ASTI Agricultural Science & Technology Indicators

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AGRICULTURAL R&D IN CENTRAL AMERICA

POLICY, INVESTMENTS, AND INSTITUTIONAL PROFILE

ASTI Regional Report

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ABOUT THE ASTI INITIATIVE

The Agricultural Science and Technology Indicators (ASTI) initiative compiles, processes, and disseminates data on institutional developments and investments in agricultural R&D worldwide, and analyzes and reports on these trends. Tracking these developments in ways that make for 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 the productivity growth of the agriculture sector. The ASTI initiative is managed by the International Service for National Agricultural Research (ISNAR) division of the International Food Policy Research Institute **(www.ifpri.org)** and comprises a network of national, regional, and international agricultural R&D agencies. Primary funding for the ASTI initiative's survey round in Central America was provided by the Inter-American Development Bank (IDB). The ASTI data and associated reports are made freely available for research policy formulation and priority-setting purposes, and can be found at the ASTI website: **www.asti.cgiar.org**.

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Boxes

List of Acronyms

AgGDP	agricultural gross domestic product
AGEXPRONT	Asociación Guatemalteca de Exportadores de Productos no Tradicionales [Guatemalan Nontraditional Products Exporters Association]
AGROCYT	Fondo Competitivo de Desarrollo Tecnológico Agroalimentario [Fund for Agro-Alimentary Technological Development; Guatemala]
ANACAFE	Asociación Nacional del Café de Guatemala [Guatemalan Coffee Association]
APASAN	Asociación Panameña para la Sostenibilidad de la Agricultura y los Recursos de la Naturaleza [Panamanian Association for Sustainability of Agriculture and Natural Resources]
ATP(s)	agricultural technology project(s)
CAC	Consejo Agropecuario Centroamericano [Central American Agricultural Council]
CAFTA	Central American Free Trade Agreement
CARDI	Caribbean Agricultural Research and Development Institute
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]
CENTA	Centro Nacional de Tecnología Agropecuaria y Forestal [National Center of Agricultural and Forestry Technology; El Salvador]
CGIAR	Consultative Group on International Agricultural Research
CIAL	Comité de Investigación Agrícola Local [Local Agricultural Research Committee]
CIAT	Centro Internacional de Agricultura Tropical [International Center for Tropical Agriculture]
CICAFE	Centro de Investigaciones en Café [Coffee Research Center; Costa Rica]
CICYT	Consejo Interinstitucional de Ciencia y Tecnología [Interministerial Council for Science and Technology]
CIFOR	Center for International Forestry Research
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo [International Maize and Wheat Improvement Center]
CIP	Centro Internacional de la Papa [International Potato Center]
COHCIT	Consejo Hondureño de Ciencia y Tecnología [Honduran Council for Science and Technology]
CONACTA	Consejo Nacional de Tecnología Agrícola [National Advisory Council for Science and Farming Technology; Honduras]
CONCYT (1)	Comisión Nacional de Ciencia, Tecnología e Innovación [National Commission for Science, Technology, and Innovation; Panama]
CONCYT (2)	Consejo Nacional de Ciencia y Tecnología [National Science and Technology Council; Guatemala]
CONICIT	Consejo Nacional para Investigaciones Científicas y Tecnológicas [National Council of Science and Technology; Costa Rica]
CONITTA	Comisión Nacional de Investigación Agraria y Transferencia de Tecnología [National Commission on Agricultural Research and Technology Transfer; Costa Rica]
CORBANA	Corporación Bananera Nacional S.A. [National Banana Corporation; Costa Rica]
CURLA	Centro Universitario Regional de Litoral Atlántico [University Center of the Atlantic Coast Region; Honduras]
DIA (1)	Departamento de Investigación Agrícola [Crops Research Department, Costa Rica]

DIA (2)	Dirección de Investigaciones Agropecuarias [Directorate for Agricultural Research]
DICTA	Dirección de Ciencia y Tecnología Agropecuaria [Directorate for Agricultural Research and Technology, Honduras]
EARTH	Escuela de Agricultura de la Región Tropical [Agricultural School for the Humid Tropic Regions]
ECAG	Escuela Centroamericana de Ganadería [Central American Livestock School]
ESNACIFOR	Escuela Nacional de Ciencias Forestales [National School of Forestry Science, Honduras]
FAITAN	Fondo de Apoyo a la Investigación Tecnológica Agrícola en Nicaragua [Support Fund for Agricultural Techfanology Research in Nicaragua]
FAO	Food and Agriculture Organization of the United Nations
FAT	Fondo de Asistencia Técnica [Fund for Technical Assistance; Nicaragua]
FHIA	Fundación Hondureña de Investigación Agrícola [Honduran Foundation for Agricultural Research]
FONACITI	Fondo Nacional para el Desarrollo de la Ciencia, la Tecnología y la Innovación [National Fund for the Development of Science Technology and Innovation]
FONACTA	Fundo Nacional de Ciencia y Tecnología Agroalimentaria [Fund for the Development of Agricultural Research and Technology Transfer; Honduras]
Fte(s)	full-time equivalent(s)
FUNDE	Fundación Nacional para el Desarrollo [National Development Foundation; El Salvador]
FUNICA	Fundación para el Desarrollo Tecnológico Agropecuario y Forestal de Nicaragua [Foundation for Technological Development of Agriculture and Forestry]
GDP	gross domestic product
ICAFE	Instituto de Café de Costa Rica [Costa Rican Coffee Institute]
ICRAF	World Agroforestry Center
ICTA	Instituto de Ciencia y Tecnología Agrícolas [Institute of Agricultural Science and Technology; Guatemala]
IDA	International Development Association
IDB	Inter-American Development Bank
IDIAP	Instituto de Investigación Agropecuaria de Panamá [Agricultural Research Institute of Panama]
IDR	Instituto de Desarrollo Rural [Rural Development Institute; Nicaragua]
IHCAFE	Instituto Hondureña del Café [Honduran Institute for Coffee]
IICA	Instituto Interamericano de Cooperación para la Agricultura [Inter-American Institute for Cooperation on Agriculture]
ILRI	International Livestock Research Institute
INAB	Instituto Nacional de Bosques [National Forestry Institute; Guatemala]
INBio	Instituto Nacional de Bioversidad [National Biodiversity Institute; Costa Rica]
INTA (1)	Instituto Nacional de Innovación y Transferencia en Tecnología Agropecuaria [National Institute of Agricultural Innovation and Technology Transfer; Costa Rica]
INTA (2)	Instituto Nicaragüense de Tecnología Agropecuaria [Institute of Agricultural Technology]
JICA	Japan International Cooperation Agency
MIFIC	Ministerio de Fomento, Industria y Comercio [Ministry of Economic Development; Nicaragua]
NCCARD	National Coordinating Committee for Agricultural Research and Development (Belize)

NITLAPAN	Instituto de Investigación Aplicada y Promoción del Desarrollo Local [Institute for Applied Research and the Promotion of Local Development; Nicaragua]
OECD	Organisation for Economic Co-operation and Development
PASOLAC	Programa para la Agricultura Sostenible en Laderas de América Central [Program for Sustainable Agriculture in Central America]
PATH	People Protecting Animals and their Habitat
PCCMCA	Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales [Central American Cooperative Program for Crops and Animal Improvements]
PIDA	Programa de Investigación y Desarrollo Agrícola [Agricultural Research and Development Program; Guatemala]
PPP	purchasing power parity
PROCAFE	Fundación Salvadoreña para la Investigación del Café [Salvadorian Foundation for Coffee Research]
PROCICARIBE	Caribbean Agricultural Science and Technology Networking System
PROESA	Promoviendo Inversión en El Salvador [National Investment Promotion Agency of El Salvador]
PROMECAFE	Programa Cooperativo Regional para el Desarrollo Tecnológico de la Caficultura en Centroamérica, Panamá, República Dominicana y Jamaica [Regional Cooperative Program for the Development of Coffee in Central America, the Dominican Republic, and Jamaica]
R&D	research and development
SDC	Swiss Agency for Development and Cooperation
S&T	science and technology
SAG	Secretaría de Agricultura y Ganadería [Secretariat of Agriculture and Livestock; Honduras]
SENACYT	Secretaría Nacional de Ciencia, Tecnología e Innovación [National Secretariat of Science Technology and Innovation; Panama]
SICTA	Sistema de Integración Centroamericana de Tecnología [Central American Integration System for Agricultural Technology]
Sida	Swedish International Development Cooperation Agency
SINALIT	Sistema de Alianza para la Tecnología Agrícola y Forestal [National System of Alliances for Technological Innovation; El Salvador]
SINIIAF	Sistema Nacional de Investigación - Innovación para la Agricultura y Forestal [National System of Research-Innovation for Agriculture and Forestry; Panama]
SNITTA	Sistema Nacional de Investigación y Transferencia de Tecnología [National System for Agricultural Research and Technology Transfer; Costa Rica]
UCA	Universidad Centroamericana [Central American University]
UCC	Universidad de Ciencias Comerciales [University of Commercial Sciences; Nicaragua]
UCR	Universidad de Costa Rica [University of Costa Rica]
UNA (1)	Universidad Nacional de Costa Rica [National University of Costa Rica]
UNA (2)	Universidad Nacional Agraria [National Agricultural University]
UNAH	Universidad Nacional Autónoma de Honduras [National Autonomous University of Honduras]
UNAN	Universidad Nacional Autónoma de Nicaragua [National Autonomous University of Nicaragua]
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPOLI	Universidad Politécnica de Nicaragua [Polytechnical University of Nicaragua]
USAC	Universidad de San Carlos de Guatemala [University of San Carlos in Guatemala]

USAID	United States Agency for International Development
URL	Universidad Rafael Landívar [University Rafael Landívar; Guatemala]
UT	Universidad Tecnológica [University of Technology; Costa Rica]
WSPA	World Society for the Protection of Animals

Abstract

Drawing from comprehensive datasets derived from primary surveys, this report reviews the major institutional developments and investment and human resource trends in public agricultural research and development (R&D) in the seven countries that constitute Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama.

A high degree of diversity exists with regard to Central America's agricultural R&D efforts. The size of the national-level R&D systems varies largely in terms of number of research staff, ranging from just 17 fte research staff in Belize to 283 in Costa Rica. Average degree levels of agricultural research staff also diverged widely from one country to the next. In El Salvador, only 1 out of every 5 agricultural scientists holds postgraduate degrees, while in Belize, Nicaragua, and Costa Rica, more than 50 percent of all agricultural research staff were trained to the MSc or PhD level.

Distribution of spending among countries in the Central American region is very uneven, with Costa Rica and Nicaragua accounting for the lion's share of the region's agricultural research expenditures. Total agricultural R&D spending has remained fairly stagnant since the early 1980s. Growth in spending in Costa Rica and Belize during 1981-2006 was offset by cuts in Guatemala and El Salvador. Funding for agricultural research is still predominantly through government allocations in Panama and El Salvador. Agricultural R&D in Nicaragua, on the other hand, is extremely dependent on foreign donor funding. A number of countries have sought to fund agricultural R&D by a tax on agricultural production or exports while other countries have been successful in commercializing their research results.

INTRODUCTION

Although the countries of Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama) are comparatively small and diverse, they face similar socioeconomic and agricultural challenges, they share common agroecological and climatic conditions, and collectively they represent about 40 million people of a common cultural heritage. During the 1980s, the region's economic progress was severely constrained by civil conflict and inappropriate economic policies, such that growth in the region's gross domestic product (GDP) barely reached a rate of 2 percent per year. Between 1990 and 2006, however, conflict resolution, macroeconomic stabilization, and structural reform supported annual GDP growth of 8 percent in recent years. Nonetheless, this economic progress has not been accompanied by improved social conditions. Poverty is still widespread in all countries in the region, with the exception of Costa Rica and Panama, and—like in other parts of Latin America—income distribution remains highly uneven (Rodlauer and Schipke 2005).

Since the mid-1990s, Central America has undergone a trade liberalization process by which each of the countries—either individually or as a group—have entered free trade agreements with third countries, including Mexico, Chile, and Canada. A free trade agreement with the United States was signed and ratified recently by all countries, with the exception of Costa Rica where it is still under negotiation. Similar free trade agreements have been or are close to being signed with the European Union and a number of Asian countries. The flow of goods and services within the region is also set to be enhanced once the Central America Customs Union is established. Besides, a set of regional institutions has been created to support the coordination of policy and regulations in areas such as governance and banking. Examples of such institutions include the Secretariat for Central American Economic Integration, the Central American Integration System, and the Central American Agricultural Council, among others.

Agriculture in Central America

In 2005, agriculture represented 13 percent of the region's GDP (World Bank 2008), with country-level shares ranging from 8 percent in Panama to 23 percent in Guatemala (Table 1). The economic impact of agriculture on the region's economy is much higher when linkages with farm input, food processing, and distribution industries are included. 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 agriculture contributes a much higher share of GDP than is reflected in official data (Trejos, Segura, and Arias 2004).[1] Costa Rica's expanded AgGDP in 1997, for instance, totaled 33 percent of the country's output that year compared with the official share of just 11 percent. Agriculture is also an important source of employment in the region. In 2006, agriculture employed more than one-third of the national labor force in both Guatemala and Honduras, 29 percent in Nicaragua, 18 percent in El Salvador and in Panama, and 14 percent in Costa Rica—and of course from a rural perspective, these shares are considerably higher. More than half the rural labor force of Central America was employed in agriculture in 2006, ranging from about one-third in Costa Rica to two-thirds in Nicaragua. Consistent with other developing regions of the world, Central America's strong focus on agriculture is accompanied by persistent rural poverty. All Central American countries have higher rates of poverty in rural areas than in urban areas. In Panama, the share of the population living below the poverty line was more than twice as high in rural areas than in urban areas in 2006, and in Honduras and Nicaragua more than three-quarters of the rural population are poor.

[1] Details of the methodology used to calculate agriculture's expanded contribution to the economy can be found in Trejos, Segura, and Arias (2004).

Table 1. Selected agricultural and poverty indicators (%)

Indicator	Belize	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama
Agricultural share of GDP, 2005	14.1	8.7	10.3	22.8	13.9	18.6	7.7
Share of total labor force employed in agriculture, 2006	22.5	13.8	18.4	36.2	35.1	29.0	19.5
Share of rural population employed in agriculture, selected years[a]	48.7	33.4	42.5	57.7	60.8	65.9	52.1
Share of population living below the poverty line, 2006[b]							
Nationwide	na	19.0	47.5	60.2	71.5	69.3	30.8
In rural areas	na	20.4	56.8	68.0	81.5	77.0	46.6
In urban areas	na	18.0	41.2	45.3	59.4	63.8	21.7
Agricultural share of exports, 2007	45.9	26.4	24.8	31.8	35.2	44.7	45.8

Sources: For shares of total labor force employed in the agricultural sector and population living below poverty line, ECLAC (2008); for agricultural share of GDP, Sauma (2008); for share of rural population employed in agriculture, World Bank (2008); and for agricultural share of exports, UN Comtrade (2008).
Note: na indicates that data were not available.
[a] Data for Belize and Guatemala are for 2000; for Nicaragua, 2001; for El Salvador and Panama, 2003; for Honduras, 2004; and for Costa Rica, 2005.
[b] Poverty is defined as the percentage of the population with income of less than twice the cost of the basic food basket.

Agricultural productivity in Central America is primarily founded on cereals and legumes including maize, beans, rice, and sorghum. Export crops, such as coffee, sugarcane, bananas, tobacco, and oil plants also play an important role. Roots and tubers, including potatoes, sweet potatoes, yams, and cassava, are important food crops. Notably, certain nontraditional products, such as pineapples, fresh vegetables, and flowers, have become more important in recent decades. Rather than growing these and other crops on large company landholdings, contract farming is becoming widespread because it provides farmers with a guaranteed market for their produce, provided they meet the required quality standards.

Livestock production also plays an essential role in Central America. Cattle, swine, and poultry are raised extensively throughout the region. The Central American fisheries industry includes wild catches from the Caribbean Sea and Pacific Ocean, freshwater catches from numerous rivers and lakes, and numerous farm-raised species. The most profitable species are shrimp and lobster in both wild and farmed forms.[2] The region also houses a large variety of commercially valuable tree species, including pine, rosewood, mahogany, and cedar, which are cultivated for timber exports.

Agricultural exports are also a significant contributor to the Central American economy. During 2002–04, agricultural exports accounted for close to one-third of the region's total exports. In Belize, Panama, and Nicaragua, agricultural products constituted as much as 45 percent of national exports. Agricultural export proceeds have grown in most countries in Central America since 2000, which can largely be explained by rising world market prices for traditional crops. Combined, these traditional crops (mainly coffee and bananas) account for one-third of the region's total agricultural export value. Meanwhile, many countries in the region have also diversified into nontraditional crops. Some of these crops, notably pineapples, melon, palm oil, and cardamom, were in the region's top export crop rankings for the 2004–06 period (UN Comtrade 2008).

Challenges to Agricultural Development in Central America

Agriculture in Central America faces numerous challenges. Studies by IICA indicate that scarcity in arable land per capita is a growing problem for the region, reaching previously unheard-of levels for Latin America (IICA 2007). In 1965, Central America had approximately 1.0 hectare of arable land available for each inhabitant, whereas by 2005 this figure had shrunk to less than 0.5 hectares. In comparison, the

[2] Farmed shrimp provides high economic value but has been shown to damage coastal mangroves and fish breeding sites in recent years.

2005 levels for Southern Cone countries, the Andean region, and North America were 1.8, 1.1, and 1.3 hectares per capita, respectively.

Central America needs higher yields for its main crops to feed a growing population and generate surpluses in household incomes and international trade. But yield growth for certain important crops indicates that the region is facing serious difficulties. While, on average, oil crop yields grew substantially (6.8 percent per year during 1980–2006), yields for food crops like cereals, beans, and vegetables grew very slowly (0.5, 0.6, and 2.1 percent per year, respectively, during 1980–2006). Analyzing annual growth rates of major crops in different Central American countries, Pomareda (2005) argues that productivity gains have been marginal despite improvements in the quality and marketing of products in certain sectors (such as horticulture). Prices of agricultural crops have increased, but so have costs of land, chemical inputs, and energy, making technological innovation necessary if improved productivity and quality are to be achieved (Pomareda 2005).

Agricultural research and development (R&D) is a key factor in securing agricultural advances through a vast array of channels, including the introduction of improved crops and cropping practices, labor- and input-saving technologies, and food storage and processing techniques, along with the equally important aspects of improved distribution and marketing techniques, improved governance and management practices, enhanced infrastructure development, and innovative training and information dissemination methods. These necessary advances depend on the level, distribution, and efficiency of agricultural R&D investments and capacities, which are often particularly low in developing countries, with the result that innovation-led economic and agricultural growth is impeded for the rural poor.

This report provides empirical evidence on existing agricultural R&D capacities in the seven countries of Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. Based on data from unpublished surveys conducted in 2007/08 by the International Food Policy Research Institute (IFPRI) and IICA under IFPRI's Agricultural Science and Technology Indicators (ASTI) initiative, the report provides information on institutional developments, recent trends in human and financial resources, and collaborative linkages among the various agricultural R&D agencies. The report also presents a brief discussion of a number of regional organizations and networks operating in Central America. This information is intended to support decisionmakers in public and private institutions in their efforts to stimulate agricultural development in the region through R&D.

INSTITUTIONAL SETTINGS FOR AGRICULTURAL R&D

National Programs and Institutions

Six national agricultural research institutes operate in Central America: The Central Farm Agricultural Research Station in Belize, the National Institute of Agricultural Innovation and Technology Transfer (INTA) in Costa Rica, the National Center of Agricultural and Forestry Technology (CENTA) in El Salvador, the Institute of Agricultural Science and Technology (ICTA) in Guatemala, the Nicaraguan Institute of Agricultural Technology (INTA), and the Agricultural Research Institute of Panama (IDIAP). In Honduras, public agricultural R&D is conducted by the Directorate for Agricultural Science and Technology (DICTA) within the Ministry of Agriculture. While the institutes in Costa Rica, El Salvador, and Panama are autonomous, they fall under the direct supervision of their respective ministries of agriculture, and their directors are appointed by their national governments. Managed by a board of directors, including government representatives, the institutes in Guatemala and Nicaragua have greater independence. ICTA (Guatemala) focuses on R&D and training, CENTA (El Salvador) focuses on R&D and extension, and INTA (Nicaragua) focuses on R&D, training, and extension. All six institutes are financed by direct allocations from government budgets to support infrastructure and salaries, but they depend on national science and development funding, as well as contributions from bi- and multilateral donors, to support their operating expenses.

In addition to these national bodies, a number of sector-specific institutes also conduct research on major export crops, such as coffee and bananas. These smaller institutes are financed by the government and through commodity taxes levied on production or exports. A significant amount of national-level agricultural R&D is also conducted at state universities. 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.

Several Central American countries have made efforts to integrate organizations executing agricultural research (and in some cases extension), linking them with central organizing bodies. Examples are the National System for Agricultural Research and Technology Transfer (SNITTA) in Costa Rica and the Foundation for Technological Development of Agriculture and Forestry (FUNICA) in Nicaragua. In Honduras, a national system has been developed, but it is not yet operational. Guatemala has recently developed a proposal to integrate agricultural research under the National Council of Science and Technology and the Ministry of Agriculture. Initiatives to integrate agricultural R&D activities in other countries in the region are occurring less formally, but such methods—while generally successful when applied to government sector agencies—have been shown to be less effective and efficient in integrating diverse entities from the government, nongovernmental, higher education, and private sectors.

Central American countries follow different models when it comes to the organization and financing of agricultural research. Costa Rica, for example, operates a system whereby higher education agencies focus on R&D relating to the country's principal cash crops, and the national research institute, INTA, undertakes research of relevance to smallholders. The government sector's role in agricultural research in Belize, El Salvador, and Panama is more pronounced, primarily due to lack of capacity in their higher education sectors. Honduras and Nicaragua largely depend on donor funding given the influence of the international community in their economic and agricultural development. Common to all Central American countries is the presence of agricultural R&D focusing on export crops (such as coffee, fresh fruits, horticulture, and fisheries), which is increasing the prevalence of research institutes funded issues funded by commodity levies.

A significant amount of new knowledge and technology in the region is promoted by large private companies either through direct purchase, the employment of consultants and specialists, or the adoption of innovations from the developed world. This has been the case for nontraditional products like shrimp, melons, and flowers.

The specifics of national systems are discussed in more detail below.

The Structure of Agricultural R&D in Belize

The principal goal of national development planning in Belize is to develop and expand the agricultural sector. Agricultural research on tropical crops, livestock, and pasture is conducted at the Central Farm Research Station, which also operates an agricultural training college and provides mechanical, veterinary, and quarantine services to farmers. In addition, the Taiwanese Mission in Belize supports an important agricultural research program adjacent to the station. The overseeing body for agricultural R&D is the National Coordinating Committee for Agricultural Research and Development (NCCARD), which includes a subcommittee for specific commodity groups, such as grains and pulses, fruits, and small ruminants. Some private research in Belize is conducted through the Citrus Growers Association focusing on extension and education.

At the regional level, beyond Central America, Belize maintains longstanding ties with the countries of the Caribbean. The Caribbean Agricultural Research and Development Institute (CARDI), which is headquartered in Trinidad and Tobago, has a presence in Belize, and through CARDI, Belize participates in the commodity and thematic networks of the Caribbean Agricultural Science and Technology Information Networking System (PROCICARIBE).

The Structure of Agricultural R&D in Costa Rica

Costa Rica has the region's largest and most advanced agricultural research system. INTA conducts the majority of this research, together with a number of decentralized research and outreach centers located at state universities including the University of Costa Rica (UCR), the National University (UNA), and the University of Technology (UT). A number of private research initiatives focus on bananas, coffee, and sugarcane. Complementary government support and levy funding has led to the creation of the National Coffee Institute (ICAFE) and the Banana Corporation (CORBANA), both of which conduct substantial research. In addition, a number of private-sector firms and nongovernmental institutions conduct R&D of relevance to agriculture.

In 1996, under the leadership of the National Commission on Agricultural Research and Technology Transfer (CONITTA), Costa Rica created SNITTA with the aim of coordinating and integrating the research and transfer activities of 23 national programs and agencies in the government, higher education, and private sectors. SNITTA, which is overseen by the Ministry of Agriculture and Livestock, also operates as a funding mechanism to foster the technological development of traditional and nontraditional agricultural and agro-industrial products, while at the same time assuring sustainability and food security. SNITTA not only supports agricultural research activities but also administrative development processes.

The Costa Rican government places a high priority on science and technology (S&T) and stresses the importance of sufficient investment in R&D. Hence, the public budget for R&D related to S&T has been more than doubled over the course of the past decade. The National Council of Science and Technology (CONICIT) promotes S&T in areas of high priority for the national economy; it provides grants for research, scholarships, conferences, courses, and scientific exchange programs, and it administers science programs and financial recourses from bilateral and multilateral donors.

The Structure of Agricultural R&D in El Salvador

The principal government body involved in agricultural R&D and technology transfer in El Salvador is CENTA, which is managed by a board of directors consisting of representatives from different agricultural subsectors and unions. CENTA is headquartered in San Salvador and operates five experimental stations and specialized laboratories, as well as a large gene bank. CENTA's mandate includes extension.[3]

[3] Extension is conducted through the center's 31 extension agencies and 10 outreach centers. An estimated 200 extension agents work closely with the center's research staff.

In the higher education sector, agricultural R&D is carried out by the agricultural faculties of the University of El Salvador and Dr. José Matías Delgado University. The Salvadorian Foundation for Coffee Research (PROCAFE) and the Salvadorian Sugar Company (CASSA) are important semi-private agencies involved in agricultural R&D. The National Development Foundation (FUNDE), the Foundation for Technological and Agricultural Innovation (FIAGRO), and the National Investment Promotion Agency of El Salvador (PROESA) are all involved in the promotion and financing of S&T in El Salvador.

In 2001, the Inter-American Development Bank (IDB) launched a seven-year project with the aim of retooling El Salvador's agro-enterprise sector. In order to strengthen the country's capacity to conduct research and transfer technology, a new National System of Alliances for Technological Innovation (SINALIT) was established. SINALIT manages a competitive financing mechanism to develop alliances among the principal actors involved in technology generation and transfer. Since the establishment of SINALIT, alliances have been established among agricultural producers, agro-industrial companies, universities, government agencies (such as CENTA), and nongovernmental institutions. The objective of this strategy is to develop a market for technology innovation.

The Structure of Agricultural R&D in Guatemala

ICTA is the main government agency involved in agricultural R&D in Guatemala. It operates 5 regional research centers and 13 experiment stations across the country. In 2005, IICA was invited to collaborate in the restructuring of ICTA, a process that is currently under implementation. The principal higher education agencies involved in agricultural R&D are the University of San Carlos (USAC) and University Rafael Landívar (URL). Research in Guatemala's main agricultural export products—coffee and sugarcane—falls under the responsibility of the National Coffee Association of Guatemala (ANACAFE) and the Guatemalan Center of Sugarcane Research and Training (CENGICAÑA), respectively. The country's principal agency involved in forestry research is the National Forestry Institute (INAB).

The Guatemalan government created the National Science and Technology Council (CONCYT) in the 1990s with a view to developing technology. As part of CONCYT, a competitive Fund for Agro-Alimentary Technological Development (AGROCYT) was established as a mechanism for financing technological innovation projects. In November 2005, the formulation of the National Plan of Science, Technology and Innovation (2005–14) was completed. As a part of this plan, the agricultural sector was integrated through the introduction of a sectoral commission, which has proposed the establishment of a national system of agricultural research and technology transfer. This effort has the support and collaboration of the Ministry of Agriculture, ICTA, and producers organizations, among others.

The Agricultural Research and Development Program (PIDA) is an initiative launched by Guatemala's Nontraditional Products Exporters Association (AGEXPRONT). The program was established to support local exporters and producers and to promote agricultural research projects that can be implemented immediately. The purpose of the program is to improve the quality of nontraditional agricultural products for export by providing technical assistance in the execution of experiments, field activities, and technology transfer activities.

The Structure of Agricultural R&D in Honduras

As previously mentioned, the principal agency involved in agricultural R&D is DICTA, under the Secretariat of Agriculture and Livestock (SAG) of the Ministry of Agriculture. The government supports public schools and universities, such as the National School of Forestry Science (ESNACIFOR) in Siguatepeque; the National Agricultural University (UNA) in Olancho; the National Autonomous University of Honduras (UNAH) in Tegucigalpa, which undertakes research related to the agricultural sciences; and UNAH's University Centre for the Atlantic Coast Region (CURLA), which is the country's main public institute for higher agricultural education.

R&D activities, however, have been marginalized due to the scarcity of government and donor funding (COHCIT–IDB–CTCAP 2000). DICTA, for example, undertakes project-based research activities, but it does not operate a comprehensive research program focused on development. These

weaknesses go hand in hand with structural issues in the higher education system, where staff is underqualified and financial and other incentives are lacking. To date, initiatives by the Honduran Council for Science and Technology (COHCIT) have not been successful in redressing these trends.

Given the persistence of weak public agricultural R&D, nongovernmental institutions have come to the fore as leaders of the country's R&D agenda. For example, the Panamerican Agricultural School Zamorano, which trains students from all over Latin-America, receives substantial private and international donor funding to conduct development-oriented agricultural research of relevance to Honduras. Similarly, the Honduran Foundation of Agricultural Research (FHIA), a nonprofit foundation established by an international banana company, provides laboratory, R&D, and capacity strengthening services to the private sector and developing communities.

A recent joint government and donor initiative proposes the creation of a National Agricultural Research and Technology Transfer System (SNITTA). This will include the establishment of a National Council for Science and Technology (CONACTA) comprising a large variety of stakeholders in agricultural innovation, a technical secretariat, and a planning and project unit. A Fund for the Development of Agricultural Research and Technology Transfer (FONACTA) is also envisaged as part of SNITTA. This fund will be accessible to technology service providers such as universities and colleges, as well as international organizations according to criteria established by CONACTA. National programs executed by SAG, including DICTA, will be administered by CONACTA. It is yet to be determined, however, whether SNITTA should be a government program, and funding has yet to be secured for FONACTA.

The Structure of Agricultural R&D in Nicaragua

Various agencies in Nicaragua promote agricultural R&D in the context of economic, agricultural, and rural development; S&T; and higher education. INTA, the Institute for Applied Research and the Promotion of Local Development (NITLAPAN) based at the private Central American University (UCA), and the public Rural Development Institute (IDR) foster research and extension in the more traditional sectors, while the Ministry of Economic Development (MIFIC) and some development cooperation programs are the leading promoters of agricultural R&D in the nontraditional sectors. Until recently, INTA delivered agricultural research and extension services, cofinanced with either public or private technical assistance providers (Saín 2005).

Other important agencies that generate and disseminate innovations are the higher education sector, international research and development agencies, and companies that supply agricultural inputs (seed, feed, machinery, and so on). The main higher education agencies involved in agricultural R&D is the National Agrarian University (UNA). Other universities include UCA, the National Autonomous University of Nicaragua (UNAN), the University of Commercial Sciences (UCC), and the Polytechnical University of Nicaragua (UPOLI).

Funding for agricultural research in Nicaragua is primarily derived from development cooperation agencies or aid from international development banks. For example, the World Bank has supported the national agricultural technology, knowledge, and innovations system through two consecutive International Development Association (IDA) credits (2000 and 2005), which were primarily channeled through INTA and other government agencies. Given the presence of a large number of donor funding initiatives and development cooperation projects, international donor agencies and R&D organizations have dominated agricultural R&D in Nicaragua since the 1990s (Hartwich et al. 2006). Furthermore, fragmentation in the performance of agricultural R&D has led to innovation gaps in primary production in nontraditional sectors and in processing and postharvest activities in traditional sectors (Hartwich et al. 2006).

The Structure of Agricultural R&D in Panama

The performance of agricultural R&D in Panama is largely dominated by IDIAP, a semiautonomous body managed by a board of directors chaired by the Minister for Agriculture (Santamaria 2005). IDIAP is

headquartered in Panama City and operates four regional research centers, ten subregional centers, two research farms, and eight experiment sites. IDIAP comprises six departments, two of which—the Department of Agriculture and the Department of Livestock—are mainly involved in agricultural R&D. Other departments deal with field trials and technology transfer, seed production, administration, and planning (Ekboir, Pereira de Herrera, and Becerra 2004). The University of Panama's Faculty of Agricultural Sciences and Faculty of Agricultural Technology are the principal higher education agencies involved in agricultural R&D.

Concerted efforts to establish a comprehensive S&T policy have recently been initiated under the leadership of the National Secretariat for Science, Technology, and Innovation (SENACYT). Plans involve the creation of an Interministerial Council for Science and Technology (CICYT), and a National Commission for Science, Technology, and Innovation (CONACYT). Two funds for R&D activities will be created: the National Fund for the Development of Science, Technology, and Innovation (FONACITI), and a Competitive Fund administered by Panamá Compite. A recently developed National Plan for Science and Technology outlines how national and international organizations and companies can participate and how research results will be disseminated to users. This plan also mentions the creation of a National Research and Innovation System for Agriculture and Forestry (SINIIAF), under which various organizations are expected to participate, including IDIAP, university faculties, public technical assistance services, public funding and trade promotion agencies, producer associations, nongovernmental institutions, and private companies.

Regional Initiatives

Given the commonalities among Central American countries, research conducted in one country often has relevance for one or more other countries. Certain R&D agencies, such as the National Biodiversity Institute (INBio) in Costa Rica, have developed regionwide programs in areas such as biodiversity and biotechnology. In addition, certain R&D organizations, most of which are education-based, have a regional mandate:

- The *Agronomic Center for Research and Education* (CATIE). CATIE is an autonomous nonprofit institution that focuses on agricultural and rural development and natural resource management in its member states, which include all Central American countries, Mexico, the Dominican Republic, Venezuela, Colombia, Bolivia, and Paraguay. CATIE combines research, training, education, and outreach. Through its graduate school, CATIE's research programs focus on forestry and agroforestry systems, strategic inputs for sustainable agriculture, valuation of natural resources and environmental services, and rural development.
- The *Agricultural School for the Humid Tropic Regions* (EARTH). EARTH is an international university focusing on agricultural sciences and natural resources. It aims to contribute to sustainable development in the tropics, balancing agriculture and natural resources. The school is mostly active in the tropical regions of Latin America but has also contributed to sustainable development initiatives in other tropical regions around the world. The school's research concentrates on sustainable management of agricultural, fishery, and forestry production.
- The *Central American Livestock School* (ECAG) is a regional higher education institution created in 1996 with support from the British Government and the IDB. It offers studies in the fields of food technology, agrotourism, animal production, and forestry and wildlife management. The school is involved in limited agricultural R&D, mostly through student thesis work.
- The *Panamerican Agricultural School Zamorano* is a university college that trains students in agronomy, agribusiness, food processing, and socioeconomic development. The vast majority of Zamorano's R&D relates to pest management, agricultural production, applied

biotechnology, and food processing for agribusiness. Although Zamorano is a regional agency in the strict sense of the word, it is considered to be a Honduran agency for the purpose of this study, given that 80 percent of its work is relevant to Honduras.

Some institutes of the Consultative Group on International Agricultural Research (CGIAR) are also active in Central America, although seemingly less so than in the past. The International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Tropical Agriculture (CIAT) conduct research on maize and beans and operate national and regional offices in Honduras and Nicaragua. CIAT also supports the local agricultural research committees (CIALs) and many local initiatives on participatory research for farmers. In addition, the World Agroforestry Center (ICRAF), the International Livestock Research Institute (ILRI), and the International Potato Center (CIP) all operate programs of relevance to Costa Rica, Nicaragua, Honduras, and Guatemala.

An attempt has been made to link and integrate the different national research institutes in Central America. IICA has promoted such linkages by providing legal, technical, financial, and administrative support to the Central American Integration System for Agricultural Technology (SICTA). SICTA aims to contribute to regional R&D integration through the promotion of institutional and technological change in agriculture, livestock, and forestry. The system brings together the public agricultural research institutes of the seven countries and has been endorsed by the Agricultural Ministers of Central America under the Central American Agricultural Council (CAC). Recent achievements of SICTA include the establishment of researcher networks by crop and by subject; the creation of an information system that integrates R&D results from all countries; the integration of agrobiotechnology and biosafety strategies; and the formulation of a common agricultural technology policy. SICTA also hosts programs such as RED SICTA, a funding scheme supported by the Swiss Development Cooperation (SDC) to assist farmers in maize and bean-based farming systems with the promotion, development, and adoption of technologies at different stages along the value chain. In the future, SICTA will host a number of thematic research programs related to priority products, providing access to funding and enabling the exchange of information through virtual networking, collaboration, and joint learning. Overall, SICTA has proved to be helpful in coordinating R&D activities among public research organizations and, in certain cases, universities. Nevertheless, it has yet to demonstrate how it will support initiatives that comprise a wider range of agents contributing to agricultural innovation, such as nongovernmental institutions, private companies, farmer organizations, and agricultural service providers.

A few larger regional research programs operate in Central American countries. For example, the Regional Cooperative Program for the Development of Coffee (PROMECAFE) operates in Central America, the Dominican Republic, and Jamaica, with the support of IICA. PROMECAFE's objective is the modernization, improvement, and sustainable development of coffee production in its member countries through technical and scientific cooperation in the production, processing, postharvest management, trade, and environmental protection of the coffee industry. PROMECAFE recently formulated and implemented projects in Central American countries linking coffee quality to its origin, in efforts improve product quality and market positioning. Other regional networks foster the exchange of information and technology in the region. An example is the Central American Cooperative Program for Crops and Animal Improvements (PCCMCA), which disseminates the latest information and relevant research results among scientists and professionals through annual meetings hosted by public agricultural research institutes. This program began as a cooperative initiative to improve the quality and production of maize in Central America. As it developed linkages with other research centers and professionals, PCCMCA was gradually expanded to include other crops, forestry, genetic resources, livestock, resource management and socioeconomics.

Private-Sector Agricultural R&D

Agricultural research conducted by the private sector has expanded in recent years, especially in the developed world. Nevertheless, the role of the private sector in developing countries is still small and is likely to remain so given the weak funding incentives for private research. In addition, many of the

private-sector research activities in the developing world focus solely on the provision of input technologies or technological services for agricultural production, but most of those technologies are produced in the developed world (Beintema and Stads 2006; Pardey et al. 2006). Central America is no exception. But it is important to make a distinction between private for-profit and private nonprofit R&D agencies. Although the region houses several private nonprofit agencies (such as FHIA in Honduras, classified as a nongovernmental agency in this study),[4] no national, private for-profit R&D agencies are active in the region. However, certain multinational companies involved in plantation production, fruit processing, and other export fields operate small R&D labs in Central America, through which they develop applied technologies. Examples of such companies include Standard Fruit Company in Honduras and Palmatica in Costa Rica. The majority of other for-profit companies import technologies from abroad or hire specialized consultants to gain access to advanced knowledge. This is particularly the case in the nontraditional cash crop sectors such as fruits, horticulture, ornamental plants, and aquaculture.

Many private-sector companies in Central America require applied research on optimizing production, reducing costs, and controlling pests and diseases only after the new species have been introduced for some time. Then, they often contract specialized university institutes to solve emerging problems. Some argue that most innovations that have changed agriculture in Central America over the past decades have been generated in this way with very few contributions from the public national agricultural research institutes.

Little information could be accessed on the capacity and expenditure trends in the private agricultural R&D sector in Central America. Private for-profit agencies are therefore excluded from further analysis in this report.

Challenges to Agricultural Innovation in Central America

An innovation system can be defined as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance. An innovation system comprises not only the suppliers of the information or technology but also the dynamic interactions of all the actors involved in the process of innovation. The system extends beyond the creation of knowledge to encompass the factors affecting the demand for and use of knowledge (World Bank 2006). Limitations to agricultural innovation are diverse and complex, including lack of investment in R&D, lack of access to knowledge and technology, and lack of available resources to apply innovations. Depending on the farming systems within which farmers operate, innumerable factors—such as limited access to finance, land, labor, farm inputs, infrastructure, technology, information, training, and marketing channels—can constitute profound obstacles to innovation (Pomareda 2005).

With regard to agriculture in Central America, IICA argues that innovation is seriously constrained by the region's institutional agricultural R&D structure, among other factors. The existence of a dominant linear (often top-down) model of technological supply is considered a crucial element in widening the gap between what farmers/producers want and what R&D agencies can deliver. Institutional changes are therefore essential if the region is to respond to challenges not addressed in the current R&D framework. These include plant genetic resources management, intellectual property rights, information management for technological innovation, increase of decisionmaking skills, alliance-based R&D, and competitive funding mechanisms (IICA 2007). IICA argues that in order to foster agriculture from a technological perspective, it is not only necessary to overcome limitations in human capacity, infrastructure, and spending levels in R&D, but also to incorporate new goals into the R&D agenda in order to contribute to the millennium development goals, to improve the relationship between agriculture and the environment, and to increase the competitiveness of farmers and agribusinesses. Also, it is

[4] Producer organizations are classified as nonprofit organizations following the institutional classification in the Frascati Manual (see OECD 2002). In this report we use the term nongovernmental institutions as an equivalent for nonprofit organizations.

necessary to create awareness with political decision makers that R&D and technological innovation are key factors that contribute to economic and social development.

HUMAN RESOURCES IN PUBLIC AGRICULTURAL RESEARCH

This next to chapters review the major capacity, investment, and institutional trends in public agricultural research in Central America since 1981, using data recently collected under the ASTI initiative (IFPRI–IICA 2007/08). Quantitative data are important in measuring, monitoring, and benchmarking the inputs, outputs, and performance of agricultural 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 policy formulating and making decisions about strategic planning, priority setting, monitoring, and evaluation. They also provide information to government and other involved in the public debate on the state of agricultural S&T at the national, regional, and international levels.

Overall Trends

In 2006, the seven Central American countries employed a total of 903 full-time equivalent (fte) researchers at 63 agencies. Close to half of these researchers worked in the government sector, while 36 percent were employed in the higher education sector and 16 percent in nongovernmental institutions, which includes producer organizations (Table 2). However, the institutional composition of total researchers varied considerably across countries. In Costa Rica, Honduras, and Nicaragua, for example, the higher education sector employed more agricultural researchers than the government sector. In Belize, on the other hand, the higher education sector's share of total agricultural R&D staff was only 8 percent. Nongovernmental institutions played an important role in Belize and Honduras, accounting for 38 and 30 percent of agricultural R&D staff, respectively, but their share of researchers was negligible in Nicaragua. The relative institutional shares shifted noticeably between 1996 and 2006. The role of the government in Central American agricultural R&D has decreased over the years, while the higher education sector has gained prominence.

Table 2. Institutional orientation of agricultural research, 1996 and 2006 (%)

	Share of fte researchers					
	1996			2006		
Country	Government agencies	Nongovern-mental institutions[a]	Higher education agencies	Government agencies	Nongovern-mental institutions[a]	Higher education agencies
Belize (7)	59.0	41.0	0.0	53.9	38.3	7.8
Costa Rica (16)	40.5	19.2	38.3	39.5	19.8	40.6
El Salvador (6)	76.4	16.9	6.7	78.0	8.2	13.8
Guatemala (7)	81.8	8.8	10.0	67.8	16.6	15.6
Honduras (12)	17.4	39.7	42.8	14.6	30.2	55.2
Nicaragua (8)	na	na	na	32.7	0.3	67.0
Panama (7)	78.4	9.2	12.4	74.1	11.8	14.1
Total (63)				48.2	15.9	35.9
Total excluding Nicaragua (55)	56.8	18.9	24.3	50.9	18.6	30.5

Sources: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08) and Beintema et al. (2000).
Notes: The number of agencies in each country is indicated in parentheses; na indicates that data were not available.
[a]Nongovernmental institutions fall under the official category of nonprofit institutions (see Appendix A) and include producer organizations.

Public agricultural R&D in Central America remains heavily fragmented, with 40 of the 63 sample agencies employing fewer than 10 fte researchers. The average number of fte scientists within the nongovernmental institutions and higher education agencies was much lower than at the government agencies. This can be partly explained by the fact that staff employed in the nongovernmental and higher

education sectors spend a large share of their time on activities other than R&D. In addition, many higher education agencies operate a number of different units that undertake agricultural R&D, and each represents a separate entity in the context of this study. In 2006, Central America's 14 government agricultural R&D agencies employed 31 fte researchers, on average, compared with just 12 at the region's 27 higher education agencies and 7 at the 22 nongovernmental institutions. IDIAP in Panama is the region's largest agricultural R&D agency in terms of fte scientists. In 2006, the institute employed 106 fte researchers, followed by the University of Costa Rica's Agricultural Research Institute (72 fte's), ICTA in Guatemala (63 fte's), UNA in Nicaragua (61 fte's), and CENTA in El Salvador (60 fte's).

Costa Rica had the largest agricultural R&D system in Central America when expressed in fte scientists. In 2006, 283 of Central America's 903 fte researchers worked in Costa Rica (31 percent) (Table 3). With 167 fte's in 2006, Panama operated the region's second-largest agricultural R&D system. The systems of Nicaragua, Honduras, and Guatemala employed between 100 and 135 fte scientists each. Agricultural research staff numbers in El Salvador and Belize were much smaller, accounting for only 9 and 2 percent of the regional share in 2006, respectively.

During 1981–86, the total number of researchers employed in agricultural research in Central America increased at an average rate of 6.6 percent per year, mainly as a result of growth at DIA (INTA's predecessor) in Costa Rica and IDIAP in Panama. Swift declines occurred at DIA in 1987, however, causing the regional total to plunge. Overall, capacity growth stalled in the late-1980s and throughout the 1990s, reflecting the changing priorities of Central American governments in light of structural reform and the push toward smaller government. In Guatemala, capacity plummeted in 1998, following severe cuts in the number of scientists employed at ICTA. Since 1998, agricultural staff numbers have remained stable in Central America at around 900 fte researchers.

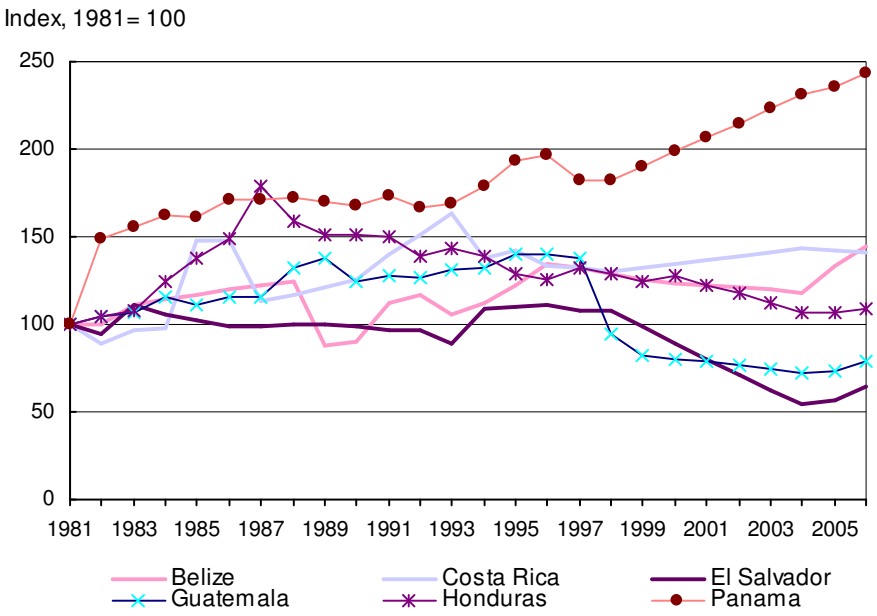
Table 3. Trends in public agricultural research staffing, 1981–2006

	Total number of fte researchers				Annual growth rate (%)[a]			
Country	**1981**	**1991**	**2001**	**2006**	**1981–91**	**1991–2001**	**2001–06**	**1981–2006**
Belize (7)	11.6	13.0	14.2	16.7	–0.28	1.45	3.22	0.91
Costa Rica (16)	200.1	279.7	273.6	282.9	3.52	–1.25	0.73	1.26
El Salvador (6)	119.9	116.5	95.4	76.9	–0.42	–0.99	–5.22	–1.91
Guatemala (7)	129.9	166.4	101.8	102.4	2.76	–5.61	–0.26	–1.86
Honduras (12)	113.7	170.4	139.1	123.7	4.87	–1.71	–2.58	–0.54
Nicaragua (8)	na	na	na	133.4	na	na	na	na
Panama (7)	68.4	164.1	141.4	166.7	7.94	0.28	1.55	1.69
Total (63)				902.6				
Total excluding Nicaragua (55)	643.7	864.4	765.7	769.2	3.59	–1.76	–0.06	0.04

Sources: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08) and Beintema et al. (2000).
Notes: The number of agencies in each country is indicated in parantheses. Fte indicates full-time equivalent; na indicates that data were not available.
[a]Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period.

Annual growth in research staff numbers varied considerably across countries. For the period 1981–2006, overall staff growth was highest in Panama, with fte researcher numbers averaging 1.7 percent growth per year (Figure 1). Growth was also strong in Costa Rica and Nicaragua, where rates for the 1981–2006 period averaged 1.3 and 1.0 percent per year, respectively. In contrast, El Salvador and Guatemala experienced significant contractions in their research capacity during this period (negative growth rates averaged 1.9 percent in both countries). Given this divergent growth in national capacities, it is not surprising that the composition of agricultural R&D at the regional level underwent significant shifts, and the role of Panama has become increasingly important alongside that of Costa Rica, which also expanded its research capacity over this timeframe, but from a much stronger initial base.

Figure 1. Trends in public agricultural research staff numbers, 1981–2006

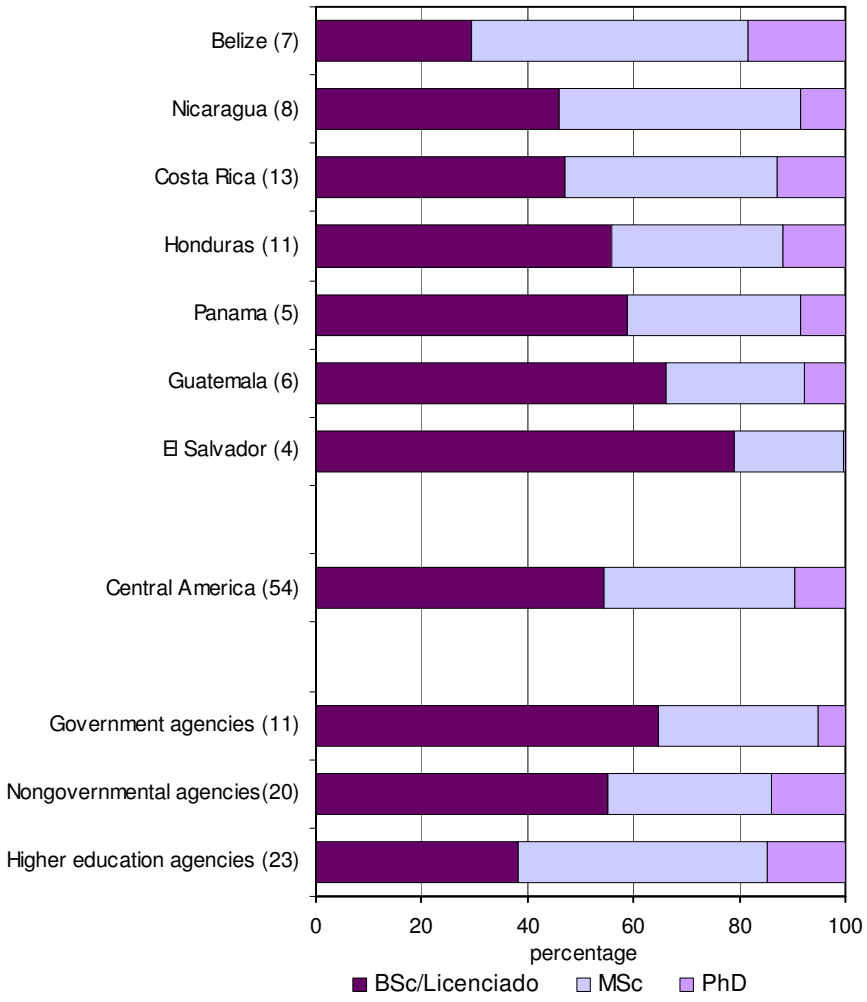


Sources: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08) and Beintema et al. (2000).

Degree Status

In 2006, 45 percent of the 816 fte researchers in a sample of 54 agricultural R&D agencies in Central America held postgraduate degrees, and just 10 percent of the total held doctorate degrees (Figure 2). Although these shares are similar to corresponding shares recorded in Colombia (43 and 11 percent, respectively), they are lower than shares in other Latin American countries such as Mexico (78 and 38 percent, respectively), Chile (62 and 26 percent, respectively), and Uruguay (55 and 24 percent, respectively) (Stads and Romano 2008; Stads et al. 2008; Stads and Covarrubias Zuñiga 2008; Stads, Cotro, and Allegri 2008). Similarly, postgraduate shares in Sub-Saharan Africa in 2000 (75 percent) and in the Asia–Pacific region in 2002 (72 percent) were well above those recorded in Central America in 2006 (Beintema and Stads 2006, 2008).

Figure 2. Educational attainment of research staff by institutional category, 2006 (%)



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: The number of agencies in each country and category is indicated in parentheses. The 54 agencies included in the sample accounted for 91 percent of total agricultural R&D staff in Central America in 2006.

Agricultural research staff employed in the higher education sector in Central America are significantly more qualified than their colleagues in the government and nongovernmental sectors. This is a consistent finding over time and across developing countries worldwide (Pardey et al. 2006). In 2006, more than 60 percent of fte scientists at Central American universities held postgraduate degrees, compared with just 35 percent at the government agencies and 45 percent at the nongovernmental institutions. Of all the researchers at the higher education agencies, 15 percent were trained to the PhD level, compared with just 5 percent of their colleagues in the government sector.

From a country-level perspective, agricultural researchers in Belize were by far the most highly qualified in the region, with more than 70 percent holding MSc or PhD degrees in 2006. This puts Belize on par with countries in other parts of Latin America. In Nicaragua and Costa Rica, over half the agricultural researchers had received postgraduate training compared with 44 percent in Honduras, 41 percent in Panama, and 34 percent in Guatemala. El Salvador's agricultural research staff is among the

least qualified worldwide. In 2006, only one of every five researchers held a postgraduate degree, and the country's share of PhD-qualified agricultural researchers was negligible (0.6 percent).

For the total sample of 54 national agencies for which information on degree qualifications was available, only 79 fte researchers held PhD degrees. As an indicator of regional agricultural R&D capacity, this extremely low number is a cause for concern. Nevertheless, postgraduate qualification levels improved somewhat between 1996 and 2006, particularly at INTA in Costa Rica and ICTA in Guatemala, but also at FHIA and DICTA in Honduras. In contrast, the share postgraduate-qualified staff at CENTA in El Salvador was cut by half over this period.

Research Focus

The allocation of resources among various lines of research is a significant policy decision, so detailed information was collected on the number of fte researchers focusing on specific commodity areas. In 2006, close to two-thirds of the 712 fte Central American researchers in a 50-agecny sample conducted crop research, while livestock research accounted for 17 percent (Table 4). Natural resources research accounted for 6 percent, while the remaining scientists focused on postharvest, forestry, fisheries, or other research. Large differences in research focus were observed across countries. Although crop research predominates, the shares of crop research fluctuated widely. Researchers in El Salvador spent more than 90 percent of their time on crops (partly due to the lack of a national institute focusing on livestock research), whereas just 43 percent of researchers in Panama focused on crop research. Livestock research in Panama, which accounted for 42 percent of the country's agricultural research, was significantly more important than in any of the six other countries. In fact, Panama employed more than half of the region's livestock researchers in 2006, and IDIAP alone employed 53 fte scientists involved in beef and dairy research in 2006. Similarly, fisheries research is prominent in Belize but negligible (less than 1 percent) in the region's six other countries. Postharvest, forestry, and natural resources research play more important roles in Guatemala than in the other countries of Central America.

Table 4. Researcher focus by major commodity area, 2006 (%)

Country/institutional category	Crops	Livestock	Forestry	Fisheries	Postharvest	Natural resources	Other
Belize (7)	62.9	9.0	0.8	26.9	0.4	0.0	0.0
Costa Rica (14)	71.4	10.9	1.7	0.3	0.3	3.0	12.2
El Salvador (5)	91.7	5.8	0.0	0.2	0.1	1.4	0.7
Guatemala (6)	50.6	3.7	5.5	0.0	13.6	16.9	9.6
Honduras (5)	71.6	4.6	3.6	0.8	2.4	6.7	10.3
Nicaragua (8)	61.3	19.3	0.7	0.2	4.5	7.3	6.7
Panama (5)	42.5	42.0	3.0	0.2	1.5	3.8	7.1
Total (50)	62.8	16.9	2.2	0.9	3.2	5.8	8.1
Government agencies (11)	67.2	18.8	1.4	1.2	3.3	4.7	3.4
Nongovernmental institutions[a] (20)	70.1	0.8	2.5	0.2	1.9	4.4	20.0
Higher education agencies (19)	44.4	26.6	4.4	0.7	4.1	10.2	9.7

Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: The number of agencies in each country and category is shown in parentheses. The 50 agencies included in the sample accounted for 79 percent of total agricultural R&D staff in Central America in 2006.
[a]Nongovernmental institutions fall under the official category of nonprofit institutions (see Appendix A) and include producer organizations.

The main crops under study in Central America are fruits, coffee, rice, and vegetables, accounting for 21, 13, 10, and 10 percent of all fte crop researchers in 2006, respectively (Table 5). Other important crops include maize, sugarcane, beans, and cassava, each (6 percent each). Fruits are the focus of research in all seven countries (although with a relatively low level of intensity in Nicaragua). Coffee research is relatively important in all countries with the exception of Belize. Coffee was the principal crop under research in Panama and Nicaragua, where it accounted for 32 and 23 percent of all crop research,

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 for their male colleagues (Sheridan 1998; IAC 2006). In 2006, in a 51-agency sample of Central American agricultural R&D agencies, one in five agricultural researchers was female, but this average masks significant variation across countries (Figure A). In Belize, close to one-third of all agricultural researchers were women, which is consistent with averages in English-speaking Caribbean countries. In both Nicaragua and Costa Rica, the share of female agricultural researchers in 2006 was 27 percent, well above the regional average. Shares in Panama, El Salvador, and Guatemala averaged around 15 percent, whereas in Honduras the 2006 share was just 7 percent. DICTA, IHCAFE, and PASOLAC employed no female scientists in 2006, and just two of the 32 fte scientists at FHIA and three of the 23 fte scientists in the higher education sector were women. On average, Central America's higher education agencies employed a much larger share of female scientists compared with the government agencies and nongovernmental institutions (33 percent compared with 16 and 15 percent, respectively).

The average share of female scientists and the underlying cross-country variation is common in other regions around the world as well. On average, 20 percent of agricultural scientists in the developing world are female (Beintema 2006). In South American countries like Uruguay, Chile, and Colombia, as well as in Mexico, shares of female researchers in 2006 averaged 46, 32, 30, and 22 percent, respectively (Stads, Cotro, and Allegri 2008; Stads and Covarrubias-Zuñiga 2008; Stads and Romano 2008; Stads, Moctezuma López, Espinosa García, Cuevas Reyes, and Jolalpa Barrera 2008). Unfortunately, no information is available on the level of female participation agricultural R&D in developed countries.

Despite the relatively low number of female scientists in agricultural R&D in Central America, female researchers do not appear to be less well qualified than their male counterparts (Figure B). The average share of women holding postgraduate degrees is higher than the corresponding male share (52 percent compared with 45 percent in 2006). However, fewer women held PhD degrees compared with their male counterparts (8 percent compared with 11 percent in 2006). In Belize, 80 percent of female agricultural researchers held postgraduate degrees in 2006 compared with two-thirds of their male colleagues. In Nicaragua, Honduras, and Costa Rica, on the other hand, male agricultural researchers were more likely to hold PhD degrees than were their female colleagues.

Figure A. Share of female research staff, 2006

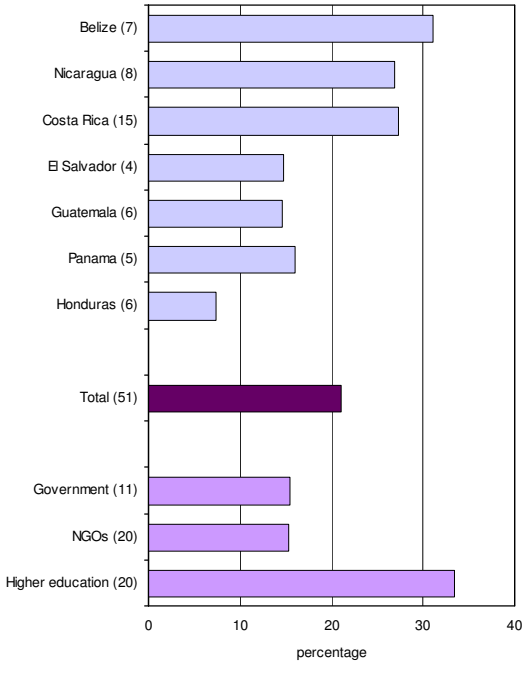
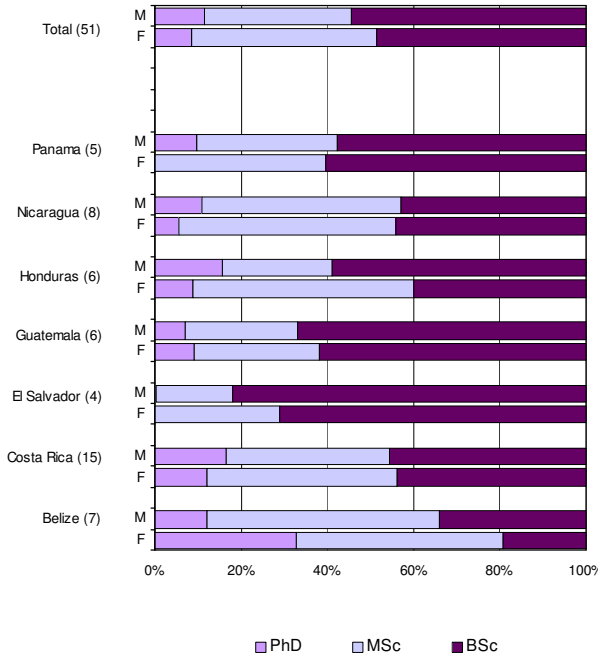


Figure B. Researcher degree levels by gender, 2006



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: M indicates male researchers and F, female researchers. The number of agencies in each country and category is indicated in parentheses.
[a]Nongovernmental institutions include producer organizations.

respectively. Rice research was important across all countries, whereas sugarcane research was relatively more important in the region's northernmost countries (Guatemala and Belize).

Table 5. Crop researcher focus by major crop item, 2006

Country	Major crop items
Belize	Fruits (35%), sugarcane (23%), rice (7%)
Costa Rica	Fruits (21%), cassava (17%), rice (13%), vegetables (12%), coffee (7%), bananas (5%), sugarcane (5%), potatoes (5%)
El Salvador	Fruits (41%), coffee (7%), maize (7%), sorghum (7%), vegetables (5%), rice (5%)
Guatemala	Sugarcane (33%), fruits (15%), vegetables (14%), maize (10%), beans (5%)
Honduras	Vegetables (16%), fruits (15%), cacao (13%), bananas (13%), beans (10%), coffee (8%), rice (7%), maize (7%), potatoes (7%)
Nicaragua	Coffee (23%), sorghum (12%), maize (9%), rice (9%), beans (8%), vegetables (5%), potatoes (5%)
Panama	Coffee (32%), fruits (22%), rice (15%), vegetables (7%), maize (6%)
Total	Fruits (21%), coffee (13%), rice (10%), vegetables (10%), maize (6%), sugarcane (6%), beans (6%), cassava (6%)

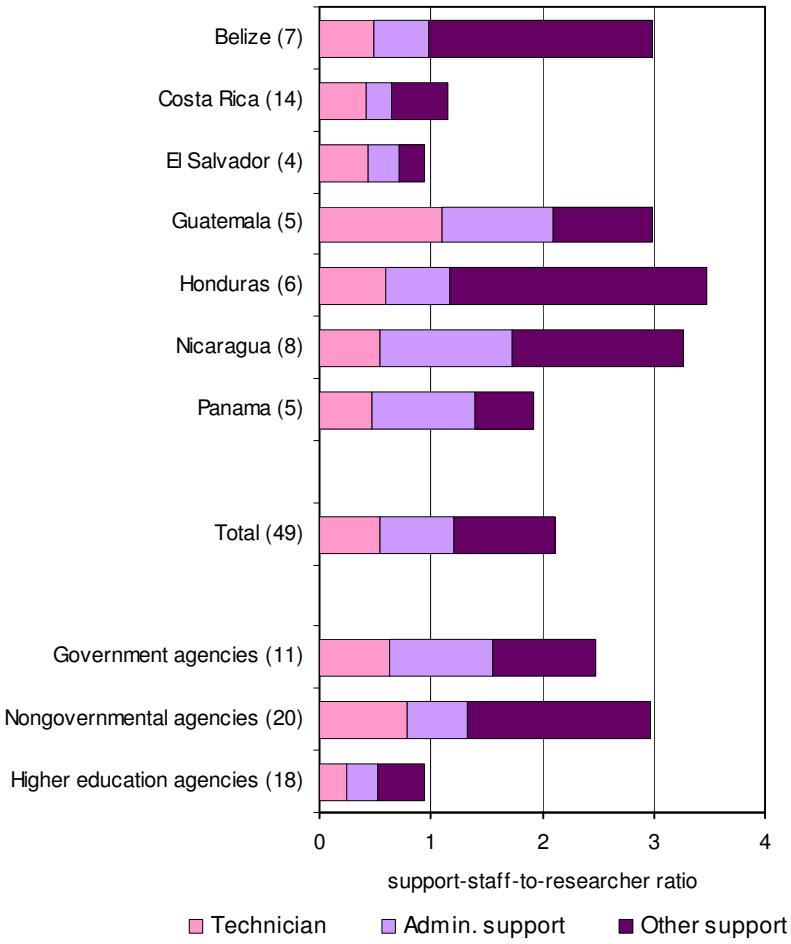
Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Note: Major crop items are defined as crops that are the focus of at least 5 percent of the total crop research staff in a particular country.

More than half of Central American livestock researchers focused on beef, close to a quarter focused on dairy, and 11 percent focused on pastures and forages. The remainder were involved in swine, sheep and goats, poultry (2 percent each), and other livestock themes (5 percent). As previously mentioned, Panama dominates the region's livestock research. More than three-quarters of Central America's beef research and 45 percent of the region's dairy research is carried out in Panama. Livestock research plays only a minor role in Belize, Honduras, Guatemala, and El Salvador. None of these countries employed more than 5 fte livestock researchers.

Support Staff

In 2006, the average number of support staff per scientist in a sample of 49 agencies across Central America was 2.1, comprising 0.5 fte technicians, 0.7 fte administrative personnel, and 0.9 other support staff such as laborers, guards, and drivers (Figure 3). The region's higher education agencies employed only 0.9 fte support staff per researcher, but this relatively lower ratio compared with other institutional categories is consistent with findings in other parts of the world. Also consistent is the higher support-staff-to-researcher ratio found in the nongovernmental sector (3.0), explained in part by the high number of support staff employed at FHIA in Honduras. Support-staff-to-researcher ratio ranged from 3.5 in Honduras and 3.3 in Nicaragua to as low as 1.2 in Costa Rica and 0.9 in El Salvador.

Figure 3—Support-staff-to-researcher ratios by support staff category, 2006



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: The number of agencies in each country and category is shown in parentheses. The 49 agencies included in the sample accounted for 84 percent of total agricultural R&D staff in Central America in 2006. Nongovernmental institutions[a] fall under the official category of nonprofit institutions (see Appendix A) and include producer organizations.

PUBLIC AGRICULTURAL R&D SPENDING

General Trends

In 2006, combined spending on public agricultural R&D for the seven Central American countries totaled $92.0 million (in 2005 international dollars) (Table 6). Costa Rica ($30 million) accounted for roughly one-third of this total, Nicaragua ($24 million) for roughly one-quarter, whereas Honduras and Panama each accounted for just over 10 percent each ($11 and $10 million, respectively). Expenditures were much lower in Guatemala, El Salvador, and Belize ($8, $6, and $3 million, respectively). Financial data in the remainder of this report are provided in real values using GDP deflators and purchasing power parity (PPP) indexes taken from the World Bank (2008). 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 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 (see Appendix A for further explanation).

Table 6. Public agricultural research spending, 1981–2006

	Total spending (million 2005 international dollars)				Annual growth rate (%)[a]			
Country	1981	1991	2001	2006	1981–91	1991–2001	2001–06	1981–2006
Belize (7)	1.0	2.3	2.3	2.6	2.5	1.3	2.4	2.4
Costa Rica (16)	13.4	20.9	26.7	29.9	-0.5	1.1	2.3	2.8
El Salvador (6)	13.5	10.5	6.0	5.7	-2.3	-5.5	-5.6	-3.3
Guatemala (7)	21.4	11.4	9.4	8.3	-1.4	-4.4	-4.8	-3.0
Honduras (12)	8.0	17.4	14.8	11.0	10.4	0.7	-2.3	-6.1
Nicaragua (8)	na	na	na	24.1	na	na	na	na
Panama (7)	10.1	12.7	10.5	10.0	1.4	-0.7	-1.2	-1.0
Total (63)				91.6				
Total excluding Nicaragua (55)	67.5	75.1	69.6	67.5	1.3	-0.9	-0.6	-0.4

Sources: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08) and Beintema et al. (2000).
Note: The number of agencies in each country is indicated in parentheses. na indicates that data were not available.
[a]Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period.

During 1981–2006, total public agricultural research spending in six Central American countries combined (excluding Nicaragua) remained fairly stagnant. This average, however, masks a substantial degree of institutional and cross-country variation. Agricultural R&D spending by government agencies appears to have steadily declined, whereas the higher education sector reported gradual increases in investment levels. This trend is of concern, because government agencies typically conduct research in areas relevant to smallholder farmers. Research at higher education agencies (especially those in Costa Rica), on the other hand, tends to focus more on problems that medium- and large-scale farmers face. Spending in the nongovernmental sector was more erratic, and spending increases by these organizations in Costa Rica were offset by declines in Honduras.

Total public agricultural research spending in Guatemala and El Salvador was severely cut during 1981–2006 (Figure 4). ICTA received substantial amounts of funding through an IDB loan, which financed a project in the 1980s, but the institute's total spending dropped abruptly thereafter. In addition, ICTA's funding from the Guatemalan government continued to decline in real terms throughout most of the 1990s and early 2000s. The rapid decline in total Salvadorian agricultural R&D spending was largely the result of reduced spending by PROCAFE, which saw its previously healthy budget shrink progressively during 1981–2006.

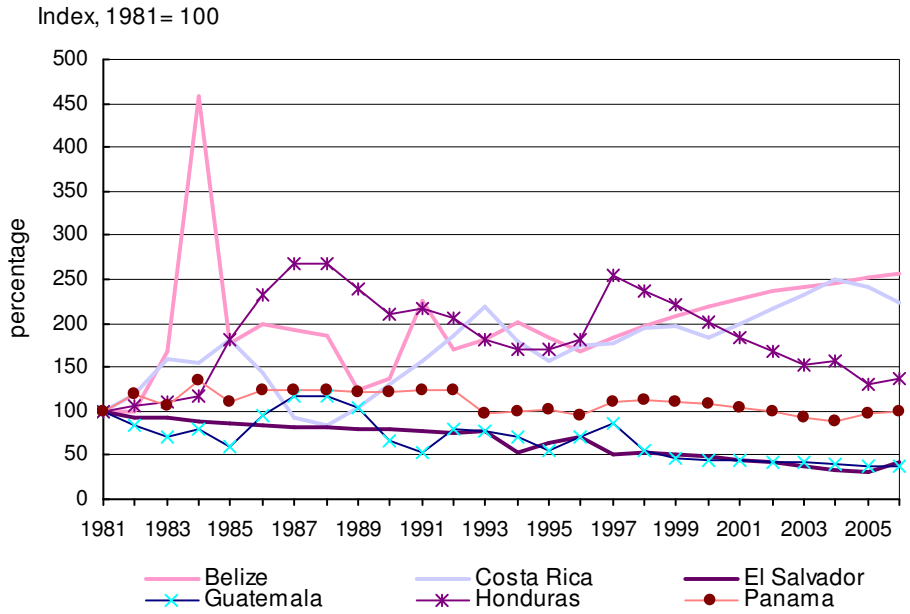
In contrast, Costa Rica experienced a period of overall growth in agricultural R&D spending during 1981–2006, at an average rate of almost 3 percent per year. This growth can largely be attributed

to increased spending in the country's nongovernmental sector. In 1981, this sector spent just $1 million on agricultural R&D, compared with $12 million in 2006. CORBANA's spending grew substantially throughout the 1980s, while INBio was responsible for most of the growth recorded between 1981 and 2006. INTA also reported important growth in its expenditures since its establishment in 2001.

Spending trends in Panama and Honduras proved to be more erratic. In Panama, annual spending levels ranged from $9 to $14 million, largely due to fluctuations in spending at IDIAP. IDIAP is largely financed by the Panamanian government but received substantial funding from the United States Agency for International Development (USAID) in the 1980s. Total agricultural R&D spending in Honduras has also been highly erratic. Spending rose by an average of 10.4 percent per year during 1981–91, mainly due to the establishment of FHIA in 1985. FHIA is by far the largest agency in Honduras in terms of agricultural R&D spending, and fluctuations in its expenditures have a noticeable effect on the country's overall R&D spending. During 1991–2006, FHIA spending fluctuated between $7 million and $13 million. FHIA's funding situation is unique in that it is derived from interest on an endowment fund. In its earlier years FHIA received more than 90 percent of its funding from USAID, a number of other donors, and the Honduran government. In Belize, after a decade of severe fluctuations in the 1980s, total agricultural research spending increased steadily for most of the 1990s and early 2000s.

Unfortunately, time-series data were unavailable for Nicaragua. INTA, the country's main government agency, accounted for close to one-fifth of the region's agricultural R&D spending in 2006. Nonetheless, INTA is highly donor-dependent, and its total spending levels vary significantly from year to year (for example, the institute spent $8 million in 2005 compared with $17 million in 2006).

Figure 4. Trends in public agricultural R&D spending, 1981–2006



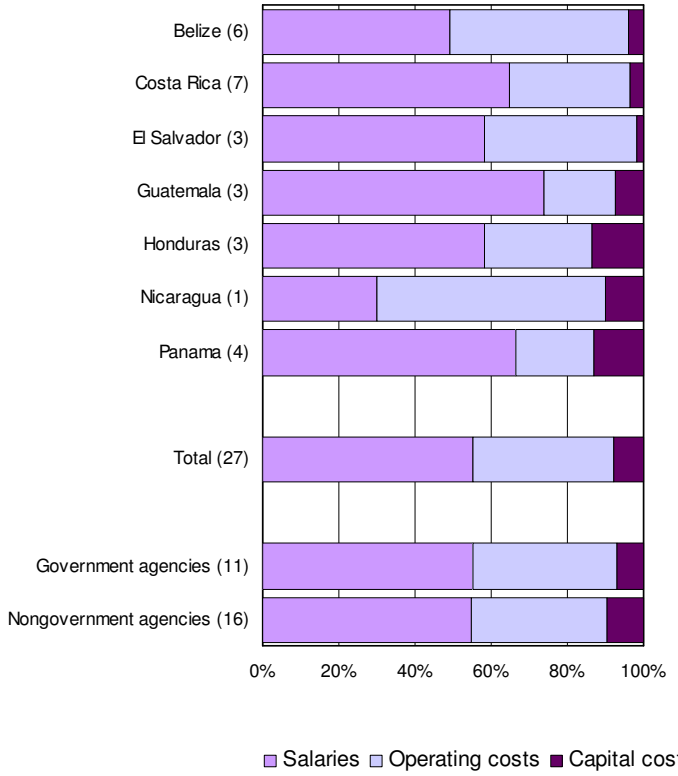
Sources: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08) and Beintema et al. (2000).
Note: Time-series data for Nicaragua were not available; hence, it is excluded from this figure.

Cost Structures

The allocation of research budgets across salaries, operating costs, and capital costs affects the efficiency of agricultural R&D; hence, detailed data on cost categories were collected as part of this study. In 2006, the 27 government agencies and nongovernmental institutions for which cost category data were available spent a combined 55 percent of their budgets on salaries, 37 percent on operating costs, and 8 percent on capital investments, and these average shares differed little between the government and

nongovernmental sectors (Figure 5). At the country level, however, relatively large differences were observed. In 2006, just 30 percent of expenditures by INTA in Nicaragua—the region's largest agency in terms of expenditures—were spent on salaries. Agencies in the six other Central American countries in the region all reported spending much higher shares of their budgets on salaries, ranging from 49 percent in Belize to 74 percent in Guatemala. The shares allocated to operating and capital costs follow a similar trend to the regional average. The three sample agencies in Guatemala and the four sample agencies in Panama combined spent 20 and 19 percent of their budgets on operating costs, respectively. In Belize and Nicaragua, on the other hand, these shares were as high as 47 and 60 percent, respectively. Agencies in Nicaragua (notably INTA) spent relatively more on capital costs than agencies in other Central American countries. In 2006 capital expenditures in Belize, Costa Rica, and El Salvador accounted for just 4 percent or less of total expenditures.

Figure 5. Government agency and nongovernmental institution expenditures by cost category, 2006



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: Nongovernmental institutions fall under the official category of nonprofit institutions (see Appendix A) and include producer organizations. The number of agencies in each category is shown in parentheses. Combined, the 27 agencies included in the sample accounted for 72 percent of total agricultural R&D spending in Central America in 2006.

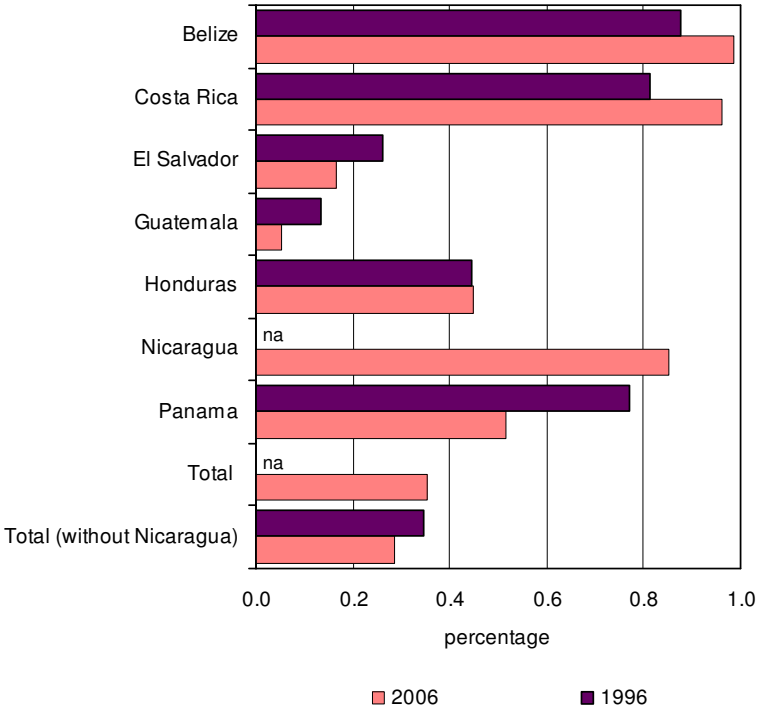
Country-level time-series data on cost categories were only available for the principal government agencies in Belize, El Salvador, Guatemala, and Panama, as well as for CORBANA in Costa Rica. Although these sample agencies provide only a partial picture of the cost structure of agricultural R&D in Central America during 1996–2006, they are indicative of important shifts. CARDI, CORBANA, and ICTA spent relatively less on salaries and more on operating costs in 2006 compared with 1996, whereas the opposite was true for IDIAP and Central Farm Agricultural Research Station. Notably,

CENTA experienced a steep decline in its share of capital spending, from 31 percent in 1996 to only 2 percent in 2006.

Intensity Ratios

Comparing a country's agricultural R&D budget with the size of its agricultural sector offers a means of evaluating the country's agricultural R&D commitment and of placing its expenditure within an international context. The most common indicator of this research intensity is total public agricultural R&D spending as a percentage of agricultural GDP (AgGDP). In 2006, the seven Central American countries combined invested $0.31 for every $100 of agricultural output (Figure 6). This level is much lower than other countries in Latin America, such as Mexico and Colombia (1.27 and 0.49, respectively), or other regions in the world, such as Sub-Saharan Africa (0.72 in 2000) (Stads and Beintema 2008; Pardey et al. 2006). During the period 1996–2006, the region's agricultural research intensity (excluding Nicaragua) declined from 0.33 to 0.26, meaning that, over this timeframe, growth in the region's agricultural sectors was on average faster than growth in collective spending on agricultural research.

Figure 6. National and regional agricultural research intensities, 2006



Sources: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08). AgGDP data are from World Bank (2008).
Note: Intensity ratios are the ratio of total pubic agricultural R&D spending to total AgGDP. na indicates that data were not available.

From a country-level perspective, in 2006 only three countries in Central America—Belize, Costa Rica, and Nicaragua—had an agricultural research intensity ratio around 1.0 percent. Levels in Panama and Honduras were 0.50 and 0.37 percent, respectively. The intensities for Guatemala and El Salvador were among the lowest in the world, at 0.06 and 0.15 percent, respectively. Intensities fell significantly in Guatemala and El Salvador during 1996–2006 given that agricultural R&D spending in both countries was cut by half (in real terms). This drop in spending, combined with steadily rising AgGDP caused Guatemala's intensity level to drop from 0.15 percent in 1996 to just 0.06 percent in 2006. Guatemala's

intensity ratio has consistently been below corresponding ratios in other Central and Latin American countries. This reflects Guatemala's substantially higher AgGDP but, nonetheless, indicates that the country is seriously underinvesting in agricultural R&D.

Using intensity ratios is not always appropriate, because they do not take into account the policy and institutional environment within which agricultural research takes place, or the broader size of a country's agricultural sector and economy. Small countries, like those of Central America, need higher levels of investment in research because—despite regional R&D integration—they cannot benefit from economies of scale in the way that larger countries can. Countries with greater agricultural diversity or more complex agroecological conditions also have more complex research needs and hence require higher funding levels (Beintema and Stads 2008). In addition, technological breakthroughs spill across countries with similar agroclimatic conditions. A low intensity ratio in a country that imports many of its agricultural technologies is therefore not necessarily a cause for concern.

The Role of Regional Agricultural R&D Agencies

As previously mentioned, a number of regional organizations are conducting agricultural R&D in Central America. These agencies play a nonnegligible role, and they add to the overall R&D capacity and expenditures reported in the previous section. CATIE is by far the largest regional agency in terms of agricultural research staff and spending. In 2006, the center employed 72 fte scientists, 21 of which were trained to the PhD level, and 29 of which were trained to the MSc level. Further, CATIE spent $12 million (in 2005 constant prices) in the Central American region—a significantly higher amount than was spent on agricultural R&D by countries like Belize, El Salvador, Guatemala, and Panama. CATIE's expenditures rose by more than 60 percent during 2004–06, largely due to increased donor funding. As previously mentioned, the seven Central American countries combined spent $0.31 for every $100 on agricultural R&D in 2006; were CATIE included, this level would rise to 0.35 percent. The inclusion of EARTH and ECAG could further increase this spending intensity, but seemingly not substantially (unfortunately, data for EARTH and ECAG were unavailable). Even though, in the strict sense, Zamorano is a regional agency, for the purpose of this study it is classified as a Honduran agency, given that 80 percent of its research focuses on Honduras.

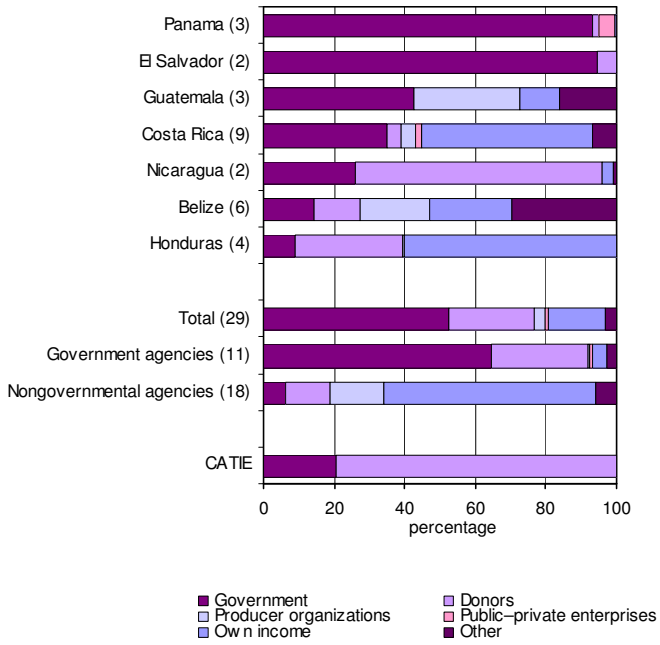
FINANCING PUBLIC AGRICULTURAL RESEARCH

Government funding is the dominant source of finance for agricultural R&D in Central America, although a variety of other sources are also becoming increasingly important. For a limited sample of 29 government agencies and nongovernmental institutions for which data were available, national government funding contributed 52 percent, foreign donors 24 percent, and internally generated income 16 percent. The remainder was derived from a variety of sources including taxes levied on production or exports via producer organizations and marketing boards, and contributions from public and private enterprises through contract research (Figure 7). At the country level, El Salvador and Panama rely almost exclusively on national government funding, whereas Nicaragua has traditionally depended on foreign donors to support its agricultural R&D. In 2006, just 26 percent of INTA's budget was financed by the Nicaraguan government, whereas 70 percent was contributed by donors and multilateral development banks. As previously mentioned, the World Bank has been an important contributor to INTA through two consecutive agricultural technology projects (ATPs). Under ATP-I (2000–05), INTA developed 134 new farming technologies, and under ATP-II (2005–09), INTA is developing a further 42 technologies. In addition to important food crops, ATP has focused on products and techniques to increase Nicaragua's competitiveness in domestic and export markets within the framework of CAFTA (World Bank 2005). Aside from World Bank and IDB funding, INTA has also received substantial donor contributions from Austria, Denmark, Japan, Norway, Sweden, Switzerland, Taiwan, and the United States, as well as from organizations such as the World Society for the Protection of Animals (WSPA), and People Protecting Animals and their Habitat (PATH). Donor funding is also important, although to a much smaller degree, in Honduras and Belize (5 percent or less). In Costa Rica and Honduras, a significant amount of agricultural R&D is funded via resources generated by the institutions themselves. In 2006, 20 percent of INTA's funding in Costa Rica, for example, was derived from contract research with commodity research agencies, such as ICAFE, while agencies like INBio in Costa Rica and FHIA in Honduras generate the vast majority of their income through service contracts. Research financing by producer organizations played an important role in agricultural R&D in Guatemala and Belize, where it accounted for 30 and 20 percent of total agricultural R&D funding, respectively.

For commodity organizations such as CORBANA and CICAFE in Costa Rica and CENGICANA in Guatemala, sectoral agreements between the national government and the producer associations are in place to support agricultural R&D financed through levies. Producers pay a tax on the production or export value of the commodity, and a share of the resulting revenues are earmarked for development, including research. The mechanisms for collecting revenues and shares allocated to research vary across commodities and countries. CENGICANA, for example, receives most of its funding from sugarcane growers through export taxes.

CATIE, the only regional agency for which funding data were available, is heavily dependent on donor support. In 2006, 80 percent of the center's R&D expenditures were financed by foreign donor agencies, including the Swedish International Development Cooperation Agency (Sida), the Norwegian Foreign Ministry, the Swiss Agency for Development and Cooperation (SDC), the Japan International Cooperation Agency (JICA), as well as multilateral institutions including the European Union, the World Bank, IDB, the Center for International Forestry Research (CIFOR), and Bioversity International. It appears that in recent years funding sources and mechanisms have become more diversified in a number of Central American countries, and new funding mechanisms for public agricultural R&D are gradually gaining ground (Table 7). The university sector, for example, is increasingly tapping into funding sources established by governmental and international S&T bodies. In Costa Rica, under the National Commission of Scientific and Technological Research (CONICYT), and in Nicaragua, under FUNICA, competitive funding mechanisms were introduced as an alternative means to disbursing government funding for agricultural research. Competitive funds have several advantages and disadvantages compared with conventional direct allocations. They are seen as means of more readily redirecting research priorities; increasing the involvement of universities and private companies in research; establishing stronger links among government, academic, and private research agencies; and increasing flexibility.

Figure 7—Funding sources for agricultural R&D, 2006



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: The number of agencies in each category is shown in parentheses. Combined, the 29 agencies included in the sample accounted for 74 percent of total agricultural R&D spending in Central America. Producer organizations include marketing boards. Nongovernmental institutions fall under the official category of nonprofit institutions (see Appendix A) and include producer organizations.

However, competitive mechanisms often involve higher transaction costs; favor short-term, applied research over basic, long-term research; and often only support operating costs, not salaries or infrastructure. Some believe, therefore, that competitive grant systems should complement conventional block-grants from the government rather than replace them (Beintema and Pardey 2001; Echeverría 2006).

A number of private-sector entities contract R&D services from consultancies abroad. This is particularly the case for high-value agriculture related to shrimp, horticulture, and ornamental plants. Unfortunately, within the framework of this study, it was not possible to elicit information on private sector R&D activities, which appear to have increased in recent years.

Table 7. Diversity in funding sources and mechanisms for public agricultural R&D

Country	Funding trends
Belize	Central Farm Agricultural Station finances the bulk of its activities through internally generated resources and donor funding; funding from the national government constitutes a relatively limited share. CARDI, on the other hand, receives the lion's share of its funding from the national government.
Costa Rica	INTA, being state-owned, receives more than three-quarters of its funding through government allocations, while the remainder is derived from foreign donors and internally generated resources. Research at ICAFE and CORBANA, which focuses on coffee and bananas, respectively, is largely financed through a sales levy on production or exports. INBio generates the majority of its income by conducting contract research for the private sector. The University of Costa Rica relies on a mix of government support, contract research for the private sector, and internally generated resources.
El Salvador	CENTA is mainly funded through direct government appropriations. In 2006, 95 percent of the agency's expenditures were financed this way. The remainder came from foreign donors, including JICA, Taiwan, CIMMYT, CIAT, and CIP. Sugarcane and coffee research at CASSA and PROCAFE is largely financed through commodity taxes.
Guatemala	Funding for government-sector agricultural research (ICTA and INAB) is mainly derived from the national government and supplemented by limited internally generated resources. CENGICANA, the country's sugarcane research institute, is entirely financed through commodity taxes levied on sugarcane production.
Honduras	Being government-controlled, DICTA receives most of its funding from the national government, although donor funding also plays an important role, including contributions from Japan and IDB. FHIA, the country's largest agricultural R&D agency in terms of agricultural research staff and spending, relies heavily on contract research for the private sector. It also reported a sizeable amount of donor support, including funding from USAID, the Netherlands, Germany, Japan, and the European Union.
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 National Institute of Agricultural Technology (INTA). In recent years, INTA has depended to a large extent on donor support (mainly from the World Bank, Canada, Denmark, and Austria), with the result that its research agenda has become highly donor-driven. FUNICA, established in 2000, manages a competitive fund consisting of the Support Fund for Agricultural Technology Research in Nicaragua (FAITAN), which finances agricultural research submitted 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 IDIAP's funding (94 percent in 2006) is derived from the national government, with the remainder contributed by foreign donors or generated internally. APASAN also received the bulk of its funding from the national government, complemented with limited support from producer organizations and internally generated funds.

Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).

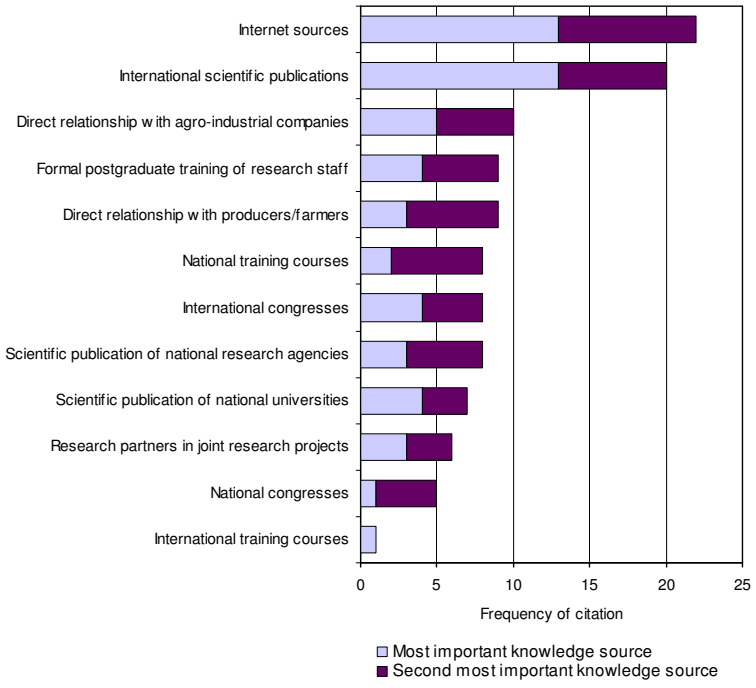
AGRICULTURAL R&D IN CENTRAL AMERICA WITHIN A WIDER INNOVATION SYSTEM CONTEXT

Newer thinking on the dynamics of innovation systems and networking suggests that it is not only the capacity of R&D agents and users that determines innovative development in the agricultural sector, but also the interconnection among these agents and the way they collaborate and exchange information and knowledge.[5] In order to shed light on the issue of networking and connectivity, and contributions to innovation by other than R&D organizations, data was collected on the linkages between agricultural R&D organizations and other agents, how research results are disseminated to stakeholders, and what knowledge sources form important inputs to agricultural R&D. This type of information provides insights into how agricultural R&D agencies in Central America operate within the wider context of innovation systems.

Sources of Knowledge

A total of 48 Central American agencies provided information on their most-important channels of information (Figure 8). Overall, the Internet was most frequently cited (13 agencies named the Internet as their primary information source, and 9 agencies named it as their second most important source). Scientific publications have also been prominent sources of knowledge, particularly among government agencies and nongovernmental institutions. The Internet was a more important knowledge source for higher education agencies. Direct relationships with producers and farmers serve as an important source of information for only a handful of organizations, and more so for those in the government sector than in the nongovernmental or higher education sectors.

Figure 8. Main sources of knowledge cited by agricultural R&D agencies



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Note: The sample includes 48 of Central America's 63 agricultural R&D agencies.

[5] For more information on new innovation systems thinking, see Hartwich et al. (2007).

Connectivity

Given the importance of the Internet as a source for new knowledge to agricultural R&D organizations in Central America, data on Internet availability were collected in terms of the ratio of Internet-connected computers to fte (Table 8). The average number of Internet-connected computers was surprisingly low for the national agricultural R&D institutes included in the sample. INTA (Costa Rica), CENTA, and ICTA reported having only 1 computer for every 3 or 4 fte scientists. The situation was not much better at INTA (Nicaragua) and DICTA, both of which had 1 Internet-connected computer for approximately every 2.5 fte scientists. Average Internet connectivity ratios per scientist were much higher in the nongovernmental and higher education sectors.

Table 8. Internet connections per fte scientist for a number of Central American agricultural R&D agencies, 2006/07

Country	Agency	Institutionalcategory	Number of computers with Internet access, 2006	Internet connections per fte scientist, 2007
Belize	CARDI	Government	3	1.0
	Central Farm	Government	5	3.3
Costa Rica	INTA	Government	22	0.3
	CICAFE	Nongovernmental	10	1.3
	CORBANA	Nongovernmental	32	1.5
	INBIO	Nongovernmental	115	7.5
	UCR	Higher education	111	1.5
El Salvador	CENTA	Government	16	0.3
Guatemala	ICTA	Government	20	0.3
	INAB	Government	4	0.6
	CENGICANA	Nongovernmental	33	2.2
Honduras	DICTA	Government	7	0.4
	FHIA	Nongovernmental	50	1.6
	IHCAFE	Nongovernmental	4	1.0
Nicaragua	INTA	Government	20	0.4
	UNA	Higher education	110	1.8
Panama	IDIAP	Government	na	na
	APASAN	Nongovernmental	8	0.4
	FCA	Higher education	35	1.5

Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: See the list of acronyms for full names of agencies. Fte indicates full-time equivalent; na indicates that data were not available.

In addition to the Internet, most agricultural R&D agencies reported having access to international libraries via virtual networks provided by local universities, universities in the developed world, CGIAR centers, CATIE, and U.N. agencies such as the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Development Programme (UNDP). Access to such libraries was more pronounced in countries like Costa Rica and Panama and less frequent in Honduras and El Salvador.

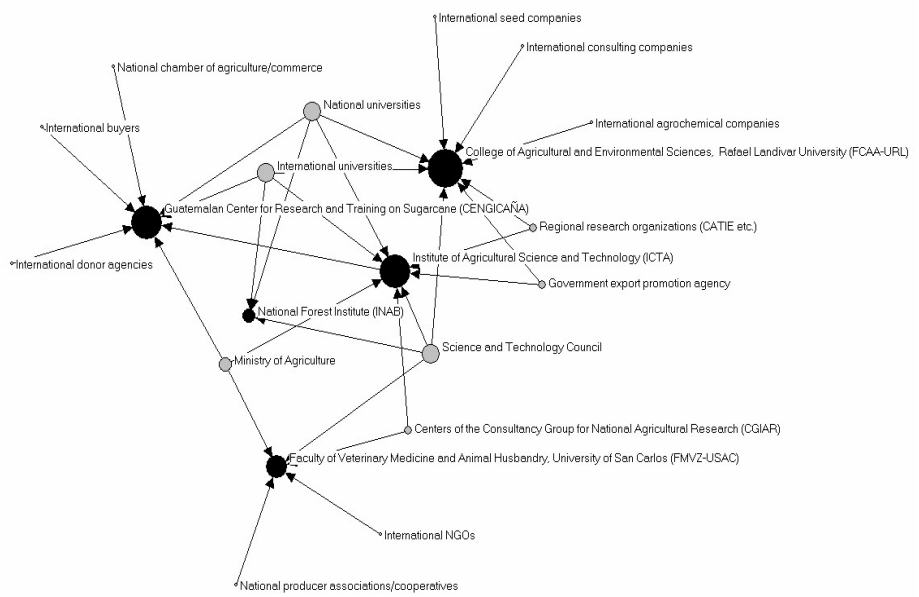
Collaborative Networking

Networking of R&D organizations at the country and regional level was also explored under this study. Many agencies provided only partial information, and reciprocal ties could therefore not be established. Nevertheless, partial diagrams could be drawn (see Figure 9a and b) depicting the interconnectivity of selected R&D organizations (black nodes) in Guatemala and Honduras to certain categories of organizations in the wider agricultural innovation system (grey nodes). The size of each node in Figures 9a and 9b depicts the number of linkages to each organization. Both figures show that national R&D organizations collaborate intensively with bilateral donor agencies and national universities, as well as those in other Central American countries, Europe, and the United States. Interestingly, agencies in the higher education and nongovernmental sectors are often better connected to international networks than

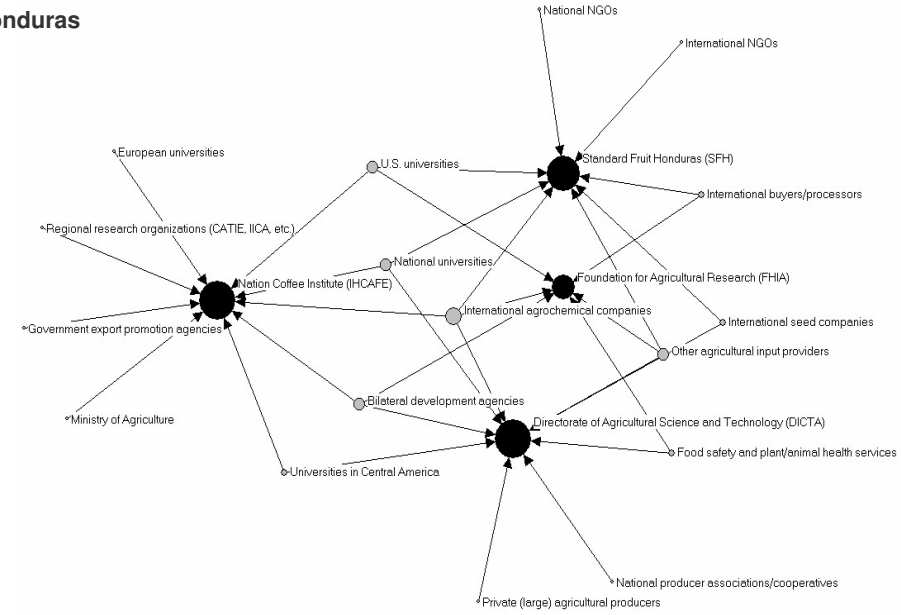
are the national agricultural research institutes. Although these figures are far from complete, they provide interesting insights into the relationships among various innovation agents, and they clearly demonstrate the complexity of innovation networks.

Figure 9. Network of collaboration of research agencies in Guatemala and Honduras

a. Guatemala



b. Honduras

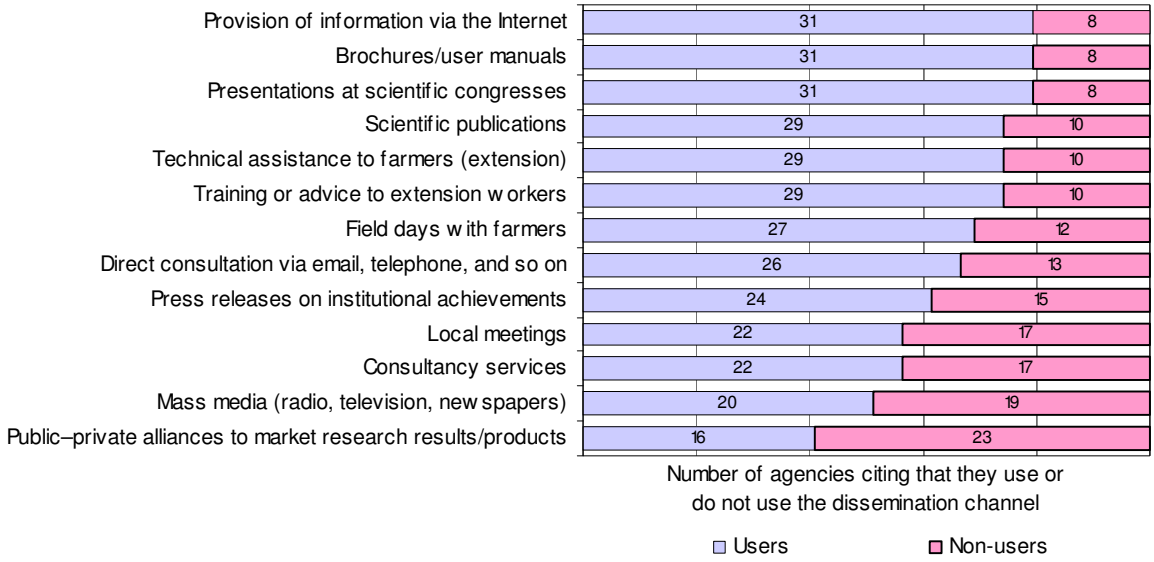


Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).

Dissemination of Research Results

The sample agencies were also asked to identify the main channels used to disseminate their research results. Again, the Internet ranked as the most important means of communication, along with brochures/manuals and scientific congresses; 31 of the 39 sample organizations reported to have used these means to disseminate their research results (Figure 10). Meanwhile, 29 of the 39 organizations cited publications in scientific journals and technical assistance/training of farmers and extension workers as a primary means to disseminate their research results.

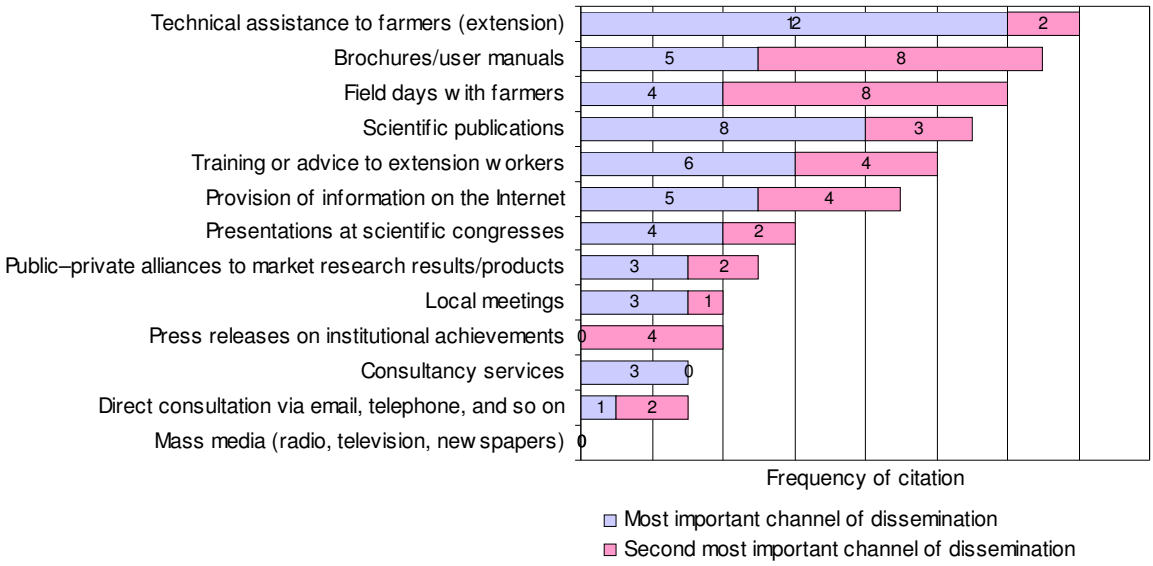
Figure 10. Channels used by selected agricultural R&D agencies to disseminate research results



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: The sample includes 39 of Central America's 63 agricultural R&D agencies. The numbers in the bars depict the number of users and non-users.

The information on which dissemination channels agricultural R&D agencies consider most important reveals the importance of capacity strengthening (Figure 11). The figure only depicts the dissemination channels that were cited as most important and second most important. Of the sample agencies, 12 cited technical assistance to farmers as the most important method of disseminating their results, and a further 2 agencies cited technical assistance as the second most important method. Field days with farmers and training or advice to extension workers were also prominent among the rankings. Dissemination through brochures/manuals and scientific publications were also cited as important. Although the majority of the sample agencies reported using the Internet as a means of disseminating their R&D results, only 9 agencies cited the Internet as the most important or second most important method.

Figure 11. Most important channels used by selected agricultural R&D agencies to disseminate research results



Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Note: The sample includes 39 of Central America's 63 agricultural R&D agencies.

CONCLUSIONS AND POLICY IMPLICATIONS

Although the countries in Central America share many cultural and socioeconomic characteristics, important national differences of relevance to agricultural R&D exist among them. In countries like Guatemala and El Salvador, agricultural R&D is largely undertaken by government agencies, whereas most of the research in Honduras, Nicaragua, and Costa Rica is conducted by higher education agencies. In addition, the nongovernmental sector—which includes producer organizations—plays a significant role in carrying out agricultural R&D in Honduras and Costa Rica.

In terms of capacity, Belize—the region's smallest country—employed just 17 fte scientists in agricultural R&D in 2006 compared with 283 fte's in Costa Rica. Central America as a whole spent $92 million (in 2005 constant prices) on agricultural R&D in 2006, equivalent to 0.31 percent of the region's agricultural output. Although these totals would be somewhat higher if expenditures by regional agencies like CATIE were included, they are still very low compared with other parts of Latin America, other developing regions, and especially the developed world.

Costa Rica has the region's most advanced agricultural R&D system and plays an important role in the development of new technologies, particularly for the emergent horticulture and food processing industries. In 2006, Costa Rica accounted for one-third of total Central American agricultural R&D spending, closely followed by Nicaragua. INTA—Nicaragua's national agricultural research agency, which receives the vast majority of its budget from donors and multilateral development banks—accounted for nearly one-fifth of Central America's agricultural R&D spending in 2006. Growth in agricultural R&D spending varied greatly across countries. During 1996–2006, Costa Rica experienced a 30 percent growth in its agricultural R&D investments, whereas spending in El Salvador and Guatemala shrank by more than 40 percent.

Sources of agricultural R&D funding also differ widely across Central American countries. Research in El Salvador and Panama relies almost exclusively on funds provided by their national governments. Public agricultural R&D in Nicaragua, on the other hand, has traditionally been highly donor-dependent. Agencies in Costa Rica and Honduras show an increasing reliance on internally generated resources compared with other countries in the region, which can partly be explained by the large nongovernmental sectors in these countries.

Linkages among the Central American countries have grown in the past decade, as have linkages with the United States—Central America's largest trading partner. Although CAFTA, the free trade agreement, may have a negative effect on some of the region's agricultural industries, it also offers broad economic opportunities to the region. To take advantage of these opportunities, the countries of Central America will have to overcome a range of challenges that affect its competitiveness. An often-voiced concern is that the region's overall performance in agricultural innovation and capacity has been held back due to the fragmented nature of the region's agricultural R&D systems and the lack of efficiency, for example, in term of duplication of effort. New innovation system and networking theory suggests that it is not only the capacity of R&D agents and users that determine the level of innovation in the agricultural sector, but also the level of interaction, collaboration, and exchange of information and knowledge.

Greater economies of scope and scale could be achieved if the countries of Central America continue to integrate their agricultural R&D systems within each country, as a region, and in terms of the broader innovation system. Although some progress has already been made in this regard (for example, SICTA), integration should be extended to include nongovernmental institutions, producer organizations, the higher education sector, and the private for-profit sector. In addition to enhanced integration, a boost in agricultural R&D investments is called for—particularly in Guatemala and El Salvador—if Central America is to enhance smallholder production, cut (rural) poverty and to compete with top-quality agricultural products in a global market.

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APPENDIX A. ASTI METHODOLOGY AND DATA COLLECTION

The ASTI initiative involves a large quantity 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 it 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 copublishes the resulting country briefs with IFPRI. These surveys focus on research agencies, not research programs.

The datasets for the country samples underpinning this report includes information on roughly 65 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, Science, and Cultural Organization (UNESCO) for compiling R&D statistics (UNESCO 1984; OECD 2002). 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. Nongovernmental 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 under universities. Private-sector agencies are agencies 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.

A complete list of agencies involved in agricultural R&D was identified at the onset of the survey, and each agency was approached to participate. To this end, three different survey forms were developed: one for government agencies and nonprofit institutions, one for faculties and schools, and one for the private sector. All forms had different sets of questions, and those for government agencies and nonprofit institutions requested the most detail. In general the forms consisted of 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 (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); the remaining indicators were mostly 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 in full-time equivalent (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 R&D, such as extension, teaching, or technical services. The contribution of PhD students in 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, given that roughly two-thirds of research expenditures are 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 2005 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 that year. In contrast, the corresponding 2005 ratio for Kenya of 0.20 in Kenya 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 across 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 figures 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 (Belize dollar, Costa Rican colón, Guatemalan quetzal, Honduran lempira, Nicaraguan córdoba oro, and Panamanian balboa; data for El Salvador and CATIE were collected in US$). 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 (both the GDP deflators and PPP values were taken from the World Bank 2008). For convenience of interpretation, the reference currency—in this case international dollars—is set equal to a U.S. dollar in the benchmark year 2005.

APPENDIX B. AGENCY SAMPLE, 2006 SURVEY

Belize

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	Caribbean Agricultural Research and Development Institute (CARDI)	Crops	3	3.0
	Central Farm Agricultural Station: Ministry of Agriculture and Fisheries	Crops, livestock	3	1.5
	Caribbean Regional Fisheries Mechanism (CRFM)	Fisheries	9	4.5
Nongovernmental institutions	Citrus Research and Education Institute, Belize	Citrus fruits	5	4.0
	Citrus Growers Association (CGA)			
	Taiwan Technical Mission (ROC)	Crops	4	0.8
	Sugar Industry Research and Development Institute (SIRDI)	Sugarcane	4	2.4
Higher education agencies	University of Belize (UB)	Crops, livestock, forestry	13	1.3

Costa Rica

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	National Institute of Technological Innovation (INTA)	Crops, livestock, natural resources	87	87.0
	Costa Rican Institute for Fisheries and Aquaculture (INCOPESCA)	Fisheries	14.7	4.4
	National Center for Food Science and Technology (CITA) - UCR	Crops, livestock	34	20.4
Nongovernmental institutions	Coffee Research Center (CICAFE), Costa Rica Institute of Coffee (ICAFE)	Coffee	8	8.0
	National Banana Corporation, S.A. (CORBANA)	Banana	22	22.0
	Directorate of Research and Extension of Sugarcane (DIECA), Agricultural Industrial Cane League (LAICA)	Sugarcane	16	6.3
	Ranchers Corporation (CORFOGA)	Beef	6	1.2
	National Horticulture Corporation	Crops	1	0.2
	National Rice Corporation (CONARROZ)	Rice	8	3.2
	National Biodiversity Institute (INBio)	Natural resources	61	15.3
Higher education agencies	Technological Institute of Costa Rica (ITCR)	Crops, forestry, natural resources	33	11.2
	Agricultural Research Institute, University of Costa Rica (UCR)	Crops, livestock, other	111	72.2
	Research Center for Environmental Pollution, University of Costa Rica (UCR)	Crops, natural resources	26	10.4
	National University of Costa Rica (UNC)	Crops, livestock, natural resources	41	16.4
	Center for the Study of Tropical Apiculture, National University (UNA)	Fruits, bees	8	4.8

El Salvador

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	National Center for Agricultural and Forestry Technology (CENTA)	Crops, forestry	60	60.0
Nongovernmental institutions	Salvadoran Sugar Company, S.A. (CASSA)	Sugarcane	4	0.8
	Salvadoran Foundation for Coffee Research (PROCAFE)	Coffee	5	5.0
	National Center for Renewable Natural Resources (CENREN)	Natural resources	na	0.5
Higher education agencies	Faculty of Agronomy, University of El Salvador (UES)	Crops, livestock	34	8.5
	College of Agriculture and Agricultural Research, University of "Dr. José Matías Delgado" (UJMD)	Crops, livestock, fisheries	7	2.1

Guatemala

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	Institute of Agricultural Science and Technology (ICTA)	Crops, livestock, natural Resources, fisheries	63	63.0
	National Forest Institute (INAB)	Forestry, natural resources	43	6.5
Nongovernmental institutions	National Association of Coffee in Guatemala (ANACAFE), Department of Investigations	Coffee	10	2.0
	Guatemalan Center for Research and Training on Sugarcane (CENGICAÑA)	Sugarcane	15	15.0
Higher education agencies	Faculty of Agriculture (FA), University of San Carlos Guatemala (USAC)	Crops, natural resources	na	14.0
	Faculty of Veterinary Medicine and Animal Husbandry (FMVZ), University of San Carlos Guatemala (USAC)	Livestock	2	0.5
	College of Agricultural and Environmental Sciences, Rafael Landivar University (URL)	Crops, natural resources	6	1.5

Honduras

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	Directorate of Science and Agricultural Technology (DICTA)	Crops	18	18.0
Nongovernmental institutions	Honduran Foundation of Agricultural Research (FHIA)	Crops	32	32.0
	Honduran Coffee Institute (IHCAFE)	Coffee	6	4.2
	Program for Sustainable Agriculture in Central America (PASOLAC)	Crops, natural resources	2	1.2
Higher education agencies	National School of Forestry (ESNACIFOR)	Livestock, forestry, natural resources	19	5.7
	Central Region University of the Atlantic Coast (CURLA)	Na	194	19.4
	National Autonomous University of Honduras (UNAH)	Na	na	3.5
	National Agricultural University (UNA)	Na	na	6.5
	Central University of Technology (UNITEC)	Na	na	0.4
	University of San Pedro Sula (U-SPS)	Na	na	1.4
	Panamerican Agricultural School, Zamorano	Crops, livestock, fisheries, forestry, natural resources, biotechnology	54	8.1

Nicaragua

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	Nicaraguan Institute of Agricultural Technology (INTA)	Crops, pastures, and forages	58	46.4
Nongovernmental institutions	Center for the Promotion of Research and Rural and Social Development (CIPRES)	Crops	2	0.4
Higher education agencies	Research Center of Aquatic Ecosystems (CIDEA), Central American University (UCA)	Natural resources	11	6.6
	Faculty of Economics (CINET), National Autonomous University of Nicaragua (UNAN), Managua	Crops, postharvest	74	11.1
	Faculty of Agrarian Sciences (FCA), University of Commercial Science (UCC)	Livestock	20	5.0
	Research and Development Institute (IID), University of Central America (UCN), Nitlapan	Socioeconomics	16	5.6
	National Agrarian University (UNA)	Crops, livestock, natural resources	173	60.6
	Faculty of Building Technology (FTC), National University of Engineering (UNI)	Crops, renewable energy	2	0.5

Panama

Type of agency	Executing agency	Research focus	Researchers	
			Headcount	Fte's
Government agencies	Institute of Agricultural Research of Panama (IDIAP)	Livestock, crops	178	105.5
	Aquatic Resources Authority (ARA)	Fisheries, natural Resources	na	15.9
	National Bureau of Aquaculture (DINAC)	Fisheries	na	2.2
Nongovernmental institutions	Achotines Laboratory	Aquaculture	7	7.0
	Panamanian Association for Sustainable Agriculture and Natural Resources (APASAN)	Forestry, natural resources, health	19	10.5
	Center for the Tropics in Latin America and the Caribbean (CATHALAC)	Natural resources	21	2.1
Higher education agencies	Faculty of Agricultural Sciences (FCA), University of Panama (UP)	Crops, livestock	94	23.5

Source: Compiled by authors from ASTI survey data (IFPRI–IICA 2007/08).
Notes: Na denotes "not available". Zamorano is a regional agency in the strict sense of the word, but given that 80 percent of the agency's research is of relevance to Honduras, it is considered a Honduran agency for the purpose of this study.