ASTI AGRICULTURAL SCIENCE & TECHNOLOGY INDICATORS
led by IFPRI

ASTI PRACTITIONER'S GUIDE FOR NATIONAL AND REGIONAL FOCAL POINTS

METHODOLOGY AND DATA COLLECTION STANDARDS

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ABOUT ASTI

Extensive empirical evidence demonstrates that agricultural research and development (R&D) investments have greatly contributed to economic growth, agricultural development, and poverty reduction in developing regions. Numerous international and regional initiatives emphasize the importance of agricultural R&D to achieving the productivity growth urgently needed to feed expanding populations; reduce poverty levels; and address new challenges, such as those imposed by climate change. Agricultural Science and Technology Indicators (ASTI), led by the International Food Policy Research Institute (IFPRI) and operating within the portfolio of the CGIAR Research Program on Policies, Institutions, and Markets (PIM), contributes to this agenda by collecting, analyzing, and publishing quantitative and qualitative information and trends on funding sources, spending levels and allocations, human resource capacities, and institutional developments in agricultural research in low- and middle-income countries. Working with a large network of country-level collaborators, ASTI conducts primary surveys to collect data from government, higher education, nonprofit, and private for-profit agricultural R&D agencies in around 80 developing countries worldwide. ASTI's scope of activities also includes additional policy-relevant analyses of R&D investments, institutions, and human capacities in order to disseminate greater knowledge and understanding of their impact on agricultural development.

ABOUT IFPRI

The International Food Policy Research Institute (IFPRI), established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. The Institute conducts research, communicates results, optimizes partnerships, and builds capacity to ensure sustainable food production, promote healthy food systems, improve markets and trade, transform agriculture, build resilience, and strengthen institutions and governance. Gender is considered in all of the Institute's work. IFPRI collaborates with partners around the world, including development implementers, public institutions, the private sector, and farmers' organizations.

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ACRONYMS

AgGDP	agricultural gross domestic product
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASTI	Agricultural Science and Technology Indicators
CORAF/WECARD	West and Central African Council for Agricultural Research and Development
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FTE(s)	full-time equivalent(s)
GTZ	German Agency for International Cooperation
IFPRI	International Food Policy Research Institute
JICA	Japan International Cooperation Agency
LAC	Latin America and the Caribbean
OECD	Organisation for Economic Co-operation and Development
PPP(s)	purchasing power parity (exchange rates)
R&D	research and development
SADC	Southern African Development Community
SA	South Asia
SEAP	Southeast Asia and the Pacific
SSA	Africa south of the Sahara
UNESCO	United Nations Educational, Science, and Cultural Organization
USAID	United States Agency for International Development
WANA	West Asia and North Africa

1. INTRODUCTION

Agricultural Science and Technology Indicators (ASTI) data collection activities were rather ad hoc in the past and focused mainly on updating out-of-date datasets. The initiative is undergoing a process of transformation with the goal of a sustainable, decentralized system of frequent data compilation and analysis. This transition involves institutionalizing regular data collection via a network of national and regional focal points to facilitate more frequent data gathering, synthesis, and analysis. Its purpose is to enhance local ownership of the data and stimulate fuller use of the datasets for country-level advocacy and analysis purposes. More continuous data collection is already enabling closer monitoring of trends in agricultural research and development (R&D) investment and capacity.

Like its predecessor projects at the International Food Policy Research Institute (IFPRI) and the International Service for National Agricultural Research (ISNAR), ASTI has amended and improved its list of indicators over the years. It has also refined the underlying definitions and data collection procedures, based on its own experience and consultation with partners during the various national survey rounds. This ***PRACTITIONER'S GUIDE FOR NATIONAL AND REGIONAL FOCAL POINTS*** sets out the definitions and procedures currently in use by ASTI and its network of national and regional focal points. The aim of the guide is to help practitioners implement the national survey rounds while enhancing their understanding of the ASTI datasets, stimulating better use of the datasets at the national and regional level.

2. OVERVIEW

CURRENT INDICATORS AND DATA AVAILABILITY BY REGION

National survey rounds have been rather ad hoc in the past, focusing on one region at a time depending on the availability of funds. As a result, most regional data collection has been limited to updating datasets. ASTI uses various indicators to measure agricultural research investment and capacity. Table 1 summarizes these, as well as the regions and time periods covered.

Table 1. ASTI indicators and geographical and time coverage as of 2017

Indicator	Regions and years covered	Details
Human resources		
Professional research staff	- SSA: 1971–2014 - SA: 1981/91– 2009-2012/14 - SEAP: 1981/91–2002/03 - LAC: 1971–1996, 2006-2012/13 - WANA: 1991/96–2012	- By degree level (PhD, MSc, and BSc) - Collected for multiple years - Government, higher education, and nonprofit
Professional female research staff	- SSA: 2000/01; 2008; 2011; 2014 - SA: 2002/03 2009; 2012/14 - SEAP: 2002/03 - LAC: 2006; 2012/13 - WANA: 2012	- By degree level (PhD, MSc, and BSc) - By age group (<30, 31–40, 41–50, 51–60, >61) - Government, higher education, and nonprofit
Professional research staff by age group	- SSA: 2011; 2014 - SA: 2009-2012/14 - LAC: 2012/2013 - WANA: 2012	- By degree level (PhD, MSc, and BSc) - By gender - Government, higher education, and nonprofit
Professional research staff by discipline	- SSA: 2014 - India: 2014	- By degree level (PhD, MSc, and BSc) - Government, higher education, and nonprofit
Research focus by subsector	- SSA: 2000/01; 2008; 2011; 2014 - SA: 2002/03; 2009; 2012/14 - SEAP: 2002/03 - LAC: 1996; 2006; 2012/13 - WANA: 2012	- Includes crops, livestock, forestry, fisheries, postharvest, natural resources, socioeconomics - Government, higher education, and nonprofit
Research focus by crop and livestock items	- SSA: 2000/01; 2008; 2011; 2014 - SA: 2002/03; 2009; 2012/14 - SEAP: 2002/03 - LAC: 1996; 2006; 2012/13 - WANA: 2012	- Includes ± 20 crops, ± 6 livestock items, and ± 6 other items - Listed crops differ by region - Government, higher education, and nonprofit
Thematic research focus	- SSA: 2000/1; 2008 - SA: 2002/03; 2009; 2012/14 - SEAP: 2002/03 - LAC: 1996, 2006; 2012/13 - WANA: 2012	- Includes ± 4 themes related to crops, ± 5 to livestock, and ± 7 other - Government, higher education, and nonprofit

Indicator	Regions and years covered	Details
Technicians	- SSA: 2001–2011; 2014 - SA: 1996–2009-2012/14 - WANA: 2009–12	- By degree level (PhD, MSc, BSc, other/without diploma) - By gender - Government, higher education, and nonprofit
Support staff	- SSA: 1991–2011; 2014 - SA: 1996–2012/14 - SEAP: 1991/96–2002/03 - LAC: 1991–96; 2004–2012/13 - WANA: 2009–2012	- By administrative and other support - Government, higher education, and nonprofit
Number of students enrolled	- SSA: 2009–2012; 2014 - SA: 2009–2012 - LAC: 2007–2013 - WANA: 2009–2012	- By degree level (PhD, MSc, and BSc) - By gender - Higher education
Number of students graduated	- SSA: 2014 - SA: 2009–2012 - LAC: 2007–2013 - WANA: 2009–2012	- By degree level (PhD, MSc, and BSc) - By gender - Higher education
Financial resources		
Research expenditures	- SSA: 1971–2014 - SA: 1981/91–2012/14 - SEAP: 1981/91–2002/03 - LAC: 1971–1996, 2004–2012/13 - WANA: 1991/96–2012	- By salaries, operating costs, and capital investments - Government and nonprofit
Funding sources	- SSA: 1991, 2000/1–2014 - SA: 1996; 2009–2012/14 - SEAP: 1996; 2002/12 - LAC: 1996, 2004–2012/13 - WANA: 2009–2012	- Government, (multilateral and bilateral) donors, producers and marketing boards, public and private enterprises, own income, other - Sources differ by region and by country - Government and nonprofit
Research outputs		
Peer-reviewed publications	- SSA: 2012–2014 - SA: 2010–2012	- By international, regional, and national journals; books; and book chapters - Main government and higher education agencies
Varieties released	- SSA: 2012–2014 - SA: 2007–2012	- By name of crop, type of crop, key traits of crop, year of release, and type of protection (if any) - Main government agencies
Release of noncrop products and technologies	- SSA: 2012–2014 - SA: 2007–2012	- By name of product, type of product, year of release, and type of protection (if any) - Main government agencies

Source: ASTI datasets.

Notes: LAC = Latin America and the Caribbean, SA = South Asia, SEAP = Southeast Asia and the Pacific, SSA = Africa south of the Sahara, WANA = West Asia and North Africa. Country coverage from 2001 to 2014 includes 34 countries in SSA, 5 countries in SA, 6 countries in SAEP, 15 countries in LAC, and 9 countries in WANA. Yearly coverage applies for most, but not all, countries. "/" between years means that timeseries data is available for the first or second year.

CHALLENGE: Boundaries of ASTI datasets

ASTI has chosen to limit itself to agricultural R&D rather than expanding to include indicators on the multiple dimensions of the agricultural innovation process. Appropriate national-level measures for agricultural innovation remain difficult to develop. Even the role of agricultural R&D warrants further study, especially with regard to the contribution of R&D to agricultural innovation performance. There is no clear consensus as to how such research can best be done. Analysis on these issues, though important, is not ASTI's core business.

ASTI has traditionally focused on measuring inputs into agricultural R&D, rather than outputs or outcomes. It recognizes, however, that the latter are key supplementary indicators for assessing agricultural R&D performance. R&D outputs are difficult to measure at the national level and over time, in addition to being hard to compare internationally. Since 2014, ASTI has initiated analysis on agricultural R&D outputs in select regions.

IMPLEMENTATION OF NATIONAL SURVEY ROUNDS

ASTI conducts national survey rounds in close collaboration with "focal points," most of whom are based at national agricultural research institutes. In some cases, the national focal point is a consultant or agency other than the national agricultural research institute itself. In a few instances, it is a regional organization, which may be responsible for multiple countries. At the start of each national survey round a complete list is compiled of all agencies involved in agricultural R&D. Each agency is approached to participate. Three survey forms are used: one for government and nonprofit agencies, one for institutions of higher education, and one for the private sector. Each type of form has different sets of questions. Those for government and nonprofit agencies are the most detailed. In general, the forms have five sections:

- **Institutional details:** basic information such as address, affiliation, and organizational structure.
- **Human resources:** number of researchers and technicians employed, degree levels, the proportion of time that various staff spend on research, the age distribution of research staff, the number of women researchers, researcher discipline background, and support staff by various categories.
- **Financial resources:** research expenditures by cost category and sources of funding.
- **Research focus:** commodities and program focus of the research conducted.
- **Research outputs:** new varieties and technologies that are released, and the number of publications R&D agencies produce.

Time-series data are collected for three main indicators: research totals (by degree if possible), expenditures (by cost category if possible), and funding sources. The remaining indicators are collected

for benchmark years for use in cross-country comparisons. Additional qualitative information is gathered during country visits through in-depth meetings with various agencies and through a qualitative survey. These provide a fuller picture of developments in agricultural R&D than could be generated with quantitative data alone.

OECD FRASCATI MANUAL

ASTI collects and processes its datasets using standard procedures and definitions developed by the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Science, and Cultural Organization (UNESCO). These are described in the *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*. The manual was originally published in 1963 as a handbook for science and technology studies in OECD countries. It has since become the global standard for both national and international organizations and has been revised numerous times. The manual, along with other publications in "the Frascati Family,"[1] is a key tool for understanding the role of science and technology in economic development.

CHALLENGE: Suitability of the *Frascati Manual* for use in developing countries

The procedures and definitions in the *Frascati Manual* were developed by and for industrialized countries. They are therefore not always directly applicable to R&D statistics in the developing world. While ASTI's methodology is largely based on procedures in the *Frascati Manual*, it has made some adjustments to align its data collection activities better with the nature of its subject-matter: measuring agricultural R&D indicators in developing countries.

[1]These OECD reports are *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development* (2002) <web link>, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (2005) <web link>, and *Manual on the Measurement of Human Resources Devoted to S&T: Canberra Manual* (1995) <web link>.

3. GENERAL DEFINITIONS AND PROCEDURES

RESEARCH AND DEVELOPMENT

The *Frascati Manual* (2002) <web link> defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge….. and the use of this stock of knowledge to devise new applications." It goes on to categorize R&D as basic research, applied research, and experimental development. ASTI currently does not divide R&D into these more specific areas. The manual also lists a number of areas that are not considered to fall under the definition of R&D. The most important of these categories in relation to agricultural R&D are the following four:

- **Education and training.** However, research conducted by PhD students at universities, is included, if possible.
- **Science and technology information services.** Specialized activities to collect, code, record, classify, disseminate, translate, analyze, and evaluate data are considered R&D only when they are conducted primarily for the purpose of R&D support.
- **General purpose data collection.** In relation to the agricultural sector, this means that topographical mapping and geological, oceanographic, and meteorological surveying are not defined as R&D, though such activities are often conducted within fisheries, forestry, and natural resource management agencies.
- **Administration and other support activities.** Activities related to the financing of R&D and indirect support are not included. However, administration and clerical activities that are exclusively for R&D are included. For example, administration of an agricultural research institute is considered to be part of R&D.

CHALLENGE: What activities do and do not support R&D?

It is sometimes difficult to identify which activities should be included and which should be omitted from agricultural R&D statistics. No all-encompassing definition exists. For example, ASTI includes agricultural extension and training in its R&D statistics only when it is done by an agency that is focused entirely on R&D.

RESEARCH PERFORMER

ASTI measures the human and financial resources invested by "performers" of agricultural R&D. The "performer" is the entity that carries out the research, not the funder of the research. Agricultural R&D agencies often derive funding from multiple sources, including the private sector. In such cases, the government R&D agency is considered the performer, not the private-sector enterprise funding the research.

NATIONAL RESEARCH

Up until now ASTI has focused on national agricultural research systems. The concept of "national" refers to domestically targeted research activities that are funded or executed by the research agencies within a particular country. Therefore, research activities undertaken by international and bilateral research agencies are excluded unless they are executed by national institutes. Also excluded are research activities undertaken by short-term development projects.

CHALLENGE: Including R&D beyond the national level

Research conducted by international entities and foreign-owned organizations plays an important role in developing countries. To incorporate these contributions, the *Frascati Manual* recommends creation of a "foreign institution" sector. This category is particularly relevant for the agricultural R&D sector, which includes the 15 centers of the CGIAR Consortium, various other international organizations, and a number of foreign governmental and nonprofit agencies that have research units in developing countries. ASTI has maintained data on CGIAR research spending, but not on CGIAR human resources (the latter are collected through the CGIAR Gender and Diversity Program). The "foreign institution" category is expected to become increasingly relevant for the ASTI data with the ongoing enhancement of regional agricultural research. In Africa, in particular, plans are being made to create agricultural R&D "centers of excellence."

AGRICULTURE

ASTI defines agricultural research to include research on crops, livestock, forestry, fisheries, natural resources, and the socioeconomic aspects of primary agricultural production. Also included is research concerning the ***on-farm*** storage and processing of agricultural products, commonly referred to as postharvest or food-processing research. R&D in the agrochemical industry, agricultural machinery, and the food processing industry ***off farm*** is not included in the current ASTI data (these are better reported under those industries). Also not included are the more discipline-oriented basic research activities undertaken by departments such as microbiology and zoology, except when this work has a clear focus on agriculture. Strict delineations, however, cannot always be made.

CHALLENGE: Food-processing R&D in advanced developing countries

A large number of agricultural R&D agencies, especially those in the more advanced developing countries, conduct research related to food processing and agribusiness concerns. Strictly speaking, these R&D activities should be reported under the manufacturing sector instead of under agriculture.

INSTITUTIONAL CATEGORIES

ASTI groups "performers" of agricultural R&D into different institutional categories, including government agencies, institutions of higher education, nonprofit institutions, and private for-profit agencies. The latter category includes businesses and public (for-profit) enterprises. Public enterprises exist in only a handful of countries, mostly in Asia (for example, China and India). In most cases, the country and regional-level data reported by ASTI exclude the private for-profit sector.

Table 2. Sector and institutional classifications for measuring resources invested in agricultural R&D

Institutional categories		Definitions
1. Government		Research organizations directly administered by the national government, typically as a department or arm of a ministry
2. Higher education		Academic agencies that combine university-level education with research; they include agricultural faculties, as well as specialized R&D institutes administered by universities
3. Nonprofit		Agencies not directly controlled by the national government and without an explicit profit-making objective; in the agricultural sector these agencies are often linked to producer organizations or commodity boards
4. Private for-profit	4a. Business	Entities with the primary aim of producing goods and services for profit; some of these companies have a R&D unit dedicated to agricultural research, though R&D is generally not their main activity
	4b. Public enterprises	Enterprises that are owned by government units; their primary activity is typically the marketing and sale for profit of goods and services, which are often produced by private enterprises

Source: Compiled by authors from the *Frascati Manual* 2002<web link>.

CHALLENGE: Blurring institutional boundaries

Increasing diversity in the structure of agricultural research agencies has made it more difficult to classify an R&D unit as "government," "higher education," or "nonprofit." In addition, the boundaries between public and private research are becoming increasingly blurred. The *Frascati Manual* developed a decision tree to assist statisticians in assigning the proper institutional classification. Nonetheless, some ambiguous situations remain. In some of these cases ASTI follows the *Frascati Manual*'s institutional classification; but in other cases it has developed its own classification scheme. For example, a number of government research agencies have a semi-public or a semi-autonomous status. Their administrative control is nongovernmental, but they continue to depend on government for funding. Examples include the Colombian Corporation for Agricultural Research (CORPOICA) and the National Institute for Agricultural Research (INIA) in Uruguay. ASTI follows the *Frascati Manual* in classifying these institutions as government agencies. The National Agricultural Research Center (CNRA) in Côte d'Ivoire, on the other hand, is largely funded by the private sector. Although ostensibly a private company, CNRA still falls under the supervision of the Ministry of Higher Education and Scientific Research, from which it derives the public share of its funding, and is mandated to undertake research for the general public. Following the *Frascati Manual*, ASTI also classifies CNRA as a government agency.

CHALLENGE: Private-sector coverage

Obtaining complete and accurate agricultural R&D investment data for private for-profit enterprises is very difficult. Many private companies are reluctant to share information on their agricultural R&D resources and investments due to confidentiality concerns. In addition, private research activities in low-income and middle-income countries tend to be small in scale and ad hoc, making it difficult for surveyors to capture full information. Obtaining private-sector data requires an approach that is very different from ASTI's usual survey work.

4. HUMAN RESOURCE DEFINITIONS AND PROCEDURES

PROFESSIONAL RESEARCH STAFF

Professional research staff are counted as all individuals employed in a formal research position within an organization and holding at least a BSc degree or equivalent (that is, at least three, but usually four, years of full-time university training). This includes long-term consultants and contractual research staff, as well as managers (for example, directors, deputy directors and heads of research program). Only staff on-post should be included (that is, excluding any staff away on long-term unpaid leave and positions approved but not filled).

TECHNICAL AND OTHER SUPPORT STAFF

ASTI identifies three levels of support staff:

- **Technical support staff.** Those who directly support the design and conduct of agricultural research activities but do not hold a formal research position are classified as technical support staff. These employees have at least a secondary education level (i.e., high-school or middle-school) plus additional technical training. Some technical support positions may require a university degree. Examples of these are laboratory and field technicians and station managers.
- **Administrative support staff.** Personnel who carry out secretarial and administrative tasks and have at least a secondary education plus additional professional training are classified as administrative support staff. Examples are accountants, computer personnel, personnel managers, and secretaries.
- **Other support staff.** Included in this category are various remaining staff positions not classified in any of the above categories. Examples are drivers, laborers, and guards.

CHALLENGE: Professional research staff versus support staff holding a university degree

In some countries, an expanding pool of support staff (technicians, research assistants, and laboratory assistants) have obtained bachelor's, master's and even occasionally, doctorate degrees, but do not hold an official researcher position. This may be because at least a master's degree is required for scientific posts, for example, as at the Senegalese Agricultural Research Institute (ISRA). Or promotion opportunities may be limited due to a fixed number of approved scientific positions combined with an increasing access to degree training for junior staff, for example, as at Uganda's National Agricultural Research Organisation (NARO). In contrast to the situation in Uganda and Senegal, technical support staff at Tanzania's Directorate of Research and Development (DRD) are promoted to the researcher level upon obtaining their bachelor's degree.

ASTI accounts for such differences by collecting technician data by degree level. This also recognizes that technical staff with a bachelor's degree are a component of the future pool of agricultural scientists.

TIME SPENT ON RESEARCH VERSUS OTHER ACTIVITIES

ASTI calculates its human resource and financial data in full-time equivalents (or "FTEs"). Its method takes into account the proportion of time that researchers spend on R&D versus other activities. University employees, for example, spend the bulk of their time on activities other than research, such as teaching, administration, and student supervision. These hours are excluded from ASTI calculations of human resources invested in agricultural R&D. Thus, four faculty members estimated to spend 25 percent of their time on research would individually represent 0.25 FTE and collectively be counted as 1.0 FTE.

DEGREE QUALIFICATIONS

ASTI collects time-series data on university qualifications of professional research and technical support staff by degree (PhD, MSc, and BSc). If the degree-level equivalent is unclear, the following scale is applied:

- **Research doctoral degrees (e.g., PhD, DSc).** Equivalent to more than six years of full-time university education, including a doctoral thesis.
- **Master's degrees (e.g, MSc, MEcon, MPhil).** Equivalent to five to six years of full-time university education.
- **Bachelor degrees (e.g., BSc, BVM, BPhil).** Equivalent to at least three (but usually four) years of full-time university education. This category also includes staff with honors degrees.

CHALLENGE: Degree levels in non-Anglophone countries

ASTI collects data on the number of researchers with PhD, MSc, and BSc degrees. However, universities in many countries offer a much larger variety of academic degrees. Classifying these degrees into the simple PhD-MSc-BSc system is not always easy. Although France has harmonized its academic degree system with those of other European countries, the university systems in many former French colonies in Africa are still based on the old French system. Some small differences remain across francophone African countries, but as a general rule, degrees from francophone universities correspond to the following PhD-MSc-BSc equivalents:

- PhD = Doctorat
- MSc = Doctorat de médicine vétérinaire, DESS, DEA, master, maîtrise, ingénieur
- BSc = Licence

Degree systems in Spanish- and Portuguese-speaking countries are similar to those in the anglophone world.

EXPATRIATE RESEARCH STAFF

Many African agricultural research systems were staffed by expatriates in the 1960s. After independence, most countries made great strides in nationalizing their research capacity. The share of expatriate workers in African agricultural R&D gradually declined and is now negligible in most places. There are countries, however, where expatriates still play a key role in national agricultural research. As expatriates are paid by their mother institutes, expatriate salaries do not show up on the payroll of national agricultural research institutes. Nonetheless, it is important to capture the number of expatriate researchers (in FTEs) active in a country to get a complete picture of agricultural R&D investment and capacity.

ASTI defines an expatriate researcher as a person sent by a development cooperation or international agency to carry out long-term research (one year or more) at an agricultural research agency in a developing country. ASTI estimates the average cost of an expatriate researcher based on salaries and benefits of outposted CGIAR staff. This assumes that that most expatriate researchers from North America, Europe, and Australia receive similar salaries and benefits.

CHALLENGE: Foreign researchers working abroad independently

The expatriate category excludes foreign researchers working independently at another institute within the region; for example, a Ugandan researcher taking up employment at a research institute in a neighboring country. Furthermore, the salaries and benefits earned by outposted researchers differ, depending on the expatriate's country of origin and the place of employment. For example, the case of a North Korean researcher working at the Guinean Agricultural Research Institute (IRAG) is quite different from a CGIAR researcher working in Africa. Adjustments have to be made to accurately calculate the average cost of these expatriate researchers. It is therefore important to collect information on the country of origin of foreign researchers working abroad.

GENDER

Professional research staff and technician data by degree are classified by gender for benchmark years. As a number of agencies and programs seek to encourage women to pursue careers in agricultural science, this indicator helps to track progress over time in achieving greater gender parity.

POSITION

Professional research staff are classified by gender and position for benchmark years for non-Francophone Africa countries and for India. In Francophone Africa, position titles are more difficult to standardize and are therefore not collected. Position data are only available at the agency-level, and are not yet aggregated at the national level.

DISCIPLINE

ASTI recently began collecting data on discipline by degree for benchmark years. Specified disciplines include five in crop sciences, seven in animal sciences, forestry, fisheries, soil science, other natural resources areas, and socioeconomics among others.

DEMOGRAPHIC STRUCTURE OF PROFESSIONAL RESEARCH STAFF

Age is an increasingly important indicator because many research agencies have an aging pool of scientists with a larger number of staff set to retire in the coming years. ASTI therefore collects data on the number of professional staff by age group ("under 31 years," "31–40 years," "41–50 years," "51–60 years," "over 60 years"), by degree.

COMMODITY FOCUS OF PROFESSIONAL RESEARCH STAFF

ASTI collects detailed information on the share of researchers working in about 40 specific commodities. These include more than twenty field and horticultural crops, five livestock items, pastures and forages, forestry, marine fisheries, inland fisheries, agricultural engineering, off-farm postharvest R&D, natural resources, and socioeconomics. Nonetheless, it is not always possible to associate all researchers with one of the commodity-specific categories. For example, a soil scientist working as part of a wheat research program would fall under the wheat commodity category, but if the soil scientist was not part of a commodity program, the researcher would be recorded in the natural resources category.

In addition, ASTI requests a list of the agency's formal research programs, along with a breakdown of the number of FTEs of professional research staff assigned to each.

STUDENT ENROLLMENTS AND GRADUATES

ASTI recently expanded its data coverage to include the number of female and male students enrolled in and graduated from institutions of agricultural higher education. This provides an indication of the future pool of agricultural scientists and professionals in developing countries.

5. FINANCIAL RESOURCE DEFINITIONS AND PROCEDURES

SPENDING

ASTI requests survey respondents to provide actual expenditure figures, not budgeted or projected expenditures. Spending data is recorded in thousands in the current local currency in the reporting year.

If the financial year does not match the calendar year, expenditures are reported in the calendar year that covers most of the financial year. For example, if the 2015/16 financial year starts 1 April, costs incurred until 31 March 2016 are to be reported under 2015. If the 2015/16 financial years starts 1 July, all costs incurred from 1 July 2015 to 30 June 2016 are to be reported under 2016.

COST CATEGORIES

ASTI collects three categories of detailed cost data from government and nonprofit agencies:

- **Salaries.** All staff remuneration expenditures are reported here such as wages, pension plan contributions, insurance premiums, child education and housing allowances. This category also includes the labor cost of temporary staff like day laborers and long-term consultants, which is often mistakenly included under operating expenditures.
- **Operating and program expenditures.** Items such as gasoline, electricity, stationery, books, agricultural inputs, staff training, travel, and per diem expenses are included here. Running costs and maintenance of buildings, cars and equipment are reported here as well.
- **Capital expenditures.** All expenditures related to the purchase or rental of items that last longer than a year are reported in this category. Examples are research equipment, furniture, computers, cars and vehicles, land and buildings. Depreciation costs (and interest charges) for past capital investments are also included here.

CHALLENGE: Devaluation and redenomination of currencies

ASTI collects time-series data on expenditures and funding sources in thousand local currency units. Changes in a currency (such as devaluations or redenominations) therefore make collecting financial data complex. For example, in July 2007, Ghana replaced the old Ghanaian cedi with the new Ghanaian cedi at an exchange rate of 1 to 10,000. In such a case, it is important to make sure that all participating agencies express spending in the same currency units.

The introduction of a new currency (such as the euro in 2002) can also complicate the collection of time-series data. It is important to be certain in what currency historical data are provided. In a few exceptional cases, it may be impossible to collect data in local currency units. Hyperinflation in Zimbabwe in 2006–2009, for example, caused great difficulties in converting data collected in Zimbabwean dollars.

FUNDING SOURCES

All funds actually received within a (fiscal) year are to be reported, not budgeted or projected funds. Sources of funding are indicated for all salaries, operating and program costs, and capital investments. Funding source categories are as follows:

- **Government core allocations.** This category is made up of direct institutional funding derived from a central budget, such as funds provided by a supervisory ministry for day-to-day operations and salaries.
- **Other government allocations.** This category is for reporting government funding that complements annual appropriations from national budgets, for example, in the form of competitive funds and science and technology funds.
- **Loans from multilateral donors.** Loans, for example, from the World Bank, are reported here.
- **Grants from multilateral and bilateral donors and private foundations.** This category is for reporting grants from multilateral donors, such as the World Bank (excluding its loans), the African Development Bank, FAO, and the European Union, and from bilateral donors, such as USAID, JICA, GTZ, and the Government of France. Grant providers may also be regional or international organizations and entities, such as CGIAR centers, FARA, ASARECA, CORAF/WECARD, and SADC. Or grants may be awarded by private foundations such as the Bill & Melinda Gates Foundation.
- **Commodity levies and producer organizations.** Funding provided through commodity taxes levied on agricultural production and exports are reported here.
- **Sale of goods and services.** Income to be reported in this category includes earnings from contract research for public and private enterprises.
- **Other.** Funds from sources other than the above categories should be reported here.

CHALLENGE: Mismatching cost and funding categories

Agencies' financial reporting systems do not always match the classifications used by ASTI. This can make it difficult to extract data according to the definitions outlined above. If necessary, follow-up queries should be submitted to clarify the details underlying the financial data provided. Footnotes can be used if the definition of a data category differs from ASTI's usual practice.

Expenses incurred and funding received may not match in a given year, as funding for multi-year projects may reach institutions at the start of a project and budgeted costs may not yet be realized at year's end. Occasionally large discrepancies are found between funding and spending data. Often, these are due to agencies having forgotten to report the source of salary outlays (in many cases, salaries are funded from a different government source than operating and capital expenditures). In many other cases, discrepancies are more difficult to explain and require additional delving into the financial records of the agency.

CHALLENGE: Funding for research within institutions of higher education

Research expenditure data has been difficult to compile for the higher education sector. The data obtained in the past were often limited to spending explicitly earmarked as research—such as the operating costs associated with university research or project funds received from an external source. For ASTI's purposes, a more comprehensive accounting is needed of R&D costs including salaries, rent, and utilities appropriately prorated to reflect the share of total faculty time spent on research. ASTI estimates expenditures for higher education R&D using the average expenditure per researcher for government agencies and nonprofit institutions and scaling that figure by the total number of research FTEs employed by the higher education institutions in the sample.

CHALLENGE: Loans and grants from donors

National governments often finance various agencies with money borrowed from development banks such as the World Bank to fund agricultural research. Given that ASTI conducts surveys at the agency level, it can sometimes be difficult for an agency to differentiate between government funding and funding from donors and development banks.

6. RESEARCH OUTPUT DEFINITIONS AND PROCEDURES

ASTI has recently expanded its coverage to include information on the outputs of agricultural research systems. These output indicators measure the quantity of goods and services produced by agricultural research agencies. By counting and classifying publications and new varieties/technologies, one can gain insight into the main lines of an agency's research and the innovative power of the laboratories that produce new ideas and/or technologies. It is important to note that these output indicators are not a qualitative measure of the performance of research agencies. To assess the quality of research outputs, other measures (such as citation rates and adoption of new varieties) would be more constructive. These are difficult to obtain, however, and currently not part of ASTI's indicator range.

ASTI currently collects time-series data on the following agency-level research outputs:

- **Peer-reviewed publications** in an agricultural field in: international journals, regional journals, national journals, books, and book chapters. Workshop procedures, extension leaflets, brochures, annual reports, and other non-scientific publications are not included.
- New **crop and horticultural varieties** released through in-house research: variety name, crop type, key traits, release year, type of protection (i.e. patents or registration), and origin (i.e. local germplasm; parent germplasm from a CGIAR center or other source, with crossing, selection, and testing performed locally by the agency; or with local adaptation and testing performed by the agency).
- **Non-crop products and technologies** released through in-house research: product/technology name, type, release or adaptation year, and type of protection (if any). Non-crop products/technologies include fertilizers, pesticides, agricultural machinery, livestock breeds, tree and fish species, among others.

7. GENERATION OF ASTI DATASETS AND REPORTS

FULL-TIME EQUIVALENTS

ASTI presents its time-series data on human and financial resources for agricultural R&D in FTEs. These account for the proportion of time scientists actually spend on R&D activities. It is especially important to accurately report the time spent on research by professional staff at universities, as academic staff have a considerable number of non-research tasks, such as teaching, administration, and student guidance. These other activities are omitted from the R&D resource calculations. Faculty members typically spend just 25 percent of their time on research and are therefore represented as 0.25 FTE.

PURCHASING POWER PARITIES VERSUS MARKET EXCHANGE RATES

Differences in price levels from country to country make international comparisons of economic data highly complex. No fully satisfactory method has yet been devised to compare consumption and expenditure trends across countries. At present, the preferred conversion method for calculating the relative size of economies and other economic data, such as agricultural R&D spending, is the "PPP index" or "purchasing power parity index." PPPs measure the relative purchasing power of currencies. PPP indexes are compiled using the local prices of a wide range of goods and services. They are in turn used to convert current prices within individual countries into a common currency. In contrast, official exchange rates tend to understate values in economies with relatively low price levels and to overstate those in economies with relatively high price levels.

ASTI collects data on national agricultural R&D spending in local currency units, which must be converted into a common currency before regional and international comparisons can be made. To do this, ASTI first deflates research expenditures in current local currency units and then converts these amounts into a common currency unit using PPPs. The base year was selected as 2011 to correspond with the latest benchmark PPP indexes released by the World Bank.

ASTI country-specific publications present investment data in constant (currently for base year 2011) local currencies and PPP dollars. Its country, regional and global reports use constant PPP dollars. The ASTI website, however, also provides the investment data in current local currencies and in 2011 US dollars using market exchange rates.

INTENSITY RATIOS OF SPENDING

One way to quantify a country's agricultural R&D investments in an internationally comparable manner is to measure total agricultural R&D spending as a percentage of agricultural gross domestic product (AgGDP). This relative measure indicates the intensity of investment in agricultural research, not just the total amount of research spending.

CHALLENGE: Assessing intensity within a wider economic context

Intensity ratios are a good indicator of research investment levels. However, they do not take into account the policy and institutional environment in which agricultural research takes place or the size and structure of a country's agricultural sector and economy. These factors may be influential. For example, small countries need relatively higher research investments because they do not benefit from the economies of scale that larger countries enjoy. Similarly, countries with greater agricultural diversity or more complex agroecological conditions may have more complex research needs, requiring higher funding levels.

To address these concerns ASTI recently developed the ASTI Intensity Index. For more information see: http://astinews.ifpri.info/2016/09/30/comparing-apples-to-apples-asti-discussion-paper-on-new-agricultural-intensity-index/.

FROM NATIONAL TRENDS TO REGIONAL AND GLOBAL TRENDS

In addition to country notes, ASTI produces regional synthesis overviews. Between 2001 and 2017, national survey rounds were conducted in more than 60 low-income and middle-income countries. The overall country coverage in the various regions was relatively high, but ASTI has not been able to achieve complete country coverage in any of the developing regions. Regional totals are therefore estimated by scaling up from the country samples prepared from the ASTI datasets and secondary sources. For the 2012 update, spending totals were estimated for countries that were excluded in the ASTI survey rounds, which represented 11 percent of the reported Africa south of the Sahara total, <1 percent of the Asia–Pacific total, 13 percent of the Latin America and Caribbean total, 14 percent of the West Asia and North Africa total, and 16 percent of the high-income country total.

CHALLENGE: High dependency on secondary data for non-ASTI regions

ASTI relies on a number of secondary sources to calculate agricultural R&D spending levels. For China it uses national science and technology indicators published by the Ministry of Science and Technology. Data for various Eastern European and former Soviet Union countries is provided by Eurostat as well as other secondary sources. The OECD science and technology indicators provide data on agricultural research spending for member states. Unfortunately, the coverage and quality of this data for the agricultural sector has decreased substantially over time, perhaps reflecting the declining role of agriculture in the OECD countries' economies.