecological stress and to recover and preserve the environment.

Cereal production systems: To provide technologies to improve the competitiveness of Brazilian food production.

Fruit and vegetable production systems: To develop new technological processes, knowledge and competitive products for fruit, vegetable and cassava production, to minimize the negative impacts of the production systems and to stabilize the supply in the domestic market.

Animal production systems: To develop competitive technologies to improve productivity in animal production, taking into account the environment and human health.

Raw material production systems: To improve the quality and quantity of agroindustrial raw material by reducing losses, increasing productivity and producing new varieties.

Forestry production systems: To increase forest productivity and quality, to reduce costs and to develop new processes in wood products.

Small-scale farming: To improve the well-being of small-scale farmers, taking into account resource availability, rationality and market links.

Post-harvest, extraction, transformation and preservation of agricultural products: To improve the competitiveness of the Brazilian food industry and contribute to food security.

Environmental protection and evaluation: To evaluate the environmental impact of agricultural activities, to develop specific procedures to recover environment quality and to improve environmental management.

Agricultural automation: To generate and apply scientific knowledge in computers, software development, systems integration and processes, for the modernization of agricultural, forestry and agroindustrial activities.

Rural and regional development support: To identify specific research activities, to address new technological demands and to disseminate the results of agricultural, forestry and agroindustrial research.

Production and exchange of information to support research and development: To improve the efficiency of the generation and dissemination of knowledge, services and new technologies.

Improvement and modernization of state systems of agricultural research: To support the modernization process of the States' Agricultural Research System, one of the most important instruments of the Strategic Planning System (SEP).

Administration and institutional development: To provide administrative support to the EMBRAPA organization.

3. Colombia: Colombian Agricultural and Livestock Institute (ICA)

Institutional organization. In the 1960s the Colombian Agricultural and Livestock Institute (ICA) was created "to contribute to a sustained development of the agricultural sector and the national economy through the generation of modern technologies, the transfer of technology and the protection of agricultural production from diseases and pests." ICA had an extensive infrastructure, research stations in almost all the regions of the country and a large number of employees.

ICA's research activities were organized by crops, by basic disciplines (phytopathology, soils, etc.) and by projects. Two important laws dictated in 1986 and 1987 have significantly affected ICA: the first initiated a process of administrative decentralization, and the second transferred responsibility for technical assistance for smallholders from the Central Government to the municipalities. To accomplish this task, ICA created 66 Regional Centres for Training and Technology Transfer (CRECEDs). In 1989, the National System for Technology Transfer was created, giving an important role to ICA.

As a result of the above changes, ICA was transformed into an agricultural development agency, with developmental activities that became more important than the agricultural research activities.

In 1990, the Government established a new National Council on Science and Technology with 11 programme areas. The Agricultural Science and Technology Programme, with representatives from both the public and private sectors, coordinates sectoral planning in science and technology. Responsibilities include approving policies for agricultural science and technology, promoting funding for related programmes and integrating scientific advisory committees. In addition, the Government has supported the association of public institutions with private organizations to create corporations and foundations and to carry out special research and technology projects or programmes.

This new legal framework has provided the conditions for privatizing ICA in order to make it more efficient and competitive, to simplify its function and to decentralize its decisions. In 1993 ICA separated its responsibilities in two organizations: (a) ICA, which is in charge of phytosanitary protection, input regulation and coordination of research policies, and (b) the Colombian Corporation for Agricultural Research (CORPOICA), which is responsible for the promotion, strengthening and developing of research and technology transfer. CORPOICA is a mixed institution regulated by private law. This allows greater flexibility in its organization, structure, planning and management and better opportunities for association with the private sector.

Personnel. In 1994-1995, there were 688 researchers working in the different programmes and projects of CORPOICA. According to Falconi and Pardey (1993), the entire Colombian NARS employed approximately 819 researchers in 1991. More than half of these corresponded to the public sector, 10.4% to universities, 29.8% to semi-public organizations (farmers and government) and 4.9% to private companies (see table 37). Falconi and Elliot (1994) estimate that the public sector employed 84.2% of the total number of doctorates and master's degrees (see table 38), but expenditure per researcher was almost 70% higher in the private sector.

Table 37

COLOMBIA: OVERVIEW OF THE NATIONAL AGRICULTURAL RESEARCH SYSTEM, 1991

Organization	Research focus	Number of research sites	Number of researchers
PUBLIC			
Colombian Agricultural and Livestock Institute (ICA)	Crops, livestock, natural resources, biotechnology	25	438
National Institute for Renewable Natural Resources and the Environment (INDERENA)	Natural resources, forestry	2	3
Colombian Enterprise for Veterinary Products (VECOL)	Veterinary products	1	9
ACADEMIC			
1.- National University:			
• Department of Agronomy	Crops	1	42
• Biotechnology Institute	Biotechnology	n/a	24
2.- University of Valle:			
• Department of Biology	Crops, biological control	n/a	19
SEMI-PUBLIC			
National Research Centre for Coffee (CENICAFE)	Coffee	16	132
National Research Centre for Sugar Cane (CENICAŃA)	Sugarcane	7	25
National Rice Growers' Association (FEDEARROZ)	Rice	4	29
National Cereal Growers' Association (FENALCE)	Wheat, barley, oats, maize, sorghum	n/a	10
National Research Centre for Oilpalm (CENIPALMA)	Oilpalm	n/a	5
National Cotton Growers' Association (FEDEALGODON)	Cotton	3	13
Colombian Association of Flower Exporters (ASOCOLFLORES)	Flowers	n/a	3
National Cacao Growers' Association (FEDECACAO)	Cacao	n/a	7
National Corporation for Forestry Research and Promotion (CONIF)	Forestry	1	15
Andean Fruit Centre (CFA)	Tropical fruits	n/a	5
PRIVATE			
Hoescht	Agrochemical, seeds	2	17
Cargill	Seeds	n/a	1
Floramerica	Flowers	2	22
Total		64	819

Source: Falconi and Pardey, *Statistical Brief on the National Agricultural Research System of Colombia*, Statistical Brief No. 6, The Hague, International Service for National Agricultural Research (ISNAR), 1993.

Table 38

COLOMBIA: EDUCATIONAL STATUS IN THE NATIONAL AGRICULTURAL RESEARCH SYSTEM
RESEARCHERS (FULL-TIME EQUIVALENTS)

Researcher status	1981-1985	1986-1990	1991
Government:			
Doctorate	40.6	69.4	91.0
Master's degree	177.2	226.4	278.0
Bachelor's degree	188.0	244.6	69.0
On leave	0.0	4.4	12.0
Total	405.8	544.8	450.0
Semi-public			
Doctorate	9.0	15.0	21.0
Master's degree	28.6	37.6	52.0
Bachelor's degree	66.3	118.2	171.0
Total	103.9	170.8	244.0
Academic			
Doctorate	10.0	12.0	14.0
Master's degree	9.0	17.2	23.0
Bachelor's degree	2.0	2.2	6.0
Total	21.0	31.4	43.0
Private			
Doctorate	0.0	1.8	3.0
Master's degree	3.2	8.6	12.0
Bachelor's degree	6.2	15.4	25.0
Total	9.4	25.8	40.0
TOTAL			
Doctorate	59.6	98.2	129.0
Master's degree	218.0	289.8	365.0
Bachelor's degree	262.5	380.4	271.0
On leave	0.0	4.4	12.0
TOTAL	540.1	772.8	777.0

Source: Falconi and Pardey, *Statistical Brief on the National Agricultural Research System of Colombia*, Statistical Brief No. 6, The Hague, International Service for National Agricultural Research (ISNAR), 1993.

Links within the private sector. CORPOICA has reached collaborative research agreements with various private-sector organizations, including the National Ranchers' Association (FEDEGAN), the National Cotton Growers' Association (FEDEALGODON), the National Research Centre for Sugar Cane (CENICAÑA) the Colombian Tobacco Company (COLTABACO), the National Rice Growers' Association (FEDEARROZ) and the Urabá Banana Growers' Union (UNIBAN). CORPOICA has 349 strategic alliances with different sectors, including 223 with the Government, 68 with the private sector and 27 with universities.

The ICA budget varied widely between 1986 and 1994 (see table 39). Nevertheless, between 1990 and 1994, the budget experienced an important increase as a result of reforms implemented in ICA and the creation of CORPOICA.

Table 39

COLOMBIA: BUDGET OF THE COLOMBIAN AGRICULTURAL AND LIVESTOCK INSTITUTE (ICA), BY FUNCTIONAL AREA
(in millions of 1992 dollars)

Functional Area	1986	1987	1988	1989	1990	1994
Operating expenses	4.31	4.86	4.91	15.69	14.95	20.90
Research	10.84	9.87	10.41	9.13	8.94	26.00
Technical transfer	18.50	23.16	22.84	12.05	12.39	-
Debt service	3.81	5.19	12.52	10.12	12.18	18.00
Other	19.04	32.45	17.31	23.45	11.93	14.00
Total	56.50	75.53	67.99	70.44	60.39	78.90

Source: Colombian Agricultural and Livestock Institute (ICA) and Colombian Corporation for Agricultural Research (CORPOICA) Annual Reports.

In spite of the growing participation of the private sector, the Government is still by far the most important source of agricultural research in Colombia. The private sector increased its participation throughout the 1980s, accounting for just over 8% of funds for agricultural research in 1991 (see table 40). Recent estimations, however, have established private-sector participation around 15%, almost twice the previous figure. If this figure is confirmed, it would establish Colombia as a good example of success in this field.

Table 40

COLOMBIA: AGRICULTURAL RESEARCH EXPENDITURES
(in millions of 1985 PPP dollars)

	1981-1985 a/	1986	1987	1988	1989	1990	1991
Government	67.94	88.18	116.44	76.99	94.24	73.34	61.19
Semi-public	21.45	26.33	32.09	30.59	30.70	28.26	28.71
Academic	0.11	0.27	0.84	0.84	1.22	1.67	2.06
Private	3.23	5.42	8.07	8.07	8.31	7.09	8.56
TOTAL	92.74	120.21	116.49	116.49	134.47	109.35	100.51

Source: César Falconi and Philip C. Pardey, *Statistical Brief on the National Agricultural Research System of Colombia*, Statistical Brief, No. 6, The Hague, International Service for National Agriculture Research (ISNAR) 1993.

a/ Annual average.

4. Ecuador

(a) National Institute of Agricultural Research (INIAP)

Created in 1959, the National Institute of Agricultural Research (INIAP) is one of the oldest agricultural research institutes in Latin America. INIAP expanded rapidly in its first 15 years, mainly focusing on research infrastructure. Between 1962 and 1974, six experimental stations were created and organized (four on the coast, one in the Cuenca Valley, and one in the Amazon region). INIAP received additional experimental farms in the 1980s, increasing its infrastructure and also its costs.

INIAP currently has seven experimental stations and eight research farms in different ecological regions of the country. INIAP has contributed to the modernization of the agricultural sector through the generation, testing and transfer of technology. Since its foundation, INIAP has developed more than 160 varieties with high yields, pest resistance and other special characteristic adapted to different ecological environments. Additionally, the institute has worked on animal production technologies and since 1977 INIAP has focused its efforts on the development of technologies adapted to small-scale farming.

The generation of own resources has received special attention, in order to increase the institute's independence from the public treasury. Since its creation, INIAP has sold goods and services such as certified seeds, plants, and tests for pesticides and other agrochemicals.

Until 1994, research was structured by crop within five national programmes in plant protection, soil management, genetic resources, biotechnology and economics. In 1994, the research system was restructured. All national programmes were abolished except for one on bananas, with specialists moving to general agricultural extension services. As in other countries in the region, Government policy seeks to privatize extension services, with the target that farmers pay 50% of the costs of technical assistance. INIAP is attempting to fortify farmers' associations and to promote mechanisms to finance these services.

In 1995, INIAP implemented a strategic plan in which producing technology according to demand is the priority. This includes addressing the needs of small farmers with potential to incorporate technological changes. Small farmers without modernization potential obtain support from the Integrated Rural Development Programme financed by the World Bank, which is managed by the Ministry of Social Welfare.

Other priorities that have been set by the Institute include setting research priorities according to clients' demands; focusing research on production systems and agro-ecological areas; rationalizing the use of resources and increasing the generation of own resources; and establishing strategic alliances with users and clients.

INIAP has undertaken joint research projects in several areas. The institute is working with the National Banana Programme and the Agrarian University of Ecuador to control Black Sigatoga and to develop new plant varieties resistant to this disease. In the case of cacao, INIAP and the Agrarian University of Ecuador are together developing a new clone with high yields. An agreement with a multinational company for the production of industrial potato varieties is under way.

INIAP maintains agreements with the International Centre for Tropical Agriculture (CIAT), the International Maize and Wheat Improvement Centre (CIMMYT) and the Centre for Preinvestment and Information for Latin America and the Caribbean (CIP), from which it receives improved germ plasm; with regional organizations such as the Inter-American Institute for Cooperation on Agriculture (IICA) and the Tropical Agricultural Research and Training Centre (CATIE); and with several national and North American universities.

As to INIAP activities, 60% correspond to adaptive research, one-third or more to applied research and only 5% to basic research. In the past, research was mostly geared toward the commercial farming sector and was more inclined to the introduction of innovations. For this reason, research results from INIAP were very positive in the case of modern crops for coastal areas, such as soybean, rice, maize and African palm. Also external funding was available for this research, which compensated for the decline in public funding.

Personnel. Since 1973, under the Ministry of Agriculture, INIAP has increased its financial and human resources, peaking in the mid-1980s. From 1985 to 1997, the permanent staff was reduced from 529 to 390; support staff was reduced by more than half, while the number of researchers dropped about 20% (see table 41). Few of the researchers have a doctorate degree, but INIAP has implemented a special programme to improve the qualifications of its researchers. Currently, six employees are studying for a doctorate and 23 for a master's degree. It is expected that 10 researchers will start superior studies in 1998, 10 for a doctorate and 23 for a master's.

Table 41
ECUADOR: HUMAN RESOURCES QUALIFICATIONS AND NUMBER OF RESEARCHERS AT THE NATIONAL INSTITUTE OF AGRICULTURAL RESEARCH (INIAP), 1975-1995

Year	Doctorate	Master's degree	Bachelor's degree	Total researchers	Support a/	Other b/	Services c/	TOTAL
1975	5	38	115	158	91	163		412
1976	5	38	117	160	92	162		414
1977	5	39	134	178	93	169		440
1978	5	36	147	188	90	167		445
1979	6	51	119	176	96	197		469
1980	4	49	147	200	95	195		490
1981	5	54	117	176	95	193		464
1982	5	55	117	177	91	195		463
1983	5	58	169	232	98	196		526
1984	5	67	163	235	81	199		515
1985	4	67	162	233	97	199		529
1986	4	67	136	207	94	190		491
1987	4	70	131	205	92	187		484
1988	3	58	130	191	97	182		470
1989	1	53	143	197	96	192		485
1990	1	54	145	200	98	197		495
1991	1	55	144	200	95	210		505
1992	1	56	168	225	98	208	137	688
1993	1	65	149	215	93	201	141	650
1994	3	62	123	188	47	105	50	390
1995	4	63	123	190	47	105	48	390
1996	4	63	122	189	46	107	47	389
1997	5	66	118	189	47	107	47	390

Source: Rinske Warner (ECLAC) and Pablo Játiva (INIAP).
a/ Research assistant.
b/ Administrative support and services.
c/ Service personnel has been classified separately since 1992.

Resources. In July 1992, a law was approved granting INIAP autonomy in administration and budget management and access to state resources. It also provided an endowment of US$ 10 million to generate resources for research operations. As of August 1995, US$ 5 million has been granted to INIAP. As to financing INIAP's operations, less than 50% comes from public resources, around 12% comes from the World Bank, and about 30% is generated through the commercialization of certified seeds, some control seed operations, pesticide testing and other services. INIAP maintains legal control over basic seed reproduction, currently representing half of the domestic market. In connection with pesticides, importers must pay 90% of total test costs for approval of a pesticide's use.

These measures increased INIAP's total budget dramatically between 1990 and 1997, restructured funding sources. Public treasury funds represented almost 52% of the total budget in 1990 but only 30% in 1997. Resources generated by INIAP increased during this period, reaching 61% of the total budget (see table 42).

Table 42
ECUADOR: SOURCES OF FINANCING FOR THE NATIONAL INSTITUTE OF AGRICULTURAL RESEARCH (INIAP)
(in millions of sucre)

Source	1990	1991	1992	1993	1994	1995	1996	1997
Public treasury	1,859	2,174	4,135	4,693	4,429	4,578	5,126	5,493
Own resources	711	1,053	1,285	2,115	5,243	5,300	9,794	11,500
BID IC/EC 207 Loan	873	585	944	1,349	640	0	0	0
BIRF EC-3390 Loan	0	0	0	240	316	400	400	400
Agreements	144	262	198	314	166	500	900	1,400
TOTAL	3,587	4,074	6,562	8,711	10,794	10,778	16,220	18,793

Source: National Institute of Agricultural Research (INIAP) Planning Department and Pablo Játiva.

With regard to expenditures, 60% corresponds to salaries, 20% to operation costs and 20% to capital costs and transfers (see table 43).

Table 43
ECUADOR: EXPENDITURES BY ITEM WITHIN THE NATIONAL INSTITUTE OF AGRICULTURAL RESEARCH (INIAP)
(in percentages and millions of 1992 dollars)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
						(Percentages)					
Salaries	51.76	68.84	66.93	50.00	52.8	60.05	56.29	53.69	73.12	59.95	63.91
Operative costs	25.40	22.19	19.55	22.36	23.60	23.45	21.57	25.22	14.36	31.85	28.97
Investments	15.57	5.10	4.47	16.12	7.96	5.70	6.96	10.84	8.01	0.27	0.23
Debts, transferences and other	7.26	3.87	9.06	11.52	15.64	10.79	15.18	10.24	4.51	7.93	6.89
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Millions of 1992 dollars	400.0	412.5	512.9	1,238.9	1,468.0	2,073.2	3,077.7	5,142.2	9,822.8	6,149.0	8,036.4

Source: National Institute of Agricultural Research (INIAP) Planing Departament and Pablo Játiva

(b) The private sector

The private sector manages eight experimental farms, two laboratories for in-vitro work and one experimental station. Other entities involved in agricultural research include three universities; companies such as Latinreco (Nestlé) on cacao, coffee and quinoa; seed companies such as Agripac and cereal producers; and the large sugar mills. According to a study by the International Service for National Agricultural Research (ISNAR) (Working Paper No. 25), although operational funds per researcher declined during the structural adjustment period in Ecuador, this was not as significant in the private sector as in the public sector.

Table 44

ECUADOR: NUMBER OF RESEARCHERS IN THE PRIVATE SECTOR

	1986	1987	1988	1989	1990	1991
Doctorate	5	6	4	3	3	3
Master's degree	4	6	6	5	6	6
Bachelor's degree	7	7	8	8	11	13
Total	16	19	18	16	20	22
Technical support	13	19	22	20	24	24
Other	89	87	90	89	89	89
TOTAL	118	125	130	125	133	135

Source: International Service for National Agricultural Research (ISNAR).

Private-sector expenditures were double the expenditures made by the public sector, according to the ISNAR study and other sources. Private-sector investments, expressed as a percentage of public-sector research expenditure, were 40%. However, private-sector expenditures relative to agricultural GDP remain low in Ecuador (Falconi and Elliot,1994).

Table 45

ECUADOR: PRIVATE-SECTOR EXPENDITURES ON AGRICULTURAL RESEARCH

Year	Total expenditures (millions of dollars)	Expenditures as a percentage of agricultural GDP
1986	2.9	0.07
1987	2.4	0.06
1988	3.7	0.09
1989	3.6	0.09
1990	3.7	0.10
1991	4.0	0.10

Source: International Service for National Agricultural Research (ISNAR).

Table 46

ECUADOR: REAL EXPENDITURE PER RESEARCHER
(in millions of 1985 dollars)

Year	Private sector	Public sector	Private:public (ratio)
1986	106.12	35.37	3.0
1987	73.47	25.85	2.8
1988	81.63	24.49	3.3
1989	78.91	29.93	2.6
1990	74.83	27.21	2.8
1991	82.99	24.49	3.4

Source: International Service for National Agricultural Research (ISNAR); and C. Falconi and H. Elliot, *Public and private R&D in Latin America and the Caribbean*, Harare, Zimbabwe, International Conference of Agricultural Economists, August 1994.

(c) Foundations

The Foundation for Agricultural Development (FUNDAGRO) was created in 1987 to play a catalytic and coordinating role in revitalizing agricultural research, extension and education systems. FUNDAGRO does not conduct research directly, but rather supports research through contracts, mainly with INIAP. In fact, around 90% of FUDAGRO's total expenditures corresponds to contracts with INIAP. Most of the research is downstream, and the technology generated under this sponsorship is freely accessible in the market.

5. Chile

The basic institutional organization for science-based agricultural research in Chile was set up in the 1960s. Presently, the Chilean NARS consists of the Institute of Agricultural Research (INIA), five major universities (University of Chile, Catholic University of Chile, University of Concepción, Austral University of Chile and Valparaíso Catholic University), other new universities (established after 1981) and a number of small, private experimental stations, biotechnology laboratories, winter nurseries and business research units (such as the National Farmers' Association, Semillas Baer and ANASAC). Other institutions marginally involved in agricultural research include a few non-governmental organizations (Venezian and Muchnik, 1994).

(a) Institute of Agricultural Research (INIA)

Institutional organization. INIA Chile was created in 1964, based on several experimental stations administered by the Ministry of Agriculture. At present INIA has seven Regional Research Centres (CRIs), a National Entomology Centre and several experimental centres and technical offices covering Regions III to XII (almost the entire country) (see table 47). INIA has a total of 1,200 employees, including more than 200

specialized researchers grouped in four departments: animal production, plant production, natural resources and management and production systems.

INIA is currently reorganizing its structure to focus its activities, taking into account the demands of actual and potential clients. For this purpose, each CRI created an advisory committee with the participation of members from the private and public sectors. To improve efficiency and obtain economies of scale, INIA reorganized its activities through national departments closely linked with the CRIs.

Low profit in agricultural activities, low-quality products, marginalization of a significant number of small- and medium-scale farmers and deterioration of natural resources were identified as priorities for INIA's future research agenda.

Personnel. Table 48 shows the evolution in the qualifications of human resources. Researchers holding a doctorate currently represent 20% of total researchers, compared to 15% in 1983. Between 1983 and 1993, INIA suffered a decrease in total research staff. This level had almost recovered in 1997.

Table 47

CHILE: REGIONAL AND NATIONAL RESEARCH CENTRES OF THE INSTITUTE OF AGRICULTURAL RESEARCH (INIA)

Regional or national research centre	Localization	Area of influence (hectares)	Specialization
Intihuasi	IV Region	III and IV regions: 125,740 irrigated ha; 1 million dry ha	Fruits, horticulture, non-irrigated agriculture
La Cruz a/	V Region		Biological control
La Platina	Metropolitan Region	V, Metropolitan and VI regions; 4.8 million ha	Agriculture, horticulture, cattle, forestry
Los Tilos b/	Metropolitan		
Litueche b/	Region IV Region		
Quilamapu	VIII Region	VII and VIII regions: 3.5 million ha	Fruits, wine, sheep, wheat, legumes
Cauquenes a/	VII Region		Wine, legumes
Humán b/	VII Region		forages, sheep, cattle, pastures
Sta. Rosa a/	VIII Region		Irrigated and non-irrigated agriculture
Carillanca	IX Region	2.8 million ha	Annual crops, cattle, milk
Alto Andino b/	IX Region		Mountain agriculture
Remehue	X Region	1.5 million ha	Pastures, milk, potatoes
La Pampa b/	X Region		Seeds (potato, wheat, oats, forages)
Tamel Aike	XI Region		Pastures, cattle, sheep
Chile Chico b/			
Kampenaike	XII Region		Sheep

Source: Institute of Agricultural Research (INIA) Annual Reports.
a/ National centre.
b/ Experimental centre.

Table 48

CHILE: HUMAN RESOURCES AT THE INSTITUTE OF AGRICULTURAL RESEARCH (INIA)

	1983		1993		1997	
	No.	%	No.	%	No.	%
Bachelor's degree	169	61.6	75	46.2	114	53.9
Master's degree	64	23.4	64	39.6	55	25.9
Doctorate	41	15.0	23	14.2	43	20.2
Total	274	100.0	162	100.0	212	100.0

Source: Institute of Agricultural Research (INIA) Annual Reports.

Resources. INIA's budget increased dramatically between 1990 and 1996 as result of an increase in the allocation of public funds and an increase in the sale of goods and services (see table 49). Public-sector contributions represented around 50-58% of total resources throughout this period. The remainder corresponded to contracts with the private sector, the sale of goods and services and the sale of assets. As the table shows, INIA's capacity to generate own resources through these secondary sources fluctuated between 43% and 55% in this period. On the other hand, the importance of competitive funds in INIA's budget grew rapidly.

Salaries represented one-third of total expenditures in 1993, reaching 48.5% in 1994 and dropping to 40% in 1996. This salary participation is one of the lowest of the region's public institutes for agricultural research. On the other hand, operation costs have fluctuated between 27% and 36%, while investment represented approximately 13% in the period considered (see table 50).

Table 49

CHILE: SOURCES OF FUNDING FOR THE INSTITUTE OF AGRICULTURAL RESEARCH (INIA), 1990-1996
(in millions of dollars and percentage of total income)

Year	Public sector					Private sector						Total income
	Transfers	IDB Loan	Contracts, research, studies	Total		Contracts	Sale of goods and services	Sale of assets	Other income	Total		
				Millions of dollars	% of total					Millions of dollars	% of total	
1990	3.80	2.56	0.24	6.60	56.1		4.78	0.16	0.23	5.17	43.9	11.77
1991	4.83	0.56	0.23	5.62	48.6	0.39	5.25	0.21	0.10	5.95	51.4	11.57
1992	7.22	1.19	0.43	8.84	55.4	0.77	6.07		0.27	7.11	44.6	15.95
1993	7.06	0.05	0.44	7.55	45.2	0.71	5.94		2.52	9.17	54.8	16.72
1994	6.60	6.04	1.03	13.67	52.3	1.24	6.86		4.35	12.45	47.7	26.12
1995	11.48	2.56	2.15	16.19	55.6	0.80	7.91	1.22	2.99	12.92	44.4	29.11
1996	13.11	6.42	3.07	22.60	57.5	0.70	11.94	0.19	3.86	16.69	42.5	39.29

Source: Institute of Agricultural Research (INIA) Annual Reports.

Table 50

CHILE: EXPENDITURE BY ITEM WITHIN THE INSTITUTE OF AGRICULTURAL RESEARCH (INIA)
(in millions of dollars and percentages)

Year	Salaries		Operation		Investments		Other	
	Millions of dollars	%	Millions of dollars	%	Millions of dollars	%	Millions of dollars	%
1992	4.67	33.1	n/a		0.53		n/a	
1994	12.45	48.5	7.05	27.4	3.79	14.8	2387.6	9.3
1995	13.87	45.3	11.26	36.8	3.03	9.9	2482.1	8.1
1996	15.36	40.3	12.41	32.5	4.95	13.0	5428.6	14.2

Source: Institute of Agricultural Research (INIA) Annual Reports.

(b) Universities

In 1992 university Departments of Agriculture had 437 researchers,[4] of which 262 worked on a full-time basis. Approximately 61% had a Master's or a doctorate degree. University participation in agricultural research has increased. In 1975, university expenditures represented 18.5% of total expenditures on agricultural research. By 1991, that figure had grown to 23.2% (see table 51).

Table 51

CHILE: TOTAL EXPENDITURES OF THE INSTITUTE OF AGRICULTURAL RESEARCH (INIA), UNIVERSITIES AND THE PRIVATE SECTOR, 1975-1992
(in millions of 1990 dollars and percentages)

Year	INIA		Universities		Private sector		Total
	Millions of dollars	% of total	Millions of dollars	% of total	Millions of dollars	% of total	Millions of dollars
1975	6.48	80.1%	1.50	18.5	0.11	1.4%	8.09
1985	8.23	72.9%	2.86	25.3%	0.20	1.8%	11.29
1990	12.82	78.5%	3.25	19.9%	0.26	1.6%	16.33
1991	11.29	74.8%	3.50	23.2%	0.30	2.0%	15.09
1992	12.88	-	n/a	-	n/a	-	12.88

Source: E. Venezian, Case Study: Funding of Agricultural Research in Chile; Food and Agriculture Organization of the United Nations (FAO) and Special Programme for African Agricultural Research (ISNAR), February, Nairobi, 1993.

[4] Consejo de Rectores de las Universidades Chilenas; Anuarios Estadísticos.

(c) The private sector

According to some estimates, private-sector expenditures in agricultural research are significantly higher than the figures shown in table 51. Venezian (1993) cites private-sector expenditures for 1990-1991 at around 13% of the total; this is approximately US$ 2 million. The two most important private agents, the National Farmers' Association and Semillas Baer Company are engaged fundamentally with certified seed production at their experimental stations. Their research is focused on the introduction of genetic lines and varieties, production of some hybrids and seed testing. INIA is by far the most important institution, with more than 70% of total expenditures on agricultural research.

(d) Competitive Funds

Chile was one of the first countries in Latin America and the Caribbean to use competitive funds for agricultural research. Several funds are currently available with public financial support for specific purposes. Within the funds allocated for agriculture, animal production, forestry and fisheries, each competitive fund has different priorities to its objectives. On average, the distribution for 1996 was the following: agriculture, 31%; forestry, 25%; animal production, 11%; fisheries, 8%; and general agriculture purposes, 25% (see tables 52 and 53).

Table 52
CHILE: COMPETITIVE FUNDS RESEARCH AND DEVELOPMENT PROJECTS,1990-1994
(in millions of 1994 dollars and percentages)

	FONDECYT	FONDEF	FONTEC	FIA	Total	
					Millions of dollars	Percentage
Miscellaneous	1,609.4	7,335.9	200.5	337.8	9.48	30.2
Fruit production	1,461.0	3,850.2	689.0	452.2	6.45	20.5
Livestock	2,425.2	1,492.1	934.0	259.9	5.11	16.3
Fruits and horticulture	126.5	4,104.1	384.7	-	4.62	14.7
Crops	849.1	1,089.5	371.2	361.2	2.67	8.5
Vegetables	275.5	-	978.8	82.2	1.34	4.3
Pastures and forage grasses	860.5	-	154.8	243.3	1.26	4.0
Flowers	-	-	365.2	70.4	0.44	1.4
Fungi	-	-	62.1	-	0.06	0.2
Total	7,607.2	17,871.8	4,140.3	1,807.0	31.43	100.0
Percentage of total	24.2	56.9	13.2	5.7	100.00	

Source: L. López Cordovez and C. Morales, *Investigación agrícola y su impacto sobre la productividad de la agricultura chilena*, Chile, 1995 (unpublished).
Note: FONDECYT: National Fund for Scientific and Technological Development; FONDEF: Fund for the Promotion of Scientific and Technological Development; FONTEC: National Fund for Technological Development and Productive Research; FIA: Fund for Agricultural Research.

Table 53

CHILE: USE OF NEW FUNDING SCHEMES FOR AGRICULTURAL RESEARCH BY INSTITUTION, 1990-1994
(in percentages)

Institution	FONDECYT	FONDEF	FONTEC	FIA	Total
Institute of Agricultural Research (INIA)	0.26	3.78	-	2.95	6.99
Catholic University of Chile	2.97	15.01	-	0.65	18.63
University of Chile	8.96	7.96	-	0.56	17.48
University Austral of Chile	6.54	3.66	-	-	10.20
University of La Frontera	0.77	5.58	-	-	6.35
University of Tarapacá	0.98	3.50	-	-	4.48
University of Concepción	2.08	1.62	-	0.10	3.80
Catholic University of Valparaíso	0.17	3.23	-	-	3.40
University of Talca	-	1.67	-	-	1.67
University of Santiago	0.78	-	-	-	0.78
University of La Serena	0.71	-	-	-	0.71
University of Magallanes	-	-	-	0.03	0.03
Metropolitan University	-	-	-	0.03	0.03
Private sector	-	10.86	13.17	1.43	25.46
Total	24.21	56.87	13.17	5.75	100

Source: L. López Cordovez and C. Morales, *Investigación agrícola y su impacto sobre la productividad de la agricultura chilena*, Chile, 1995 (unpublished).

Note: FONDECYT: National Fund for Scientific and Technological Development; FONDEF: Fund for the Promotion of Scientific and Technological Development; FONTEC: National Fund for Technological Development and Productive Research; FIA: Fund for Agricultural Research.

The public funds for scientific and technological research and innovation are the following:

- National Fund for Scientific and Technological Development (FONDECYT)
- Fund for Development in Priority Areas (FONDAP)
- Fund for the Promotion of Scientific and Technological Development (FONDEF)
-

Two additional funds support technological research and innovation:

- Fund for Technological Research (FONTEC)
- Fund for Programmes and Projects in Social Services (FONSIP)
-

There are three funds for sectoral research:

- Fund for Agricultural Research (FIA)
- Fund for Fisheries Research (FIP)
- Antarctic Research Fund

Finally one fund finances superior education:

- Fund for the Development of Institutional Universities

Additionally, the Funds for Innovation Development (FDI) is a competitive fund created by the Production Development Corporation (CORFO), and the National Institute for Agricultural Development (INDAP) administers the Agricultural Fund for Technology Transfer (FTT). The following is a short description of some of the funds available within the Chilean agricultural research system. From the point of view of the resources allocated, FONDEF is the most important competitive fund.

FONDECYT. This instrument was created in 1982 to fund scientific and technological research projects in all areas of knowledge. As with the other competitive funds, FONDECYT is part of the Chilean Science and Technology Programme. The areas supported are mathematics, physics, chemistry, biology, earth sciences, astronomy, engineering, medicine, agronomy and social sciences. Biology, medicine and engineering are the dominant disciplines. Tables 54 and 55 show the number of approved projects and the resources allocated for agriculture, animal production and food technology.

FONDEF. This fund was created in 1991 as a part of the Chilean Science and Technology Programme. It aims to strengthen the country's research and development capacity, to increase quantity and quality of scientific and technological research, to expand the supply of services related to science and technology (S&T) and to transfer S&T knowledge effectively to productive sectors. FONDEF finances three types of projects: research and development, infrastructure and technological transfer.

FONDEF supports universities, technological institutes and research and development centres from both the public and private sectors. In 1991 and 1992, FONDEF defined six priority areas: agriculture, fisheries and aquaculture, forestry, information technology, manufacturing and mining.

Table 56 shows the number of projects selected since 1991 by programme area and by allocation of resources. Agriculture is the second most important area according to the number of projects approved as well as resources allocated.

Table 54

CHILE: NUMBER OF PROJECTS APPROVED BY THE NATIONAL FUND FOR SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT (FONDECYT), 1988-1997

Programme area	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
Agronomy	12	24	18	14	18	15	17	19	19	22	178
Food technology	3	6	4	4	5	4	6	5	5	5	47
Animal health and production	13	15	15	16	12	10	10	9	8	7	115
Other	352	460	374	485	365	433	399	421	356	320	3,965
Total	380	505	411	519	400	462	432	454	388	354	4,305

Source: National Fund for Scientific and Technological Development (FONDECYT)

Table 55

CHILE: RESOURCES ALLOCATED BY THE NATIONAL FUND FOR SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT (FONDECYT) IN THE FIRST YEAR
(in millions of June 1996 dollars)

Programme area	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
Agronomy	166.03	245.72	177.98	165.51	236.81	206.50	244.61	314.92	331.55	435.90	2.525.53
Food technology	40.67	94.77	56.73	65.56	65.51	59.17	72.07	93.60	88.56	89.58	726.22
Animal health and production	197.79	185.05	204.77	189.63	133.19	175.24	165.93	128.71	170.84	138.68	1,689.83
Other	4,273.440	5,381.62	4,156.61	5,866.18	4,581.92	5,611.39	5,497.14	6,590.33	6128.00	6,003.59	54,090.22
Total	4,677.93	5,907.16	4,596.09	6,286.88	5,017.43	6,052.30	5,979.75	7127.56	6,718.95	6,667.75	59,031.80

Source: National Fund for Scientific and Technological Development (FONDECYT). **Source:** National Fund for Scientific and Technological Development (FONDECYT).

Table 56

CHILE: PROJECTS APPROVED BY THE FUND FOR THE PROMOTION OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT (FONDEF)
(in millions of 1995 dollars)

	1991 and 1992		1995		1997	
Programme area	Number of projects	Resources allocated	Number of projects	Resources allocated	Number of projects	Resources allocated
Mining	24	38.2	3	580	4	1,112
Agriculture	23	34.7	8	1,595	4	945
Forestry	17	24.4	6	1,590	6	1,198
Manufacturing	13	16.5	3	671	1	196
Fisheries and aquaculture	12	18.0	9	2,969	4	1,068
Information technology	7	27.0	3	696	-	-
Other	3	7.6	-		3	670
Total	99	166.4	32	8,101	22	5,189

Source: National Commission on Scientific and Technological Research (CONICYT); Fund for the Promotion of Scientific and Technological Development (FONDEF).

FONTEC. FONTEC was created in 1991 to promote, finance and subsidize projects in technological research and development infrastructure and, in general, to promote all phases of technological product development carried out by private national enterprises, either individually or working in groups or associations. CORFO is the governmental agency in charge of this fund. Between 1991 and 1996, FONTEC used 32.6% of its resources to finance agriculture, forestry, fisheries and aquaculture projects (see table 57).

Table 57

CHILE: PROJECTS APPROVED BY THE FUND FOR TECHNOLOGICAL RESEARCH (FONTEC), 1991-1996

Economic sector	Number of projects	Total costs (millions of dollars)	FONTEC's funding (millions of dollars)	Sectoral participation (%)
Agriculture	140	14.39	7.38	18.1
Forestry	15	1.76	0.88	2.2
Fisheries and aquaculture	46	9.19	5.03	12.3
Other	411	58.87	27.51	67.4
Total	612	84.21	40.80	100.0

Source: National Commission on Scientific and Technological Research (CONICYT); Production Development Corporation (CORFO)

FIA. FIA was created in 1981 by the Ministry of Agriculture as an autonomous institution that operates as a private organization, promoting agricultural innovation and technology transfer in the agriculture, forestry, animal production and aquaculture sectors. In 1996, 53% of the FIA's resources were awarded to agriculture, 29% to

animal production, 11% to forestry and 7% to aquaculture projects. The total resources allocated since its foundation appear in table 58.

Table 58

CHILE: SELECTED COMPETITIVE FUNDS FOR AGRICULTURAL, FORESTRY AND FISHERIES RESEARCH
(in millions of dollars)

Year	Fondo de Desarrollo Productivo	FONDECYT	FIA	FTT (INDAP)	F.Investigación Subscretaría Pesca	FIP	FONTEC	FONDEF	Total
1979	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02
1980	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09
1981	0.00	0.00	0.12	0.00	0.14	0.00	0.00	0.00	0.26
1982	000	0.09	0.14	0.00	0.14	0.00	0.00	0.00	0.37
1983	0.00	0.07	0.10	0.00	0.02	0.00	0.00	0.00	0.19
1984	0.08	0.07	0.11	0.46	0.02	0.00	0.00	0.00	0.74
1985	0.13	0.13	0.12	0.73	0.05	0.00	0.00	0.00	1.16
1986	0.22	0.50	0.13	0.91	0.03	0.00	0.00	0.00	1.79
1987	0.36	0.97	0.15	1.04	0.03	0.00	0.00	0.00	2.55
1988	0.40	1.93	0.17	2.07	0.03	0.00	0.00	0.00	4.60
1989	0.66	4.35	0.19	2.35	0.05	0.00	0.00	0.00	7.60
1990	0.89	6.03	0.23	2.88	0.07	0.00	0.00	0.00	10.1
1991	0.00	8.79	n.a	5.87	0.11	0.00	0.00	0.00	14.77
1992	0.00	11.29	0.22	10.17	0.21	0.00	5.09	10.8	37.78
1993	0.00	13.88	0.25	11.47	0.24	3.59	6.42	18.3	54.15
1994	0.00	16.99	0.29	14.36	0.29	3.84	7.64	20.14	63.55
1995	0.00	26.72	2.01	17.39	1.29	3.39	11.1	11.91	73.81
1996	0.00	33.65	4.05	26.3	1.42	2.71	13.02	16.99	98.14
1997	2.74	37.54	5.8	27.1	1.93	5.10	14.96	18.18	113.35
Total	5.48	163	14.08	123.1	6.18	18.63	58.23	96.32	485.02

Source: National Commission on Scientific and Technological Research (CONICYT).

Fund for Technology Transfer (FTT). Created in 1984, this fund is administered by the National Institute for Agriculture Development (INDAP) of the Ministry of Agriculture. It is oriented to technology transfer for small farmers. The resources allocated since 1984, appear in table 58.

Competitive funds to support general research and transfer has increased dramatically since their creation, particularly in the 1990s when the Government has given more importance to these instruments. FONDEF is currently the most important, according to the amount of resources allocated. Research and transfer activities in agriculture, forestry and fisheries have benefited from these trends. Although these areas do not have specific new funds, significant allocations were made in funds such as FONDEF, FONTEC and FONDEC, and FIA and FTT (INDAP) increased their allocations.

6. Mexico: National Institute for Agricultural, Livestock and Forestry Research (INIFAP)

Institutional organization: Mexico has a successful tradition of agricultural research and extension that has contributed to higher yields in wheat, maize, sorghum, rice, dairy products and other agricultural activities (Alarcón and Calle, 1994). The main research institution, the National Institute for Agricultural, Livestock and Forestry Research (INIFAP), was created in 1985 by merging three institutes previously responsible for livestock and forestry research. INIFAP's main objectives are the following: to reinforce strategic and adaptive agricultural research; to coordinate research on ecological, biological and technological restrictions for vegetable and animal production; to support research on natural resources; and to validate experimental results under producers' conditions. As a result of reforms, INIFAP has refocused these objectives, granting increased importance to natural resources and ecological and environmental concerns.

INIFAP is a partially descentralizated institution within the Secretariat of Agriculture, Livestock and Rural Development (SAGAR). Although it is not an independent entity, INIFAP can receive funds from both federal and non-federal sources.

INIFAP is currently organized in 34 Centres for Agricultural, Livestock and Forestry Research (CIFAPs). The centres are organized by agroclimate zones, as part of a successful decentralization carried out in 1985. The CIFAPs, which are responsible for managing 87 experimental stations throughout the country, work in close connection with state and local representatives of SAGAR. INIFAP manages around 61,000 hectares in experimental stations: 14,000 for crops, 34,000 for livestock and 13,000 for forestry.

Specialized work is conducted through national centres for programme areas (CENIDs). They include Microbiology in Mexico City, Parasitology in Morelos, Agroclimatology in Durango, Physiology in Queretaro and Wood Technology in Puebla. The CIFAPs and CENIDs have scientific, administrative and budgetary autonomy, as well as freedom to execute programmes; evaluate results and staff; and sign agreements with producers and other sources of private funds.

Research resources: Staff costs have represented a high proportion of the total budget in recent years. From 85% in 1990, the staff costs passed to 71% in 1993. The remaining resources are mostly spent on operational costs, with a small amount for maintenance and investment. This situation has seriously affected the research capacity of the institute, particularly during the 1980s because of budget cuts.

While the number of researchers increased between the periods 1983-88 and 1989-92, resources for research decreased (see table 59). Consequently, resources per researcher dropped almost by half, which seriously affected research activities. In 1997 the number of researchers was again reduced by 20%, and the number of researchers holding a doctorate fell by around 50%.

From 80 to 90% of INIFAP's budget is provided by the Federal Government; the rest is provided by state and local governments, producer organizations and service fees. Funds from other sources are insignificant in spite of the fact that the potential to raise funds is high. The CIFAP of Sonora, for example, gets 43% of its total resources from a public-private partnership organization and from the State Government.

Table 59

MEXICO: EVOLUTION OF SELECTED INDICATORS OF ACTIVITY AT THE NATIONAL INSTITUTE FOR AGRICULTURE, LIVESTOCK AND FORESTRY RESEARCH (INIFAP)

Period	Number of researchers	Research expenditure (millions of dollars)	Research expenditures (% of agri-cultural GDP)	Expenditure per researcher (dollars)	Total Federal expenditure (millions of dollars)	Rural development expenditure (millions of dollars)
1983/88	1,718	106.2	0.45	69,500	116.76	9.95
1989/92	1,853	67.5	0.28	32,600	91.70	7.11

Source: John McIntire, on the basis of World Bank data, 1994.

Research priorities: Irrigated areas was the main priority for public research in the past, with good success. The focus has now changed to other problem areas, such as rainfed and tropical areas, where private research and extension is still very weak. INIFAP has defined five principal agro-climatic zones (i.e., dry tropical, temperate, humid tropical, sierra and arid/semi-arid) to focus research activities according to the main problems of each area.

An INIFAP evaluation in 1992 found that in maize, the most important crop of Mexico, research and extension have failed to transfer high-yielding cultivars from the experimental stage to production. In grains, legumes and oilseeds, adaptive research has failed to incorporate the results of basic research, while technology transfer has not always had good results for farmers. In irrigated areas, an issue of growing importance involves competition for water among grains, oilseeds and high-value fruit and vegetable crops. In livestock production, not much has been done to improve forages and animal health. Research in animal health is largely executed by the private sector, while forage production research is conducted by the public sector. Natural resources and the environment have not been sufficiently studied; areas of particular concern include soil conservation, forestry and integrated pest management.

INIFAP is currently researching over 100 crops, 60 forestry species and 8 animal species, with 20 animal products. Additionally, INIFAP is conducting research in more than 80 disciplines. INIFAP has produced 886 different varieties of crops, and is working on the reduction of risk in vegetable and animal production. INIFAP also coordinates technology transfer with 32 foundations in the country.

Personnel: 7,500 employees work at INIFAP, of which about 1,700 are professionals. Of these, 94%, are researchers and the rest provide administrative support. Almost two-thirds of the researchers work in agriculture, 23% in animal production, and 12% in forestry. 82% work in regional research centres, 8% in CNIDs, 1% at headquarters and the rest, 9%, are taking post-graduates courses.

7. Uruguay: National Institute for Agricultural Research (INIA)

The National Institute for Agricultural Research (INIA) was created in October 1989 by merging other institutes dedicated to agricultural research. INIA has a Board of Directors composed of two members from the Government, one from the farmers' associations

and one representing other organizations (i.e., Cooperatives, the National Commission on Rural Development and Regional Centres for Agricultural Research).

INIA has five Regional Offices that are responsible for experimental stations and units. The experimental stations are the following: Tacuarembó, Las Brujas (Canelones), Treinta y Tres, La Estanzuela (Colonia) and Salto Grande. Additionally, INIA has five Regional Advisory Councils (CAR), one in each region. The CARs are made up of members from the private sector of the specific region. INIA has defined three research areas with 13 national programmes; table 60 shows the organization of the national programmes at each experimental station.

Table 60

URUGUAY: NATIONAL PROGRAMMES WITHIN THE NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INIA)

AREA	PROGRAMME	Tacua-renbó	Las Brujas	Treinta y Tres	La Estan-zuela	Salto Grande
CROPS	Summer crops					
	Winter crops					
	Rice					
	Crop evaluation					
ANIMAL PRODUCTION	Milk cattle					
	Meat cattle					
	Pastures					
	Sheep and goats					
	Small animals					
HORTICULTURE FRUTICULTURE FORESTRY	Horticulture					
	Fruits					
	Citrus					
	Forestry					

Source: National Institute for Agricultural Research (INIA).

National programme headquarters

Location of projects within the national programmes

The Fund for Promotion of Agricultural Technology (FPTA). INIA created a special mechanism to join the efforts and interests of universities, non-governmental organizations and the private sector. The Fund for the Promotion of Agricultural Technologies (FPTA) finances projects executed by institutions and researchers outside INIA, in accord with the goals of the national programmes of the institution.

The Fund is financed through its own resources (i.e., 10% of a specific tax levied to finance INIA), Government resources, private-sector resources and external resources. Numerous projects have been financed through this mechanism (see table 61).

Table 61

URUGUAY: PROJECTS APPROVED BY THE FUND FOR THE PROMOTION OF AGRICULTURAL TECHNOLOGIES (FPTA)

Programme area	In execution a/	Executed b/
Forestry	1	2
Meat cattle	4	4
Milk cattle	3	4
Sheep and goats	6	4
Pastures	2	8
Summer crops	2	2
Winter crops	1	2
Horticulture	5	9
Rice	2	3
Citrus	1	4
Small animals	--	8
Fruits	--	3
Without specific programme	1	8
TOTAL	28	61

Source: National Institute for Agricultural Research (INIA).
a/ In execution: after 19 May 1997
b/ Executed: before 18 May 1997

Agreements and International Relations. INIA maintains a wide network of relations with different governments and organizations. Currently, INIA has 19 cooperation projects, 15 cooperation agreements and 4 permanent agreements (see table 62).

INIA maintains permanent relations with Israel for export-oriented fruits, the International Organization for Migration (IOM) for human resources, CIP for potato and sweet potato research and ISNAR for institutional aspects.

Staff qualifications. Although the total number of INIA researchers is high, it experienced an important increase between 1983 and 1993, from 80 to 126. The most significant change, as in other countries, is related to qualifications. None of the researchers held a doctorate in 1983; these now represent 11% of the total. An even more remarkable improvement is observed in the number of staff with a Master's degree (see table 63).

Budget allocations. INIA's budget fluctuates between US$ 12 million and US$ 14 million, except in 1994 when allocations were superior. Government and farmers' contributions (in the same proportion) are the main sources of funding. The largest expenses is for personnel salaries, which have increased since INIA creation (see table 64).

Table 62

URUGUAY: INTERNATIONAL AGREEMENTS ESTABLISHED BY THE NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INIA)

Country	Agency	Status	Topic
Canada	Canadian International Development Agency (CIDA)	active	wheat
France		active	citrus, compost, pastures, extension
Germany	German Agency for Technical Cooperation (GTZ)	active	milk
Great Britain	Overseas Development Administration (ODA)	ended	cattle production
Israel		active	fruits
Japan	Japan International Cooperation Agency (JICA)	active	fruits, forestry
New Zealand		active	pastures
Sweden	Swedish Agency for Research Cooperation with Developing Countries (SAREC)	ended	nitrogen, fixation
European Union	INCO	active	potato
Organizations			
OIEA/RCAL		active	rice, oats
CIP		active	potato, sweet potato
International Maize and Wheat Improvement Centre (CIMMYT)		active	wheat
United Nations Development Programme (UNDP)		active	forages
World Bank			pastures, natural resources, irrigation

Source: National Institute for Agricultural Research (INIA).

Table 63
URUGUAY: STAFF QUALIFICATIONS AT THE NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INIA)

Degree	1983		1993		1997	
	Number	%	Number	%	Number	%
Doctorate	--	--	5	4.0	11	8.9
Master's degree	18	22.5	46	36.5	53	43.1
Bachelor's degree	62	77.5	75	59.5	59	48.0
Total	80	100.0	126	100.0	123	100.0

Source: National Institute for Agricultural Research (INIA) Data Base; and E. Lindarte; *Resultados del Inventario Institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, Coronado, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA), 1995.

Table 64

URUGUAY: BUDGET SOURCES AND USE OF FUNDS WITHIN THE NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INIA), 1993 - 1997
(in millions of dollars and percentages)

	1993		1994		1995		1996		1997	
	millions of dollars	%	millions of dollars	%	millions of dollars	%	millions of dollars	%	millions of dollars	%
Sources										
Government	3,195.2	25.8	3,487.8	20.8	3,994.5	32.0	5,377.9	38.9	5,652.5	41.1
Farmers	3,195.2	25.8	3,487.8	20.8	3,994.5	32.0	5,377.9	38.9	5,652.5	41.1
Sale of goods and services	799.6	6.4	894.8	5.3	1,235.4	9.9	1,735.1	12.6	1,200.0	8.7
Other	5,204.5	42.0	8,905.1	53.1	3,267.3	26.1	1,313.5	9.6	1,250.0	9.1
Total	12,394.5	100.0	16,775.5	100.0	12,491.7	100.0	13,804.4	100.0	13,755.0	100
Expenses										
Salaries	4,231.2	37.6	4,775.8	34.9	5,725.5	38.1	5,971.0	47.6	7,615.0	58.0
Operational cost	3,943.5	35.1	3,858.1	28.2	3,639.4	24.2	4,467.3	35.5	4,949.0	37.7
Capital expenses	3,077.1	27.3	5,061.2	36.9	5,669.0	37.7	2,117.4	16.9	560.0	4.3
Total	11,251.8	100	13,695.1	100	15,033.9	100	12,555.7	100	13,124.0	100

Source: National Institute for Agricultural Research (INIA).

8. Costa Rica: National System for Agricultural Research and Technology Transfer (SNITTA)

The National System for Agricultural Research and Technology Transfer (SNITTA) was created in 1996 based on the National Commission on Agricultural Research and Technology Transfer (CONITTA), which coordinated and integrated the research and transfer activities for 23 national programmes and institutions within the public sector, universities and private sector. SNITTA aims to contribute to the technological development of traditional and non-traditional agricultural and agro-industrial products, taking into account sustainability and food security. The most important member of CONITTA is the Ministry of Agriculture and Livestock, which leads the majority of the programmes and institutions mentioned above.

A recent study reveals that agricultural research is not SNITTA's main activity: of a total of 1,176 employees linked with SNITTA, only 16.4% work in agricultural research activities and 67.8% in technology transfer; the rest work in administrative fields (González, 1996). The same study shows that public institutions are mainly involved in technology transfer (78% of the time), while the private sector dedicates 50% of its time to research activities. With regard to human resources, 33.4% of the personnel have a master's degree or doctorate.

Apart from the facilities of IICA and the Tropical Agricultural Research and Training Centre (CATIE), Costa Rica has 57 research units, 80% of which belongs to the public sector and 20% to the private sector and non-governmental organizations.

The public sector is the main source of funding for agricultural research. Despite this, the budgets of public institutions indicate that the main part is destined to pay salaries; operational costs represent only around 10% of the budget.

CONCLUSION

Almost all the countries of the region have institutions that could form part of a national system of agricultural innovations. Coordination is usually very weak, however, wasting the potential for complementation and synergy. National institutes of agriculture research are by far the most important agents from the point of view of the available budget, resources allocated, human resources and experience. On the other hand, the private sector has increased its participation in recent years, in some cases through producers' organizations constructed around specific products as in Colombia and Costa Rica, and in other cases, such as Ecuador, through enterprises that provide specialized inputs such as seeds, chemical products, machinery and irrigation equipment.

In the 1980s, public resources allocated for agricultural research were reduced significantly as a consequence of the crisis and adjustment programmes. Public institutes for agricultural research were generally obligated to reduce salaries and qualified personnel, which affected their research capacities. At the same time the deregulatory process, trade liberalization and urbanization created the conditions to generate a new group of technological demands linked with the agroindustrial process, post-harvest, storage and conservation stages in order to increase quality and competitiveness. However, Latin America and the Caribbean also experienced a worrying increase in poverty, deterioration of natural resources and the environment and losses of biodiversity. The public institutes for agricultural research under increasing pressures from different sectors to dedicate significant efforts to creating technological solutions for this kind of problem, particularly if the resources come from international agencies or developed countries.

Facing structural reforms and deep changes in the social and economic environment, national institutes of agricultural research proved to be stronger than previously supposed. They have shown a big capacity to adapt to the new conditions. All these institutes have implemented reforms to improve efficiency in the allocation of resources and to define research priorities according to client demand, at the same time incorporating problems related to poverty and extreme poverty, natural resources and environmental degradation and biodiversity. Sources of funding to finance agricultural research have also changed. Governments have implemented special competitive funds. A new kind of non-public organizations -the foundations- also obtain financing from different sources for agricultural research and technology transfer, and non-governmental organizations are transferring technologies to small farmers.

At present, the national institutes for agricultural research show a significant heterogeneity at the regional level in terms of the resources allocated, human resources, experiences and capacities. The Southern Cone subregion exhibits the best conditions, while in the opposite extreme are the Caribbean, Central America and the Andean subregions. Additionally, common and collaborative actions between national institutes are sporadic, scarce or non-existent, in spite of the evidence of the advantages of sharing complementary capacities and specialties.

In general, the national institutes have improved their resource management and they are making important efforts to guide research priorities according demand-driven criteria. Several of the biggest institutes have recovered and even improved their budgets for different reasons, including the recovery of direct public-sector

contributions, the allocation of competitive funds, the presence and participation of non-public foundations for agricultural research, the participation of the private sector through specific taxes (as in Uruguay), the sale of goods and services and royalties. However, the increased availability of resources for agricultural research must be understood within the new structure of demand, which is wider and more complex than in the past.

To accomplish their mission, the national institutes must balance objectives that are sometimes very different and even conflicting. The complexity of this task, together with the relative scarcity of resources, requires a significant effort to organize a real agricultural innovation system incorporating the national institutes, public and non-public universities, foundations, non-governmental organizations, farmers' organizations, the private sector and all the agents involved and interested in agricultural research and technology transfer. Collaboration with other national institutes is crucial because of the possibility for diminishing costs, obtaining economies of scale and benefiting from other experiences. Similar considerations are appropriate in connection with international agricultural research centres.

References

Alarcón, E. and E. Calle (1994), "Planeación, seguimiento y evaluación del INIFAP. México", *Administración de la investigación agropecuaria: experiencias en las Américas*, Andrés R. Novoa and Douglas Horton (eds.), Bogotá, International Service for National Agriculture Research (ISNAR), Colombian Programme for the Advancement of Research (PROCADI), Tercer Mundo Editores.

Consejo de Rectores de las Universidades Chilenas (various years), *Anuarios estadísticos*, Santiago, Chile.

Dirven, Martine (1997), El empleo agrícola en América Latina y el Caribe: pasado reciente y perspectivas (LC/G.1961), Desarrollo productivo series, No. 43, Agricultural and Rural Development Network, Santiago, Chile, Agricultural Development Unit, Economic Commission for Latin America and the Caribbean (ECLAC).

Echeverría, Rubén, Eduardo J. Trigo and Derek Byerlee (1996), *Cambio institucional y alternativas de financiación de la investigación agropecuaria en América Latina*, Washington, D.C., Social Programs and Sustainable Development Department, Inter-American Development Bank (IDB), August.

Falconi, César and Howard Elliot (1994), *Public and Private R&D in Latin America and the Caribbean*, International Conference of Agricultural Economists, Harare, Zimbabwe, 22-29 August.

Falconi, César and Philip C. Pardey (1993), *Statistical Brief on the National Agricultural Research System of Colombia*, Statistical Brief, No. 6, The Hague, International Service for National Agriculture Research (ISNAR).

FAO (Food and Agriculture Organization of the United Nations) (1996), *The State of Food and Agriculture*, Rome.

Fuglie, Keith and others (1995), *The Value and Role of Public Investment in Agricultural Research*, Staff Paper, No. AGES-9510, Washington, D.C., United States Department of Agriculture, Economic Research Service, May.

GAO (United States General Accounting Office) (1996), *Agricultural Research. Information on Research System and USDA's Priority Setting* (GAO/RECED-96-92), Washington, D.C., March.

Ghezan, Graciela (1996), "El sistema de ciencia y tecnología en Argentina", consultant's paper prepared for the Agricultural Development Unit, Economic Commission for Latin America and the Caribbean (ECLAC), Santiago, Chile, unpublished.

González, Fernando (1997), Paper presented at the International Seminar *El nuevo entorno del desarrollo rural*, sponsored by the National University of Costa Rica.

Global Forum Toward Global Partnership in Agricultural Research (1996), *Plan of Action for Strengthening Global Agricultural Research. The NARS Perspective*, International Centers Week, Washington D.C., 30-31 October.

Katz, Jorge (1994), "Technology, economics, and late industrialization", *The Uncertain Quest: Science, Technology, and Development*, Jean Jacques Salomon, Francisco Sagasti and Céline Sachs-Jeantet (eds.), Tokyo, United Nations University Press.

_____ (1993), "Market failure and technological policy", *CEPAL Review*, No. 50 (LC/G.1767-P), Santiago, Chile, August.

Klotz, Cassandra, Keith Fuglie and Carl Pray (1996), "Private sector agricultural research expenditures in the United States, 1960-92", No. 9525, Economic Research Service.

Lele, Uma (1996), *Understanding Determinants of Agricultural Technology Adoption*, paper presented at the International Symposium on Food Security and Innovations: Success and Lessons Learned, Stuttgart, University of Hohenheim, 11-13 March.

Lindarte, Eduardo (1995), *Resultados del inventario institucional de 1993 sobre recursos, capacidades y áreas de concentración de entidades de investigación agropecuaria en América Latina y el Caribe*, San José, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA).

_____ (1994a), *Los institutos nacionales de investigación agropecuaria: Apuntes sobre su papel y evolución*, San José, Costa Rica, Inter-American Institute for Cooperation on Agriculture (IICA).

_____ (1994b), *Towards a NARS Vision on International Agricultural Research in Latin America and the Caribbean*, document prepared for the International Consultation on the NARS Vision of International Agricultural Research, Rome, International Fund for Agricultural Development (IFAD), 12-14 December.

López Cordovez, Luis and César Morales (1995), *Investigación agrícola y su impacto sobre la productividad de la agricultura chilena*, document presented at the seminar "Agroindustria y la innovación agrícola", Santiago, Chile.

Martínez Nogueira, Roberto (1988) "The descentralization process in the Instituto Nacional de Tecnología Agropecuaria of Argentina", Discussion Paper, The Hague, International Service for National Agriculture Research (ISNAR).

Muchnik, Eugenia (1997), "Globalización, regionalización y apertura económica", *El cambio global y el desarrollo tecnológico agropecuario y agroindustrial del Cono Sur: implicancias para los INIAS y el PROCISUR*, Montevideo, Southern Cone Technological Development Cooperation Programme for Agriculture (PROCISUR), June.

Nelson, Richard (1997), "How new is new growth theory? A different point of view", *Challenge*, vol. 44, No. 5, September/October.

Pannell, David J. (1996), "Toward a balance between strategic-basic and applied agricultural research, Discussion Paper, No. 6/96, Nedlands, Western Australia, Faculty of Agriculture, University of Western Australia.

Pardey, P.G., J. Roseboom and J. Anderson (eds.) (1991), *Agricultural Research Policy: International Quantitative Perspectives*, Cambridge, Massachusetts, Cambridge University.

Piñeiro, Martín (1996), *Hacia un sistema regional de innovación tecnológica para el sector agroalimentario*, Washington, D.C., Social Programs and Sustainable Development Department, Inter-American Development Bank (IDB), March.

PROCISUR (Programa Cooperativo para el desarrollo Tecnológico Agropecuario del Cono Sur) (1997), *Libro verde: elementos para una política agroambiental en el Cono Sur*, Montevideo, October.

Rosegrant, M. and others (1995), "Global food projections to 2020", Discussion Paper, No. 5, Washington, D.C., International Food Policy Research Institute (IFPRI).

Trigo, Eduardo (1995), "Agriculture, technological change, and the environment in Latin America: a 2020 perspective", Discussion Paper, No. 9, Washington, D.C., International Food Policy Research Institute (IFPRI), December.

University of Georgia (1995), "Indicators of global agricultural research and development progress", Report on a workshop, Athens, Georgia, September.

Venezian, E. (1993), *Case study: Funding of agricultural research in Chile*, Nairobi, Food and Agriculture Organization of the United Nations (FAO) and Special Programme for African Agricultural Research (SPAAR).

Venezian, E. and E. Muchnik (1994), "Structural adjustment and agricultural research in Chile", Discussion Paper, No. 94-5, The Hague, International Service for National Agricultural Research (ISNAR), February.

WTO (World Trade Organization) (1995), *El comercio internacional. Tendencias y estadísticas*, Geneva.