

PARAGUAY

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Quantitative data are important in measuring, monitoring, and benchmarking the inputs, outputs, and performance of agricultural science and technology (S&T) systems. They are an indispensable tool when it comes to assessing the contribution of agricultural S&T to agricultural growth and, more generally, economic growth. S&T indicators assist research managers and policymakers in policy formulation and decision-making on strategic planning, priority setting, monitoring, and evaluation. They also provide information to government and other institutions (e.g., policy research institutes, universities, and the private sector) involved in the public debate on the state of agricultural S&T at national, regional, and international levels. This brief reviews the major investment, capacity, and institutional trends in public agricultural research in Paraguay since 1981, using recent data collected under the Agricultural Science and Technology Indicators (ASTI) initiative (IFPRI-DIA 2007–08).¹ It provides important updates on trends in Paraguay's public agricultural research previously published by Beintema, Zambrano, Nuñez, and Pardey (2000).

INTRODUCTION

Paraguay has a population of 6 million and is one of South America's poorest countries. Agriculture accounted for 27 percent of the country's gross domestic product (GDP) in 2006, and a large percentage of the population derive their living from agricultural activity, often on a subsistence basis. Traditionally, the Paraguayan economy is based on cattle livestock and the cultivation of manioc, sugarcane, cotton, soybeans, and yerba maté (a species of holly native to the country). Over the past decade, soybean has become the principal product of Paraguayan agriculture and the country's main export product. Paraguay is now ranked as the world's third largest exporter of soybeans. Raising livestock is also a key economic activity in Paraguay. The sector prospered particularly after the closure of the Argentinean, Brazilian, and Uruguayan markets following outbreaks of foot and mouth disease in these countries in the early 2000s. More recently,

KEY TRENDS

- Total agricultural R&D capacity contracted significantly during 1991–2006.
- Agricultural R&D spending developed more erratically, but it has been on the increase in recent years due mainly to increased support from IDB to university-led research and the 2005 separation of SENAVE from MAG, leading to increased funding for agrochemical and seed trials for DIA.
- Agricultural R&D is mostly financed by the national government and internally generated resources. In-kind donor funding also plays a significant role in financing DIA's research.
- Average degree levels of Paraguayan agricultural research staff are among the lowest in Latin America.
- The recent approval of IPTA by the Paraguayan senate could lead to a boost in agricultural R&D capacity and spending in the years to come.

ABOUT ASTI

The Agricultural Science and Technology Indicators (ASTI) initiative comprises a network of national, regional, and international agricultural R&D agencies and is managed by the International Service for National Agricultural Research (ISNAR) division of the International Food Policy Research Institute (IFPRI). The ASTI initiative compiles, processes, and makes available internationally comparable data on institutional developments and investments in public and private agricultural R&D worldwide, and analyses and reports on these trends in the form of occasional policy digests for research policy formulation and priority setting purposes.

Funding for the ASTI initiative's activities in Latin America was provided by the Inter-American Development Bank (IDB), the World Bank via the Consultative Group on International Agricultural Research (CGIAR) and the International Food Policy Research Institute (IFPRI).

Table 1—Composition of public agricultural research expenditures and research staff, 2006

Type of agency	Total spending		Total research staff (fte's)	Share of research staff (percentage)	Agencies in sample ^a (number)
	2005 Paraguayan guaraníes (millions)	2005 (PPP) international dollars			
DIA			64.0	49.9	1
DIPA			2.0	1.6	1
CETAPAR			1.8	1.4	1
Higher education			60.5	47.2	3
Total	28,862.2^{b,c}	13.2^{b,c}	128.3	100	6

Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08) and CONACYT (2005).

^a See note 2 for a list of the 6 agencies included in this sample.

^b Spending totals are from CONACYT (2005) and include agricultural R&D expenditures by all public agencies in the country. Spending data by agency were unavailable.

^c Expenditure totals were estimated based on expenditure totals for 2005 and annual changes that occurred at DIA, DIPA, and CETAPAR during 2005–06.

Argentina and Brazil have recovered their markets, providing increased competition for the Paraguayan meat sector. Nonetheless, Paraguayan beef exports are substantial for a country of its size. The disappearance of vast tracts of the original forests has reduced timber production in Paraguay, but sustainable wood cultivation is now on the increase.

Despite difficulties arising from political instability, corruption, and slow structural reforms, Paraguay has been a member of the Southern Common Market (MERCOSUR) free trade bloc since 1991. Because it is landlocked, Paraguay's economy is very dependent on those of its neighboring countries and major MERCOSUR trade partners, Brazil and Argentina. Close to 40 percent of Paraguay's GDP is derived from trade and exports to Brazil and Argentina. Besides being trade partners, Brazil and Argentina are also Paraguay's main competitors because these countries share similar agroclimatic conditions with Paraguay and 54 percent of Paraguay's total exports are agricultural products (MAG 2006). To remain competitive in a global market, it is very important that Paraguay's agricultural products remain cheaper and of higher quality than those of its competitors. Investments in research and development (R&D) are crucial in this regard. Agricultural R&D has proven to be key to improving agricultural productivity, and it has shown very high returns on investment in all regions across the world. Improved productivity and enhanced crop and livestock varieties can ultimately make Paraguay more competitive in international markets. A well-developed national agricultural research system and adequate levels of investments are important prerequisites for this to happen.

SCIENCE AND TECHNOLOGY POLICY

Over the past three decades, Paraguay has gradually set up a system of rules, institutions, and other policy instruments to ensure the coordination of the country's science, technology, and innovation activities. The National Council of Science and Technology (CONACYT) is an independent agency that reports directly to the country's president and is composed of representatives from various ministries, industrial associations, state and private universities, trade unions, and the Scientific Society. In 2002, CONACYT launched its National Policy on Science and Technology, which provides the basis for its current priority sectors: energy, water resources, environment, agricultural production, and health services. It was not until 2006 that CONACYT, with support from the Inter-American Development Bank (IDB), actually defined and developed major S&T programs with a strong focus on public-private partnerships. In 2006, a loan agreement was approved between the government of Paraguay and IDB for a program in support of the development of science, technology, and innovation. Its main components include financing research and technological innovation projects; strengthening national postgraduate courses; providing scholarships for postgraduate studies in the country, short-term training and complementary support for graduate students who study abroad; and strengthening Paraguay's national innovation system through joint actions. At this stage, it is too early to give details on the success of these programs (CONACYT 2008).

Because of the relatively late establishment of an official S&T structure in the country compared to other countries in South America, Paraguay now lags well behind many of its

A Short History of Public Agricultural Research in Paraguay

Agricultural research in Paraguay began with the establishment of a private research station in Yaraguarazapá in 1887, the Agronomic Station in Puerto Bertoni in 1894, and the National School of Agriculture (ENA) in Trinidad in 1896. In 1923, the Division of Agriculture and Agricultural Defense was established with the aim of promoting cotton, tobacco, and other strategic crops. Twenty years later, the Inter-American Technical Service for Agricultural Cooperation (STICA)—a U.S. government agency—established the National Agronomic Institute (IAN) in Caacupé and the Experiment Station Barrerito in Caapucú. IAN focused its research predominantly on crops and pastures, and Barrerito began as a demonstration farm for livestock. In 1953 a second agricultural experiment farm, Chacra Experimental, was established in Capitán Miranda. The latter was renamed the Regional Center for Crops Research (CRIA) in 1970 and focused its research on fruits, soybeans, corn, cotton, and wheat.

The Ministry of Agriculture and Livestock (MAG) was created in 1950 but did not instigate research activities until 1966, when the ministry was restructured and STICA's responsibilities were transferred to its newly created Agricultural Research and Rural Extension Directorate (DIAER). Among other activities, DIAER had two separate research programs, one for crops and forestry and the other for livestock. The former took over IAN and CRIA's operations, and the latter took over Barrerito's operations.

DIAER's Crops and Forestry Program focused on 10 commodities (oilseeds, fruits, vegetables, wood, cotton, wheat, tobacco, meat, milk, and industrial oilseeds) and in 1969 was restructured and renamed the Agricultural and Forestry Research and Extension Directorate (DIEAF). At the same time, DIAER's livestock program was renamed the National Livestock Research and Extension Program (PRONIEGA), which was initiated by an international cooperation agreement between the U.S. Agency for International Development (USAID), MAG, and the Faculty of Agronomy and Veterinary Sciences at the National University of Asunción (UNA).

During the 1970s and early 1980s, Paraguay received funding to improve existing research facilities and to fund graduate-level training via two consecutive loans from the Inter-American Development Bank (IDB). Although these two loans contributed considerably to the improvement of the research facilities and training of staff, in actuality, research activities did not proceed at many of the newly established or improved facilities. Two of the newly established experiment stations, for example, were never properly staffed or made fully operational.

In 1990, MAG's organizational structure was simplified with the establishment of three subsecretariats. DIEAF was renamed the Directorate of Agricultural Research (DIA) and placed under the subsecretariat for crops. The subsecretariat for livestock took over the responsibility for PRODEGA and PRONIEGA, and these two were merged in 1994 to become the Directorate of Animal Research and Production (DIPA).

In 1956, the Faculty of Agronomy and Veterinary Sciences was established at the UNA, located in San Lorenzo. This faculty was divided in 1974 to become the Faculty of Agronomic Engineering and the Faculty of Veterinary Sciences (FCV). The Faculty of Agronomic Engineering was renamed the Faculty of Agricultural Sciences (FCA) in 1994.

Sources: Beintema et al. (2000) and IDB (1971).

South American counterparts when it comes to (agricultural and nonagricultural) R&D spending. In 2005, the country spent US\$7 million on (agricultural and nonagricultural) R&D, or just 0.09 percent of its GDP. This share has not changed much over the 2001–05 period. In comparison, neighboring countries such as Brazil (0.82 percent), Argentina (0.46 percent), and Chile (0.68 percent) all spent much larger shares of their GDP on R&D in 2005. In fact, Paraguay ranks second to the last in South America just before Ecuador (0.07 percent) when it comes to R&D spending (RICyT 2008). Because of the recent establishment of CONACYT and significant support from IDB, Paraguay's share of R&D investments over GDP is expected to rise somewhat in the future. However, the country has a long way to go if it is to catch up with its neighbors.

Compared to other fields of science, agricultural S&T represents a significant portion of total S&T conducted in Paraguay. In 2005, the country's agricultural S&T sector accounted for 35 percent of total S&T staff in Paraguay, up from a 31 percent share in 2001. In comparison, in 2005, social sciences and engineering accounted for 16 percent each, and natural sciences and medical sciences accounted for 15 and 11 percent of total S&T staff, respectively (RICyT 2008).

INSTITUTIONAL DEVELOPMENTS IN AGRICULTURAL R&D

The current study identified six public sector agencies involved in agricultural research in Paraguay in 2006.² Combined, these six agencies employed 128 full-time equivalent (fte) researchers and spent 29 billion constant 2005 Paraguayan guaraníes on agricultural R&D, the equivalent of 13 million international dollars in 2005 constant prices using a purchasing power parity (PPP) index (Table 1 on page 1).³ PPPs are synthetic exchange rates used to reflect the purchasing power of currencies, which typically compare prices among a broader basket of goods and services than do conventional exchange rates.⁴ Unlike most other countries in Latin America, Paraguay lacks a national agricultural research institute. Since the early 1990s, numerous attempts have been made to create a national-level R&D agency involved in crop, livestock, and forestry research: the Paraguayan Institute of Agrarian Technology (IPTA).⁵ However, the establishment of this institute has not yet materialized despite strong support from certain farmer organizations.

Reasons for the delay are largely political. During 2003–07, for example, Paraguay had five different ministers of agriculture, which severely complicated political decision making. In April 2008, the Colorado Party lost the presidential election after having been in power for more than 60 years. This has caused tremendous change throughout the country. Just two months after the presidential elections, in June 2008, the senate approved the establishment of IPTA. The chamber of deputies has also given its approval, albeit with some minor modifications, which still need to be approved by the senate as of November 2008. The new IPTA could therefore come into being rather soon. It is likely to consist of the current Agricultural Research Directorate (DIA); the Animal Research and Production Directorate (DIPA); and some departments of the National Forestry Institute (INFONA) that are currently not involved in research, but will receive a research mandate with the creation of the new IPTA. Various discussions on the actual

organizational and programmatic structure of IPTA are still ongoing, but as of November 2008, it looks very likely that the institute will secure chamber of deputy approval.

For the moment, the lion's share of Paraguayan agricultural R&D still takes place within government directorates under the Ministry of Agriculture and Livestock (MAG) and the National University of Asunción (UNA). MAG's DIA is by far the largest agency involved in agricultural R&D in Paraguay. In 2006, the directorate employed 64 fte researchers, accounting for half of the country's agricultural research capacity. DIA's headquarters are located in San Lorenzo, 11 kilometers from Paraguay's capital, Asunción, and accommodates the national director and four departments: the Planning, Monitoring, and Evaluation Department; the Technology Transfer Department; the Management and Technological Services Department; and the Technical Coordination Department. In addition, DIA consists of the National Agronomic Institute (IAN); the Regional Center for Crops Research (CRIA); the Chaco Central Experiment Station; and six experimental farms located in various regions of the country. Chaco Central is the only unit in DIA that is located in the western region of Paraguay; all other units, including DIA's headquarters, are located in the country's eastern region. IAN and CRIA have adequate technical staff and infrastructure to conduct long-term research. The experiment station and six farms are considerably smaller and are used mainly for varietal testing and for site replication of research projects. Research activities are organized into 15 programs, 11 of which focus on crops. The remaining four programs concentrate on pastures and forages, soil, agrometeorology, and biotechnology.

MAG-led livestock, veterinary, and fisheries research officially fall under the responsibility of the San Lorenzo-headquartered DIPA. In the past, DIPA carried out research in relation to meat, dairy, beekeeping, fisheries, sheep and goats, animal nutrition, meat byproducts, and veterinary diagnosis. However, the directorate's capacity and budget have been severely cut in recent years, and its current (limited) research activities focus solely on dairy and pastures and forages. Neither DIPA nor any other public agency in the country currently conduct any fisheries research. DIPA operates experiment stations named Barrerito (in Caapucú), Chaco (in Río Verde), and Eusebio Ayala (in Eusebio Ayala). In 2006, the agency employed just two fte researchers. Nonetheless, the agency is rather strong in technology transfer and animal health-related issues.

The Technological and Agricultural Center in Paraguay (CETAPAR) engages in research, extension, and training activities predominantly for Japanese settlers in Paraguay. Research focuses mainly on horticulture (melons and tomatoes) and livestock. Although CETAPAR is a relatively small agency, its research has played a prominent role in the agricultural development of eastern Paraguay. CETAPAR has claimed that the introduction and rapid expansion of soybean production in the 1990s can be traced to its research and extension efforts. CETAPAR's research takes place in Yguazú in the Alto Paraná department. It also has an extension center in Pirapó. In 2006, the agency employed two fte researchers.

Three higher education agencies are involved in agricultural R&D activities in Paraguay. Combined, these agencies employed 61 fte researchers in 2006—close to half of the country's total agricultural research staff. Paraguay's main

university is UNA. Two of UNA's faculties are involved in agricultural research: the Faculty of Agricultural Sciences (FCA) and the Faculty of Veterinary Sciences (FCV). FCA undertakes research in the areas of agronomic engineering, forestry, human ecology, and fruit trees. FCV conducts research in the areas of animal production and veterinary medicine. FCA and FCV are both headquartered in San Lorenzo, but research takes place in five additional local centers scattered over the country. In 2006–07, an important restructuring of the university took place as part of the “strengthening the actors of the national innovation system” component of the IDB-financed loan, mentioned previously. For the first time in its history, the university has a research directorate, which is in charge of organizing all research activities and establishing linkages between UNA and outside bodies. The research directorate also manages a small competitive fund for research activities (discussed in the *Financing Public Agricultural R&D* section on page 7). Besides a research directorate, an extension division and a postgraduate division were established at UNA. The Catholic University Nuestra Señora de la Asunción is a private university with branches in various regions. Agricultural research falls under the Faculty of Science and Technology of the university's Itapúa branch. In 2006, the university employed an estimated eight fte agricultural research staff.

A few other agencies and private initiatives in Paraguay have some (often ad hoc) research activities, but their contributions to total agricultural research are hard to measure. Some nongovernmental organizations (NGOs) carry out agricultural research, predominantly on a regional basis, specializing in crops like cassava and other staple foods for smallholder farmers. Its aim is to safeguard traditional agricultural practices for sustainable agriculture. In the livestock sector, the products of cooperative-based and other private initiatives on animal breeding, animal selection, and improvement of herd handling are sometimes more obvious than public (DIPA and FCV) efforts in this field (Reynolds 2006).⁶ No research is conducted by multinational private companies in Paraguay. Private sector and NGO research is excluded from the data analysis in the remainder of this paper because it accounts for a supposedly minimal share of total agricultural R&D in Paraguay, and it is difficult to measure accurately. DIA, however, carries out some limited research on behalf of private sector seed and agrochemical companies.

Paraguay's agricultural R&D agencies participate in a significant amount of collaborative research nationally, regionally, and internationally. There are many interactions between DIA, DIPA, CETAPAR, and UNA. At the international level, DIA has ongoing cooperation agreements with various international technical corporation agencies such as the Japan International Cooperation Agency (JICA), the Japan International Research Center for Agricultural Sciences (JIRCAS), the French Agricultural Research Center for International Development (CIRAD), the Canadian International Development Agency (CIDA), and the plant genetic resources department of the United States Department of Agriculture (USDA). In addition, cooperation agreements exist between DIA and the Inter-American Institute for Agricultural Cooperation (IICA) and the International Maize and Wheat Improvement Center (CIMMYT).

The recently established research directorate of UNA's FCA is officially charged with deepening the relationships with other

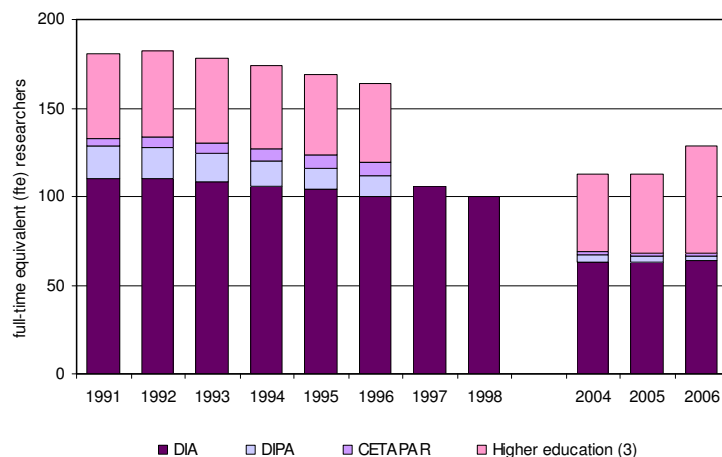
agricultural R&D agencies in Paraguay as well as abroad. Although the university has established various teaching agreements with foreign (mostly Brazilian) universities, research cooperation agreements are far fewer due to severe budget limitations. Official agreements have been established with JICA, however.

HUMAN AND FINANCIAL RESOURCES IN PUBLIC AGRICULTURAL R&D

Overall Trends

The total number of public fte agricultural researchers in Paraguay contracted sharply from 181 ftes in 1991 to 128 in 2006 (Figure 1). This drop can be attributed to the rapidly falling researcher totals at DIA, DIPA, and CETAPAR in recent years. In contrast, total capacity at the country's higher education sector has remained relatively unchanged during this period. Total fte research staff of the government agencies increased steadily from the late 1970s through the early 1990s. From 1992, however, total government research staff decreased to 112 fte researchers in 1996. This decline coincides with cuts to government funding and was more severe for DIPA, which experienced an average decline of 9.6 percent per year during the early 1990s. The decline in DIA's research staff during the same period appears to be the result of structural changes. When the directorate moved from Asunción to Caacupé, not all staff agreed to move; some remained at MAG, and five researchers went to FCA when the Caazapá Experiment Station moved there from DIA in 1996 (Beintema et al. 2000).

Figure 1—Composition of public agricultural researchers, 1991–98 and 2004–06



Sources: Compiled by authors from ASTI survey data (IFPRI 2007-08) and Beintema et al. (2000).

Notes: See Table 1. Figures in parentheses indicate the number of higher education agencies. Data for DIPA, CETAPAR, and higher education agencies were unavailable for 1997-2003. Data were unavailable for DIA for 1999-2003.

Since the late 1990s, researcher totals for DIA and DIPA have fallen rapidly. Both agencies have lost qualified personnel to the private sector as well as to UNA, where salaries are higher. CRIA, in particular, lost some very qualified scientists to the private sector. In addition, with a view to slimming down the Paraguayan public sector, civil servants (which includes staff at state agencies like DIA and DIPA) are generally not replaced

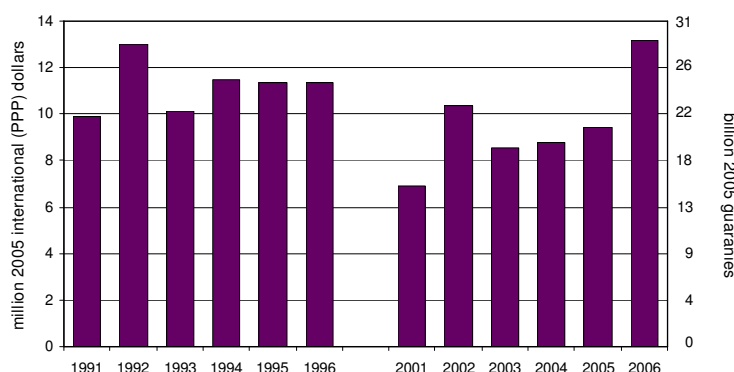
once they retire, leading to a gradual decline in total research staff numbers.

DIPA's total research capacity is currently so low that the agency can hardly be considered an important player in the country's livestock R&D sector (although it does play an important role in technology transfer). The establishment of IPTA could boost government-led livestock research in the future. For now, however, public sector livestock research remains largely a university affair. CETAPAR also experienced an important cut in its researcher totals from eight ftes in 1996 to two ftes a decade later. This cut can largely be ascribed to a failed transfer of CETAPAR to MAG due to budget restrictions and a lack of political will. Japanese descendants have taken over the administration of the center, and many (non-Japanese) Paraguayan research staff have moved away to other jobs.

In contrast to the government and nonprofit sectors, total agricultural R&D capacity in Paraguay's higher education sector remained relatively stable during 1991–2005 at an average of 46 fte scientists; but during 2005–07, the total capacity of UNA's FCA more than doubled (from 16 to 36 ftes), causing a rapid rise in the country's overall agricultural R&D capacity in the higher education sector. The doubling of the faculty research staff was largely the result of the above mentioned restructuring of FCA, the establishment of a research directorate, and funding through IDB. Many new researchers have joined FCA since 2006, including a large number of young scientists. Paraguayan agricultural researchers widely regard the country's universities as more attractive employers than the government agencies, as employees are given more autonomy at universities and salaries are reportedly higher. In recent years, UNA is widely seen as the most important link in the country's agricultural R&D system, but this may change with the establishment of IPTA.

Total public agricultural research expenditures in Paraguay have shown erratic development during 1991–2006 (Figure 2). During 1991–96, they averaged around \$11 million annually. By 2001, this total had dropped to a mere \$7 million, which was largely the result of an increasingly unstable political situation in Paraguay itself and the meltdown of the Argentinean economy, which is one of Paraguay's largest trade partners. However, agricultural R&D spending showed steady growth during 2001–05, peaking in 2006 at \$13 million. This sudden peak is largely due to an important influx of IDB funding for the creation of a solid S&T system in Paraguay. Most of the funds of this project are earmarked for building and other infrastructure costs at UNA. In addition, the 2005 separation of the Plant Health and Seeds Division (SENAVE) from MAG has led to a rise in DIA spending. By law, SENAVE transfers 15 percent of its total budget for agrochemical and seed trials to DIA on an annual basis.

Figure 2—Public agricultural R&D spending, 1991–96 and 2001–06



Source: Compiled by authors from ASTI survey data (IFPRI 2007-08), Beintema et al. (2000), and CONACYT (2005).

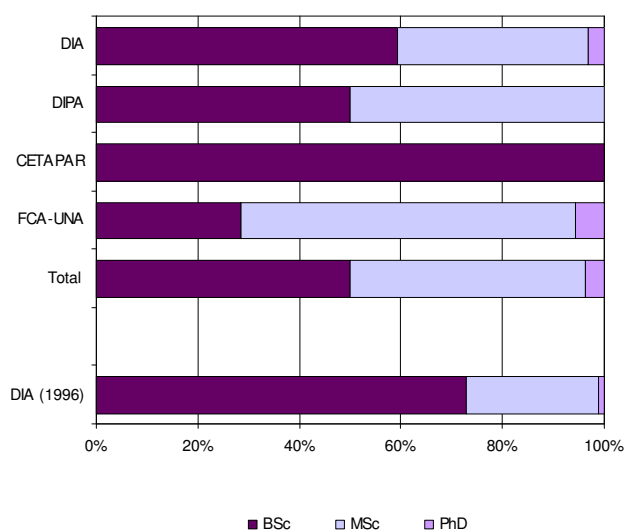
Notes: Spending data were unavailable for 1997–2000.

Human Resources

In 2006, 50 percent of the 100 fte researchers in a four-agency sample was trained to the postgraduate level, and just 3 percent held PhD degrees, which is one of the lowest shares in the world (Figure 3). The higher education sector had a higher share of researchers with postgraduate (72 percent) and PhD (6 percent) degrees than did the government and nonprofit sectors, which is a consistent finding across most countries in the region and developing countries around the world. The total number of PhD-qualified agricultural researchers in Paraguay is very low compared to other countries in South America, such as Argentina (17 percent), Chile (26 percent), and Uruguay (24 percent; Stads, Cotro, and Allegri 2008; Stads and Covarrubias Zuñiga 2008; Stads, Ruíz, and De Greef 2008). The fact that the country's universities do not offer PhD courses can partly explain Paraguay's relatively low share of PhD-qualified agricultural research staff. In contrast, most other countries in Latin America began their agriculture-related PhD programs in the 1970s. The Paraguayan agricultural scientists who do pursue PhD training typically go to universities in Brazil and Spain and, to a lesser extent, Argentina and the United States. UNA actively encourages its scientists to pursue PhD training abroad (mainly in Brazil), even continuing to pay them their salary in Paraguay. On a positive note, the recently established postgraduate division at UNA gives reason to anticipate the establishment of more MSc programs and the introduction of a PhD program in agricultural sciences in Paraguay.

In 2006, 41 percent of DIA researchers were trained to the postgraduate level, which represents an improvement over the corresponding ratio recorded a decade earlier (27 percent). Just two of DIA's 64 scientists hold PhD degrees. DIA lacks official training programs for its staff. As DIA is still a department under MAG, rather than an independent S&T institute, researchers working at DIA are considered civil servants and therefore receive the same treatment as other civil servants in nonresearch bodies under MAG. Many researchers hope that with the establishment of IPTA more emphasis and money will be directed toward training research staff.

Figure 3—Educational attainment of researchers by institutional category, 1996 and 2006

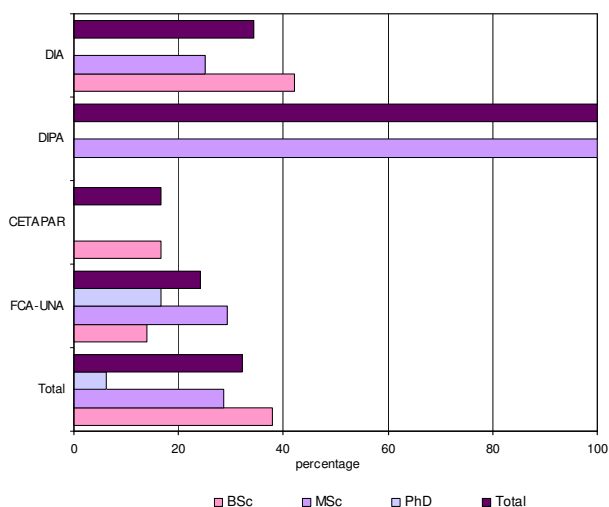


Sources: Compiled by authors from ASTI survey data (IFPRI 2007-08) and Beintema et al. (2000).

Note: Data for FCV-UNA and FCA-Universidad Católica were unavailable.

Despite an increase in the number of women pursuing scientific careers worldwide, women still tend to be underrepresented in senior scientific and leadership positions (IAC 2006). Paraguay is no exception. In 2006, 32 percent of Paraguay's total fte researchers in a four-agency sample were women; 6 percent held a doctorate degree, 29 percent held an MSc degree, and 38 percent held a BSc degree (Figure 4). Paraguay's share of women agricultural researchers as a percentage of total research staff is similar to corresponding shares recorded in other countries in the region, such as Chile (30 percent) and Colombia (32 percent; Stads and Covarrubias-Zuñiga 2008; Stads and Romano 2008). It is of note that both researchers at DIPA were women. DIA—the only agency for which historical data were available—experienced a substantial increase in the share of women in total research staff from 14 percent in 1986 to 29 percent in 1998 to 34 percent in 2006, despite the overall decline in staff numbers over the past decade.

Figure 4—Share of female researchers, 2006

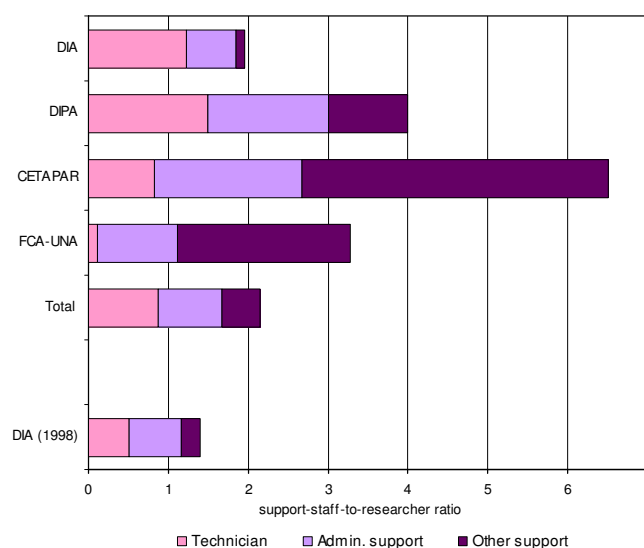


Source: Compiled by authors from ASTI survey data (IFPRI 2007-08).

Note: Data for FCV-UNA and FCA-Universidad Católica were unavailable.

In 2006, the average number of support staff per scientist in a four-agency sample for which data were available was 2.1, comprising 0.9 technicians, 0.8 administrative personnel, and 0.5 other support staff, such as laborers, guards, and drivers (Figure 5). Average support staff per scientist was much lower at DIA (2.0) than at the other three agencies. Overall, average support staff per scientist levels at DIA have risen over the past decade. Beintema et al. (2000) reported an overall share of 1.4 support staff per scientist in 1998. However, this rise was due mainly to a fall in total number of research staff rather than an actual rise in total support staff numbers.

Figure 5—Support-staff-to-researcher ratios, 2006



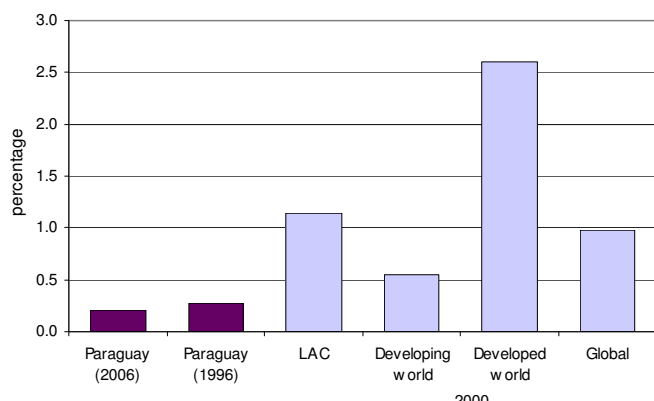
Source: Compiled by authors from ASTI survey data (IFPRI 2007-08).

Note: Data for FCV-UNA and FCA-Universidad Católica were unavailable.

Spending

Total public spending as a percentage of agricultural output (AgGDP) is a common research investment indicator that helps to place a country's agricultural R&D spending in an internationally comparable context. In 2006, Paraguay invested \$0.20 on agricultural research for every \$100 of AgGDP, which was slightly lower than the corresponding ratio in 1996 (\$0.27; Figure 6). In comparison, the 2006 intensity ratios for other MERCOSUR countries such as Chile (\$1.22), Argentina (\$1.27), Brazil (\$1.68), and Uruguay (\$1.99) were much higher (Stads and Beintema 2008). The 2000 ratio for Paraguay was also lower than the reported 2000 average for Latin America and the Caribbean (\$1.14), the developing world (\$0.55), and the global average (\$0.98; Beintema and Stads 2008a).

Figure 6—Paraguay's agricultural research intensity compared regionally and globally



Sources: Paraguay data are compiled from Figure 2; AgGDP data are from World Bank (2008); all other intensity ratios are from Beintema and Stads (2008a). LAC stands for Latin America and Caribbean.

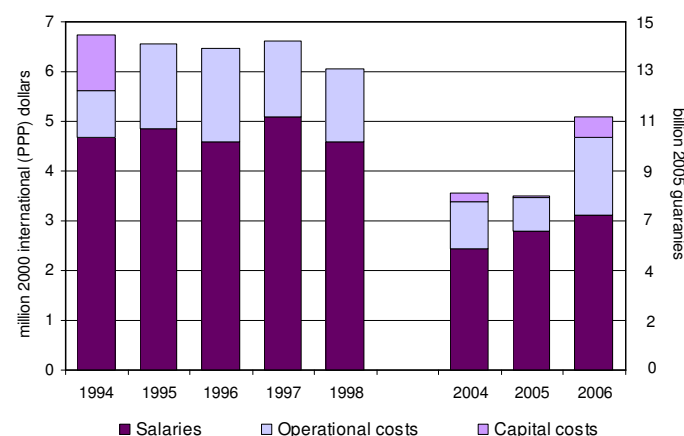
Using intensity ratios as a rule of thumb is not always appropriate because they do not take into account the policy and institutional environment within which agricultural research takes place or the broader size and structure of a country's agricultural sector and economy. For example, small countries need more investments in research because they cannot benefit from economies of scale as larger countries can. Countries with greater agricultural diversity or more complex agro-ecological conditions also have more complex research needs and hence require higher funding levels. In addition, technological breakthroughs spill across countries with similar agroclimatic conditions. A low intensity ratio in a country that imports many of its agricultural technologies is therefore not necessarily a cause for concern (Beintema and Stads 2008b). Paraguay is extremely dependent on new technologies from Brazil. Resourceful Brazilian farmers own vast tracts of land in Paraguay close to the border with Brazil, as prices per hectare are roughly three times lower on the Paraguayan side of the border than on the Brazilian side. The Brazilian farmers bring a lot of new technologies to Paraguay, particularly for soybean, sugarcane, and livestock. Paraguay's research intensity ratios as presented above do not, therefore, properly reflect the influx of foreign technologies and the country's capacity to leapfrog technologies generated elsewhere.

On the downside, the fact that so many Brazilian-generated technologies trickle down to Paraguay has created a widespread perception that Paraguay will acquire access to new technologies without needing to invest in them. It has created a climate in which agricultural R&D is not considered a priority and no one is willing to finance any long-term research programs. The country, for example, does not have any research programs for commercial crops and relies exclusively on R&D carried out in Argentina and Brazil. If Argentina and Brazil decide to cut their research programs, the impact will be immediately felt in Paraguay. However, the installation of a new government and the pending approval of IPTA are signs that change may be on the horizon.

The allocation of research budgets across salaries, operating costs, and capital costs affects the efficiency of agricultural R&D, and therefore detailed data on cost categories of government agencies were collected as part of this study. In

2006, 61 percent of DIA's investments was spent on salaries, 31 percent on operating costs, and 8 percent on capital costs (Figure 7). These relative shares have changed significantly over time. Just one year earlier, 80 percent of DIA's expenditures went to salaries and 19 percent to operating costs. The reason for the rapid rise in the share of operating costs in total spending is the above mentioned restructuring of SENAVE in 2005. Salaries for DIA's researchers have also increased in recent years. However, they are still below salaries of scientists at UNA.

Figure 7—Cost category shares in DIA's expenditures, 1994-98 and 2004-06

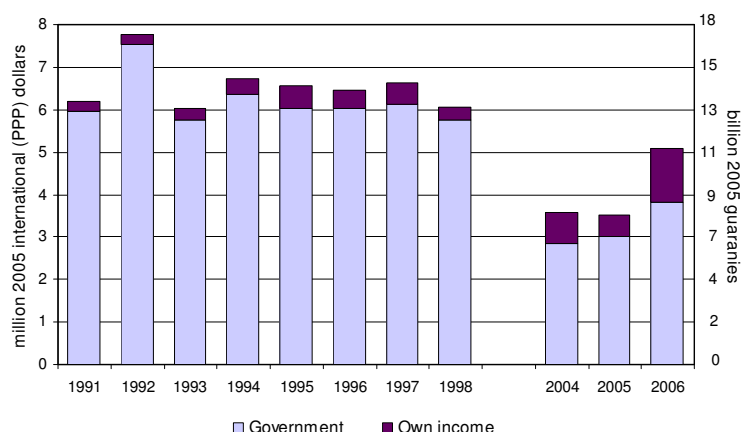


Sources: Compiled by authors from ASTI survey data (IFPRI 2007-08) and Beintema et al. (2000).

FINANCING PUBLIC AGRICULTURAL R&D

Agricultural research in Paraguay is financed largely by the national government and internally generated resources. Salary costs of DIA and DIPA are financed directly through government appropriations. However, the Paraguayan government does not set aside a budget for actual research costs. These are largely financed through internally generated income, the sale of seeds/livestock and services, and the performance of on-demand trials for the private sector. In 2006, for example, three-quarters of DIA's budget was financed by the government, and the remainder was funded through internally generated resources (mostly revenues from the sale of products such as seed, cotton fiber, and laboratory services; Figure 8). MAG allocations to DIA and DIPA are set annually, and the two directorates do not know how much they will be effectively allocated in a year's time. As previously mentioned, the frequent changes within MAG over the past period mean that promises made by one minister can quickly be undone by a successor, adding significant financial uncertainty and making advance research planning extremely difficult.

Figure 8— Funding sources of DIA, 1991-98 and 2004-06



Sources: Compiled by authors from ASTI survey data (IFPRI 2007-08) and Beintema et al. (2000).

Note: In-kind donor funding is very difficult to measure, and therefore not included in this graph.

In addition to government funding and internally generated income, DIA receives significant support from foreign donors. This support is mostly in the form of in-kind contributions (e.g., infrastructure and equipment), and the exact value is difficult, if not impossible, to estimate. Such contributions have been ongoing since DIA's predecessor, the Agricultural and Forestry Research and Extension Directorate (DIEAF), was established. In addition, DIA has received considerable international technical cooperation over the years in the form of long- and short-term visiting researchers. Japan is DIA's primary donor, providing substantial in-kind contributions. Moreover, a number of JICA researchers have visited DIA to provide technical assistance, particularly in the field of soybean and vegetable research. Other donors include CIRAD, which provides technical assistance through visiting cotton scientists, and the Technical Agricultural Mission of Taiwan, which provides assistance and contributions in kind for research on flowers, swine, and Newcastle disease.⁷ Unsurprisingly, CETAPAR is completely funded by the Japanese government.

Research at UNA is financed largely by the Paraguayan government. Until very recently, the university did not have a specific research budget. Instead, research was financed by taking what was needed from the university's regular budget. In early 2008, UNA launched a call for research proposals from each of its faculties. Scientists from each faculty were encouraged to submit research proposals, which are reviewed and approved/declined by the university's research directorate. Each faculty will be allocated around 40 million guaraníes per year (roughly US\$10,000) for research purposes (UNA 2008). Internally generated resources (either from services or through student fees) play a small role in financing agricultural R&D at the university. Donor funding also plays a small, though not insignificant, role. Most of the donor funding is in kind. In recent years, JICA, IDB, German Technical Cooperation (GTZ), IICA, and the World Bank have all financed research equipment at the UNA or provided technical assistance. By contrast, the private Catholic University is funded entirely by student fees.

Although the National Fund for Science and Technology (FONACYT) was established in 1997 as a competitive fund for financing (agricultural and nonagricultural) research, only very limited amounts have been disbursed. More recently, however,

with an influx of funding from IDB, steps have been made to "reintroduce" a competitive R&D fund in Paraguay similar to Chile's Fund for the Promotion of Scientific and Technological Development (FONDEF). FONDEF was founded in 1991 to strengthen Chile's R&D capacity, to increase the quantity and quality of S&T, to expand the supply of services related to S&T, and to transfer S&T knowledge effectively to productive sectors. All the projects selected by FONDEF should have an R&D component, a high socioeconomic impact, cofinancing with private sector companies or other counterparts, and an orientation toward the creation of relevant technological businesses. FONDEF has proven to be highly successful in distributing R&D funding to priority areas and in enhancing cooperation between R&D agencies in both the public and private sector in Chile (Stads and Covarrubias Zuñiga 2008).

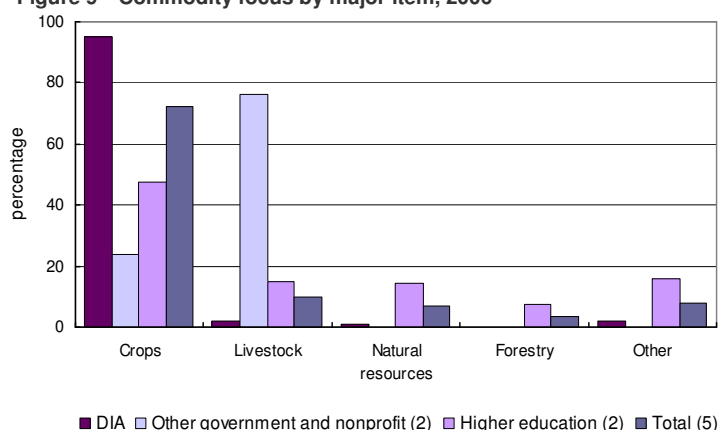
The first competitively funded pilot projects in Paraguay are currently underway as part of the IDB-financed program in support of the development of science, technology, and innovation in Paraguay. The pilot project aims to translate the lessons learned in Chile to a Paraguayan context. It serves as a useful tool in defining a set of future rules for project admission, assessment, selection, and monitoring once the pilot project has been successfully completed and an official competitive fund is established. So far, the pilot project has been rather successful, and some initial research projects with durations of one year are already being financed this way. Plans also exist to create a new competitive fund that will finance agricultural R&D in the new IPTA.

RESEARCH ORIENTATION

Commodity Focus

The allocation of resources among various lines of research is a significant policy decision, and so detailed information was collected on the number of fte researchers working in specific commodity and thematic areas. In 2006, 72 percent of the 120 fte researchers of our five-agency sample conducted crop research. Livestock research accounted for 12 percent of the total, natural resources research for 7 percent, and forestry research for 4 percent (Figure 9). None of the agencies included in our sample reported any fisheries research. Research staff at DIA spent relatively more time on crop research (95 percent) than did their counterparts in the other agency categories. Close to half of all agricultural research in the higher education sector was on crops. Research on soybeans—Paraguay's major export crop—accounted for 17 percent of all research conducted on crops in the country. Research on cotton accounted for 16 percent, on vegetables for 13 percent, on fruits for 12 percent, on sugarcane and on maize for 9 percent each, and on wheat for 8 percent (Figure 10). Soybean and cotton research dominate DIA's research agenda, whereas CETAPAR focuses almost exclusively on horticultural crops. Sesame was the most researched crop at UNA. In 2006, 26 percent of the university's crop researchers were involved in sesame research. Most of Paraguay's livestock researchers focused their research efforts on beef (23 percent), followed by dairy (16 percent), and poultry (6 percent). The lion's share of the country's livestock research is carried out by UNA (8 of the total 12 ftes).

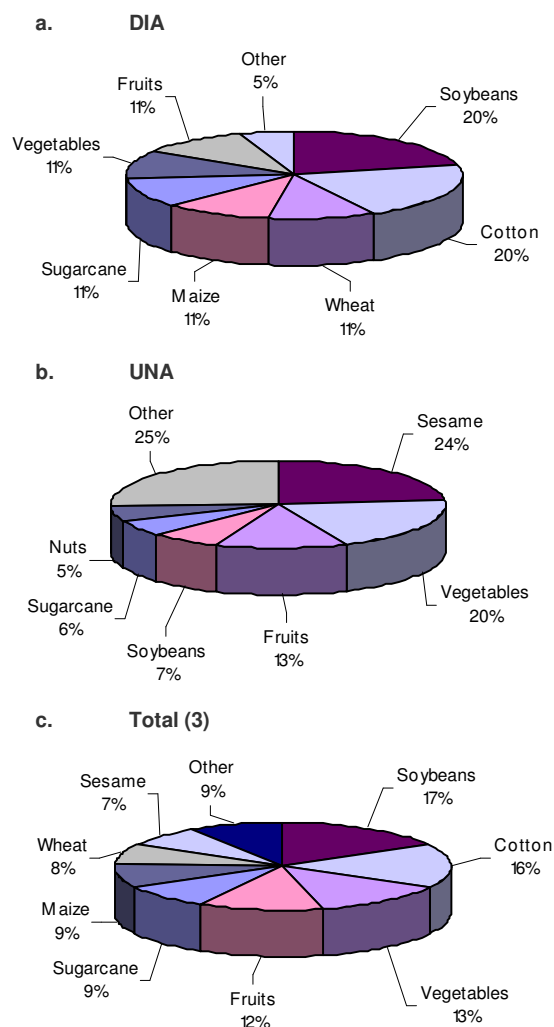
Figure 9—Commodity focus by major item, 2006



Source: Compiled by authors from ASTI survey data (IFPRI 2007-08).

Notes: Figures in parentheses indicate the number of agencies in each category. No fisheries research is conducted in Paraguay. Data for FCA-Universidad Católica were unavailable.

Figure 10—Commodity focus by major crop item, 2006



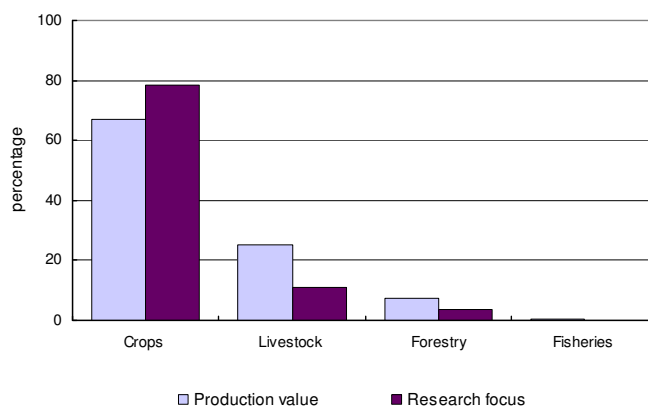
Source: Compiled by authors from ASTI survey data (IFPRI 2007-08).

Notes: Figures in parentheses indicate the number of agencies in each category. CETAPAR is included in Total (3); CETAPAR spends 90 percent on fruit research and 10 percent on nuts.

The congruency or parity model is a commonly used method of assessing the allocation of research resources. This usually involves allocating funds (or, in this instance research personnel) among research areas in proportion to their corresponding contribution to the value of agricultural production. For example, if the value of rice output were twice that of maize, then congruency would be achieved if research on rice were to receive twice as much funding (or, say, employ twice as many scientists) as research on maize. The model assumes that an additional dollar spent on research would yield a higher return if spent in areas with a relatively low ratio of research funding to output value; therefore, funds should flow to programs with relatively low research intensities and from those with high research intensities. If research spending or scientist shares were congruent with the corresponding value of output for a particular commodity, then the congruency ratio for that commodity—measuring the commodity share of researchers to the corresponding share of output—would be equal to 1.0.⁸

Figure 11 shows the shares of crops, livestock, forestry, and fisheries in gross value of agricultural production with the corresponding share of research staff in these areas. In 2006, 85 percent of the researchers in our subsample (which excludes postharvest and natural resources research) undertook crops research—significantly higher than the share of crops in Paraguay's total value of production (67 percent). In contrast, the share of livestock and forestry researchers was lower than its share in total production value, resulting in congruency ratios of 0.5 each.

Figure 11—Congruence between agricultural R&D and production value, 2005-06



Sources: Compiled by authors from ASTI survey data (IFPRI 2007-08).

Production values are from MAG (2006).

Notes: Postharvest and natural resources research themes are not included. Production values are for 2005, research focus values are for 2006.

CONCLUSION

In 2006, Paraguay employed just 128 fte researchers and spent \$13 million (in 2005 PPP prices) on agricultural research. The country compares very unfavorably to its MERCOSUR neighbors when it comes to agricultural research capacity and investments. Paraguay has experienced a steady decline in agricultural researcher totals since the early 1990s; it has one of the lowest shares of agricultural R&D staff with PhD degrees in the world; and its agricultural R&D investments as a share of agricultural GDP are five to seven times lower than those in neighboring Argentina and Brazil.

Many of the weaknesses above can be ascribed to the relatively late establishment of an official S&T structure, a lack of political will to invest in agricultural R&D, and a widespread reliance on technologies generated elsewhere—mainly in Brazil and Argentina. Numerous changes within MAG over the past year have caused various delays in the establishment of IPTA, the long awaited national agricultural research institute. Paraguay is unique among its MERCOSUR neighbors in that it lacks such a national agricultural research institute. This has created a climate in which the higher education sector (mainly UNA) is the strongest component of the national agricultural research system.

Nevertheless, increased IDB support for the development of science, technology, and innovation as well as the Paraguayan government's recent approval for the creation of IPTA are signs that change may be on the horizon. With the creation of IPTA, agricultural R&D in Paraguay is expected to receive a boost in funding (through various mechanisms), but exactly how much remains a question of speculation. Paraguay currently depends too much for its principal export crops on R&D carried out by its neighbors. The new IPTA, therefore, has the important role of focusing on research that will increase the value of Paraguay's agricultural products and thus make Paraguay's competitive position stronger in a global market.

NOTES

1. The authors are grateful to numerous colleagues in Paraguay for their time and assistance with the data collection, and thank Nienke Beintema, Ricardo Pedretti, and José Schwartzman for their useful comments on drafts of this brief.
2. The six-agency sample consisted of
 - two government agencies/units: the *Dirección de Investigación Agrícola* (DIA) and the *Dirección de Investigación y Producción Animal* (DIPA);
 - one nonprofit agency: the *Centro Tecnológico Agropecuario en Paraguay* (CETAPAR);
 - three higher education agencies/units: the *Facultad de Ciencias Agrarias* and the *Facultad de Ciencias Veterinarias*, both under the *Universidad Nacional de Asunción*, and the *Facultad de Ciencias Agrarias* of the *Universidad Católica Nuestra Señora de Asunción*.

This sample excludes the *Universidad Nacional del Este* (UNE) and the *Universidad Nacional de Itapúa* (UNI) for which data were unobtainable. Both universities have recently been established and their agricultural R&D efforts are reportedly limited.
3. Unless otherwise stated, all data on research expenditures are reported in 2005 international dollars (using a PPP index from World Bank 2008) or in 2005 Paraguayan guaraníes.
4. Like the International Monetary Fund (IMF) and the World Bank, ASTI presents all its macroeconomic data in PPP dollars.
5. English translations of agency names have been used throughout the brief except in note 3, where the original Spanish is provided.
6. Livestock farmers interested in applied experimentation have become privately organized in the Livestock Consortium for Agricultural Experimentation (CEA). CEA holds a highly appreciated international congress on technology transfer every year in Asunción. CEA members even organized an information trip of farmers to Queensland, Australia; they returned with new ideas about cattle breeds and grass cultivars (Reynolds 2006).
7. Newcastle disease is a highly contagious bird disease affecting many domestic and wild avian species. Its effects are most notable in domestic poultry.
8. It is important to note, as Alston et al. (1998) describe, that the model overlooks key factors affecting the payoff to R&D, such as the differences in probability of research success, likely adoption rates, and the likely extent of research-induced productivity gains. It also does not account for the spill-in of technologies from other countries or differences in the costs per scientists among different areas of R&D. So, although the congruence rule is a useful tool for allocating resources and a distinct improvement over precedence and some other shortcut methods, congruency ratios that differ from 1.0 are not necessarily a cause for concern.

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METHODOLOGY

- Most of the data in this brief are taken from unpublished surveys (IFPRI 2007-08) and Beintema et al. (2000).
- The data were compiled using internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 2002; UNESCO 1984). The authors grouped estimates using three major institutional categories—government agencies, higher-education agencies, and business enterprises, the latter comprising the subcategories private enterprises and nonprofit institutions. The researchers defined public agricultural research to include government agencies, higher-education agencies, and nonprofit institutions, thereby excluding private enterprises. Private research includes research performed by private-for-profit enterprises developing pre, on, and postfarm technologies related to agriculture.
- Agricultural research includes crops, livestock, forestry, and fisheries research plus agriculturally related natural resources research, all measured on a performer basis.
- Financial data were converted to 2005 international dollars by deflating current local currency units with a Paraguayan GDP deflator of base year 2005 and then converting to U.S. dollars with a 2005 purchasing power parity (PPP) index, taken from World Bank (2008). PPP's are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than conventional exchange rates.
- Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values, especially at the end point of the period.

See the ASTI website (<http://www.ASTI.cgiar.org>) for more details on methodology.

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