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Quantitative data are important in measuring, monitoring, and benchmarking the inputs, outputs, and performance of agricultural science and technology (S&T) systems. They are an indispensable tool when it comes to assessing the contribution of agricultural S&T to agricultural growth and, more generally, economic growth. S&T indicators assist research managers and policymakers in policy formulation and decision-making on strategic planning, priority setting, monitoring, and evaluation. They also provide information to government and other institutions (e.g., policy research institutes, universities, and the private sector) involved in the public debate on the state of agricultural S&T at national, regional, and international levels. This brief reviews the major investment, capacity, and institutional trends in public agricultural research in Mexico since 1981, using recent data collected under the Agricultural Science and Technology Indicators (ASTI) initiative (IFPRI-INIFAP 2007-08) and underlying data sets of an unpublished report by Beintema et al. (2001).[1]

INTRODUCTION

Mexico, officially known as the United Mexican States, is the world's eighth largest nation, covering nearly 800,000 million square miles (or 2 million square kilometers). It is an upper-middle-income country, but income distribution is very uneven. With a population of over 100 million people, it is the largest Spanish-speaking country in the world. The country is subdivided into 31 states and the Federal District of Mexico City, which has a

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

Type of agency	Total spending: 2005 Mexican pesos	Total spending: 2005 (PPP) international dollars	Total research staff	Share: Spending	Share: Research staff	Agencies in sample[a]
	(billion)	*(million)*	*(fte's)*	*(percent)*	*(percent)*	*(number)*
INIFAP[b]	800.9	112.3	1,023.0	21.7	25.2	14
Other government[c]	894.1	125.4	844.4	24.2	20.8	28
Nonprofit agencies	0.6	0.1	2.1	0.0	0.1	2
UACh[d]	364.6	51.1	401.7	9.9	9.9	10
ColPos[d]	314.1	44.0	346.0	8.5	8.5	6
UAAAN[d]	161.9	22.7	178.4	4.4	4.4	3
Other higher education[d]	1,153.7	161.8	1,271.0	31.3	31.3	107
Total	**3,689.9**	**517.5**	**4,066.7**	**100**	**100**	**170**

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

[a] See Mexico country profile on http://www.asti.cgiar.org/profiles/mexico.aspx for a list of the 170 agencies included in this sample.

[b] INIFAP includes headquarters in Mexico City and eight regional research centers (CIRs) and five national disciplinary research centers (CENIDs).

[c] Expenditures for 15 of the smaller government agencies for which no financial information was available are estimates based on average expenditures per researcher at the remaining government agencies. Staff employed in the 28 other government agencies spent between 10 and 100 percent of their time on research, resulting in 844.4 fte researchers.

[d] Expenditures for UACh, ColPos, UAAAN, and the other higher education agencies are estimates based on average spending per researcher at the government agencies. Staff at the higher education agencies spent between 10 and 100 percent of their time on research, resulting in 2,197.1 fte researchers.

KEY TRENDS

- The share of INIFAP in total Mexican agricultural R&D spending and capacity has gradually declined over the past decades in favor of other government agencies and the university sector. INIFAP's share is expected to decline further in the future, given that a large portion of its scientist pool is up for retirement within the next decade.
- Agricultural R&D spending in Mexico rose gradually during 1991–2006 due mainly to increased investments by the higher education sector and government agencies other than INIFAP.
- The national government largely finances public agricultural research through either block grants or competitive funding mechanisms.
- The private sector plays a relatively limited role in conducting agricultural R&D in Mexico.
- Overall, average qualification levels of Mexican agricultural R&D staff improved significantly during 1996–2006, and the country now has one of the most highly qualified researcher pools in Latin America.

ABOUT ASTI

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

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

special status within the federation. Mexico has great climatic diversity because of its location in both temperate and tropical zones and because of a large variation in altitudes. Annual rainfall varies from 3 inches (76 millimeters [mm]) in the northwest of the country to 82 inches (2,082 mm) in the tropical south of the country. The country as a whole suffers from a lack of natural water supply, making large areas of it unproductive for farming. Only 12 percent of Mexico's land area is arable, 3 percent of which is irrigated. Much of the farming is done on plateaus at altitudes of 5,000 feet (1,500 meters) or more. Agriculture accounted for 4 percent of Mexico's gross domestic product (GDP) in 2006, down from 7 percent in 1980 and 25 percent in 1970. Yet, agricultural employment accounted for over 16 percent of total employment in 2006, consisting mostly of subsistence farmers (World Bank 2008). Top revenue-generating crops include maize, tomatoes, sugarcane, dry beans, and avocados. Mexico also generates significant revenue from the production of beef, poultry, pork, and dairy products.

Trade and investment in Mexico have been transformed over the past two decades due to the 1994 launch of the North American Free Trade Agreement (NAFTA), as well as more recent trade deals with the European Union, Japan, and other Latin American countries. The country's economy is strongly dependent on the U.S. economy and shocks in the U.S. economy are immediately felt by its southern neighbor. Implementation of NAFTA has opened Mexico's agricultural sector to the forces of globalization and competition, and some farmers have greatly benefited from increased market access, whereas others have been excluded from the sector. Since 1994, Mexico's nonoil exports have grown fourfold and farm exports to NAFTA partners have risen threefold. In particular, fruit and vegetable exports from Mexico have increased dramatically in recent years. However, structural inefficiencies—such as a lack of infrastructure, inadequate supplies of credit, and the large number of subsistence farmers that are not part of the formal economy—continue to limit improvements in productivity and living standards for many in the agricultural sector.

Increased investment in a competitive and more efficient Mexican agricultural sector may result in higher income in the long run for the sector. It goes without saying that agricultural research and development (R&D) can play a tremendous role in this regard. R&D is key to improving agricultural productivity and has shown very high returns on investment in all regions across the world. Improved productivity and enhanced crop and livestock varieties can ultimately make Mexico more competitive in international markets. A well-developed national agricultural research system and adequate levels of investments are important prerequisites in this regard.

A Short History of Public Agricultural Research in Mexico

Despite various short-lived efforts in earlier years, government-led agricultural R&D in Mexico did not start until 1932, when the Ministry of Agriculture and Development established the Department of Experimental Fields within the General Directorate of Agriculture as a coordinating body of agricultural R&D conducted in the country. In the early 1940s, the Mexican government and the Rockefeller Foundation initiated a joint program that led to the creation of the Office of Special Studies (OEE) in 1944. OEE's mandate was to increase the yields of basic food crops and train Mexican agricultural scientists. During its existence, OEE created large genebanks that formed the basis of modern varietal crop improvement research. In later years, OEE broadened its scope beyond crops to include agricultural economics and information, diseases, and animal nutrition.

The Institute of Agricultural Research (IIA), which succeeded the Department of Experimental Fields in 1947, conducted research on cotton, rice, rubber, cacao, and basic food crops. There was a clear overlap in the mandates of OEE and IIA without there being any collaboration between them, and this had led to instances of duplication of research effort. In 1960 the Ministry of Agriculture and Livestock was reorganized, and the Rockefeller Foundation ended its program in Mexico. OEE and IIA were merged to form the National Institute of Agricultural Research (INIA), which became the ministry's crops research institute. After a decade of insufficient funding for agricultural R&D, INIA's budget increased during the 1970s—both in nominal and real terms. But in the years that followed, Mexico's inflation rate was so high that, although INIA's budget still increased in nominal terms, it decreased in real terms.

Livestock research in Mexico started with the establishment of the Institute of Veterinary Medicine in 1929. After various name changes and mergers, the National Institute of Livestock Research became Mexico's principal body involved in livestock research in the 1950s. Despite some earlier efforts, it was not until 1958 that serious forestry research was initiated in Mexico with the establishment of the National Institute of Forestry Research (INIF). In 1985 INIA, INIF, and INIP were consolidated under the National Institute for Forestry and Agricultural Research (INIFAP). Integrating these three institutes into one agency proved very difficult. To strengthen the institute's presence in the states, INIFAP was reorganized into 32 State Centers for Forestry and Agricultural Research (CIFAD) in 1987. In addition, five National Disciplinary Research Centers (CENIDs) were set up to focus on national-level priorities. In 1991, the institute took a more subsectoral and regional focus. Eight regional centers were created, and Directorates of Coordination were created in each of the 32 states for state-level presence. The institute was renamed National Institute for Forestry, Crops, and Livestock Research in 1996, but it maintained the same acronym, INIFAP. This structure remains in effect.

Initial efforts to establish formal agricultural education in Mexico dates back to 1853 when the National Agricultural College (currently UACh) was established. In 1906 a second agricultural school, the Particular Agricultural School, was established in the state of Chihuahua. In 1923, a third school, the Regional Agricultural School Antonio Narro (currently Autonomous Agricultural University Antonio Narro, UAAAN), was created. During the 1920s and 1930s, a large number of small agricultural education institutions were established within the Secretariat of Higher Education or SAGAR. By 1970 Mexico counted 20 agricultural higher education agencies, which were brought together under the newly established System of Agricultural Technological Education. In 1979 postgraduate training was split from undergraduate training at UACh and the Postgraduate College (ColPos) was created. To this day, UACh and ColPos are Mexico's principal higher education agencies in the field of agriculture.

Source: Beintema, Rodriguez del Bosque, Moctezuma López, and Pardey (2001).

SCIENCE AND TECHNOLOGY POLICY

The institutionalization of Mexico's science and technology (S&T) policy dates back to the late 1960s and early 1970s, when the first government agencies responsible for the design and implementation of such policies were created. The National Science and Technology Council (CONACYT) was created in 1970; it is charged with the promotion and strengthening of scientific development and technological modernization of Mexico. It carries out this mandate through human resource training, high-level advocacy, funding of research projects, and the dissemination of scientific and technological information (CONACYT 2008). CONACYT also oversees 27 national research centers related to specific economic activities such as power and oil, environment and natural resources, health services, and agriculture, livestock, and forestry.

Total (agricultural and nonagricultural) R&D spending in Mexico quadrupled from US$0.7 billion in 1990 to US$2.9 billion in 2005. Despite this rapid increase, total R&D spending accounted for just 0.37 percent of the country's GDP in 2005. This is lower than many other countries in Latin America with similar states of development (RICYT 2008), such as Argentina (0.46), Brazil (0.82), and Chile (0.68). Within the Organisation of Economic Cooperation and Development (OECD), Mexico is also one of the member countries with the weakest R&D intensity, along with Greece and Slovakia. The role of public institutions and universities in R&D remains important, but the share of R&D spending performed by the business sector is well below the OECD average. In 2005 business enterprises performed only 46 percent of Mexican R&D, and the higher education sector conducted around 20 percent (OECD 2007).

INSTITUTIONAL DEVELOPMENTS IN AGRICULTURAL R&D

The current study identified 169 public sector agencies involved in agricultural research in Mexico in 2006.[2] Combined, these 169 agencies employed 4,067 full-time equivalent (fte) researchers and spent 3.7 billion constant 2005 Mexican pesos on agricultural R&D, the equivalent of 518 million international dollars in 2005 constant prices, using a purchasing power parity (PPP) index (Table 1).[3] PPPs are synthetic exchange rates used to reflect the purchasing power of currencies and typically compare prices among a broader basket of goods and services than do conventional exchange rates.[4] The National Institute for Forestry, Agricultural, and Animal Husbandry Research (INIFAP) is by far the most important player in agricultural R&D in Mexico.[5] In 2006, the agencies placed under INIFAP employed 1,023 fte researchers and spent $112 million (in 2005 constant prices), accounting for roughly one-quarter of the country's agricultural research staff and expenditures. INIFAP is under the Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA) and is headquartered in Mexico City.

Besides its headquarters, the institute operates eight regional research centers (CIRs) and five national disciplinary research centers (CENIDs). Mexico's 31 states can be grouped into eight regions (Northwest, North Center, Northeast, Gulf Center, Pacific Center, Center, Pacific South, and Southeast). INIFAP operates 38 experimental fields scattered over the various states. Each state has a state director who reports directly to one of the eight regional directors. The CIRs attend to a broad range of agricultural R&D needs for each of Mexico's eight regions, and the five CENIDs are characterized by their high degree of expertise and specialization in particular disciplines. The CENIDs have a nationwide mandate but work closely with the CIRs at the regional level. Individual CENIDs include those for the Conservation and Improvement of Forest Ecosystems (COMEF); the Relationship between Water, Soil, Plant, and Atmosphere (RASPA); and three livestock CENIDs—for Veterinary Microbiology, for Physiology and Animal Improvement (FvMA), and for Veterinary Parasitology (PAVET). In 2001, INIFAP's legal status changed, and the institute was given more autonomy. SAGARPA no longer has a say in how INIFAP spends its budget. In 2003, INIFAP was officially labeled "public research center" by CONACYT, a legal status that gives the institute a certain degree of technical, operative, and administrative autonomy.

Twenty-eight other government agencies were identified as conducting agricultural R&D in Mexico. Combined, they accounted for 21 percent of the country's agricultural R&D staff and 24 percent of agricultural research spending in 2006. The Research Center for Food and Development (CIAD) under CONACYT aims to answer the problems of the Mexican food sector, carrying out studies, consultancies, and services for the agricultural, fisheries, industrial, and commercial sectors. CIAD is involved in three basic areas: the production, preservation, quality, and commercialization of food; health and biological development of the human being; and the socioeconomic impact of the processes of economic development and international integration. In 2006, 179 fte researchers, spread over the headquarters in Hermosillo (Sonora) and five regional centers, were active at CIAD.

The National Fisheries Institute (INP) is Mexico's principal agency involved in fisheries and aquaculture research. It is also placed under SAGARPA and has a nationwide mandate. The institute is headquartered in Mexico City, but research takes place in three regional centers in the states of Veracruz, Colima, and Sinaloa. Combined, these INP agencies employ 179 fte research staff members who direct their efforts mostly to fisheries production technologies.

The Morelos-based Mexican Institute for Water Technology (IMTA) is a decentralized public agency under SAGARPA. IMTA is mandated to combat the causes of the challenges associated with national and regional water management and outline new approaches in research and technological development that will protect the resource and allocate it efficiently and equitably among various users (IMTA 2008). In 2006, 154 fte researchers were active at IMTA.

The Scientific Research Center of Yucatán (CICY) under CONACYT is very important in the field of plant biology, natural resources, and materials. It operates a large botanical garden in Mérida in which basic and applied research is conducted on native plant species. It is estimated that 104 of the center's scientists are involved in research with relevance to agriculture.

The Jalisco State Research and Assistance Center for Technology and Design (CIATEJ) is a public research agency under CONACYT that serves the agroindustrial and pharmaceutical industries through innovation, technological services, and the training of human resources. Its 92 fte researchers conduct research in the field of crop biotechnology, industrial biotechnology and microbiology, food development and quality, food technology and bioprocessing, and environmental technologies. Besides its headquarters in Guadalajara, CIATEJ also operates a small R&D center in Yucatán. The remaining 23 government agencies are much smaller, each employing between 1 and 26 fte researchers in 2006.

The nonprofit sector accounts for a negligible share in Mexican agricultural R&D. Only two nonprofit agencies were identified, the Research Center for the Development of Fruit Growing in Tamaulipas, A.C., and Rural Development of Matamoros, A.C. Combined, these two agencies employed just two fte researchers in 2006.

The higher education sector, on the other hand, plays a prominent role in Mexican agricultural R&D; 126 higher education agencies are involved in agricultural R&D activities in the country. Combined, these agencies employed close to 2,200 fte researchers in 2006: 54 percent of the country's total agricultural research staff. A distinction can be made between public and private universities. Research efforts at public universities are largely financed through public funds, whereas private universities finance their research for the most part with student fees and private contracts. Mexico's public universities typically focus on basic research; their private counterparts tend to be more involved in solving specific problems that (private sector) producers encounter. The principal public universities in Mexican agricultural R&D are the Autonomous University Chapingo (UACh), the Postgraduate College (ColPos), and the Autonomous Agrarian University Antonio Narro (UAAAN).

UACh is the largest agricultural university in Mexico, and the majority of agricultural researchers in government agencies have a degree from this university. UACh manages the principal seed bank in Mexico and operates 12 campuses around the country, each one in a different agroecological zone. The Texcoco (Mexico State) main campus centrally coordinates research at each of the campuses, but the regional campuses are autonomous in terms of budget and day-to-day management. In 2008 alone, UACh carried out more than 800 separate agricultural research projects. In recent years, genetic improvement of maize, beans, and livestock have become increasingly important. In 2006, 384 fte researchers were active at UACh.

ColPos is a public research/teaching agency under SAGARPA. It was established in 1979 when it separated from UACh and became an independent university. UACh and ColPos occupy adjacent sites in Mexico State (just outside Mexico City). The 1979 decree creating ColPos mandated that the agency offer graduate teaching, perform R&D, and provide services and technical assistance in agriculture and forestry. Besides its main campus in Texcoco, ColPos operates six smaller campuses scattered around the country in Puebla, Tabasco, San Luis Potosí, Campeche, and two in Veracruz. These campuses operate relatively independently from the main campus and generally focus on different crops (e.g., tropical crops in tropical areas). In 2006, ColPos employed 346 fte researchers. Agricultural research is organized along 16 thematic lines, including biotechnology, climate change, nanotechnology, and important social research. In 2001, ColPos was recognized as a public research center by SAGARPA and CONACYT.

UAAAN is a federal public university that is dedicated to agriculture, forestry, and related disciplines, such as entomology, botany, and plant genetics. Its main campus is located in Saltillo (Coahuila), and a smaller campus is in Torreón (Coahuila). Experimental and demonstrative plots for crops and animal production facilities occupy a substantial share of the campuses. In addition, UAAAN has several experimental agriculture fields across Mexico, which encompass climates from the wet tropics in Veracruz to the desert in Chihuahua. In 2006, the university employed 178 fte researchers.

Besides the three agricultural universities described above, a large number of other public universities are engaged in agricultural research, often through faculties of agriculture or veterinary medicine or specialized research institutes. The National Autonomous University of Mexico (UNAM) is the largest university in Latin America in terms of student numbers. In addition to Ciudad Universitaria, UNAM's main campus in Mexico City, UNAM operates a large number of small campuses all over Mexico, aimed mainly at research and graduate studies. Although the university is known mainly for social sciences and medicine, agriculture plays an important role as well. In 2006, the university employed 163 fte agricultural researchers scattered over 11 separate UNAM units. The most important of these is the Cuautitlán campus in the State of Mexico, which has close to 100 ftes. This campus is Mexico's main research agency involved in animal health and veterinary science.

The National Polytechnic Institute (IPN) is Mexico's largest technical university. The Institute is organized around 77 academic units including 24 university colleges, 15 scientific and technical research centers, 11 centers for continuing education, and 16 vocational high schools located primarily in Mexico City, although several extension and research facilities are distributed over 15 different states. Agriculture plays an important role at IPN. In 2006, 265 fte researchers spread over 12 different IPN agencies were involved in agricultural R&D. The largest of these agencies include the Center for Research and Advanced Studies (CINVESTAV, 74 ftes); the Center for the Development of Biotic Products (CEPROBI, 54 ftes); the Interdisciplinary Center for Marine Sciences (CICIMAR, 34 ftes); the Center for Genomic Biotechnology (CBG, 27 ftes); and the Interdisciplinary Research Center for Integral Regional Development in Oaxaca (CIIDIR-Oaxaca, 26 ftes). Some units enjoy a high degree of academic and budgetary freedom. CINVESTAV is a very well-known center, both nationally and internationally. All of its researchers have PhD degrees, and they use top quality resources to carry out their research. The center operates eight research centers, four of which are involved in agricultural R&D. It is particularly well known for its biotechnology research.

Other public universities with important agricultural R&D activities include the Autonomous University of Baja California (UABC); the University of Sonora (USON); the Autonomous University of Chihuahua (UAC); the Autonomous University of Nuevo Leon (UANL), the Autonomous University of San Luis Potosí (UASLP); the Autonomous University of Tamaulipas (UAT); and Veracruzana University. The remaining higher education agencies are much smaller.

Tecnológico de Monterrey is the largest of Mexico's private universities involved in agricultural R&D. Its campuses are distributed throughout the country, and it has academic centers in Mexico and in other Latin American countries. It also operates international offices in the United States, Europe, and Asia. Although most of the university's research is on nonagricultural subjects, Tecnológico de Monterrey is an important player in the field of biotechnology, nanotechnology, and natural resources research. In 2006, the university's Agriculture and Food Technology Division employed 17 ftes.

The private for-profit sector plays a relatively limited role in Mexican agricultural research. Most private sector companies contract their research needs out to the public sector, rather than conducting their own R&D. INIFAP, for instance, carries out pesticide research on behalf of Bayer Crop Science (a crop protection company); wheat research on behalf of Grupo Bimbo (a bakery and food company); pest control research on behalf of Grupo Maseca (a large tortilla maker); barley research on behalf of Impulsora Agricola (an agribusiness company); natural resources research on behalf of Peñoles (a mining company); and dairy research on behalf of Nestlé (a packaged food company). The private sector companies that conduct their own agricultural R&D focus nearly exclusively on seed research. Monsanto, for example, is an important player in maize and sorghum seed research. In 1999, a new law came into effect that allowed tax breaks and incentives for private sector R&D. This is particularly the case for the horticultural and tropical fruits sectors, where local governments stimulate the private sector through tax cuts and offerings of land.

National and International Linkages and Cooperation

Mexico's agricultural R&D agencies participate in a significant amount of collaborative research nationally, regionally, and internationally. At the national level, INIFAP carries out joint research with CIAD, CINVESTAV, and ColPos. Linkages with universities are particularly strong. INIFAP scientists are involved in teaching at universities and organizing scientific congresses and seminars in close cooperation with agricultural universities. In addition, many university students do work placement at INIFAP for a short period. INIFAP also works closely with a number of producer organizations and industrial organizations involved in maize, oil, and malt production, as well as with the private sector. At the regional level, INIFAP linkages are particularly strong with the Agricultural Research Service (ARS) and Forest Service (FS) in the United States, the Brazilian Agricultural Research Corporation (EMBRAPA), and the Cooperative Program on Agricultural Research and Technology in North America (PROCINORTE), which facilitates technological and scientific cooperation between Canada, the United States, and Mexico. INIFAP also has close ties with the Inter-American Institute for Cooperation on Agriculture (IICA) and with a number of centers under the Consultative Group of International Agricultural Research (CGIAR). CGIAR's International Maize and Wheat Improvement Center (CIMMYT) is headquartered in Texcoco in Mexico State. INIFAP also hopes to enhance collaboration with CIMMYT, the Africa Rice Center (WARDA), the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Livestock Research Institute (ILRI), and the International Rice Research Institute (IRRI) in the field of biotechnology.

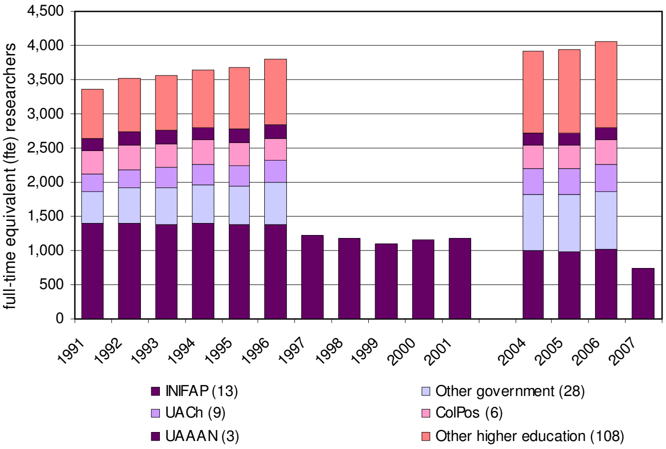
Despite their separation in 1979, UACh and ColPos still collaborate closely in a large number of R&D projects. UACh also reported close collaboration with INIFAP (mostly student work placement) and a number of universities in the United States. ColPos works closely with other universities such as UNAM, CINVESTAV, and Universidad Veracruzana. At the state level, local campuses have relationships with local universities. Internationally, ColPos works with the Food and Agriculture Organization of the United Nations (FAO) on soil conservation and with the United Nations Development Program (UNDP) on hillside crops as part of its rural development program. Limited R&D cooperation also takes place with the private sector. ColPos conducts potato research on behalf of Monsanto and Sabritas (part of Pepsi). UAAAN reported collaborative agreements with FAO, the U.S. Department of Agriculture, the World Wildlife Fund, Pogue Agri Partners (a U.S.-based seed company), and Olds College (a Canadian agricultural university). CINVESTAV reported close collaboration with partner institutes in Canada, Cuba, France, Switzerland, and the United States.

HUMAN AND FINANCIAL RESOURCES IN PUBLIC AGRICULTURAL R&D

Overall Trends

The number of public fte agricultural researchers in Mexico rose at an average rate of 1.0 percent per year from 3,365 ftes in 1991 to 4,067 in 2006 (Figure 1).[6] However, growth did not occur evenly over time and between the various agency categories. Research staff totals at INIFAP show a steadily falling trend. In 1991, the institute employed 1,404 fte researchers, compared to just 1,023 ftes in 2006. This decline is occurring primarily because retiring researchers are not being replaced. In December 2007, the situation was exacerbated when the Mexican government introduced a voluntary early retirement scheme, and 280 INIFAP researchers (i.e., more than a quarter of the institute's scientists) took this opportunity and left the institute more or less immediately. As a result, by March 2008 the total number of fte INIFAP researchers was 743, roughly half the 1991 level.[6] INIFAP lost scientists with PhDs, MScs, and BScs in CENIDs and in CIRs. These scientists were all very experienced; most of them had been working with the institute for decades. Understandably, this has had a tremendous impact on the execution of ongoing R&D projects and the overall success and effectiveness of the organization. Because the Mexican Treasury did not allow the ensuing vacancies to be filled, INIFAP now has to carry out the same work with far fewer resources. A large number of university students are now working at the institute as interns. Although these students are a great resource, they cannot replace the experienced scientists. INIFAP's total research capacity is expected to decline even further in the near future. The average age of the institute's scientist pool is currently 52, meaning that a lot more researchers are up for retirement within the next few decades.

Figure 1—Composition of public agricultural R&D staff, 1991–2007



Sources: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08), Beintema et al. (2001) and a number of agency websites.
Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. Nonprofit agencies account for a negligible share of total capacity and spending and are excluded from these graphs. Staff data for the other government agencies and higher education agencies were unavailable for 1997-2003 and 2007. Staff data were unavailable for INIFAP for 2002-03.

In contrast to INIFAP, Mexico's other government agencies involved in agricultural R&D combined showed a steady increase in their research staff totals during 1991–2006, with an average annual growth rate of 4 percent. Research staff totals at CIAD, IMTA, and CIATEJ rose particularly rapidly throughout this period, whereas totals at INP declined slightly. The situation at INP is similar to the situation at INIFAP. INP research staff have consistently not been replaced, leading to gradually falling researcher totals.

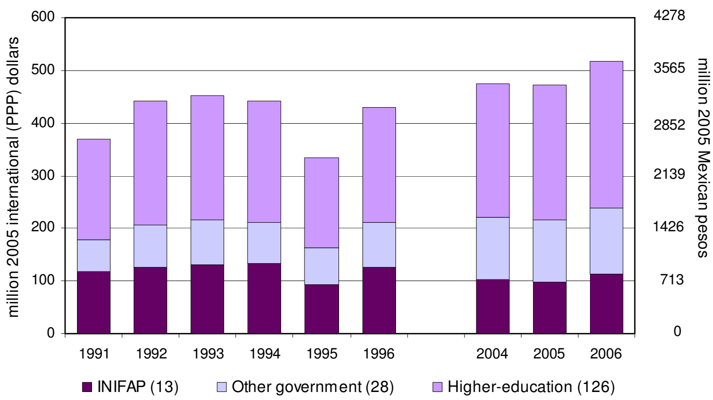
Overall, the number of fte agricultural scientists in Mexico's higher education sector rose from 1,744 to 2,182 ftes during 1991–2006, at 2.3 percent per year. Growth was particularly strong at UACh. This university experienced a 63 percent increase in the number of agricultural researchers during this period, partly due to the fact that student numbers have continued to increase, which has allowed the university to hire more staff. Additionally, the introduction of PhD-level training in 2001 has attracted many additional professionals. Finally, CONACYT recently labeled all UACh's MSc and PhD programs as "excellent." Because CONACYT funding is tied to the number of programs of excellence, UACh has managed to grow. By contrast, ColPos recently lost four programs of excellence. This in combination with falling student numbers has led to a decline of fte research staff at ColPos. Some of the scientists that left ColPos have taken up employment in the private sector where salaries are reportedly higher. The number of research staff at UAAAN fluctuated between 170 and 200 ftes during 1991–2006.

The institutional structure and focus of agricultural R&D in Mexico is now much more diversified, compared with the early 1980s, because of a rapid fall in researcher totals at INIFAP and the increased agricultural research activities undertaken by other government and higher education agencies. In 1981, INIFAP still accounted for 38 percent of Mexico's total agricultural R&D staff. This share has gradually fallen over the years to just 25 percent in 2006. Given the recent departure of 280 INIFAP scientists and expectations of a further decline in research staff numbers, the share of INIFAP in Mexican agricultural R&D staff is foreseen to dwindle further in the near future. Concurrently, the share of other government agencies increased from 14 percent in 1981 to 20 percent in 2006. This was the result of large staff increases at CIAD, IMTA, and CIATEJ. Mexico's higher education sector accounted for 55 percent of total agricultural R&D staff in 2006, up from 48 percent in 1981.

In addition to looking at the agencies by institutional category, one can look at them by region. Central Mexico is by far the largest region in terms of agricultural research staff (Table 2). This region houses the headquarters of the country's two largest agricultural universities (UACh and ColPos), as well as four INIFAP centers and some other large higher education agencies such as UNAM and INP. In 2006, 1,416 fte researchers were active in this region, most of them employed in the higher education sector. With 558, 491, and 466 fte researchers, respectively, the Northwest, the Pacific South, and the Northeast were the second, third, and fourth largest regions in terms of research staff primarily due to the presence of other large INIFAP centers and agricultural universities. The remaining regions employed between 250 and 350 fte researchers in 2006.

Total 1991–2006 public agricultural research spending in Mexico developed erratically, fluctuating around or below the $500 million mark (in 2005 constant prices; Figure 2). The sudden drop in total agricultural R&D spending in 1995 can be attributed to the December 1994 economic crisis, which a sudden devaluation of the Mexican peso triggered. However, the Mexican economy recovered quickly from this crisis. By 1996, total agricultural R&D spending was close to precrisis levels. Overall, INIFAP spending shows an erratic but declining trend. During 1992–96, spending levels were above the $125 million mark (with the exception of 1995, just after the financial crisis). By 2005, spending had dropped to $98 million. However, 2006 spending levels were much higher again ($112 million). Due to the falling number of research staff numbers, salary expenditures have gradually declined, explaining the overall drop in INIFAP spending over the years.

Figure 2—Composition of public agricultural R&D spending, 1991–2006



Sources: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08), Beintema et al. (2001), and a number of agency websites.
Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. Nonprofit agencies account for a negligible share of total capacity and spending and are excluded from these graphs.

Table 2—Composition of public agricultural R&D staff by region, 2006

	Total researchers			Shares			Number of agencies		
	Govern-ment	Higher education	Total	Govern-ment	Higher education	Total	Govern-ment	Higher education	Total
	(in full-time equivalents)			(percentages)					
Northwest	316.3	241.3	557.6	16.9	10.7	13.5	7	15	22
North Center	181.9	92.0	273.9	9.7	4.1	6.6	9	17	26
Northeast	131.6	334.0	465.6	7.0	14.8	11.3	4	16	20
Pacific Center	227.0	111.6	338.6	12.2	5.0	8.2	4	13	17
Center	394.9	1,020.9	1,415.8	21.1	45.3	34.4	8	24	31
Gulf Center	164.3	131.5	295.8	8.8	5.8	7.2	4	16	20
Pacific South	262.0	228.9	490.9	14.0	10.2	11.9	3	16	19
Southeast	189.4	94.0	283.4	10.1	4.2	6.9	3	9	12
Total	**1,867.4**	**2,254.2**	**4,121.6**	**100.0**	**100.0**	**100.0**	**42**	**126**	**168**

Sources: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08) and a number of agency websites.
Notes: The table excludes the 2 nonprofit agencies. Northwest includes the states of Baja California Norte, Baja California Sur, Sinaloa, and Sonora. North Center includes the states of Aguascalientes, Chihuahua, Durango, Zacatecas, and La Laguna. Northeast includes the states of Coahuila, Nuevo León, San Luis Potosí, and Tamaulipas. Pacific Center includes the states of Colima, Jalisco, Michoacán, and Nayarit. Center includes the states of Estado de Mexico, Guanajuato, Hidalgo, Querétaro, Tlaxcala, and Distrito Federal. Gulf Center includes the states of Tabasco, Veracruz, and Puebla. Pacific South includes the states of Chiapas, Guerrero, Oaxaca, and Morelos. Southeast includes the states of Campeche, Yucatán, and Quintana Roo.

INIFAP's annual budget is set to grow according to the Mexican inflation rate. From time to time, INIFAP's director general visits congress to call for more funding, which can lead to temporary budget increases (as was the case in 2006).

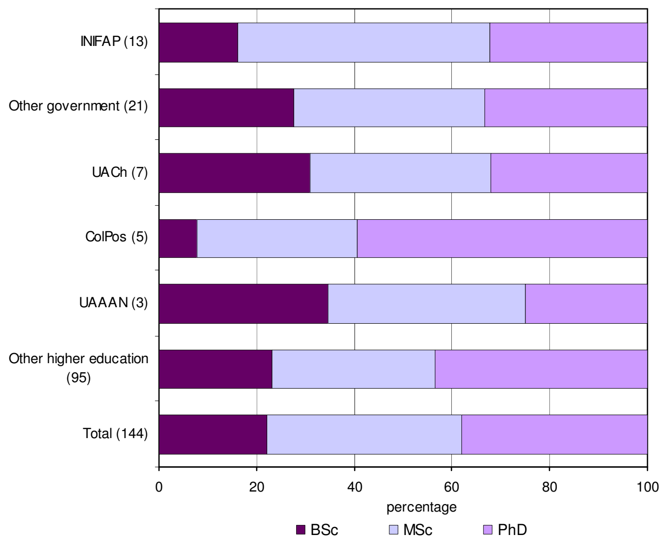
Spending at the other government agencies doubled during 1991–2006. This increase was due mainly to increased spending by CIAD, CIATEJ, and IMTA. Overall, the higher education sector also experienced increases in its agricultural research expenditures over the past decade.

Human Resources

In 2006, 78 percent of the 3,887 fte researchers in our 144-agency sample of Mexican agricultural R&D agencies were trained to the postgraduate level, and 38 percent held Ph.D. degrees (Figure 3), which is one of the highest levels of a sample of 14 Latin American and Caribbean countries (Stads and Beintema 2009). The share of PhD holders at ColPos (59 percent) is significantly higher than in other higher education categories, which is not surprising given that the university offers only postgraduate training. INIFAP employed more scientists with PhD degrees (43 percent) than did the other government agencies, UACh, UAAAN, and the other higher education agencies. Timeseries data were available for 44 public sector agricultural R&D agencies in Mexico. Average qualification levels of staff at these 44 agencies combined have improved considerably over the past decade. In 1996, just two-thirds of fte researchers in the public sector held postgraduate degrees (Figure 4).

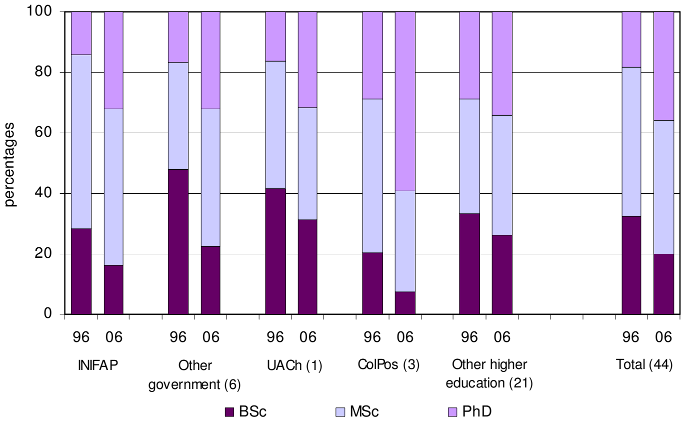
The average share of postgraduate researchers in total research staff increased rapidly in all agency categories during 1996–2006. INIFAP actively encourages its younger scientists (under the age of 48) to pursue postgraduate (mostly PhD) training, and it uses various means to support these scientists. However, as the average age of INIFAP researchers is 52, more than half of the institute's scientists do not qualify for such training. Those who do qualify typically pursue their postgraduate training in Mexico and the United States, with a minor share going to Europe or other Latin American countries. Besides official degree-level training, INIFAP also organizes various short training courses, ranging from one week to six months. The number of PhD holders at ColPos has increased markedly over the past five years due to a program that stimulates MSc holders to pursue PhD training outside ColPos. Similarly, the share of PhD holders at UACh doubled during 1996–2006, from 16 to 32 percent. Most UACh scientists received PhDs in Mexico. Roughly 40 percent were trained abroad, mostly in the United States, but also in Belgium, Canada, France, Canada, Spain, and the United Kingdom. As previously mentioned, CINVESTAV employs no researchers without a PhD degree.

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



Source: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08).
Notes: Figures in parentheses indicate the number of agencies in each category. Timeseries data were available for 18 agencies. Combined, these 18 agencies accounted for 83 percent of Mexican agricultural R&D staff in 2006.

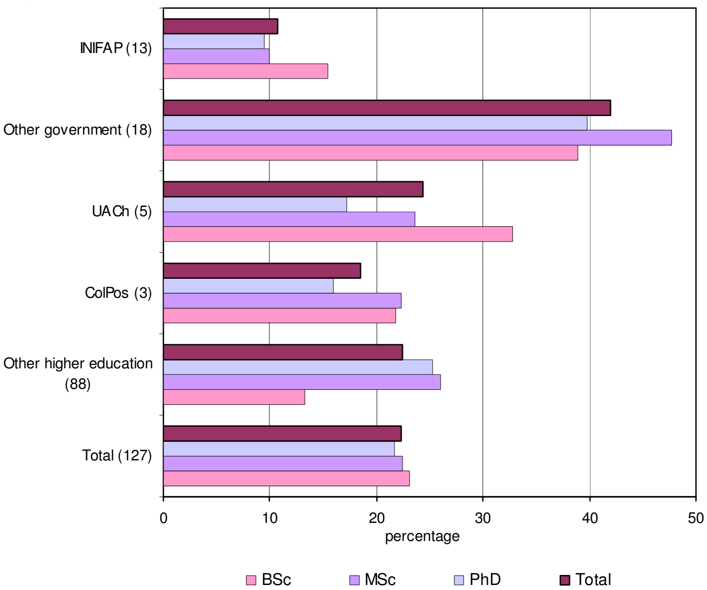
Figure 4—Educational attainment of researchers by institutional category, 1996 and 2006



Sources: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08) and Beintema et al. (2001).
Notes: Figures in parentheses indicate the number of agencies in each category. Data for INIFAP-COMEF were unavailable for 1996. UACh only includes the main campus in Texcoco. ColPos (3) excludes the campuses in Tabasco, Córdoba, and Campeche. Timeseries data were available for 44 agencies. Combined, these 44 agencies accounted for 66 percent of Mexican agricultural R&D staff in 2006.

Despite an increase in the number of women pursuing scientific careers worldwide, women still tend to be underrepresented in senior scientific and leadership positions (IAC 2006). Mexico is no exception. In 2006, 22 percent of Mexico's total fte researchers in a 127-agency sample were women. Overall, the share of women researchers did not differ much among degree levels (Figure 5). Mexico's share of women agricultural researchers as a percentage of total research staff is lower than corresponding shares recorded in other countries in the region, such as Colombia (32 percent), Chile (30 percent), and Costa Rica (26 percent; Stads and Covarrubias Zuñiga 2008; Stads and Romano 2008; Stads et al. 2008). The agencies in the "other government" category employed more women researchers than the other categories did (42 percent). At

Figure 5—Share of female researchers, 2006

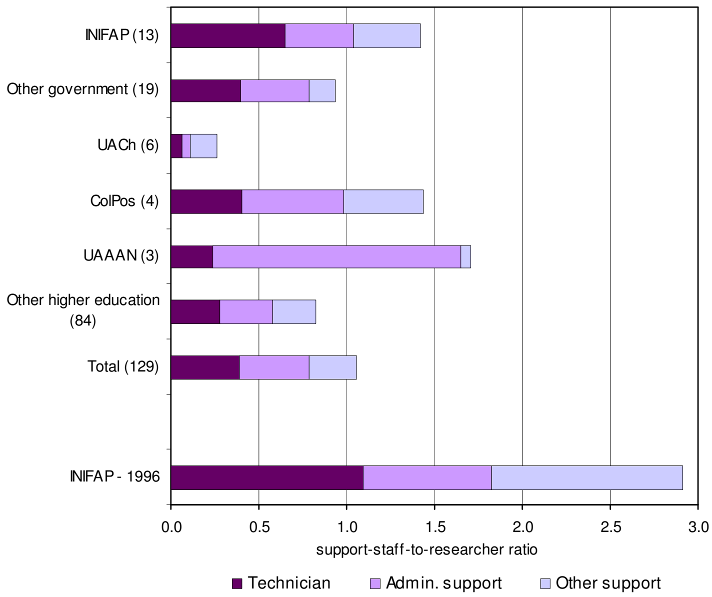


Source: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08).
Note: Figures in parentheses indicate the number of agencies in each category.

INIFAP, on the other hand, just 11 out of every 100 scientists are women. Despite this low share, it still represents an improvement over the agency's 1996 share of just 8 percent.

In 2006, the average number of support staff per scientist in a 129-agency sample for which data were available was 1.1, comprising 0.4 technicians, 0.4 administrative personnel, and 0.3 other support staff such as laborers, guards, and drivers (Figure 6). Average support staff per scientist was higher at UAAAN, ColPos, and INIFAP than in the other three categories. Average support staff per scientist levels have fallen sharply at INIFAP over the past decade. In 1996, the agency employed 2.9 support staff per researcher. By 2006, this figure had halved. Retrenchments occurred in all three support staff categories and were due mainly to the fact that retiring support staff were not replaced either. At CENID-COMEF, for example, five administrative support staff recently took voluntary leave, and only one replacement was contracted in June 2008.

Figure 6—Support-staff-to-researcher ratios, 2006

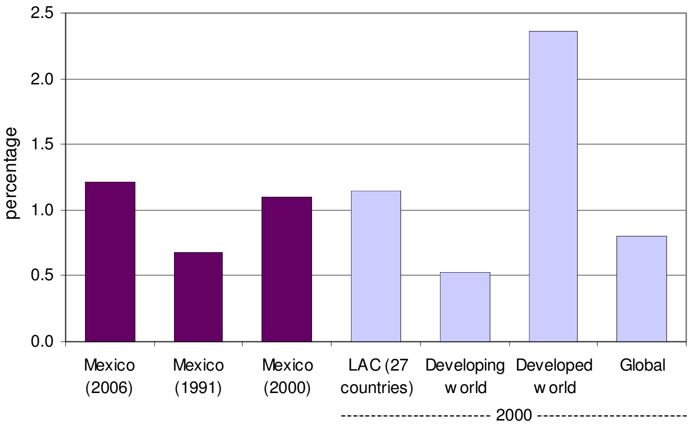


Source: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08).
Note: Figures in parentheses indicate the number of agencies in each category.

Spending

Total public spending as a percentage of agricultural output (AgGDP) is a common research investment indicator that helps to place a country's agricultural R&D spending in an internationally comparable context. In 2006, Mexico invested $1.21 on agricultural research for every $100 of agricultural output, which was 80 percent higher than the corresponding ratio in 1991 (0.67; Figure 7). It is important to note that this increase in Mexico's research intensity ratio is due not only to a rise in agricultural R&D spending but also to a fall of the country's AgGDP levels. During 1991–2006, total Mexican agricultural production value fell by a quarter (in real terms). By way of comparison, the 2006 intensity ratios for other countries in the region, such as Costa Rica (0.93), Guatemala (0.06), and Panama (0.50), were lower than those in Mexico (Stads et al. 2008). The 2000 ratio for Mexico was slightly higher than the reported 2000 average for Latin America and the Caribbean (1.15) but higher than the developing world (0.53) and global averages (0.97; Beintema and Stads 2008).

Figure 7—Mexico's agricultural research intensity compared regionally and globally

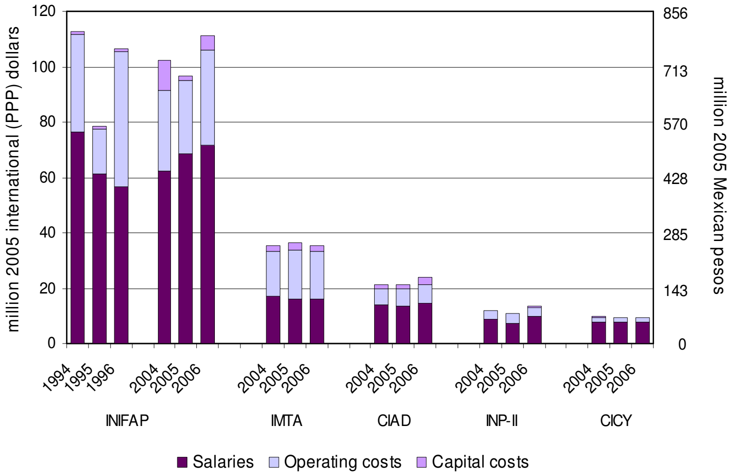


Sources: Mexico data are compiled from Figure 2; AgGDP data are from World Bank (2008); all other intensity ratios are from Beintema and Stads (2008). LAC stands for Latin America and Caribbean.

The allocation of research budgets across salaries, operating costs, and capital costs affects the efficiency of agricultural R&D, and therefore detailed data on cost categories of government agencies were collected as part of this study. In 2006, salaries accounted for 64 percent of total spending of the 13 INIFAP agencies combined, operating costs for 31 percent, and capital costs for 5 percent. At the individual agency level, shares of salary spending in total expenditures ranged from 50 percent at the CIR for the Pacific South (CIRPS) to 84 percent at the CIR for the Gulf Center region (CIRGOC). Operating and capital cost expenditure shares showed similar variation. In 2006, close to one-fifth of CIRPS's total expenditures went to capital investments, mainly for renovations of field stations. INIFAP spent a relatively larger share on capital costs during 2004–06 than it did a decade earlier, which can be explained partly by the 1995 financial crisis (Figure 8). The relative shares spent on salaries, operating costs, and capital costs at IMTA and CICY have not changed much over time, whereas trends at INP-II were somewhat more irregular.

All SAGARPA agencies present their annual budgets to the Secretariat of Finance and Public Credit (SHCP) for ultimate approval by the National Congress. SHCP is in charge of setting all government salaries and salary increases. Salary differences between agricultural R&D agencies are minimal. Differences occur mainly in the field of benefits, which researcher unions secure. Because INIFAP has no such union, INIFAP's benefits are among the lowest in the Mexican agricultural R&D market, and the institute therefore has difficulty attracting the most talented research staff.

Figure 8—Cost category shares in government agencies' expenditures, 1994-2006



Sources: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08) and Beintema et al. (2001).

FINANCING PUBLIC AGRICULTURAL R&D

Mexico has diverse sources of funding for agricultural research, but government contributions continue to dominate. They are distributed in a variety of ways, including block grants to various institutions, special programs, cofinancing, external loans and donations, and competitive funds. The private sector is also involved in funding public research, as will be discussed later. In some cases, producer organizations also finance agricultural R&D. In Sinaloa State, for example, a small foundation called Patronato (which is separate from Fundación Produce Sinaloa) finances horticulture research through income it generates from sales of products.

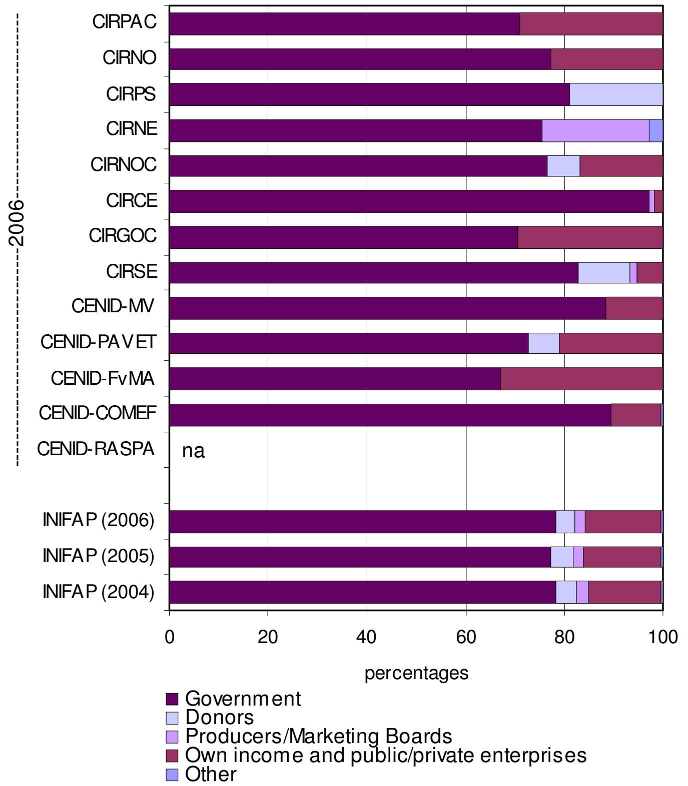
INIFAP

INIFAP relies largely on financial support from the national government. During 2004–06, the Mexican government provided an average of 78 percent of INIFAP's funds (which includes funds disbursed through competitive funds), public/private enterprises 9 percent, internally generated resources 6 percent, and foreign donors 4 percent (Figure 9). Since the mid-1990s, these comparative shares have remained relatively unchanged.

However, a considerable degree of cross-agency variation exists from one INIFAP center to the next. Roughly 30 percent of the budget for agencies like CENID-FvMA and CIRGOC is internally generated. The CIR for the Central Pacific (CIRPAC), on the other hand, received more than a quarter of its total budget from public/private enterprises in 2006. Donor funding was nonexistent or negligible for most INIFAP agencies, with the exception of the CIR for the Southern Pacific (CIRPS) and the CIR for the Southeastern Region (CIRSE), which received 19 and 11 percent, respectively, of their 2006 budget through donor contributions. Producer organizations played a relatively important role (22 percent) in financing the research of the CIR for the Northeastern Region (CIRNE).

The private sector plays a relatively important role in financing INIFAP's research. INIFAP has established agreements with the malt and oil industries. The new varieties that INIFAP researchers breed go straight to these industries. Companies such as Nestlé, MASECA, Peñoles, and Cámara Nacional de la Industria Farmacéutica fund important parts of INIFAP's dairy, maize, forestry, and livestock research, respectively.

Figure 9—Funding sources of INIFAP, 2004-06



Source: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08).
Note: na denotes "not available".

Higher education agencies

Unlike INIFAP, which receives its core funding directly from SHCP without direct interference from SAGARPA, UACh has less financial autonomy and receives its funding through SAGARPA. In 2007, SAGARPA allocated 12 million current Mexican pesos (or 0.7 percent of the university's total budget) to UACh for research activities. It is important to note that this amount excludes salaries for scientists and support staff as well as capital costs. SAGARPA funding is expected to increase to 16 million in 2008 and to 21 million by 2010. Along with SAGARPA funding, competitive funds and funds from state governments play an important role in financing UACh research. Genetic resources research has become UACh's main research theme to attract outside financing. Roughly 9 million pesos are expected for this type of research in 2008. The private sector plays a limited role in financing UACh research. From time to time, Monsanto contracts the university for product validation activities.

ColPos receives the lion's share of its funding from SAGARPA (core funding) and CONACYT (competitive project funding). Donor funding generally plays a limited role in financing agricultural R&D at Mexican universities. FAO and the UNDP have financed small research programs in the past. The private sector finances some ColPos research.

Competitive Funds

Starting in the early 1990s, competitive funds have been adopted as the most important mechanism to allocate public funds for scientific research in Mexico. In the case of agricultural research, two main competitive programs were established: the subprogram for research and technology transfer, managed by the Produce Foundations (FP for its Spanish acronym Fundación Produce), and the Sector Fund for Agricultural Research, jointly managed by SAGARPA, CONACYT, and the National Coordinating Body of Producer Organizations (COFUPRO). To seek increased funding for INIFAP and to encourage research staff to be more responsive to farmers' needs, in 1996 the federal administration negotiated the creation of local FPs with each of Mexico's 32 states. Currently, each FP manages a competitive fund aimed at solving the technological needs of its state (e.g., FP Michoacán and FP Hidalgo). A board consisting of representatives of the federal and state governments and farmers manages each FP. The farmers control the FPs, and the government representatives take on an advisory role. Both the federal and state governments contribute to FP core funding, but farmers and private companies pay a share of specific projects. COFUPRO is the body that represents and coordinates the activities of all 32 FPs. Experiences and best practices of one FP can quickly be shared with others through COFUPRO. The FPs are playing an increasingly important role in financing Mexican agricultural R&D. When they were established in 1996, combined FP funding amounted to US$11 million (in current prices), compared to US$31 million in 2005 (Vera-Cruz et al. 2007).

CONACYT's involvement in agricultural research was limited up until the late 1990s, when its role and power in the definition of Mexico's agricultural R&D agenda gradually increased at SAGARPA's expense. Broadly speaking, CONACYT operates three types of competitive funds: institutional, sectoral, and mixed. In the first case, CONACYT maintains full autonomy for goal setting and management of the funds' resources and structure. In the cases of the sectoral and mixed funds, goal setting and management take place in cooperation with other government agencies and state governments, respectively. These partners provide counterpart funding and receive almost full responsibility for defining the characteristics and technical operation of the funds; CONACYT plays a role as an administrator of the resources. Presently almost all of CONACYT's R&D funding is allocated through competitive funds (Vera-Cruz et al. 2007). CONACYT, SAGARPA, and COFUPRO operate the Sector Fund for Agricultural Research. It has limited resources compared to the FPs. In 2004 and 2005, both peak years, the fund disbursed no more than US$14 million annually (Vera-Cruz et al. 2007). Some important differences exist between the FPs and the Sector Fund for Agricultural Research. The Sector Fund, for example, requires at least two partners in a particular project, whereas the FPs do not. Additionally, CONACYT tends to generously finance a limited number of projects. The FPs, on the other hand, finance many small projects, but the budgets for each individual project are relatively small.

A few other competitive funds with relevance to agriculture exist in Mexico. The National Forestry Commission (CONAFOR) manages the National Fund for Forestry Development (FONADEFO) and the National Water Commission (CONAGUA) manages the Sector Fund for R&D in water. The Ministry of Environment and Natural Resources (SEMARNAT) and the Ministry of Public Education (SEP) also operate competitive funds.

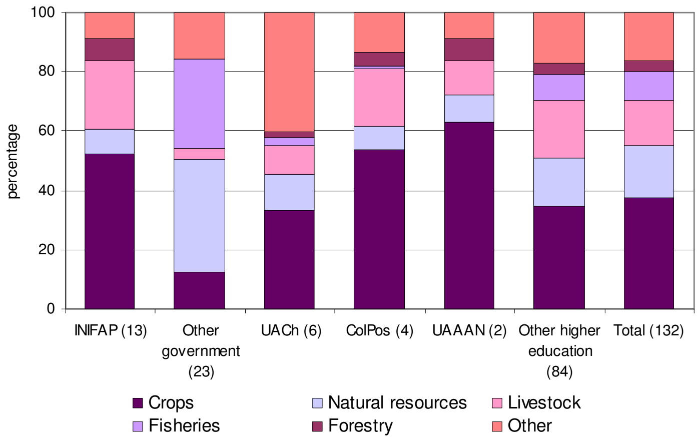
RESEARCH ORIENTATION

The allocation of resources among various lines of research is a significant policy decision, and so detailed information was collected on the number of fte researchers working in specific commodity and thematic areas. In 2006, 38 percent of the 3,803 fte researchers of a 131-agency sample conducted crop research. Natural resources research accounted for 17 percent of the total, livestock research for 16 percent, and fisheries research for 9 percent (Figure 10a). Research staff at the UAAAN, ColPos, and INIFAP spent more than half of their time on crop research. Natural resources and fisheries research was most important at agencies in the “other government” category. INIFAP and ColPos are the most important players in the livestock research field. Forestry research plays a relatively important role at INIFAP and UAAAN. Of note is the relatively high focus on other research themes at UACh (45 percent). This includes more basic research fields.

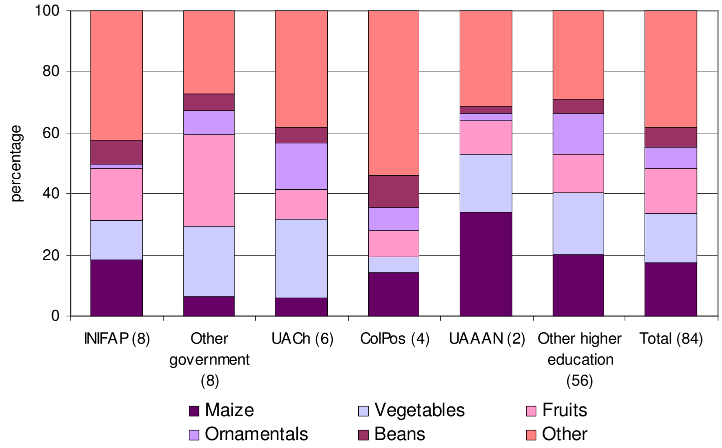
Maize—Mexico’s most important food crop—accounted for 18 percent of all research conducted on crops in the country. Vegetables and fruits accounted for 16 and 15 percent, respectively, ornamentals and beans for 7 percent each, and wheat for 6 percent (Figure 10b). More than one-third of all UAAAN’s crop research is on maize. Maize also represents the most important crop researched at INIFAP and ColPos. Vegetables were most important at UACh; fruit research dominated at the agencies in the other government category. Most livestock researchers focused their research efforts on beef (25 percent), sheep and goats (22 percent), pastures and forages, and dairy (17 percent each; Figure 10c). INIFAP, which has three national research centers dedicated to livestock research (PAVET, FvMA, and Microbiology) carry out 40 percent of Mexico’s livestock research.

Figure 10

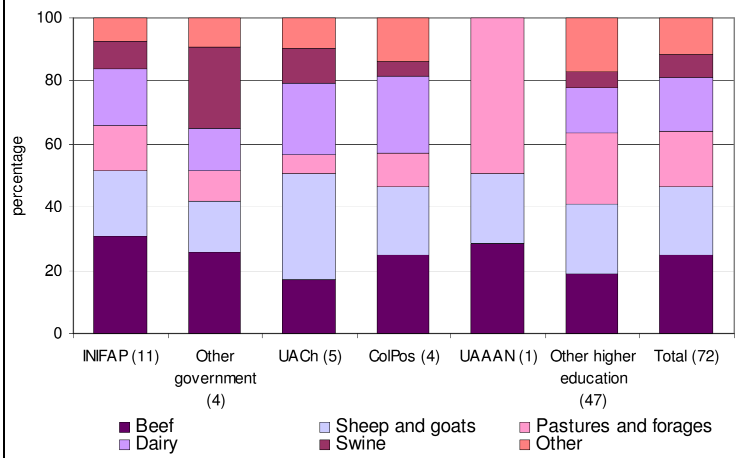
a—Commodity focus by major item, 2006



b—Commodity focus by major crop item, 2006



c—Commodity focus by major livestock item, 2006

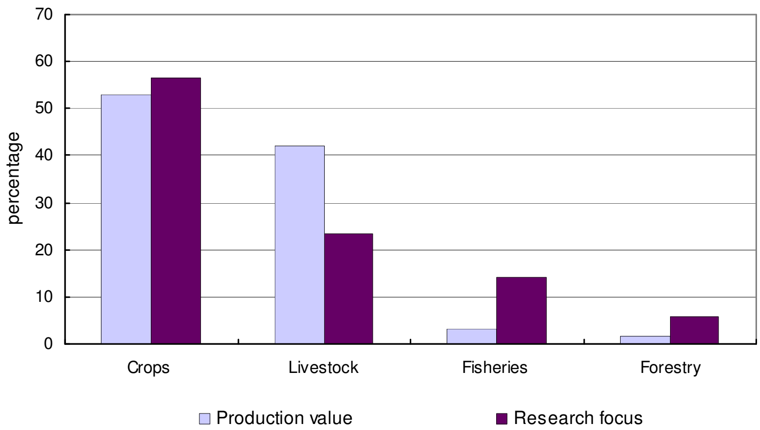


Source: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08).
Notes: Figures in parentheses indicate the number of agencies in each category. Figure 9b only includes agencies involved in crop research; Figure 9c only includes agencies involved in livestock research.

The congruency or parity model is a commonly used method of assessing the allocation of research resources. This usually involves allocating funds (or, in this instance, research personnel) among research areas in proportion to their corresponding contribution to the value of agricultural production. For example, if the value of rice output were twice that of maize, then congruence would be achieved if research on rice were to receive twice as much funding (or, say, employ twice as many scientists) as research on maize. The model assumes that an additional dollar spent on research would yield a higher return if spent in areas with a relatively low ratio of research funding to output value; therefore funds should flow toward programs with relatively low research intensities and from those with high research intensities. If research spending or scientist shares were congruent with the corresponding value of output for a particular commodity then the congruency ratio for that commodity—measuring the commodity share of researchers to the corresponding share of output—would be equal to 1.0.[7]

Figure 11 shows the shares of crops, livestock, and fisheries in gross value of agricultural production with the corresponding share of research staff in these areas. In 2006, 57 percent of the researchers in our subsample (which excludes postharvest and natural resources research) undertook crops research—slightly higher than the share of crops in Mexico's total value of production (53 percent). In contrast, the share of livestock researchers was much lower than its share in total production value, resulting in a congruency ratio of 0.6. The congruency ratios for fisheries and forestry were very high (4.5 and 3.8, respectively).

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



Sources: Compiled by authors from ASTI survey data (IFPRI-INIFAP 2007-08). Production values are from MADR-IICA-OAC (2006).
Notes: Postharvest and natural resources research themes are not included. Production values are for 2005, research focus values are for 2006.

CONCLUSION

Total public agricultural R&D capacity in Mexico has gradually increased over the past two decades. In 2006, the country as a whole employed more than 4,000 fte agricultural research staff, making it the second largest agricultural R&D system in Latin America after Brazil. The institutional structure of the country's agricultural R&D, however, has become increasingly diversified. Since the early 1990s, research staff increases were observed for the higher education sector and government agencies other than INIFAP, whereas totals at INIFAP have continuously declined. The latter suffered a particularly severe blow in December 2007 when the Mexican government announced a voluntary early retirement scheme and INIFAP lost 280 scientists virtually overnight. The average age of INIFAP's current researcher pool is 52, meaning that many more scientists are up for retirement within the next decade.

Total agricultural R&D spending in Mexico has risen gradually since the early 1990s, due mainly to increased investments by the higher education sector and government agencies other than INIFAP. In 2006 Mexico invested $518 million (in constant 2005 PPP prices) in agricultural R&D, or 1.27 percent of the country's agricultural output. A similar shift was seen in the composition of Mexico's public agricultural research spending, with other government agencies and the higher education sector gradually gaining prominence at the expense of INIFAP.

Agricultural R&D in Mexico is largely financed by the national government, with SAGARPA allocating funding to the main agricultural universities and INIFAP receiving funding directly through SHCP. The private sector funds some of the research activities of INIFAP, ColPos, and UACh, but the sector seems to favor contracting with internationally renowned institutes like Tecnológico de Monterrey and CINVESTAV for its research needs. In recent years, a number of competitive funds (at the national, state, and sector level) have become increasingly important in financing agricultural R&D.

Overall, the Mexican public agricultural R&D system appears to be adequately staffed and financed when compared to other countries in the region and developing countries worldwide. However, the very large number of agricultural R&D agencies scattered over the country, often with only a handful of research staff and overlapping research mandates, has made Mexico's agricultural research system somewhat weak and ineffective. It has also created a climate in which a few well-funded agencies producing world-class research operate alongside less productive agencies that are struggling for funding. Greater economies of scope and scale may be achieved if the agricultural R&D agencies in Mexico continue to better integrate their research efforts. A more effective distribution of agricultural research funding and a clear long-term national research strategy that involves both the public and private sector would contribute to this goal.

NOTES

1. The authors are grateful to numerous colleagues in Mexico for their time and assistance with the data collection and thank Pieter Heringa, Kristin Rhondeau, and Jifar Tarekegn for their capable research assistance and Nienke Beintema, Pedro Brajcich Gallegos, and Mario Guerrero for their useful comments on drafts of this brief.
2. The 169-agency sample consisted of:

   - 41 government agencies, of which the major ones are the *Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias* (INIFAP) as well as 8 regional research centers and 5 national disciplinary research centers placed under INIFAP; the *Instituto Nacional de la Pesca; the Centro de Investigación en Alimentación y Desarrollo* (CIAD); the *Instituto de Ecología* (INECOL); the *Instituto Mexicano de Tecnología del Agua* (IMTA); the *Centro de Investigación Científica de Yucatán* (CICY); and the *Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco* (CIATEJ);

   - 2 nonprofit agencies: the *Centro de Investigación para el Desarollo de la Fruticultura en Tamaulipas* and the *Funcación de Desarollo Rural de Matamoros*.

   - 126 higher education agencies, of which the major ones are the *Universidad Autónoma de Chapingo* (UACh); the *Colegio de Posgraduados* (ColPos); the *Universidad Autónoma Agraria Antonio Narro* (UAAAN); the *Universidad Nacional Autónoma de México* (UNAM); the *Instituto Politécnico Nacional* (IPN); the *Universidad Autónoma de Baja California* (UABC); the *Universidad de Sonora* (USON); the *Universidad Autónoma de Chihuahua* (UAC); the *Universidad Autónoma de Nuevo Leon* (UANL), the *Universidad Autonoma de San Luis Potosí* (UASLP); the *Universidad Autónoma de Tamaulipas* (UAT); and *Universidad Veracruzana* (UV).

   For a complete overview of the Mexican agricultural R&D agencies, see the Mexico country profile on the ASTI website http://www.asti.cgiar.org/profiles/mexico.aspx
3. Unless otherwise stated, all data on research expenditures are reported in 2005 international dollars or in 2005 Mexican pesos.
4. Like the International Monetary Fund and the World Bank, ASTI presents all its macroeconomic data in PPP dollars.
5. English translations of agency names have been used throughout the brief except for note 2. The original names in Spanish can be found on http://www.asti.cgiar.org/profiles/mexico.aspx.
6. By May 2008, this total had risen to 769 ftes. In June 2008, INIFAP contracted 62 temporary researchers, an insufficient number to replace the losses incurred earlier in the year.
7. It is important to note, as Alston et al. (1998) describe, that the model overlooks key factors affecting the payoff to R&D, such as the differences in probability of research success, likely adoption rates, and the likely extent of research-induced productivity gains. It also does not account for the spill-in of technologies from other countries or differences in the costs per scientists among different areas of R&D. So, although the congruence rule is a useful tool for allocating resources and a distinct improvement over precedence and some other shortcut methods, congruency ratios that differ from 1.0 are not necessarily a cause for concern.

METHODOLOGY

- Most of the data in this brief are taken from unpublished surveys (IFPRI 2007-08) and Beintema et al. (2001).
- The data were compiled using internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 2002; UNESCO 1984). The authors grouped estimates using three major institutional categories—government agencies, higher-education agencies, and business enterprises, the latter comprising the subcategories private enterprises and nonprofit institutions. The researchers defined public agricultural research to include government agencies, higher-education agencies, and nonprofit institutions, thereby excluding private enterprises. Private research includes research performed by private-for-profit enterprises developing pre, on, and postfarm technologies related to agriculture.
- Agricultural research includes crops, livestock, forestry, and fisheries research plus agriculturally related natural resources research, all measured on a performer basis.
- Financial data were converted to 2005 international dollars by deflating current local currency units with a Mexican GDP deflator of base year 2005 and then converting to U.S. dollars with a 2005 purchasing power parity (PPP) index, taken from World Bank (2008). PPP's are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than conventional exchange rates.
- Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values, especially at the end point of the period.

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

REFERENCES

Alston, J.M., G.W. Norton, and P.G. Pardey. 1998. *Science under scarcity: Principles and practice for agricultural research evaluation and priority setting.* Wallingford, United Kingdom: CAB International.

Beintema, N.M., L.A. Rodriguez del Bosque, G. Moctezuma López, and P. Pardey. 2001. *Agricultural R&D in Mexico: Policy, investments and institutional profile*. Washington, D.C.: International Food Policy Research Institute (unpublished report).

Beintema, N.M., and G.J. Stads. 2008. *Measuring agricultural R&D investments: A revised global picture*. Washington, D.C.: International Food Policy Research Institute.

IAC (Inter-Academy Council). 2006. *Women for science: An advisory report*. Amsterdam.

International Food Policy Research Institute (IFPRI) and National Institute for Forestry, Agricultural, and Animal Husbandry Research (INIFAP). 2007–2008. *Agricultural science & technology indicators survey for Mexico*. Unpublished surveys. Washington, D.C.: IFPRI.

Mexican Institute of Water Technology (IMTA). 2008. ¿Quiénes somos? <http://www.imta.gob.mx/instituto/index.html> Accessed June 2008.

National Science and Technology Council (CONACYT). 2008. Breve historia del CONACYT. <http://www.conacyt.mx/Acerca/Acerca_conacyt.html> Accessed June 2008.

Organisation for Economic Co-operation and Development (OECD). 2002. *Frascati Manual: Proposed standard practice for surveys on research and experimental development.* Paris: OECD.

______. 2007. OECD Science, Technology, and Industry Scoreboard 2007: Briefing note on Mexico. <http://www.oecd.org/dataoecd/19/52/39695478.pdf> Accessed June 2008.

Ibero-American and Inter-American Network on Science and Technology Indicators (RICyT). 2008. Indicadores comparativos. <http://www.ricyt.edu.ar/interior/interior.asp?Nivel1=1&Nivel2=2&Idioma=> Accessed June 2008.

Stads, G.J. and N.M. Beintema. 2009. *Public agricultural research in Latin America and the Caribbean: Investment and capacity trends.* ASTI regional report. Washington, D.C.: International Food Policy Research Institute and Inter-American Development Bank (forthcoming).

Stads, G.J., and C. Covarrubias Zuñiga. 2008. *Chile*. ASTI Country Brief No. 42. Washington, D.C. and Santiago de Chile, Chile: International Food Policy Research Institute and National Agricultural Research Institute.

Stads, G.J., F. Hartwich, and D. Rodriguez. 2008. *Agricultural R&D in Central America: Policy, Investments, and Institutional Profile*. ASTI regional report. Washington, D.C., and San José, Costa Rica: International Food Policy Research Institute and Inter-American Institute for Cooperation on Agriculture.

Stads, G.J. and L. Romano. 2008. *Colombia*. ASTI Country Brief No. 39. Washington, D.C.: International Food Policy Research Institute.

United Nations Educational, Scientific and Cultural Organization (UNESCO), Division of Statistics on Science and Technology. 1984. *Manual for statistics on scientific and technological activities*. Paris, France: UNESCO. [Mimeo].

Vera-Cruz, A.O., G. Dutrénit, J. Ekboir, G. Martinez, and A. Torres Vargas. 2007. *Virtues and limits of competitive funds to finance research and innovation in the agricultural sector: The case of the Mexican Produce Foundations.* Mexico City, Mexico: Global Network for Economics of Learning, Innovation, and Competence Building Systems.

World Bank. 2008. *World development indicator*s 2008. Washington, D.C.: World Bank. [CD-ROM].

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