AGRICULTURAL R&D IN SUB-SAHARAN AFRICA:

AN ERA OF STAGNATION

Agricultural Science and Technology Indicators (ASTI) Initiative

Background Report

Nienke M. Beintema and Gert-Jan Stads

August 2006 • Washington, D.C.

Published by: International Food Policy Research Institute
2033 K Street, NW, Washington, DC 20006-1002 USA
Tel.:+1202-862-5600 • Fax:+1202-467-4439 • Email: ifpri@cgiar.org
www.ifpri.org / www.asti.cgiar.org

About the ASTI Initiative

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

The ASTI data and associated reports are made freely available for research policy formulation and priority setting purposes, and can be found at the ASTI website: **http://www.asti.cgiar.org**.

About the Authors

Nienke Beintema is head of, and **Gert-Jan Stads** a consultant with, the Agricultural Science and Technology Indicators (ASTI) initiative, based within the International Service for National Agricultural Research (ISNAR) Division of the International Food Policy Research Institute (IFPRI).

Acknowledgments

This report was prepared with financial support from the United States Agency for International Development (USAID). The underlying dataset and individual country briefs were developed through a comprehensive survey conducted in 27 countries in collaboration with many African partners during 2000–03. Funding for these surveys was provided by the Consultative Group on International Agricultural Research (CGIAR) Finance Committee/World Bank, USAID, the European Union, and the Australian Centre for International Agricultural Research (ACIAR). The authors thank Liliane Ndong for her capable research assistance and Kristin Davis, Howard Elliott, Peter Hazell, Were Omamo, and an anonymous reviewer for comments on drafts of this report.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Boxes

List of Acronyms

AgGDP	Agricultural gross domestic product
ARC	Agricultural Research Council (South Africa)
ARI	Agricultural research intensity
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AVRDC	Asian Vegetable Research and Development Center
CAADP	Comprehensive Africa Agricultural Development Program
CIRAD	Center for International Cooperation and Agricultural Research for Development [*Centre de coopération internationale en recherche agronomique pour le développement*]
CGIAR	Consultative Group on International Agricultural Research
CILSS	Permanent Interstate Committee for the Fight Against Drought in the Sahel [*Comité Inter-État pour la Lutte contre la Sécheresse au Sahel*]
CNRA	National Agricultural Research Center [*Centre national de recherche agronomique*]
CORAF/WECARD	West and Central African Council for Agricultural Research and Development [*Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles*]
CSIR	Council for Scientific and Industrial Research (Ghana)
DAR	Department of Agricultural Research (Botswana)
DARS	Department of Agricultural Research Services (Malawi)
EARO	Ethiopian Agricultural Research Organization
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
fte	Full-time equivalent
GDP	Gross domestic product
GFAR	Global Forum for Agricultural Research
GM	Genetically modified
IAASTD	Intergovernmental Assessment on Agricultural Science and Technology for Development
IAC	InterAcademy Council
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Centre of Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFDC	International Fertilizer Development Center

IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
INEAC	National Institute of Agronomic Studies of the Congo [*Institut National pour l'Étude Agronomique au Congo*] (Belgian Congo)
INSAH	Institute of the Sahel
IRD	Institute for Research for Development [*Institut de Recherche pour le Développement*] (France)
IRRI	International Rice Research Institute
ISNAR Division	The International Service for National Agricultural Research Division of IFPRI
ITC	International Trypanotolerance Centre
KARI	Kenya Agricultural Research Institute
LDC	Least developed countries
MSIRI	Mauritius Sugar Industry Research Institute
NEPAD	New Partnership for Africa's Development
OECD	Organisation of Economic Co-Operation and Development
ORSTOM	Office of Overseas Scientific and Technical Research [*Office de la Recherche Scientifique et Technique Outre-Mer*] (France)
PARAO	West Africa Agricultural Research Support Program [*Programme d'appui à la Recherche Agricole en Afrique de l'Ouest*]
PPP	Purchasing power parity
R&D	Research and development
SACCAR	Southern African Centre for Cooperation in Agricultural and Natural Resources Research and Training
SADC	Southern African Development Community
SPAAR	Special Program for African Agricultural Research
SRO	Subregional organization
S&T	Science and technology
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USAID	United States Agency for International Development
WARDA	Africa Rice Center

Preface

Following two decades of increasing investments, growth in public agricultural research spending (adjusted for inflation) largely stagnated in Sub-Saharan Africa during the 1980s and 1990s, at an average rate of about 1 percent per year. This continentwide trend masks significant variation among countries. During 1991–2000, about half the countries in our 27-country sample experienced a contraction in total agricultural research and development (R&D) spending. Declines often occurred during periods of political unrest or following the completion of large donor-funded projects. The majority of African agricultural research is still conducted by the public sector.

The declining growth in public agricultural R&D investments has not been justified by the growing needs of the agricultural sector, nor counteracted by growth in investments by alternative suppliers, such as the private sector or international research centers. In addition, with its current investment patterns, Africa will probably miss out on most of the biotechnology advances that are being made in other regions in the world. Institutional reforms may have improved efficiency in a number of countries, but without a corresponding increase in financial support, such gains will be insufficient to turn the trends around. The funding base for African R&D urgently needs to be restored, with increased commitments from both governments and donors. This should go hand-in-hand with the pursuit of innovative funding mechanisms.

INTRODUCTION

In contrast with other regions, such as Latin America and Asia, per capita food availability in Sub-Saharan Africa (hereafter, Africa) has decreased over time, and the region suffers from widespread food insecurity. As a result, the number of poor and undernourished people in Africa has increased substantially in recent decades. At the turn of the millennium, at least one in four Africans were undernourished (Benson 2004). Africa continues to be highly dependent on the agricultural sector for its livelihood, employing more than 80 percent of the labor force in many countries. Small-scale farmers predominate in a climate of increasing population pressure, food insecurity, very low (and declining) levels of agricultural productivity, and rapid natural resource degradation. Lessening African poverty requires an increase in agricultural productivity. Agricultural research and development (R&D) investments are a crucial determinant of agricultural productivity through the introduction of improved crops and cropping practices, labor-saving technologies, improved quality of food storage, processing, and marketing (IAC 2004). In addition to newly developed technologies, existing technologies need to be better disseminated throughout Africa. Considerable empirical evidence indicates high rates of return from agricultural R&D investments, making agricultural research a cost-effective way for governments to accelerate agricultural development (Alston et al. 2000; Evenson 2003; Thirtle, Lin, and Piess 2003). But despite all this, overall growth in agricultural research investments in Africa has effectively stagnated over the past two decades. In addition, a large, and seemingly increasing, number of countries have such low levels of support that they are unlikely to have a real impact on the continent's rural development and poverty reduction.

In recent years, reports from a number of influential initiatives—such as the New Partnership for Africa's Development (NEPAD), the InterAcademy Council (IAC), the United Kingdom-led Commission for Africa, and the recently initiated World Bank/United Nations Intergovernmental Assessment on Agricultural Science and Technology for Development (IAASTD)—have pointed out the critical role of Science and Technology (S&T) for African economic and social development. NEPAD's Framework for African Agricultural Productivity (FAAP) emphasized the critical role of technical change and recommends a doubling of the current level of public agricultural R&D funding by 2015 (NEPAD 2002). In line with FAAP, the IAC study (2004) recommended a doubling in the intensity of the region's agricultural research spending—that is, agricultural research spending as a share of agricultural gross domestic product (AgGDP)—by 2015. But it is not simply a matter of increasing spending; improving the efficiency of agricultural research through better funding, management, and capacity practices is also critical. Nevertheless, this report will show that reaching these goals is highly unlikely in light of the reality of declining investment growth in African public agricultural R&D. The funding base for African R&D needs to be restored urgently, with increased commitments from both governments and donors. This should go hand-in-hand with the pursuit of innovative funding mechanisms and greater private-sector participation in agricultural research.

The quantitative analysis in this report draws directly on a new set of data for 1991–2000 developed through a comprehensive 27-country survey conducted as part of the Agricultural Science and Technology Indicators (ASTI) initiative (see Appendix A for an overview of methodology and data collection processes). This report begins with a description of Africa's R&D investment trends since the 1970s, followed by a description of developments in human resources in public agricultural R&D. It then goes on to explore the role of government and donor funding of agricultural research in Africa and concludes with a short description of the role of international and regional research agencies.

PUBLIC AGRICULTURAL R&D EXPENDITURES

Overall Trends

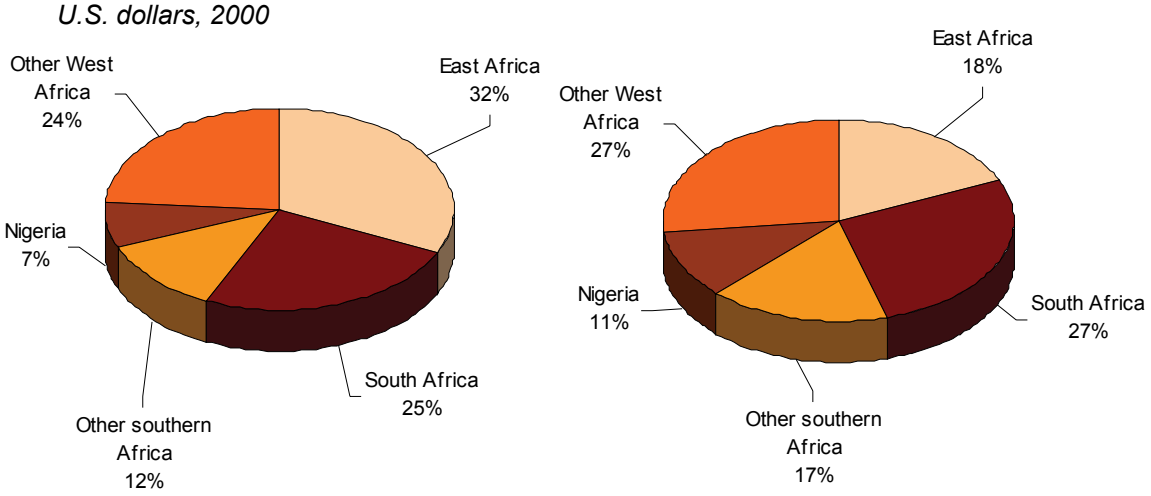
African agricultural research systems have endured greater instability than those of other world regions, mainly as a result of political unrest (civil turmoil and war), social and economic disarray, and institutional instability. Many research agencies have undergone repeated reshuffling, relocation, mergers, and subdivisions, involving other agencies—and not necessarily research agencies. Frequently these institutional changes have been driven by political motivations rather than efforts to improve agricultural research performance within changing economic contexts (Roseboom, Pardey, and Beintema 1998). As a result, public agricultural research spending has fluctuated in many countries, and its overall growth has declined in recent years.

In 2000, spending on public agricultural R&D totaled nearly US$1.5 billion 1993 international dollars. Of this, 37 percent was spent in southern Africa, with the remainder roughly divided between East and West Africa (Figure 1a). Nigeria employed the highest number of researchers, but its share of total spending was considerably lower (7 percent). In contrast, South African researchers had a considerably higher share of financial resources than their counterparts in other countries, with the result that South Africa, alone, accounted for a quarter of the region's public agricultural spending.

Financial data in the remainder of this report are provided in real values using GDP deflators and purchasing power parity (PPP) indexes, both taken from the World Bank (2004). PPPs are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than conventional exchange rates. Using PPPs as conversion factors to denominate value aggregates in international dollars results in more realistic and directly *comparable* estimates of agricultural research spending across countries than would result from the use of market exchange (see Appendix A for further explanation). Using official exchange rates to convert agricultural R&D expenditures in local currencies to U.S. dollars gives a substantially lower regional total of public agricultural R&D spending (US$508 million) and a different distribution of resources across the three subregions (Figure 1b). The southern African region, which includes countries with relatively higher price levels (such as South Africa) accounts for 44 percent of the region's total public agricultural R&D spending using exchange rates rather than PPPs, while for East Africa

the regional expenditure share is much lower using exchange rates compared with PPPs. For these reasons, the PPP method is deemed a superior measure for analyzing the financial data in the remainder of this report. Sufficiently complete time-series data were available (or could be estimated) for a sample of 27 countries of the 48 countries constituting Sub-Saharan Africa. As a result, the report accounts for about three-quarters of the region's AgGDP in 2001.[1]

Figure 1—*Total public agricultural research spending in Sub-Saharan Africa in international and U.S. dollars, 2000*



a. 2000: $1,460 million (1993 international dollars) **b. 2000: $507 million (1993 US dollars)**

Source: Compiled by authors from the datasets underlying the ASTI country briefs.

Notes: The sample includes all 48 Sub-Saharan African countries. The research capacity of 21 of the countries (most of them small in terms of and agricultural output and research capacity) was estimated in line with their share of total agricultural output. Data for West Africa, with the exception of Nigeria, are for 2001.

Most of the growth in African public agricultural research capacity took place in the 1960s, when real (inflation adjusted) public agricultural R&D spending increased by more than 6 percent per year (Pardey, Roseboom, and Beintema 1997).[2] During 1971–2000, real public agricultural R&D spending for a 27-country sample grew much more slowly, at an average annual rate of 1.4 percent (Table 1). Spending growth declined from 2.0 percent per year in the 1970s to 0.8 percent in the 1990s.[3]

[1] The country-specific data quoted in this report are based on information provided in a series of ASTI country briefs published between 2002 and 2004. These briefs and their underlying datasets are available on the ASTI website (www.asti.cgiar.org).

[2] Annual growth rates were calculated using the least-squares regression method, taking into account all observations in a period. Hence, the resulting growth rates reflect general trends that are not disproportionately influenced by exceptional values, especially at the end point of the period.

[3] Regional growth rates for public agricultural R&D spending in the 1980s and 1990s differ somewhat in this report from those reported in Pardey, Roseboom, and Beintema (1997). This is due to the larger sample size in the current report and some modifications made to the earlier dataset, particularly in regard to South Africa.

Table 1—*Trends in public agricultural research spending by subregion, 1971–2000*

Subregion	Total spending (million 1993 international dollars)				Annual growth rate (percent)[a]			
	1971	1981	1991	2000[b]	1971–81	1981–91	1991–2000	1971–2000[b]
East Africa (7)	136.5	185.6	292.7	341.4	2.21	5.07	0.88	3.17
Southern Africa (6)	371.3	370.2	398.2	427.9	–0.19	0.30	1.20	1.25
West Africa (14)	224.0	358.2	345.5	315.3	4.62	0.14	0.06	0.39
Total (27)	731.8	914.0	1,036.4	1,084.7	2.02	1.32	0.77	1.43
Nigeria	62.5	127.9	68.3	106.0	5.64	–6.71	6.27	–1.84
South Africa	287.5	300.3	313.3	365.6	0.11	0.14	1.85	1.65
Total excluding Nigeria and South Africa (25)	381.8	485.8	654.8	613.1	2.46	3.31	–0.30	1.89

Source: Appendix Table C.1.

Notes: Figures in parentheses indicate the number of countries in each category. The 7 East African countries are Burundi, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, and Uganda; the 6 southern African countries are Botswana, Madagascar, Malawi, Mauritius, South Africa, and Zambia; the 14 West African countries are Benin, Burkina Faso, Republic of Congo, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, and Togo. Data were not available prior to 1991 for 6, mainly small, countries; hence, they were estimated using trends for the other countries in the respective subregions.

[a] Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period.

[b] For West Africa, total spending data are for 2001 and the growth rate is for 1991–2001.

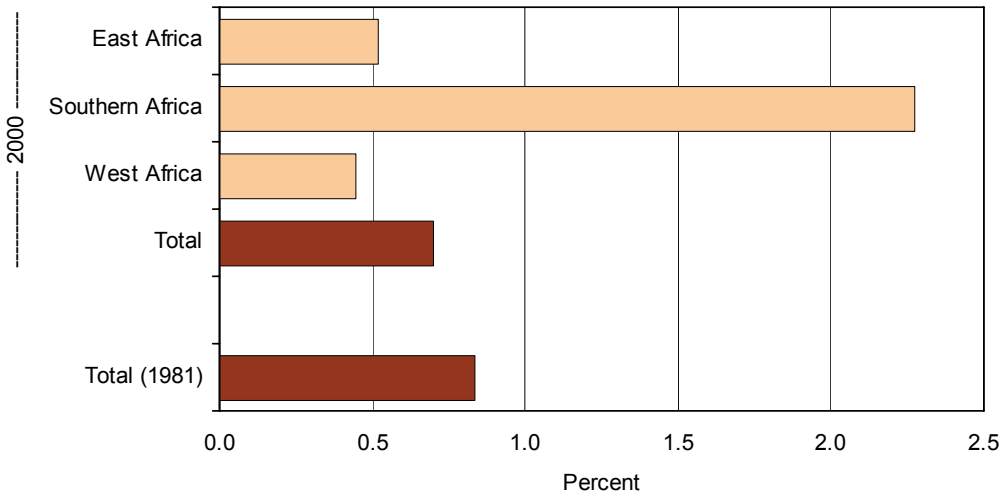
More detailed data reveal a substantial degree of cross-country variation around the regional average (Appendix Table C.1). From 1991 to 2000, about half of the 27 countries in our sample experienced negative annual growth, with Burundi, the Republic of Congo, and Sudan having negative rates in excess of 10 percent. The collapse of national agricultural R&D spending in these countries was the effect of political unrest (Burundi and Sudan) or the conclusion of large donor projects, often funded through World Bank loans (Republic of Congo, Madagascar, Niger, Senegal, and Zambia). In contrast, total spending in Nigeria rose by 6.3 percent per year during the 1990s, on average, which was the combined result of an increase in agricultural research capacity and a substantial boost in civil service salaries in 2000. South African spending also grew during the 1991–2000 period, but this growth took place during the first half of the decade; in more recent years agricultural R&D spending contracted considerably as a result of cuts in federal and provincial government funding for agricultural research. Excluding Nigeria and South Africa, total public agricultural R&D spending among the remaining countries declined by 0.2 percent per year during the 1990s.

Intensity Ratios

Analyzing absolute levels of research expenditures explains only so much. Another way to measure a country's agricultural R&D efforts in an internationally comparable context is investment intensity. The most common indicator of research intensity is total public

agricultural R&D spending as a percentage of AgGDP.[4] In 2000, Africa invested $0.70 for every $100 of agricultural output—lower than the $0.84 ratio in 1981 (Figure 2). In other words, growth in African agricultural research spending fell behind the growth of its agricultural sector.

Figure 2—*African agricultural research intensities, 1981 and 2000*



Source: Compiled by authors from datasets underlying the ASTI country briefs.
Note: Data for western Africa, with the exception of Nigeria, are for 2001.

Once again, when the two largest research systems are excluded (that is, Nigeria and South Africa, in particular, given its high 2.04 ratio), the intensity ratio falls to a substantially lower 0.53. At the country level, ratios ranged from 0.20 or lower in The Gambia, Niger, and Sudan, to over 3.00 percent in Botswana, Mauritius, and South Africa—all three located in southern Africa, explaining the high average intensity ratio for that subregion. In fact, the research intensities of these three southern African countries were high even in the context of many developed countries.

Gauging researcher numbers or investment levels against the total population or economically active agricultural population are other popular research intensity measures that facilitate cross-country comparisons. In 2000, African countries spent $2.2 per capita on agricultural research, on average, which was about $1 less than the two prior decades, and also lower than the 1991 level (Table 2). Total agricultural research spending per economically active member of the agricultural population indicates a slower decline—from $10.0 in 1981 to $8.1 in 2000. This is the result of the much slower growth in agricultural research spending in proportion to the economically active population than in proportion to the total population in most African countries.

[4] Some exclude for-profit private agricultural research expenditures when forming this ratio, presuming that such spending is directed toward input and postharvest activities that are not reflected in AgGDP. For reasons of consistency with these other studies, we excluded national and multinational private companies (but not nonprofit institutions) from the intensity ratios calculated in this section.

Table 2—*Other selected public research intensity ratios, 1981–2000*

Region	Expenditures per capita (1993 international dollars)			Expenditures per economically active population in agriculture (1993 international dollars)		
	1981	1991	2000	1981	1991	2000
East Africa (7)	1.7	1.9	1.8	4.2	5.0	4.9
Southern Africa (6)	6.9	5.7	5.1	34.6	29.3	28.0
West Africa (14)	2.8	2.0	1.4	9.7	8.1	6.4
Total (27)	3.1	2.6	2.2	10.0	9.0	8.1
Total excluding Nigeria and South Africa (25)	2.5	2.4	1.8	6.4	6.7	5.2

Sources: Compiled by authors from datasets underlying the ASTI country briefs. Total population and economically active population in agriculture are from FAO (2004).

Notes: Figures in parentheses indicate the number of countries in each category. The 7 East African countries are Burundi, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, and Uganda; the 6 southern African countries are Botswana, Madagascar, Malawi, Mauritius, South Africa, and Zambia; the 14 West African countries are Benin, Burkina Faso, Republic of Congo, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, an Togo. Data for West Africa, with the exception of Nigeria, are for 2001.

African Spending in a Global Context

In 2000, African public agricultural R&D investments accounted for 6 percent of the $23 billion spending on agricultural R&D worldwide (Table 3). During the 1990s, the least developed countries (LDCs) as a group spent more on agricultural research than the developed world. However, Africa's share of total spending decreased over the past two decades, from 8 percent in 1981 to 6 percent in 2000. This is in part due to Africa's relatively low, 1 percent annual growth rate during the 1990s. In contrast, the corresponding growth rate for the Asia–Pacific region was 3.9 percent per year for the same period, resulting in a strong increase in that region's share of total developing-country spending. Just two countries in the Asia–Pacific region, China and India, accounted for 22 percent of global expenditures in 2000, representing a substantial increase over their 10 percent share in 1981. Nonetheless, Africa's R&D intensity ratio was considerably higher than the average for the Asian region: in 2000, African countries as a group spent $0.72 on public agricultural R&D for every $100 of agricultural output compared with $0.41 for the Asia–Pacific region. While Africa's intensity ratio was lower than the average for Latin America ($1.15) and the developed world ($2.36), only 10 of the 26 countries in our African sample reported higher intensity ratios in 2000 than in 1981, while intensity ratios for most of the countries in the Asian and Latin American samples increased during the 1981–2000 period (Pardey et al. 2006).

Table 3—*African public agricultural R&D spending in a global context*

Region	Spending share in global total (percent)		Annual growth rate (percent)		Spending as a share of AgGDP (percent)	
	1981	2000	1981–91	1991–2000	1981	2000
Sub-Saharan Africa	7.9	6.3	1.25	0.82	0.84	0.72
Asia–Pacific	20.0	32.7	4.33	3.92	0.36	0.41
Latin America and the Caribbean	12.5	10.7	1.13	1.98	0.88	1.15
West Asia and North Africa	5.0	6.0	4.12	1.87	0.61	0.66
Developing-country subtotal	45.4	55.7	3.04	2.88	0.52	0.53
Developed-country subtotal	54.6	44.3	2.63	1.19	1.41	2.36
Total	100	100	2.46	0.75	0.79	0.80

Source: Pardey et al. (2006).

Human Resources

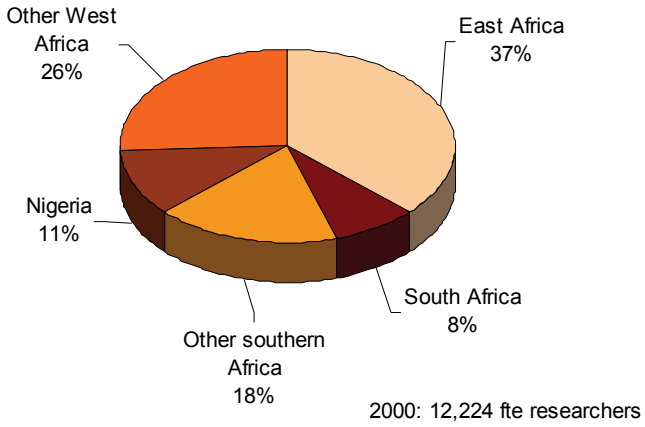
Overall Trends

Since independence, most African countries have made considerable process in building capacity, specifically in terms of replacing expatriate staff with national researchers. This was followed by a further expansion in the number of national staff, as well as an improvement in the quality of their training (in terms of postgraduate degrees). In 2000, there were over 12,000 full-time equivalent (fte)[5] researchers working in the public agricultural research agencies in Africa; 37 percent were based in East Africa, 37 percent in West Africa, and 26 percent in southern Africa (Figure 3). In addition, African agricultural research agencies employed 1.2 technicians and 3.7 other support staff per scientist on average (including administrative staff and laborers), bringing the total number of fte staff at African agricultural research agencies to 72,000. This is a considerable decrease from the estimated 96,000 fte's employed in 1991 (Pardey, Roseboom, and Beintema 1997). The decline primarily stemmed from cuts in average support-staff-per-scientist numbers in many countries during the 1990s.

In 2000, just 5 of the 48 countries in the region employed about 40 percent of all fte research staff in agriculture. Nigeria (in West Africa) and South Africa (in southern Africa) reported the largest capacities, at 1,352 and 1,029 fte researchers, respectively, while Kenya, Sudan, and Ethiopia (in East Africa) employed 740, 780, and 822 fte researchers, respectively.

[5] Researcher numbers are expressed as full-time equivalents (fte's). Adjustments were made when more than 20 percent of reported research staff time was spent on activities other than R&D, such as extension, teaching, or technical services.

Figure 3—*Total public agricultural research staff in Sub-Saharan Africa, 2000*



Source: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: The sample includes all 48 Sub-Saharan African countries. The research capacity of 21 countries (most of them small in terms of and agricultural output and research capacity) was estimated in line with their share of total agricultural output. Data for West Africa, with the exception of Nigeria, are for 2001.

Over the past three decades, total researcher numbers for the 27 countries for which time-series data were available increased threefold. This growth did not, however, occur evenly throughout the period, nor across subregions and countries (Table 4). During 1971–2000, the total number of public agricultural researchers increased by an average of 4.0 percent per year, though most of this growth occurred in the 1970s and 1980s. Since then, growth rates have been very low in all three subregions: 1.6 percent in East Africa, 1.3 percent in West Africa, and 0.8 in southern Africa. The lower growth rate for the southern African region stems from the comparatively early establishment of the South African research system.

The subregional averages mask considerable differences among the various countries in our sample (Appendix Table C.2). For example, Burundi and Côte d'Ivoire experienced a strong decline in total fte researchers during the 1990s—the first due to civil war, the second as a result of the departure of French expatriates during the earlier 1990s and staff cuts following the merger of several government agencies. In contrast, the total number of research staff in Botswana, Ethiopia, and Gabon increased by more than two-thirds during the same period. In Botswana and Ethiopia the increase was due to an intensification of the governments' investments in agricultural R&D capacity. Though Gabon's growth rates were also high, they grew from an extremely low base; hence, the country's research staffing remained relatively low compared with other African countries, reflecting Gabon's traditional focus on economic sectors other than agriculture. After years of moderate to stagnating growth, researcher numbers in South Africa shifted into negative growth between 1996 and 2000 (–3.1 percent per year on average). This was the result of the aforementioned contraction in the total number of fte researchers in the federal and provincial government sectors. Total research staff at South Africa's Agricultural Research Council (ARC) declined by one-third from 1996 to 2003 as a result of reduced core government funding and changes in leadership and management styles.

Many of these departing staff members were the council's most experienced and highly trained. Provincial R&D capacity also dwindled, as high costs and poor restructuring plans led to the near cessation of agricultural research in some provinces. Understandably, this decline will have very negative implications for South Africa's future agricultural research capacity. In contrast, total numbers of fte research staff increased considerably in Nigeria during the late 1990s (at an average of 4.3 percent per year), mainly as a result of increased agricultural research capacity in the higher education sector.

Table 4—*Trends in public agricultural researchers by subregion, 1971–2000*

	Total researchers (full-time equivalents)				Annual growth rate[a] (percent)			
Subregion	**1971**	**1981**	**1991**	**2000[b]**	**1971–81**	**1981–91**	**1991–2000**	**1971–2000[b]**
East Africa (7)	760.9	1,452.8	2,817.9	3,291.7	5.83	6.25	1.62	5.48
Southern Africa (6)	1,027.8	1,335.7	1,760.8	1,806.5	2.18	2.19	0.79	2.39
West Africa (14)	1,028.8	2,233.4	3,174.2	3,648.5	8.76	2.85	1.38	3.8
Total (27)	2,817.5	5,022.0	7,752.9	8,746.8	5.89	3.74	1.31	3.97
Nigeria	366.2	908.3	1,135.8	1,351.9	10.67	1.39	1.95	3.32
South Africa	678.0	807.4	1,047.0	1,028.6	1.31	1.66	0.18	1.88
Total excluding Nigeria and South Africa (25)	1,773.3	3,306.3	5,570.1	6,366.2	6.13	4.78	1.42	4.65

Sources: Appendix Table C.2.

Notes: Figures in parentheses indicate the number of countries in each category. The 7 East African countries are Burundi, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, and Uganda; the 6 southern African countries are Botswana, Madagascar, Malawi, Mauritius, South Africa, and Zambia; the 14 West African countries are Benin, Burkina Faso, Republic of Congo, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, an Togo. Data were not available prior to 1991 for 6, mainly small, countries; hence, they were estimated using trends for the other countries in the respective subregions.

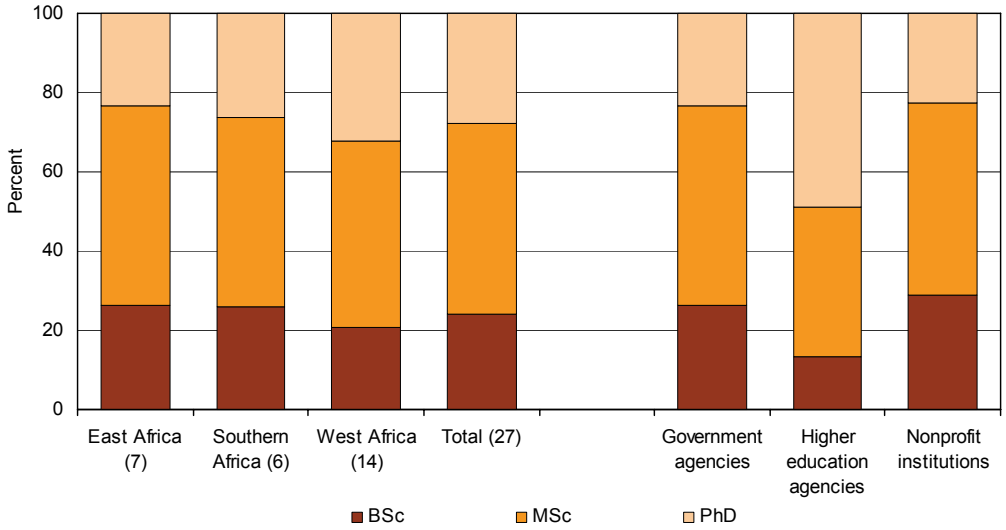
[a] Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period.

[b] . Data for West Africa, with the exception of Nigeria, are for 2001 and growth rate for 1991–2001.

Degree Levels and Training Programs

In 2000, 75 percent of all fte researchers in our 27-country sample had undergone postgraduate-level training, and about one-quarter held doctorate degrees (Figure 4). Similar postgraduate shares were found in the three subregions, although the West African share was slightly higher, and relatively fewer researchers held doctorate degrees in East Africa. In addition, a higher proportion of university staff held PhD degrees compared with staff at other agencies—a pattern that was prevalent among most of the countries in the region. This is consistent over time and with other regions such as Latin America (Pardey et al. 1999; Beintema and Pardey 2001).

Figure 4—*Degree status of public agricultural researchers, 2000*



Source: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: Figures in parentheses indicate the number of countries in each category. The 7 East African countries are Burundi, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, and Uganda; the 6 southern African countries are Botswana, Madagascar, Malawi, Mauritius, South Africa, and Zambia; the 14 West African countries are Benin, Burkina Faso, Republic of Congo, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, an Togo. Data for West Africa, with the exception of Nigeria, are for 2001.

The standard of research staff—measured as the share of researchers with PhD and MSc degrees—varied markedly across countries (Appendix Table C.3). In 2000, more than 80 percent of the fte researchers in an 11-country sample were trained to the postgraduate level. In Burkina Faso, Madagascar, Senegal, and Togo over 94 percent of researchers had MSc or PhD training, which is well above than the regional average and averages in other parts of the world. Most of these postgraduates held MSc degrees, although close to half the researchers in Senegal were trained to the doctorate level. These high shares stem in large part from continuous training programs during the 1990s funded either by World Bank loans (in Burkina Faso, Madagascar, and Togo) or by United States Agency for International Development (USAID) contributions (in Senegal), once again reflecting the important role of foreign support in strengthening capacity in Africa. In contrast, the shares of postgraduate degree holders in Eritrea, Ethiopia, Guinea, and Mauritius were between 31 and 53 percent. Eritrea had the lowest share of PhD-qualified researchers, at 5 percent, while corresponding shares for the other three countries were between 9 and 15 percent.

Box 1. Female researchers in agricultural R&D

Over the past few decades, the number of female scientists and managers working in agricultural research has increased significantly in both industrialized and developing countries, although empirical studies have repeatedly shown a disproportionately low number of women working in senior scientific positions (Sheridan 1998). Throughout the world, female scientists are subjected to more stereotyping and associated negative biases in the work place than their male colleagues; they are less well connected to informal social and professional networks, ultimately leading to lower publication rates; and the cultural stereotypes of men's and women's roles within the household still appear to limit women's opportunities for advancement into senior positions. For this reason, the integration of women into research agencies, which have traditionally been staffed largely by men, poses challenges for women interested in building a career in the sciences, as well as for employers responding to demographic shifts (Sheridan 1998; Brush et al. 1995).

In 2000, 18 percent of African agricultural researchers in our 27-country sample were female (Figure A). Close to one-third of agricultural researchers in Botswana, South Africa, and Mauritius (all within the southern African region) were female, while the corresponding share in 9 of the 14 West African countries was 10 percent or lower. In East Africa, large variations existed across countries: of total research staff in 2000, female researchers accounted for more than a quarter in Sudan; about one-fifth in Kenya, Uganda, and Tanzania; but only 7 and 4 percent in Ethiopia and Eritrea, respectively.

Figure A—*Share of female research staff by country, 2000*

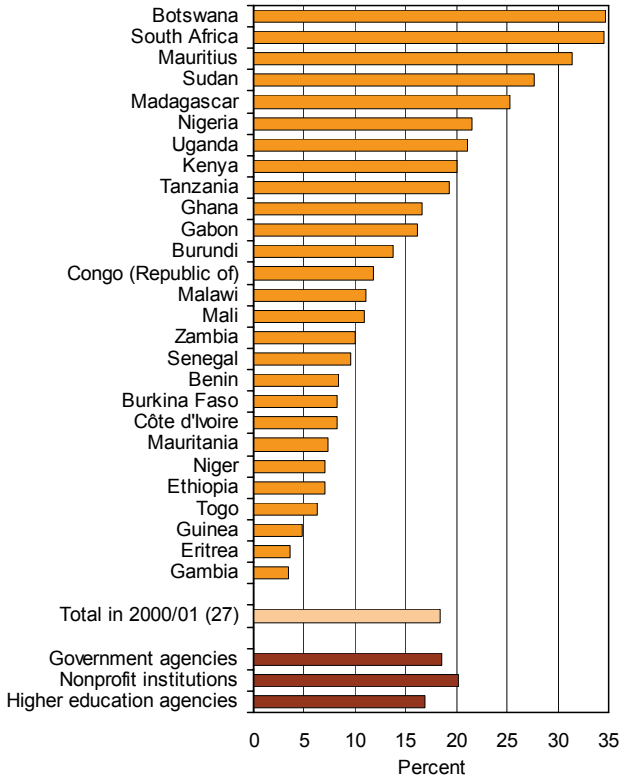
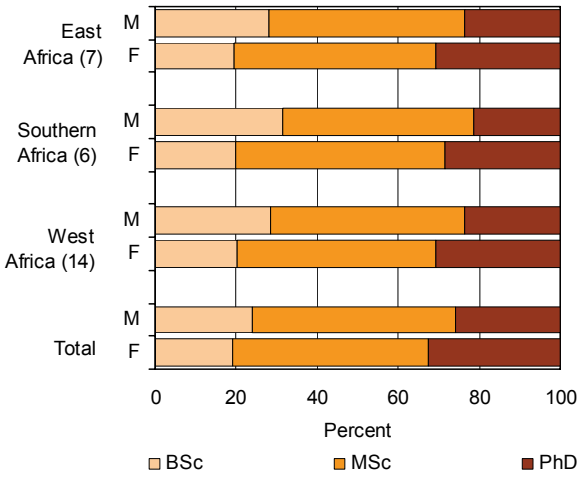


Figure B—*Degree levels of female and male researchers, 2000*



Source: Compiled by authors from datasets underlying the ASTI country briefs.
Notes: For agencies sample sizes see specific country briefs. Data for West Africa, with exception of Nigeria, are for 2001.

Box 1. Continued

The share of female agricultural researchers in Africa increased slightly during the 1990s. In 1991, women accounted for 17 percent of the total agricultural research staff in a 14-country sample for which historical information was available (Roseboom and Beintema 1996). By 2000, the average for these 14 countries had increased to 21 percent. Increases of 10 percentage points or more are notable in South Africa, Sudan, and Nigeria. In contrast, Madagascar, Tanzania, and Burkina Faso reported declining female researcher shares of between 4 and 6 percentage points.

Overall, in all three African subregions, fewer female researchers held PhD degrees compared with their male counterparts (20 percent compared with 28 percent in 2000) (Figure B).

Since independence, many countries have made great strides in nationalizing their research capacity. The share of expatriate workers in African agricultural R&D (excluding South Africa) declined from 90 percent in the early 1960s, to about 30 percent in the early 1980s, to 11 percent in 1991, and just 2 percent in 2000. The number of higher education agencies in Africa increased considerably over the past four decades, from fewer than 20 universities in 1960 to more than 200 by the early 2000s. Of these, at least 96 have faculties of agriculture or agriculture-related sciences (Beintema, Pardey, and Roseboom 1998; Temu, Mwanje, and Mogotsi 2003).

Information on the levels and dates of establishment of degrees was available for 131 of the 200 higher education units covered under the ASTI survey. About three-quarters of these agencies provided at least MSc training, while 57 percent offered PhD degrees (Table 5). Half of these MSc and PhD programs, however, were initiated after 1990.

Table 5—*Number of higher education agencies offering MSc and PhD degrees over time*

Timeframe	Number of agencies offering		Share of total (percent)	
	MSc degrees	PhD degrees	MSc degrees	PhD degrees
Before 1980	28	23	28.6	30.7
1980s	21	14	21.4	18.7
1990 onward	49	38	50.0	50.7
Total	*98*	*75*		

Source: Compiled from ASTI surveys.

Note: Data are based on a sample of 131 higher education agencies that participated in the ASTI survey and provided detailed information on degrees offered and year of initiation.

Given the recent origins of most African higher education training programs in the agricultural sciences, most of the national researchers obtained their education (especially at the postgraduate level) abroad, mainly at western universities during the 1970s and 1980s. Beintema, Pardey, and Roseboom (1998) found, for example, that of all faculty staff with PhD degrees employed in 1991 at 34 agricultural science and related faculties (located in 10 Anglophone African countries), at least 85 percent had undertaken their degrees overseas, and about two-thirds had also obtained their MSc degree overseas. Many countries received considerable financial support for research staff training, often as part of large World Bank loans or through contributions from

donor countries and other agencies, such as France, USAID, and the Rockefeller Foundation. In recent years, however, most donors have cut or eliminated their funding for graduate training undertaken in developed countries. Reasons for this include the high costs of training students overseas and the relatively high nonreturnee rate. These days, it appears that more researchers are sent to other developing countries, such as India, South Africa, or Egypt, where the cost of PhD training can be less than half that of programs in developed countries. Of the research staff at the Ethiopian Agricultural Research Organization (EARO) studying outside Ethiopia in mid-2003, for example, 77 were located at South African universities, 117 at Asian universities, and 21 at Jordanian universities. Only 4 researchers received training at European universities, while no researchers were being trained in the United States. In addition to these cost-saving measures, new cost-cutting models have been developed, such as sandwich programs[6] and distance learning programs, for example using information and communications technologies (Eicher 2004).

The generation of African agricultural researchers trained during the first decades of independence has long since retired. In most countries, the conditions of service, salary levels, and retirement packages are poor. This is often accompanied by inferior work environments in terms of outdated scientific infrastructure and insufficient operating budgets. The so-called brain drain of research staff is a serious problem for Africa, with a substantial number of scientists leaving the public sector for better opportunities in the private sector and abroad. Another important factor affecting staffing levels is HIV/AIDS and related diseases, which have devastated populations and overall agricultural research capacity in many Africa countries (Eicher 2004). In some countries this has led to the inability to fill all of the available positions. For example, only 72 percent of the professional positions at the Department of Agricultural Research (DAR) in Botswana were filled as of early 2003. Around the same time, the situation was even worse at Malawi's Department of Agricultural Research Services (DARS), where only 57 percent of the available positions were filled. African universities deal with similar staffing problems. In addition, high and increasing university enrollments (while positive in themselves) have significantly reduced the research capacity of faculty staff (IAC 2004; Eicher 2004). In addition, university staff have to deal with limited research funding; lack of equipments, such as computers; and lack of professional opportunities, such as sabbaticals abroad and other forms of professional development.

[6] Sandwich programs are a less costly option to traditional overseas training. Such programs usually combine initial introductory course work at a student's home university, followed by a period of study at a developed-county or other advanced university, such as in India or South Africa. In addition to the cost savings, students spend less time away from their homes and jobs, while still obtaining a valuable credential. This arrangement requires an official agreement between the two participating institutions on standards, requirements, and who will grant the degree.

Support Staff

In 2000, the average number of support staff per scientist in our 27-country sample was 4.9—comprising 1.2 fte technicians, 1.1 fte administrative personnel, and 2.6 fte other support staff such as laborers, guards, and drivers (Table 6). Higher education agencies employed only 1.4 fte support staff per researcher, but this relatively lower ratio compared with other institutional categories is consistent with our findings in other regions. Also consistent is the high support-staff-to-researcher ratio found in the nonprofit sector (11.0), explained in part by the high number of other support staff employed in coffee and tea production at the nonprofit institutions. On average, agricultural R&D agencies in East Africa employed slightly higher numbers of support staff per researcher (5.7) than their counterparts in southern and West Africa (4.4 each).

Table 6—*Support-staff-to-researcher ratios by type, subregion, and institutional category, 2000*

Category	Technical	Administrative	Other	Total
By subregion				
East Africa (7)	1.2	1.4	3.0	5.7
Southern Africa (6)	1.1	0.7	2.7	4.4
West Africa (14)	1.2	0.9	2.2	4.4
Total (27)	1.2	1.1	2.6	4.9
Nigeria	1.7	1.8	3.2	6.8
South Africa[a]	0.7	0.5	2.4	3.7
Total excluding Nigeria and South Africa (25)	1.2	1.0	2.6	4.8
By institutional category				
Government agencies	1.4	1.2	2.9	5.4
Nonprofit institutions	2.1	1.3	7.7	11.0
Higher education agencies	0.3	0.5	0.5	1.4

Source: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: Figures in parentheses indicate the number of countries in each category. The 7 East African countries are Burundi, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, and Uganda; the 6 southern African countries are Botswana, Madagascar, Malawi, Mauritius, South Africa, and Zambia; the 14 West African countries are Benin, Burkina Faso, Republic of Congo, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, an Togo. Data for West Africa, with exception of Nigeria, are for 2001. For agency sample sizes, see specific country briefs.

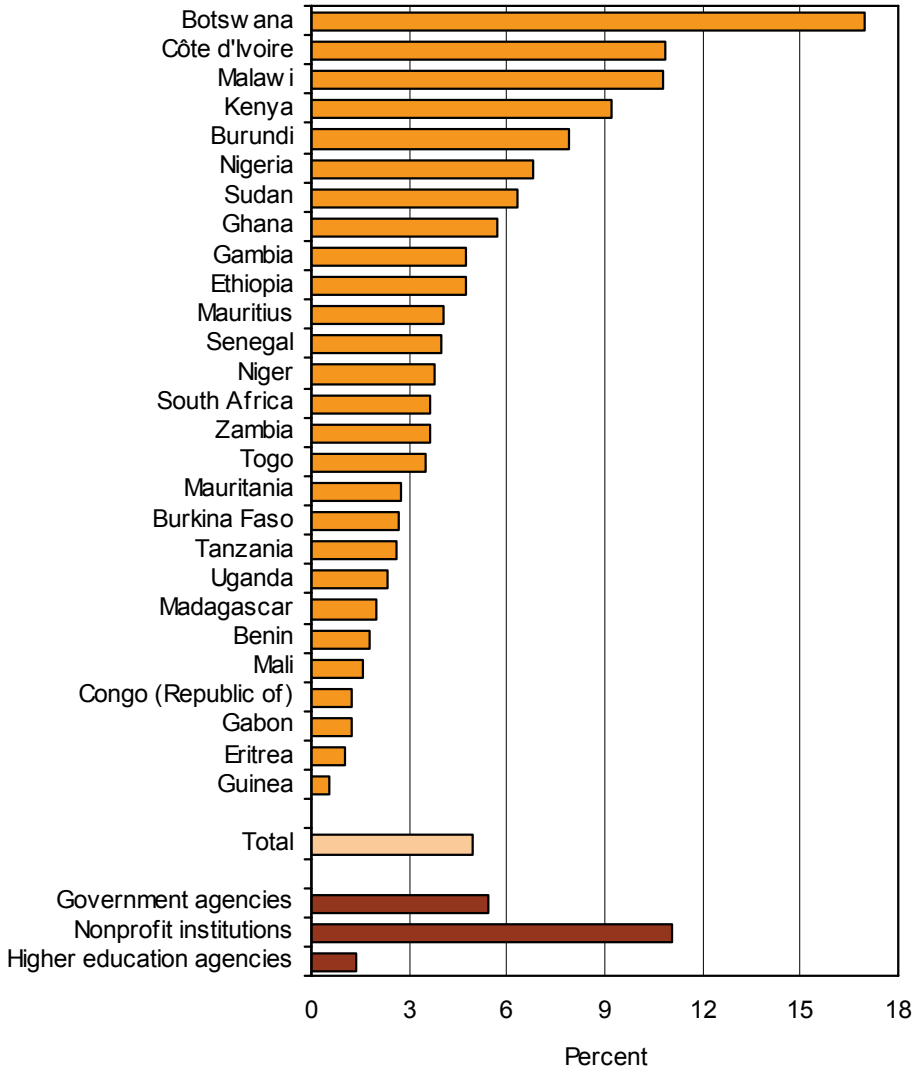
[a] Includes the Agricultural Research Council (ARC) only.

Even larger differences were identified at the country level, ranging from a support-staff-to-researcher ratio of 10.0 or higher for Botswana, Côte d'Ivoire, Malawi, and Kenya, to ratios below the 1.0 mark in Eritrea and Guinea (Figure 5).

The combination of the restructuring of agricultural R&D initiated in the early 1980s to improve agricultural research efficiency and more recent funding cuts has prompted staff redundancies, recruitment freezes, and voluntary departure and early retirement schemes for support staff in many African countries. Support staff information for the early 1990s was available for principal agricultural research agencies from 21 countries. Of these, 16 agencies showed a considerable (and often dramatic) drop in the number of support staff per researcher. On average, the "other support staff" category at many of these 21 agencies was most affected, although technical and administrative

support-staff-per-researcher ratios also indicated severe declines in some cases. The main agricultural research agencies in Madagascar, Guinea, Benin, and Ghana, for example, all experienced a decline in their support-staff-per-researcher ratio of 50 percent or more.

Figure 5—*Support-staff-to-researcher ratios by country, 2000*



Source: Compiled by authors from datasets underlying the ASTI country briefs.

Note: Data for West Africa, with exception of Nigeria, are for 2001.

RESOURCE ALLOCATION INDICATORS

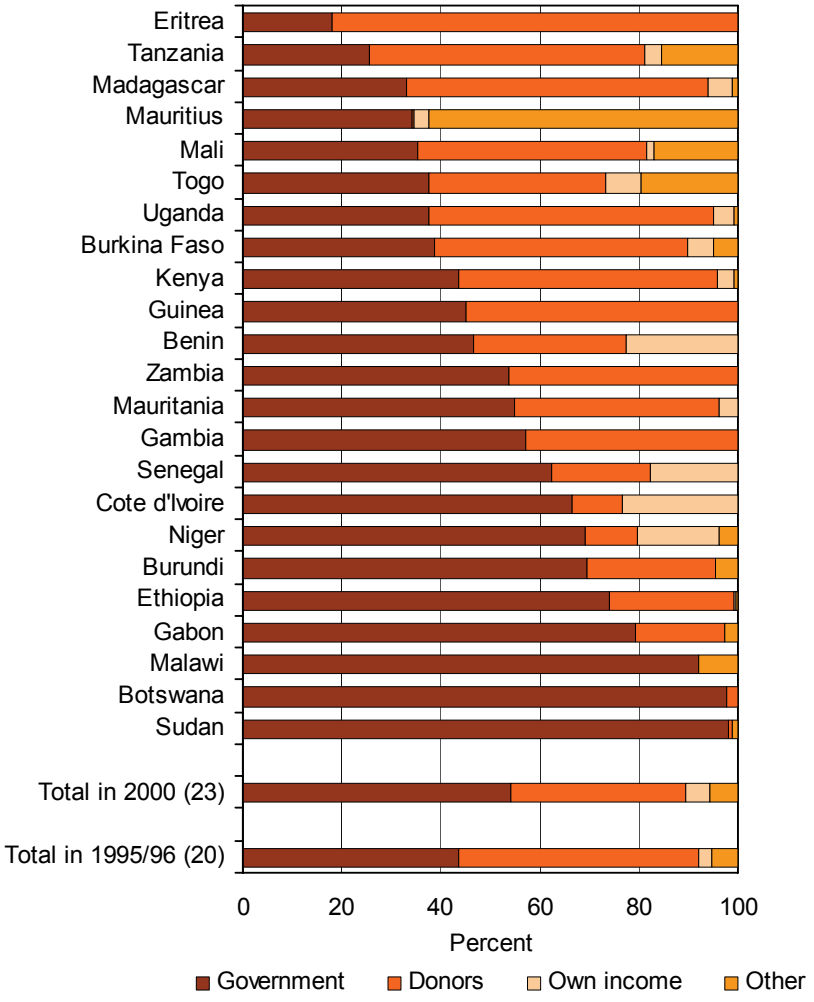
Funding Allocations of Public Agricultural R&D

Agricultural research is still largely financed by government contributions in most African countries. Over the past few decades, however, donor support has become increasingly important. Pardey, Roseboom, and Beintema (1997) found that in 1991, 43 percent of total agricultural research spending for a group of 22 countries (excluding South Africa) was derived from donors in the form of loans and grants; this compares with 34 percent in the early 1980s. This high donor-dependence continued until the mid-1990s, after which donor contributions declined. In 2000, donor funding averaged 36 percent at the main agricultural research agencies in 21 African countries. Five years earlier, close to half the funding for the main agencies in 18 of these countries came from donor contributions (Figure 6). These averages mask wide differences among countries, however. In 2000, donor funding accounted for more than half of all agricultural research funding in 7 of the 21 countries. Unsurprisingly, Eritrea and Niger were extremely donor-dependent: the principal agricultural research agencies in these countries received more than three-quarters of their funding via donor contributions. In contrast, donor funding was insignificant (less than 5 percent) in Malawi, Mauritius, and Sudan. From the mid-1990s to 2000, 6 of the 18 countries for which time-series data were available reported declines of 10 percentage points or more in their shares of donor funding, while for 6 countries, donor dependency increased by 10 percentage points or more. The large drop in donor funding from more than 50 percent of the total in the mid-1990s to less than 10 percent in 2000 is notable for the principal agricultural R&D agencies in Malawi, Niger, and Sudan. In these three countries, the sharp decline in donor funding can be attributed to the closure of World Bank, USAID, or Food and Agriculture Organization of the United Nations (FAO) projects in support of agricultural research. The donor share of total funding at the principal agricultural R&D agencies in Tanzania and Burundi, on the other hand, was more than 20 percentage points higher in 2000 than in the mid-1990s, this time due to the second Tanzania Agricultural Research Project, which ran from 1998 until 2002 and was financed by the World Bank, the African Development Bank, and various bilateral donors. Civil war in Burundi in the mid-1990s meant that donor funding was nonexistent, and this situation improved only slightly with the reinstatement of bilateral and multilateral donor support once inter-ethnic tensions eased toward the end the decade.

As evidenced above, the World Bank was an extremely important contributor to agricultural research activities in Africa through loan-supported projects in the 1990s. Projects variously focused on agricultural research and on agriculture more generally, with an agricultural R&D component. Some projects aimed to reshape a country's entire national agricultural research system, whereas others focused on specific crops, agencies, or general research management and coordination. After peaking at US$120 million dollars in 1991, total World Bank funding in support of African agricultural research declined precipitously during 1991–2002, reaching US$8 million in 2002 (in 1993 prices). Total funding by USAID similarly declined from a high of US$80 million in

1982 to just US$4 million in 1999 (IAC 2004). These rapid funding declines left many research agencies in serious financial trouble. The closure of World-Bank financed projects in Niger and Guinea, for example, forced the main agricultural R&D agencies in these countries to severely cut research activities and staff recruitment.

Figure 6—*Sources of funding by country, 1995/96 and 2000*



Source: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: Figures in parentheses indicate the number of countries in each total. Funding sources are for the main agricultural research agencies only. Combined, these agencies accounted for 76 percent of total spending for the 23-country sample in 2000. Data for West Africa are for 2001. The total for 1995/96 excludes Benin, Côte d'Ivoire, and Gabon.

Some countries were able to generate funding through other means, with the result that funding from nongovernment/nondonor sources grew from 8 percent in the mid-1990s to 11 percent in 2000. The principal agricultural research agencies of Benin and Côte d'Ivoire, for example, generated significant shares of total funding from research contracts, commercialization of agricultural products, and dissemination of

research results. In the case of Côte d'Ivoire, the World Bank's Second National Agricultural Services Support Project included an important commercialization component, stipulating that 35 percent of the annual budget of the National Agricultural Research Center (CNRA) was to be self-generated, for example, through commodity sales. The nine agencies working under the Council for Scientific and Industrial Research (CSIR) in neighboring Ghana were also required to derive 30 percent of their budget from private sources. Internally generated resources also represented 17 percent of total funding for the two principal agricultural research agencies in Senegal and Niger in 2001. In most other countries, however, self-generated sources of income were small (7 percent or less of total funding). This is because only the more commercially oriented agencies that focus on export crops are able to achieve such ambitious revenue targets.

Historically, research on export crops in many East African countries have been financed by the producers themselves in the form of commodity levies. The producer pays a tax on the production or export value of the commodity, and a share of the resulting revenues is earmarked for research. The mechanisms for collecting revenues and shares allocated to research vary across countries and commodities. Significant shares of coffee, tea, cotton, tobacco, cashew, and sugarcane research are financed this way in Tanzania and Kenya, and to a lesser extent Uganda.

In certain African countries, the share of total research financed through competitive funds appears to be increasing. These funds typically aim to optimize the performance of agricultural research by encouraging research collaboration among national agencies. Such mechanisms were in place in Kenya, Mali, Senegal, and Tanzania, for example, as part of broader World Bank-supported projects. Research proposals are typically submitted by a research team drawn from various agencies. A committee then reviews the proposals, making their selection based on a range of criteria. Research agencies in countries where competitive funding mechanisms have been introduced are increasingly forced to respond to farmer demands in order to secure sufficient funding for their research projects.

Only limited funding information was available for the two large systems, Nigeria and South Africa. Currently, agricultural research in Nigeria is largely funded by the government, but during the 1990s a considerable share of funding was provided through the National Agricultural Research Project (NARP), financed through a World Bank loan. Funding for agricultural research in South Africa is derived primarily from the national government, commodity trusts, producer levies, and private-sector enterprises. The limited amount of donor funding differentiates South Africa from most other African countries.

Research by government agencies in some African countries has been seriously thwarted as a result of large discrepancies between budget allocations and actual disbursements of funds, along with significant delays in the disbursement of funds. During 1992–99, for example, the Nigerian government released slightly more than half of the planned recurrent budget, on average, while only 5 percent of the proposed capital allocation was disbursed.

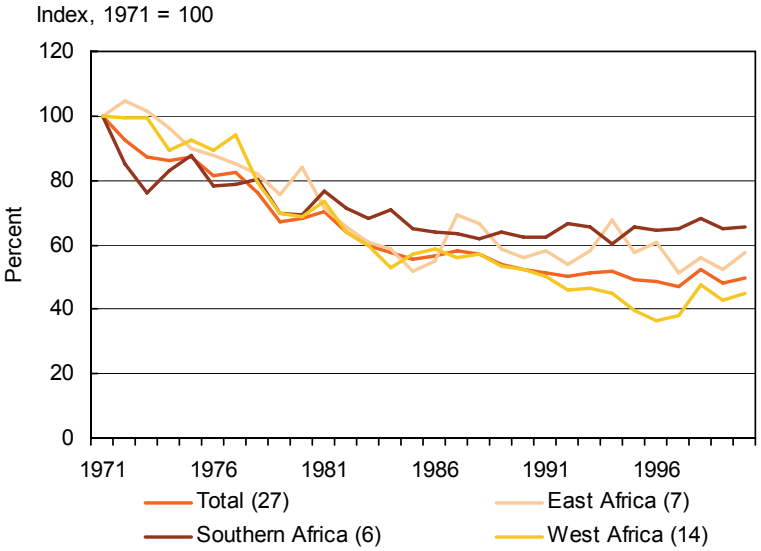
The future funding of agricultural R&D in Africa remains uncertain. The shift away from national government and donor financing is likely to continue, and

commodity levies, internally generated resources, local government funding, and commercial contracts are expected to gain greater importance (IAC 2004).

Spending per Scientist

Indexing the spending patterns described earlier by researcher provides different perspectives on the various (sub)regional trends (Figure 7). Spending per scientist levels declined considerably at African agricultural R&D agencies in the last three decades of the 20th century. In 2000, the average expenditure per researcher in a 27-country sample was about $100,000 in 1993 international dollars, which was about 32 percent lower than the value recorded two decades earlier and less than half the corresponding 1971 figure. This trend reflects the rapid growth in numbers of research staff in the 1970s and 1980s, combined with a very slow funding growth. Only two countries in our sample, Ghana and Kenya, had higher resources per scientist in 2000 than in 1981. The revamping of the level of resources per researcher during the 1990s is notable in countries such as Mali, Mauritius, Nigeria, and South Africa, although part of the increase recorded in these countries resulted from a decline in the number of researchers rather than an increase in financial resources. Nevertheless, most other African countries continued to experience (strong) declines in their resources per agricultural researcher.

Figure 7—*Trends in public agricultural research spending per researcher, 1971–2000*



Sources: Tables 1 and 4.

There is significant variation in the levels of spending per scientist in African countries, as well as among agencies within countries. In the nonprofit organizations, spending per agricultural researcher was generally about twice the level of their colleagues in government and higher education agencies. This in part reflects the higher

salary packages offered by the nonprofit institutions (one of the reasons for the attrition rates in the public sector).

Box 2. Biotechnology Research

Biotechnology has provided unparalleled prospects for improving the quality and productivity of crops, livestock, fisheries, and forestry. Conventional biotechnologies have been around for a very long time, while genetically modified (GM) technologies have emerged more recently. GM crops and technologies are making rapid progress worldwide. As of the early 2000s, 95 percent of biotechnology research in agriculture is undertaken (and research results patented) by multinational corporations (Bindraban and Rabbinge 2004).

Biotechnology could play a significant role in improving crop production for African farmers and in enhancing the nutritional value of many crops. But Africa lacks the capacity and resources to take advantage of modern biotechnology research either by developing new technologies relevant to local conditions or by adapting existing ones developed elsewhere. Only a handful of (larger) African countries have taken steps in this direction, and, in contrast to the developed world, biotechnology research is mainly performed by the public sector (Cohen 2005). South Africa is by far the most important participant in the biotechnology field in Africa; it is the only country to have successfully commercialized GM crops—mainly maize and cotton—thus far. All the necessary regulations to test and commercialize GM crops have been put in place by South Africa's National Department of Agriculture. Countries like Zimbabwe, Kenya, and Nigeria have also begun field trials on crops like cotton, maize, sweet potatoes, cassava, and tomatoes in order to determine whether genetically improved varieties offer benefits to local farmers and consumers, but they have yet to develop the necessary legislative frameworks to ensure the biosafety of GM organisms. Most other African countries are still expressing concern regarding the food and environmental safety issues, with the result that testing and importation of GM crops have been put on hold in many African countries (Bindraban and Rabbinge 2004).

Eicher (2005) argues that donor organizations can assist by providing financial support to African countries to build their human resource capacities and infrastructure in GM crop research, assisting with risk assessment, and supporting important institutional innovations that needed to advance African GM crop research.

Allocation by Research Area

The allocation of resources among various lines of research is a significant policy decision, so detailed information was collected on the number of fte researchers focusing on specific commodity areas. Close to half of the 7,840 fte researchers in a 26-country sample conducted crop research in 2000, while 20 percent focused on livestock research (Table 7). Natural resources research accounted for 9 percent of fte researchers, while forestry, socioeconomics, fisheries, and postharvest research each accounted for between 5 and 6 percent. More than two-thirds of the fte research staff in Malawi and Mauritius focused on crops, explaining the higher share of crop research in southern Africa. Similarly, close to 40 percent of the researchers in Sudan—one of the largest East African countries in terms of total fte researchers—conducted livestock research, resulting in the high subregional share.

Table 7—*Research focus by major area, 2000* (percent)

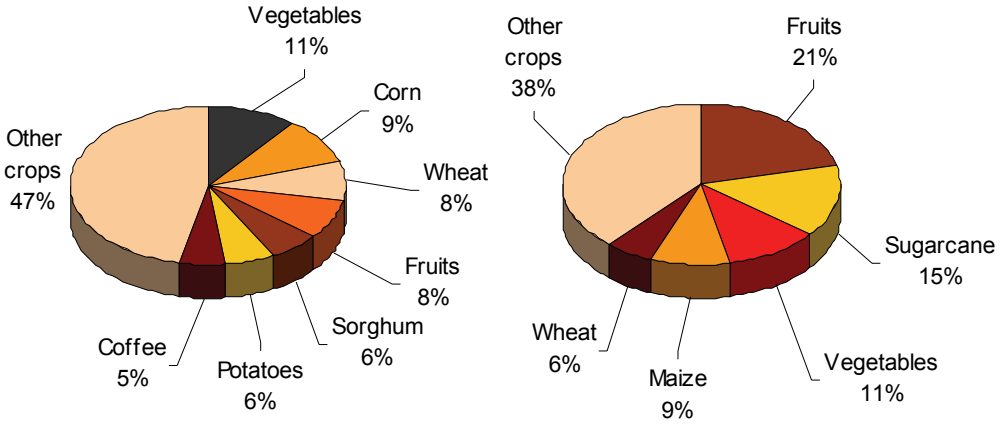
Area of research	East Africa (7)	Southern Africa (6)	West Africa (13)	Sub-Saharan African Total (26)
Crops	43.0	49.5	45.9	45.5
Livestock	22.0	20.7	17.5	19.9
Natural resources	9.5	10.9	7.1	8.8
Forestry	7.6	3.2	6.9	6.4
Socioeconomics	5.5	2.9	6.9	5.5
Fisheries	5.2	3.1	6.6	5.3
Off-farm postharvest	2.6	6.4	6.1	4.8
Other	4.6	3.3	3.0	3.7

Sources: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: Figures in parentheses indicate the number of countries in each category. The 7 East African countries are Burundi, Eritrea, Ethiopia, Kenya, Sudan, Tanzania, and Uganda; the 6 southern African countries are Botswana, Madagascar, Malawi, Mauritius, South Africa, and Zambia; the 13 West African countries are Burkina Faso, Republic of Congo, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, an Togo. For agency sample sizes see specific country briefs. Data for West Africa, with the exception of Nigeria, are for 2001.

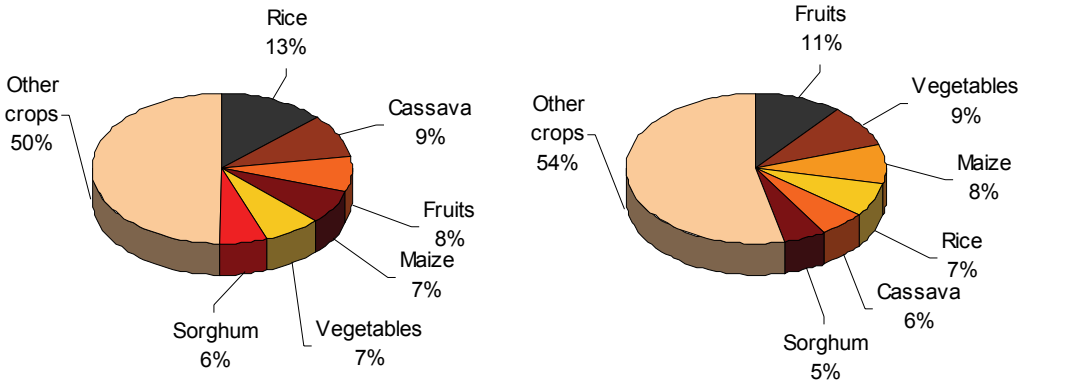
The major crops being researched in Africa are fruits, vegetables, and maize, accounting for 11, 9, and 8 percent of all fte crop researchers in 2000, respectively (Figure 8). Other important crops include rice, cassava, and sorghum, each accounting for between 5 and 7 percent of total crop researchers. More than half of the crop researchers, however, focused on a wide variety of other crops, each representing less than 5 percent of all crop researchers. Looking at the focus of crop researchers by subregion provides a somewhat different picture. Rice and cassava dominated in West Africa, with 2000 shares of 13 and 9 percent, respectively. Wheat and maize, representing shares of 11 and 10 percent, respectively, were strong in East Africa, while in southern Africa, 20 percent of crop researchers focused on fruit. The 15 percent share in southern Africa reflects the importance of sugarcane production and, hence, research in Mauritius through the Mauritius Sugar Industry Research Institute (MSIRI), which has attained world-class status.

Figure 8—*Crop research by major crop items, 2000*



a. East Africa (1,287 fte researchers) **b. Southern Africa (791 fte researchers)**

Figure 8—*Continued*



c. West Africa (1,492 fte researchers) **d. Total Sub-Saharan Africa (3,570 fte researchers)**

Source: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: For agency sample sizes see specific country briefs. Data for West Africa, with the exception of Nigeria, are for 2001.

Sector Size and Institutional Distribution

African agricultural research is still dominated by the government sector, which in 2000 accounted for more than three-quarters of total agricultural R&D staff (Table 8). The share of total research staff in the higher education sector represented 19 percent in 2000, up from 9 percent in 1971.[7] In absolute terms, the number of fte researchers in the higher education sector grew sixfold over this period, mainly as a result of the establishment of new higher education units involved in agricultural research. In 1971, close to 80 such agencies were identified in the 27-country sample, while three decades later this number had grown to over 200. Most of these new agencies were located in Nigeria and Sudan, which accounted for 38 and 29 percent of fte researchers in 2000, respectively—much higher than comparable shares in the other sample countries (Appendix Table C.4). Despite the high number of higher education agencies conducting agricultural research, the individual capacity of most of them (in terms of fte researcher numbers) is very small. As previously mentioned, faculty staff spend the great majority of their time teaching. While the amount of time spent on research by faculty staff has gradually risen over the years, it still represented less than 25 percent in 2000. This is, however, considerably higher than the 15 percent reported in 1991 by Roseboom, Pardey, and Beintema (1995). In addition, most of the research conducted at the higher education agencies is often discipline-based rather than applied research that focuses on solving specific production problems at the farmer level (Roseboom, Pardey, Beintema 1995).

[7] Funding for researchers at the higher education agencies was comparatively lower than for researchers at the other agencies; hence the higher education agencies' share of total agricultural R&D spending was slightly lower (16 percent).

Table 8—*The institutional orientation of agricultural research, 1961–2000*

Institutional category	Share of fte researchers				Annual growth rate[a]
	1971	1981	1991	2000	1971–2000
Government agencies	88.1	86.3	82.7	77.4	3.51
Higher education agencies	8.5	11.3	14.6	19.3	6.90
Nonprofit agencies	3.4	2.5	2.7	3.3	4.33
Total	100	100	100	100	3.97

Source: Compiled by authors from datasets underlying the ASTI country briefs.

Note: Sample includes 27 countries.

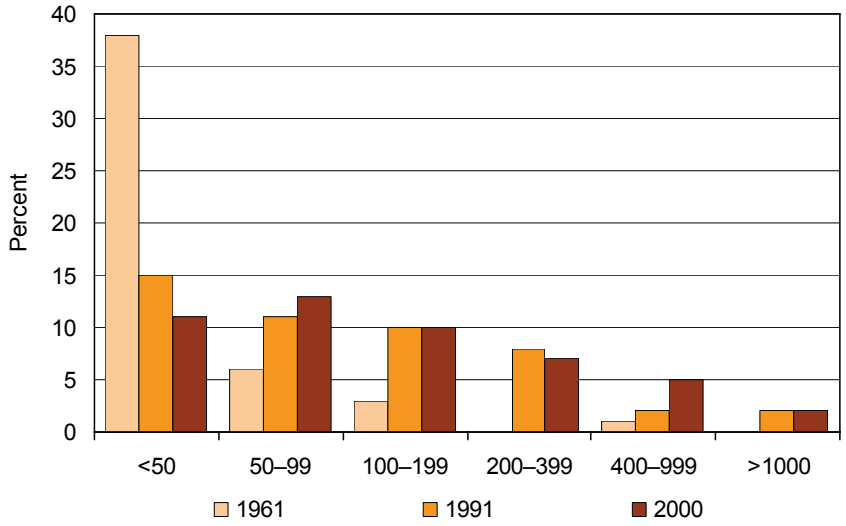
[a] Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period.

While nonprofit institutions often have more freedom than publicly funded entities, they are often linked to producer organizations and receive most of their funding via levies on production or exports. Examples include agencies conducting research on tea (Kenya, Tanzania, Malawi), coffee (Uganda, Kenya, Tanzania), cotton (Zambia), and sugar (Mauritius, South Africa). There are, however, other forms of nonprofit institutions in a number of countries, including Madagascar and Togo, although these play a limited role in agricultural research, accounting for only 3 percent of agricultural research staff in 2000.[8] That year, the southern African region employed about three-quarters of all researchers in the nonprofit institutions, most of which were located in Madagascar, Mauritius, and South Africa. Togo was the only West African country reporting nonprofit institutions involved in agricultural research, but the activities of these agencies have only very recently begun and remain relatively small (9 fte researchers in 2001). Although in absolute terms the number of fte researchers employed in the nonprofit sector has increased considerably in recent years, the sector's overall growth has been low compared with the government and higher education sectors; hence, nonprofit institutions in most countries accounted for a smaller share of agricultural research in 2000 than they did three decades earlier.

The size of national agricultural research systems across Africa has changed markedly in the past three decades (Figure 9). In 1961, only 4 of the 48 countries employed more than 100 fte researchers (Kenya, Nigeria, South Africa, and Zimbabwe), while only South Africa employed more than 400. By 2000, there were seven medium-sized systems (200–399 fte researchers) and four large systems (400–999 fte researchers). In addition, two countries (Nigeria and South Africa) employed more than 1,000 fte researchers. Similarly, only 11 of the 48 countries employed fewer than 50 fte researchers in 2001 compared with 38 in 1961. Nevertheless, African agricultural research remains heavily fragmented with more than half the countries employing fewer than 100 fte researchers.

[8] Funding per scientist at the nonprofit institutions is, on average, higher than funding per scientist in the government and higher education sectors; as a result, the nonprofit share of total agricultural R&D spending was twice that of the overall average (6 percent).

Figure 9—*Distribution of national agricultural R&D capacity by number of fte researchers, 1961, 1991, and 2000*



Sources: 1961 and 1991 data are from Pardey, Roseboom, and Beintema (1997); 2000 data are compiled by authors from datasets underlying the ASTI country briefs and Roseboom, Beintema, and Mitra (2004).

Note: Data includes all 48 Sub-Saharan African countries.

When comparing the size of R&D systems, an alternative to cross-country comparisons is the distribution of fte researcher numbers across research agencies. Analyzing the distribution of fte researchers across the 427 sample agencies shows that agencies with fewer than 10 fte researchers predominate with a share of about 61 percent—that is, 260 of the 427 agencies (Table 9). In 2000, 15 agricultural research agencies (4 percent) employed more than 100 fte researchers. The largest agencies in our sample were South Africa's ARC and the Kenyan Agricultural Research Institute (KARI), employing 634 and 469 fte researchers, respectively. The individual capacity of the majority of higher education units remains very small. More than half of the 200 higher education units—many being university faculties and departments—employed fewer than 5 fte researchers. Many of these higher education units were located in Nigeria and Sudan. In Nigeria, for example, more than half of the 59 higher education agencies included in our sample employed fewer than 5 fte researchers in 2000, nearly a quarter employed fewer than 2, and only 3 higher education agencies employed between 25 and 50 fte researchers. Similarly, two-thirds of the 30 higher education agencies in Sudan employed fewer than 10 fte researchers (13 of which employed fewer than 5) and only two higher education agencies employed more than 30 fte researchers. Research capacity in the private sector also remained small: of the 29 identified agencies, 24 employed fewer than 5 fte researchers, while none of the remaining 5 agencies employed more than 10 fte researchers in 2000.

Table 9—*Distribution of fte researchers across categories of agricultural R&D agencies*

Number of fte researchers	Government agencies		Higher education agencies	Nonprofit agencies	Private agencies	Total
	Principal	Other				
Less than 5	7	34	103	7	24	175
5–9	7	27	42	4	5	85
10–19	15	14	32	5		66
20–49	29	16	23	3		71
50–99	11	3		1		15
100–200	10					10
More than 200	5					5
Total	84	94	200	20	29	427

Sources: Compiled by authors from datasets underlying the ASTI country briefs.

Note: Based on a sample of 427 agricultural research agencies in 27 countries.

Compared with the 1991 distribution found in Roseboom, Pardey, and Beintema (1998), fragmentation in national agricultural research systems has increased somewhat over the years, which is mainly the result of the establishment nonprofit institutions and higher education units in the 1990s (the overall number of government agencies in our 27-country sample remained fairly constant).

Over the past two decades, many African countries have restructured their agricultural research systems aiming to improve efficiency and effectiveness, often as part of World Bank-funded projects. Examples of such countries include Côte d'Ivoire and Togo, where reforms included integrating research activities within a single agency; coordinating and developing national agricultural research plans; and improving management practices, such as planning, monitoring, and evaluation. In more recent years, reforms in Africa have moved toward redefining the government's role in agricultural research, decentralizing decisionmaking processes, increasing farmer/stakeholder participation, identifying new funding sources and mechanisms, and strengthening system linkages (Chema, Gilbert, and Roseboom 2003). As Chema, Gilbert, and Roseboom (2003) stated, these types of reform have great potential for enhancing the significance and efficiency of agricultural research, but in practice their success will depend on how well they are applied and modified to suit local conditions. In addition, sufficient time and resources are needed to facilitate the implementation of reforms. The authors also warn that conditions for agricultural research system reforms are unfavorable in some African countries, given geopolitical and institutional fragmentation of S&T capacity, unarticulated S&T strategies, poor technology and knowledge diffusion mechanisms, stagnant or volatile investment, high donor dependency, overstretched budgets, extremely low salaries, and weak organization and management.

THE ROLE OF OTHER AGENTS IN AGRICULTURAL R&D

With diminishing financial support for public agricultural research in Africa, the role of the private sector and regional and international research bodies is gaining importance.

Private Sector Investments

Private-sector investments in agricultural R&D have grown in recent years, especially in the developed world, but their role in the developing world is still minimal and will likely remain so given the lack of appropriate funding incentives. In addition, many of the private-sector R&D activities in developing countries focus solely on the provision of input technologies or technological services for agricultural production, but most of these technologies are adopted from the developed world.

In 2000, private firms in our 27-country sample invested $26 million in agricultural R&D, in 1993 international dollars, representing only 2 percent of total (public and private) research investments that year (Table 10). South Africa, with $16 million in private funding, was responsible for nearly two-thirds of all agricultural research conducted by the private sector. The private sector, however, plays a stronger role in funding, as opposed to conducting, agricultural research, however, given that many private companies contract government and higher education agencies to perform research on their behalf.

Table 10—*Estimated public and private agricultural R&D investments, 2000*

Region/country	Expenditures (million 1993 international dollars)			Shares (percent)	
	Public	Private	Total	Public	Private
East Africa (7)	341.4	5.4	346.8	98.4	1.6
South Africa[a]	365.6	15.6	381.2	95.9	4.1
Other southern Africa (5)	62.4	2.8	65.2	95.7	4.3
Nigeria[b]	106.0	—	106.0	100.0	—
Other West Africa (13)[c]	209.3	1.8	211.1	99.1	0.9
Total (27)	1,084.7	25.6	1,110.3	97.7	2.3
Total excluding Nigeria and South Africa (25)	613.1	9.8	622.9	98.5	1.5

Sources: Compiled by authors from datasets underlying the ASTI country briefs.

Notes: Figures in parentheses indicate the number of countries in each category. In some countries, a number of private companies chose not to share their financial and human resource data and hence are excluded.

[a] The share of omitted companies was estimated to be about one-third of South Africa's private-sector agricultural R&D spending.

[b] Private-sector involvement in Nigerian agricultural research (as well for a few other African countries) was negligible and often ad hoc.

[c] Data for other West African countries are for 2001.

For reasons of confidentiality, many private companies are reluctant to provide information on their resources and investments in agricultural research. In addition,

private research activities in Africa are often small in scale and ad hoc, making it difficult to capture accurate information. For these reasons, data for the private agencies in Africa slightly underestimate the private-sector share of agricultural research investments—but seemingly not substantially so.

Of the total 22 companies for which detailed information was available, 15 were locally owned, and 7 were affiliated with a foreign company headquartered elsewhere. The majority of the companies conducted seed research and crop production research predominantly related to export crops. Overall, the companies have small research facilities and low numbers of fte research staff. Only one company, the Kenana Sugar Company in Sudan, employed more than 10 fte researchers, while 17 of the remaining 21 companies employed 4 fte researchers or fewer.

Regional and International Efforts

Regional Research and Coordination

In the colonial era, (sub)regionally financed and coordinated research was widespread (see Appendix B for a short history on the organization of agricultural research during the twentieth century), but in the early years after independence in most countries, such collaboration ceased. In recent years, with the advent of globalization and the lack of funding for research, there has been renewed interest in regional and subregional approaches to agricultural research in Africa, following trends in other parts of the world.

Subregional agricultural research and coordination has changed considerably over the past two decades. The Special Program for African Agricultural Research (SPAAR) was established in 1985, based at the World Bank. SPAAR aimed to foster regional collaboration in agricultural R&D between donor organizations and African agricultural research systems and to enable Africa to benefit from the accumulated knowledge of global agricultural research and technology generation and transfer. SPAAR sought to strengthen networking in the region, and USAID and the World Bank assisted with the establishment of subregional organizations (SROs). The Southern African Centre for Cooperation in Agricultural and Natural Resources Research and Training (SACCAR) was the most active and well-organized SRO during the early 1990s, but most of its activities were discontinued in recent years due to a major reorganization of the Southern African Development Community (SADC), its parent organization, in 2001. There have been severe delays in the implementation of a proposed competitive grant mechanism as a result of this reorganization. In contrast, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), established in 1993, has made considerable progress in coordinating agricultural research activities in its 10 member countries through the establishment of various research networks. In 2004, ASARECA established a subregional competitive grant system, funded by the European Union, and it is envisaged that this will further improve regional collaboration. The West and Central African Council for Agricultural Research and Development (CORAF/WECARD), founded in 1987, has 21 member countries. The council coordinates various regional research networks and projects, encompassing a variety of research themes. CORAF/WECARD signed a contract with the European Union in 2000, within the

framework of the West Africa Agricultural Research Support Program (PARAO), which includes a competitive fund. Other donors have since shown interest in strengthening this fund, which has not yet become operational.

The Forum for Agricultural Research in Africa (FARA) was established in 2002 by the three SROs and succeeded SPAAR. Headquartered in Ghana, FARA is one of the regional forums linked to the Rome-based Global Forum of Agricultural Research (GFAR). FARA and a number of centers of the Consultative Group on International Agricultural Research (CGIAR) have developed a CGIAR Challenge Program specifically for Africa, which was approved in October 2004. This program aims to examine how CGIAR centers can collaborate more efficiently as equal partners with African national agricultural research systems.

Research networks were instigated by the international agricultural research centers prior to the establishment of the SROs, but these networks are now vital to the operation of SROs. Networks have proved to be a successful method of collaboration and information sharing compared with joint research programs on approved regional priorities. They allow specialization of particular national agricultural research systems in certain fields. Nonetheless, reaching agreement on regional priorities has been difficult as countries continue to pursue self-sufficiency in the fields of agricultural R&D in which they are weak (IAC 2004).

In 2001, various African leaders pledged to eradicate poverty, which led to the establishment of NEPAD of the African Union to address Africa's socioeconomic challenges and develop an integrated framework to overcome them. It targets a number of areas, including agriculture. The partnership aims to reinforce the capacity of Africa's agricultural R&D and extension systems in direct cooperation with FARA, the World Bank, FAO, and CGIAR. As mentioned previously, NEPAD's FAAP emphasizes the critical role of technical change and recommends a doubling of the current level of public agricultural R&D funding by 2015 in order to achieve regional annual agricultural growth of 6 percent (NEPAD 2002).

The CGIAR and *Other International Research Efforts*

The majority of international research in Africa is carried out by the CGIAR. In 2003, 45 percent (US$178 million) of the CGIAR's total budget of US$393 was spent on activities specifically related to Africa. Converting this to 1993 dollars, CGIAR spending on African issues represented about 10 percent of the combined $1.5 billion in total spending by the African national agricultural research agencies in 2003. Of the current 15 centers under the CGIAR, four are headquartered in Sub-Saharan Africa (Appendix Table C.5). Research specifically targeted to Africa represented between 66 and 100 percent of the research activities undertaken by these four centers in 2003. Activities focusing on Africa by the other 11 CGIAR centers ranged from 4 to 51 percent that year.[9] Most centers headquartered outside Africa—with the exception of International Rice Research Institute

[9] This share of CGIAR research efforts in Africa does not take into account the benefit of research spillovers across various agroecological regions. In addition, many CGIAR research efforts have a global orientation and are often broadly applicable.

(IRRI) and International Center for Agricultural Research in the Dry Areas (ICARDA)—currently have offices in Africa, and in some cases they have considerable research facilities with ample internationally recruited staff. Examples include IFPRI's recently established International Service for National Agricultural Research (ISNAR) Division in Ethiopia, and the seven centers of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) scattered across Africa.

During the CGIAR's annual general meeting in 2003, a broad study on the rationalization of CGIAR operations was endorsed (CGIAR 2004). The initial focus of this rationalization process was Africa. The CGIAR established two task forces, the first concentrating on programmatic alignment in the CGIAR, and the second focusing on organizational alignment. The task forces prepared a joint report that identified various areas of programmatic overlap among the centers working on Africa, stressing the importance of improving programmatic alignment and undertaking structural and governance reforms within the CGIAR. The key recommendation of the report was the creation of a single CGIAR center for Africa (CGIAR Secretariat 2005). Following discussions at the CGIAR's annual meetings in 2004, the task forces and centers decided to prepare two medium-term plans—one for the East and Central African subregion and one for the West African subregion.

Several other international and regional organizations have a presence and conduct agricultural research in Africa. The largest two in terms of budget are French: the Center for International Cooperation and Agricultural Research for Development (CIRAD) and the Institute for Research for Development (IRD, previously ORSTOM).[10] In 2001, their combined research budget was slightly lower than the CGIAR budget for Africa. CIRAD's commodity-oriented research focuses on food and export crops, livestock, forestry, fisheries, and agricultural mechanizations, while IRD's research activities are more thematic. In addition, the Asian Vegetable Research and Development Center (AVRDC) conducts vegetable research in Africa, the Permanent Interstate Committee for Drought Control in the Sahel (CILLS) at the Sahel Institute (INSAH) conducts research on socioeconomics and population, the International Centre of Insect Physiology and Ecology (ICIPE) focuses on insects, the International Fertilizer Development Center (IFDC) conducts research on fertilizer use, and the International Trypanotolerance Centre (ITC) undertakes research on trypanotolerance.[11]

CONCLUSION

Public agricultural research staff and spending in Africa increased rapidly during the 1960s. Since then, expenditure growth has stalled for the region as a whole. By 2000, R&D spending in Africa had reached nearly $1.5 billion (in 1993 international dollars).

[10] Roseboom, Beintema, and Mitra (2004) estimated that in 2001 CIRAD and IRD spent US$64 and US$89 million, respectively, on research activities in Africa compared with US$173 million of total CGIAR spending in the region for 2003.

[11] In 2001, AVRDC and ICIPE spent US$3 and US$9 million on research activities in Africa, but detailed budget information for the three organizations was unavailable (Roseboom, Beintema, and Mitra 2004).

Many individual countries, however, actually experienced a decline in agricultural R&D expenditures during the 1990s when funding became increasingly scarce, irregular, and donor-dependent. Large differences can be observed between African countries. For example, about half of the 27 sample countries experienced negative annual growth in agricultural R&D spending—some in excess of 10 percent per year. In contrast, a handful of countries experienced growth of 5 percent or more per year. Other key indicators show similar discrepancies among African countries.

Total donor funding in support of agricultural R&D has declined since the mid-1990s, often as a result of the closure of large projects financed by the World Bank, USAID, and FAO. Despite waning financial support to public agricultural R&D, the private sector has yet to make a significant contribution. Reliable estimates on private research spending are hard to estimate, but the best (and most recent) evidence suggests that, in 2000, the private sector accounted for only 2 percent of total (public and private) research investments in Africa. Reportedly, most of the private technologies in use throughout the region are based on research conducted elsewhere.

One positive development is the renewed interest in regional and subregional approaches to agricultural research in Africa. Through such regional networks, technological innovations made in one country can quickly impact research in other countries with similar agroclimatic conditions, thereby creating an important leapfrog effect. In addition, the CGIAR and other international research bodies have increased their focus in the region, many now having a substantial local presence. Nevertheless, the increased agricultural R&D activities of these alternative suppliers does not appear to have counterbalanced the stalling growth in public agricultural R&D spending.

In recent years, a number of highly influential initiatives have emphasized the critical role of (agricultural) science and technology for poverty alleviation and food security. New and better targeted technologies are essential to increasing agricultural productivity, as are well-developed and well-funded agricultural research systems. However, the recommendations and growth targets set by the IAC report and NEPAD's FAAP seem overly ambitious without substantial accompanying funding increases. Doubling Africa's agricultural research intensity ratio from 0.7 percent in 2000 to 1.5 percent by 2015 as recommended by IAC in 2004 would require average annual growth in agricultural R&D spending of 10 percent. Given that there is no evidence that governments and donor organizations have substantially increased their funding to agricultural research over the 1 percent per year average of the 1990s, this goal can only be considered unrealistic. In addition, based on existing investment patterns, Africa will probably miss out on most of the advances in biotechnology that are currently being made in other regions in the world. Given the continued withdrawal of donor funding, other funding sources will need to be consolidated and further developed to counteract the impending steady erosion of agricultural R&D capacity. In addition, foreign donors and African governments must renew their commitment to financing agricultural R&D, accompanied by innovative funding mechanisms, institutional reforms, and the formulation of sound S&T policies, all of which are prerequisites for improving the efficiency and effectiveness of the region's agricultural research.

REFERENCES

Alston, J. M., C. Chan-Kang, M. C. Marra, P. G. Pardey, and T. J. Wyatt. 2000. *A meta-analysis of rates of return to agricultural R&D: Ex pede herculem?* IFPRI Research Report 113, Washington, D.C.: International Food Policy Research Institute.

Alston, J. M., S. Dehmer, and P. G. Pardey. 2006. International initiatives in agricultural R&D: the changing fortunes of the CGIAR. Chapter 12 in *Agricultural research and development policy in the developing world*: *Too little too late?* P. G. Pardey, J. M. Alston, and R. Piggott, eds. Washington, D.C.: International Food Policy Research Institute.

Beintema, N. M., and P. G. Pardey. 2001. Recent developments in the conduct of Latin American agricultural research. Paper prepared for the international conference on agricultural science and technology, Beijing, November 7–9.

Beintema, N. M., P. G. Pardey, and J. Roseboom. 1998. *Educating agricultural researchers: A review of the role of African universities*. Environment and Production Technology Division Discussion Paper No. 36. Washington, D.C.: International Food Policy Research Institute.

Benson, T. 2004. *Assessing Africa's food and nutrition security situation*. 2020 Africa Conference Brief No. 1. Washington, D.C.: International Food Policy Research Institute.

Bindraban, P. S., and R. Rabbinge. 2004. *Technologies that can make a difference: Enhancing agricultural productivity in Africa*. Background Paper No. 2 commissioned by the InterAcademy Council Study Panel on Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa. Amsterdam: InterAcademy Council.

Brush, E. G., D. Merrill-Sands, D. P. Gapasin, and V. L. Mabesa. 1995. *Women scientists and managers in agricultural research in the Philippines.* ISNAR Research Report No. 7. The Hague: International Service for National Agricultural Research.

CGIAR (Consultative Group on International Agricultural Research). 2004. *Annual report 2003*. Washington, D.C.

CGIAR Secretariat. 2005. Report of the CGIAR Sub-Saharan Africa task forces: The Tervuren Consensus. <http://www.cgiar.org/pdf/agm05/agm05_ssa_tf_report%20.pdf>. Accessed February 2006.

Chema, S., E. Gilbert, and J. Roseboom. 2003. *A review of the key issues and recent experiences in reforming agricultural research in Africa*. Research Report No. 24. The Hague: International Service for National Agricultural Research.

Cohen, J. 2005. Poorer nations turn to publicly developed GM crops. *Nature Biotechnology* 23 (1): 27–33.

Eicher, C. K. 2004. *Rebuilding Africa's scientific capacity in food and agriculture.* Background paper No. 1 to the Inter-Academy Council panel on S&T strategies for improving agricultural productivity and food security in Africa. Amsterdam: InterAcademy Council.

Eicher, C. K., K. Maredia, and I. Sithole-Niang. 2005. *Crop biotechnology and the African farmer*. Staff Paper 2005-8. East Lansing, Michigan: Department of Agricultural Economics, Michigan State University.

Evenson, R. E. 2003. Production impacts of crop genetic improvement. In *Crop variety improvement and its effect on productivity. The impact of international agricultural research*, R. E. Evenson and D. Gollin, eds. Wallingford, United Kingdom and Cambridge, Massachusetts: CABI publishing.

FAO (Food and Agriculture Organization of the United Nations). 2002. FAOSTAT databases. <http://faostat.fao.org/default.htm>. Accessed January 2004.

IAC (InterAcademy Council). 2004. *Realizing the promise and potential of African agriculture. Science and technology strategies for improving agricultural productivity and food security in Africa*. Amsterdam.

NEPAD (New Partnership for Africa's Development) 2002. *Comprehensive Africa Agriculture Development Programme*. Midrand, South Africa.

OECD (Organisation for Economic Co-Operation and Development). 1994. *The measurement of scientific and technical activities 1993: Standard practice for surveys of research and experimental development—Frascati manual*. Paris.

Pardey, P. G., and N. M. Beintema. 2001. *Slow magic: Agricultural R&D a century after Mendel*. IFPRI Food Policy Report. Washington, D.C.: International Food Policy Research Institute.

Pardey, P. G., J. Roseboom, and N. M. Beintema. 1998. Investments in African agricultural research. *World Development* 25 (3): 409–423.

Pardey, P. G., N. M. Beintema, S. Dehmer, and S. Wood. 2006. A*gricultural Research: A growing global divide?* University of Minnesota and IFPRI, St. Paul and Washington, D.C.

Pardey, P. G., J. Roseboom, N. M. Beintema, and C. Chan-Kang. 1999. *Cost aspects of African agricultural research.* Environment and Production Technology Division Discussion Paper No.42. Washington, D.C.: International Food Policy Research Institute.

Roseboom, J. and N. M. Beintema. 1996. Taking count: Agricultural researchers in Sub-Saharan Africa*. Third World Organization for Women in Science Newsletter* 14 (January/June): 9.

Roseboom, J., N. M. Beintema, and S. Mitra. 2004 *Building impact-oriented R&D institutions.* Background Paper No. 3 for the Inter-Academy Council panel on S&T strategies for improving agricultural productivity and food security in Africa. Amsterdam: Inter-Academy Council.

Roseboom, J., P. G. Pardey, and N. Beintema. 1998. *The changing organizational basis of African agricultural research.* Environment and Production Technology Division Discussion Paper No.37. Washington, D.C.: International Food Policy Research Institute.

Sheridan, B. 1998. *Strangers in a strange land: a literature review of women in science.* CGIAR Gender Program Working Paper No. 17. Boston and Washington, D.C.: Simmons Institute for Leadership and Change and CGIAR Secretariat.

Temu, A., I. Mwanje, and K. Mogotsi. 2003. *Improving agriculture and natural resources education in Africa: A stitch in time*. Nairobi: World Agroforestry Centre.

Thirtle, C., L. Lin. and J. Piess. 2003. The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. *World Development* 31 (12): 1959-1975.

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

APPENDIX A — ASTI Methodology and Data Collection

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

The dataset for the 27-country sample underpinning this report includes information on more than 400 agencies and was processed using internationally accepted statistical procedures and definitions developed by the Organisation of Economic Co-operation and Development (OECD) and the United Nations Educational, Science, and Cultural Organization (UNESCO) for compiling R&D statistics (OECD 1994; UNESCO 1984). Agricultural R&D investments are measured on a performer basis. Estimates were grouped into four major institutional categories: government agencies, higher education agencies, nonprofit institutions, and business enterprises. Public agricultural research is defined to include government agencies, higher education agencies, and nonprofit institutions, thereby excluding private enterprises. Government agencies are directly administered by the national government and are typically departments or institutes within a certain ministry. Nonprofit institutions, on the other hand, are not directly controlled by the national government and have no explicit profit-making objective. These agencies are often linked to producer organizations or commodity boards. Higher education agencies are academic agencies that combine university-level education with research. They include agricultural faculties as well as specialized R&D institutes placed under universities. Private-sector agencies are agencies whose primary activity is the production of goods and services for profit. Some of these companies have an R&D unit dedicated to agricultural research, but R&D is generally not their main activity. Agricultural research activities undertaken by international organizations are explicitly excluded from the dataset and are reported separately.

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

In each of the 27 African countries included in this study, a complete list of agencies involved in agricultural R&D was identified at the onset of the survey and each

agency was approached to participate in the survey. To this end, three different survey forms were developed: one for government agencies and nonprofit institutions, one for faculties and schools, and one for the private sector. All forms had different sets of questions with the one for government agencies and nonprofit institutions requesting the most detail. In general the forms consisted of four sections:

- institutional details such as address, affiliation, organizational structure (including number of research stations), institutional history, and so on;
- human resource information, such as number of researchers by degree level, head count and full-time equivalents (that is, staffing adjusted for time spent on research), share of female researchers, and support staff by various categories;
- financial resources, such as expenditures by cost category and funding source; and
- research focus by commodity (about 35–40 items) and by theme (about 20 items).

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

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

Internationally Comparable Measures of R&D, Using PPPs

Comparing economic data from one country to the next is very complex due to important price level differences that exist between countries. Putting the agricultural R&D expenditures of two countries side by side is particularly difficult, given the fact that roughly two-thirds of research expenditures is typically spent on local research and support staff, rather than on capital or other goods and services, which are usually traded internationally.

The quantity of research resources used in economies with relatively low price levels tends to be understated when R&D spending is converted from different countries to a single currency using official exchange rates. Similarly, the quantity of resources used in countries with high price levels tends to be overstated. Purchasing power parities (PPP) are conversion rates that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. Therefore, a PPP rate can be thought of as the exchange rate of dollars for goods in the local economy, while the U.S.

dollar exchange rate measures the relative cost of domestic currency in dollars. A country's international price level is the ratio of its PPP rate to its official exchange rate for U.S. dollars. Thus the international price level is an index measuring the cost of a broad range of goods and services in one country relative to the same bundle of goods and services in a reference country, in this case the United States. For example, Japan's international price level (that is, the ratio of PPP to exchange rate) of 1.57 in the year 2000 implies that the price of goods and services in Japan was 57 percent higher than the price of comparable goods and services in the United States during that year. In contrast, the corresponding 2000 ratio for Kenya of 0.20 in Kenya indicates that a bundle of goods and services that cost $20 in Kenya would have cost $100 in the United States (Pardey and Beintema 2001).

No fully satisfactory method has so far been devised to compare consumption or expenditures between countries, either at different points in time or the same point in time. The measures obtained, as well as their interpretation, can be highly sensitive to the deflator and currency converter used. Most financial figures in this report have been expressed in "international dollars" for the benchmark year 2000. At the country level, all expenditure and funding data have been collected in local currency units. These amounts were subsequently converted to 2000 international dollars by deflating the local currency amounts with each country's GDP deflator of base year 2000 and converting to U.S. dollars with a 2000 PPP index (both the GDP deflators and PPP values were taken from the World Bank 2004). For convenience of interpretation, the reference currency—in this case international dollars—is set equal to a U.S. dollar in the benchmark year 2000.

APPENDIX B—Historical Developments of African Agricultural Research

Formal agricultural research in Africa began in the late 19th century when most of the region was colonized.[12] The three main colonizing powers, England, France, and Belgium, followed different strategies, each leaving their mark on agricultural R&D institutions to the present day. Prior to World War I, the British and, to a lesser extent, the French, Belgian, Portuguese, and German governments established numerous significant botanical gardens and model farms, as well as a small number of experimental farms throughout the continent. Research at that time focused mainly on tropical export crops. African agricultural research infrastructure continued to expand after World War I, becoming increasingly specialized. In line with this trend was the establishment of commodity-specific research stations. Agricultural research was managed by the local colonial administration with limited interference from the central colonial governments. Following World War II, the involvement of the British and French central governments increased substantially.

The British government reorganized and expanded agricultural research activities in its East African colonies by setting up a system of regional agricultural research organizations.[13] In contrast, in British West Africa, commodity agencies were restructured as regional institutes, and in British central Africa research was undertaken by project teams of different disciplines. Funding for agricultural research by ministerial institutes was managed and funded at the local level, while the regional institutes were funded directly from London. Agricultural research in the French colonies was more centrally managed through the creation of the Office of Overseas Scientific and Technical Research (ORSTOM) and several specialized and often commodity-oriented agricultural research institutes.[14] The commodity-oriented institutes focused largely on applied research, while ORSTOM was responsible for basic research. The distinction between the federal and local research institutes was further strengthened through a three-tiered research system of French-based commodity centers, federal research centers and stations, and local research stations. Similar to the British system, the French-based commodity centers and federal centers and stations were funded by the government in Paris, while the local stations received funding through the local administration.

Upon independence, the local agricultural research infrastructure was transferred to the newly formed nations. Britain provided some technical and financial assistance in

---

[12] This section is derived from Roseboom, Pardey, and Beintema (1998) and Chema, Gilbert, and Roseboom (2003).

[13] During 1946–52, seven such regional organizations were established in British East Africa: the East African Agriculture and Forestry Research Organisation, the East African Freshwater Fisheries Research Organisation, the East African Marine Fisheries Research Organisation, the East African Trypanosomiasis Research Organisation, the East African Veterinary Research Organisation, the Tea Research Institute of East Africa, and the Tropical Pesticides Research Institute of East Africa. The East African Agricultural and Forestry Research Council was created to monitor and coordinate the research activities of these regional as well as local institutes (Roseboom, Pardey, and Beintema 1998).

[14] Three such regional West African institutes were established for cocoa, rice, and oil palm. These institutes were part of the West African Interterritorial Research Organisation (Roseboom, Pardey, and Beintema 1998).

the first years of independence, but this support rapidly diminished. The regional organizations in British East and central Africa were discontinued or taken over by the new national governments. The regional organizations in British West Africa continued for some time but eventually collapsed as the newly independent countries vied for funding and managerial and operational control. In contrast, the French continued to manage and fund local research facilities affiliated with the French commodity institutes headquartered in Paris or Montpellier. In most cases bilateral agreements were made (often for 10 years) whereby France provided and paid for the scientists and related costs, and the African governments provided support staff. By the early 1970s, when most agreements ended, African governments slowly took over the stations and incorporated them into their newly established agricultural research systems. Nevertheless, the French continued to support these systems, and, as a result, expatriate researchers continued to play an important role.

Prior to 1960, Belgium had the largest tropical research institute of all colonial powers: the National Institute of Agronomic Studies of the Congo (INEAC). INEAC was headquartered in Belgium, had a large central research station in Yangambi (in the present-day Democratic Republic of Congo) and 36 research stations throughout the Belgian Congo, Burundi, and Rwanda. After independence, agricultural research infrastructure in Congo (Zaire) deteriorated quickly as a result of political and civil unrest. In Burundi and Rwanda, INEAC's infrastructure was transferred to the national governments. The Belgian government, however, remained influential in these two countries for many years, providing most of the funding and research staff for the two national research agencies.

The agricultural research infrastructure established by the colonial powers did not always fulfill the needs of the newly established governments. Some countries inherited very specialized institutes that did not necessarily address their production needs, but often focused on export crops. Other (often smaller) countries, were unable to sustain their systems when financial resources and expatriate research staff were withdrawn. Hence, many countries were left with minimal physical, human resource, or organizational research capacity. Most national governments, therefore, focused their attention on capacity building, specifically in terms of replacing expatriate staff with national researchers and enhancing research infrastructure. By the early 1980s, the focus of reform turned toward improving the effectiveness of national agricultural R&D, which involved merging various research activities within a single agency; coordinating and developing national agricultural research plans; and improving management practices such as planning, monitoring, and evaluation. This was particularly the case in Anglophone Africa. In more recent years, reforms in Africa have moved toward redefining the government's role in agricultural research, decentralizing decisionmaking processes, increasing farmer/stakeholder participation, identifying new funding sources and mechanisms, and strengthening system linkages.

APPENDIX C—SUPPLEMENTARY TABLES

Appendix Table C.1—*Trends in public agricultural research spending by country and subregion, 1971–2000*

Country	Total expenditures (1993 international dollars)				Annual growth rate[a] (percent)			
	1971	1981	1991	2000[b]	1971–81	1981–91	1991–2000	1971–2000[b]
East Africa								
Burundi	n.a.	n.a.	31.8	7.7	n.a.	n.a.	–16.21	1.01
Eritrea	—	—	—	8.9	—	—	—	—
Ethiopia	12.9	26.9	47.4	80.9	6.21	11.58	7.06	6.13
Kenya	51.6	62.4	101.5	123.6	1.27	4.97	0.57	3.51
Sudan	43.2	49.8	69.2	36.2	0.35	–2.21	–11.03	–1.62
Tanzania	n.a.	n.a.	n.a.	24.5	n.a.	n.a.	9.15	4.40
Uganda	n.a.	n.a.	n.a.	59.6	n.a.	n.a.	7.93	4.41
Subtotal (7)	136.5	185.6	292.7	341.4	2.21	5.07	0.88	3.17
Southern Africa								
Botswana	2.7	9.0	10.5	16.2	12.43	0.11	5.59	5.26
Madagascar	25.4	12.7	16.7	7.4	–4.58	3.03	–7.94	–2.38
Malawi	16.4	17.9	17.1	9.0	1.34	0.67	–5.48	–1.70
Mauritius	8.0	11.0	13.6	21.0	2.49	1.16	6.21	3.34
South Africa	287.5	300.3	313.3	365.6	0.11	0.14	1.85	1.65
Zambia	31.3	19.3	27.0	8.7	–4.70	–0.25	–7.25	–2.86
Subtotal (6)	371.3	370.2	398.2	427.9	–0.19	0.30	1.20	1.25
West Africa								
Benin	6.7	4.2	7.1	8.1	–4.14	5.65	–0.65	1.49
Burkina Faso	3.9	12.5	34.5	21.6	11.65	6.37	–3.16	6.57
Congo	n.a.	n.a.	6.5	2.4	n.a.	n.a.	–12.72	–1.67
Côte d'Ivoire	46.5	60.6	61.6	27.4	2.76	0.10	–3.36	–1.18
Gabon	n.a.	n.a.	1.0	1.6	n.a.	n.a.	4.08	2.33
Gambia	n.a.	n.a.	2.5	1.1	n.a.	n.a.	–7.07	–0.44
Ghana	30.6	21.3	54.3	61.9	–3.51	16.51	1.10	3.04
Guinea	n.a.	n.a.	14.5	7.0	n.a.	n.a.	–2.82	0.75
Mali	n.a.	30.1	23.6	27.5	n.a.	–2.07	1.08	1.65
Mauritania	n.a.	n.a.	6.2	8.9	n.a.	n.a.	3.70	2.86
Niger	6.3	12.0	16.5	6.3	12.86	2.98	–8.42	2.28
Nigeria	62.5	127.9	68.3	106.0	5.64	–6.71	6.27	–1.84
Senegal	27.5	38.0	27.9	21.8	3.58	–3.46	–3.06	–0.36
Togo	8.7	26.1	21.2	13.8	12.33	–0.64	–4.42	–0.31
Subtotal (14)	224.0	358.2	345.5	315.3	4.62	0.14	0.06	0.39
Total (27)	731.8	914.0	1,036.4	1,084.7	2.02	1.32	0.77	1.43
Total – Nigeria and South Africa (25)	381.8	485.8	654.8	613.1	2.46	3.31	–0.30	1.89

Sources: Compiled by authors from datasets underlying the ASTI country briefs.

[a] Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period.

[b] Data for West Africa, with the exception of Nigeria, are for 2001 are for 2001 and growth rates for 1991–2001. Subtotals include estimates for countries for which data were not available (indicated by "n.a.").

Appendix Table C.2—*Trends in public agricultural researchers by country and subregion, 1971–2000*

Country	Total researchers (full-time equivalents)				Annual growth rate[a] (percent)			
	1971	1981	1991	2000[b]	1971–81	1981–91	1991–2000	1971–2000[b]
East Africa								
Burundi	27.6	74.6	199.0	76.6	9.46	10.21	–11.81	4.34
Eritrea	—	—	—	85.8	—	—	—	—
Ethiopia	56.4	115.3	388.7	740.2	5.12	12.77	6.94	10.47
Kenya	297.3	453.7	953.0	822.3	3.28	6.56	–1.55	4.52
Sudan	127.3	324.0	516.4	779.7	8.59	4.43	4.69	5.88
Tanzania	n.a.	n.a.	n.a.	542.3	n.a.	n.a.	–0.07	n.a.
Uganda	107.7	209.2	225.5	244.9	7.84	0.46	1.30	2.71
Subtotal (7)	760.9	1,452.8	2,817.9	3,291.7	5.83	6.25	1.62	5.48
Southern Africa								
Botswana	20.2	46.9	58.5	95.5	8.51	2.02	4.93	5.28
Madagascar	90.9	107.2	179.2	202.2	0.57	6.17	1.36	4.72
Malawi	63.9	119.6	155.3	154.3	7.84	2.42	-0.36	3.07
Mauritius	38.0	72.0	116.2	147.0	5.98	4.30	4.48	4.73
South Africa	678.0	807.4	1047.0	1028.6	1.31	1.66	0.18	1.88
Zambia	136.8	182.7	204.6	178.8	1.67	0.92	0.03	1.05
Subtotal (6)	1,027.8	1,335.7	1,760.8	1,806.5	2.18	2.19	0.79	2.39
West Africa								
Benin	16.5	56.3	97.3	143.6	12.32	5.44	3.69	6.74
Burkina Faso	28.5	97.9	176.6	260.5	12.17	2.87	3.80	6.43
Congo	n.a.	n.a.	105.7	134.7	n.a.	n.a.	2.24	n.a.
Côte d'Ivoire	131.4	179.7	273.2	153.9	3.59	3.83	–5.55	1.09
Gabon	n.a.	n.a.	27.3	53.1	n.a.	n.a.	6.64	n.a.
Gambia	n.a.	n.a.	32.3	47.3	n.a.	n.a.	4.36	n.a.
Ghana	133.1	192.0	327.3	474.5	3.40	5.21	3.27	4.45
Guinea	n.a.	n.a.	219.5	269.3	7.56	3.75	2.04	4.45
Mali	n.a.	203.4	306.6	300.3	n.a.	3.75	–0.63	3.56
Mauritania	n.a.	n.a.	70.6	97.7	n.a.	n.a.	3.59	n.a.
Niger	13.7	47.7	99.4	108.7	17.36	6.68	1.28	7.17
Nigeria	366.2	908.3	1,135.8	1,351.9	10.67	1.39	1.95	3.32
Senegal	76.8	193.1	194.8	150.9	11.12	–0.63	–2.91	2.38
Togo	15.0	59.2	108.0	102.4	14.16	7.29	–0.30	5.89
Subtotal (14)	1,028.8	2,233.4	3,174.2	3,648.5	8.76	2.85	1.38	3.80
Total (27)	2,817.5	5,022.0	7,752.9	8,746.8	5.89	3.74	1.31	3.97
Total—Nigeria and South Africa (25)	1,773.3	3,306.3	5,570.1	6,366.2	6.13	4.78	1.42	4.65

Sources: Compiled by authors from datasets underlying the ASTI country briefs.

[a] Annual growth rates are calculated using the least-squares regression method, which takes into account all observations in a period.

[b] Data for West Africa, with the exception of Nigeria, are for 2001 and growth rates for 1991–2001. Subtotals include estimates for countries for which data were not available (indicated by "n.a.")

Appendix Table C.3—*Degree status by country and subregion, 2000*

Country	Share of fte researchers (percent)		
	PhD	MSc	BSc
East Africa			
Burundi	10.7	63.2	26.2
Eritrea	4.9	36.4	58.7
Ethiopia	9.3	42.5	48.2
Kenya	26.6	58.7	14.6
Sudan	33.8	45.0	21.2
Tanzania	25.6	52.2	22.2
Uganda	32.9	56.1	11.0
Subtotal (7)	23.2	50.3	26.4
Southern Africa			
Botswana	16.7	44.9	38.4
Madagascar	22.4	71.5	6.1
Malawi	23.5	52.5	24.0
Mauritius	11.9	41.0	47.2
South Africa	32.3	42.5	25.2
Zambia	19.9	51.3	28.8
Subtotal (6)	26.4	47.7	25.9
West Africa[a]			
Benin	16.3	64.8	18.9
Burkina Faso	50.0	45.4	4.6
Congo	33.2	55.7	11.1
Côte d'Ivoire	48.3	36.5	15.2
Gabon	29.1	45.1	25.8
Gambia	8.1	57.0	34.9
Ghana	33.6	50.1	16.2
Guinea	15.2	16.6	68.2
Mali	29.9	46.2	24.0
Mauritania	16.7	47.7	35.6
Niger	23.9	65.6	10.6
Nigeria	32.7	47.7	19.6
Senegal	45.8	53.4	0.8
Togo	39.4	56.5	4.2
Subtotal (14)	32.3	46.9	20.8
Total (27)	27.6	48.4	24.0
Total excluding Nigeria and South Africa (25)	25.9	49.4	24.6

Source: Compiled by authors from datasets underlying the ASTI country briefs.

[a] Data for West Africa, with the exception of Nigeria, are for 2001.

Appendix Table C.4—*Institutional orientation of public agricultural research capacity by country, 2000*

Country	Share of fte researchers (percent)		
	Government agencies	Nonprofit agencies	Higher education agencies
East Africa			
Burundi	77	0	23
Eritrea	96	0	4
Ethiopia	89	0	11
Kenya	75	9	16
Sudan	71	0	29
Tanzania	78	7	16
Uganda	80	0	20
Subtotal (7)	80	4	17
Southern Africa			
Botswana	86	4	9
Madagascar	86	10	4
Malawi	57	33	10
Mauritius	37	60	3
South Africa	77	8	15
Zambia	73	9	18
Subtotal (6)	75	12	14
West Africa[a]			
Benin	80	—	19
Burkina Faso	94	—	6
Congo	62	20	18
Côte d'Ivoire	87	—	13
Gabon	78	—	22
Gambia	92	—	8
Ghana	84	—	16
Guinea	90	—	10
Mali	90	—	10
Mauritania	92	—	8
Niger	84	—	16
Nigeria	62	—	38
Senegal	81	—	19
Togo	76	12	12
Subtotal (14)	78	1	22
Total (27)	78	6	16

Source: Compiled by authors from datasets underlying the ASTI country briefs.

[a] Data for West Africa, with the exception of Nigeria, are for 2001.

Appendix Table C.5—*CGIAR activities and share of budget in sub-Saharan Africa, 2003*

	Main areas of focus				Budget		
CGIAR center	**Activity**	**Commodity**	**Location of headquarters**	**Offices in Sub-Saharan Africa**	**Total (million U.S.$)**	**Sub-Saharan Africa (million U.S.$)**	**Sub-Saharan African Share (percent)**
International Institute for Tropical Agriculture (IITA)	Rice, maize, cassava, cocoyam, soybean	Farming systems	Nigeria	Benin, Cameroon, Cote d'Ivoire, Malawi, Mozambique, Tanzania, Uganda, Zimbabwe	37.7	37.4	100
International Livestock Research Institute (ILRI)	Livestock production, animal health		Kenya, Ethiopia	Burkina Faso, Ethiopia, Nigeria	31.0	20.5	66
Africa Rice Center (WARDA)[a]		Rice	Côte d'Ivoire	Nigeria, Senegal	10.1	10.1	100
World Agroforestry Centre[b]	Agroforestry, multipurpose trees		Kenya	Burkina Faso, Cameroon, Malawi, Mali, Mozambique, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Uganda, Zambia, Zimbabwe	27.4	21.7	79
International Center for Tropical Agriculture (CIAT)	Tropical pastures	Pasealous bean, cassava, rice	Colombia	Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Malawi, Zimbabwe	32.9	10.8	33
Center for International Forestry Research (CIFOR)	Sustainable forestry management		Indonesia	Cameroon, Zimbabwe	13.6	4.1	30
International Maize and Wheat Improvement Center (CIMMYT)		Wheat, maize	Mexico	n.a.	37.5	13.9	37
International Potato Center (CIP)		Potato, sweet potato, other root crops	Peru	Kenya, Uganda, Malawi	17.6	7.2	41
International Center for Agricultural Research in the Dry Areas (ICARDA)	Farming systems	Barley, lentil, faba bean	Syria	—	26.2	3.9	15
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Farming systems	Sorghum, millet, pigeon pea, chickpea, groundnut	India	Kenya, Niger, Malawi, Mali, Nigeria, Zimbabwe	24.0	12.3	47

Appendix Table C.5—*Continued*

CGIAR center	Main areas of focus: Activity	Main areas of focus: Commodity	Location of headquarters	Offices in Sub-Saharan Africa	Budget: Total (million U.S.$)	Budget: Sub-Saharan Africa (million U.S.$)	Budget: Sub-Saharan African Share (percent)
International Food Policy Research Institute (IFPRI)	Identify and analyze national and international strategies and policies for reducing hunger and malnutrition		United States	Ethiopia, Uganda, Senegal	26.5	12.8	48
International Plant Genetic Resources Institute (IPGRI)	Promote activities to further collection, conservation, evolution, and utilization of germplasm		Italy	Benin, Cameroon, Kenya, Uganda	28.3	8.5	30
International Rice Research Institute (IRRI)	Rice-based ecosystems	Rice	Philippines	—	28.8	1.1	4
International Service for National Agricultural Research (ISNAR)[c]	Strengthening national agricultural research systems		The Netherlands	Nigeria, South Africa	12.8	5.0	46
International Water Management Institute (IWMI)	Water and irrigation management		Sri Lanka	Ghana, Kenya, Senegal, South Africa	23.0	4.3	19
WorldFish Center[d]	Sustainable aquatic resource management		Malaysia	Cameroon, Malawi	15.5	4.7	30
Subtotal[d]					393.1	178.3	45

Sources: CGIAR (2004); Roseboom, Beintema, and Mitra (2004); Alston, Dehmer, and Pardey (2006).

[a] Known as the West African Rice Development Association (WARDA) until 2003.

[b] Known as the International Centre for Research in Agroforestry (ICRAF) until 2002.

[c] ISNAR was closed as a stand-alone center in April 2004, and is now a division of the International Food Policy Research Institute based in Addis Ababa, Ethiopia.

[d] Known as the International Centre for Living Aquatic Resource Management (ICLARM) until 2002.