PUBLIC AGRICULTURAL RESEARCH IN LATIN AMERICA AND THE CARIBBEAN

Investment and Capacity Trends

Gert-Jan Stads and Nienke M. Beintema

ASTI Synthesis Report • March 2009

ASTI
Agricultural Science &
Technology Indicators

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Contents

Tables

Figures

Boxes

Acknowledgments

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Acronyms

AECID	Agencia Española de Cooperación Internacional [Spanish Agency for International Cooperation and Development]
AgGDP	agricultural gross domestic product
APASAN	Asociación Panameña para la Sostenibilidad de la Agricultura y los Recursos de la Naturaleza [Panamanian Association for Sustainability of Agriculture and Natural Resources]
APTA	Agência Paulista de Tecnologia dos Agronegócios [São Paulo's Agency for Agribusiness Technology]
CACM	Central American Common Market
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community and Common Market
CASSA	Compañía Azucarera Salvadoreña S.A. de C.V. [Salvadorian Sugar Company]
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza [Agronomic Center for Research and Education]
CENGICAÑA	Centro Guatemalteco de Investigación y Capacitación de la Caña de Azúcar [Guatemalan Sugarcane Research and Training Center]
CENID	Centro Nacional de Investigaciones Disciplinarias [National Disciplinary Research Center; Mexico]
CENICAFE	Centro Nacional de Investigaciones de Café [National Coffee Research Center, Colombia]
CENIPALMA	Centro de Investigación en Palma de Aceite [Palm Oil Research Center, Colombia]
CENICAÑA	Centro de Investigación de la Caña de Azúcar [Sugarcane Research Center, Colombia]
CENTA	Centro Nacional de Tecnología Agropecuaria y Forestal [National Center of Agricultural and Forestry Technology; El Salvador]
CEPEC	Centro de Pesquisa do Cacau [Research Center for Cacao; Brazil]
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical [International Center for Tropical Agriculture]
CIMMYT	Centro Internacional de Majoramiento de Maíz y Trigo [International Maize and Wheat Improvement Center]
CIP	Centro Internacional de la Papa [International Potato Center]
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement [French Agricultural Research Centre for International Development]
CIR	Centro de Investigación Regional [Regional Research Center; Mexico]
ColPos	Colegio de Postgraduados [Postgraduate College; Mexico]
CONICET	Consejo Nacional de Investigaciones Científicas y Técnicas [National Council for Scientific and Technical Research; Argentina]
CONSEPA	Conselho Comunitário de Segurança Publica de Alfenas [Council of State Organizations Agricultural Research; Brazil]
CORBANA	Corporación Bananera Nacional [National Banana Corporation; Costa Rica]
CORPOICA	Corporación Colombiana de Investigación Agropecuaria [Colombian Corporation for Agricultural Research]
DIA	Dirección de Investigación Agrícola [Agricultural Research Directorate; Paraguay]
DICTA	Dirección de Ciencia y Tecnología Agropecuaria [Directorate for Agricultural Research and Technology, Honduras]
DIPA	Dirección de Investigación y Producción Animal [Animal Research and Production Directorate; Paraguay]
ECLAC	Comisión Económica para América Latina y el Caribe [Economic Commission for Latin America and the Caribbean]
Embrapa	Brazilian Agricultural Research Corporation
EU	European Union
FAITAN	Fondo de Apoyo a la Investigación Tecnológica Agropecuaria en Nicaragua [Support Fund for Agricultural Technology Research in Nicaragua]
FAT	Fondo de Asistencia Técnica [Fund for Technical Assistance; Nicaragua]
FEDEARROZ	Federación de Productores de Arroz [National Rice Growers Association; Colombia]
FHIA	Fundación Hondureña de Investigación Agrícola [Honduran Foundation for Agricultural Research]
FONTAGRO	Fondo Regional de Tecnología Agropecuaria [Regional Fund for Agricultural Technology]

FORAGRO	Forum for the Americas on Agricultural Research and Technology Development [Foro de las Américas para la Investigación y Desarrollo Tecnológico Agropecuario]
FHIA	Fundación Hondureña de Investigación Agricola [Honduran Foundation of Agricultural Research]
FTE	full-time equivalent
FUNICA	Fundación para el Desarrollo Tecnológico Agropecuario y Forestal de Nicaragua [Foundation for Technological Development of Agriculture and Forestry]
GDP	gross domestic product
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis [Brazilian Institute for the Environment and Renewable Natural Resources]
ICA	Instituto Colombiano Agropecuario [Colombian Agricultural Institute]
ICAFE	Instituto del Café de Costa Rica [Costa Rica Institute of Coffee]
IDB	Inter-American Development Bank
IDIAF	Instituto Dominicano de Investigaciones Agropecuarias y Forestales [Dominican Institute for Agricultural and Forestry Research]
IDIAP	Instituto de Investigación Agropecuaria de Panamá [Agricultural Research Institute of Panama]
IICA	Instituto Interamericano de Cooperación para la Agricultura [Inter-American Institute for Cooperation on Agriculture]
INBio	Instituto Nacional de Biodiversidad [National Biodiversity Institute; Costa Rica]
INIA(1)	Instituto Nacional de Investigaciones Agropecuarias [National Agricultural Research Institute]
INIA(2)	Instituto Nacional de Investigación Agropecuaria [National Agricultural Research Institute; Uruguay]
INIA(3)	Instituto de Investigaciones Agropecuarias [Agricultural Research Institute; Chile]
INIFAP	Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias [National Institute for Forestry, Agricultural, and Animal Husbandry Research; Mexico]
INRA	Institut national de la recherche agronomique [French National Institute for Agriculture Research]
INTA (1)	Instituto National de Innovación y Transferencia en Tecnología Agropecuaria [National Institute of Agricultural Innovation and Technology Transfer; Argentina]
INTA (2)	Instituto Nicaragüense de Tecnología Agropecuaria [Nicaraguan Institute of Agricultural Technology]
INTA (3)	Instituto Nacional de Transformación Agraria [National Institute of Technological Innovation; Costa Rica]
INTI	Instituto Nacional de Tecnología Industrial [National Institute for Industrial Technology; Argentina]
IPTA	Instituto Paraguayo de Tecnología Agropecuaria [Paraguayan Institute for Agricultural Technology]
JICA	Japan International Cooperation Agency
LAC	Latin America and the Caribbean
MAA	Ministério da Agricultura, Pecuária e Abastecimento [Ministry of Agriculture and Food Supply; Brazil]
MERCOSUR	Mercado Comun del Sur / Mercado Comum do Sul [Southern Common Market]
NAFTA	North American Free Trade Agreement
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity
PROCAFE	Fundación Salvadoreña para la Investigación del Café [Salvadorian Foundation for Coffee Research]
PROCIs	Programa de Cooperación en Investigación y Tecnología Agrícola [Cooperative Research and Technology Transfer Programs]
PROCISUR	Programa Cooperativo para el Desarrollo Tecnológico Agroalimentario y Agroindustrial del Cono Sur [Cooperative Program for the Technological Development of the Agro-food and Agro-industry in the Southern Cone]
PROCITROPICOS	Programa Cooperativo de Investigación, Desarollo e Innovación Agrícola para los Trópicos Suramericanos [Cooperative Program on Research and Technology Transfer for the South American Tropics]
PROCIANDINO	Programa Cooperativo de Innovación Tecnológica Agropecuaria para la Región Andina [Cooperative Program for Agricultural Technology Research and Transfer in the Andean Region]

Acronyms continued

PROCICARIBE	Caribbean Agricultural Science and Technology Networking System
R&D	research and development
S&T	science and technology
SICTA	Sistema de Integración Centroamericana de Tecnología Agrícola [Central American Integration System for Agricultural Technology]
UAAAN	Universidad Autónoma Agraria Antonio Narro [Autonomous Agricultural University Antonio Narro; Mexico]
UACh	Universidad Autónoma Chapingo [Autonomous University Chapingo; Mexico]
UdelaR	Universidad de la República [University of the Republic; Uruguay]
UNASUR	Unión de Naciones Suramericanas/União de Nações Sul-Americanas [Union of South American Nations]
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Introduction

The countries of Latin America and Caribbean (LAC) represent a wealth of natural resources; the world's greatest agrobiodiversity; and immense economic, social, and environmental diversity. As an example, the region is home to Brazil—the world's fifth-largest country in terms of both area and population—yet it also comprises numerous Caribbean island nations populated by fewer than 100,000 people. Nonetheless, LAC countries exhibit much commonality, including significant urban populations, high ethnic diversity, and increasing inequality and poverty. Another shared factor is that many LAC countries have reformed or are in the process of reforming their economies through structural adjustment programs. Agriculture faces many challenges in LAC, especially in the context of development. Rising food prices are a growing policy concern for both low- and middle-income countries, and, whereas the region as a whole is a net food exporter, poor consumers suffer the negative impacts of food-price inflation on their incomes and thus on their health and nutrition. In addition, international value chains and supermarkets are transforming domestic food markets, thereby posing serious challenges to smallholders in their ability to remain competitive. As commercial agriculture expands, the agricultural labor market and rural nonfarm economy become vital if resulting productivity gains are to have a beneficial effect on rural poverty (World Bank 2008a).

Substantial empirical evidence supports the argument that investment in agricultural research and development (R&D) has contributed to economic growth, agricultural development, and poverty reduction in LAC over the past 50 years (IAASTD 2008; World Bank 2007). New technologies resulting from R&D investments have enhanced the quantity and quality of agricultural outputs, while at the same time enhancing sustainability, reducing consumer food prices, providing rural producers with access to market opportunities, and improving gender-based allocations and accumulations of physical and human capital within households. In many countries, these outcomes have lead to higher incomes, greater food security, and better nutrition. Some countries in the temperate northern and southernmost parts of LAC have a distinct advantage over their tropical counterparts when it comes to adopting technologies generated in high-income countries with similar agroclimatic conditions. Nonetheless, well-developed national agricultural research systems and adequate levels of investment are important prerequisites for agricultural development, food security, and poverty reduction in all of the region's countries.

To this end, quantitative data are important for 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, to economic growth. S&T indicators assist research managers and policymakers in formulating policy and making decisions about strategic planning, priority setting, monitoring, and evaluation. They also provide information to governments and others involved in the public debate on the state of agricultural S&T at national, regional, and international levels.

This report reviews major institutional developments and investment and human resource trends in public agricultural R&D in LAC from 1981 to 2006, drawing from a set of country briefs and a regional report for Central America prepared by the Agricultural Science and Technology Indicators (ASTI) initiative using comprehensive ASTI datasets derived from primary surveys for a 15-country sample conducted during 2007–08.[1] These datasets have been linked with investment and human resources data collected in the region during the late 1990s, as well as with ASTI's global datasets, to provide a wider context for agricultural R&D investment trends over time and across other regions.

Economic Context

In 2007, average growth in the region's annual gross domestic product (GDP) totaled 6 percent (ECLAC 2008), but this economic progress has not been accompanied by improved social conditions. Currently, of the estimated 510 million people living in

[1] The 15 sample countries are Argentina, Belize, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, and Uruguay. In 2006, these countries represented 88 percent of agricultural R&D spending in LAC. The original ASTI country briefs and reports (listed in the reference section) are or soon will be available at http://www.asti.cgiar.org/pubs-ap.aspx.

LAC, about 27 million live on less than US$1 per day and 170 million live on less than US$2 per day. The region is characterized by striking inequality in the distribution of wealth: the poorest 20 percent of the population receive only 3 percent of all income, whereas the wealthiest 20 percent receive 60 percent of the income. Although urban poverty rates in some countries are high, overall, poverty is more widespread in the rural areas of LAC. More than 60 percent of rural people live below the poverty line, and over the past two decades the number of poor people in rural areas has increased in both absolute and relative terms. Consequently, reducing poverty is a major challenge (ECLAC 2008).

Globalization has increasingly affected LAC, inducing significant economic integration since the 1980s. A large number of subregional agreements have been established over recent decades for the purpose of removing trade barriers among LAC countries. Such agreements include the Southern Common Market (MERCOSUR), the Andean Community, the Central American Common Market (CACM), and the Caribbean Community and Common Market (CARICOM). Similar free trade agreements have been, or are close to being, signed with the United States and Canada (The North American Free Trade Agreement or NAFTA), as well as with the European Union and a number of Asian countries. Political integration in LAC, on the other hand, is still in its early stages. In May 2008, 12 South American Heads of State agreed to the establishment of a Union of South American Nations (UNASUR) to promote the integration of political, economic, cultural, environmental, energy, and infrastructure policy. Similar initiatives are currently under development for both Central America and the Caribbean.

In 2005, agriculture represented 5 percent of LAC's total GDP (ECLAC 2008), but this average masks important differences across countries. In Trinidad and Tobago, for instance, agriculture accounted for just 1 percent of national GDP, whereas the share was 20 percent or higher in Nicaragua and Paraguay (World Bank 2008b). Agriculture's impact on the region's economy is much higher when linkages with farm-input, food-processing, and distribution industries are taken into account. Although data is limited to certain countries and years, results of studies undertaken by the Inter-American Institute for Cooperation on Agriculture (IICA) indicate that the sector contributes a much higher share of GDP than is reflected in the official data (Trejos, Segura, and Arias 2004). Such data for Costa Rica or Uruguay in 2006, for instance, was estimated to be between 30 and 35 percent of these countries' national output compared with official shares of just 9 percent each. Strong forward linkages to the agribusiness and food services sectors exist in many of the region's countries; examples include soybean oil and derivatives in Argentina, Brazil, and Paraguay; fruit and salmon in Chile; cut flowers in Colombia and Ecuador; beef production in Uruguay; and bananas in Ecuador.

Agriculture is also an important source of employment in the region. In 2006, the agricultural sector employed more than 30 percent of the national labor force in Bolivia, El Salvador, Guatemala, Paraguay, and Peru, and when looked at from a rural perspective, these shares rise to more than 50 percent. In contrast, agriculture accounted for just 5 percent of Uruguay's total labor force and only 1 percent of Argentina's (ECLAC 2008). Compared with other regions, agricultural growth and economic growth more generally have not reduced rural poverty in LAC, which remains high despite a 31 percent increase in agricultural production during 1995–2005 (ECLAC 2008). Overall, agricultural employment has not provided a pathway out of poverty, and as a result subsistence agriculture remains prevalent in the region's poorest countries.

Nevertheless, agriculture in LAC is highly complex and dynamic, with farm households, traditional production systems, and sophisticated enterprises operating side by side. Nonetheless, all sectors are challenged by emerging threats like climate change, inequality, changing consumption patterns, natural resource management, food safety demands, and increased urbanization.

The Institutional Framework of Agricultural R&D in LAC

Historical Developments. In the late 1950s, Argentina and Ecuador were the first of the region's countries to introduce a model of public agricultural research founded on a single national agricultural research institute (INIA). Throughout the 1960s, this model was adopted by the majority of Latin American countries, often with technical and financial support from foreign agencies and foundations. Until the mid-1970s, the levels of public funding and staffing at these institutes increased rapidly, often with significant financial support from agencies like the World Bank, the Inter-American Development Bank (IDB), and the United States Agency for International Development (USAID). Most INIAs were established to conduct research on all aspects of crop and livestock production, although in many

countries forestry, fisheries, veterinary, and postharvest research are undertaken in parallel by separate organizations. One discernable trend of the 1970s and 1980s was growth in the number of university faculties engaged in agricultural research; another was the expansion of research conducted by nonprofit and for-profit private agencies. Profit-based agencies tended to focus on export crops of national economic value. In the late 1990s, however, differentiation was made between agricultural R&D for the purposes of rural development and poverty alleviation and agricultural R&D for technology development. This trend was accompanied by the growing participation of the private sector in funding (and sometimes implementing) agricultural R&D activities (Pardey, Roseboom, and Anderson 1991; FAO 1999).

The current structure of agricultural research systems varies widely across the countries of LAC. The large- and medium-sized countries in the survey sample generally have the more advanced national systems, whereas agricultural R&D in most of the smaller countries is carried out by a mere handful of agencies. Unsurprisingly, the systems in countries like Argentina, Brazil, and Mexico are significantly more complex.[2] It is important to note that the ASTI surveys covered 15 countries of the LAC region and that the remaining countries (most notably Bolivia, Ecuador, Peru, and Venezuela) are excluded from further analysis in this report due to a lack of available time-series data. The agricultural research systems of 14 of the 15 sample countries for which data were available are summarized in Table 1.

Given that, as previously mentioned, Brazil is by far the largest of the region's countries, its agricultural R&D system is understandably complex, but it is even more so because of the country's two-tier system of federal- and state-based agencies. Among the government agencies, the Brazilian Agricultural Research Corporation (Embrapa) predominates. As a semiautonomous federal agency administered by the Ministry of Agriculture and Food Supply, Embrapa is the largest agricultural R&D agency in Latin America in terms of both staff numbers and expenditure. The agency is headquartered in Brasilia and operates 37 research centers throughout the country. The Research Center for Cacao (CEPEC) and the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) are two additional federal agencies involved in agricultural R&D. In addition, 16 of Brazil's 26 states operate agricultural research agencies, although most state-level activities are carried out in São Paulo. The state's Agency for Agribusiness Technology (APTA) was founded in 2001 and coordinates all São Paulo's crop and livestock research activities organized under four strategic programs: bioenergy, environmental sustainability, organization of the rural and outlaying areas, and food safety. Research is carried out by 64 experiment units and 43 research laboratories located across the state. Brazil also has a substantial number of (mostly federal and state) universities that conduct research at more than 100 faculties or schools of agricultural sciences. Only a few of the private universities undertake agricultural research in Brazil, and the nonprofit sector plays only a modest role (Beintema, Avila Dias, and Pardey 2001).

The organization of agricultural R&D in Mexico is also very complex. Government-led agricultural R&D has traditionally been overseen by National Institute for Forestry, Agricultural, and Animal Husbandry Research (INIFAP). Besides its headquarters in Mexico City, INIFAP operates eight regional research centers (CIRs) spread over the country, as well as five national disciplinary research centers (CENIDs). While the CIRs attend to a broad range of agricultural R&D needs for each of Mexico's eight regions, the CENIDs are characterized by their high degree of expertise and specialization in a particular discipline. Besides INIFAP, a large number of other government agencies are involved in agricultural R&D in Mexico, both at the state as well as the country-level. The higher education sector plays a particularly important role in Mexican agricultural research. Some 125 separate faculties or university units are involved in agricultural R&D. The principal public agricultural universities are the Autonomous University Chapingo (UACh), the Postgraduate College (ColPos), and the Autonomous Agricultural University Antonio Narro (UAAAN).

The National Institute of Agricultural Technology (INTA) is Argentina's major government agricultural R&D agency. INTA integrates research and extension, making it unique among S&T institutions. Aside from INTA, a large number of agencies under the National Scientific and Technical Research Council (CONICET) undertake scientific research covering a broad and heterogeneous spectrum of both agricultural and nonagricultural disciplines. In addition, a large number of geographically dispersed universities conduct agricultural R&D, principal among them being the University of Buenos Aires.

2 For more information on national institutional developments, see the specific ASTI country briefs and reports listed in the reference section.

Table 1 The institutional structure of agricultural research in a 14-country sample of Latin America and the Caribbean, 2006

Country	Main government agencies	Main universities	Important nongovernment institutions
		(Share of total public agricultural research staff)	
Argentina	National Institute of Agricultural Technology (INTA), 48%	University of Buenos Aires, 7% National University of La Plata, 4% National University of Tucumán, 3%	—
Belize	Caribbean Regional Fisheries Mechanism (CRFM), 27% Caribbean Agricultural Research and Development Institute (CARDI), 18% Central Farm, 9%	University of Belize, 8%	Citrus Growers Association (CGA), 19% Sugar Industry Research and Development Institute (SIvRDI), 14% Taiwan Technical Mission (ROC), 5%
Brazil	Brazilian Agricultural Research Corporation (Embrapa), 44% São Paulo's Agency for Agribusiness Technology (APTA), 15%	Na	—
Chile	Agricultural Research Institute (INIA), 40% Fisheries Development Institute (IFOP), 16% Forestry Institute (INFOR), 8%	Catholic University of Temuco, 6% University of Chile, 7% University of Concepción, 7% Pontificia Catholic University of Chile (PUCC), 3%	—
Colombia	Colombian Corporation of Agricultural Research (CORPOICA), 27% Marine and Coastal Research Institute (INVEMAR), 7% Colombian Rural Development Institute (INCODER), 6%	National University of Colombia (UNC), 8%	National Coffee Research Center (CENICAFE), 17% Palm Oil Research Center (CENIPALMA), 5% Sugarcane Research Center (CENICAÑA), 4% National Rice Growers Association (FEDEARROZ), 4%
Costa Rica	National Institute of Agricultural Innovation and Technology Transfer (INTA), 31% National Center of Food Science and Technology (CITA), 7%	University of Costa Rica (UCR), 29% National University of Costa Rica (UNC), 6% Technological Institute of Costa Rica (ITCR), 4%	National Banana Corporation (CORBANA), 8% National Biodiversity Institute (INBio), 5%
El Salvador	National Center of Agricultural and Forestry Technology (CENTA), 78%	University of El Salvador, 11%	Salvadorian Sugar Company (CASSA), 10% Salvadorian Foundation for Coffee Research (PROCAFE), 7%
Guatemala	Agricultural Science and Technology Institute (ICTA), 62% National Forestry Institute (INAB), 6%	University of San Carlos de Guatemala, 14%	Guatemalan Sugarcane Research and Training Center (CENGICAÑA), 15%
Honduras	Agricultural Science and Technology Directorate (DICTA), 15%	Panamerican Agricultural School, El Zamorano, 25% Regional University Center of the Atlantic Coast (CURLA), 16% National Agricultural University (UNA), 5% National School of Forestry Sciences (ESNACIFOR), 5%	Honduran Agricultural Research Foundation (FHIA), 26% Honduran Coffee Institute (IHCAFE), 3%
Mexico	14 agencies under the National Institute for Forestry, Agricultural and Animal Husbandry Research (INIFAP), 25%	Autonomous University of Chapingo (UACh), 10% Postgraduate College (ColPos), 9% National Polytechnic Institute (IPN), 7% Autonomous Agricultural University Antonio Narro (UAAAN), 4% National Autonomous University of Mexico (UNAM), 4%	—

Table 1 (continued)

Country	Main government agencies	Main universities	Important nongovernment institutions
		(Share of total public agricultural research staff)	
Nicaragua	Nicaraguan Institute of Agricultural Technology (INTA), 33%	National Agrarian University (UNA), 45% Central American University (UCA), 9% National Autonomous University of Nicaragua (UNAN), 8% University of Commercial Sciences (UCC), 4%	Center for Rural and Social Promotion, Research, and Development (CIPRES), 3%
Panama	Agricultural Research Institute of Panama (IDIAP), 63% Aquatic Resources Authority of Panama (ARAP), 10%	University of Panama, 14%	Panamanian Association for the Sustainability of Agriculture and Natural Resources (APASAN), 6% Achotines Laboratory, 4%
Paraguay	Agricultural Research Directorate (DIA), 50%	National University of Asunción (UNA), 41% Catholic University Nuestra Señora de la Asunción, 6%	—
Uruguay	National Agricultural Research Institute (INIA), 36% National Aquatic Resources Directorate (DINARI), 7% Biological Research Institute Clemente Estable (IIBCE), 5%	University of the Republic (UdelaR), 41%	—

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Percentages indicate the respective agencies' shares of total public agricultural research staff in 2006 based on full-time-equivalent researchers. Main government agencies include those with at least a 5-percent share of total public agricultural R&D staff; main universities and nonprofit institutions include those with at least a 3-percent share of total public agricultural research staff; nongovernment institutions (NGOs) include producer organizations, marketing boards, and nonprofit organizations (see the appendix for an explanation of the definitions of government and nongovernment agencies). The Dominican Republic is excluded from our 15-country sample in this instance due to a lack of a full set of available data; na indicates that sufficient information was not available; and — indicates that the category is not applicable to the country in question.

The remaining countries in our 15-country sample have very different agricultural R&D systems. Most countries in the region have one national agricultural research institute, accounting for the lion's share of agricultural research staff, in combination with a number of smaller government, higher education, and nonprofit agencies conducting agricultural R&D. Examples of such countries include Chile, El Salvador, Guatemala, and Panama. Some other countries have a national agricultural research institute, but the institute's activities account for only a modest share of total agricultural research staff. This is the case in Costa Rica, but also increasingly so in Colombia and Uruguay. Colombia, for example, has a large number of producer organizations that are involved in agricultural research. Other countries do not have a national agricultural research institute at all, and most of the innovation in the agricultural sector is carried out by players in the higher education and nonprofit sectors, as is the case in Honduras and Paraguay.[3]

Agricultural R&D in the Caribbean is understandably less well-established. The subregion's larger countries (Cuba, the Dominican Republic, and Haiti) each operate an INIA under their ministries of agriculture, as well as having universities and nonprofit agencies that undertake agricultural R&D. Many of the smaller Caribbean countries delegate the implementation of their agricultural research to regional agencies, such as the Caribbean Agricultural Research and Development Institute (CARDI), or to bilateral agencies, as in the case of France's Agricultural Research Centre for International Development (CIRAD) and National Institute for Agricultural

3 In June 2008, the Paraguayan Senate approved the establishment of an INIA in Paraguay: the Paraguayan Institute of Agrarian Technology (IPTA). The establishment of IPTA is currently pending approval by the country's Chamber of Deputies.

Research (INRA) for the French Caribbean, and the United States Department of Agriculture (USDA) for Puerto Rico and the U.S. Virgin Islands (Roseboom, Cremers, and Lauckner 2001).

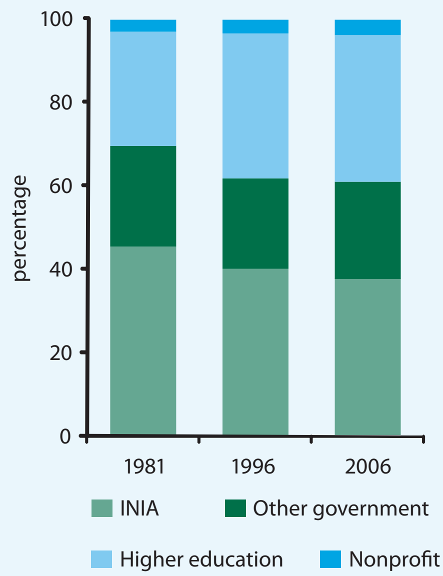
Institutional Distribution of Agricultural R&D

Most public agricultural R&D in LAC is conducted by government agencies. For example, for our 15-country sample in 2006, the government sector employed 61 percent of public agricultural R&D staff as an overall average, whereas the higher education sector accounted for 35 percent, and the nonprofit sector for 4 percent (Figure 1). From a country-level perspective, the government sector accounted for more than 70 percent of the total number of agricultural research staff in Brazil, El Salvador, and Panama, whereas the higher education sector accounted for two-thirds of the country's agricultural R&D staff in Nicaragua (Table 1). The university sector was also significant in Honduras and Mexico, but the nonprofit sector—which mostly comprises producer organizations—was strong in Belize, Colombia, and Honduras, were it accounted for shares of over 30 percent of total researcher capacity compared with nonexistent or negligible shares in countries like Argentina, Brazil, Mexico, Nicaragua, and Paraguay.

Important shifts in the institutional categories discussed above have occurred over time. In 1981, for example, the government sector accounted for close to 70 percent of the total number of agricultural researchers in 15-country sample, with the higher education and nonprofit sectors accounting for 29 and 2 percent, respectively. On average, the relative role of the INIAs in conducting agricultural R&D has declined since the early 1980s, most noticeably in Colombia, Costa Rica, Honduras, and Mexico. In Colombia, for example, the Colombian Agricultural Institute (ICA)—the predecessor of the Colombian Corporation for Agricultural Research (CORPOICA)—accounted for more than 70 percent of total agricultural R&D staff in the early 1980s, but by 2006 its share had fallen to just over a quarter. In Mexico, staffing levels at the National Institute for Forestry, Agricultural, and Animal Husbandry Research (INIFAP) have gradually declined since the mid-1980s, whereas researcher numbers at other government agencies and within the country's higher education sector have increased. All countries, however, have not adhered to this trend. At Argentina's INTA, for example, researcher numbers as a share of national agricultural R&D staff increased significantly in recent years due to the recruitment of roughly 1,000 new scientists since 2004 (Table 2).

Despite the large number of higher education agencies involved in agricultural in LAC, the individual capacity of the majority of them—in terms of full-time-equivalent researcher numbers—is small. In Mexico, for example, more than 125 higher education agencies were identified as being involved in agricultural R&D, though the majority only employed a handful of research staff. With certain notable exceptions, faculty staff at most higher education agencies devote only a small proportion of their time to research; teaching is still the main activity for most. Generally speaking, INIA research tends to be more applied, whereas university research is generally more basic. In some of the region's countries, however, the university sector is often more innovative than the government sector. In Costa Rica, for example, the specialized research and outreach institutes of the three state universities conduct the majority of research related to developing new technologies, particularly for the emergent horticulture and food processing industries. The country's government agencies typically focus on areas relevant to smallholder farmers.

Figure 1 The institutional orientation of agricultural research, 1981, 1996, and 2006



SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Data include 14 of the 15 sample LAC countries (Argentina, Belize, Brazil, Chile, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, and Uruguay). The Dominican Republic is excluded due to lack of available data.

Regional Initiatives

Awareness of the need for regional and international partnerships in agricultural research has grown in recent decades. Networks have proved to be a successful method of collaborating and sharing information, and they facilitate specialization (Beintema and Stads 2008a). They also help countries keep pace with global scientific developments and issues (Paroda and Mruthyunjaya 1999). Cross-country collaboration is cost-effective because countries can more readily capture technology spillovers across geographic and national boundaries and because they can reduce duplication of effort. Some LAC countries have well-developed national agricultural research programs and produce technologies and methods that are applicable to other countries in the region and other parts of the world. Multilateral organizations, such as the Consultative Group on International Agricultural Research (CGIAR), also address the issue of technology spillovers and provide global public goods to all countries.

Aside from promoting and facilitating dialogue among numerous stakeholders, the Forum for the Americas on Agricultural Research and Technology Development (FORAGRO) encourages the development of a regional agricultural R&D agenda, identifies regional priorities, facilitates regional projects, and advocates for increased—and better targeted—agricultural R&D investments. FORAGRO manages a variety of Cooperative Research and Technology Transfer Programs (PROCIs), which are subregional initiatives involving numerous INIAs. PROCIs mainly concentrate on developing and strengthening institutions, formulating and coordinating projects, transferring technologies, and promoting networking. PROCISUR, the oldest of these initiatives, was created in the 1970s to serve the Southern Cone's member states (Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay). Prompted by the success of PROCISUR, PROCITROPICOS was created in 1990 with a view of integrating agricultural R&D efforts in the tropical regions of South America (Brazil, Bolivia, Colombia, Ecuador, Peru, Surinam, and Venezuela). Similarly, PROCIANDINO was established in 1986 to integrate R&D conducted in the mountainous areas of Bolivia, Colombia, Ecuador, Peru, and Venezuela; PROCICARIBE followed in 1998 to address the needs

Table 2 Institutional orientation of agricultural R&D by country, 1981, 1996, and 2006

	1981			1996			2006		
	Government	Higher education	Nonprofit	Government	Higher education	Nonprofit	Government	Higher education	Nonprofit
	(percentage)								
Argentina	44.8	55.2	0.0	41.7	58.3	0.0	55.4	44.6	0.0
Belize	74.7	0.0	25.3	59.0	0.0	41.0	53.9	7.8	38.3
Brazilb	83.8	14.4	3.2	80.6	17.1	1.8	81.2	17.2	1.7
Chile	64.9	35.1	0.0	72.6	26.0	1.4	67.5	29.3	3.2
Colombia	71.8	12.9	15.3	59.7	16.5	23.7	46.4	18.3	35.3
Costa Rica	49.2	39.1	11.7	40.5	40.3	19.2	39.5	40.6	19.8
El Salvador	57.8	4.5	37.7	76.0	7.2	16.8	78.0	13.8	8.2
Guatemala	91.6	7.4	1.0	81.1	10.0	8.8	67.8	15.6	16.6
Honduras	55.0	34.6	10.5	17.4	42.8	39.7	14.6	55.2	30.2
Mexico	74.0	25.9	0.1	52.8	47.2	0.1	45.9	54.0	0.1
Nicaragua	29.7	69.9	0.4	30.7	69.1	0.2	32.7	67.0	0.3
Panama	78.1	12.6	9.2	78.4	12.4	9.2	74.2	14.1	11.7
Paraguay	80.6	19.4	0.0	72.8	27.2	0.0	52.8	47.2	0.0
Uruguay	50.4	46.6	3.1	44.4	51.9	3.7	53.2	42.6	4.3
Sample total (14)	69.1	28.5	2.9	61.6	34.6	3.6	61.0	35.2	3.8

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Data for the Dominican Republic are excluded. Although agencies like CORPOICA in Colombia and INIA in Uruguay are in reality semi-private entities, for the purposes of this study they are categorized as government agencies because the bulk of their funding is derived from government sources.

of the Caribbean countries; and Central America has created a PROCI-like system called the Central American Integration System for Agricultural Technology (SICTA). Overall, the PROCIs are widely regarded as a valuable institutional resource in the region that responds to the needs and demands of their member countries (FAO 1999). Over time they have become increasingly outward-looking and now also include non-INIA partners.

IICA, which is headquartered in Costa Rica, was established in 1940 to promote agricultural science in the Americas and to coordinate, promote, and facilitate sustainable agricultural development in LAC. IICA works throughout the region and with a number of regional and international organizations, including the centers of the CGIAR. IICA also financially supports the Agronomic Center for Research and Education (CATIE) and the Caribbean Agricultural Research and Development Institute (CARDI), which is discussed further below, and provides financial, administrative, and legal support to the PROCIs.

The Regional Fund for Agricultural Technology (FONTAGRO) is an alliance of 14 LAC countries, together with Spain, to support research and innovation in the agricultural sector. More specifically, FONTAGRO aims to contribute to reducing poverty, promoting competitiveness, and encouraging the sustainable management of natural resources. FONTAGRO is sponsored by the International Development Bank (IDB) and IICA and encourages cooperation in S&T among member countries and centers of excellence (FONTAGRO 2008).

The majority of the LAC's international research is carried out by the CGIAR via partnerships that date back to the 1960s. In 2006, the CGIAR invested more than 14 percent of its US$426 million budget to generating science-based solutions to problems of agricultural development in LAC. Although total allocations to the region have increased over time, their relative share has remained unchanged in recent years (CGIAR Secretariat 2007). Of the current 15 CGIAR centers, three are headquartered in the LAC region: The International Center for Tropical Agriculture (CIAT) in Colombia, the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and the International Potato Center (CIP) in Peru. In addition, 10 other CGIAR centers have established more than 20 offices in the region.

Several other international and regional organizations have a presence and conduct agricultural research in LAC. The Caribbean Agricultural Research and Development Institute (CARDI) was founded in the mid-1960s in efforts to upgrade and coordinate regional agricultural R&D activities following the creation of CARICOM. CARDI is headquartered at the University of the West Indies in Trinidad and Tobago, and over the years it has become the main agency involved in agricultural R&D in the English-speaking countries of the Caribbean. CARDI focuses on strategic research of regional significance or requiring the procurement of skills beyond the scope of national budgets. CARDI members include Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, St. Vincent and the Grenadines, St. Lucia, and Trinidad and Tobago (FAO 1999).

The Agronomic Center for Research and Education (CATIE) is an autonomous nonprofit institution that focuses on agricultural and rural development and natural resource management on behalf of its member states, which include all the countries of Central America, as well as Mexico, Bolivia, Colombia, the Dominican Republic, Paraguay, and Venezuela. CATIE combines research, training, education, and outreach, and—through its graduate school—its research programs focus on forestry and agroforestry systems, strategic inputs for sustainable agriculture, the valuation of natural resources and environmental services, and rural development.

Involvement of the Private, For-Profit Sector

Data indicate that, overall, the involvement of the private sector in agricultural research in LAC is comparatively high compared with other developing regions, such as Africa and the Middle East, but low compared with a number of countries in the Asia-Pacific region, such as Indonesia and the Philippines. Aspects of LAC agriculture are technologically advanced by world standards, as well as being serviced by a sophisticated system of private input supply, postharvest handling, and processing. Private firms now supply much of the improved animal genetics and seeds used by LAC farmers. Furthermore, some of the region's countries have legislated tax relief for privately performed R&D, and many countries stipulate private-sector involvement in research projects under competitive funding mechanisms. The private sector in Chile, for example, is well known for its considerable expansion of fruit, salmon, and wine production in recent decades. This progress has been achieved with substantial public support, not for direct private research but for the importation of foreign technologies and the subsidization of agribusinesses (Hartwich, Janssen, and Tola 2002).

Most private for-profit companies still outsource their research to government agencies or universities, or they import technologies from abroad. Only a limited number of private companies operate their own research programs, and the companies that do so often employ only a handful of researchers. Examples of national companies conducting agricultural R&D in the region include Floramerica, a Colombian flower grower and exporter, and Unimilho, a Brazilian seed company. Many multinational seed and agrochemical producers—such as BASF, Dupont, Monsanto, Novartis, Pioneer, and Syngenta—actively conduct agricultural R&D in the region, as do multinational fruit growers such as Chiquita, Delmonte, and Dole.

Little information could be accessed on capacity or expenditure trends in the private agricultural R&D in LAC. Beintema and Pardey (2001) estimate that in 1996 privately conducted research represented only 4.4 percent of all public and private investment in agricultural R&D that year, and that more than half of those investments were made in Brazil. Nevertheless, no (quantitative or qualitative) information is available on the private sector's role in agricultural R&D in the region since the mid-1990s. Private for-profit agencies are, therefore, excluded from further analysis in this report.

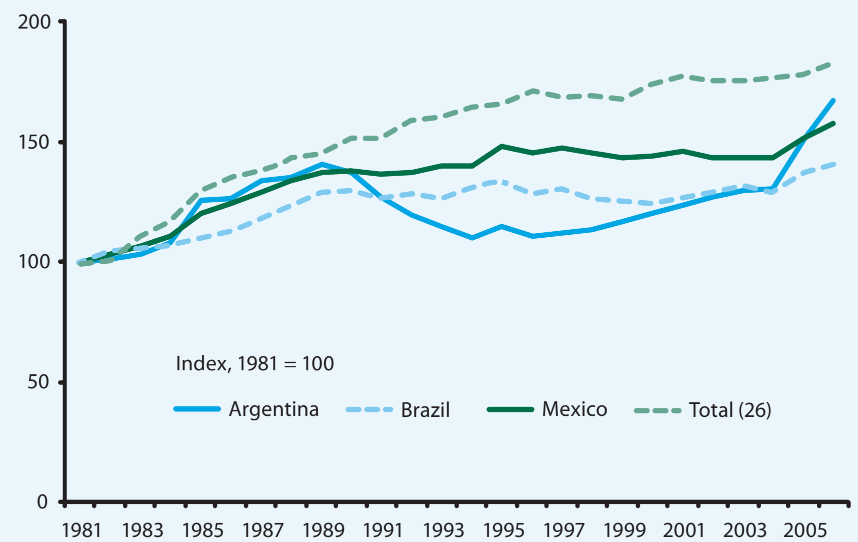
Human Resources In Public Agricultural Research

Overall Trends

In 2006, roughly 19,000 full-time equivalent (FTE) agricultural researchers were active in LAC. Brazil (5,400 FTEs), Mexico (4,100 FTEs), and Argentina (3,900 FTEs) together accounted for 70 percent of this regional total, while Chile, Colombia, Peru, and Venezuela each accounted for between 4 and 6 percent, and the combined capacity of the remaining 20 countries accounted for 14 percent of the regional total.

Since the early 1980s, most LAC countries have made considerable progress in building their research staff capacity, both in terms of total researcher numbers and qualification levels (that is, postgraduate degrees). The participation of female scientists has also increased in some countries (see Box 1). From 1981 to 2006, total agricultural researcher numbers for the region as a whole increased at as rate of 1.4 percent per year from about 12,000 to about 19,000 FTEs (Table 3 and Figure 2), although substantial national differences should be noted over time and in terms of age and experience. Capac-

Figure 2 Staffing trends in public agricultural research, 1981–2006



SOURCE: See Table 3.

ity growth was particularly high during the 1980s, averaging 3.6 percent per year, but stalled to just 0.6 percent in the 1990s, largely due to reduced growth in some of the region's larger countries and declines in Paraguay and some countries in Central America. After 2000, however, overall growth rebounded, averaging 1.6 percent per year during the 2001–06 period.

Argentina and Mexico both experienced significant capacity growth during 1981–2006. Mexico increased its total number of FTEs by 2,000, and most of this growth occurred in the higher education sector. In contrast, the number of researchers at Mexico's INIFAP gradually declined from the mid-1980s onward. Argentina's total capacity remained relatively stable from the mid-1980s until 2002, but thereafter it increased significantly. Similarly, staffing levels at Argentina's INTA increased by 1,000 FTEs during 2004-06 given increased support from the national government and the commencement of a large IDB-financed S&T project. It should be noted, however, that the majority of these researchers were comparatively young and, having just completed their BSc training, were also inexperienced. Total research capacity in Brazil has stagnated since the early 1990s after a period of strong growth in the 1980s.

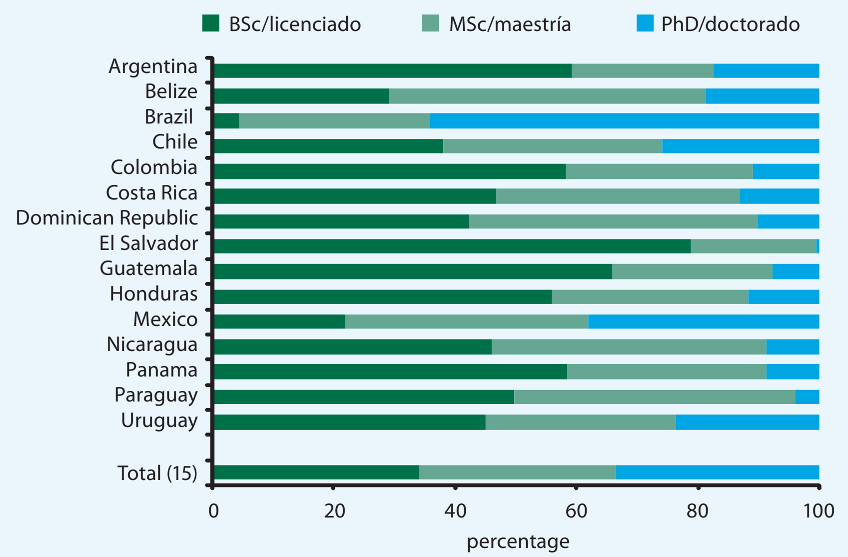
The remaining sample countries follow three different patterns of capacity growth during 1981–2006: capacity increased in Chile, Colombia, Panama, and Uruguay at rates averaging 2.0 to 3.0 percent per year; in Belize, Costa Rica, the Dominican Republic Nicaragua, and Paraguay, growth was more moderate, at less than 2.0 percent per year; and in El Salvador, Guatemala, and Honduras growth was significantly negative, largely due either to reduced government spending or the completion of donor-funded projects.

Degree Status

In 2006, of the total number of agricultural research staff in the 15-country LAC sample, 33 percent were trained to the PhD degree level, 32 percent to the MSc degree level, and 34 percent to the BSc degree level (Figure 3). From a national perspective, Brazil's agricultural researchers were the most qualified: in 2006, 64 percent of the combined research staff employed at Embrapa and APTA were trained to the PhD level, whereas only 4 percent held BSc degrees (it should be noted, however, that degree-level information for the remaining Brazilian government and higher education agencies was not available). Mexico had the second-highest share of PhD-qualified researchers, followed by Chile, and Uruguay. Mexico's INIFAP actively encourages its younger scientists to pursue postgraduate (mostly PhD) training and has a variety of resources with which to support them in doing so. The number of PhD-qualified staff employed in Mexico's higher education sector has also increased markedly in recent years, in part given that Mexico's two largest agricultural universities—ColPos and UACh—offer PhD-level programs. In contrast, El Salvador's agricultural research staff is among the least qualified worldwide. In 2006, the country's share of PhD-qualified agricultural researchers was negligible (0.6 percent). Argentina also occupies a comparatively low ranking when it comes to well-qualified staff, but this is largely due to the aforementioned recruitment of 1,000 recent BSc graduates. Overall, agricultural researchers in Central America are generally less well-qualified than their counterparts in other parts of the region.

Most countries in the region have improved the overall qualification levels of their agricultural research staff over the past decade, and in many cases foreign donors have played an important

Figure 3 Degree status of public agricultural research staff, 2006



SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Data for Brazil only includes the Brazilian Agricultural Research Corporation (Embrapa) and São Paulo's Agency for Agribusiness Technology (APTA).

Box 1 Female researchers in agricultural R&D

Over the past few decades, the number of female scientists and managers working in agricultural research has increased significantly in both industrialized and developing countries, although empirical studies have repeatedly shown a disproportionately low number of women working in senior scientific positions. In addition, the attrition rate of female researchers in S&T agencies is higher than that of their male colleagues (IAC 2006). In a 15-country sample for 2006, 34 percent of all agricultural researchers were female, but this average masks large variations across countries (Figure A). Southern Cone countries had far higher female researcher ratios compared with other parts of Latin America and the Caribbean. In Uruguay and Argentina, for example, more than 40 percent of all agricultural researchers were female. In Central America and Mexico, on the other hand, shares were much lower. Less than 20 percent of all agricultural research staff in Honduras, Guatemala, El Salvador, and Panama were female, and just 22 percent of all agricultural researchers in Mexico were female. Low average shares of female scientists are common in other developing world regions, the average being 20 percent (Beintema 2006). Unfortunately, no information is available on female participation n agricultural research in developed countries.

In LAC, higher education agencies employ a comparatively higher share of female agricultural scientists than do government or nonprofit agencies (34 percent compared with 31 and 27 percent, respectively). Women at higher education agencies are on average also more highly qualified than their colleagues at the government and nonprofit agencies.

Female scientists are also generally less well-qualified than their male counterparts (Figure B). In 2006, for example, fewer women than men held postgraduate degrees in LAC (60 percent compared with 67 percent). The gender gap in qualification levels was least pronounced in Brazil and Mexico but more pronounced in other parts of the region.

Figure A Share of female research staff, 1996 and 2006

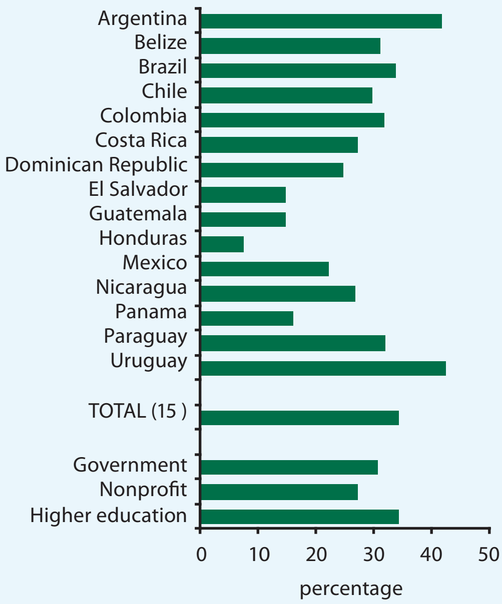
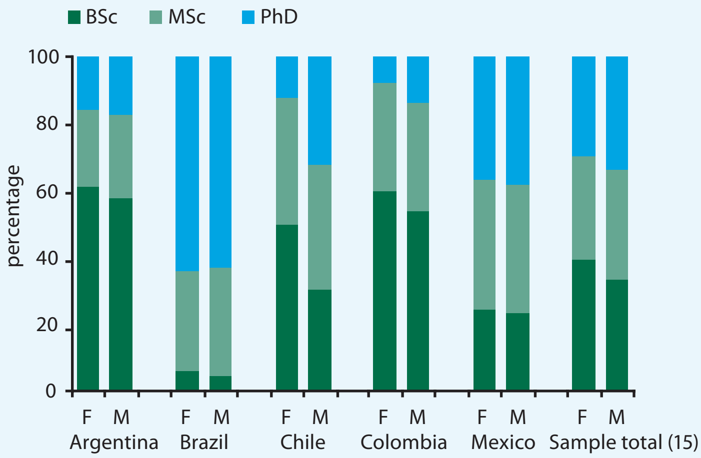


Figure B Degree levels of female and male researchers, 2006



role in financing postgraduate training for researchers. At Uruguay's INIA, for example, the total number of PhD-qualified staff increased from 7 to 46 individuals during 1996–2006. The IDB, the Fulbright program of the U.S. Institute of International Education's (IIE's), and the Spanish Agency for International Cooperation and Development (AECID) have all funded postgraduate training for INIA staff in recent years. Chile's INIA self-funds the majority of its staff's postgraduate training, along with short courses abroad; as a result, the agency's share of scientists with postgraduate training increased from 44 to 59 percent during 1990–2006.

Table 3 Public agricultural research staff, 1981–2006

Country	Total number of FTE researchers				Annual growth rate (%)			
	1981	1991	2001	2006	1981–91	1991–2001	2001–06	1981–2006
Argentina	2,358	2,996	2,916	3,947	3.57	–0.02	6.02	0.80
Belize	12	13	14	17	–0.28	1.45	3.22	0.91
Brazil	3,825	4,850	4,865	5,402	2.74	–0.17	2.02	0.98
Chile	398	530	655	690	3.42	2.75	0.97	2.40
Colombia	540	824	1,022	999	5.92	2.84	–0.55	2.63
Costa Rica	200	280	274	283	3.52	–1.25	0.73	1.26
Dominican Republic	145	137	161	139	–0.61	2.07	–2.05	0.02
El Salvador	120	115	95	77	–0.50	–0.75	–5.22	–1.92
Guatemala	130	166	102	102	2.76	–5.61	–0.26	–1.86
Honduras	114	170	139	124	4.84	–1.71	–2.58	–0.52
Mexico	2,227	3,365	3,927	4,067	4.60	1.23	0.66	2.15
Nicaragua	99	110	122	133	1.03	1.03	1.58	1.06
Panama	69	116	142	167	3.11	1.87	3.28	2.11
Paraguay	78	181	135	128	8.23	–2.75	–1.91	0.58
Uruguay	209	333	389	404	4.73	0.87	0.67	2.61
Sample total (15)	10,524	14,186	14,957	16,675	3.58	0.47	2.09	1.35
Total (26)	12,095	16,549	17,687	19,087	3.64	0.60	1.58	1.40

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Figures in parentheses indicate the number of countries in each category. Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period. 2001 totals are estimates based on country-level interpolations. For Brazil, total staffing trends for a number of government agencies and a large number of higher education agencies were estimated using 1996 data and average trends for the Brazilian Agricultural Research Corporation (Embrapa), São Paulo's Agency for Agribusiness Technology (APTA), and other government research agencies for which data were available. Total researcher numbers for the 11 nonsample countries (Bolivia, Ecuador, Peru, Venezuela, Antigua and Barbuda, Dominica, Guyana, Jamaica, Saint Kitts and Nevis, Surinam, and Trinidad and Tobago) were calculated using estimated shares of total regional expenditures (see Table 6).

Research Focus

The allocation of resources among various lines of research is a significant policy decision, so the ASTI surveys collected detailed information on the allocation of FTE researchers across specific commodity areas. In 2006, more than 40 percent of the more than 10,000 FTE researchers in a 14-country sample (excluding Brazil due to a lack of data) conducted crop research, whereas 22 percent undertook livestock research (Table 4). Natural resources research accounted for 13 percent, while the remaining researchers focused on fisheries (5 percent), forestry (4 percent), and postharvest research (4 percent). Large differences were observed in the focus of agricultural research across countries. Crop research was the focus of 70 percent or more of the researchers in El Salvador, Costa Rica, Honduras, and Paraguay. In contrast, Uruguay is unique to both Latin America and developing countries more generally in that more of its researchers focus on livestock than on crop research (43 compared with only 25 percent). Fisheries research accounted for 10 percent or less of agricultural researchers in all sample countries, with the exception of Belize, where more than a quarter of all agricultural researchers focus on issues related to fisheries. Natural resources research is dominant in Chile (18 percent), Guatemala (17 percent), and Mexico (17 percent).

In 2006, the major crops being researched in a 15-country sample were fruits (14 percent), vegetables (12 percent), beans (9 percent), coffee (6 percent), and wheat (6 percent) (Table 5). With the exception of Nicaragua, fruits accounted for 11 percent or more of all crop research in LAC. Understandably, some important differences in the focus of commodity research exist across countries. In 2006, researchers in the region's tropical countries focused more on bananas, coffee, and rice, whereas those in Southern

Table 4 Researcher focus by major commodity area, 2006

Country	Crops	Livestock	Forestry	Fisheries	Post-harvest	Natural resources	Other
				(percentage)			
Argentina	38.5	27.6	5.9	2.9	4.0	14.4	6.7
Belize	62.9	9.0	0.8	26.9	0.4	0.0	0.0
Chile	44.2	20.4	5.8	3.1	2.9	17.5	6.1
Colombia	47.4	20.9	2.5	4.2	2.2	9.4	13.3
Costa Rica	71.4	10.9	1.7	0.3	0.3	3.0	12.2
Dominican Republic	49.1	13.2	4.0	3.0	0.3	6.6	23.8
El Salvador	91.7	5.8	0.0	0.2	0.1	1.4	0.7
Guatemala	50.6	3.7	5.5	0.0	13.6	16.9	9.6
Honduras	71.6	4.6	3.6	0.8	2.4	6.7	10.3
Mexico	37.6	15.6	3.9	9.4	4.3	17.3	11.6
Nicaragua	61.3	19.3	0.7	0.2	4.5	7.3	6.7
Panama	42.5	42.0	3.0	0.2	1.5	3.8	7.1
Paraguay	72.1	10.0	3.2	0.0	0.4	6.8	7.4
Uruguay	25.2	42.5	2.1	8.6	7.3	5.9	8.4
Sample total (14)	43.6	21.5	4.3	4.8	3.9	13.1	8.7

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Data for Brazil were not available.

Table 5 Crop researcher focus by major crop item, 2006

Country	Major crop items
Argentina	Fruits (other than grapes) (13%), vegetables (11%), wheat (8%), soybeans (7%), maize (7%), grapes (5%)
Belize	Fruits (35%), sugarcane (23%), soybeans (10%), rice (7%)
Chile	Fruits (other than grapes) (30%), grapes (23%), vegetables (14%), wheat (10%), potatoes (6%)
Colombia	Coffee (32%), fruits (11%), palms (11%), sugarcane (8%), rice (8%)
Costa Rica	Fruits (other than bananas) (21%), cassava (17%), rice (13%), vegetables (12%), coffee (7%), bananas (5%), sugarcane (5%), potatoes (5%)
Dominican Republic	Fruits (other than bananas) (21%), bananas (15%), rice (15%), beans (7%), cacao (7%), maize (6%), sorghum (5%)
El Salvador	Fruits (41%), coffee (7%), maize (7%), sorghum (7%), beans (7%), vegetables (5%), rice (5%)
Guatemala	Sugarcane (33%), fruits (15%), vegetables (14%), maize (10%), beans (5%)
Honduras	Vegetables (16%), fruits (other than bananas) (15%), cacao (13%), bananas (13%), beans (10%), coffee (8%), rice (7%), maize (7%), potatoes (7%)
Mexico	Maize (18%), vegetables (16%), fruits (11%), ornamental flowers (7%), beans (7%), wheat (6%)
Nicaragua	Coffee (23%), sorghum (12%), maize (9%), rice (8%), beans (8%), potatoes (5%), vegetables (5%)
Panama	Coffee (32%), fruits (22%), rice (15%), vegetables (7%), maize (6%)
Paraguay	Cotton (17%), soybeans (16%), vegetables (13%), fruits (12%), sugarcane (9%), maize (9%), wheat (8%), cacao (7%)
Uruguay	Fruits (other than grapes) (26%), vegetables (16%), rice (15%), wheat (9%), cacao (7%), grapes (7%)
Total (14)	Fruits (14%), vegetables (12%), beans (9%), coffee (6%), wheat (6%)

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Major crop items are defined as those on which at least 5 percent of a country's crop researchers focus. Data for Brazil were not available.

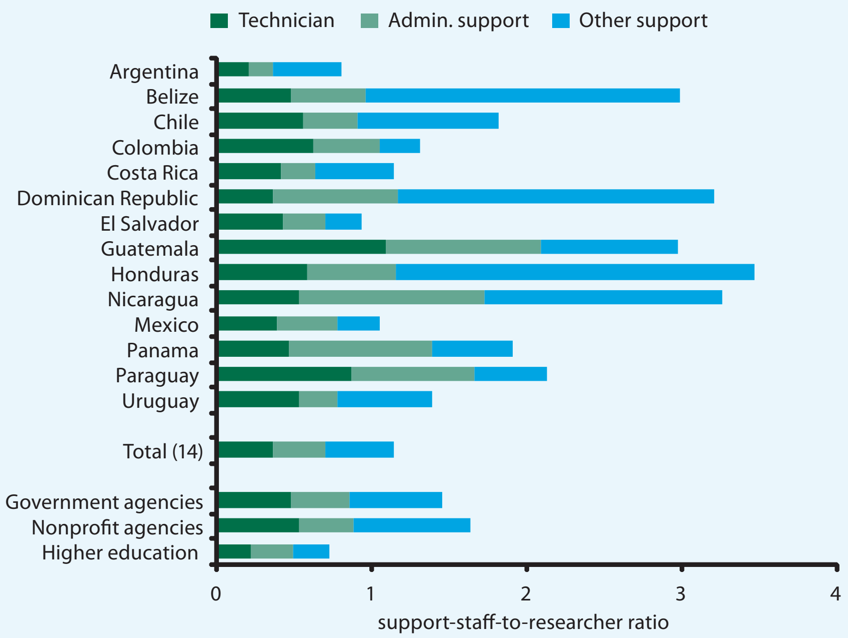
Cone countries focused more on vegetables, grapes, wheat, and soybeans.

Support Staff

In 2006, the average number of FTE support staff per scientist for a 14-country sample (excluding Brazil) was 1.2, comprising 0.4 technicians, 0.3 administrative personnel, and 0.4 other support staff such as laborers, guards, and drivers (Figure 4). Higher education agencies employed only 0.7 support staff per researcher, but this relatively lower ratio is consistent with findings for higher education sectors in other parts of the world.

Large country-level differences were identified: support-staff-to-researcher ratios ranged from fewer than 1.0 in Argentina and El Salvador to more than 3.0 in Honduras, Nicaragua, and the Dominican Republic. Guatemala employed the highest number of technicians per researcher (1.1), closely followed by Paraguay (0.9). The number of "other support staff" per researcher was particularly high in Honduras, Belize, and the Dominican Republic. In many of the region's countries, the average number of support staff per researcher has declined over time, but this trend is consistent with other regions.

Figure 4 Support-staff-to-researcher ratios by support staff category, 2006



SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Data for Brazil were not available.

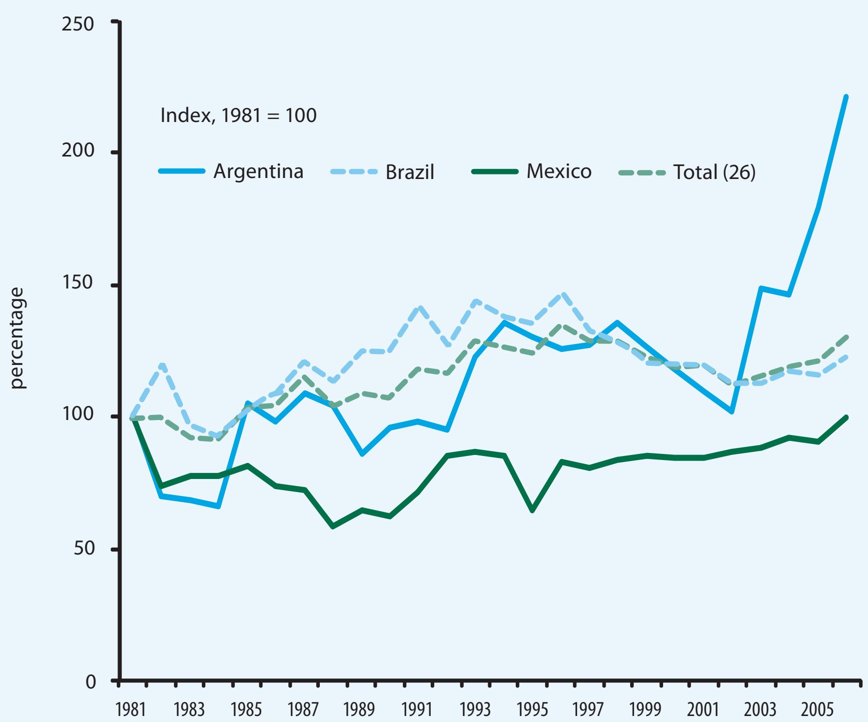
Public Agricultural Research Spending

Overall Trends

It is estimated that in 2006 the 27 countries of the LAC region spent a total of nearly $3.0 billion (in 2005 purchasing power parity or PPP dollars)[4] on agricultural research (Table 6 and Figure 5), which represents a 32-percent increase over the levels recorded in 1981 ($2.3 billion).[5] Together, the region's three largest countries (Argentina, Brazil, and Mexico) accounted for nearly three-quarters of this spending. Argentina's and Mexico's spending shares increased during the 1981–2006 period, whereas the relative shares of Brazil, Chile, and Colombia all declined.

Brazil accounted for 41 percent of the region's total agricultural R&D spending in 2006, and, whereas expenditures grew consistently during 1984–96, thereafter they declined due to reduced spending by Brazil's state government agencies. Spending also contracted at Embrapa during 1996–99, but this is actually a reflection of a spike in spending in 1996 resulting from unusually large outlays associated with an early retirement scheme offered to staff that year (Beintema, Dias Avila, and Pardey 2001); Embrapa's spending rebounded after 1999, reaching $750 million in 2006 (or a quarter of LAC's total expenditures). Spending in Argentina has grown rapidly in recent years, largely due to growth at INTA (despite contracted spending during the financial crisis of 1999–2002). Since 2003, IDB has funded an important S&T project that has led to an influx of additional funding both agricultural research and for S&T more generally. During 2002–06, Argentina's total agricultural R&D expenditures more than doubled from $207 million to $449 million. Mexico has also shown consistent growth in its agricultural R&D spending since the mid-1990s, which is attributable to increased agricultural research within the country's higher education sector and by its government agencies (other than INIFAP). In 2006, Mexico invested $518 million in agricultural R&D, of

Figure 5 Trends in public agricultural research spending, 1981–2006



SOURCE: See Table 6.

NOTES: See Table 6.

[4] Financial data in the remainder of this report are provided in real values using GDP deflators and PPP indexes taken from the World Bank (2008b). PPPs are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than do conventional exchange rates. Using PPPs as conversion factors to denominate value aggregates in international dollars results in more realistic and directly comparable estimates of agricultural research spending across countries than would result from the use of market exchange rates (see the appendix for more information).

[5] Note that this total does not include spending by regional organizations such as the Agronomic Center for Research and Education (CATIE). Although these regional organizations play a nonnegligible role at the national level in some Central American and Caribbean countries, they represent a very small share of total agricultural R&D spending in LAC.

Table 6 Public agricultural research spending, 1981–2006

Country	Total spending 1981	1991	2001	2006	Annual growth rate (%) 1981–91	1991–2001	2001–06	1981–2006
	(Million 2005 PPP dollars)				*(Percentage)*			
Argentina	202.7	199.0	221.9	448.6	2.57	1.33	16.01	2.97
Belize	1.0	2.3	2.3	2.6	2.50	1.33	2.38	1.92
Brazil	1,005.4	1,432.5	1,194.9	1,224.1	2.99	–1.63	–0.66	0.58
Chile	58.2	65.6	124.3	98.1	5.54	6.71	–4.63	3.41
Colombia	104.0	135.0	176.3	152.4	3.73	3.92	–3.75	0.41
Costa Rica	13.4	20.9	26.7	29.9	–0.49	1.07	2.82	3.04
Dominican Republic	14.8	12.2	14.6	17.4	–1.99	1.83	4.17	–0.23
El Salvador	13.5	10.5	6.0	5.7	–2.27	–5.48	–3.32	–4.23
Guatemala	21.4	11.4	9.0	8.3	–1.43	–4.70	–2.04	–3.82
Honduras	5.5	15.8	13.0	11.0	14.60	0.68	–2.94	1.62
Mexico	517.6	369.2	437.0	517.6	–3.20	0.85	2.98	0.84
Nicaragua	11.6	14.6	22.5	24.1	1.28	4.03	–2.27	2.62
Panama	10.1	12.6	10.5	10.0	1.35	–0.68	–0.98	–0.92
Paraguay	2.8	3.4	2.6	3.1	–6.53	–3.41	1.54	–0.34
Uruguay	17.6	28.5	41.8	59.8	8.30	0.80	9.71	4.94
Sample total (15)	1,999.7	2,333.6	2,303.5	2,614.5	1.79	–0.12	2.56	0.99
Total (26)	2,274.7	2,697.5	2,702.9	2,983.7	1.86	0.02	2.14	1.05

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: Figures in parentheses indicate the number of countries in each category. Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period. Totals for 2001 are estimates based on country-level interpolations. For Brazil, total spending trends for a number of government research agencies and a large number of higher education agencies were estimated using 1996 data and average trends for the Brazilian Agricultural Research Corporation (Embrapa), São Paulo's Agency for Agribusiness Technology (APTA), and other government research agencies for which data were available. Total spending levels for the 11 nonsample countries (Bolivia, Ecuador, Peru, Venezuela, Antigua and Barbuda, Dominica, Guyana, Jamaica, Saint Kitts and Nevis, Surinam, and Trinidad and Tobago) were estimated based on average regional agricultural research intensity ratios and country AgGDP levels.

which INIFAP accounted for 22 percent. Spending in Chile contracted in recent years, reflecting reduced spending by the county's principal government agencies. Similarly, Colombia recorded negative spending growth in recent years due to reduced spending by CORPOICA, and aggregate spending in Central America also contracted.

Cost Structures

The allocation of research budgets across salaries, operating costs, and capital costs affects the efficiency of agricultural R&D, so detailed cost-category data were collected for this study. In 2006, the 83 government and nonprofit agencies for which cost-category data were available spent 56 percent of their combined budgets on salaries, 31 percent on operating costs, and 13 percent on capital expenditures (Figure 6). Operating costs accounted for more than half of all agricultural R&D expenditure in Nicaragua and Uruguay, whereas salaries were the largest expense in all other countries. In Guatemala, salaries accounted for close to three-quarters of all spending, leaving little funding for operating costs or capital investments. Capital spending shares varied across countries from just 2 percent in El Salvador to 22 percent in Argentina.

Agricultural Intensity Ratios

Another way of evaluating a country's agricultural R&D commitment—and of placing it within an international context—is to compare its agricultural research spending with the size of its agricultural sector. This indicator is known as a research intensity ratio, and the most common method of calculation is public agricultural R&D spending as a percentage of agricultural GDP (AgGDP). In 2006, the 15 sample

countries as a whole invested $1.14 in agricultural research for every $100 of agricultural output. This average is lower than the comparable share for 1996 of 1.31 (Figure 7). In other words, average growth in agricultural production in these countries outpaced average growth in agricultural research investments during 1996–2006. Note, however, that the 2006 share was higher than comparable shares for both 1981 (0.91) and 1991 (1.08). From a disaggregated perspective, intensity ratios in Central America have been consistently lower than those in other parts of Latin America, while Mexico and many Southern Cone countries—such as Argentina, Brazil, Chile, and Uruguay—invest over 1.0 percent of their agricultural GDP in agricultural R&D. Unsurprisingly, agricultural intensity ratios in poorer countries like Guatemala, El Salvador, and Paraguay are significantly lower (less than 0.3 percent).

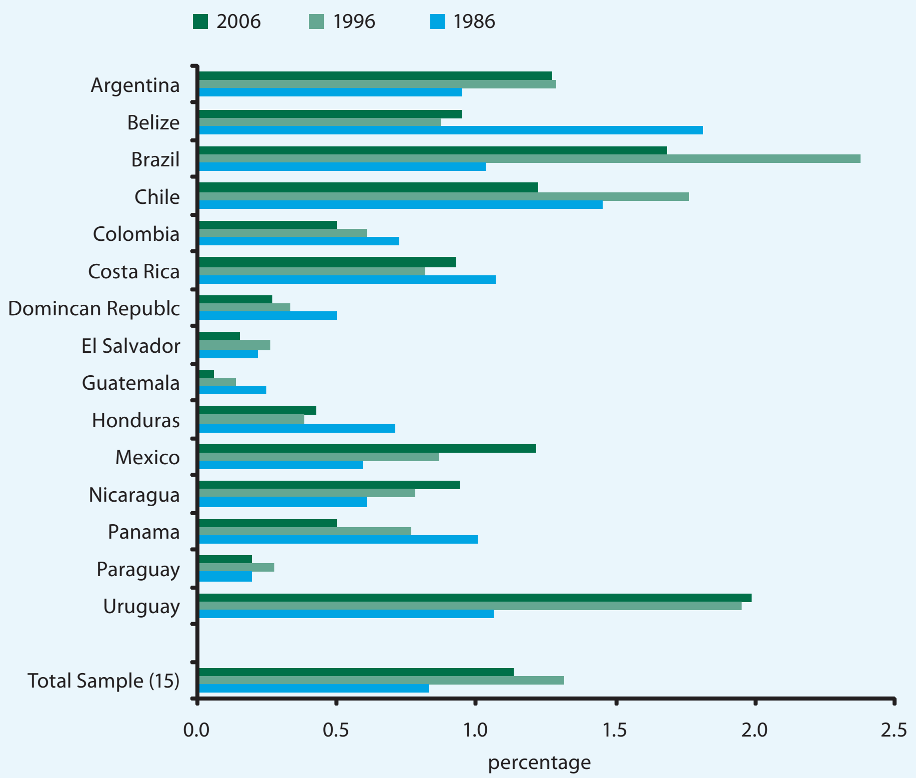
Although intensity ratios are a good indicator of research investment levels, they do not take into account the policy and institutional environment within which agricultural research takes place or the broader size and structure of a country's agricultural sector and economy. For example, small countries need more research investments because they cannot benefit from economies of scale in the same way larger countries can. Equally, countries with greater agricultural diversity or more complex agroecological conditions can also have more complex research needs requiring higher funding levels (Beintema and Stads 2008b). A low intensity ratio in a country that imports many of its agricultural technologies is therefore not necessarily a cause for concern. Paraguay, for instance, is extremely dependent on new technologies from Brazil. Resourceful Brazilian farmers

Figure 6 Cost category shares of the principal agencies, 2006

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: The sample includes 85 agencies, accounting for 81 percent of the combined total government and nonprofit spending in the 15 countries. Data for Brazil only include Embrapa.

Figure 7 Agricultural intensity ratios, 1986, 1996, and 2006



SOURCE: Table 6 and AgGDP data from World Bank (2008b).

own vast tracts of land in Paraguay near the border of Brazil where prices per hectare are roughly three times lower. As a result, Brazilian farmers transfer many new technologies to Paraguay, particularly relating to the production of livestock, soybeans, and sugarcane, so Paraguay's low agricultural research intensity ratio, at 0.20, needs to be evaluated in the context of this influx of foreign technologies. Another factor requiring consideration is that increased agricultural R&D intensity ratios don't always reflect increased agricultural R&D spending; they can also reflect a drop in agricultural output. Mexico, for example, invested $1.21 on agricultural research for every $100 of agricultural output in 2006, which was 80 percent higher than the corresponding 1991 ratio (0.67). But this increase was partly due to a reduction in Mexico's AgGDP during this period. In the case of Uruguay, one could argue that official AgGDP figures do not fully reflect the importance of agriculture in the national economy. In 2006, agriculture accounted for 9 percent of the country's GDP. However, the country's expanded AgGDP is much higher, because it includes industries like beef production and wine making (which account for a considerable part of the country's economy). It is very difficult to measure the exact linkages of Uruguay's agricultural sector with the country's manufacturing and distribution sectors. However, it is clear that Uruguay's expanded AgGDP is much higher than the country's official AgGDP and that the country's agricultural research spending as a share of expanded AgGDP would be much lower than agricultural research spending as a share of official AgGDP.

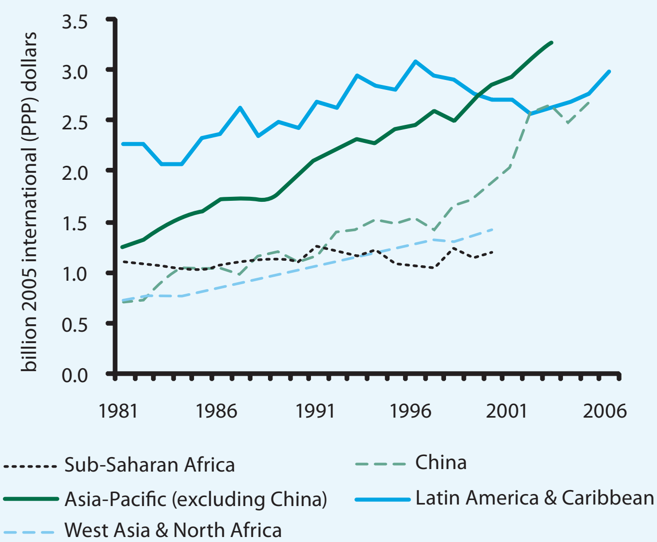
Despite these drawbacks, intensity ratios reveal the worrying bifurcation of the region's low- and middle-income countries when it comes to agricultural R&D spending. Argentina, Brazil, Chile, Mexico and Uruguay spend a much larger share of their agricultural GDP on agricultural research compared with countries like El Salvador, Guatemala, and Paraguay.

Regional Agricultural R&D Spending within a Global Context

In 2000, LAC's $2.8 billion agricultural R&D spending represented 12 percent of the $23.2 billion global total that year (Beintema and Stads 2008b), slightly less than the 1981 share of 14 percent. The contraction is largely attributable to the increasing role of agricultural R&D in the Asia-Pacific region, where total public agricultural R&D spending grew by an average of 3.6 percent per year from 1981 to 2002 in inflation-adjusted terms (Figure 8). Most of this growth took place in China and India, where public spending more than tripled over this timeframe (Beintema and Stads 2008a).

As previously discussed, in 2006 the LAC region as a whole invested $1.14 in agricultural research for every $100 of agricultural output, which is high compared with other developing regions of the world, such as Africa (0.65) and the Asia-Pacific (0.42). Nevertheless, as has been emphasized throughout this report, LAC's diversity must be taken into consideration, given that the intensity ratios of individual countries in the region vary from as little as 0.2 to as high as 2.0, which is close to ratios reported in the developed world.

Figure 8 Trends in agricultural R&D expenditures in developing countries, 1981–2006



SOURCE: Beintema and Stads (2008b).

Financing Public Agricultural Research

Looking at 2006 averages for the 15 sample countries of LAC as a whole, 83 percent of agricultural R&D was financed by national governments, 8 percent was generated internally (whether by public and private entities), 5 percent was derived from producer organizations, and 3 percent was contributed by foreign donors and development banks (Figure 9). From a national perspective, more than 90 percent of agricultural R&D was financed (through a variety of mechanisms) by the national government in countries like Argentina, Brazil, El Salvador, and Panama, whereas government financing was of only minor importance in countries like Honduras, Belize, and Nicaragua (Table 7). Donor funding is comparatively more important in certain countries of Central America and the Caribbean. In Nicaragua, for example, about three-quarters of public agricultural R&D is financed by foreign donors and multilateral development banks.

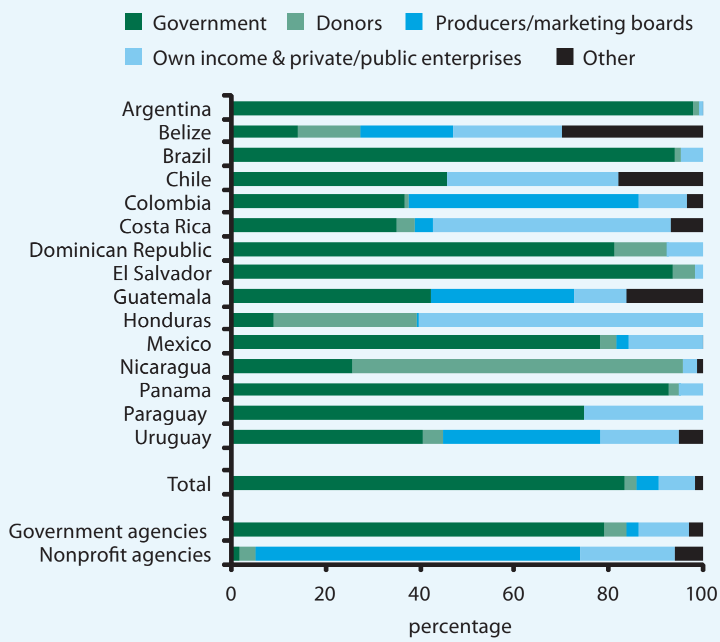
Colombia is one of the most advanced countries when it comes to raising finance through commodity taxes, as has become popular in several countries of the region (following the global trend). Such levies fund more than three-quarters of the research undertaken by the country's main producer organizations—the National Coffee Research Center (CENICAFE), the Sugarcane Research Center (CENICAÑA), and the Palm Oil Research Center (CENIPALMA). Similarly, levies on coffee and sugar contribute to research revenues in Costa Rica, Guatemala, and Honduras. In 2006, 20 percent of funding for Costa Rica's INTA, for example, was generated through research undertaken on behalf of nongovernmental organizations (NGOs) such as the Costa Rica Institute of Coffee (ICAFE). Similarly, NGOs like the National Biodiversity Institute (INBio) in Costa Rica and the Honduran Foundation of Agricultural Research (FHIA) generated the bulk of their funding through contract research.

Uruguay's INIA has a unique funding structure compared with other Latin American institutes in that it is the beneficiary of the proceeds of a commodity tax on the total value of the country's agricultural commodity sales. In addition, the national government provides INIA with quarterly counterpart funding in direct proportion to the funds generated by the tax.

Some private enterprises are also involved in funding public agricultural R&D in LAC, most notably in Chile and Mexico. INIFAP in Mexico, for instance, carries out pesticide research on behalf of Bayer Crop Science, wheat research on behalf of Grupo Bimbo (a food-production company), pest control research on behalf of Grupo Maseca (a large producer of tortillas), barley research on behalf of Impulsora Agricola (an agribusiness company), natural resources research on behalf of Peñoles (a mining company), and dairy research on behalf of Nestlé. Unfortunately, data on agricultural R&D funding in the higher education sector are unavailable, but many universities in Argentina, Chile, Costa Rica, and Mexico, conduct on-demand research for private companies.

Several Latin American countries have created competitive funds as an alternative means of dis-

Figure 9 Funding sources, 2006



SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

NOTES: The sample includes 98 agencies, accounting for more than 80 percent of the sample 15 countries' total combined government and nonprofit spending. Data for Brazil only includes Embrapa and APTA.

bursing research resources. Competitive funding mechanisms have gained favor among some (but not all) policymakers, donors, and even researchers, and they come with several pros and cons compared with more conventional block-grant approaches. Such mechanisms are seen as a means of redirecting research priorities, increasing the role of the private and academic sectors in the performance of research, and possibly forging linkages among government, academic, and private research agencies. Nevertheless, competitive mechanisms often involve higher transactions costs (such as the need to write and screen proposals) and can incur increased rent-seeking costs (such as lobbying). On a positive note, competitive mechanisms may lower the social costs of research by ensuring that a broad spectrum of research projects are considered, thereby circumventing the allocation of funding purely on the basis of precedence, which is more likely under block grant mechanisms. Competitive mechanisms also tend to increase flexibility, but they often favor short-term, applied research at the expense of more basic, long-term endeavors (Echeverría 2006). Competitive mechanisms are a significant means of funding agricultural R&D in Chile, which was one of the first countries in Latin America to introduce such mechanisms for agricultural R&D in the 1980s. In 2006, 18 percent of government-sector agricultural R&D in Chile was financed through competitive funds. In many other countries—including Brazil, Colombia, Costa Rica, Mexico, and Uruguay—competitive funds are playing an increasingly important role in agricultural R&D.

FONTAGRO also plays an important role in financing agricultural R&D in LAC. In 2007, the regional fund supported 56 projects dealing with productivity, natural resources, innovation in agrifood chains, competitiveness, agricultural policies, and institutional strengthening. That year, FONTAGRO provided $15.7 million in grants, mobilized over $32 million in counterpart funding, and received more than 330 proposals (FONTAGRO 2008).

Table 7 Funding sources and mechanisms for public agricultural R&D

Country	Funding trends
Argentina	Agricultural research in Argentina is highly dependent on government funding, and government contributions increased sharply between 2002 and 2006. In addition, the Inter-American Development Bank (IDB) has played an important role in financing an S&T program in Argentina in recent years, but since these funds were disbursed via the Ministry of Science and Technology and the National Agency for Scientific and Technological Promotion (ANPCyT), it is difficult to establish exactly how much the National Institute of Agricultural Innovation and Technology Transfer (INTA), the National Institute for Industrial Technology (INTI), and the National Council for Scientific and Technical Research (CONICET) received. Argentina's private sector also finances some research undertaken by the country's government agencies and higher education sector.
Belize	The Central Farm Agricultural Station finances the bulk of its research activities through donor contributions or by generating its own resources; funding from the national government constitutes a comparatively limited share. The Caribbean Agricultural Research and Development Institute (CARDI), on the other hand, receives the majority of its funding from the national government.
Brazil	The Brazilian Agricultural Research Corporation (Embrapa) is mostly funded by the federal government, and numerous state-run agencies—most notably São Paulo's Agency for Agribusiness Technology—are state funded, although a proportion of these federal and state funds are allocated via competitive mechanisms. Other sources of funding, including internally generated resources, have increased in recent years but still represent a small share of total agricultural R&D funding in Brazil.
Chile	Roughly half of INIA's funding is provided by the Chilean government, and the remainder is generated internally (mainly through the sale of seed, laboratory services, and contract research for the private sector) or through competitive funding, which is significant to both public and private agricultural R&D compared with other LAC countries. The key competitive funds in Chile are the National Fund for Science and Technology Development (FONDECYT), the Fund for the Promotion of Scientific and Technological Development (FONDEF), the National Fund for Technological and Productive Development (FONTEC), the Agricultural Innovation Fund (FIA), the Development and Innovation Fund (FDI), and the Fund for Fisheries Research (FIP). Each of these focuses on different themes or areas of agricultural S&T, and they all require private-sector involvement through counterpart funding or collaborative research to ensure relevance to industry.
Colombia	More than 90 percent of research in Colombia carried out by the country's four principal producer associations is financed through commodity taxes on private agricultural production or exports. In contrast, the Colombian Corporation for Agricultural Research (CORPOICA) receives the majority of its funding from the national government, with the remainder generated internally or derived from the private sector or foreign donors. In recent years, competitive funds have become increasingly important.

Table 7 (continued)

Country	Funding trends
Costa Rica	Being state-owned, the National Institute of Technological Innovation (INTA) receives most of funding (more than three-quarters in 2006) through government allocations, while the remainder is derived from foreign donors or is generated internally. Research at the Costa Rica Institute of Coffee (ICAFE) and the National Banana Corporation (CORBANA), which focuses on coffee and bananas, respectively, is largely financed through a levy on production or exports. The National Biodiversity Institute (INBio) generates the majority of its income by conducting contract research for the private sector, and the University of Costa Rica relies on a mix of government support, private contract research, and internally generated resources.
Dominican Republic	The Dominican Institute for Agricultural and Forestry Research (IDIAF) receives most of its funding from the Dominican government. Foreign donors (mostly Spain, Japan, and the United States) and internally generated resources constitute the remainder of the institute's funding.
El Salvador	The National Center of Agricultural and Forestry Technology (CENTA) is mainly funded through direct government appropriations (in 2006, this direct funding represented 95 percent of the agency's expenditure). The balance of funding in 2006 was derived from foreign donors, including the Japan International Cooperation Agency (JICA), Taiwan, the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Tropical Agriculture (CIAT), and the International Potato Center (CIP). Sugarcane and coffee research at the Salvadorian Sugar Company (CASSA) and the Salvadorian Foundation for Coffee Research PROCAFE is largely financed through commodity taxes.
Guatemala	Funding for government-sector agricultural research is mainly derived from the national government and supplemented by limited internally generated resources. The Guatemalan Sugarcane Research and Training Center (CENGICAÑA), the country's sugarcane research institute, is entirely financed through commodity taxes levied on sugarcane production.
Honduras	Being government-controlled, the Directorate for Agricultural Research and Technology (DICTA) receives most of its funding from the national government, although donor funding is also important, including contributions from Japan and IDB. The Honduran Foundation for Agricultural Research (FHIA), the country's largest agricultural R&D agency in terms of both staffing and spending, relies heavily on contract research for the private sector. FHIA also reported a sizeable amount of donor support, including funding from the European Union, Germany, Japan, the Netherlands, and USAID.
Mexico	Agricultural R&D in Mexico is largely financed by the national government, with the Ministry of Agriculture allocating funding to the main agricultural universities and the National Institute for Forestry, Agricultural, and Animal Husbandry Research (INIFAP) receiving funding directly from the Treasury. The private sector also funds some public research. Competitive funds play an important role in financing Mexican agricultural R&D. Each state has a Fundación Produce that manages a competitive fund aimed at solving the technological needs of its state. The National Science and Technology Council (CONACYT) also operates three competitive funds focusing on institutional, sectoral, and mixed themes.
Nicaragua	Agricultural R&D in Nicaragua is highly dependent on funding from donors and multilateral development banks. The donor community has generously contributed to the country's National Institute of Agricultural Technology (INTA). In recent years, INTA has depended on donor support (mainly from Austria, Canada, Denmark, and the World Bank), such that its research agenda has become highly donor driven. The Foundation for Technological Development of Agriculture and Forestry (FUNICA), established in 2000, manages the Support Fund for Agricultural Technology Research in Nicaragua (FAITAN)—a competitive fund that finances agricultural research undertaken by domestic and foreign research organizations—and the Fund for Technical Assistance (FAT), which stimulates competitive, private agricultural advisory services.
Panama	The vast majority of the Agricultural Research Institute of Panama (IDIAP's) funding (94 percent in 2006) is derived from the national government, with the remainder contributed by foreign donors or generated internally. The Panamanian Association for Sustainability of Agriculture and Natural Resources (APASAN) also received the bulk of its funding from the national government but complements it budget by generating limited revenues internally and from producer organizations.
Paraguay	Agricultural research in Paraguay is largely financed by the national government and internal sources. Salaries at the Agricultural Research Directorate (DIA) and the Animal Research and Production Directorate (DIPA) are directly funded through government appropriations, and operating costs are largely financed through internally generated revenues; the sale of seed, livestock, and services; and through the conduct of experiment trials on a contract basis for the private sector. DIA also receives significant in-kind support from foreign donors, notably Japan. Recently, with an influx of funding from IDB, steps have been taken to introduce a competitive fund similar to Chile's FONDEF.
Uruguay	The National Agricultural Research Institute (INIA) receives the proceeds of a commodity tax on the national sales value of agricultural commodities. In addition, the national government provides INIA with quarterly counterpart funding in direct proportion to the commodity tax revenues. Internal resources also account for a sizeable share of INIA's funding. The University of the Republic (UdelaR) funds its research through a combination of government support and private contract research. IDB loans and competitive funding are also important in Uruguay.

SOURCE: Compiled by authors from datasets underlying ASTI country briefs and reports (ASTI 2008-09).

Conclusion

In 2006, LAC as a whole employed more than 19,000 FTE researchers in agriculture and invested $3.0 billion in agricultural R&D (in 2005 constant prices), which corresponds to 1.14 percent of the region's total agricultural output. Nevertheless, 70 percent of this total was spent by just three countries: Argentina, Brazil, and Mexico. Were these "big three" countries excluded, the region's agricultural R&D investments as a percentage of AgGDP would be substantially lower (0.72 percent). Regionwide investments grew by 1.1 percent per year during 1981–2006, but this average masks significant differences over time and among countries. During 1996–2006, agricultural research spending in countries like Argentina, Costa Rica, and Uruguay rose markedly, whereas expenditures in countries like Chile, El Salvador, Guatemala, Honduras, and Paraguay contracted. Brazil, the region's largest country, also experienced a modest decline in its agricultural R&D investments since the mid-1990s largely due to reduced spending by the country's state government agencies in recent years.

LAC's human resource capacity in agricultural R&D shows similar diversity across countries. Argentina, Brazil, and Mexico each have large and comparatively complex systems employing thousands of scientists, whereas capacity in the countries of the Caribbean and Central American is understandably much smaller. Overall, entities conducting agricultural R&D in the LAC region have become increasingly diversified in recent decades, with the INIAs occupying a progressively lower share of total research staff numbers. Large national differences in the average qualifications of agricultural scientists are also present; nonetheless, qualification improved overall in most countries in the past decade. A worrying trend, however, is that the pool of scientists is aging and some countries have failed to address this with initiatives to hire and train younger scientists.

Most agricultural R&D in LAC is funded by national governments, but sources differ widely across countries. Commodity taxes on the sale of production or exports have become popular in many countries, especially Colombia and Costa Rica, and competitive funding mechanisms are also gaining popularity in a large number of countries. Donor dependency for the LAC region as a whole is much lower than in Sub-Saharan Africa, although it remains very high in countries like Nicaragua and Honduras. Internally generated resources and private funding play an important role in financing agricultural research in the region as well. In addition to financing research directly, national and multinational private enterprises also carry out their own research in some countries; the exact share of private-sector involvement in agricultural R&D in LAC, however, is difficult (if not impossible) to measure.

Beintema and Pardey (2001) stated that the most worrying trend in agricultural R&D in LAC was the apparent bifurcation of agricultural research. More recent data to 2006 confirm that the gap between the region's low- and middle-income countries has in fact widened. Some of the poorer, agriculture-dependent countries—such as Guatemala, El Salvador, and Paraguay—experienced sharp cuts in their agricultural research expenditures and intensity ratios over the past decade, while some of the more economically advanced countries (such as Argentina and Mexico) experienced growth. It is becoming increasingly clear that the region's low-income countries are slipping behind in their ability to generate new technologies and varieties. Moreover, most of the region's poorest and technologically most challenged countries are in tropical zones, putting them at a disadvantage compared with their more advanced neighbors in temperate zones, which gain large benefits from the spillover of technologies and varieties generated in high-income countries with similar agroclimatic conditions.

Sustainable financial support for agricultural R&D is crucial in all countries of the region, not only in support of revenue-generating export crops, but also in support of much-needed food crops and, more generally, development initiatives to alleviate rural poverty. If the region is to achieve food security, reduce poverty, and compete in an increasingly competitive global market, strong political support for agricultural R&D is called for in addition to financial support, as is greater integration of agricultural R&D systems both within and among countries.

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[6] Note that all ASTI reports and briefs are also available in Spanish, and the Brazilian country brief is also available in Portuguese.

Appendix

ASTI Methodology and Data Collection

The ASTI initiative involves a large amount of original and ongoing survey work focused on developing countries, but it also maintains access to relevant S&T data for developed countries collected by other agencies. The initiative maintains collaborative alliances with a number of national and regional R&D agencies, as well as international institutions, and over the years has produced numerous national, regional, and global overviews and policy analyses of agricultural R&D investment and institutional trends. For each country in which ASTI is active, the research team typically works with the national agricultural research institute, which coordinates the in-country survey round and coauthors and co-publishes the resulting country briefs with IFPRI. These surveys focus on research agencies, not research programs.

The dataset for the 15-country sample underpinning this report includes information on more than 450 agencies and was processed using internationally accepted statistical procedures and definitions developed by the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) for compiling R&D statistics (OECD 1994; UNESCO 1984). Agricultural R&D investments are measured on a performer basis. Estimates were grouped into four major institutional categories: government agencies, higher education agencies, nonprofit institutions, and business enterprises. Public agricultural research is defined to include government agencies, higher education agencies, and nonprofit institutions, thereby excluding private enterprises. Government agencies are directly administered by the national government and are typically departments or institutes within a certain ministry. Nonprofit institutions, on the other hand, are not directly controlled by the national government and have no explicit profit-making objective. These agencies are often linked to producer organizations or commodity boards. Higher education agencies are academic agencies that combine university-level education with research. They include agricultural faculties as well as specialized R&D institutes administered by universities. Private-sector agencies are those whose primary activity is the production of goods and services for profit. Some of these companies have an R&D unit dedicated to agricultural research, but R&D is generally not their main activity. Agricultural research activities undertaken by international organizations are explicitly excluded from the dataset and are reported separately.

Agricultural research, as defined here, includes research on crops, livestock, forestry, fisheries, natural resources, the use of agricultural inputs, and the socioeconomic aspects of primary agricultural production. Also included is research concerning the onfarm storage and processing of agricultural products, commonly referred to as postharvest or food-processing research. Not included in the current data compilation are research activities in support of agrochemical, agricultural machinery, or food processing industries (which are better reported under those industries), as well as the more basic and discipline-oriented research activities undertaken by departments such as microbiology and zoology. Strict delineations, however, have not always been possible.

In each of the 15 countries included in this study, a complete list of agencies involved in public agricultural R&D was identified at the onset of the survey, and each agency was approached to participate. To this end, two different survey forms were developed: one for government agencies and nonprofit institutions, and one for schools and faculties. The private sector was excluded from this study given the inherent obstacles associated with obtaining data on private enterprises. All survey forms included different sets of questions, with the one for government agencies and nonprofit institutions requesting the most detail. In general, the forms comprised four sections:

- institutional details, such as address, affiliation, organizational structure (including number of research stations), institutional history, and so on;
- human resource information, such as number of researchers by degree level, head count and full-time equivalents or FTE (that is, staffing adjusted for time spent on research), share of female researchers, and support staff by various categories;
- financial resources, such as expenditures by cost category and funding source; and
- research focus by commodity (about 35–40

items) and by theme (about 20 items).

Time-series data were collected for the main indicators (research investments, research funding sources, and research staff totals), while the remaining indicators were generally for a particular benchmark year. Additional qualitative information was collected through country visits involving in-depth meetings with various agencies, given that quantitative information often doesn't provide the full picture of developments in agricultural R&D resources.

The reported research personnel data are expressed as FTE researchers. Researchers should hold at least a BSc degree or equivalent. FTE corrections were made only when more than 20 percent of the reported research staff time was spent on activities other than research, such as extension, teaching, or technical services. The contribution of PhD students to research taking place at higher education agencies is usually not included.

Internationally Comparable Measures of R&D, Using PPPs

Comparing economic data across countries is highly complex due to important price differences. Putting the agricultural R&D expenditures of two countries side by side is particularly difficult, because roughly two-thirds of research expenditures is typically spent on local research and support staff, rather than on capital or other goods and services, which are usually traded internationally.

The quantity of research resources used in economies with relatively low price levels tends to be understated when R&D spending is converted from different countries to a single currency using official exchange rates. Similarly, the quantity of resources used in countries with high price levels tends to be overstated. Purchasing power parities (PPP) are conversion rates that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. Therefore, a PPP rate can be thought of as the exchange rate of dollars for goods in the local economy, while the U.S. dollar exchange rate measures the relative cost of domestic currency in dollars. A country's international price level is the ratio of its PPP rate to its official exchange rate for U.S. dollars. Thus the international price level is an index measuring the cost of a broad range of goods and services in one country relative to the same bundle of goods and services in a reference country, in this case the United States. For example, Japan's international price level (that is, the ratio of PPP to exchange rate) of 1.57 in the year 2000 implies that the price of goods and services in Japan was 57 percent higher than the price of comparable goods and services in the United States during that year. In contrast, the corresponding 2000 ratio for Kenya of 0.20 indicates that a bundle of goods and services that cost $20 in Kenya would have cost $100 in the United States (Pardey and Beintema 2001).

No fully satisfactory method has so far been devised to compare consumption or expenditures among countries, either at different points in time or the same point in time. The measures obtained, as well as their interpretation, can be highly sensitive to the deflator and currency converter used. Most financial data in this report have been expressed in "international dollars" for the benchmark year 2005. At the country level, all expenditure and funding data have been collected in local currency units. These amounts were subsequently converted to 2005 international dollars by deflating the local currency amounts with each country's GDP deflator of base year 2005 and converting to U.S. dollars with a 2005 PPP index. The GDP deflators were taken from the World Bank's World Development Indicators (World Bank 2008b). In early 2008, the World Bank released a revised set of PPP indexes with a base year of 2005. These indexes differ considerably for important developing countries such as China and India. The revised PPP index for China, for example, was two thirds higher. Due to these revised PPP indexes, the allocation of public agricultural research investments across countries and regions deviate significantly than the global investment trends published in Pardey and Beintema (2001) and Pardey et al. (2006) (Beintema and Stads 2008b).

Abstract

This report reviews institutional developments and major investment and human resource trends in public agricultural research and development (R&D) in Latin America and Caribbean (LAC). The report draws on comprehensive primary datasets for 15 sample countries, supplemented by national agricultural GDP data and estimates of average agricultural research intensity ratios for the remaining countries to provide a wider regional and global context.

Since the early 1980s, most LAC countries have made considerable progress in building their research capacity in terms of numbers of researchers and researcher qualification levels. In 2006, the region as a whole employed roughly 19,000 full-time equivalent agricultural researchers, although 70 percent of these researchers were active in just three countries: Argentina, Brazil, and Mexico. The performance of agricultural research has become increasingly diversified since the early 1980s. The average share of agricultural R&D staff employed at the national agricultural research institutes (INIAs) has progressively declined as other government, higher education, and nonprofit agencies have become more prominent.

In 2006, as a whole, LAC spent close to US$3 billion on agricultural R&D (in 2005 constant prices); the distribution of national spending was highly uneven, however, with Argentina, Brazil, and Mexico accounting for the bulk of these investments. Many of the region's countries realized impressive growth in agricultural R&D spending during 1996–2006, whereas spending in other countries actually declined, reflecting the worrying trend of a spending gap between the region's low- and middle-income countries. Agricultural research is still predominantly funded by the government, although a number of countries have instituted a dual funding system that incorporates a competitive government allocation. In addition, a number of countries have followed the global of trend of raising additional agricultural R&D revenues by imposing a commodity tax on agricultural production or exports or, where possible, by commercializing their research results.

About the ASTI Initiative

The Agricultural Science and Technology Indicators (ASTI) initiative compiles, processes, and disseminates data on institutional developments and investments in worldwide agricultural R&D, and analyzes and reports on these trends. Tracking these developments in ways that facilitate meaningful comparisons among different countries, types of agencies, and points in time is critical for keeping policymakers abreast of science policy issues pertaining to agriculture. The main objective of the ASTI initiative is to assist policymakers and donors in making better informed decisions about the funding and operation of public and private agricultural science and technology agencies by making available internationally comparable information on agricultural research investments and institutional changes. Better-informed decisions will improve the efficiency and impact of agricultural R&D systems and ultimately enhance productivity growth of the agriculture sector.

The ASTI initiative comprises a network of national, regional, and international agricultural R&D agencies and is managed by the International Food Policy Research Institute (IFPRI), a research center of the Consultative Group on International Agricultural Research. ASTI data and associated reports are made freely available for research policy formulation and priority-setting purposes (http://www.asti.cgiar.org).

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